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Department of Veterans Health Administration

Electronic Health Record Modernization (EHRM) Infrastructure Upgrades – Fort Meade, SD

Contract No. 36C77621C0078

Black Hills Health Care System

Fort Meade

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Volume 2

Divisions 21 - 27

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NEED PRECAST

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SECTION 21 13 13
WET-PIPE SPRINKLER SYSTEM MODIFICATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Existing sprinklers require relocation due to changes in some of the telecommunication rooms (TR). General locations are shown on the reflected ceiling drawings.

B. Contractor shall shut off the appropriate sprinkler system zone valve, drain the water in the piping in that zone, relocate the indicated heads, flush the piping in the affected zone, and recharge the zone.

C. New sprinklers shall be quick response unless quick response sprinklers are specifically prohibited for the location and hazard.

D. It is not permissible to mix quick response and standard response sprinklers. Sprinklers within the same compartment shall have the same response characteristics.

E. Sprinkler systems protecting Telecommunication Spaces (TS) in Building 145, Room 132, Main Computer Room (MCR) will be valved separately from other sprinkler systems.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 07 84 00, FIRESTOPPING.

C. Section 08 34 00.10, AISLE CONTAINMENT CURTAIN

D. Section 09 91 00, PAINTING.

1.3 DESIGN CRITERIA

A. Design Basis Information: Provide materials, equipment, installation, and inspection in accordance with the requirements of NFPA 13.

B. Sprinkler hazard classifications shall be:

1. In Telecommunication Spaces (TS) Ordinary Hazard Group I (Building 145, Room 132, Main Computer Room (MCR)).

2. In Telecommunication Rooms (TR) Light Hazard or existing density if greater than light hazard.

3. In spaces that are being abandoned and converted to other uses, hazard classification shall be in accordance with NFPA 13.

4. In Building 145, Room 139A (Storage / PBX) and in Room 137 (OIT), sprinkler contractor shall evaluate storage heights and commodities to determine appropriate hazard classification.

5. In spaces changing from a higher to lower hazard classification, existing hazard classification may remain unchanged.

1.4 SUBMITTALS

A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Prepare detailed working drawings that are signed by a NICET Level III or Level IV Sprinkler Technician or stamped by a Registered Professional Engineer licensed in the field of Fire Protection Engineering. As the Government review is for technical adequacy only, the installer remains responsible for correcting any conflicts with other trades and building construction that arise during installation. Partial submittals will not be accepted. Material submittals shall be approved prior to the purchase or delivery to the job site. Suitably bind submittals in notebooks or binders and provide an index referencing the appropriate specification section. In addition to the hard copies, provide submittal items in Paragraphs 1.4(A)1 through 1.4(A)5 electronically in pdf format on a compact disc or as directed by the COR. Submittals shall include, but not be limited to, the following:

1. Qualifications:
   a. Provide a copy of the installing contractors fire sprinkler and state contractor’s license.
   b. Provide a copy of the NICET certification for the NICET Level III or Level IV Sprinkler Technician who prepared and signed the detailed working drawings unless the drawings are stamped by a Registered Professional Engineer licensed in the field of Fire Protection Engineering.
   c. Provide documentation showing that the installer has been actively and successfully engaged in the installation of commercial automatic sprinkler systems repairs and modifications for the past ten years.
2. Drawings: Submit detailed 1:100 (1/8 inch) scale (minimum) working drawings conforming to the Plans and Calculations chapter of NFPA

13. Drawings shall include graphical scales that allow the user to determine lengths when the drawings are reduced in size.

3. Manufacturer's Data Sheets: Provide data sheets for all materials and equipment proposed for use on the system. Include listing information and installation instructions in data sheets. Where data sheets describe items in addition to those proposed to be used for the system, clearly identify the proposed items on the sheet.
4. Valve Charts: Provide a valve chart that identifies the location of each control valve of the zones affected by the work in this specification section. Coordinate nomenclature and identification of control valves with COR.
5. Final Document Submittals: Provide as-built drawings, testing and maintenance instructions in accordance with the requirements in Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. In addition, submittals shall include, but not be limited to, the following:
   a. Material and Recharging Certificate: Upon completion of the sprinkler system installation modifications and flushing, provide a copy of a completed Material and Activation Certificate as indicated in NFPA 13. Certificates shall be provided to document all parts of the new work.

1.5 QUALITY ASSURANCE

A. Installer Reliability: The installer shall possess a valid State of South Dakota fire sprinkler contractor's license. The installer shall have been actively and successfully engaged in the repair of commercial automatic sprinkler systems for the past ten years.

B. Materials and Equipment: All equipment and devices shall be of a make and type approved by FM and/or listed by UL or other nationally recognized testing laboratory for the specific purpose for which it is used. All materials, devices, and equipment shall be approved by BHHCSVA Fire Chief and GDM's Fire Protection Engineer. All materials and equipment shall be free from defect. All materials and equipment shall be new unless specifically indicated otherwise on the contract drawings.

1.6 APPLICABLE PUBLICATIONS

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

B. National Fire Protection Association (NFPA):

13-22.....Installation of Sprinkler Systems

25-20.....Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

101-21.....Life Safety Code

170-21.....Fire Safety and Emergency Symbols

C. Underwriters Laboratories, Inc. (UL):

Fire Protection Equipment Directory (2011)

D. Factory Mutual Engineering Corporation (FM):

Approval Guide

PART 2 - PRODUCTS

2.1 PIPING & FITTINGS

A. Piping and fittings for sprinkler systems shall be in accordance with NFPA 13 and match the existing system's materials.

B. Plastic piping shall not be permitted except for drain piping.

C. Flexible sprinkler hose shall be FM Approved and limited to hose with threaded end fittings with a minimum inside diameter or 1-inch and a maximum length of 6-feet.

2.2 VALVES

A. General:

1. Valves shall be in accordance with NFPA 13.
2. Do not use quarter turn ball valves for 50 mm (2 inch) or larger drain valves.

B. Control Valve: The control valves shall be a listed indicating type. Control valves shall be UL Listed or FM Approved for fire protection installations. System control valve shall be rated for normal system pressure but in no case less than 175 PSI.

C. Check Valve: Shall be of the swing type with a flanged cast iron body and flanged inspection plate.

D. Automatic Ball Drips: Cast brass 20 mm (3/4 inch) in-line automatic ball drip with both ends threaded with iron pipe threads.

2.3 SPRINKLERS

A. All sprinklers shall be FM approved.

B. Provide standard response sprinklers with fusible link heads in telecommunication spaces (TS) and quick response sprinklers in all other areas.

C. Data Center 132 in Building 145 is a Main Computer Room (MCR) classified as a Telecommunication Space (TS). Due to use of drop-out ceiling in cold aisle containment, sprinklers shall be intermediate temperature; do not use ordinary temperature sprinklers.

D. Provide sprinkler guards in telecommunication spaces (TS). Provide sprinkler guards in accordance with NFPA 13 in all other areas. The sprinkler guard shall be UL listed or FM approved for use with the corresponding sprinkler. See Specification 21 13 45.

2.4 SPRINKLER CABINET

A. Provide sprinkler cabinet with the required number of sprinkler heads of all ratings and types installed, and a sprinkler wrench for each type of sprinkler in accordance with NFPA 13. Locate adjacent to the riser.

B. Provide a list of sprinklers installed in the property in the cabinet. The list shall include the following:

1. Manufacturer, model, orifice, deflector type, thermal sensitivity, and pressure for each type of sprinkler in the cabinet.
2. General description of where each sprinkler is used.
3. Quantity of each type present in the cabinet.
4. Issue or revision date of list.

2.5 PIPE HANGERS, SUPPORTS AND RESTRAINT OF SYSTEM PIPING

Pipe hangers, supports, and restraint of system piping shall be in accordance with NFPA 13.

2.6 WALL, FLOOR AND CEILING PLATES

Provide chrome plated steel escutcheon plates.

2.7 VALVE TAGS

Engraved black filled numbers and letters not less than 15 mm (1/2 inch) high for number designation, and not less than 8 mm (1/4 inch) for service designation on 19 gage, 40 mm (1-1/2 inches) round brass disc, attached with brass "S" hook, brass chain, or nylon twist tie.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Installation shall be accomplished by the licensed contractor. Provide a qualified technician, experienced in the installation and operation of the type of system being installed, to supervise the installation and testing of the system.

B. Installation of Piping: Accurately cut pipe to measurements established by the installer and work into place without springing or forcing. In any situation where bending of the pipe is required, use a standard pipe-bending template. Pipe hangers, supports, and restraint of system piping, and seismic bracing shall be installed accordance with NFPA 13.

C. Provide escutcheon plates for exposed piping passing through walls, floors or ceilings.

D. Supervisory Switches: Provide supervisory switches for sprinkler control valves.

E. Clearances: For systems requiring seismic protection, piping that passes through floors or walls shall have penetrations sized 50 mm (2 inches) nominally larger than the penetrating pipe for pipe sizes 25 mm (1 inch) to 90 mm (3 ½ inches) and 100 mm (4 inches) nominally larger for penetrating pipe sizes 100 mm (4 inches) and larger.

F. Sleeves: Provide for pipes passing through masonry or concrete. Provide space between the pipe and the sleeve in accordance with NFPA 13. Seal this space with a UL Listed through penetration fire stop material in accordance with Section 07 84 00, FIRESTOPPING. Where core drilling is used in lieu of sleeves, also seal space. Seal penetrations of walls, floors and ceilings of other types of construction, in accordance with Section 07 84 00, FIRESTOPPING.

G. Firestopping shall be provided for all penetrations of fire resistance rated construction. Firestopping shall comply with Section 07 84 00, FIRESTOPPING.

H. Painting of Pipe: In finished areas where walls and ceilings have been painted, paint primed surfaces with two coats of paint to match adjacent surfaces, except paint valves and operating accessories with two coats of gloss red enamel. Exercise care to avoid painting sprinklers. Painting of sprinkler systems above suspended ceilings and in crawl spaces is not required. Painting shall comply with Section 09

91 00, PAINTING. Any painted sprinkler shall be replaced with a new sprinkler.

I. Sprinkler System Signage: Provide rigid sprinkler system signage in accordance with NFPA 13 and NFPA 25. Sprinkler system signage shall include, but not limited to, the following:

1. Identification Signs:

a. Provide signage for each control valve, drain valve, sprinkler cabinet, and inspector's test.

b. Provide valve tags for each operable valve. Coordinate nomenclature and identification of operable valves with COR. Where existing nomenclature does not exist, the Tag Identification shall include no less than the following: (FP-B-F/SZ-#) Fire Protection, Building Number, Floor Number/Smoke Zone (if applicable), and Valve Number. (E.g., FP-500-1E-001) Fire Protection, Building 500, First Floor East, Number 001.)

J. Repairs: Repair damage to the building or equipment resulting from the installation of the sprinkler system by the installer at no additional expense to the Government.

K. Interruption of Service: There shall be no interruption of the existing sprinkler protection, water, electric, or fire alarm services without prior permission of the Contracting Officer. Contractor shall develop an interim fire protection program where interruptions involve occupied spaces. Request in writing at least one week prior to the planned interruption.

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SECTION 21 13 45
SPRINKLER GUARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Supply and installation of sprinkler guards for existing wet-pipe system sprinklers in all Telecommunication Spaces(TS).

1.2 RELATED WORK

A. Section 02 41 00, DEMOLITION OF EXISTING CEILING SYSTEMS.

1.3 DESIGN CRITERIA

A. Hard-wire cage designed to incase the sprinkler and protect it from mechanical damage. Guards shall be approved by the manufacture for use with upright or pendent style sprinklers.

1.4 SUBMITTALS

A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
   1. Manufacturers technical data
   2. Two samples of each proposed type

1.5 QUALITY ASSURANCE

A. Listings and Approvals
   1. UL listed
   2. FM approved class 2901

1.6 APPLICABLE PUBLICATIONS

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

B. National Fire Protection Association (NFPA):
   13-22 .....Installation of Sprinkler Systems

C. Underwriters Laboratories, Inc. (UL):
   Fire Protection Equipment Directory (2011)

D. Factory Mutual Engineering Corporation (FM):
   Approval Guide

PART 2 - PRODUCTS

2.1 PIPING & FITTINGS

A. Basis of Design

1. The sprinkler guard shall be listed for use with the make and model of the sprinkler being protected.
2. Viking model D-1 Sprinkler guard
   The Viking Corporation, 2010 N Industrial Park Drive, Hastings, MI 49058. Telephone: 269-945-9501 Technical Services: 877-384-5494 Fax:269-818-1680 Email:techsvcs@vikingcorp.com
   www.vikinggroupinc.com
3. Or approved equal.

2.2 SPARES

A. Provide four(4) spare guards of each type

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be accomplished by a qualified technician, experienced in the installation of sprinkler guards.

B. Repairs: Repair damage to the building or equipment resulting from the installation of the sprinkler guards by the installer at no additional expense to the Government.

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SECTION 21 22 00

CLEAN AGENT FIRE SUPPRESSION SYSTEM

PART 1 – GENERAL

1.1 DESCRIPTION

A. The requirements in this specification section include the design, installation and testing of a calculated automatic and manual fixed total flooding clean agent fire extinguishing system and releasing system in accordance with VHA Office of Occupational Safety Health (19HEF) Fire Protection Design Manual Eighth Edition – June 1, 2021, NFPA 2001, NFPA 72, NFPA 70, and NFPA 75 and proposed clean agent manufacturer's written instructions for the telecommunication space on the contract drawings. The installation shall include all mechanical, controls and electrical components necessary for a complete and operating clean agent fire suppression system.

B. The Telecommunication Space (TS) for this project is Data Center 132 in Building 145, Main Computer Room (MCR).

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

B. Section 07 84 00, FIRESTOPPING

C. Section 09 91 00, PAINTING

D. Section 28 05 13, CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

E. Section 28 05 28.33, CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY

F. Section 28 31 00, FIRE DETECTION AND ALARM

1.3 DESIGN CRITERIA

A. The clean agent fire extinguishing system shall be a fixed total flooding type utilizing clean agent designed to provide a uniform concentration throughout the protected spaces in accordance with NFPA 2001 for a Class C fire.

1. The system shall provide a minimum design concentration by volume, throughout the protected spaces at the minimum anticipated temperature within the protected space.
2. The design concentration within any protected space shall not exceed by volume the no observable adverse effects level (NOAEL). Special

means such as mechanical exhaust shall not be permitted to be used to achieve this criterion.

3. The clean agent shall have a global warming potential (GWP) of less than 4,000 and the clean agent shall be readily available throughout the continental United States.
4. Provide the quantity of clean agent as required by NFPA 2001 and agent's manufacturer's calculations and written instructions. Such factors as unenclosed openings (if any), "rundown" time of fans, time required for dampers to close, and any other feature of the facility that could affect concentration shall be addressed in clean agent quality to maintain an agent concentration of 85% for a 10 minute time duration per NFPA 2001.
5. Provide seismic bracing for the clean agent fire extinguishing system components per specification Section 13 05 41.

1.4 SUBMITTALS

A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Prepare detailed working drawings that are signed by a NICET Level IV Special Hazards Suppression Systems Technician. As the Government review is for technical adequacy only, the installer remains responsible for correcting any conflicts with other trades and building construction that arise during installation. Partial submittals will not be accepted. Material submittals shall be approved prior to the purchase or delivery to the job site. Suitably bind submittals in notebooks or binders and provide an index referencing the appropriate specification section. In addition to the hard copies, provide submittal items in Paragraphs 1.4(A)1 through 1.4(A)5 electronically in PDF format on a compact disc or as directed by the Contracting Officers Representative (COR). Submittals shall include, but not be limited to, the following:

1. Qualifications:
   a. Provide a copy of the installing contractor's and state of South Dakota contractor's license.
   b. Provide a copy of the NICET certification for the NICET Level IV Special Hazards Suppression System Technician who will prepare and sign the detailed working drawings.

c. Provide documentation showing that the installer has been actively and successfully engaged in the installation of clean agent fire suppression systems for the past ten (10) years.

2. Drawings: Submit detailed 1:100 (1/8 inch) scale (minimum) working plans and drawings of the clean agent fire extinguishing system conforming to NFPA 2001. Submit detailed 1:100 (1/8 inch) scale (minimum) working plans and drawings of the releasing system conforming to NFPA 72. Drawings shall include graphical scales that allow the user to determine lengths when the drawings are reduced in size.
3. Manufacturers Data Sheets:
   a. Provide for all materials and equipment proposed for use on the clean agent fire extinguishing system, including the releasing system. Include listing information and installation instructions in data sheets. Where data sheet describes items in addition to that item being submitted, clearly identify proposed item on the sheet.
4. Calculation Sheets:
   a. Submit flow calculation sheets in tabular form conforming to the requirements of NFPA 2001. Calculations shall include total storage capacity, flooding concentrations, enclosure leakage rates, discharge times, flow through distribution network, pipe sizes, and nozzle orifice sizes.
   b. Submit battery calculations sheets in tabular form conforming to the requirements of NFPA 72.
   c. Submit voltage drop calculations in tabular form. Calculations shall indicate circuit amperage draw, wire resistance, circuit length, and voltage drop. The voltage drop shall demonstrate that voltage provided at the each appliance is within its operating voltage range. Voltage drop calculations shall assume an initial voltage of 20.4 volts.
   d. Submit calculations of loads for sizing of sway bracing.
5. Clean Agent Recharging Certification: Provide a letter to the COR certifying that the installer maintains or has access to a clean agent recharging station. The installer shall also provide proof of

the ability to recharge the largest clean agent fire extinguishing system capacity within 48 hours.

6. Test Plan: Provide a test plan to the COR. The testing plan shall describe the procedures to be used to test the system. The testing plan shall include a step-by-step procedure of all tests to be performed, including indication of which tests will present a disruption to building occupants. No tests shall be conducted until the testing plan is approved by the COR or his designated representative.
7. Final Record Document Submittals: Provide as-built drawings, testing and maintenance instructions in accordance with the requirements in Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Submittals shall include, but not be limited to, the following:
   a. A complete set of as-built drawings showing the installed system with the specific interconnections between the system switches and the fire alarm equipment. Provide a complete set in the formats as follows. Submit Items 2 and 3 below on a compact disc or as directed by the COR.
      1) One full size (or size as directed by the COR) printed copy.
      2) One complete set in electronic PDF format.
      3) One complete set in AutoCAD format or a format as directed by the COR.
   b. System Certification: Upon completion of the clean agent fire extinguishing system installation, including testing, the authorized representative of the installing contractor and the NICET IV designer shall certify that the installation complies with all requirements and that satisfactory total system operation has been achieved. Provide a copy of the Record of Completion for the releasing system in accordance with NFPA 72.
   c. Operating and Maintenance Manuals that include step-by-step procedures required for operation, shutdown, and routine maintenance and testing. The manuals shall include the manufacturer's name, model number, parts list, the name of the local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization,

including address and telephone number, for each item of equipment.

d. One (1) paper copy of the System Certification and Record of Completion and the Operating and Maintenance Manuals listed above shall be provided in a binder. In addition, these materials shall be provided in PDF format on a compact disc or as directed by the COR.

e. Provide one (1) additional copy of the Operations and Maintenance Manual for the system in a binder and mount in an accessible location adjacent to the storage cylinder(s).

1.5 QUALITY ASSURANCE

A. Installer Reliability: The installer shall possess a valid state of South Dakota contractor's license. The installer shall have been actively and successfully engaged in the installation of five similar sized clean agent special suppression systems for the past ten years. The installer shall maintain or have access to a clean agent recharging station. The installer shall provide proof of the ability to recharge the clean agent fire extinguishing system capacity within 48 hours.

B. Materials and Equipment: All equipment and devices shall be UL listed or approved by FM. All materials, devices, and equipment shall be approved by the VA. All materials and equipment shall be free from defect.

1.6 APPLICABLE PUBLICATIONS

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

B. National Fire Protection Association (NFPA):

70-2021.....National Electric Code

72-2022.....National Fire Alarm Code

75-2020.....Fire Protection of Information Technology Equipment

170-2021.....Fire Safety Symbols

2001-2022.....Installation of Clean Agent Fire Extinguishing Systems

C. Underwriters Laboratories, Inc. (UL): Fire Protection Equipment

As of Contract Award Date Directory

D. Factory Mutual Engineering Corporation (FM): Approval Guide
As of Contract Award Date

1.7 WARRANTY

All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of one year from the date of acceptance of the entire installation by the COR.

PART 2 PRODUCTS

2.1 GENERAL

A. All equipment and components shall be new and the manufacturer's current model. All equipment and components shall be UL listed or FM approved for its intended use. The authorized representative of the manufacturer of the major equipment shall certify that the installation complies with all manufacturer's requirements and that satisfactory total system operation has been achieved.

B. Fire extinguishing agents approved by VA are limited to:
1. FK-5-1-12 (NOVEC 1230 Sapphire)
2. HFC-227ea (FM-200, MH 227, NAF 5227)
3. IG-541 (Inergen)

2.2 CLEAN AGENT FIRE EXTINGUISHING SYSTEM

A. General:
1. The clean agent fire extinguishing system shall be UL listed and shall be in accordance with NFPA 2001.

B. Piping and fittings:
1. All piping and fittings shall be in compliance with NFPA 2001.
2. Multi-outlet fittings, other than tees, shall not be permitted.
3. All piping shall be reamed, blown clear, and swabbed with appropriate solvent to remove mill varnish and cutting oils before assembly.
4. Ordinary cast iron steel and non-metallic piping and fittings and flexible hoses shall not be used unless specifically required by the manufacturer.

C. Piping Support:

1. All piping shall be supported in accordance with the manufacturer's written instructions.
2. Piping shall be supported within 12 inches (304 mm) of discharge nozzles. The supports shall prevent the upward movement of the nozzle.

D. Storage Cylinders:
1. Provide storage cylinders as required by the manufacturer's written instructions and in accordance with NFPA 2001.
2. Cylinder assemblies shall be of steel construction designed to meet the requirements of the U.S. Department of Transportation.
3. Filling of the storage cylinders shall be by an authorized systems distributor in conjunction with a factory authorized agent filling station. Initial filling and recharge shall be performed in accordance with manufacturer's written instructions and shall not require replacement components for normal service.
4. Cylinders shall be securely attached to the wall. Provide factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.
5. For halocarbon clean agents, storage cylinders shall be provided with a low agent pressure switch.

E. Valve Actuators:
1. Electric valve actuators shall be of brass construction and stackable design with swivel connections to allow removal of actuators for maintenance or testing.
2. Operation of actuators shall not require replacement of components. No electro-explosive devices may be used to actuate the valve assembly. Actuators shall include an indication if they are set or actuated.
3. Electric valve actuators shall be magnetic latch, continuous duty type for 24 VDC operation.
4. Actuation devices shall be UL-listed or FM-approved for use with the system.
5. Removal of the electric valve actuator shall cause a trouble on the clean agent control panel.

F. Discharge Nozzles:

1. Nozzles shall be permanently marked with the manufacturer’s part number. The nozzles shall be threaded directly to the discharge piping without the use of special adaptors.

2.3 RELEASING SYSTEM

A. General

1. The releasing system shall be an analog addressable intelligent reporting, microprocessor-controlled system, capable of remote sensitivity testing of the smoke detectors, and be installed in accordance with NFPA 70, 72, and 2001.

B. Clean Agent Control Panel:

1. General:

a. The clean agent control panel shall be UL-listed or FM-approved and include a UL-listed or FM-approved releasing module.

b. Each protected space shall be provided with its own clean agent control unit.

c. All circuits shall be monitored for integrity.

d. Visually and audibly annunciate all alarm, supervisory, and trouble signals including, but not limited to main power failure, open circuit, short circuit, ground faults, and system bypass activation.

e. The panel or releasing module shall include a 0-60 second programmable timer.

f. The clean agent control panel shall be provided with separate contacts to provide common supervisory, alarm, and trouble signals to the main building fire alarm system.

2. Enclosure:

a. The clean agent control unit shall be housed in a cabinet suitable for both recessed and surface mounting. The cabinet and front panel shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish.

b. The cabinet shall contain all necessary relays, terminals, lamps, and legend plates to provide control for the system.

3. Power Supply:

a. The clean agent control unit shall derive its normal power from a 120 volt, 60 Hz dedicated supply connected to the emergency power system. Standby power shall be provided by a 24 volt DC battery as hereinafter specified. The normal power shall be transformed, rectified, coordinated, and interfaced with the standby battery and charger.
b. The power supply for smoke detection systems shall be taken from the clean agent control unit.

4. Circuit Supervision: Each alarm initiating device circuit, signaling line circuit, and notification appliance circuit, shall be supervised against the occurrence of an open, short circuit, or ground fault condition in the field wiring. These conditions shall cause a trouble signal to sound in the control unit until manually silenced by an off switch.
   a. Initiating device circuits (IDC) shall be wired Class B in accordance with NFPA 72.
   b. Signaling line circuits (SLC) shall be wired Class B in accordance with NFPA 72.
   c. Notification appliance circuits (NAC) shall be wired Class B in accordance with NFPA 72.
5. Supervisory Alarm Devices: The low agent pressure switch and maintenance lockout switch shall initiate a supervisory signal.
6. Trouble signals:
   a. Arrange the trouble signals for automatic reset (non-latching).
   b. System trouble switch off and on lamps shall be visible through the control unit door.
7. Function Switches: Provide the following switches in addition to any other switches required for the system:
   a. Remote Alarm Transmission By-pass Switch: Shall prevent transmission of all signals to the building fire alarm control unit when in the "off" position. A clean agent control unit system trouble signal shall be energized when switch is in the off position.
   b. Alarm Off Switch: Shall disconnect power to notification appliance circuits on the clean agent control panel. A system

trouble signal shall be activated when the switch is in the off position.

c. Trouble Silence Switch: Shall silence the trouble signal whenever the trouble silence switch is operated. This switch shall not reset the trouble signal.

d. Reset Switch: Shall reset the system after an alarm, provided the initiating device has been reset. The system shall lock in alarm until reset.

e. Lamp Test Switch: A test switch or other approved convenient means shall be provided to test the indicator lamps.

f. AHU Bypass: Provide a means to disable air handling unit shutdown and dampers from closing upon operation of an initiating device designed to interconnect with these devices. A system trouble signal shall be activated when switch is in the off position.

8. Reset Capability: Each clean agent control unit shall be installed and programmed so that each must be reset locally after an alarm, before the main fire alarm control unit can be reset.

C. Conduit, Boxes, and Wire

1. Conduit shall be in accordance with Section 28 05 28.33 CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY and as follows:

a. All new conduits shall be installed in accordance with NFPA 70.

b. Conduit fill shall not exceed 40% of interior cross-sectional area.

c. All new conduits shall be 3/4 inch (19 mm) minimum.

2. Wire:

a. Wiring shall be installed in conduit.

b. Wiring shall be in accordance with NEC article 760, Section 28 05 13, CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY, and as recommended by the manufacturer of the fire alarm system. All wires shall be color coded. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 18 AWG for initiating device circuits and 14 AWG for notification appliance circuits.

c. Signaling line circuits shall be twisted and shielded unless other wiring methods are specifically required by the fire alarm equipment manufacturer in writing.

3. Terminal Boxes, Junction Boxes, and Cabinets:
   a. These shall be galvanized steel in accordance with UL requirements.
   b. All boxes shall be sized and installed in accordance with NFPA 70.
   c. Covers shall be repainted red in accordance with Section 09 91 00, PAINTING and shall be identified with white markings as "CA FA" or as directed by the COR for junction boxes and as "CLEAN AGENT FIRE ALARM SYSTEM" for cabinets and terminal boxes. Lettering shall be a minimum of 3/4 inch (19 mm) high.
   d. Terminal boxes and cabinets shall have a volume 50 percent greater than required by NFPA 70. Minimum sized wire shall be considered as 14 AWG for calculation purposes.
   e. Terminal boxes and cabinets shall have identified screw type terminal strips and shall be located in an accessible location. Terminal strips shall be labeled as to what circuit it is or as approved by the COR.

D. Standby Power Supply
   1. Batteries:
      a. The batteries shall be of the sealed, maintenance free type, 24-volt nominal.
      b. The batteries shall have sufficient capacity to power the clean agent control panel and its peripherals for not less than 24 hours plus five (5) minutes of alarm to an end voltage of 1.14 volts per cell, upon a normal AC power failure.
      c. Battery racks shall be steel with an alkali-resistant finish.
   2. Battery Charger:
      a. The battery charger shall be completely automatic, with constant potential charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 120-volt, 60 hertz emergency power source.

b. The battery charger shall be rated for fully charging a completely discharged battery within 48 hours while simultaneously supplying any loads connected to the battery.
c. The battery charger shall have protection to prevent discharge through the charger.
d. The battery charger shall have protection for overloads and short circuits on both AC and DC sides.
e. A trouble condition shall actuate the fire alarm trouble signal.
f. The battery charger shall have automatic AC line voltage regulation, automatic current-limiting features, and adjustable voltage controls.

E. Spot-type Smoke Detectors
1. Smoke detectors shall be photoelectric plug-in type and UL-listed for use with the clean agent control panel being furnished. Each detector shall be monitored individually, via an integral, analog addressable element.
2. Photoelectric detectors shall be factory calibrated and readily field adjustable. The sensitivity of any photoelectric detector shall be factory set at 3.0 plus or minus 0.25% obscuration per foot.
3. Smoke detectors of the protected spaces shall be spaced in accordance with NFPA 72 for high air movement areas. Air velocities within the protected spaces shall be suitable for the listed detection air velocity range of the smoke detector.
4. Each protected space shall have at least 2 detectors.
5. Provide red stickers with an "A" on the ceiling below the location of the above ceiling smoke detectors when above ceiling detectors are provided. Provide red stickers with a "U" on the ceiling above the location of the under floor smoke detectors. Each sticker shall also include the address of the detector. The address shall be the same as that address that shows on the fire alarm control unit when the detector is activated.
6. For smoke detectors located under the floor, the smoke detectors shall be mounted with a steel angle or channel support independent

of the raised floor structure. The smoke detectors shall be mounted in a vertical orientation.

F. Manual Activation Stations:

1. Shall be non-break glass, address reporting type.
2. Station front shall be constructed of durable material such as cast or extruded metal or high impact plastic. Stations shall be semi-flush type.
3. Shall be of dual action pull down type with suitable operating instructions provided on front in raised or depressed letters, and clearly labeled "AGENT RELEASE."
4. Operating handles shall be constructed of a durable material. On operation, the lever shall lock in alarm position and remain so until physically reset. A key shall be required to gain front access for resetting, or conducting tests and drills.
5. Shall be located at least 3.28 ft (1m) from any fire alarm manual pull station and adjacent to each exit from the TS

G. Notification Appliances:

1. Pre-discharge Bells:
   a. Shall be 24 VDC and be capable of producing an alarm signal of not less than 85 dBa at 10 feet.
   b. Shall be at least 6 inches (150 mm) in diameter.
2. Pre-discharge Strobes:
   a. Be listed in accordance with UL 1971.
   b. Shall be a minimum of 75 candela.
   c. Shall be provided with an amber lens.
   d. Shall be synchronized with other pre-discharge strobes in the protected space.
3. Discharge Strobes:
   a. Be listed in accordance with UL 1971.
   b. Shall be a minimum of 75 candela.
   c. Shall be provided with a red lens.
   d. Shall be synchronized with other discharge strobes outside the protected space.

H. Addressable Interface Module

1. Addressable interface modules shall be installed in individual boxes in accordance with the manufacturer's product listing. The addressable interface module shall be provided with a protective cover provided by the device manufacturer. The protective cover shall have the provision for viewing the operational LED of the addressable interface module. Addressable interface modules shall not be installed in a back-box with other devices or relays.
2. The installer shall provide, install, and test addressable interface modules as necessary to comply with the sequence of operations, whether shown on the drawings or not.

I. Graphic Floor Plans:

1. Provide readable scaled graphics of the protected area. The graphics shall show the location and address of each the ceiling smoke detectors, above ceiling smoke detectors, and under floor smoke detectors, on separate plans.
2. The graphic shall be framed and shall be located in an area approved by the COR.
3. Where approved by the COR a single graphic floor plan shall be permitted.

J. Abort Switches:

1. The abort switch front shall be constructed of durable material such as cast or extruded metal or high impact plastic. The abort switch shall be semi-flush type.
2. The abort switch shall not be a locking or keyed type.
3. The abort switch shall be of single action dead-man spring loaded type with suitable operating instructions provided on front in raised or depressed letters, and clearly labeled "ABORT."
4. Shall be located adjacent to each exit from the TS.

2.4 SWITCHES

A. Maintenance Lock-out Switch

1. Shall be key-operated only allowing the removal of the key in the "Normal" position. A red indicator lamp shall be included on the switch assembly to be illuminated when in the "Lock-out" position. The clean agent control panel shall indicate a supervisory alarm condition when in the "Lock-out" position.

2. The terminals shall be of the screw type.

3. Shall be provided adjacent to the clean agent control panel.

2.5 SIGNAGE

A. Signage shall have white lettering on a red plastic background.

B. The letters shall be 1 inch (25 mm) high with a stroke width of 3/8 inches (9.5 mm).

PART 3 – EXECUTION

3.1 INSTALLATION

A. Installation shall be accomplished by the licensed contractor. Provide a factory trained qualified technician, experienced in the installation and operation of the type of system being installed, to supervise the installation and testing of the system.

B. Install clean agent fire extinguishing system piping and fittings level and plumb, according to manufacturer's written instructions.

C. Where installing piping adjacent to equipment, allow space for service and maintenance.

D. Identity piping, agent storage cylinders, and control panels with signage in accordance with NFPA 2001.

E. Provide signage for the pre-discharge bells and strobes. The sign shall say "FIRE. CLEAN AGENT RELEASE IMMINENT". The sign shall be permanently affixed to the wall within 12 inches (304 mm) of the pre-discharge strobe.

F. Provide signage for the discharge strobes. The sign shall say "CLEAN AGENT DISCHARGE". The sign shall be permanently affixed to the wall within 12 inches (304 mm) of the discharge strobe.

G. Provide signage on the exterior of the protected space at each entrance. The sign shall say "THIS SPACE IS PROTECTED BY A CLEAN AGENT FIRE EXTINGUISHING SYSTEM. DO NOT ENTER WITHOUT AUTHORIZATION DURING OR AFTER DISCHARGE. THE RED STROBE INDICATES SYSTEM DISCHARGE." The sign shall be permanently affixed to the wall adjacent to the door.

H. Provide signage adjacent to each manual activation station. The sign shall say "ACTUATION OF THIS DEVICE WILL CAUSE FIRE SUPPRESSION GAS TO DISCHARGE. BEFORE ACTUATING, ENSURE THAT PERSONNEL ARE CLEAR OF THE AREA." The sign shall be permanently affixed to the wall within 12 inches (304 mm) of the station.

I. Firestopping shall be provided for all penetrations of fire resistance rated construction. Firestopping shall comply with Section 07 84 00, FIRESTOPPING.

J. Repairs: Repair damage to the building or equipment resulting from the installation of the clean agent fire extinguishing system by the installer at no additional expense to the Government.

K. Supervise clean agent control panel for alarm, supervisory, and trouble signals by the building fire alarm system in accordance with Section 28 31 00, FIRE DETECTION AND ALARM.

L. Where duct detectors are provided within computer room air conditioning units, addressable interface modules shall be used to monitor the activation of the duct detector as a supervisory signal on the clean agent control unit.

M. Control emergency power off with addressable interface modules.

N. Nozzles and smoke detection shall be placed within the cold aisle containment area as necessary to ensure the space is protected while drop out panels are in place.

3.2 SEQUENCE OF OPERATIONS

A. The clean agent extinguishing fire extinguishing system shall operate as follows:

1. Activation of any single smoke detector shall:
   a. Energize an alarm LED lamp on the activated detector and clean agent control panel.
   b. Transmit an alarm signal to the building’s fire alarm system.
2. Activation of a second smoke detector shall:
   a. Energize an alarm LED lamp on the activator detector.
   b. Activate pre-discharge bell notification appliance and pre-discharge strobe notification appliance.
   c. Close dampers, release door hold open devices, and shut down air handling units serving the protected space.
   d. Initiate a programmable 30-second time delay (agent release) sequence.
3. Activation of a manual activation station shall:
   a. Energize an alarm LED lamp on the clean agent control panel.

b. Activate pre-discharge bell notification appliance and pre-discharge strobe notification appliance.
c. Close dampers, release door hold open devices, and shut down air handling units serving the protected space.
d. Transmit an alarm signal to the building's fire alarm system.
e. Initiate a programmable 20-second time delay (agent release) sequence.

4. Activation of the abort switch shall:
   a. Cease the time delay. Once the abort switch is released, the time delay countdown shall resume from where it ceased. The time delay shall not reset.
   b. Transmit a trouble signal to the building's fire alarm system.
5. Upon completion of the time delay, the system shall:
   a. Deenergize the pre-discharge bell and pre-discharge strobe notification appliance.
   b. Activate a discharge strobe notification appliance inside and outside of the protected area.
   c. Energize valve actuator for agent cylinders releasing gaseous agent into the protected area.
6. Activation of the low agent tank pressure switch and maintenance lockout switch shall:
   a. Energize a supervisory LED lamp on the clean agent control panel.
   b. Transmit a supervisory alarm signal to the building's fire alarm system.
7. Presence of any fault, bypass function, or removal of the electric valve actuator shall:
   a. Energize a trouble LED lamp on the clean agent control panel.
   b. Transmit a trouble signal to the building's fire alarm system.
8. Activation of duct detector within a computer room air condition unit shall energize a supervisory signal LED lamp on the clean agent control panel.

3.3 INSPECTION AND TEST

A. Room Enclosure Test: A room pressurization test shall be conducted for the protected space. The testing shall be done in accordance with NFPA 2001 Annex C. The contractor shall be responsible for sealing the

enclosure to ensure the success of the room pressurization test. The test shall be deemed successful if the tested leakage rate is less than or equal to the leakage rate assumed in the calculations.

B. Pressure Test: Pneumatically pressure test piping in a closed circuit in accordance with NFPA 2001.

C. Flow Test: Subject system to a flow test utilizing nitrogen to verify that flow is continuous and that the piping and nozzles are unobstructed.

D. Preliminary Testing: System function operation test system as specified in NFPA 2001 and NFPA 72, in the presence of the COR or his designated representative.

E. Final Inspection and Testing: Subject system to tests in accordance with NFPA 2001 and NFPA 72, and when all necessary corrections have been accomplished, advise COR to schedule a final inspection and test. Connection to the fire alarm system shall have been in service for at least ten days prior to the final inspection, with adjustments made to prevent false alarms. Furnish all instruments, labor and materials required for the tests and provide the services of the installation foreman or other competent representative of the installer to perform the tests. Correct deficiencies and retest system as necessary, prior to the final acceptance. Include the operation of all features of the systems under normal operations in test.

3.4 TRAINING

A. The manufacturer's authorized representative shall provide instruction and training to the VA on the dates requested by the COR as follows:

1. Six (6) one-hour sessions to employees working in protected area, engineering staff, security police and VA Fire Department personnel where there is a VA Fire Department present on site for simple operation of the system. Two sessions at the start of installation, two (2) sessions at the completion of installation and two (2) sessions three (3) months after the completion of installation.
2. Four (4) two-hour sessions to engineering staff for detailed operation of the system. Two (2) sessions at the completion of installation and two (2) sessions three (3) months after the completion of installation.

3. Three (3) eight-hour sessions to electrical technicians for maintaining, programming, modifying, and repairing the system at the completion of installation and one (1) eight-hour refresher session three (3) months after the completion of installation.

B. Each initial training session shall be videotaped.

- - - E N D - - -

SECTION 22 05 11

COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section shall apply to all sections of Division 22.

1.2 DEFINITIONS

A. Exposed: Piping and equipment exposed to view in finished rooms.

B. Exterior: Piping and equipment exposed to weather be it temperature, humidity, precipitation, wind or solar radiation.

C. Option or optional: Contractor's choice of an alternate material or method.

D. Provide: Furnish and install.

1.3 ABBREVIATIONS/ACRONYMS

A. ABS: Acrylonitrile Butadiene Styrene

B. ACR: Air Conditioning and Refrigeration

C. A/E: Architect/Engineer

D. AFF: Above Finish Floor

E. AFG: Above Finish Grade

F. AISI: American Iron and Steel Institute

G. ASHRAE: American Society of Heating, Refrigeration, & Air Conditioning Engineers

H. ASJ: All Service Jacket

I. ASME: American Society of Mechanical Engineers

J. ASPE: American Society of Plumbing Engineers

K. AWG: American Wire Gauge

L. BACnet: Building Automation and Control Network

M. BAg: Silver-Copper-Zinc Brazing Alloy

N. BAS: Building Automation System

O. BCuP: Silver-Copper-Phosphorus Brazing Alloy

P. Btu: British Thermal Unit

Q. Btu/h: British Thermal Unit per Hour

R. C: Celsius

S. CDA: Copper Development Association

T. CGA: Compressed Gas Association

U. CFM: Cubic Feet per Minute

V. CLR: Color

W. CO: Contracting Officer

X. COR: Contracting Officer’s Representative

Y. CPVC: Chlorinated Polyvinyl Chloride

Z. CR: Chloroprene

AA. CRS: Corrosion Resistant Steel

AB. CWP: Cold Working Pressure

AC. CxA: Commissioning Agent

AD. dB: Decibels

AE. db(A): Decibels (A weighted)

AF. DCW: Domestic Cold Water

AG. DDC: Direct Digital Control

AH. DI: Deionized Water

AI. DN: Diameter Nominal

AJ. DO: Digital Output

AK. DOE: Department of Energy

AL. DVD: Digital Video Disc

AM. DWG: Drawing

AN. DWS: Domestic Water Supply

AO. DWV: Drainage, Waste and Vent

AP. ECC: Engineering Control Center

AQ. EMCS: Energy Monitoring and Control System

AR. EPA: Environmental Protection Agency

AS. EPACT: Energy Policy Act

AT. EPDM: Ethylene Propylene Diene Monomer

AU. EPT: Ethylene Propylene Terpolymer

AV. F: Fahrenheit

AW. FAR: Federal Acquisition Regulations

AX. FD: Floor Drain

AY. FDC: Fire Department (Hose) Connection

AZ. FED: Federal

BA. FG: Fiberglass

BB. FNPT: Female National Pipe Thread

BC. FSK: Foil-Scrim-Kraft Facing

BD. FSS: VA Construction & Facilities Management, Facility Standard Service

CE. GAL: Gallon

CF. GPD: Gallons per Day

CG. GPH: Gallons per Hour

CH. GPM: Gallons per Minute

CI. HDPE: High Density Polyethylene

CJ. HEFP: Healthcare Environment and Facilities Program (replacement for OCAMES)

CK. Hg: Mercury

CL. HOA: Hands-Off-Automatic

CM. ID: Inside Diameter

CN. IPC: International Plumbing Code

CO. IPS: Iron Pipe Size

CP. IW: Indirect Waste

CQ. lb: Pound

CR. lbs/hr: Pounds per Hour

CS. MAWP: Maximum Allowable Working Pressure

CT. MAX: Maximum

CU. MBH: 1000 Btu per Hour

CV. MED: Medical

CW. MER: Mechanical Equipment Room

CX. MFG: Manufacturer

CY. mm: Millimeter

CZ. MIN: Minimum

DA. NC: Normally Closed

DB. NIC: Not in Contract

DC. NO: Normally Open

DD. NOM: Nominal

DE. NPTF: National Pipe Thread Female

DF. NPS: Nominal Pipe Size

DG. NPT: Nominal Pipe Thread

DH. NTS: Not to Scale

DI. OC: On Center

DJ. OD: Outside Diameter

DK. OSD: Open Sight Drain

DL. PD: Pressure Drop or Difference

DM. PDI: Plumbing and Drainage Institute

DN. ppb: Parts per Billion

DO. ppm: Parts per Million

DP. PSI: Pounds per Square Inch

DQ. PSIA: Pounds per Square Inch Atmosphere

DR. PSIG: Pounds per Square Inch Gauge

DS. PVC: Polyvinyl Chloride

DT. SAN: Sanitary Sewer

DU. SCFM: Standard Cubic Feet per Minute

DV. SPEC: Specification

DW. SQFT/SF: Square Feet

DX. SS: Stainless Steel

DY. STD: Standard

DZ. TD: Temperature Difference

EA. TDH: Total Dynamic Head

EB. TEMP: Temperature

EC. TIL: Technical Information Library http//www.cfm.va.gov/til/indes.asp

ED. T/P: Temperature and Pressure

EE. TYP: Typical

EF. V: Vent

EG. V: Volt

EH. VA: Veterans Administration

EI. VA CFM: VA Construction & Facilities Management

EJ. VA CFM CSS: VA Construction & Facilities Management, Consulting Support Service

EK. VAMC: Veterans Administration Medical Center

EL. VHA OCAMES: This has been replaced by HEFP.

EM. VSD: Variable Speed Drive

EN. VTR: Vent through Roof

EO. W: Waste

EP. WC: Water Closet

EQ. WG: Water Gauge

ER. WPD: Water Pressure Drop

ES. WSFU: Water Supply Fixture Units

1.4 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 07 84 00, PENETRATION FIRESTOPPING.

F. Section 07 92 00, JOINT SEALANTS.

G. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS

H. Section 22 07 11, PLUMBING INSULATION

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below shall form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):

1. B31.1-2013 Power Piping

2. BPVC Section IX-2019 Boiler and Pressure Vessel Code - Welding, Brazing, and Fusing Qualifications

C. American Society for Testing and Materials (ASTM):

1. A36/A36M-2019 Standard Specification for Carbon Structural Steel

2. A575-96(2013)e1 Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

3. E84-2013a Standard Test Method for Surface Burning Characteristics of Building Materials

4. E119-2012a Standard Test Methods for Fire Tests of Building Construction and Materials

D. International Code Council, (ICC):

1. IBC-2018 International Building Code

2. IPC-2018 International Plumbing Code

E. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc:

1. SP-58-2018 Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application and Installation

F. Military Specifications (MIL):

1. P-21035B Paint High Zinc Dust Content, Galvanizing Repair (Metric)

G. National Electrical Manufacturers Association (NEMA):

1. MG 1-2016 Motors and Generators

H. National Fire Protection Association (NFPA):

1. 51B-2019 Standard for Fire Prevention During Welding, Cutting and Other Hot Work

2. 54-2018 National Fuel Gas Code

3. 70-2020 National Electrical Code (NEC)

4. 99-2018 Healthcare Facilities Code

I. NSF International (NSF):

1. 5-2019 Water Heaters, Hot Water Supply Boilers, and Heat Recovery Equipment

2. 14-2019 Plastic Piping System Components and Related Materials

3. 61-2019 Drinking Water System Components – Health Effects

4. 372-2016 Drinking Water System Components – Lead Content

J. Department of Veterans Affairs (VA):

1. PG-18-10-2018 Plumbing Design Manual

2. PG-18-13-2018 Barrier Free Design Guide

1.6 QUALITY ASSURANCE

A. Plumbing, mechanical, electrical, and associated systems shall be safe, reliable, efficient, durable, easily and safely operable and maintainable, easily and safely accessible, and in compliance with applicable codes as specified. The systems shall be comprised of high quality institutional-class and industrial-class products of

manufacturers that are experienced specialists in the required product lines. All construction firms and personnel shall be experienced and qualified specialists in industrial and institutional plumbing.

B. Products Criteria:

1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years.

2. Equipment Service: There shall be permanent service organizations, authorized and trained by manufacturers of the equipment supplied, located within 160 km (100 miles) of the project.

3. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.

4. The products and execution of work specified in Division 22 shall conform to the referenced codes and standards. Local codes and amendments shall be enforced by the local code official and by local authorities such as the natural gas supplier. If the local codes are more stringent, then the local code shall apply. Any conflicts shall be brought to the attention of the Contracting Officer's Representative (COR) before executing the work.

5. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

6. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.

7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on plumbing fixtures and equipment, or name or trademark cast integrally with same, stamped or otherwise permanently marked on each item.

8. Asbestos products or equipment or materials containing asbestos shall not be used.

C. 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 furnished to the COR prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

D. Execution (Installation, Construction) Quality:

1. All items shall be applied and installed in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract drawings and specifications shall be referred to the COR for resolution. Written hard copies or computer files of manufacturer’s installation

instructions shall be provided to the COR at least two weeks prior to commencing installation of any item.

2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, shall be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include, but are not limited to: all types of valves, and strainers. Prior to commencing installation work, refer conflicts between this requirement and contract documents to COR for resolution.

3. Installer Qualifications: Installer shall be licensed and shall provide evidence of the successful completion of at least five projects of equal or greater size and complexity. Provide tradesmen skilled in the appropriate trade.

4. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or additional time to the Government.

5. Provide complete layout coordination drawings. See Paragraph, SUBMITTALS. Construction work shall not start on any system until these drawings have been accepted.

E. Guaranty: Warranty of Construction, FAR clause 52.246-21.

F. Plumbing Systems: IPC, International Plumbing Code. Unless otherwise required herein, perform plumbing work in accordance with the latest version of the IPC. For IPC codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word “should” shall be interpreted as “shall”. Reference to the “code official” or “owner” shall be interpreted to mean the COR.

1.7 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 05 11, COMMON WORK RESULTS FOR PLUMBING", with applicable paragraph identification.

C. If the project is phased, contractors shall submit complete phasing plan/schedule with manpower levels prior to commencing work. The phasing plan shall be detailed enough to provide milestones in the process that can be verified.

D. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements, and all equipment that requires regular maintenance, calibration, etc are accessible from the floor or permanent work platform. It is the Contractor’s responsibility to ensure all submittals meet the VA specifications and requirements and it is assumed by the VA that all submittals do meet the VA specifications unless the Contractor has requested a variance in writing and approved by COR prior to the submittal. If at any time during the project it is found that

any item does not meet the VA specifications and there was no variance approval the Contractor shall correct at no additional cost or time to the Government even if a submittal was approved.

E. If equipment is submitted which differs in arrangement from that shown, provide documentation proving equivalent performance, design standards and drawings that show the rearrangement of all associated systems. Additionally, any impacts on ancillary equipment or services such as foundations, piping, and electrical shall be the Contractor’s responsibility to design, supply, and install at no additional cost or time to the Government. VA approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.

F. Prior to submitting shop drawings for approval, Contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

G. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only by groups.

H. Manufacturer's Literature and Data including: Manufacturer’s literature shall be submitted under the pertinent section rather than under this section.

1. Electric motor data and variable speed drive data shall be submitted with the driven equipment.

2. Equipment and materials identification.

3. Firestopping materials.

4. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.

5. Wall, floor, and ceiling plates.

I. Coordination/Shop Drawings:

1. Submit complete consolidated and coordinated shop drawings for all new systems, and for existing systems that are in the same areas.

2. The coordination/shop drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:32 (3/8-inch equal to 1 foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed coordination/shop drawings of all piping and duct systems. The drawings should include all lockout/tagout points for all energy/hazard sources for each piece

of equipment. Coordinate lockout/tagout procedures and practices with local VA requirements.

3. Do not install equipment foundations, equipment or piping until coordination/shop drawings have been approved.

4. In addition, for plumbing systems, provide details of the following:

a. Mechanical equipment rooms.

b. Hangers, inserts, supports, and bracing.

c. Pipe sleeves.

d. Piping or equipment penetrations of floors, walls, ceilings, or roofs.

J. Rigging Plan: Provide documentation of the capacity and weight of the rigging and equipment intended to be used. The plan shall include the path of travel of the load, the staging area and intended access, and qualifications of the operator and signal person.

K. Plumbing Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.

2. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

a. Include complete list indicating all components of the systems.

b. Include complete diagrams of the internal wiring for each item of equipment.

c. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

3. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.

L. Provide copies of approved plumbing equipment submittals to the TAB and Commissioning Subcontractor.

M. Completed System Readiness Checklist provided by the CxA and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00 COMMISSIONING OF PLUMBING SYSTEMS.

N. Submit training plans, trainer qualifications and instructor qualifications in accordance with the requirements of Section 22 08 00 COMMISSIONING OF PLUMBING SYSTEMS.

1.8 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.

2. Damaged equipment shall be replaced with an identical unit as determined and directed by the COR. Such replacement shall be at no additional cost to the Government.

3. Interiors of new equipment and piping systems shall be protected against entry of foreign matter. Both inside and outside shall be cleaned before painting or placing equipment in operation.

4. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.

5. Protect plastic components, piping, equipment, and tanks from ultraviolet light (sunlight) while in pre-construction. Plastic piping and tanks shall not be installed exposed to sunlight without metal jacketing to block ultraviolet rays.

B. Cleanliness of Piping and Equipment Systems:

1. Care shall be exercised in the storage and handling of equipment and piping material to be incorporated in the work. Debris arising from cutting, threading and welding of piping shall be removed.

1.9 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ‘third party testing company’ requirement.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps

to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. As-built drawings:

1. As-built drawings are to be provided, and a copy of them on Auto-Cad version 2018 or newer provided on compact disk or DVD.

F. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.10 JOB CONDITIONS – WORK IN EXISTING BUILDINGS

A. Building Operation: Refer to Division 1 for building operation information for the facility.

B. Maintenance of Service: Refer to Division 1 for requirements regarding work hours and interruption of programs/service at the facility.

C. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 18 degrees C (65 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. Storm water or ground water leakage is prohibited. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA. Maintain all egress routes and safety systems/devices.

D. Acceptance of Work for Government Operation: As new equipment, systems and facilities are made available for operation and these items are deemed of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.

PART 2 - PRODUCTS

2.1 MATERIALS FOR VARIOUS SERVICES

A. Material or equipment containing a weighted average of greater than 0.25 percent lead shall not be used in any potable water system intended for human consumption, and shall be certified in accordance with NSF 61 or NSF 372.

B. In-line devices such as check valves, fittings, and backflow preventers shall comply with NSF 61 and NSF 372.

2.2 FACTORY-ASSEMBLED PRODUCTS

A. Standardization of components shall be maximized to reduce spare part requirements.

B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.

1. All components of an assembled unit need not be products of same manufacturer.

2. Constituent parts that are alike shall be products of a single manufacturer.

3. Components shall be compatible with each other and with the total assembly for intended service.

4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.

C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

D. Major items of equipment, which serve the same function, shall be the same make and model.

2.3 COMPATIBILITY OF RELATED EQUIPMENT

A. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational system that conforms to contract requirements.

2.4 LIFTING ATTACHMENTS

Equipment shall be provided with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered, without bending or distortion of shape, such as rapid lowering and braking of load.

2.5 EQUIPMENT AND MATERIALS IDENTIFICATION

A. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 48 mm (3/16-inch) high of brass with black-filled letters or rigid black plastic with white letters shall be permanently fastened to the equipment. Unit components such as water heaters, tanks, pumps, and similar items, shall be identified.

B. Pipe Markers:

1. Comply with 1.

2. Pipe markers shall include system label and flow direction.

3. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

4. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

5. Color code as follows:

   a. Potable, Cooling, Boiler, Feed, Other Water: Green with white letters.

   b. Drain, Waste, Vent: Yellow with black letters.

C. Valve Tags and Lists:

1. Plumbing: All valves shall be provided with valve tags and listed on a valve list (Fixture stops not included).

2. Valve tags: Engraved black filled numbers and letters not less than 13 mm (1/2-inch) high for number designation, and not less than 6.4 mm(1/4-inch) for service designation on 19 gage, 38 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.

3. Valve lists: Valve lists shall be created using a word processing program and printed on plastic coated cards. The plastic coated valve list card(s), sized 216 mm (8-1/2 inches) by 280 mm (11 inches) shall show valve tag number, valve function and area of control for each service or system. The valve list shall be in a punched 3-ring binder notebook. A copy of the valve list shall be mounted in picture frames for mounting to a wall.

   a. COR shall instruct contractor where frames shall be mounted.

4. A detailed plan for each floor of the building indicating the location and valve number for each valve shall be provided. Each valve location shall be identified with a color coded sticker or thumb tack in ceiling.

2.6 PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

A. Type Numbers Specified: For materials, design, manufacture, selection, application, and installation refer to MSS SP-58.

B. For Attachment to Concrete Construction:

1. Concrete insert: Type 18, MSS SP-58.

2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 102 mm (4 inches) thick when approved by the COR for each job condition.

3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 102 mm (4 inches) thick when approved by the COR for each job condition.

C. For Attachment to Steel Construction: MSS SP-58.

1. Welded attachment: Type 22.

2. Beam clamps: Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23 mm (7/8-inch) outside diameter.

D. For Attachment to Wood Construction: Wood screws or lag bolts.

E. Hanger Rods: Hot-rolled steel, ASTM A36 or A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 38 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

F. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts. Trapeze hangers are not permitted for steam supply and condensate piping.

1. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).

2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4-inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 13 mm (1/2-inch) galvanized steel bands, or insulated calcium silicate shield for insulated piping at each hanger.

G. Pipe Hangers and Supports: (MSS SP-58), use hangers sized to encircle insulation on insulated piping. Refer to Section 22 07 11 PLUMBING INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or insulated calcium silicate shields. Provide Type 40 insulation shield or insulated calcium silicate shield at all other types of supports and hangers including those for insulated piping.

1. General Types (MSS SP-58):

a. Standard clevis hanger: Type 1; provide locknut.

b. Riser clamps: Type 8.

c. Wall brackets: Types 31, 32 or 33.

d. Roller supports: Type 41, 43, 44 and 46.

e. Saddle support: Type 36, 37 or 38.

f. Turnbuckle: Types 13 or 15.

g. U-bolt clamp: Type 24.

h. Copper Tube:

1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with isolation tape to prevent electrolysis.

2) For vertical runs use epoxy painted or plastic coated riser clamps.

3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.

4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.

H. Seismic Restraint of Piping: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.7 PIPE PENETRATIONS

A. Pipe penetration sleeves shall be installed for all pipe other than rectangular blocked out floor openings for risers in mechanical bays.

B. Pipe penetration sleeve materials shall comply with all fire stopping requirements for each penetration.

C. To prevent accidental liquid spills from passing to a lower level, provide the following:

1. For sleeves: Extend sleeve 25 mm (1 inch) above finished floor and provide sealant for watertight joint.

2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.

3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.

D. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of COR.

E. Sheet metal, plastic, or moisture resistant fiber sleeves shall be provided for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.

F. Cast iron or zinc coated pipe sleeves shall be provided for pipe passing through exterior walls below grade. The space between the sleeve and pipe shall be made watertight with a modular or link rubber seal. The link seal shall be applied at both ends of the sleeve.

G. Galvanized steel or an alternate black iron pipe with asphalt coating sleeves shall be for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. A galvanized steel Sleeve shall be provided for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, sleeves shall be connected with a floor plate.

H. Brass Pipe Sleeves shall be provided for pipe passing through quarry tile, terrazzo or ceramic tile floors. The sleeve shall be connected with a floor plate.

I. Sleeve clearance through floors, walls, partitions, and beam flanges shall be 25 mm (1 inch) greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation plus 25 mm (1 inch) in diameter. Interior

openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.

J. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS and Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

2.8 TOOLS AND LUBRICANTS

A. Furnish, and turn over to the COR, special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

B. Lubricants: A minimum of 0.95 L (1 quart) of oil, and 0.45 kg (1 pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.9 ASBESTOS

A. Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions shall be coordinated with the work of all trades. Piping, sleeves, inserts, hangers, and equipment shall be located clear of windows, doors, openings, light outlets, and other services and utilities. Equipment layout drawings shall be prepared to coordinate proper location and personnel access of all facilities. The drawings shall be submitted for review.

B. Manufacturer's published recommendations shall be followed for installation methods not otherwise specified.

C. Operating Personnel Access and Observation Provisions: All equipment and systems shall be arranged to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gages and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Maintenance and operating space and access provisions that are shown on the drawings shall not be changed nor reduced.

D. Structural systems necessary for pipe and equipment support shall be coordinated to permit proper installation.

E. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.

F. Cutting Holes:

1. Holes through concrete and masonry shall be cut by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by COR where working area space is limited.

2. Holes shall be located to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.

3. Waterproof membrane shall not be penetrated. Pipe floor penetration block outs shall be provided outside the extents of the waterproof membrane.

G. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.

H. Protection and Cleaning:

1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the COR. Damaged or defective items in the opinion of the COR, shall be replaced.

2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Pipe openings, equipment, and plumbing fixtures shall be tightly covered against dirt or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

I. Plumbing systems that interface with the HVAC control system: See Section 23 09 23 DIRECT DIGITAL CONTROLS FOR HVAC.

J. Work in Existing Building:

1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).

2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will cause the least interfere with normal operation of the facility.

K. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Government.

2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

a. Equipment installed in or above ceilings, such as strainers, valves, and pumps, etc., shall be considered "conveniently accessible" provided that suitable ceiling access is provided by

access panels and/or easily removable ceiling tiles, and that access is not blocked by other piping, ductwork, wiring, equipment, structural members, or other building components.

3.2 TEMPORARY PIPING AND EQUIPMENT

A. Continuity of operation of existing facilities may require temporary installation or relocation of equipment and piping. Temporary equipment or pipe installation or relocation shall be provided to maintain continuity of operation of existing facilities.

B. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities. The requirements of Paragraph 3.1 shall apply.

C. Temporary facilities and piping shall be completely removed and any openings in structures sealed. Necessary blind flanges and caps shall be provided to seal open piping remaining in service.

3.3 RIGGING

A. Openings in building structures shall be planned to accommodate design scheme.

B. Alternative methods of equipment delivery may be offered and will be considered by Government under specified restrictions of phasing and service requirements as well as structural integrity of the building.

C. All openings in the building shall be closed when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.

D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility.

E. Contractor shall check all clearances, weight limitations and shall provide a rigging plan designed by a Registered Professional Engineer. All modifications to structures, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.

F. Rigging plan and methods shall be referred to COR for evaluation prior to actual work.

3.4 PIPE AND EQUIPMENT SUPPORTS

A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Holes shall be drilled or burned in structural steel ONLY with the prior written approval of the COR.

B. The use of chain pipe supports, wire or strap hangers; wood for blocking, stays and bracing, or hangers suspended from piping above shall not be permitted. Rusty products shall be replaced.

C. Hanger rods shall be used that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. A minimum of 15 mm (1/2-inch) clearance between pipe or piping covering and adjacent work shall be provided.

D. For horizontal and vertical plumbing pipe supports, refer to the International Plumbing Code (IPC), latest edition, and these specifications.

E. Paint all fabricated metal support materials.

F. Overhead Supports:

1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.

2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.

3. Tubing and capillary systems shall be supported in channel troughs.

G. Floor Supports:

1. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.5 PLUMBING SYSTEMS DEMOLITION

A. Rigging access, other than indicated on the drawings, shall be provided after approval for structural integrity by the COR. Such access shall be provided without additional cost or time to the Government. Where work is in an operating plant, approved protection from dust and debris shall be provided at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.

B. Unless specified otherwise, all piping, wiring, conduit, and other devices associated with the equipment not re-used in the new work shall be completely removed from Government property. This includes all concrete equipment pads, pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. All openings shall be sealed after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with plans and specifications where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the drawings and specifications of the other disciplines in the project for additional facilities to be demolished or handled.

C. All valves including gate, globe, ball, butterfly, check, backflow prevention, and pressure reducing, all pressure gages and thermometers with wells shall remain Government property and shall be removed and delivered to COR and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these plans and specifications. Such material shall be removed from

Government property expeditiously and shall not be allowed to accumulate.

3.6 JOB CONDITIONS - WORK IN EXISTING BUILDING

A. Building Operation: Government employees will be continuously operating and managing all facilities, including temporary facilities, that serve the medical center.

B. Maintenance of Service: Schedule all work to permit continuous service as required by the medical center.

C. Phasing of Work: Comply with all requirements shown on drawings or specified.

D. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 18 degrees C (65 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. No storm water or ground water leakage permitted. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA.

E. Acceptance of Work for Government Operation: As new facilities are made available for operation and these facilities are of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.

F. Alterations to existing service piping shall be made at times that will cause the least interfere with normal operation of the facility.

3.7 UTILITY SERVICE INTERRUPTIONS

A. No utility service such as water, gas, steam, sewer, electricity, fire protection systems, or communication systems may be interrupted without prior approval of COR.

B. Limited utility service interruptions, as required for interconnections of new and existing systems, will be permitted by the COR during periods when the demands are not critical to the operation of the medical center. These non-critical periods are limited to between 8 pm and 5 am in the appropriate off-season (if applicable). Provide at least one week advance notice to the COR.

C. For utility outtages projected to last less than 8 hours, provide at least 7 days advance notice to the COR.

D. For utility outtages projected to last more than 8 hours, provide at least 14 days advance notice to the COR.

3.8 CLEANING

A. All work areas shall be maintained in a clean and workmanlike manner throughout the construction period.

B. All debris, dust, and construction waste shall be removed from the work area at the close of each work day and disposed of at an approved location.

C. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.

D. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

E. The interior of all tanks shall be cleaned prior to delivery and beneficial use by the Government. All piping shall be tested in accordance with the specifications and the International Plumbing Code (IPC), latest edition. All filters, strainers, fixture faucets shall be flushed of debris prior to final acceptance.

F. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

3.9 PAINTING

A. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Government, the plant facilities, equipment and systems shall be thoroughly cleaned and painted.

B. In addition, the following special conditions apply:

1. Cleaning shall be thorough. Solvents, cleaning materials and methods recommended by the manufacturers shall be used for the specific tasks. All rust shall be removed prior to painting and from surfaces to remain unpainted. Scratches, scuffs, and abrasions shall be repaired prior to applying prime and finish coats.

2. The following Material And Equipment shall NOT be painted::

a. Pressure reducing valves.

b. Copper, brass, aluminum, stainless steel and bronze surfaces.

c. Valve stems and rotating shafts.

d. Pressure gages and thermometers.

e. Glass.

f. Name plates.

3. Control and instrument panels shall be cleaned and damaged surfaces repaired. Touch-up painting shall be made with matching paint obtained from manufacturer or computer matched.

4. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.

3.10 IDENTIFICATION SIGNS

A. Laminated plastic signs, with engraved lettering not less than 5 mm (3/16-inch) high, shall be provided that designates equipment function, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and

identification symbols shall correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.

B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, performance shall be placed on factory built equipment.

C. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

D. Install tags with corrosion resistant chain.

E. Pipe Identification:

1. Identify service, flow direction, and pressure.

2. Install in clear view and align with axis of piping.

3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

F. Coordination with Existing Identification:

1. Final identification of piping, valves, equipment, and accessories shall match the existing identification scheme used in _____. Identification scheme shall be approved by the COR.

3.11 STARTUP AND TEMPORARY OPERATION

A. Start up of equipment shall be performed as described in the equipment specifications. Vibration within specified tolerance shall be verified prior to extended operation. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.12 OPERATING AND PERFORMANCE TESTS

A. Prior to the final inspection, all required tests shall be performed as specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TESTS and Section 22 08 00 COMMISSIONING OF PLUMBING SYSTEMS. submit the test reports and records to the COR.

B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Government.

C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then make performance tests such systems respectively during first actual seasonal use of respective systems following completion of work.

3.13 OPERATION AND MAINTENANCE MANUALS

A. Provide four bound copies. The Operations and maintenance manuals shall be delivered to COR not less than 30 days prior to completion of a phase or final inspection.

B. Provide one digital copy in PDF format. The Operations and maintenance manuals shall be delivered to COR not less than 30 days prior to completion of a phase or final inspection.

C. All new and temporary equipment and all elements of each assembly shall be included.

D. Data sheet on each device listing model, size, capacity, pressure, speed, horsepower, impeller size, and other information shall be included.

E. Manufacturer’s installation, maintenance, repair, and operation instructions for each device shall be included. Assembly drawings and parts lists shall also be included. A summary of operating precautions and reasons for precautions shall be included in the Operations and Maintenance Manual.

F. Schematic diagrams and wiring diagrams of all control systems corrected to include all field modifications shall be included.

G. Set points of all interlock devices shall be listed.

H. Trouble-shooting guide for the control system troubleshooting guide shall be inserted into the Operations and Maintenance Manual.

I. Emergency procedures.

3.15 INSTRUCTIONS TO VA PERSONNEL

Instructions shall be provided in accordance with Article, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS.

- - - E N D - - -

SECTION 22 05 23

GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the requirements for general-duty valves for domestic water and sewer systems.

1.2 RELATED WORK

A. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

B. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

C. Section 22 11 00, FACILITY WATER DISTRIBUTION.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Sanitary Engineering (ASSE):

1. 1001-2017 Performance Requirements for Atmospheric Type Vacuum Breakers

2. 1003-2009 Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems

3. 1011-2017 Performance Requirements for Hose Connection Vacuum Breakers

4. 1020-2004 Performance Requirements for Pressure Vacuum Breaker Assembly

C. American Society for Testing and Materials (ASTM):

1. A126-2019 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

2. A276/A276M-2017 Standard Specification for Stainless Steel Bars and Shapes

3. A536-2019 Standard Specification for Ductile Iron Castings

4. B62-2017 Standard Specification for Composition Bronze or Ounce Metal Castings

5. B584-2014 Standard Specification for Copper Alloy Sand Castings for General Applications

D. International Code Council (ICC):

1. IPC-2018 International Plumbing Code

E. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):

1. SP-25-2018 Standard Marking Systems for Valves, Fittings, Flanges and Unions

2. SP-70-2011 Gray Iron Gate Valves, Flanged and Threaded Ends

3. SP-71-2018 Gray Iron Swing Check Valves, Flanged and Threaded Ends

4. SP-80-2019 Bronze Gate, Globe, Angle, and Check Valves

5. SP-85-2011 Gray Iron Globe & Angle Valves, Flanged and Threaded Ends

6. SP-110-2010 Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

F. National Environmental Balancing Bureau (NEBB):

1. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems, 8th Edition 2015

G. NSF International (NSF):

1. 61-2019 Drinking Water System Components – Health Effects

2. 372-2016 Drinking Water System Components – Lead Content

H. University of Southern California Foundation for Cross Connection Control and Hydraulic Research (USC FCCCHR):

1. Manual of Cross-Connection Control, 10th Edition

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING", with applicable paragraph identification.

C. Manufacturer's Literature and Data Including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Ball Valves.

2. Check Valves.

3. Backflow Preventers.

4. Pressure Reducing Valves

D. Complete operating and maintenance manuals including, technical data sheets and information for ordering replaceable parts:

1. Include complete list indicating all components of the systems.

2. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

E. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

F. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Valves shall be prepared for shipping as follows:

1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.

3. Set ball and plug valves open to minimize exposure of functional surfaces

4. Block check valves in either closed or open position.

B. Valves shall be prepared for storage as follows:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew point temperature.

1.6 AS BUILT DOCUMENTATION

A. Comply with requirements in Paragraph "AS-BUILT DOCUMENTATION" of Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 VALVES, GENERAL

A. Asbestos packing and gaskets are prohibited.

B. Bronze valves shall be made with dezincification resistant materials. Bronze valves made with copper alloy (brass) containing greater than 15 percent zinc shall not be permitted.

C. Valves in insulated piping shall have 50 mm or DN50 (2 inch) stem extensions and extended handles of non-thermal conductive material that allows operating the valve without breaking the vapor seal or disturbing the insulation. Memory stops shall be fully adjustable after insulation is applied.

D. All valves used to supply potable water shall meet the requirements of NSF 61 and NSF 372.

2.2 SHUT-OFF VALVES

A. Cold Water:

1. 50 mm or DN50 (2 inches) and smaller: Ball, MSS SP-110, Ball valve shall be full port three piece or two piece with a union design with

adjustable stem package. Threaded stem designs are not allowed. The ball valve shall have a SWP rating of 1035 kPa (150 psig) and a CWP rating of 4138 kPa (600 psig). The body material shall be Bronze ASTM B584, Alloy C844. The ends shall be non-lead solder.

2.3 CHECK VALVES

A. Check valves less than 80 mm or DN80 (3 inches) and smaller) shall be class 125, bronze swing check valves with non metallic Buna-N disc. The check valve shall meet MSS SP-80 Type 4 standard. The check valve shall have a CWP rating of 1380 kPa (200 psig). The check valve shall have a Y pattern horizontal body design with bronze body material conforming to ASTM B 62, solder joints, and PTFE or TFE disc.

2.4 WATER PRESSURE REDUCING VALVE AND CONNECTIONS

A. 80 mm or DN80 (3 inches) or smaller: The pressure reducing valve shall consist of a bronze body and bell housing, a separate access cover for the plunger, and a bolt to adjust the downstream pressure. The bronze bell housing and access cap shall be threaded to the body and shall not require the use of ferrous screws. The assembly shall be of the balanced piston design and shall reduce pressure in both flow and no flow conditions. The assembly shall be accessible for maintenance without having to remove the body from the line.

B. The regulator shall have a tap for pressure gauge.

C. Setting: Entering water pressure, discharge pressure, capacity, size, and related measurements shall be as shown on the drawings.

D. Connections Valves and Strainers: shut off valves shall be installed on each side of reducing valve and a bypass line equal in size to the regulator inlet pipe shall be installed with a normally closed globe valve. A strainer shall be installed on inlet side of, and same size as pressure reducing valve. A pressure gage shall be installed on the low pressure side of the line.

2.5 BACKFLOW PREVENTERS

A. A backflow prevention assembly shall be installed at any point in the plumbing system where the potable water supply comes in contact with a potential source of contamination. The backflow prevention assembly shall be ASSE 1013 listed and certified.

B. Reduced pressure backflow preventers shall be installed in the following applications.

1. Water make up to computer room air conditioners and similar equipment consuming water.

C. The reduced pressure principle backflow prevention assembly shall be ASSE listed 1013 with full port OS&Y gate valves and an integral relief monitor switch. The main body and access cover shall be epoxy coated duct iron conforming to ASTM A536 grade 4. The seat ring and check valve shall be Noryl (NSF listed). The stem shall be stainless steel conforming to ASTM A276. The seat disc elastomer shall be EPDM. The checks and the relief valve shall be accessible for maintenance without

removing the device from the line. An epoxy coated wye type strainer with flanged connections shall be installed on the inlet.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Valve interior shall be examined for cleanliness, freedom from foreign matter, and corrosion. Special packing materials shall be removed, such as blocks, used to prevent disc movement during shipping and handling.

B. Valves shall be operated in positions from fully open to fully closed. Guides and seats shall be examined and made accessible by such operations.

C. Threads on valve and mating pipe shall be examined for form and cleanliness.

D. Mating flange faces shall be examined for conditions that might cause leakage. Bolting shall be checked for proper size, length, and material. Gaskets shall be verified for proper size and that its material composition is suitable for service and free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Valves shall be located for easy access and shall be provide with separate support. Valves shall be accessible with access doors when installed inside partitions or above hard ceilings.

C. Valves shall be installed in horizontal piping with stem at or above center of pipe

D. Valves shall be installed in a position to allow full stem movement.

E. Check valves shall be installed for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

F. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no cost to the Government.

3.3 ADJUSTING

A. Valve packing shall be adjusted or replaced after piping systems have been tested and put into service but before final adjusting and balancing. Valves shall be replaced if persistent leaking occurs.

3.4 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the

various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

3.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for one hour to instruct each VA Personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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SECTION 22 07 11

PLUMBING INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Field applied insulation for thermal efficiency and condensation control for

1. Plumbing piping and equipment.

B. Definitions

1. ASJ: All service jacket, white finish facing or jacket.

2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.

3. Cold: Equipment or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.

4. Concealed: Piping above ceilings and in chases, shafts, interstitial spaces, and pipe spaces.

5. Exposed: Piping and equipment exposed to view in finished areas including mechanical equipment rooms or exposed to outdoor weather. Areas such as chases, shafts, interstitial spaces, pipe spaces, unfinished attics, crawl spaces, and pipe basements are not considered finished areas.

6. FSK: Foil-scrim-kraft facing.

7. Hot: Plumbing equipment or piping handling media above 41 degrees C (105 degrees F).

8. Density: kg/m3 - kilograms per cubic meter (Pcf - pounds per cubic foot).

9. Thermal conductance: Heat flow rate through materials.

a. Flat surface: Watts per square meter (BTU per hour per square foot).

b. Pipe or Cylinder: Watts per square meter (BTU per hour per linear foot).

10. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).

11. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.

12. CW: Cold water.

13. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 RELATED WORK

A. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

B. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING.

C. Section 22 11 00, FACILITY WATER DISTRIBUTION.

D. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.3 QUALITY ASSURANCE

A. Refer to article QUALITY ASSURANCE, in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

B. Criteria:

1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, parts of which are quoted as follows:

> 4.3.3.1 Pipe insulation and coverings, vapor retarder facings, adhesives, fasteners, tapes, unless otherwise provided for in 4.3.3.1.12 shall have, in the form in which they are used, a maximum flame spread index of 25 without evidence of continued progressive combustion and a maximum smoke developed index of 50 when tested in accordance with NFPA 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
>
> 4.3.3.1.1 Where these products are to be applied with adhesives, they shall be tested with such adhesives applied, or the adhesives used shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when in the final dry state. (See 4.2.4.2
>
> 4.3.3.3 Pipe insulation and coverings shall not flame, glow, smolder, or smoke when tested in accordance with a similar test for pipe covering, ASTM C 411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation, at the temperature to which they are exposed in service.
>
> 4.3.3.3.1 In no case shall the test temperature be below 121°C (250°F).

2. Test methods: ASTM E84, UL 723, or NFPA 255.

3. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. Where optional thermal insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For pipe, use insulation manufacturer's published heat flow tables. For domestic hot water supply and return, run out insulation and condensation control insulation, no thickness adjustment need be made.

4. All materials shall be compatible and suitable for service temperature, and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.

C. Every package or standard container of insulation or accessories delivered to the job site for use must have a manufacturer's stamp or label giving the name of the manufacturer and description of the material.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Shop Drawings:

1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.

a. Insulation materials: Specify each type used and state surface burning characteristics.

b. Insulation facings and jackets: Each type used.

c. Insulation accessory materials: Each type used.

d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.

e. Make reference to applicable specification paragraph numbers for coordination.

1.5 STORAGE AND HANDLING OF MATERIAL

Store materials in clean and dry environment, pipe covering jackets shall be clean and unmarred. Place adhesives in original containers. Maintain ambient temperatures and conditions as required by printed instructions of manufacturers of adhesives, mastics and finishing cements.

1.6 APPLICABLE PUBLICATIONS

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

B. Federal Specifications (Fed. Spec.):

L-P-535E (2)-91 Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.

C. Military Specifications (Mil. Spec.):

MIL-A-3316C (2)-90 Adhesives, Fire-Resistant, Thermal Insulation

MIL-A-24179A (1)-87 Adhesive, Flexible Unicellular-Plastic Thermal Insulation

MIL-C-19565C (1)-88 Coating Compounds, Thermal Insulation, Fire-and Thermal Insulation

D. American Society for Testing and Materials (ASTM):

C177 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded -Hot-Plate Apparatus

C411-05 Standard test method for Hot-Surface Performance of High-Temperature Thermal Insulation

C449-07 Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement

C518 Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus

C534-08 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

C585-09 Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System) R (1998)

C1136-10 Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

E84-10 Standard Test Method for Surface Burning Characteristics of Building Materials

E119-09C Standard Test Method for Fire Tests of Building Construction and Materials

E136-09 b Standard Test Methods for Behavior of Materials in a Vertical Tube Furnace at 750 degrees C (1380 F)

E. National Fire Protection Association (NFPA):

101-09 Life Safety Code

251-06 Standard methods of Tests of Fire Endurance of Building Construction Materials

255-06 Standard Method of tests of Surface Burning Characteristics of Building Materials

F. Underwriters Laboratories, Inc (UL):

UL Standard for Safety Test for Surface Burning Characteristics of Building Materials with Revision of 08/03

G. Manufacturer’s Standardization Society of the Valve and Fitting Industry (MSS):

SP58-2002 Pipe Hangers and Supports Materials, Design, and Manufacture

PART 2 - PRODUCTS

2.2 FIBER GLASS – TYPE A

ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, k = 0.037 (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (446 degrees F) with an all service vapor retarder jacket (ASJ) and with polyvinyl chloride (PVC) premolded fitting covering.

2.3 INSULATION FACINGS AND JACKETS

A. Vapor Retarder, higher strength with low water permeance = 0.02 or less perm rating, Beach puncture 50 units for insulation facing on pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.

B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.

C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.

D. Field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping as well as on interior piping, piping in high humidity areas, and piping conveying fluids below ambient temperature. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 35 cm-kg (30 inch-pounds) for interior locations and 92 cm-kg (80 inch-pounds) for exterior or exposed locations or where the insulation is subject to damage.

E. Factory composite materials may be used provided.

F. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) conforming to Fed Spec L-P-335, composition A, Type II Grade GU, and Type III, minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape.

2.4 ADHESIVE, MASTIC, CEMENT

A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.

B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.

C. Mil. Spec. MIL-A-24179, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.

D. Mil. Spec. MIL-C-19565, Type I: Protective finish for outdoor use.

E. Mil. Spec. MIL-C-19565, Type I or Type II: Vapor barrier compound for indoor use.

F. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.

G. Other: Insulation manufacturers' published recommendations.

2.5 MECHANICAL FASTENERS

A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.

B. Staples: Outward clinching galvanized steel

C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.

D. Bands: 13 mm (1/2 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.6 REINFORCEMENT AND FINISHES

A. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.

B. PVC fitting cover: Fed. Spec L-P-535, Composition A, 11-86 Type II, Grade GU, with Form B Mineral Fiber insert, for media temperature 4 degrees C (40 degrees F) to 121 degrees C (250 degrees F). Below 4 degrees C (40 degrees F) and above 121 degrees C (250 degrees F). Provide double layer insert. Provide color matching vapor barrier pressure sensitive tape.

2.7 FLAME AND SMOKE

Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications. See paragraph 1.3 "Quality Assurance".

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Required pressure tests of piping joints and connections shall be completed and the work approved by the COR for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.

B. Except for specific exceptions, insulate all specified equipment and piping (pipe, fittings, valves, accessories). Insulate each pipe individually. Do not use scrap pieces of insulation where a full length section will fit.

C. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters

(NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees F) and below. Lap and seal vapor barrier over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).

D. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.

E. Plumbing work not to be insulated:

1. Piping and valves of fire protection system.

2. Chromium plated brass piping.

3. Water piping in contact with earth.

4. Small horizontal cold water branch runs in partitions to individual fixtures may be without insulation for maximum distance of 900 mm (3 feet).

F. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.

G. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited on cold applications.

H. Provide vapor barrier jackets over insulation as follows:

1. All interior piping conveying fluids piping conveying fluids below ambient temperature.

3.2 INSULATION INSTALLATION

A. Flexible Mineral Fiber Blanket:

1. Adhere insulation to metal with 75 mm (3 inch) wide strips of insulation bonding adhesive at 200 mm (8 inches) on center all around duct. Additionally secure insulation to bottom of ducts exceeding 600 mm (24 inches) in width with pins welded or adhered on 450 mm (18 inch) centers. Secure washers on pins. Butt insulation edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations with mastic. Sagging duct insulation will not be acceptable. Install firestop duct insulation where required.

2. Supply air ductwork to be insulated includes main and branch ducts from AHU discharge to room supply outlets, and the bodies of ceiling outlets to prevent condensation. Insulate sound attenuator units, coil casings and damper frames. To prevent condensation insulate trapeze type supports and angle iron hangers for flat oval ducts that are in direct contact with metal duct.

B. Molded Mineral Fiber Pipe and Tubing Covering:

1. Fit insulation to pipe or duct, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.

2. Contractor's options for fitting, flange and valve insulation:

   a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.

   b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 4 degrees C (40 degrees F), or above 121 degrees C (250 degrees F). Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.

   c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.

   d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).

C. Insulation Schedule:

PIPING	TYPE	PIPE SIZE	MINIMUM INSULATION THICKNESS
Domestic Cold Water	A	All Sizes	1”
Piping Exposed to Freezing	A	All Sizes	2"

3.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 22 08 00

COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 22.

B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned are specified in Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

C. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1.3 SUMMARY

A. This Section includes requirements for commissioning plumbing systems, subsystems and equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.

B. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for more specifics regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

A. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

A. Commissioning of a system or systems specified in Division 22 is part of the construction process. Documentation and testing of these systems, as well as training of the VA's Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and of Division 22, is required in cooperation with the VA and the Commissioning Agent.

B. The Plumbing systems commissioning will include the systems listed in Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

1.6 SUBMITTALS

A. The commissioning process requires review of selected Submittals. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES for further details.

B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

A. Commissioning of the Building Plumbing Systems will require inspection of individual elements of the Plumbing construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and the Commissioning Plan to schedule inspections as required to support the commissioning process.

3.2 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

A. Contractor tests as required by other sections of Division 22 shall be scheduled and documented in accordance with Section 01 00 00, GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING:

A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The

Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the COR. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS, for additional details.

3.5 TRAINING OF VA PERSONNEL

A. Training of the VA operation and maintenance personnel is required in cooperation with the COR and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Division 1 specifications. The instruction shall be scheduled in coordination with the COR after submission and approval of formal training plans. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and Division 22 Sections for additional Contractor training requirements.

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SECTION 22 11 00

FACILITY WATER DISTRIBUTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Domestic water systems, including piping, equipment and all necessary accessories as designated in this section.

B. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 07 84 00, FIRESTOPPING.

E. Section 07 92 00, JOINT SEALANTS.

F. Section 09 91 00, PAINTING.

G. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

H. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

I. Section 22 07 11, PLUMBING INSULATION.

J. SECTION 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.3 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 22 11 00, FACILITY WATER DISTRIBUTIONS”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. All items listed in Part 2 - Products.

D. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replacement parts:

1. Include complete list indicating all components of the systems.

2. Include complete diagrams of the internal wiring for each item of equipment.

3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

E. Completed System Readiness Checklist provided by the CxA and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

F. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.4 APPLICABLE PUBLICATIONS

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

B. American Society of Mechanical Engineers (ASME):

1. A13.1-2013 Scheme for Identification of Piping Systems

2. B16.15-2013 Cast Copper Alloy Threaded Fittings: Classes 125 and 250

3. B16.18-2012 Cast Copper Alloy Solder Joint Pressure Fittings

4. B16.22-2013 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

5. B16.24-2011 Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500

6. BPVC Section IX-2015 ASME Boiler and Pressure Vessel Code - Welding, Brazing, and Fusing Qualifications

C. American Society of Sanitary Engineers (ASSE):

1. 1010-2004 Performance Requirements for Water Hammer Arresters

D. American Society for Testing and Materials (ASTM):

1. B32-2014 Standard Specification for Solder Metal

2. B61-2013 Standard Specification for Steam or Valve Bronze Castings

3. B62-2009 Standard Specification for Composition Bronze or Ounce Metal Castings

4. B75/B75M-2011 Standard Specification for Seamless Copper Tube

5. B88-2014 Standard Specification for Seamless Copper Water Tube

6. B584-2014 Standard Specification for Copper Alloy Sand Castings for General Applications

7. B687-2011 Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples

8. C919-2012 Standard Practice for Use of Sealants in Acoustical Applications

9. E1120-2008 Standard Specification for Liquid Chlorine

10. E1229-2008 Standard Specification for Calcium Hypochlorite

E. American Water Works Association (AWWA):

1. C651-2014 Disinfecting Water Mains

F. American Welding Society (AWS):

1. A5.8M/A5.8-2011-AMD1 Specification for Filler Metals for Brazing and Braze Welding

G. International Code Council (ICC):

1. IPC-2012 International Plumbing Code

H. Manufacturers Specification Society (MSS):

1. SP-58-2009 Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation

2. SP-72-2010a Ball Valves with Flanged or Butt-Welding Ends for General Service

3. SP-110-2010 Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

I. NSF International (NSF):

1. 14-2015 Plastics Piping System Components and Related Materials

2. 61-2014a Drinking Water System Components – Health Effects

3. 372-2011 Drinking Water System Components – Lead Content

J. Plumbing and Drainage Institute (PDI):

1. PDI-WH 201-2010 Water Hammer Arrestors

K. Department of Veterans Affairs:

1. H-18-8-2013 Seismic Design Handbook

2. H-18-10 Plumbing Design Manual

1.5 QUALITY ASSURANCE

A. A certificate shall be submitted prior to welding of steel piping showing the Welder’s certification. The certificate shall be current and no more than one year old. Welder’s qualifications shall be in accordance with ASME BPVC Section IX.

B. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be by the same manufacturer as the groove components.

C. All pipe, couplings, fittings, and specialties shall bear the identification of the manufacturer and any markings required by the applicable referenced standards.

D. Bio-Based Materials: For products designated by the USDA’s Bio-Preferred Program, provide products that meet or exceed USDA recommendations for

bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit http://www.biopreferred.gov.

1.6 AS BUILT DOCUMENTATION

A. Comply with requirements in Paragraph "AS-BUILT DOCUMENTATION" of Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material or equipment containing a weighted average of greater than 0.25 percent lead shall not be used in any potable water system intended for human consumption, and shall be certified in accordance with NSF/ANSI 61 or NSF 372. Endpoint devices used to dispense water for drinking must meet the requirements of NSF/ANSI 61, Section 9.

2.2 ABOVE GROUND (INTERIOR) WATER PIPING

A. Pipe: Copper tube, ASTM B88, Type L, drawn.

B. Fittings for Copper Tube:

1. Wrought copper or bronze castings conforming to ANSI B16.18 and B16.22. Unions shall be bronze, MSS SP72 & SP 110, Solder or braze joints. Use 95/5 tin and antimony for all soldered joints.

2. Mechanical press-connect fittings for copper pipe and tube are prohibited. See Plumbing Design Manual for additional information.

C. Adapters: Provide adapters for joining screwed pipe to copper tubing.

D. Solder: ASTM B32 Composition Sb5 HA or HB. Provide non-corrosive flux.

E. Brazing alloy: AWS A5.8, Classification BCuP.

2.3 EXPOSED WATER PIPING

A. Finished Room: Use full iron pipe size chrome plated brass piping for exposed water piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those furnished by the Government or specified in other sections.

1. Pipe: Fed. Spec. WW-P-351, standard weight.

2. Fittings: ANSI B16.15 cast bronze threaded fittings with chrome finish.

3. Nipples: ASTM B 687, Chromium-plated.

4. Unions: Mss SP-72, SP-110, Brass or Bronze with chrome finish. Unions 2-1/2 inches (65 mm) and larger shall be flange type with approved gaskets.

B. Unfinished Rooms, Mechanical Rooms, Electrical Rooms, IDF Rooms, and similar spaces: Chrome-plated brass piping is not required.

1. Paint piping systems as specified in Section 09 91 00, PAINTING.

2.4 STRAINERS

A. Provide on high pressure side of pressure reducing valves, on suction side of pumps, on inlet side of indicating and control instruments and equipment subject to sediment damage and where shown on drawings. Strainer element shall be removable without disconnection of piping.

B. Water: Basket or "Y" type with easily removable cover and brass strainer basket.

C. Body: Smaller than 3 inches (80 mm), brass or bronze; 3 inches (80 mm) and larger, cast iron or semi-steel.

2.5 STERILIZATION CHEMICALS

A. Hypochlorite: ASTM E1120-08

B. Liquid Chlorine: ASTM E1229-08

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Comply with the International Plumbing Code and the following:

1. Install branch piping for water from the piping system and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.

2. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for plastic and glass, shall be reamed to full size after cutting.

3. All pipe runs shall be laid out to avoid interference with other work.

4. Install union and shut-off valve on pressure piping at connections to equipment.

5. Pipe Hangers, Supports and Accessories:

a. All piping shall be supported per the International Plumbing Code.

b. Shop Painting and Plating: Hangers, supports, rods, inserts and accessories used for pipe supports shall be shop coated with red lead or zinc chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.

c. Floor, Wall and Ceiling Plates, Supports, Hangers:

1) Solid or split un-plated cast iron.

2) All plates shall be provided with set screws.

3) Pipe Hangers: Height adjustable clevis type.

4) Adjustable Floor Rests and Base Flanges: Steel.

5) Concrete Inserts: "Universal" or continuous slotted type.

6) Hanger Rods: Mild, low carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.

7) Riser Clamps: Malleable iron or steel.

8) Rollers: Cast iron.

9) Self-drilling type expansion shields shall be "Phillips" type, with case hardened steel expander plugs.

10) Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (min.) metal protection shield Centered on and welded to the hanger and support. The shield shall be 4 inches in length and be 16 gauge steel. The shield shall be sized for the insulation.

11) Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. Provide all necessary auxiliary steel to provide that support.

12) With the installation of each flexible expansion joint, provide piping restraints for the upstream and downstream section of the piping at the flexible expansion joint. Provide calculations supporting the restraint length design and type of selected restraints.

B. Domestic Water piping shall conform to the following:

1. Grade all lines to facilitate drainage. Provide drain valves at bottom of risers and all low points in system. Design domestic hot and cold water circulating lines with no traps.

2. Connect branch lines at bottom of main serving fixtures below and pitch down so that main may be drained through fixture. Connect branch lines to top of main serving only fixtures located on floor above.

3.2 TESTS

A. General: Test system either in its entirety or in sections. Submit testing plan to COR 14 days prior to test date.

B. Potable Water System: Test after installation of piping and domestic water heaters, but before piping is concealed, before covering is applied, and before plumbing fixtures are connected. Fill systems with water and maintain hydrostatic pressure of 150 psi (1040 kPa) gage for two hours. No decrease in pressure is allowed. Provide a pressure gage with a shutoff and bleeder valve at the highest point of the piping being tested.

1. Pneumatic testing shall not be permitted.

C. All Other Piping Tests: Test new installed piping under 1-1/2 times actual operating conditions and prove tight.

3.3 STERILIZATION

A. After tests have been successfully completed, thoroughly flush and sterilize the interior domestic water distribution system in accordance with AWWA C651.

1. Replace startup strainers prior to sterilization.

B. Use liquid chlorine or hypochlorite for sterilization.

3.4 COMMISSIONING

A. Provide commissioning documentation accordance with the requirements of Section 22 08 00, COMMISSIONING FOR PLUMBING SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for one hour to instruct VA Personnel in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

- - - END - - -

SECTION 22 13 00

FACILITY SANITARY AND VENT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

This section pertains to sanitary sewer and vent systems, including piping, equipment and all necessary accessories as designated in this section.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

E. Section 07 84 00, FIRESTOPPING.

F. Section 07 92 00, JOINT SEALANTS.

G. Section 09 91 00, PAINTING.

H. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

I. Section 22 07 11, PLUMBING INSULATION.

J. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

K. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

L. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.

1.3 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 22 13 00, FACILITY SANITARY AND VENT PIPING”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Piping.

2. Cleanouts.

3. Penetration Sleeves.

4. Pipe Fittings.

5. Traps.

6. Exposed Piping and Fittings.

D. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane or the floor drain.

E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replaceable parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.

2. Include complete diagrams of the internal wiring for each item of equipment.

3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

1.4 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):

1. A13.1-2007 Identification of Piping Systems

2. A112.36.2M-1991 Cleanouts

3. A112.6.3-2019 Floor and Trench Drains

4. B1.20.1-2013 Pipe Threads, General Purpose (Inch)

5. B16.1-2015 Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

6. B16.4-2016 Grey Iron Threaded Fittings Classes 125 and 250

7. B16.15-2018 Cast Copper Alloy Threaded Fittings, Classes 125 and 250

8. B16.18-2018 Cast Copper Alloy Solder Joint Pressure Fittings

9. B16.21-2016 Nonmetallic Flat Gaskets for Pipe Flanges

10. B16.22-2018 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

11. B16.23-2016 Cast Copper Alloy Solder Joint Drainage Fittings: DWV

12. B16.24-2016 Cast Copper Alloy Pipe Flanges and Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500

13. B16.29-2017 Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings: DWV

14. B16.39-2014 Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300

15. B18.2.1-2012 Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)

C. American Society of Sanitary Engineers (ASSE):

1. 1001-2017 Performance Requirements for Atmospheric Type Vacuum Breakers

2. 1018-2001 Performance Requirements for Trap Seal Primer Valves – Potable Water Supplied

3. 1044-2015 Performance Requirements for Trap Seal Primer Devices – Drainage Types and Electronic Design Types

4. 1079-2012 Performance Requirements for Dielectric Pipe Unions

D. American Society for Testing and Materials (ASTM):

1. A53/A53M-2018 Standard Specification for Pipe, Steel, Black And Hot-Dipped, Zinc-coated, Welded and Seamless

2. A74-2017 Standard Specification for Cast Iron Soil Pipe and Fittings

3. A888-2018a Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

4. B32-2014 Standard Specification for Solder Metal

5. B43-2015 Standard Specification for Seamless Red Brass Pipe, Standard Sizes

6. B88-2016 Standard Specification for Seamless Copper Water Tube

7. B306-2013 Standard Specification for Copper Drainage Tube (DWV)

8. B687-2016 Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples

9. B813-2016 Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube

10. B828-2016 Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings

11. C564-2014 Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings

12. D2321-2018 Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

13. D2564-2018 Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems

14. D2665-2014 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings

15. D2855-2015 Standard Practice for Two-Step (Primer and Solvent Cement) Method of Joining Poly(Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) CPVCP Pipe and Piping Components with Tapered Sockets

16. D5926-2015 Standard Specification for Poly(Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems

17. F402-2018 Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings

18. F477-2014 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

19. F1545-2015e1 Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges

E. Cast Iron Soil Pipe Institute (CISPI):

1. Cast Iron Soil Pipe and Fittings Handbook

2. 301-2012 Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

3. 310-2012 Specification for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

F. Copper Development Association, Inc. (CDA):

1. A4015-14/19 Copper Tube Handbook

G. International Code Council (ICC):

1. IPC-2018 International Plumbing Code

H. Manufacturers Standardization Society (MSS):

1. SP-123-2018 Non-Ferrous Threaded and Solder-Joint Unions for Use with Copper Water Tube

I. National Fire Protection Association (NFPA):

1. 70-2020 National Electrical Code (NEC)

J. Underwriters' Laboratories, Inc. (UL):

1. 508-2013 Standard For Industrial Control Equipment

1.5 AS-BUILT DOCUMENTATION

A. Comply with requirements in Paragraph “AS-BUILT DOCUMENTATION” of Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 SANITARY WASTE, DRAIN, AND VENT PIPING

A. Cast iron waste, drain, and vent pipe and fittings

1. Cast iron waste, drain, and vent pipe and fittings shall be used for the following applications:

a. Pipe buried in or in contact with earth

b. Sanitary pipe extensions to a distance of approximately 1500 mm (5 feet) outside of the building.

c. Interior waste and vent piping above grade.

2. Cast iron Pipe shall be bell and spigot or hubless (plain end or no-hub or hubless).

3. The material for pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI Standard 301, ASTM A-888, or ASTM A-74.

4. Joints for hubless pipe and fittings shall conform to the manufacturer's installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM Standard C-564.

2.2 EXPOSED WASTE PIPING

A. Full iron pipe size chrome plated brass piping shall be used in finished rooms for exposed waste piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those furnished by the Government or specified in other sections.

1. The Pipe shall meet Fed. Spec. WW-P-351, standard weight.

2. The Fittings shall conform to ANSI B16.15, cast bronze threaded fittings with chrome finish, (125 and 250).

3. Nipples shall conform to ASTM B 687, Chromium-plated.

4. Unions shall be brass or bronze with chrome finish. Unions 65 mm (2-1/2 inches) and larger shall be flange type with approved gaskets.

B. In unfinished Rooms such as mechanical rooms, electrical rooms, and sprinkler riser rooms, chrome-plated brass piping is not required. The pipe materials specified under the paragraph "Sanitary Waste, Drain, and Vent Piping" can be used. The sanitary pipe in unfinished rooms shall be painted as specified in Section 09 91 00, PAINTING.

2.3 SPECIALTY PIPE FITTINGS

A. Transition pipe couplings shall join piping with small differences in outside diameters or different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be elastomeric, sleeve type reducing or transition pattern and include shear and corrosion resistant metal, tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:

1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.

2. For dissimilar pipes, the sleeve material shall be of a material compatible with the pipe materials being joined.

B. The dielectric fittings shall conform to ASSE 1079 with a pressure rating of 860 kPa (125 psig) at a minimum temperature of 82°C (180°F). The end connection shall be solder joint copper alloy and threaded ferrous.

C. Dielectric flange insulating kits shall be of non conducting materials for field assembly of companion flanges with a pressure rating of 1035 kPa (150 psig). The gasket shall be neoprene or phenolic. The bolt sleeves shall be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.

D. The di-electric nipples shall be electroplated steel nipple complying with ASTM F 1545 with a pressure ratings of 2070 kPa (300 psig) at 107°C (225°F). The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene.

2.4 CLEANOUTS

A. Cleanouts shall be the same size as the pipe, up to 100 mm (4 inches); and not less than 100 mm (4 inches) for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. Minimum clearance of 600 mm (24 inches) shall be provided for clearing a clogged sanitary line.

B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside calk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 50 mm (2 inches). When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs.

1. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion.

2. In the carpeted areas, carpet cleanout markers shall be provided.

3. Two way cleanouts shall be provided where indicated on drawings and at every building exit.

4. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty type.

C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 600 mm (24 inches) above the floor. If there are no fixtures installed on the lowest floor, the cleanout shall be installed at the base of the stack. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickel-bronze square frame and stainless steel cover with minimum opening of 150 by 150 mm (6 by 6 inches) shall be furnished at each wall cleanout. Where the piping is concealed, a fixture trap or a fixture with integral trap, readily removable without disturbing concealed pipe, shall be accepted as a cleanout equivalent providing the opening to be used as a cleanout opening is the size required.

D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/hubless cast iron ferrule. Plain end (hubless) piping in interstitial space or above ceiling may use plain end (hubless) blind plug and clamp.

2.5 TRAPS

A. Traps shall be provided on all sanitary branch waste connections from fixtures or equipment not provided with traps. Exposed brass shall be polished brass chromium plated with nipple and set screw escutcheons. Concealed traps may be rough cast brass or same material as pipe connected to. Slip joints are not permitted on sewer side of trap. Traps shall correspond to fittings on cast iron soil pipe or steel pipe respectively, and size shall be as required by connected service or fixture.

2.6 WATERPROOFING

A. A sleeve flashing device shall be provided at points where pipes pass through membrane waterproofed floors or walls. The sleeve flashing device shall be manufactured, cast iron fitting with clamping device that forms a sleeve for the pipe floor penetration of the floor membrane. A galvanized steel pipe extension shall be included in the top of the fitting that will extend 50 mm (2 inches) above finished floor and galvanized steel pipe extension in the bottom of the fitting that will extend through the floor slab. A waterproof caulked joint shall be provided at the top hub.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. The pipe installation shall comply with the requirements of the International Plumbing Code (IPC) and these specifications.

B. Branch piping shall be installed for waste from the respective piping systems and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.

C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe shall be reamed to full size after cutting.

D. All pipe runs shall be laid out to avoid interference with other work.

E. The piping shall be installed above accessible ceilings where possible.

F. The piping shall be installed to permit valve servicing or operation.

G. The piping shall be installed free of sags and bends.

H. Seismic restraint shall be installed where required by code.

I. Changes in direction for soil and waste drainage and vent piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep quarter bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and eighth bend fittings shall be used if two fixtures are installed back to back or side by side with common drain pipe.

Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Buried soil and waste drainage and vent piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer's written instruction for use of lubricants, cements, and other installation requirements.

K. Cast iron piping shall be installed according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings".

3.2 JOINT CONSTRUCTION

A. Hub and spigot, cast iron piping with gasket joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hubless or No-hub, cast iron piping shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.

C. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service

2. Pipe sections with damaged threads shall be replaced with new sections of pipe.

3.3 SPECIALTY PIPE FITTINGS

A. Transition coupling shall be installed at pipe joints with small differences in pipe outside diameters.

B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.

C. Specialty fittings compatible with the connected materials shall be utilized to join piping of different types.

3.4 PIPE HANGERS, SUPPORTS AND ACCESSORIES:

A. All piping shall be supported according to the International Plumbing Code (IPC), Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and these specifications. Where conflicts arise between these the code and Section 22 05 11, the most restrictive or the requirement that specifies supports with highest loading or shortest spacing shall apply.

B. Hangers, supports, rods, inserts and accessories used for pipe supports shall be shop coated with zinc chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.

C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.

D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:

1. 40 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 inch to NPS 2 inch): 1500 mm (60 inches) with 10 mm (3/8 inch) rod.

2. 80 mm or DN 80 (NPS 3 inch): 1500 mm (60 inches) with 13 mm (½ inch) rod.

3. 100 mm or DN100 to 125 mm or DN125 (NPS 4 to NPS 5): 1500 mm (60 inches) with 16 mm (5/8 inch) rod.

4. 150 mm or DN150 to 200 mm or DN200 (NPS 6 inch to NPS 8 inch): 1500 mm (60 inches) with 19 mm (¾ inch) rod.

E. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 4.57 m (15 feet).

F. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, floor, Wall and Ceiling Plates, Supports, Hangers shall have the following characteristics:

1. Solid or split unplated cast iron.

2. All plates shall be provided with set screws.

3. Height adjustable clevis type pipe hangers.

4. Adjustable floor rests and base flanges shall be steel.

5. Hanger rods shall be low carbon steel, fully threaded or threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.

6. Riser clamps shall be malleable iron or steel.

7. Rollers shall be cast iron.

8. See Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, for requirements on insulated pipe protective shields at hanger supports.

G. Miscellaneous materials shall be provided as specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.

H. Cast escutcheon with set screw shall be provided at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

I. Penetrations:

1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.

2. Water proofing: At floor penetrations, clearances shall be completely sealed around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.

J. Piping shall conform to the following:

1. Waste and Vent Drain to main stacks:

a. 80 mm or DN 80 (3 inches) and smaller: 2% minimum slope

b. 100 mm or DN 100 (4 inches) and larger : 1% minimum slope

3.5 TESTS

A. Sanitary waste and drain systems shall be tested either in its entirety or in sections.

B. Waste System tests shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.

1. If entire system is tested for a water test, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If the waste system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 3 m (10 foot) head of water. In testing successive sections, test at least upper 3 m (10 feet) of next preceding section so that each joint or pipe except upper most 3 m (10 feet) of system has been submitted to a test of at least a 3 m (10 foot) head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.

2. For an air test, an air pressure of 34 kPa (5 psig) gauge shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gauge shall be used for the air test.

3. After installing all fixtures and equipment, open water supply so that all p-traps can be observed. For 15 minutes of operation, all p-traps shall be inspected for leaks and any leaks found shall be corrected.

4. Final Tests: Either one of the following tests may be used.

a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of .25 kPa (1 inch of water) with a smoke machine. Chemical smoke is prohibited.

b. Peppermint Test: Introduce 60 ml (2 ounces) of peppermint into each line or stack.

3.6 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.7 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for one hour to instruct VA Personnel in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

- - - END - - -

SECTION 23 05 11

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 23.

1.2 DEFINITIONS

A. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.

B. Exterior: Piping, ductwork, and equipment exposed to weather be it temperature, humidity, precipitation, wind, or solar radiation.

C. Option or optional: Contractor's choice of an alternate material or method.

D. COR: Contracting Officer’s Representative.

1.3 ABBREVIATIONS/ACRONYMS

A. AC: Air Conditioning

B. ACU: Air Conditioning Unit

C. AI: Analog Input

D. AISI: American Iron and Steel Institute

E. AO: Analog Output

F. ASJ: All Service Jacket

G. AWG: American Wire Gauge

H. BACnet: Building Automation and Control Networking Protocol

I. bhp: Brake Horsepower

J. Btu: British Thermal Unit

K. Btu/h: British Thermal Unit Per Hour

L. C: Celsius

M. CFM: Cubic Foot Per Minute

N. CHR: Chilled Water Return

O. CHS: Chilled Water Supply

P. COR: Contracting Officer’s Representative

Q. CRS: Corrosion Resistant Steel

R. CW: Cold Water

S. CWP: Cold Working Pressure

T. dB: Decibels

U. dB(A): Decibels (A weighted)

V. DDC: Direct Digital Control

W. DI: Digital Input

X. DO: Digital Output

Y. DWV: Drainage, Waste and Vent

Z. F: Fahrenheit

AA. FAR: Federal Acquisition Regulations

AB. gpm: Gallons Per Minute

AC. HOA: Hands-Off-Automatic

AD. hp: Horsepower

AE. HW: Hot Water

AF. HWH: Hot Water Heating Supply

AG. HWHR: Hot Water Heating Return

AH. Hz: Hertz

AI. ID: Inside Diameter

AJ. IPS: Iron Pipe Size

AK. kg: Kilogram

AL. lb: Pound

AM. L/s: Liters Per Second

AN. MAX: Maximum

AO. m: Meter

AP. MIN: Minimum

AQ. mm: Millimeter

AR. NC: Normally Closed

AS. NO: Normally Open

AT. NPT: National Pipe Thread

AU. NPS: Nominal Pipe Size

AV. OD: Outside Diameter

AW. PID: Proportional-Integral-Differential

AX. PLC: Programmable Logic Controllers

AY. ppm: Parts Per Million

AZ. PSIA: Pounds Per Square Inch Absolute

BA. psig: Pounds Per Square Inch Gauge

BB. RPM: Revolutions Per Minute

BC. TAB: Testing, Adjusting, and Balancing

BD. TEFC: Totally Enclosed Fan-Cooled

BE. THHN: Thermoplastic High-Heat Resistant Nylon Coated Wire

BF. THWN: Thermoplastic Heat & Water-Resistant Nylon Coated Wire

BG. T/P: Temperature and Pressure

BH. V: Volt

BI. VA: Veterans Administration

BJ. VA CFM: VA Construction & Facilities Management

BK. VA CFM CSS: VA Construction & Facilities Management, Consulting Support Service

BL. VAMC: Veterans Administration Medical Center

1.4 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.

D. Section 07 84 00, FIRESTOPPING.

E. Section 09 91 00, PAINTING.

F. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

G. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

H. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

I. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

J. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. Air Movement and Control Association (AMCA):

1. 410-1996 Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

1. 15-2019 Safety Standard for Refrigeration Systems

2. 62.1-2019 Ventilation for Acceptable Indoor Air Quality

3. 90.1-2019 Energy Standard for Buildings Except Low-Rise Residential Buildings

4. 170-2017 Ventilation of Health Care Facilities

D. American Society of Mechanical Engineers (ASME):

1. B31.1-2018 Power Piping

2. B31.9-2014 Building Services Piping

3. BVPC Boiler and Pressure Vessel Code

4. Section IX-2019 Welding, Brazing, and Fusing Qualifications

E. American Society for Testing and Materials (ASTM):

1. A36/A36M-2014 Standard Specification for Carbon Structural Steel

2. A575-1996(R2018) Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

F. Association for Rubber Products Manufacturers (ARPM):

1. IP-20-2015 Specifications for Drives Using Classical V-Belts and Sheaves

2. IP-21-2016 Specifications for Drives Using Double-V (Hexagonal) Belts

3. IP-24-2016 Specifications for Drives Using Synchronous Belts

4. IP-27-2015 Specifications for Drives Using Curvilinear Toothed Synchronous Belts

G. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc.:

1. SP-58-2018 Pipe Hangers and Supports-Materials, Design, Manufacture, Selection, Application, and Installation

2. SP-127-2014a Bracing for Piping Systems: Seismic-Wind-Dynamic Design, Selection, and Application

H. Military Specifications (MIL):

1. MIL-P-21035B-2013 Paint High Zinc Dust Content, Galvanizing Repair (Metric)

I. National Fire Protection Association (NFPA):

1. 70-2017 National Electrical Code (NEC)

2. 101-2018 Life Safety Code

J. Department of Veterans Affairs (VA):

1. PG-18-10-2016 Physical Security and Resiliency Design Manual

1.6 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 05 11, COMMON WORK RESULTS FOR HVAC", with applicable paragraph identification.

C. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements, and all equipment that requires regular maintenance, calibration, etc are accessable from the floor or permanent work platform. It is the Contractor's responsibility to ensure all submittals meet the VA specifications and requirements and it is assumed by the VA that all submittals do meet the VA specifications unless the Contractor has requested a variance in writing and approved by COR prior to the submittal. If at any time during the project it is found that any item does not meet the VA specifications and there was no variance approval the Contractor shall correct at no additional cost or time to the Government even if a submittal was approved.

D. If equipment is submitted which differs in arrangement from that shown, provide documentation proving equivalent performance, design standards and drawings that show the rearrangement of all associated systems. Additionally, any impacts on ancillary equipment or services such as foundations, piping, and electrical shall be the Contractor's responsibility to design, supply, and install at no additional cost or time to the Government. VA approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.

E. Prior to submitting shop drawings for approval, Contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed contract documents, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

F. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together. Coordinate and properly integrate materials and equipment to provide a completely compatible and efficient installation.

G. Coordination/Shop Drawings:

1. Submit complete consolidated and coordinated shop drawings for all new systems, and for existing systems that are in the same areas.

2. The coordination/shop drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:32 (3/8-inch equal to one foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all

equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed coordination/shop drawings of all piping and duct systems. The drawings should include all lockout/tagout points for all energy/hazard sources for each piece of equipment. Coordinate lockout/tagout procedures and practices with local VA requirements.

3. Do not install equipment foundations, equipment or piping until coordination/shop drawings have been approved.

4. In addition, for HVAC systems, provide details of the following:

   a. Mechanical equipment rooms.

   b. Interstitial space.

   c. Hangers, inserts, supports, and bracing.

   d. Pipe sleeves.

   e. Duct or equipment penetrations of floors, walls, ceilings, or roofs.

H. Manufacturer's Literature and Data: Include full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity. Submit under the pertinent section rather than under this section.

1. Submit belt drive with the driven equipment. Submit selection data for specific drives when requested by the COR.

2. Submit electric motor data and variable speed drive data with the driven equipment.

3. Equipment and materials identification.

4. Fire-stopping materials.

5. Hangers, inserts, supports and bracing. Provide complete stress analysis for variable spring and constant support hangers.

6. Wall, floor, and ceiling plates.

I. Rigging Plan: Provide documentation of the capacity and weight of the rigging and equipment intended to be used. The plan shall include the path of travel of the load, the staging area and intended access, and qualifications of the operator and signal person.

J. HVAC Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.

2. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

a. Include complete list indicating all components of the systems.

b. Include complete diagrams of the internal wiring for each item of equipment.

c. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

3. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.

K. Provide copies of approved HVAC equipment submittals to the TAB Subcontractor.

1.7 QUALITY ASSURANCE

A. Mechanical, electrical and associated systems shall be safe, reliable, efficient, durable, easily and safely operable and maintainable, easily and safely accessible, and in compliance with applicable codes as specified. The systems shall be comprised of high quality institutional-class and industrial-class products of manufacturers that are experienced specialists in the required product lines. All construction firms and personnel shall be experienced and qualified specialists in industrial and institutional HVAC.

B. Flow Rate Tolerance for HVAC Equipment: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

C. Equipment Vibration Tolerance:

1. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Equipment shall be factory-balanced to this tolerance and re-balanced on site, as necessary.

2. After HVAC air balance work is completed and permanent drive sheaves are in place, perform field mechanical balancing and adjustments required to meet the specified vibration tolerance.

D. Products Criteria:

1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions and/or additional requirements.

2. Refer to all other sections for quality assurance requirements for systems and equipment specified therein.

3. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.

4. The products and execution of work specified in Division 33 shall conform to the referenced codes and standards as required by the specifications. Local codes and amendments shall be enforced, along with requirements of local utility companies. The most stringent requirements of these specifications, local codes, or utility company requirements shall always apply. Any conflicts shall be brought to the attention of the COR.

5. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be of the same manufacturer and model number, or if different models are required they shall be of the same manufacturer and identical to the greatest extent possible (i.e., same model series).

6. Assembled Units: Performance and warranty of all components that make up an assembled unit shall be the responsibility of the manufacturer of the completed assembly.

7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.

8. Use of asbestos products or equipment or materials containing asbestos is prohibited.

E. HVAC Equipment Service Providers: Service providers shall be authorized and trained by the manufacturers of the equipment supplied. These providers shall be capable of responding onsite and provide acceptable service to restore equipment operations within 4 hours of receipt of notification by phone, e-mail or fax in event of an emergency, such as the shutdown of equipment; or within 24 hours in a non-emergency. Submit names, mail and e-mail addresses and phone numbers of service personnel and companies providing service under these conditions for (as applicable to the project): fans, air handling units, control systems, computer workstations, and programming.

F. HVAC Mechanical Systems Welding: Before any welding is performed, Contractor shall submit a certificate certifying that welders comply with the following requirements:

1. Qualify welding processes and operators for piping according to ASME BPVC Section IX. Provide proof of current certification.

2. Comply with provisions of ASME B31 series "Code for Pressure Piping".

3. Certify that each welder and welding operator has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.

4. All welds shall be stamped according to the provisions of the AWS or ASME as required herein and by the associated code.

G. 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 furnished to the COR with submittals. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material and removal by the Contractor and no additional cost or time to the Government.

H. Execution (Installation, Construction) Quality:

1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract documents to the COR for resolution. Provide written hard copies and computer files on CD or DVD of manufacturer’s installation instructions to the COR with submittals prior to commencing installation of any item. Installation of the item will not be allowed to proceed until the recommendations are received and approved by the VA. Failure to furnish these recommendations is a cause for rejection of the material.

2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, shall be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include, but are not limited to, all types of valves, filters and strainers, transmitters, control devices. Prior to commencing installation work, refer conflicts between this requirement and contract documents to the COR for resolution. Failure of the Contractor to resolve, or point out any issues will result in the Contractor correcting at no additional cost or time to the Government.

3. Complete coordination/shop drawings shall be required in accordance with Article, SUBMITTALS. Construction work shall not start on any system until the coordination/shop drawings have been approved by VA.

4. Workmanship/craftsmanship will be of the highest quality and standards. The VA reserves the right to reject any work based on poor quality of workmanship this work shall be removed and done again at no additional cost or time to the Government.

I. Upon request by Government, provide lists of previous installations for selected items of equipment. Include contact persons who will serve as references, with current telephone numbers and e-mail addresses.

J. Guarantee: Warranty of Construction, FAR Clause 52.246-21.

1.8 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage or theft.

2. Large equipment such as chillers, fans, and air handling units if shipped on open trailer trucks shall be covered with shrink on plastics or water proof tarpaulins that provide protection from exposure to rain, road salts and other transit hazards. Protection shall be kept in place until equipment is moved into a building or installed as designed.

3. Repair damaged equipment in first class, new operating condition and appearance; or, replace same as determined and directed by the COR. Such repair or replacement shall be at no additional cost or time to the Government.

4. Protect interiors of new equipment and piping systems against entry of foreign matter. Clean both inside and outside before painting or placing equipment in operation.

5. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.

6. Protect plastic piping and tanks from ultraviolet light (sunlight).

B. Cleanliness of Piping and Equipment Systems:

1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.

2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.

3. Clean interior of all tanks prior to delivery for beneficial use by the Government.

4. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.9 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set

at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.

D. As-built drawings:

1. As-built drawings are to be provided, and a copy of them on Auto-Cad version 2018 or newer provided on compact disk or DVD.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.10 JOB CONDITIONS - WORK IN EXISTING BUILDINGS

A. Building Operation: Refer to Division 1 for building operation information for the facility.

B. Maintenance of Service: Refer to Division 1 for requirements regarding work hours and interruption of programs/service at the facility.

C. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 18 degrees C (65 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. Storm water or ground water leakage is prohibited. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA. Maintain all egress routes and safety systems/devices.

D. Acceptance of Work for Government Operation: As new equipment, systems and facilities are made available for operation and these items are deemed of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

A. Provide maximum standardization of components to reduce spare part requirements.

B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.

1. All components of an assembled unit need not be products of same manufacturer.

2. Constituent parts that are alike shall be products of a single manufacturer.

3. Components shall be compatible with each other and with the total assembly for intended service.

4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.

C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

D. Major items of equipment, which serve the same function, must be the same make and model.

2.2 COMPATIBILITY OF RELATED EQUIPMENT

Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational plant that conforms to contract requirements.

2.3 V-BELT DRIVES

A. Type: ARPM standard V-belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.

B. Dimensions, rating and selection standards: ARPM IP-20 and ARPM IP-21.

C. Minimum Horsepower Rating: Motor horsepower plus recommended ARPM service factor (not less than 20 percent) in addition to the ARPM allowances for pitch diameter, center distance, and arc of contact.

D. Maximum Speed: 25 m/s (5000 feet per minute).

E. Adjustment Provisions: For alignment and ARPM standard allowances for installation and take-up.

F. Drives may utilize a single V-Belt (any cross section) when it is the manufacturer's standard.

G. Multiple Belts: Matched to ARPM specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.

H. Sheaves and Pulleys:

1. Material: Pressed steel, or close-grained cast iron.

2. Bore: Fixed or bushing type for securing to shaft with keys.

3. Balanced: Statically and dynamically.

4. Groove spacing for driving and driven pulleys shall be the same.

I. Drive Types, Based on ARI 435:

1. Provide adjustable-pitch or fixed-pitch drive as follows:

a. Fan speeds up to 1800 RPM: 7.5 kW (10 horsepower) and smaller.

b. Fan speeds over 1800 RPM: 2.2 kW (3 horsepower) and smaller.

2. Provide fixed-pitch drives for drives larger than those listed above.

3. The final fan speeds required to just meet the system CFM and pressure requirements, without throttling the design air flow branch, shall be determined by adjustment of a temporary adjustable-pitch motor sheave or by fan law calculation if a fixed-pitch drive is used initially.

J. Final Drive Set: If adjustment is required beyond the capabilities of the factory drive set, the final drive set shall be provided as part of this contract at no additional cost or time to the Government.

2.4 SYNCHRONOUS BELT DRIVES

A. Type: ARPM synchronous belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.

B. Dimensions, rating and selection standards: ARPM IP-24 and ARPM IP-27.

C. Minimum Horsepower Rating: Motor horsepower plus recommended ARPM service factor (not less than 20 percent) in addition to the ARPM allowances for pitch diameter, center distance, and arc of contact.

D. Maximum Speed: 25 m/s (5000 feet per minute).

E. Adjustment Provisions: For alignment and ARPM standard allowances for installation and take-up.

F. Drives may utilize a single belt of manufacturer’s standard width for the application.

G. Multiple Belts: Matched to ARPM specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.

H. Sheaves and Pulleys:

1. Material: Pressed steel, or close-grained cast iron.

2. Bore: Fixed or bushing type for securing to shaft with keys.

3. Balanced: Statically and dynamically.

I. Final Drive Set: The final fan speeds required to just meet the system CFM and pressure requirements, without throttling the design air flow branch, shall be determined by fan law calculation. If adjustment is required beyond the capabilities of the factory drive set, the final

drive set shall be provided as part of this contract at no additional cost or time to the Government.

2.5 DRIVE GUARDS

A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulley, sheaves, shafts, gears and other moving parts regardless of height above the floor to prevent damage to equipment and injury to personnel. Drive guards may be excluded where motors and drives are inside factory fabricated air handling unit casings.

B. Pump shafts and couplings shall be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material shall be minimum 16-gage sheet steel; ends shall be braked and drilled and attached to pump base with minimum of four 6 mm (1/4-inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.

C. V-belt and sheave assemblies shall be totally enclosed, firmly mounted, non-resonant. Guard shall be an assembly of minimum 22-gage sheet steel and expanded or perforated metal to permit observation of belts. 25 mm (one-inch) diameter hole shall be provided at each shaft centerline to permit speed measurement.

D. Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.

E. Access for Speed Measurement: 25 mm (One inch) diameter hole at each shaft center.

2.6 LIFTING ATTACHMENTS

A. Provide equipment with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered, without bending or distortion of shape, such as rapid lowering and braking of load.

2.7 ELECTRIC MOTORS

A. All material and equipment furnished and installation methods shall conform to the requirements of Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT; Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS; and, Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide special energy efficient premium efficiency type motors as scheduled.

2.8 VARIABLE SPEED MOTOR CONTROLLERS

A. Refer to Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS and Section 26 29 11, MOTOR CONTROLLERS for specifications.

B. Coordinate variable speed motor controller communication protocol with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

C. Variable frequency drives (VFD's) shall be as manufactured by ABB or approved equal.

D. Provide variable speed motor controllers with or without a bypass contactor as indicated in contract drawings.

E. The combination of controller and motor shall be provided by the manufacturer of the driven equipment, such as pumps and fans, and shall be rated for 100 percent output performance. Multiple units of the same class of equipment, i.e. air handlers, fans, pumps, shall be product of a single manufacturer.

F. Motors shall be premium efficiency type and be approved by the motor controller manufacturer. The controller-motor combination shall be guaranteed to provide full motor nameplate horsepower in variable frequency operation. Both driving and driven motor/fan sheaves shall be fixed pitch.

G. Controller shall not add any current or voltage transients to the input ac power distribution system, DDC controls, sensitive medical equipment, etc., nor shall be affected from other devices on the ac power system.

H. Controller shall be provided with the following operating features and accessories:

1. Provide with thermal magnetic breaker or fused switch with external operator and incoming line fuses.

2. Unit shall be rated for minimum 25,000 AIC.

3. Provide AC input line reactors (3% impedance) or filters on incoming power line.

4. Provide output line reactors on line between drive and motor where the distance between the breaker and motor exceeds 50 feet.

2.9 EQUIPMENT AND MATERIALS IDENTIFICATION

A. Use symbols, nomenclature and equipment numbers specified, shown on the contract documents and shown in the maintenance manuals.

B. Identification for piping is specified in Section 09 91 00, PAINTING.

C. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 5 mm (3/16 inch) high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING permanently fastened to the equipment. Identify unit components such as coils, filters, fans, etc.

D. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 5 mm (3/16 inch) high riveted or bolted to the equipment.

E. Control Items: Label all instrumentation, temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.

F. Valve Tags and Lists:

1. HVAC and Mechanical Rooms: Provide for all valves.

2. Valve tags: Engraved black filled numbers and letters not less than 15 mm (1/2 inch) high for number designation, and not less than 6

mm (1/4 inch) for service designation on 19-gauge 40 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.

3. Valve lists: Typed or printed plastic coated card(s), sized 215 mm (8-1/2 inches) by 275 mm (11 inches) showing tag number, valve function and area of control, for each service or system. Punch sheets for a 3-ring notebook.

4. Provide detailed plan for each floor of the building indicating the location and valve number for each valve. Identify location of each valve with a color-coded thumb tack in ceiling.

G. Custom print labels with above ceiling HVAC equipment numbers.

2.10 FIRESTOPPING

A. Section 07 84 00, FIRESTOPPING specifies an effective barrier against the spread of fire, smoke and gases where penetrations occur for piping and ductwork.

B. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION, for firestop pipe and duct insulation.

2.11 GALVANIZED REPAIR COMPOUND

A. Mil-P-21035B, paint form.

2.12 HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

A. Vibration Isolators: Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

B. Supports for Roof Mounted Items:

1. Equipment: Equipment rails shall be galvanized steel, minimum 1.3 mm (18 gauge), with integral baseplate, continuous welded corner seams, factory installed 50 by 100 mm (2 by 4 inches) treated wood nailer, 1.3 mm (18 gauge) galvanized steel counter flashing cap with screws, built-in cant strip, (except for gypsum or tectum deck), minimum height 275 mm (11 inches). For surface insulated roof deck, provide raised cant strip to start at the upper surface of the insulation.

2. Pipe/duct pedestals: Provide a galvanized Unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.

C. Pipe Supports: Comply with MSS SP-58. Type Numbers specified refer to this standard. For selection and application comply with MSS SP-58. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting requirements.

D. Attachment to Concrete Building Construction:

1. Concrete insert: MSS SP-58, Type 18.

2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 100 mm (4 inches) thick when approved by the COR for each job condition.

3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 100 mm (4 inches) thick when approved by the COR for each job condition.

E. Attachment to Steel Building Construction:

1. Welded attachment: MSS SP-58, Type 22.

2. Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23 mm (7/8 inch) outside diameter.

F. Attachment to existing structure: Support from existing floor/roof frame.

G. Attachment to Wood Construction: Wood screws or lag bolts.

H. Hanger Rods: Hot-rolled steel, ASTM A36/A36M or ASTM A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 40 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

I. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (12 gauge), designed to accept special spring held, hardened steel nuts. Trapeze hangers are prohibited for use for steam supply and condensate piping.

1. Allowable hanger load: Manufacturers rating less 91 kg (200 pounds).

2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4 inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 15 mm (1/2 inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.

J. Supports for Piping Systems:

1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or preinsulated calcium silicate shields. Provide Type 40 insulation shield or preinsulated calcium silicate shield at all other types of supports and hangers including those for preinsulated piping.

2. Piping Systems except High and Medium Pressure Steam (MSS SP-58):

a. Standard clevis hanger: Type 1; provide locknut.

b. Riser clamps: Type 8.

c. Wall brackets: Types 31, 32 or 33.

d. Roller supports: Type 41, 43, 44 and 46.

e. Saddle support: Type 36, 37 or 38.

f. Turnbuckle: Types 13 or 15. Preinsulate.

g. U-bolt clamp: Type 24.

h. Copper Tube:

1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non-adhesive isolation tape to prevent electrolysis.

2) For vertical runs use epoxy painted or plastic-coated riser clamps.

3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.

4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.

i. Supports for plastic piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.

K. Pre-insulated Calcium Silicate Shields:

1. Refer to Section 23 07 11, HVAC and BOILER PLANT INSULATION, for insulation requirements.

2. Provide 360-degree water resistant high density 965 kPa (140 psig) compressive strength calcium silicate shields encased in galvanized metal.

3. Pre-insulated calcium silicate shields to be installed at the point of support during erection.

4. Shield thickness shall match the pipe insulation.

5. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.

a. Shields for supporting chilled or cold water shall have insulation that extends a minimum of 25 mm (1 inch) past the sheet metal. Provide for an adequate vapor barrier in chilled lines.

b. The pre-insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS SP-58. To support the load, the shields may have one or more of the following features: structural inserts 4138 kPa (600 psig) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36/A36M) wear plates welded to the bottom sheet metal jacket.

6. Shields may be used on steel clevis hanger type supports, roller supports or flat surfaces.

L. Seismic Restraint of Piping and Ductwork: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Comply with MSS SP-127.

2.13 PIPE PENETRATIONS

A. Install sleeves during construction for other than blocked out floor openings for risers in mechanical bays.

B. To prevent accidental liquid spills from passing to a lower level, provide the following:

1. For sleeves: Extend sleeve 25 mm (one inch) above finished floor and provide sealant for watertight joint.

2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.

3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.

C. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of COR.

D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.

E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.

F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, connect sleeve with floor plate.

G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.

H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.

I. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.

J. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS.

2.14 DUCT PENETRATIONS

A. Provide firestopping for openings through fire and smoke barriers, maintaining minimum required rating of floor, ceiling or wall assembly. See section 07 84 00, FIRESTOPPING.

B. Provide roof curbs for piping and ductwork penetrations. Provide curbs with continuously welded seams, built-in cant strips, interior baffle with acoustic insulation, and curb bottoms.

2.15 SPECIAL TOOLS AND LUBRICANTS

A. Furnish, and turn over to the COR, tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.

C. Refrigerant Tools: Provide system charging/Evacuation equipment, gauges, fittings, and tools required for maintenance of furnished equipment.

D. Tool Containers: Hardwood or metal, permanently identified for in tended service and mounted, or located, where directed by the COR.

E. Lubricants: A minimum of 0.95 L (one quart) of oil, and 0.45 kg (one pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.16 WALL, FLOOR AND CEILING PLATES

A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.

B. Thickness: Not less than 2.4 mm (3/32-inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3-inch pipe), 0.89 mm (0.035-inch) for larger pipe.

C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

2.17 ASBESTOS

A. Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 GENERAL

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions shall be coordinated with the work of all trades. The coordination/shop drawings shall be submitted for review. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Equipment coordination/shop drawings shall be prepared to coordinate proper location and personnel access of all facilities. The drawings

shall be submitted for review. Follow manufacturer's published recommendations for installation methods not otherwise specified.

B. Operating Personnel Access and Observation Provisions: Select and arrange all equipment and systems to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gauges and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Do not reduce or change maintenance and operating space and access provisions that are shown on the contract documents.

C. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.

D. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.

E. Cutting Holes:

1. Cut holes through concrete and masonry by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by COR where working area space is limited.

2. Locate holes to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.

3. Do not penetrate membrane waterproofing.

F. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other services are not shown but must be provided.

G. Electrical Interconnection of Instrumentation or Controls: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Devices shall be located so they are easily accessible for testing, maintenance, calibration, etc. The COR has the final determination on what is accessible and what is not. Comply with NFPA 70.

H. Protection and Cleaning:

1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the COR. Damaged or defective items in the opinion of the COR, shall be replaced.

2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and

equipment against dirt, water chemical, or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

I. Concrete and Grout: Use concrete and non-shrink grout 20 MPa (3000 psig) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

J. Install gauges, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gauges to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.

K. Work in Existing Building:

1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).

2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will least interfere with normal operation of the facility.

3. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the COR. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the COR for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After COR's approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.

L. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Installation of piping, ductwork, leak protection apparatus or other installations foreign to the electrical installation shall be located in the space equal to the width and depth of the equipment and extending from to a height of 1.8 m (6 ft.) above the equipment of to ceiling structure, whichever is lower (NFPA 70).

M. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Government.

2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

a. Equipment installed in or above ceilings, such as VRF indoor units, VAV boxes, fire dampers, and valves, etc., shall be considered "conveniently accessible" provided that suitable ceiling access is provided by access panels and/or easily removable ceiling tiles, and that access is not blocked by other piping, ductwork, wiring, equipment, structural members, or other building components.

3.3 RIGGING

A. Design is based on application of available equipment. Openings in building structures are planned to accommodate design scheme.

B. Alternative methods of equipment delivery may be offered by Contractor and will be considered by Government under specified restrictions of phasing and maintenance of service requirements as well as structural integrity of the building.

C. Close all openings in the building when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.

D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility. Upon request, the Government will check structure adequacy and advise Contractor of recommended restrictions.

E. Contractor shall check all clearances, weight limitations and shall offer a rigging plan designed by a Registered Professional Engineer. All modifications to structures, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.

F. Follow approved rigging plan.

G. Restore building to original condition upon completion of rigging work.

3.4 PIPE AND EQUIPMENT SUPPORTS

A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels designed by a structural engineer, secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the COR.

B. Use of chain pipe supports; wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above are prohibited. Replace or thoroughly clean rusty products and paint with zinc primer.

C. Hanger rods shall be used that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 15 mm (1/2 inch) clearance between pipe or piping covering and adjacent work.

D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-58. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.

E. HVAC Vertical Pipe Supports:

1. Up to 150 mm (6-inch pipe), 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.

2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.

F. Overhead Supports:

1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.

2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.

3. Tubing and capillary systems shall be supported in channel troughs.

G. Floor Supports:

1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Concrete bases and structural systems shall be anchored and doweled to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.

2. Bases and supports shall not be located and installed until equipment mounted thereon has been approved. Bases shall be sized to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Chiller foundations shall have horizontal dimensions that exceed chiller base frame dimensions by at least 150 mm (6 inches) on all sides. Structural contract documents shall be reviewed for additional requirements. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.

3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a granular material to permit alignment and realignment.

4. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.5 MECHANICAL DEMOLITION

A. Rigging access, other than indicated on the contract documents, shall be provided by the Contractor after approval for structural integrity by the COR. Such access shall be provided without additional cost or time to the Government. Where work is in an operating plant, provide approved protection from dust and debris at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.

B. In an operating facility, maintain the operation, cleanliness and safety. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Confine the work to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Debris accumulated in the area to the detriment of plant operation is prohibited. Perform all flame cutting to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities shall be available at all times. Perform all work in accordance with recognized fire protection standards. Inspection will be made by personnel of the VAMC, and Contractor shall follow all directives of the COR with regard to rigging, safety, fire safety, and maintenance of operations.

C. Unless specified otherwise, all piping, wiring, conduit, and other devices associated with the equipment not re-used in the new work shall be completely removed from Government property per Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT. This includes all concrete pads, pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. All openings shall be sealed after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with contract documents where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the contract documents of the other disciplines in the project for additional facilities to be demolished or handled.

D. All indicated valves including gate, globe, ball, butterfly and check, all pressure gauges and thermometers with wells shall remain Government property and shall be removed and delivered to COR and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these contract documents. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate.

3.6 CLEANING AND PAINTING

A. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Government, the plant facilities, equipment and systems shall be thoroughly cleaned and painted. Refer to Section 09 91 00, PAINTING.

B. In addition, the following special conditions apply:

1. Cleaning shall be thorough. Solvents, cleaning materials and methods recommended by the manufacturers shall be used for the specific tasks. All rust shall be removed prior to painting and from surfaces to remain unpainted. Repair scratches, scuffs, and abrasions prior to applying prime and finish coats.

2. The following material and equipment shall not be painted:

a. Motors, controllers, control switches, and safety switches.

b. Control and interlock devices.

c. Regulators.

d. Control valves and thermostatic elements.

e. Lubrication devices and grease fittings.

f. Copper, brass, aluminum, stainless steel and bronze surfaces.

g. Valve stems and rotating shafts.

h. Pressure gauges and thermometers.

i. Glass.

j. Nameplates.

3. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.

4. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats. This may include painting exposed metals where hangers were removed or where equipment was moved or removed.

5. Final result shall be smooth, even-colored, even-textured factory finish on all items. Completely repaint the entire piece of equipment if necessary to achieve this.

6. Lead based paints are prohibited.

3.7 IDENTIFICATION SIGNS

A. Provide laminated plastic signs, with engraved lettering not less than 5 mm (3/16 inch) high, designating functions, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols shall correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.

B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, performance.

C. Pipe Identification: Refer to Section 09 91 00, PAINTING.

D. Attach ceiling grid label on ceiling grid frame or access panel door or frame location directly underneath above-ceiling mechanical equipment and components such as control system equipment, valves, filter units, fans, air handling equipment, fire smoke dampers, and air terminal units.

1. Labels shall be digitally-printed adhesive vinyl.

E. Coordination with Existing Identification:

1. Final identification of ductwork, piping, valves, equipment, and accessories shall match the existing identification scheme used in the facility. Identification scheme shall be approved by the COR.

3.8 MOTOR AND DRIVES

A. Use synchronous belt drives only on equipment controlled by soft starters or variable frequency drive motor controllers without a bypass contactor. Use V-belt drives on all other applications.

B. Alignment of V-Belt Drives: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.

C. Alignment of Synchronous Belt Drives: Set driving and driven shafts parallel and align so that the corresponding pulley flanges are in the same plane.

D. Alignment of Direct-Connect Drives: Securely mount motor in accurate alignment so that shafts are per coupling manufacturer’s tolerances when both motor and driven machine are operating at normal temperatures.

3.9 LUBRICATION

A. All equipment and devices requiring lubrication shall be lubricated prior to initial operation. Field-check all devices for proper lubrication.

B. All devices and equipment shall be equipped with required lubrication fittings or devices. A minimum of 0.95 liter (1 quart) of oil and 0.45 kg (1 pound) of grease of manufacturer's recommended grade and type for each different application shall be provided; also provide 12 grease sticks for lubricated plug valves. Deliver all materials to COR in unopened containers that are properly identified as to application.

C. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.

D. All lubrication points shall be extended to one side of the equipment.

3.10 STARTUP, TEMPORARY OPERATION AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and Contractor testing of selected equipment. Coordinate the startup and Contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

D. Startup of equipment shall be performed as described in equipment specifications. Vibration within specified tolerance shall be verified prior to extended operation. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.11 OPERATING AND PERFORMANCE TESTS

A. Prior to the final inspection, perform required tests as specified in Section 01 00 00, GENERAL REQUIREMENTS Article, TESTS, and in individual Division 23 specification sections and submit the test reports and records to the COR.

B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost or time to the Government.

C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then conduct such performance tests and finalize control settings for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of work. Rescheduling of these tests shall be requested in writing to COR for approval.

D. No adjustments may be made during the acceptance inspection. All adjustments shall have been made by this point.

E. Perform tests as required for commissioning provisions in accordance with Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

3.12 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.13 DEMONSTRATION AND TRAINING

A. Refer to individual specification sections for training required to be provided for each specific system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

- - - END - - -

SECTION 23 05 12
GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation and connection of motors for HVAC equipment.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

E. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VA standard will govern.

B. American Bearing Manufacturers Association (ABMA):

1. 9–2015 Load Ratings and Fatigue Life for Ball Bearings

2. 11-2015-2014 Load Ratings and Fatigue Life for Roller Bearings

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. 90.1-2013 Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings

D. Institute of Electrical and Electronics Engineers (IEEE):

1. 112-2017 Standard Test Procedure for Polyphase Induction Motors and Generators

2. 841-2009 IEEE Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe-Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors-Up to and Including 370 kW (500 hp)

E. National Electrical Manufacturers Association (NEMA):

1. MG 1-2019 Motors and Generators

2. MG 2-2014 Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

3. 250-2014 Enclosures for Electrical Equipment (1000 Volts Maximum)

F. National Fire Protection Association (NFPA):

1. 70-2021 National Electrical Code (NEC)

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT", with applicable paragraph identification.

C. Submit motor submittals with driven equipment.

D. Shop Drawings:

1. Provide documentation to demonstrate compliance with contract documents.

2. Motor nameplate information shall be submitted including electrical ratings, efficiency, bearing data, power factor, frame size, dimensions, mounting details, materials, horsepower, voltage, phase, speed (RPM), enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.

E. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

F. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.

2. Include complete diagrams of the internal wiring for each item of equipment.

3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

G. Certification: Two weeks prior to final inspection, unless otherwise noted, certification shall be submitted to the COR stating that the motors have been properly applied, installed, adjusted, lubricated, and tested.

H. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

I. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ‘third party testing company’ requirement. Provide record drawings as follows:

   1. As-built drawings are to be provided, with a copy of them on AutoCAD version 2018 or newer provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers,

valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

PART 2 - PRODUCTS

2.1 MOTORS

A. For alternating current, fractional and integral horsepower motors, NEMA MG 1 and NEMA MG 2 shall apply.

B. For severe duty TEFC motors, IEEE 841 shall apply.

C. All material and equipment furnished and installation methods shall conform to the requirements of Section 26 29 11, MOTOR CONTROLLERS; and Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide premium efficiency type motors. Unless otherwise specified for a particular application, use electric motors with the following requirements.

D. Single-phase Motors: Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC) type. Provide capacitor-start type for hard starting applications.

E. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type.

1. Two Speed Motors: Each two-speed motor shall have two separate windings. Provide a time- delay (20 seconds minimum) relay for switching from high to low speed.

F. Voltage ratings shall be as follows:

1. Single phase:

a. Motors connected to 120-volt systems: 115 volts.

b. Motors connected to 208-volt systems: 200 volts.

2. Three phase:

a. Motors connected to 208-volt systems: 200 volts.

b. Motors, less than 74.6 kW (100 hp), connected to 240-volt or 480-volt systems: 208-230/460 volts, dual connection.

G. Number of phases shall be as follows:

1. Motors, less than 373 W (1/2 hp): Single phase.

2. Motors, 373 W (1/2 hp) and larger: 3 phase.

3. Exceptions:

a. Hermetically sealed motors.

b. Motors for equipment assemblies, less than 746 W (1 hp), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.

H. Horsepower ratings shall be adequate for operating the connected loads continuously in the prevailing ambient temperatures in areas where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation.

I. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting, acceleration, and running torque without exceeding nameplate ratings or considering service factor.

J. Motor Enclosures:

1. Shall be the NEMA types as specified and/or shown in the Contract Documents.

2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types per NEMA 250, which are most suitable for the environmental conditions where the motors are being installed. Enclosure requirements for certain conditions are as follows:

a. Motors located outdoors, indoors in wet or high humidity locations, or in unfiltered airstreams shall be totally enclosed type.

b. Where motors are located in an NEC 511 classified area, provide TEFC explosion proof motor enclosures.

c. Where motors are located in a corrosive environment, provide TEFC enclosures with corrosion resistant finish.

3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.

K. Electrical Design Requirements:

1. Motors shall be continuous duty.

2. The insulation system shall be rated minimum of Class B, 130 degrees C (266 degrees F).

3. The maximum temperature rise by resistance at rated power shall not exceed Class B limits, 80 degrees C (176 degrees F).

4. The speed/torque and speed/current characteristics shall comply with NEMA Design A or B, as specified.

5. Motors shall be suitable for full voltage starting, unless otherwise noted. Coordinate motor features with applicable motor controllers.

6. Motors for variable frequency drive applications shall adhere to NEMA MG 1, Part 30, Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General-Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both, or NEMA MG 1, Part 31, Definite-Purpose Inverter-Fed Polyphase Motors.

L. Mechanical Design Requirements:

1. Bearings shall be rated in accordance with ABMA 9 or ABMA 11 for a minimum fatigue life of 26,280 hours for belt-driven loads and 100,000 hours for direct-drive loads based on L10 (Basic Rating Life) at full load direct coupled, except vertical high thrust motors which require a 40,000 hours rating. A minimum fatigue life of 40,000 hours is required for VFD drives.

2. Vertical motors shall be capable of withstanding a momentary up thrust of at least 30 percent of normal down thrust.

3. Grease lubricated bearings shall be designed for electric motor use. Grease shall be capable of the temperatures associated with electric motors and shall be compatible with Polyurea based greases.

4. Grease fittings, if provided, shall be Alemite type or equivalent.

5. Oil lubricated bearings, when specified, shall have an externally visible sight glass to view oil level.

6. Vibration shall not exceed 3.8 mm (0.15 inch) per second, unfiltered peak.

7. Noise level shall meet the requirements of the application.

8. Motors on 180 frames and larger shall have provisions for lifting eyes or lugs capable of a safety factor of 5.

9. All external fasteners shall be corrosion resistant.

10. Condensation heaters, when specified, shall keep motor windings at least 5 degrees C (9 degrees F) above ambient temperature.

11. Winding thermostats, when specified shall be normally closed, connected in series.

12. Grounding provisions shall be in the main terminal box.

M. Special Requirements:

1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional cost or time to the Government.

2. Assemblies of motors, starters, controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.

3. Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:

a. Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers.

b. Other wiring at boilers and to control panels shall be NFPA 70 designation THWN.

c. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.

4. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.

5. Motors utilized with variable frequency drives shall be rated “inverter-duty” per NEMA MG 1, Part 31, Definite-Purpose Inverter-Fed Polyphase Motors. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.

N. NEMA Premium Efficiency Electric Motors (Motor Efficiencies): All permanently wired polyphase motors of 746 W (1 hp) or more shall meet the minimum full-load efficiencies as indicated in the following table. Motors of 746 W (1 hp) or more with open, drip-proof, or TEFC enclosures shall be NEMA premium efficiency type, unless otherwise indicated. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency

requirement is indicated for that equipment by the provisions of another section.

Minimum Premium Efficiencies Open Drip-Proof				Minimum Premium Efficiencies Totally Enclosed Fan-Cooled (TEFC)			
Rating kW (hp)	1200 RPM	1800 RPM	3600 RPM	Rating kW (hp)	1200 RPM	1800 RPM	3600 RPM
0.746 (1)	82.5%	85.5%	77.0%	0.746 (1)	82.5%	85.5%	77.0%
1.12 (1.5)	86.5%	86.5%	84.0%	1.12 (1.5)	87.5%	86.5%	84.0%
1.49 (2)	87.5%	86.5%	85.5%	1.49 (2)	88.5%	86.5%	85.5%
2.24 (3)	88.5%	89.5%	85.5%	2.24 (3)	89.5%	89.5%	86.5%
3.73 (5)	89.5%	89.5%	86.5%	3.73 (5)	89.5%	89.5%	88.5%
5.60 (7.5)	90.2%	91.0%	88.5%	5.60 (7.5)	91.0%	91.7%	89.5%
7.46 (10)	91.7%	91.7%	89.5%	7.46 (10)	91.0%	91.7%	90.2%
11.2 (15)	91.7%	93.0%	90.2%	11.2 (15)	91.7%	92.4%	91.0%
14.9 (20)	92.4%	93.0%	91.0%	14.9 (20)	91.7%	93.0%	91.0%
18.7 (25)	93.0%	93.6%	91.7%	18.7 (25)	93.0%	93.6%	91.7%
22.4 (30)	93.6%	94.1%	91.7%	22.4 (30)	93.0%	93.6%	91.7%
29.8 (40)	94.1%	94.1%	92.4%	29.8 (40)	94.1%	94.1%	92.4%
37.3 (50)	94.1%	94.5%	93.0%	37.3 (50)	94.1%	94.5%	93.0%
44.8 (60)	94.5%	95.0%	93.6%	44.8 (60)	94.5%	95.0%	93.6%
56.9 (75)	94.5%	95.0%	93.6%	56.9 (75)	94.5%	95.4%	93.6%
74.6 (100)	95.0%	95.4%	93.6%	74.6 (100)	95.0%	95.4%	94.1%
93.3 (125)	95.0%	95.4%	94.1%	93.3 (125)	95.0%	95.4%	95.0%
112 (150)	95.4%	95.8%	94.1%	112 (150)	95.8%	95.8%	95.0%
149.2 (200)	95.4%	95.8%	95.0%	149.2 (200)	95.8%	96.2%	95.4%

O. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM, and 3600 RPM. Power factor correction capacitors shall be provided unless the motor meets the 0.90 requirement without it or if the motor is controlled by a variable frequency drive. The power factor correction capacitors shall be able to withstand high voltage transients and power line variations without breakdown.

P. Energy Efficiency of Small Motors (Motor Efficiencies): All motors under 746 W (1 hp) shall meet the requirements of the DOE Small Motor Regulation.

Polyphase Open Motors Average full load efficiency				Capacitor-start capacitor-run and capacitor-start induction run open motors Average full load efficiency			
Rating kW (hp)	6 poles	4 poles	2 poles	Rating kW (hp)	6 poles	4 poles	2 poles
0.18 (0.25)	67.5	69.5	65.6	0.18 (0.25)	62.2	68.5	66.6
0.25 (0.33)	71.4	73.4	69.5	0.25 (0.33)	66.6	72.4	70.5
0.37 (0.5)	75.3	78.2	73.4	0.37 (0.5)	76.2	76.2	72.4
0.55 (0.75)	81.7	81.1	76.8	0.55 (0.75)	80.2	81.8	76.2

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motors in accordance with manufacturer's recommendations, the NEC, NEMA, as shown on the drawings and/or as required by other sections of these specifications.

B. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 FIELD TESTS

A. All tests shall be witnessed by the Commissioning Agent or by the COR.

B. Perform an electric insulation resistance Test using a megohmmeter on all motors after installation, before startup. All shall test free from grounds.

C. Perform Load test in accordance with IEEE 112, Test Method B, to determine freedom from electrical or mechanical defects and compliance with performance data.

D. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame, to be determined at the time of final inspection.

E. All test data shall be complied into a report form for each motor and provided to the COR.

3.3 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 7 working days prior to startup and testing.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

A. Training on components provided under this section will be provided as part of other systems.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

- - - END - - -

SECTION 23 05 41

NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Noise criteria, seismic restraints for equipment, vibration tolerance and vibration isolation for HVAC and plumbing work.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA and SAMPLES.

B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

C. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.3 QUALITY ASSURANCE

A. Refer to article, QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Noise Criteria:

1. Noise levels in all 8 octave bands due to equipment and duct systems shall not exceed following NC levels:

Type of Room	NC Level
a. Audio Speech Pathology	25
b. Audio Suites	25
c. Auditoriums, Theaters	35-40
d. Bathrooms and Toilet Rooms	40
e. Chapels	35
f. Conference Rooms	35
g. Corridors (Nurse Stations)	40
h. Corridors (Public)	40
i. Dining Rooms, Food Services/ Serving	40
j. Examination Rooms	35
k. Gymnasiums	50
l. Kitchens	50
m. Laboratories (With Fume Hoods)	45-55
n. Laundries	50
o. Lobbies, Waiting Areas	40

p. Locker Rooms	45
q. Offices, Large Open	40
r. Offices, Small Private	35
s. Operating Rooms	40
t. Patient Rooms	35
u. Phono/Cardiology	25
v. Recreation Rooms	40-45
w. Shops	50
x. SPD (Decontamination and Clean Preparation)	45
y. Therapeutic Pools	45
z. Treatment Rooms	35
aa. Warehouse	50
ab. X-Ray and General Work Rooms	40
ac. General Work Rooms	40

2. For equipment which has no sound power ratings scheduled on the plans, the contractor shall select equipment such that the fore-going noise criteria, local ordinance noise levels, and OSHA re-quirements are not exceeded. Selection procedure shall be in accordance with ASHRAE Fundamentals Handbook, Chapter 7, Sound and Vibration.

3. An allowance, not to exceed 5db, may be added to the measured value to compensate for the variation of the room attenuating effect between room test condition prior to occupancy and design condition after occupancy which may include the addition of sound absorbing material, such as, furniture. This allowance may not be taken after occupancy. The room attenuating effect is defined as the difference between sound power level emitted to room and sound pressure level in room.

4. In absence of specified measurement requirements, measure equipment noise levels three feet from equipment and at an elevation of maximum noise generation.

C. Seismic Restraint Requirements:

1. Equipment:

a. All mechanical equipment not supported with isolators external to the unit shall be securely anchored to the structure. Such mechanical equipment shall be properly supported to resist a horizontal force of 20 percent of the weight of the equipment furnished.

b. All mechanical equipment mounted on vibration isolators shall be provided with seismic restraints capable of resisting a

horizontal force of 100 percent of the weight of the equipment furnished.

2. Piping: Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.4 SUBMITTALS

A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturer's Literature and Data:

1. Vibration isolators:

a. Floor mountings

b. Hangers

c. Snubbers

d. Thrust restraints

e. Bases.

f. Seismic restraint provisions and bolting.

g. Acoustical enclosures.

2. Isolator manufacturer shall furnish with submittal load calculations for selection of isolators, including supplemental bases, based on lowest operating speed of equipment supported.

C. Seismic Requirements: Submittals are required for all equipment anchors, supports and seismic restraints. Submittals shall include weights, dimensions, standard connections, and manufacturer's certification that all specified equipment will withstand seismic Lateral Force requirements as shown on drawings.

1.5 APPLICABLE PUBLICATIONS

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

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):

1. Fundamentals Handbook, Chapter 7, Sound and Vibration

C. American Society for Testing and Materials (ASTM):

1. A123/A123M-09 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

2. A307-07b Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength

3. D2240-05(2010) Standard Test Method for Rubber Property - Durometer Hardness

D. Manufacturers Standardization (MSS):

1. SP-58-2009 Pipe Hangers and Supports-Materials, Design and Manufacture

E. Occupational Safety and Health Administration (OSHA):

1. 29 CFR 1910.95 Occupational Noise Exposure

F. American Society of Civil Engineers (ASCE):

1. ASCE 7-10 Minimum Design Loads for Buildings and Other Structures.

G. American National Standards Institute / Sheet Metal and Air Conditioning Contractor's National Association (ANSI/SMACNA):

1. 001-2008 Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd Edition.

H. International Code Council (ICC):

1. IBC-2018 International Building Code.

I. Department of Veterans Affairs (VA):

1. H-18-8 2010 Seismic Design Requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Type of isolator, base, and minimum static deflection shall be as required for each specific equipment application as recommended by isolator or equipment manufacturer but subject to minimum requirements indicated herein and in the schedule on the drawings.

B. Elastometric Isolators shall comply with ASTM D2240 and be oil resistant neoprene with a maximum stiffness of 60 durometer and have a straight-line deflection curve.

C. Exposure to weather: Isolator housings to be either hot dipped galvanized or powder coated to ASTM B117 salt spray testing standards. Springs to be powder coated or electro galvanized. All hardware to be electro galvanized. In addition provide limit stops to resist wind velocity. Velocity pressure established by wind shall be calculated in accordance with section 1609 of the International Building Code. A minimum wind velocity of 75 mph shall be employed.

D. Uniform Loading: Select and locate isolators to produce uniform loading and deflection even when equipment weight is not evenly distributed.

E. Color code isolators by type and size for easy identification of capacity.

2.2 SEISMIC RESTRAINT REQUIREMENTS FOR EQUIPMENT

A. Bolt pad mounted equipment, without vibration isolators, to the floor or other support using ASTM A307 standard bolting material.

B. Floor mounted equipment, with vibration Isolators: Type SS. Where Type N isolators are used provide channel frame base horizontal restraints

bolted to the floor, or other support, on all sides of the equipment Size and material required for the base shall be as recommended by the isolator manufacturer.

C. On all sides of suspended equipment, provide bracing for rigid supports and provide restraints for resiliently supported equipment.

2.3 VIBRATION ISOLATORS

A. Floor Mountings:

1. Double Deflection Neoprene (Type N): Shall include neoprene cov-ered steel support plated (top and bottom), friction pads, and necessary bolt holes.

2. Spring Isolators (Type S): Shall be free-standing, laterally stable and include acoustical friction pads and leveling bolts. Isolators shall have a minimum ratio of spring diameter-to--operating spring height of 1.0 and an additional travel to solid equal to 50 percent of rated deflection.

3. Captive Spring Mount for Seismic Restraint (Type SS):

a. Design mounts to resiliently resist seismic forces in all direc-tions. Snubbing shall take place in all modes with adjustment to limit upward, downward, and horizontal travel to a maximum of 6 mm (1/4-inch) before contacting snubbers. Mountings shall have a minimum rating of one G coefficient of gravity as calculated and certified by a registered structural engineer.

b. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection. Mountings shall have ports for spring inspection. Provide an all directional neoprene cushion collar around the equipment bolt.

4. Spring Isolators with Vertical Limit Stops (Type SP): Similar to spring isolators noted above, except include a vertical limit stop to limit upward travel if weight is removed and also to reduce movement and spring extension due to wind loads. Provide clearance around restraining bolts to prevent mechanical short circuiting. Isolators shall have a minimum seismic rating of one G.

5. Pads (Type D), Washers (Type W), and Bushings (Type L): Pads shall be natural rubber or neoprene waffle, neoprene and steel waffle, or reinforced duck and neoprene. Washers and bushings shall be reinforced duck and neoprene. Washers and bushings shall be reinforced duck and neoprene. Size pads for a maximum load of 345 kPa (50 pounds per square inch).

6. Seismic Pad (Type DS): Pads shall be natural rubber / neoprene waffle with steel top plate and drilled for an anchor bolt. Washers and bushings shall be reinforced duck and neoprene. Size pads for a maximum load of 345 kPa (50 pounds per square inch).

B. Hangers: Shall be combination neoprene and springs unless otherwise noted and shall allow for expansion of pipe.

1. Combination Neoprene and Spring (Type H): Vibration hanger shall contain a spring and double deflection neoprene element in series. Spring shall have a diameter not less than 0.8 of compressed oper-ating spring height. Spring shall have a minimum additional travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.

2. Spring Position Hanger (Type HP): Similar to combination neoprene and spring hanger except hanger shall hold piping at a fixed elevation during installation and include a secondary adjustment feature to transfer load to spring while maintaining same position.

3. Neoprene (Type HN): Vibration hanger shall contain a double deflection type neoprene isolation element. Hanger rod shall be separated from contact with hanger bracket by a neoprene grommet.

4. Spring (Type HS): Vibration hanger shall contain a coiled steel spring in series with a neoprene grommet. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.

5. Hanger supports for piping 50 mm (2 inches) and larger shall have a pointer and scale deflection indicator.

6. Hangers used in seismic applications shall be provided with a neoprene and steel rebound washer installed ¼″ clear of bottom of hanger housing in operation to prevent spring from excessive upward travel

C. Snubbers: Each spring mounted base shall have a minimum of four all-directional or eight two directional (two per side) seismic snubbers that are double acting. Elastomeric materials shall be shock absorbent neoprene bridge quality bearing pads, maximum 60 durometer, replaceable and have a minimum thickness of 6 mm (1/4 inch). Air gap between hard and resilient material shall be not less than 3 mm (1/8 inch) nor more than 6 mm (1/4 inch). Restraints shall be capable of withstanding design load without permanent deformation.

D. Thrust Restraints (Type THR): Restraints shall provide a spring element contained in a steel frame with neoprene pads at each end attachment. Restraints shall have factory preset thrust and be field adjustable to allow a maximum movement of 6 mm (1/4 inch) when the fan starts and stops. Restraint assemblies shall include rods, angle brackets and other hardware for field installation.

2.4 BASES

A. Rails (Type R): Design rails with isolator brackets to reduce mounting height of equipment and cradle machines having legs or bases that do not require a complete supplementary base. To assure adequate stiffness, height of members shall be a minimum of 1/12 of longest base dimension but not less than 100 mm (4 inches). Where rails are used with neoprene

mounts for small fans or close coupled pumps, extend rails to compensate overhang of housing.

B. Integral Structural Steel Base (Type B): Design base with isolator brackets to reduce mounting height of equipment which require a complete supplementary rigid base. To assure adequate stiffness, height of members shall be a minimum of 1/12 of longest base dimension, but not less than 100 mm (four inches).

C. Inertia Base (Type I): Base shall be a reinforced concrete inertia base. Pour concrete into a welded steel channel frame, incorporating prelocated equipment anchor bolts and pipe sleeves. Level the concrete to provide a smooth uniform bearing surface for equipment mounting. Provide grout under uneven supports. Channel depth shall be a minimum of 1/12 of longest dimension of base but not less than 150 mm (six inches). Form shall include 13-mm (1/2-inch) reinforcing bars welded in place on minimum of 203 mm (eight inch) centers running both ways in a layer 40 mm (1-1/2 inches) above bottom. Use height saving brackets in all mounting locations. Weight of inertia base shall be equal to or greater than weight of equipment supported to provide a maximum peak-to-peak displacement of 2 mm (1/16 inch).

D. Curb Mounted Isolation Base (Type CB): Fabricate from aluminum to fit on top of standard curb with overlap to allow water run-off and have wind and water seals which shall not interfere with spring action. Provide resilient snubbers with 6 mm (1/4 inch) clearance for wind resistance. Top and bottom bearing surfaces shall have sponge type weather seals. Integral spring isolators shall comply with Spring Isolator (Type S) requirements.

2.5 SOUND ATTENUATING UNITS

A. Refer to specification Section 23 31 00, HVAC DUCTS and CASINGS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Vibration Isolation:

1. No metal-to-metal contact will be permitted between fixed and floating parts.

2. Connections to Equipment: Allow for deflections equal to or greater than equipment deflections. Electrical, drain, piping connections, and other items made to rotating or reciprocating equipment (pumps, compressors, etc.) which rests on vibration isolators, shall be isolated from building structure for first three hangers or supports with a deflection equal to that used on the corresponding equipment.

3. Common Foundation: Mount each electric motor on same foundation as driven machine. Hold driving motor and driven machine in positive rigid alignment with provision for adjusting motor alignment and belt tension. Bases shall be level throughout length and width. Provide shims to facilitate pipe connections, leveling, and bolting.

4. Provide heat shields where elastomers are subject to temperatures over 38 degrees C (100 degrees F).

5. Extend bases for pipe elbow supports at discharge and suction connections at pumps. Pipe elbow supports shall not short circuit pump vibration to structure.

B. Inspection and Adjustments: Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.

3.2 ADJUSTING

A. Adjust vibration isolators after piping systems are filled and equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4inch (6-mm) movement during start and stop.

D. Adjust active height of spring isolators.

E. Adjust snubbers according to manufacturer's recommendations.

F. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

G. Torque anchor bolts according to equipment manufacturer's recommendations to resist seismic forces.

3.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems. TAB includes the following:

1. Planning systematic TAB procedures.

2. Design Review Report.

3. Preliminary air flow readings (taken prior to any system modifications):

   a. Air inlets & outlets in all spaces to be modified.

4. Systems Inspection report.

5. Systems Readiness Report.

6. Balancing air distribution systems; adjustment of total system to provide design performance; and testing performance of equipment and automatic controls.

7. Sound measurements.

8. Recording and reporting results.

9. Document critical paths of flow on reports.

1.2 DEFINITIONS

A. Basic TAB used in this Section: Chapter 39, "Testing, Adjusting and Balancing" of 2019 ASHRAE Handbook, "HVAC Applications".

B. TAB: Testing, Adjusting and Balancing; the process of checking and adjusting HVAC systems to meet design objectives.

C. AABC: Associated Air Balance Council.

D. NEBB: National Environmental Balancing Bureau.

E. TABB: Testing Adjusting and Balancing Bureau.

F. SMACNA: Sheet Metal Contractors National Association.

G. Air Systems: Includes all supply air and return air systems.

H. Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

1.3 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

C. Section 23 07 11, HVAC, AND BOILER PLANT INSULATION.

D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

E. Section 23 31 00, HVAC DUCTS AND CASINGS.

1.4 QUALITY ASSURANCE

A. Refer to Articles, Quality Assurance and Submittals, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Qualifications:

1. TAB Agency: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.

2. The TAB agency shall be either a certified member of AABC, NEBB, or TABB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the COR and submit another qualified TAB firm for approval. Any agency that has been the subject of disciplinary action by either AABC, NEBB, or TABB within the five years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency's review shows unsatisfactory work performed by the predecessor agency.

3. TAB Specialist: The TAB specialist shall be either a member of AABC, NEBB, or TABB or an experienced technician of the Agency certified by AABC, NEBB, or TABB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the COR and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either AABC, NEBB, or TABB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by an approved successor.

4. TAB Specialist shall be identified by the General Contractor within 60 days after the notice to proceed. The TAB specialist will be coordinating, scheduling and reporting all TAB work and related activities and will provide necessary information as required by the COR. The responsibilities would specifically include:

a. Shall directly supervise all TAB work.

b. Shall sign the TAB reports that bear the seal of the TAB standard. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC, NEBB, or TABB.

c. Would follow all TAB work through its satisfactory completion.

d. Shall provide final markings of settings of all HVAC adjustment devices.

e. Permanently mark location of duct test ports.

f. Shall document critical paths from the fan or pump. These critical paths are ones which are 100% open from the fan or pump to the terminal device. This will show the least amount of restriction is being imposed on the system by the TAB firm.

5. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity to this project. Qualifications must be certified by the TAB agency in writing. The lead technician shall be certified by AABC, NEBB, or TABB.

C. Test Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards, TABB/SMACNA International Standards, or NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for test and balance purpose.

D. Tab Criteria:

1. One or more of the applicable AABC, NEBB, TABB, or SMACNA publications, supplemented by ASHRAE Handbook "2019 HVAC Applications" Chapter 39, and requirements stated herein shall be the basis for planning, procedures, and reports.

2. Flow rate tolerance: The following tolerances are allowed. For tolerances not mentioned herein follow ASHRAE Handbook "2019 HVAC Applications", Chapter 39, as a guideline. Air Filter resistance during tests, artificially imposed if necessary, shall be at least 100 percent of manufacturer recommended change over pressure drop values for pre-filters and after-filters.

a. Individual room air outlets and inlets, and air flow rates not mentioned above: Minus 5 percent to plus 10 percent except if the air to a space is 100 CFM or less the tolerance would be minus 5 to plus 5 percent.

3. Systems shall be adjusted for energy efficient operation as described in PART 3.

4. Typical TAB procedures and critical path results shall be demonstrated to the COR as follows:

a. When field TAB work begins.

b. During each partial final inspection and the final inspection for the project if requested by the COR.

1.5 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Submit names and qualifications of TAB agency and TAB specialists within 60 days after the notice to proceed. Submit information on three recently completed projects and a list of proposed test equipment.

C. For use by the COR, submit one complete set of applicable AABC, NEBB, or TABB publications that will be the basis of TAB work.

D. Submit Following for Review and Approval:

1. Design Review Report within 90 days for conventional design projects after the system layout on air side is completed by the Contractor.

2. Systems inspection report on equipment and installation for conformance with design.

3. Systems Readiness Report.

4. Intermediate and Final TAB reports covering flow balance and adjustments and performance tests.

5. Include in final reports uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.

E. Prior to request for Final or Partial Final inspection, submit completed Test and Balance report for the area with noted critical paths.

1.6 APPLICABLE PUBLICATIONS

A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.

B. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):

1. HVAC Applications ASHRAE Handbook 2019, Chapter 39, Testing, Adjusting, and Balancing and Chapter 49, Sound and Vibration Control

C. Associated Air Balance Council (AABC):

1. 7th Edition 2016, AABC National Standards for Total System Balance

D. National Environmental Balancing Bureau (NEBB):

1. 9th Edition 2019 Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems

2. 3rd Edition 2015 Procedural Standards for the Measurement of Sound and Vibration

3. 2nd Edition 2019 Procedural Standards for Whole Building Technical Commissioning of New Construction

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1. 3rd Edition 2005 HVAC SYSTEMS Testing, Adjusting and Balancing

F. Testing Adjusting and Balancing Bureau (TABB):

1. TAB Procedural Guide (current edition)

PART 2 - PRODUCTS

2.1 PLUGS

A. Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.2 INSULATION REPAIR MATERIAL

A. See Section 23 07 11, HVAC and BOILER PLANT INSULATION Provide for repair of insulation removed or damaged for TAB work.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to TAB Criteria in Article, Quality Assurance.

B. Obtain applicable contract documents and copies of approved submittals for HVAC equipment and automatic control systems.

3.2 DESIGN REVIEW REPORT

A. The TAB Specialist shall review the Contract Plans and specifications and advise the COR of any design deficiencies that would prevent the HVAC systems from effectively operating in accordance with the sequence of operation specified or prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

B. The Design Review Report shall include preliminary air flow readings (taken prior to any system modifications).

1. All existing air inlets & outlets in all modified spaces.

3.3 SYSTEMS INSPECTION REPORT

A. Inspect equipment and installation for conformance with design.

B. The inspection and report is to be done after air distribution equipment is on site and duct installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that systems will be ready for TAB at the appropriate time.

C. Reports: Follow check list format developed by AABC, NEBB, TABB, or SMACNA, supplemented by narrative comments, with emphasis on air handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including their duct sizes and routing.

3.4 SYSTEM READINESS REPORT

A. Inspect each System to ensure that it is complete including installation and operation of controls.

B. Verify that all items such as ductwork, dampers, ports, terminals, connectors, and inlets and outlets, etc., that are required for TAB are installed. Provide a report to the COR.

3.5 TAB REPORTS

A. Submit an intermediate report for 25 percent of systems and equipment tested and balanced to establish satisfactory test results.

B. The TAB contractor shall provide raw data immediately in writing to the COR if there is a problem in achieving intended results before submitting a formal report.

C. If over 20 percent of readings in the intermediate report fall outside the acceptable range, the TAB report shall be considered invalid and all contract TAB work shall be repeated after engineering and construction have been evaluated and re-submitted for approval at no additional cost to the owner.

D. Do not proceed with the remaining systems until intermediate report is approved by the COR.

3.6 TAB PROCEDURES

A. TAB shall be performed in accordance with the requirement of the Standard under which TAB agency is certified by either AABC, NEBB, or TABB. Balancing shall be done proportionally to all applicable systems.

1. At least one trunk damper shall be 100% open.

2. At least one branch damper shall be 100% open per trunk.

3. At least one terminal device shall be 100% open per branch.

B. General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.

C. Coordinate TAB procedures with existing systems and any phased construction completion requirements for the project. Provide TAB reports for pre construction air flow rate and each phase of the project prior to partial final inspections of each phase of the project.

D. Allow 30 days time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.

E. Air Balance and Equipment Test: Include room diffusers/outlets/inlets.

1. Verify that dampers and other HVAC controls function properly.

2. Record final measurements for air handling equipment performance data sheets.

3.7 SOUND TESTING

A. Perform and record required sound measurements in accordance with Paragraph, QUALITY ASSURANCE in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

1. Take readings in all Exam Rooms, Consultation Rooms, Consultation Offices, Office Counselor Rooms, Group Therapy Rooms, and Telehealth Rooms.

B. Take measurements with a calibrated sound level meter and octave band analyzer of the accuracy required by AABC, NEBB, or TABB.

C. Sound reference levels, formulas and coefficients shall be according to 2019 ASHRAE Handbook, "HVAC Applications", Chapter 49, SOUND AND VIBRATION CONTROL.

D. Determine compliance with specifications as follows:

1. When sound pressure levels are specified, including the NC Criteria in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT:

a. Reduce the background noise as much as possible by shutting off unrelated audible equipment.

b. Measure octave band sound pressure levels with specified equipment "off."

c. Measure octave band sound pressure levels with specified equipment "on."

d. Use the DIFFERENCE in corresponding readings to determine the sound pressure due to equipment.

DIFFERENCE:	0	1	2	3	4	5 to 9	10 or More
FACTOR:	10	7	4	3	2	1	0

e. Sound pressure level due to equipment equals sound pressure level with equipment "on" minus FACTOR.

f. Plot octave bands of sound pressure level due to equipment for typical rooms on a graph which also shows noise criteria (NC) curves.

2. When sound power levels are specified:

a. Perform steps 1.a. thru 1.d., as above.

b. For indoor equipment: Determine room attenuating effect, i.e., difference between sound power level and sound pressure level. Determined sound power level will be the sum of sound pressure level due to equipment plus the room attenuating effect.

c. For outdoor equipment: Use directivity factor and distance from noise source to determine distance factor, i.e., difference between sound power level and sound pressure level. Measured sound power level will be the sum of sound pressure level due to

equipment plus the distance factor. Use 10 meters (30 feet) for sound level location.

E. Where measured sound levels exceed specified level, the installing contractor or equipment manufacturer shall take remedial action approved by the COR and the necessary sound tests shall be repeated.

F. Test readings for sound testing could go higher than 15 percent if determination is made by the COR based on the recorded sound data.

3.8 MARKING OF SETTINGS

A. Following approval of Tab final Report, the setting of all HVAC adjustment devices including splitters and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time. Style and colors used for markings shall be coordinated with the COR.

3.9 IDENTIFICATION OF TEST PORTS

A. The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leaks and maintain integrity of vapor barrier.

3.10 PHASING

A. Phased Projects: Testing and Balancing Work to follow project with areas shall be completed per the project phasing. Upon completion of the project all areas shall have been tested and balanced per the contract documents.

B. Existing Areas: Systems that serve areas outside of the project scope shall not be adversely affected. Measure existing parameters where shown to document system capacity.

3.11 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 23 07 11

HVAC AND BOILER PLANT INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Field applied insulation for thermal efficiency and condensation control for

1. HVAC piping and ductwork.

B. Definitions

1. ASJ: All service jacket, white finish facing or jacket.

2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.

3. Cold: Equipment, ductwork or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.

4. Concealed: Ductwork and piping above ceilings and in chases, interstitial spaces, and pipe spaces.

5. Exposed: Piping, ductwork, and equipment exposed to view in finished areas including mechanical rooms and electrical equipment rooms or exposed to outdoor weather. Attics and crawl spaces where air handling units are located are considered to be mechanical rooms. Spaces such as shafts, chases, interstitial spaces, unfinished attics, crawl spaces, and pipe basements are not considered finished areas.

6. FSK: Foil-scrim-kraft facing.

7. Hot:

a. HVAC Ductwork handling air at design temperature above 16 degrees C (60 degrees F)

b. HVAC equipment or piping handling media above 41 degrees C (105 degrees F)

c. Piping media and equipment 32 to 230 degrees C(90 to 450 degrees F)

8. Density: kg/m3 - kilograms per cubic meter (Pcf - pounds per cubic foot).

9. Runouts: Branch pipe connections up to 25-mm (one-inch) nominal size to fan coil units or reheat coils for terminal units.

10. Thermal conductance: Heat flow rate through materials.

a. Flat surface: Watt per square meter (BTU per hour per square foot).

b. Pipe or Cylinder: Watt per square meter (BTU per hour per linear foot).

11. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).

12. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.

13. RS: Refrigerant suction.

14. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 RELATED WORK

A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

C. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

D. Section 23 23 00, REFRIGERANT PIPING.

E. Section 23 31 00, HVAC DUCTS AND CASINGS.

1.3 QUALITY ASSURANCE

A. Refer to article QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Criteria:

1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, parts of which are quoted as follows:

a. 4.3.3.1 Pipe insulation and coverings, duct coverings, duct linings, vapor retarder facings, adhesives, fasteners, tapes, and supplementary materials added to air ducts, plenums, panels, and duct silencers used in duct systems, unless otherwise provided for in 4.3.3.1.1 or 4.3.3.1.2., shall have, in the form in which they are used, a maximum flame spread index of 25 without evidence of continued progressive combustion and a maximum smoke developed index of 50 when tested in accordance with NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials.

b. 4.3.3.1.1 Where these products are to be applied with adhesives, they shall be tested with such adhesives applied, or the adhesives used shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when in the final dry state.

c. 4.3.3.1.2 The flame spread and smoke developed index requirements of 4.3.3.1.1 shall not apply to air duct weatherproof coverings where they are located entirely outside of a building, do not penetrate a wall or roof, and do not create an exposure hazard.

d. 4.3.3.2 Closure systems for use with rigid and flexible air ducts tested in accordance with UL 181, Standard for Safety Factory-Made Air Ducts and Air Connectors, shall have been tested, listed, and used in accordance with the conditions of their listings, in accordance with one of the following:

   1) UL 181A, Standard for Safety Closure Systems for Use with Rigid Air Ducts and Air Connectors.

   2) UL 181B, Standard for Safety Closure Systems for Use with Flexible Air Ducts and Air Connectors.

e. 4.3.3.3 Air duct, panel, and plenum coverings and linings, and pipe insulation and coverings shall not flame, glow, smolder, or smoke when tested in accordance with a similar test for pipe covering, ASTM C 411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation, at the temperature to which they are exposed in service.

f. 4.3.3.3.1 In no case shall the test temperature be below 121°C (250°F).

g. 4.3.3.4 Air duct coverings shall not extend through walls or floors that are required to be fire stopped or required to have a fire resistance rating, unless such coverings meet the requirements of 5.4.6.4.

h. 4.3.3.6 Air duct coverings shall not be installed so as to conceal or prevent the use of any service opening.

i. 4.3.10.2.6 Materials exposed to the airflow shall be noncombustible or limited combustible and have a maximum smoke developed index of 50 or comply with the following.

j. 4.3.10.2.6.1 Electrical wires and cables and optical fiber cables shall be listed as noncombustible or limited combustible and have a maximum smoke developed index of 50 or shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with NFPA 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

k. m. 4.3.10.2.6.6 Supplementary materials for air distribution systems shall be permitted when complying with the provisions of 4.3.3.

l. 5.4.6.4 Where air ducts pass through walls, floors, or partitions that are required to have a fire resistance rating and where fire dampers are not required, the opening in the construction around the air duct shall be as follows:

   1) Not exceeding a 25.4 mm (1 in.) average clearance on all sides

   2) Filled solid with an approved material capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subjected to the time-temperature fire conditions required for fire barrier penetration as specified

in NFPA 251, Standard Methods of Tests of Fire Endurance of Building Construction and Materials.

2. Test methods: ASTM E84, UL 723, or NFPA 255.

3. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. Where optional thermal insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For pipe, use insulation manufacturer's published heat flow tables. For domestic hot water supply and return, run out insulation and condensation control insulation, no thickness adjustment need be made.

4. All materials shall be compatible and suitable for service temperature, and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.

C. Every package or standard container of insulation or accessories delivered to the job site for use must have a manufacturer's stamp or label giving the name of the manufacturer and description of the material.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Shop Drawings:

1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.

a. Insulation materials: Specify each type used and state surface burning characteristics.

b. Insulation facings and jackets: Each type used. Make it clear that white finish will be furnished for exposed ductwork, casings and equipment.

c. Insulation accessory materials: Each type used.

d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.

e. Make reference to applicable specification paragraph numbers for coordination.

1.5 STORAGE AND HANDLING OF MATERIAL

Store materials in clean and dry environment, pipe covering jackets shall be clean and unmarred. Place adhesives in original containers. Maintain ambient temperatures and conditions as required by printed instructions of manufacturers of adhesives, mastics and finishing cements.

1.6 APPLICABLE PUBLICATIONS

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

B. National Fire Protection Association (NFPA):

1. 90A-2018 Standard for the Installation of Air Conditioning and Ventilating Systems

2. 101-2018 Life Safety Code

3. 251-2014 Standard methods of Tests of Fire Endurance of Building Construction Materials

4. 255-2006 Standard Method of tests of Surface Burning Characteristics of Building Materials

PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS – TYPE A

A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m3 (3 pcf), k = 0.037 (0.26) at 24 degrees C (75 degrees F), external insulation for temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.

B. ASTM C553 (Blanket, Flexible) Type I, Class B-3, Density 16 kg/m3 (1 pcf), k = 0.045 (0.31) at 24 degrees C (75 degrees F), for use at temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.

C. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, k = 0.037 (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (450 degrees F) with an all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

2.2 FLEXIBLE ELASTOMERIC CELLULAR THERMAL – TYPE B

A. ASTM C177, C518, k = 0.039 (0.27) at 24 degrees C (75 degrees F), flame spread not over 25, smoke developed not over 50, for temperatures from minus 4 degrees C (40 degrees F) to 93 degrees C (200 degrees F).

B. No jacket required.

2.3 INSULATION FACINGS AND JACKETS

A. Vapor Retarder, higher strength with low water permeance = 0.02 or less perm rating, Beach puncture 50 units for insulation facing on exposed ductwork, casings and equipment, and for pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.

B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75 mm (3 inch) butt strip on end joints.

Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.

C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.

D. Field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping and ductwork as well as on interior piping and ductwork conveying fluids below ambient temperature. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 35 cm-kg (30 inch-pounds) for interior locations and 92 cm-kg (80 inch-pounds) for exterior or exposed locations or where the insulation is subject to damage.

E. Factory composite materials may be used provided that they have been tested and certified by the manufacturer.

F. Aluminum Jacket-Piping systems: ASTM B209, 3003 alloy, H-14 temper, 0.6 mm (0.023 inch) minimum thickness with locking longitudinal joints. Jackets for elbows, tees and other fittings shall be factory-fabricated to match shape of fitting and of 0.6 mm (0.024) inch minimum thickness aluminum. Fittings shall be of same construction as straight run jackets but need not be of the same alloy. Factory-fabricated stainless steel bands shall be installed on all circumferential joints. Bands shall be 13 mm (0.5 inch) wide on 450 mm (18 inch) centers. System shall be weatherproof if utilized for outside service.

2.4 PIPE COVERING PROTECTION SADDLES

A. Cold pipe support: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass or high density Polyisocyanurate insulation of the same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m3 (3.0 pcf).

Nominal Pipe Size and Accessories Material (Insert Blocks)

Nominal Pipe Size mm (inches)	Insert Blocks mm (inches)
Up through 125 (5)	150 (6) long

B. Warm or hot pipe supports: Premolded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be high density Polyisocyanurate (for temperatures up to 149 degrees C [300 degrees F]), cellular glass or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m3 (3.0 pcf).

2.5 ADHESIVE, MASTIC, CEMENT

A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.

B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.

C. Mil. Spec. MIL-A-24179, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.

D. Mil. Spec. MIL-C-19565, Type I: Protective finish for outdoor use.

E. Mil. Spec. MIL-C-19565, Type I or Type II: Vapor barrier compound for indoor use.

F. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.

G. Other: Insulation manufacturers' published recommendations.

2.6 MECHANICAL FASTENERS

A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel-coated or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.

B. Staples: Outward clinching monel or galvanized steel.

C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.

D. Bands: 13 mm (0.5 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.7 REINFORCEMENT AND FINISHES

A. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.

B. Corner beads: 50 mm (2 inch) by 50 mm (2 inch), 0.55 mm thick (26 gage) galvanized steel; or, 25 mm (1 inch) by 25 mm (1 inch), 0.47 mm thick (28 gage) aluminum angle adhered to 50 mm (2 inch) by 50 mm (2 inch) Kraft paper.

2.8 FIRESTOPPING MATERIAL

Other than pipe and duct insulation, refer to Section 07 84 00, FIRESTOPPING.

2.9 FLAME AND SMOKE

Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications. See paragraph 1.3 "Quality Assurance".

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Required pressure tests of duct and piping joints and connections shall be completed and the work approved by the COR for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.

B. Except for specific exceptions, insulate entire specified equipment, piping (pipe, fittings, valves, accessories), and duct systems. Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.

C. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees F) and below. Lap and seal vapor retarder over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).

D. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.

E. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable.

1. Joints in aluminum jacket systems shall be located on the underside of piping and oriented to prevent water intrusion.

F. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.

G. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights.The elbow/fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/fitting. Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited.

H. Firestop Pipe and Duct insulation:

1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed as defined in Section 07 84 00, FIRESTOPPING.

2. Pipe and duct penetrations requiring fire stop insulation including, but not limited to the following:

a. Smoke partitions

b. Fire partitions

I. Provide vapor barrier jackets over insulation as follows:

1. All piping and ductwork exposed to outdoor weather.

2. All interior piping and ducts conveying fluids exposed to outdoor air (i.e. in attics, ventilated (not air conditioned) spaces, etc.) and below ambient air temperature.

J. Provide metal jackets over insulation as follows:

1. All piping and ducts exposed to outdoor weather.

3.2 INSULATION INSTALLATION

A. Flexible Mineral Fiber Blanket:

1. Adhere insulation to metal with 75 mm (3 inch) wide strips of insulation bonding adhesive at 200 mm (8 inches) on center all around duct. Additionally secure insulation to bottom of ducts exceeding 600 mm (24 inches) in width with pins welded or adhered on 450 mm (18 inch) centers. Secure washers on pins. Butt insulation edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations with mastic. Sagging duct insulation will not be acceptable. Install firestop duct insulation where required.

2. Supply air ductwork to be insulated includes main and branch ducts from AHU discharge to room supply outlets, and the bodies of ceiling outlets to prevent condensation. Insulate sound attenuator units, coil casings and damper frames. To prevent condensation insulate trapeze type supports and angle iron hangers for flat oval ducts that are in direct contact with metal duct.

B. Molded Mineral Fiber Pipe and Tubing Covering:

1. Fit insulation to pipe or duct, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.

2. Contractor's options for fitting, flange and valve insulation:

a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.

b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 4 degrees C (40 degrees F), or above 121 degrees C (250 degrees F). Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.

c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.

d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).

C. Flexible Elastomeric Cellular Thermal Insulation:

1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions and finish with two coats

of weather resistant finish as recommended by the insulation manufacturer.

2. Pipe and tubing insulation:

   a. Use proper size material. Do not stretch or strain insulation.

   b. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer. Insulation shields are specified under Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

   c. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Make changes from mineral fiber insulation in a straight run of pipe, not at a fitting. Seal joint with tape.

3. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.

4. Pipe insulation: nominal thickness in millimeters (inches as specified in the schedule at the end of this section.

5. Minimum 20 mm (0.75 inch) thick insulation for pneumatic control lines for a minimum distance of 6 m (20 feet) from discharge side of the refrigerated dryer.

6. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a water vapor permeance of 0.00 perms.

C. Insulation Schedule:

PIPING	TYPE	PIPE SIZE	MINIMUM INSULATION THICKNESS
Cooling Glycol/Water Supply and Return	B	All Sizes	1"
Refrigerant Suction	A	All Sizes	1"
Refrigerant Hot Gas	A	All Sizes	1"
Piping Exposed to Freezing	A	All Sizes	2"

3.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 23 08 00

COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 23.

B. This project will have selected building systems commissioned. See Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

C. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00, GENERAL COMMISSIONING REQUIRMENTS.

D. A Commissioning Agent (CxA) appointed and provided by the VA will manage the commissioning process.

1.2 RELATED WORK

A. The requirements of this Section apply to all sections of Division 23.

B. Section 01 00 00, GENERAL REQUIREMENTS.

C. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 13 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

F. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 SUMMARY

A. This Section includes requirements for commissioning the HVAC systems, related subsystems, and related equipment. This Section supplements the general requirements specified in Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

B. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

A. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

A. Commissioning of a system or systems specified in Division 23 is part of the construction process. Documentation and testing of these systems, as well as training of the VA’s Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS, and of Division 23, is required in cooperation with the VA and the VA's Commissioning Agent.

B. The HVAC systems commissioning will include the systems listed in Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

1.6 SUBMITTALS

A. The commissioning process requires review of selected Submittals that pertain to the systems to be commissioned. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23, SHOP DRAWINGSS, PRODUCT DATA, AND SAMPLES for further details.

B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

1.7 APPLICABLE PUBLICATIONS

A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.

B. Department of Veterans Affairs (VA):

1. PG 18-10 2007 Mission Critical Facilities - DRAFT

2. PG 18-10 2007 Life-Safety Protected Facilities - DRAFT

C. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):

1. HANDBOOK 2019 HVAC Applications ASHRAE Handbook, Chapter 39, Testing, Adjusting, and Balancing, Chapter 44, HVAC Commissioning and Chapter 49, Sound and Vibration Control

2. HANDBOOK 2017 HVAC Fundamentals ASHRAE Handbook, Chapter 8, Sound and Vibration

D. Associated Air Balance Council (AABC):

1. 7th Edition 2016 AABC National Standards for Total System Balance

E. National Environmental Balancing Bureau (NEBB):

1. 9th Edition 2019 Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems

2. 3rd Edition 2015 Procedural Standards for the Measurement of Sound and Vibration

3. 2rd Edition 2019 Standard for Whole Building Technical Commissioning of New Construction

F. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1. 006-2006 HVAC Duct Construction Standard – Metal and Flexible Duct

2. 3rd Edition-2005 HVAC Systems Testing, Adjusting and Balancing

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

A. Commissioning of HVAC systems will require inspection of individual elements of the HVAC systems construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and the Commissioning plan to schedule HVAC systems inspections as required to support the Commissioning Process.

3.2 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. Refer to Section 13 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC, and Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

A. Contractor tests as required by other sections of Division 23 shall be scheduled and documented in accordance with Section 01 00 00, GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than seven calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING

A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the VA's COR. The Contractor

shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed.

1. See Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for additional requirements.

3.5 TRAINING OF VA PERSONNEL

A. Training of the VA operation and maintenance personnel is required in cooperation with the VA's COR and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00. The instruction shall be scheduled in coordination with the VA COR after submission and approval of formal training plans.

1. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and Division 23 Sections for additional Contractor training requirements.

- - - END - - -

SECTION 23 09 23

DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 PROJECT SCOPE

A. Controls work scope for this project shall include the following:

1. Modify the existing DDC systems as follows:

a. General:

1) Remove all demolished equipment and sensors from DDC system & graphics.

2) Provide new DDC controller & connection to VA network to integrate into site DDC system.

b. Building 040

1) Provide new temperature & humidity sensors for IT spaces.

c. Building 046

1) Provide new temperature & humidity sensors for IT spaces.

d. Building 050

1) Provide new temperature & humidity sensors for IT spaces.

e. Building 053

1) Integrate new CRAC units into DDC system.

2) Provide new temperature & humidity sensors for IT spaces.

f. Building 088

1) Integrate new CRAC units into DDC system.

2) Provide new temperature & humidity sensors for IT spaces.

g. Building 089

1) Integrate new CRAC units into DDC system.

2) Provide new temperature & humidity sensors for IT spaces.

h. Building 090

1) Integrate new CRAC units into DDC system.

2) Provide new temperature & humidity sensors for IT spaces.

i. Building 113

1) Integrate new CRAC units into DDC system.

2) Provide new temperature & humidity sensors for IT spaces.

j. Building 137

1) Provide new temperature & humidity sensors for IT spaces.

k. Building 145

1) Integrate new CRAC units into DDC system.

2) Provide new temperature & humidity sensors for IT spaces.

3) Monitor clean agent fire suppression system in MCR (room 132).

l. Building 146

1) Integrate new CRAC units into DDC system.

2) Provide new temperature & humidity sensors for IT spaces.

m. Building 148

1) Provide new temperature & humidity sensors for IT spaces.

n. Building T171

1) Integrate new conditioned IT cabinet into DDC system.

2) Provide new temperature & humidity sensors for monitoring of conditioned IT cabinet.

o. Building T296

1) Integrate new CRAC units into DDC system.

2) Provide new temperature & humidity sensors for IT spaces.

B. Controls work scope for this project shall include the following:

1. New DDC systems shall re-use existing controls wiring, conduit, and controllers as much as possible.

2. DDC communications in each building shall use a separate, dedicated LAN network from the main building LAN system.

a. The main building LAN (administered by VA IT department) shall not be utilized under this contract.

b. The existing dedicated controls LAN wiring shall be re-used to the extent possible.

c. Where no dedicated controls LAN wiring exists, contractor shall provide new controls LAN wiring.

1.2 DESCRIPTION

A. Provide (a) direct-digital control system(s) as indicated on the project documents, drawings, and as described in these specifications. Include a complete and working direct-digital control system. Include all engineering, programming, controls and installation materials, installation labor, commissioning and start-up, training, final project documentation and warranty.

1. The direct-digital control system(s) shall consist of high-speed, peer-to-peer network of DDC controllers, a control system server,

and an Engineering Control Center. Provide a remote user using a standard web browser to access the control system graphics and change adjustable setpoints with the proper password.

2. The direct-digital control system(s) shall be native BACnet. All new controllers, devices, and components shall be listed by BACnet Testing Laboratories. All new workstations, controller, devices and components shall be accessible using a Web browser interface and shall communicate exclusively using the ASHRAE Standard 135 BACnet communications protocol without the use of gateways, unless otherwise allowed by this Section of the technical specifications, specifically shown on the design drawings and specifically requested otherwise by the VA.

   a. Gateways shall support the ASHRAE Standard 135 BACnet communications protocol.

   b. Gateways shall provide all object properties and read/write services shown on VA-approved interoperability schedules.

3. The work administered by this Section of the technical specifications shall include all labor, materials, special tools, equipment, enclosures, power supplies, software, software licenses, Project specific software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, Warranty, specified services and items required for complete and fully functional Controls Systems.

4. The control systems shall be designed such that each mechanical system shall operate under stand-alone mode. The contractor administered by this Section of the technical specifications shall provide controllers for each mechanical system. In the event of a network communication failure, or the loss of any other controller, the control system shall continue to operate independently. Failure of the ECC shall have no effect on the field controllers, including those involved with global strategies.

B. Some products are not provided by, but are nevertheless integrated with the work executed by, the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the particulars of the products. These products include the following:

1. Unitary HVAC equipment (including but not limited to computer room air handling systems) controls.

   a. Generally, all available points from the HVAC equipment manufacturer's controller shall be integrated into the DDC system.

C. This facility’s existing direct-digital control system is manufactured by Johnson Controls, and its ECC is located at Building 2. The existing system’s top-end communications is via BACNet. The existing system’s

ECC and top-end controllers were installed in ____. The contractor administered by this Section of the technical specifications shall observe the capabilities, communication network, services, spare capacity of the existing control system and its ECC prior to beginning work.

D. The direct-digital control system shall start and stop equipment, move (position) damper actuators and valve actuators, and vary speed of equipment to execute the mission of the control system. Use electricity as the motive force for all damper and valve actuators.

1.3 RELATED WORK

A. Section 23 05 11, Common Work Results for HVAC

B. Section 23 08 00, Commissioning for HVAC

C. Section 23 81 23, Computer-Room Air-Conditioners.

D. Section 26 05 11, Requirements for Electrical Installations.

E. Section 26 05 26, Grounding and Bonding for Electrical Systems.

F. Section 26 05 33, Raceway and Boxes for Electrical Systems.

G. Section 27 05 11, Requirements for Communications Systems

H. Section 27 15 00, Communications Horizontal Cabling

1.4 DEFINITION

A. Algorithm: A logical procedure for solving a recurrent mathematical problem; A prescribed set of well-defined rules or processes for the solution of a problem in a finite number of steps.

B. Analog: A continuously varying signal value (e.g., temperature, current, velocity etc.

C. BACnet: A Data Communication Protocol for Building Automation and Control Networks , ANSI/ASHRAE Standard 135. This communications protocol allows diverse building automation devices to communicate data over and services over a network.

D. BACnet/IP: Annex J of Standard 135. It defines and allows for using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP sub-networks that share the same BACnet network number.

E. BACnet Internetwork: Two or more BACnet networks connected with routers. The two networks may sue different LAN technologies.

F. BACnet Network: One or more BACnet segments that have the same network address and are interconnected by bridges at the physical and data link layers.

G. BACnet Segment: One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.

H. BACnet Broadcast Management Device (BBMD): A communications device which broadcasts BACnet messages to all BACnet/IP devices and other BBMDs connected to the same BACnet/IP network.

I. BACnet Interoperability Building Blocks (BIBBs): BACnet Interoperability Building Blocks (BIBBs) are collections of one or more BACnet services. These are prescribed in terms of an "A" and a "B" device. Both of these devices are nodes on a BACnet internetwork.

J. BACnet Testing Laboratories (BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.

K. Baud: It is a signal change in a communication link. One signal change can represent one or more bits of information depending on type of transmission scheme. Simple peripheral communication is normally one bit per Baud. (e.g., Baud rate = 78,000 Baud/sec is 78,000 bits/sec, if one signal change = 1 bit).

L. Binary: A two-state system where a high signal level represents an "ON" condition and an "OFF" condition is represented by a low signal level.

M. BMP or bmp: Suffix, computerized image file, used after the period in a DOS-based computer file to show that the file is an image stored as a series of pixels.

N. Bus Topology: A network topology that physically interconnects workstations and network devices in parallel on a network segment.

O. Control Unit (CU): Generic term for any controlling unit, stand-alone, microprocessor based, digital controller residing on secondary LAN or Primary LAN, used for local controls or global controls

P. Deadband: A temperature range over which no heating or cooling is supplied, i.e., 22-25 degrees C (72-78 degrees F), as opposed to a single point change over or overlap).

Q. Device: a control system component that contains a BACnet Device Object and uses BACnet to communicate with other devices.

R. Device Object: Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet internetwork. This number is often referred to as the device instance.

S. Device Profile: A specific group of services describing BACnet capabilities of a device, as defined in ASHRAE Standard 135-2008, Annex L. Standard device profiles include BACnet Operator Workstations (B-OWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS). Each device used in new construction is required to have a PICS statement listing which service and BIBBs are supported by the device.

T. Diagnostic Program: A software test program, which is used to detect and report system or peripheral malfunctions and failures. Generally, this system is performed at the initial startup of the system.

U. Direct Digital Control (DDC): Microprocessor based control including Analog/Digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on

control algorithms and transmitted to field devices in order to achieve a set of predefined conditions.

V. Distributed Control System: A system in which the processing of system data is decentralized and control decisions can and are made at the subsystem level. System operational programs and information are provided to the remote subsystems and status is reported back to the Engineering Control Center. Upon the loss of communication with the Engineering Control center, the subsystems shall be capable of operating in a stand-alone mode using the last best available data.

W. Download: The electronic transfer of programs and data files from a central computer or operation workstation with secondary memory devices to remote computers in a network (distributed) system.

X. DXF: An AutoCAD 2-D graphics file format. Many CAD systems import and export the DXF format for graphics interchange.

Y. Electrical Control: A control circuit that operates on line or low voltage and uses a mechanical means, such as a temperature sensitive bimetal or bellows, to perform control functions, such as actuating a switch or positioning a potentiometer.

Z. Electronic Control: A control circuit that operates on low voltage and uses a solid-state components to amplify input signals and perform control functions, such as operating a relay or providing an output signal to position an actuator.

AA. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.

AB. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.

AC. Firmware: Firmware is software programmed into read only memory (ROM) chips. Software may not be changed without physically altering the chip.

AD. Gateway: Communication hardware connecting two or more different protocols. It translates one protocol into equivalent concepts for the other protocol. In BACnet applications, a gateway has BACnet on one side and non-BACnet (usually proprietary) protocols on the other side.

AE. GIF: Abbreviation of Graphic interchange format.

AF. Graphic Program (GP): Program used to produce images of air handler systems, fans, chillers, pumps, and building spaces. These images can be animated and/or color-coded to indicate operation of the equipment.

AG. Graphic Sequence of Operation: It is a graphical representation of the sequence of operation, showing all inputs and output logical blocks.

AH. I/O Unit: The section of a digital control system through which information is received and transmitted. I/O refers to analog input (AI, digital input (DI), analog output (AO) and digital output (DO). Analog signals are continuous and represent temperature, pressure, flow rate etc, whereas digital signals convert electronic signals to digital

pulses (values), represent motor status, filter status, on-off equipment etc.

AI. I/P: a method for conveying and routing packets of information over LAN paths. User Datagram Protocol (UDP) conveys information to “sockets” without confirmation of receipt. Transmission Control Protocol (TCP) establishes "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

AJ. JACE: Java Application Control Engine.

AK. JPEG: A standardized image compression mechanism stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.

AL. Local Area Network (LAN): A communication bus that interconnects operator workstation and digital controllers for peer-to-peer communications, sharing resources and exchanging information.

AM. Network Repeater: A device that receives data packet from one network and rebroadcasts to another network. No routing information is added to the protocol.

AN. MS/TP: Master-slave/token-passing (ISO/IEC 8802, Part 3). It is not an acceptable LAN option for VA health-care facilities. It uses twisted-pair wiring for relatively low speed and low cost communication.

AO. Native BACnet Device: A device that uses BACnet as its primary method of communication with other BACnet devices without intermediary gateways. A system that uses native BACnet devices at all levels is a native BACnet system.

AP. Network Number: A site-specific number assigned to each network segment to identify for routing. This network number must be unique throughout the BACnet internetwork.

AQ. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.

AR. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.

AS. Object Properties: Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.

AT. Operating system (OS): Software, which controls the execution of computer application programs.

AU. PCX: File type for an image file. When photographs are scanned onto a personal computer they can be saved as PCX files and viewed or changed by a special application program as Photo Shop.

AV. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.

AW. Peer-to-Peer: A networking architecture that treats all network stations as equal partners- any device can initiate and respond to communication with other devices.

AX. PICS: Protocol Implementation Conformance Statement, describing the BACnet capabilities of a device. All BACnet devices have published PICS.

AY. PID: Proportional, integral, and derivative control, used to control modulating equipment to maintain a setpoint.

AZ. Repeater: A network component that connects two or more physical segments at the physical layer.

BA. Router: a component that joins together two or more networks using different LAN technologies. Examples include joining a BACnet Ethernet LAN to a BACnet MS/TP LAN.

BB. Sensors: devices measuring state points or flows, which are then transmitted back to the DDC system.

BC. Thermostats : devices measuring temperatures, which are used in control of standalone or unitary systems and equipment not attached to the DDC system.

1.5 QUALITY ASSURANCE

A. Criteria:

1. Single Source Responsibility of subcontractor: The Contractor shall obtain hardware and software supplied under this Section and delegate the responsibility to a single source controls installation subcontractor. The controls subcontractor shall be responsible for the complete design, installation, and commissioning of the system. The controls subcontractor shall be in the business of design, installation and service of such building automation control systems similar in size and complexity.

2. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in production and installation of HVAC control systems. Products shall be manufacturer’s latest standard design and have been tested and proven in actual use.

3. The controls subcontractor shall provide a list of no less than five similar projects which have building control systems as specified in this Section. These projects must be on-line and functional such that the Department of Veterans Affairs (VA) representative would observe the control systems in full operation.

4. The controls subcontractor shall have in-place facility within 250 miles with technical staff, spare parts inventory for the next five (5) years, and necessary test and diagnostic equipment to support the control systems.

5. The controls subcontractor shall have minimum of three years experience in design and installation of building automation systems similar in performance to those specified in this Section. Provide evidence of experience by submitting resumes of the project manager,

the local branch manager, project engineer, the application engineering staff, and the electronic technicians who would be involved with the supervision, the engineering, and the installation of the control systems. Training and experience of these personnel shall not be less than three years. Failure to disclose this information will be a ground for disqualification of the supplier.

6. Provide a competent and experienced Project Manager employed by the Controls Contractor. The Project Manager shall be supported as necessary by other Contractor employees in order to provide professional engineering, technical and management service for the work. The Project Manager shall attend scheduled Project Meetings as required and shall be empowered to make technical, scheduling and related decisions on behalf of the Controls Contractor.

B. Codes and Standards:

1. All work shall conform to the applicable Codes and Standards.

2. Electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

1.6 PERFORMANCE

A. The system shall conform to the following:

1. Graphic Display: The system shall display up to four (4) graphics on a single screen with a minimum of twenty (20) dynamic points per graphic. All current data shall be displayed within ten (10) seconds of the request.

2. Graphic Refresh: The system shall update all dynamic points with current data within eight (8) seconds. Data refresh shall be automatic, without operator intervention.

3. Object Command: The maximum time between the command of a binary object by the operator and the reaction by the device shall be two(2) seconds. Analog objects shall start to adjust within two (2) seconds.

4. Object Scan: All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or work-station will be current, within the prior six (6) seconds.

5. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed (10) seconds.

6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every (5) seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.

7. Multiple Alarm Annunciations: All workstations on the network shall receive alarms within five (5) seconds of each other.

8. Performance: Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every

one (1) second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

9. Reporting Accuracy: Listed below are minimum acceptable reporting end-to-end accuracies for all values reported by the specified system:

Measured Variable	**Reported Accuracy**
Space temperature	±0.5°C (±1°F)
Ducted air temperature	±0.5°C [±1°F]
Outdoor air temperature	±1.0°C [±2°F]
Dew Point	±1.5°C [±3°F]
Water temperature	±0.5°C [±1°F]
Relative humidity	±2% RH
Water flow	±1% of reading
Air flow (terminal)	±10% of reading
Air flow (measuring stations)	±5% of reading
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO_2)	±50 ppm
Air pressure (ducts)	±25 Pa [±0.1"w.c.]
Air pressure (space)	±0.3 Pa [±0.001"w.c.]
Water pressure	±2% of full scale (for both absolute and differential pressure)
Electrical Power	±0.5% of reading

10. Control stability and accuracy: Control sequences shall maintain measured variable at setpoint within the following tolerances:

Controlled Variable	**Control Accuracy**	**Range of Medium**
Air Pressure	±50 Pa (±0.2 in. w.g.)	0-1.5 kPa (0-6 in. w.g.)
Air Pressure	±3 Pa (±0.01 in. w.g.)	-25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0°C (±2.0°F)	
Duct Temperature	±1.5°C (±3°F)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi)	0-1 MPa (1-150 psi)
Fluid Pressure	±250 Pa (±1.0 in. w.g.)	0-12.5 kPa (0-50 in. w.g.) differential

11. The control design shall allow for at least the following points:

    a. Points indicated on the points list(s) shown on the reference drawings.

    b. Points required to accomplish the functionality indicated in the contract documents including the reference drawings.

    c. Points required to meet applicable Code and local requirements.

1.7 WARRANTY

A. Labor and materials for control systems shall be warranted for a period as specified under Warranty in FAR clause 52.246-21.

B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no cost or reduction in service to the owner. The system includes all computer equipment, transmission equipment, and all sensors and control devices.

C. The on-line support service shall allow the Controls supplier to dial out over telephone lines to or connect via (through password-limited access) VPN through the internet monitor and control the facility's building automation system. This remote connection to the facility shall be within two (2) hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekend and holidays. If the problem cannot be resolved with on-line support services, the Controls supplier shall dispatch the qualified personnel to the job site to resolve the problem within 24 hours after the problem is reported.

D. The Controls supplier shall dispatch the qualified personnel to the job site to resolve the problem within 24 hours after the problem is reported.

E. The existing DDC systems at the Walla Walla VA campus are not connected to the internet or remotely accessible.

F. Contractor shall provide a cellular device and service to allow remote connection to the DDC systems at Building 74 during the warranty period.

1. Contractor shall coordinate with the COR to determine cellular service provider requirements, should the VA opt to maintain the cellular system after the warranty period.

2. Contractor shall provide all components (including but not limited to SIM card(s) for the cellular system.

3. All remote access shall be encrypted and secured by password.

1.8 SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer's literature and data for all components including the following:

1. A wiring diagram for each type of input device and output device including DDC controllers, modems, repeaters, etc. Diagram shall show how the device is wired and powered, showing typical connections at the digital controllers and each power supply, as well as the device itself. Show for all field connected devices, including but not limited to, control relays, motor starters, electric or electronic actuators, and temperature pressure, flow and humidity sensors and transmitters.

2. A diagram of each terminal strip, including digital controller terminal strips, terminal strip location, termination numbers and the associated point names.

3. Control dampers and control valves schedule, including the size and pressure drop.

4. Catalog cut sheets of all equipment used. This includes, but is not limited to software (by manufacturer and by third parties), DDC controllers, panels, peripherals, airflow measuring stations and associated components, and auxiliary control devices such as sensors, actuators, and control dampers. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted. Each submitted piece of literature and drawings should clearly reference the specification and/or drawings that it supposed to represent.

5. Sequence of operations for each HVAC system and the associated control diagrams. Equipment and control labels shall correspond to those shown on the drawings.

6. Color prints of proposed graphics with a list of points for display.

7. Furnish a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet-compliant device.

8. Schematic wiring diagrams for all control, communication and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.

9. An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.

10. Riser diagrams of wiring between central control unit and all control panels.

11. Scaled plan drawings showing routing of LAN and locations of control panels, controllers, routers, gateways, ECC, and larger controlled devices.

12. Construction details for all installed conduit, cabling, raceway, cabinets, and similar. Construction details of all penetrations and their protection.

13. Quantities of submitted items may be reviewed but are the responsibility of the contractor administered by this Section of the technical specifications.

C. Product Certificates: Compliance with Article, QUALITY ASSURANCE.

D. Licenses: Provide licenses for all software residing on and used by the Controls Systems and transfer these licenses to the Owner prior to completion.

E. Software Tools: Provide copy of all required software tools, access codes, graphics libraries, and hardware, etc., required to work on DDC software, to the VA at project closeout.

F. As Built Control Drawings:

1. Submit in accordance with Article, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS.

2. Furnish three (3) copies of as-built drawings for each control system. The documents shall be submitted for approval prior to final completion.

3. Furnish one (1) stick set of applicable control system prints for each mechanical system for wall mounting. The documents shall be submitted for approval prior to final completion.

4. Furnish one (1) CD-ROM in CAD DWG and/or .DXF format for the drawings noted in subparagraphs above.

G. Operation and Maintenance (O/M) Manuals):

1. Provide in accordance with Article, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS.

2. Include the following documentation:

a. General description and specifications for all components, including logging on/off, alarm handling, producing trend reports, overriding computer control, and changing set points and other variables.

b. Detailed illustrations of all the control systems specified for ease of maintenance and repair/replacement procedures, and complete calibration procedures.

c. One copy of the final version of all software provided including operating systems, programming language, operator workstation software, and graphics software.

d. Complete troubleshooting procedures and guidelines for all systems.

e. Complete operating instructions for all systems.

f. Recommended preventive maintenance procedures for all system components including a schedule of tasks for inspection, cleaning and calibration. Provide a list of recommended spare parts needed to minimize downtime.

g. Training Manuals: Submit the course outline and training material to the Owner for approval three (3) weeks prior to the training to VA facility personnel. These persons will be responsible for maintaining and the operation of the control systems, including programming. The Owner reserves the right to modify any or all of the course outline and training material.

h. Licenses, guaranty, and other pertaining documents for all equipment and systems.

H. Submit Performance Report to COR prior to final inspection.

1.9 INSTRUCTIONS

A. Instructions to VA operations personnel:

1. Perform in accordance with Article, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS, and as noted below.

2. First Phase: Formal instructions to the VA facilities personnel for a total of 8 hours, given in multiple training sessions (each no longer than 4 hours in length), conducted sometime between the completed installation and prior to the functional testing period of the control system, at a time mutually agreeable to the Contractor and the VA.

3. Second Phase: This phase of training shall comprise of on the job training during functional test period. VA facilities personnel will work with the Contractor's installation and test personnel on a daily basis during start-up and checkout period. During the performance test period, controls subcontractor will provide 8 hours of instructions, given in multiple training sessions (each no longer than 4 hours in length), to the VA facilities personnel.

4. The O/M Manuals shall contain approved submittals as outlined in Article 1.07, SUBMITTALS. The Controls subcontractor will review the manual contents with VA facilities personnel during second phase of training.

5. Training shall be given by direct employees of the controls system subcontractor.

1.10 PROJECT CONDITIONS (ENVIRONMENTAL CONDITIONS OF OPERATION)

A. The ECC and peripheral devices and system support equipment shall be designed to operate in ambient condition of 20 to 35°C (65 to 90°F) at a relative humidity of 20 to 80% non-condensing.

B. The CUs used outdoors shall be mounted in NEMA 4 waterproof enclosures, and shall be rated for operation at -40 to 65°C (-40 to 150°F).

C. All electronic equipment shall operate properly with power fluctuations of plus 10 percent to minus 15 percent of nominal supply voltage.

D. Sensors and controlling devices shall be designed to operate in the environment, which they are sensing or controlling.

1.11 APPLICABLE PUBLICATIONS

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

B. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

Standard 135-10 BACNET Building Automation and Control Networks

C. American Society of Mechanical Engineers (ASME):

B16.18-01 Cast Copper Alloy Solder Joint Pressure Fittings.

B16.22-01 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

D. American Society of Testing Materials (ASTM):

B32-08 Standard Specification for Solder Metal

B88-09 Standard Specifications for Seamless Copper Water Tube

B88M-09 Standard Specification for Seamless Copper Water Tube (Metric)

B280-08 Standard Specification for Seamless Copper Tube for Air-Conditioning and Refrigeration Field Service

E. Federal Communication Commission (FCC):

Rules and Regulations Title 47 Chapter 1-2001 Part 15: Radio Frequency Devices.

F. Institute of Electrical and Electronic Engineers (IEEE):

802.3-11 Information Technology-Telecommunications and Information Exchange between Systems-Local and Metropolitan Area Networks- Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access method and Physical Layer Specifications

G. National Fire Protection Association (NFPA):

National Electric Code

90A-09 Standard for Installation of Air-Conditioning and Ventilation Systems

H. Underwriter Laboratories Inc (UL):

Tests for Flammability of Plastic Materials for Parts and Devices and Appliances

294-10 Access Control System Units

486A/486B-10 Wire Connectors

555S-11 Standard for Smoke Dampers

916-10 Energy Management Equipment

1076-10 Proprietary Burglar Alarm Units and Systems

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations. Spare parts shall be available for at least five years after completion of this contract.

2.2 CONTROLS SYSTEM ARCHITECTURE

A. General

1. The Controls Systems shall consist of multiple Nodes and associated equipment connected by industry standard digital and communication network arrangements.

2. The ECC, building controllers and principal communications network equipment shall be standard products of recognized major manufacturers available through normal PC and computer vendor channels - not "Clones" assembled by a third-party subcontractor.

3. The networks shall, at minimum, comprise, as necessary, the following:

a. A fixed ECC.

b. A fixed operator's terminal.

c. Network computer processing, data storage and BACnet-compliant communication equipment including Servers and digital data processors.

d. BACnet-compliant routers, bridges, switches, hubs, modems, gateways, interfaces and similar communication equipment.

e. Active processing BACnet-compliant building controllers connected to other BACNet-compliant controllers together with their power supplies and associated equipment.

f. Addressable elements, sensors, transducers and end devices.

g. Third-party equipment interfaces and gateways as described and required by the Contract Documents.

h. Other components required for a complete and working Control Systems as specified.

B. The Specifications for the individual elements and component subsystems shall be minimum requirements and shall be augmented as necessary by the Contractor to achieve both compliance with all applicable codes, standards and to meet all requirements of the Contract Documents.

C. Network Architecture

1. The Controls communication network shall utilize BACnet communications protocol operating over a standard Ethernet LAN and operate at a minimum speed of 100 Mb/sec.

2. The networks shall utilize only copper and optical fiber communication media as appropriate and shall comply with applicable codes, ordinances and regulations. They may also utilize digital wireless technologies as appropriate to the application and if approved by the VA.

D. Third Party Interfaces:

1. The contractor administered by this Section of the technical specifications shall include necessary hardware, equipment, software

and programming to allow data communications between the controls systems and building systems supplied by other trades.

E. Servers:

1. Provide data storage server(s) to archive historical data including trends, alarm and event histories and transaction logs.

2. Equip these server(s) with the same software tool set that is located in the BACnet building controllers for system configuration and custom logic definition and color graphic configuration.

3. Access to all information on the data storage server(s) shall be through the same browser functionality used to access individual nodes. When logged onto a server the operator will be able to also interact with any other controller on the control system as required for the functional operation of the controls systems. The contractor administered by this Section of the technical specifications shall provide all necessary digital processor programmable data storage server(s).

4. These server(s) shall be utilized for controls systems application configuration, for archiving, reporting and trending of data, for operator transaction archiving and reporting, for network information management, for alarm annunciation, for operator interface tasks, for controls application management and similar. These server(s) shall utilize IT industry standard data base platforms which utilize a database declarative language designed for managing data in relational database management systems (RDBMS) such as SQL.

2.3 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2008, BACnet.

1. The Data link / physical layer protocol (for communication) acceptable to the VA throughout its facilities is Ethernet (ISO 8802-3) and BACnet/IP.

2. The ARCNET data link / physical protocol shall not be used in new BACnet sub-networks provided as part of this project.

3. The MS/TP data link / physical layer protocol is not acceptable to the VA in any new BACnet network or sub-network in its healthcare or lab facilities.

B. Each controller shall have a communication port for connection to an operator interface.

C. Project drawings indicate remote buildings or sites to be connected by a nominal 56,000 baud modem over voice-grade telephone lines. In each remote location a modem and field device connection shall allow communication with each controller on the internetwork as specified in Paragraph D.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs shall be viewable and editable from each internetwork controller.

2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified control system operation. An authorized operator shall be able to edit cross-controller links by typing a standard object address.

E. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring. Expansion shall not require operator interface hardware additions or software revisions.

F. ECCs and Controllers with real-time clocks shall use the BACnet Time Synchronization service. The system shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight savings and standard time as applicable.

2.4 BACNET PROTOCOL ANALYZER

A. For ease of troubleshooting and maintenance, provide a BACnet protocol analyzer. Provide its associated fittings, cables and appurtenances, for connection to the communications network. The BACnet protocol analyzer shall be able to, at a minimum: capture and store to a file all data traffic on all network levels; measure bandwidth usage; filter out (ignore) selected traffic.

2.5 NETWORK AND DEVICE NAMING CONVENTION

A. Network Numbers

1. BACnet network numbers shall be based on a "facility code, network" concept. The "facility code" is the VAMC’s or VA campus’ assigned numeric value assigned to a specific facility or building. The "network" typically corresponds to a "floor" or other logical configuration within the building. BACnet allows 65535 network numbers per BACnet internet work.

2. The network numbers are thus formed as follows: "Net #" = "FFFNN" where:

a. FFF = Facility code (see below)

b. NN = 00-99 This allows up to 100 networks per facility or building

B. Device Instances

1. BACnet allows 4194305 unique device instances per BACnet internet work. Using Agency's unique device instances are formed as follows: "Dev #" = "FFFNNDD" where

   a. FFF and N are as above and

   b. DD = 00-99, this allows up to 100 devices per network.

2. Note Special cases, where the network architecture of limiting device numbering to DD causes excessive subnet works. The device number can be expanded to DDD and the network number N can become a single digit. In NO case shall the network number N and the device number D exceed 4 digits.

3. Facility code assignments:

4. 000-400 Building/facility number

5. Note that some facilities have a facility code with an alphabetic suffix to denote wings, related structures, etc. The suffix will be ignored. Network numbers for facility codes above 400 will be assigned in the range 000-399.

C. Device Names

1. Name the control devices based on facility name, location within a facility, the system or systems that the device monitors and/or controls, or the area served. The intent of the device naming is to be easily recognized. Names can be up to 254 characters in length, without embedded spaces. Provide the shortest descriptive, but unambiguous, name. For example, in building #123 prefix the number with a “B” followed by the building number, if there is only one chilled water pump "CHWP-1", a valid name would be "B123.CHWP. 1.STARTSTOP". If there are two pumps designated "CHWP-1", one in a basement mechanical room (Room 0001) and one in a penthouse mechanical room (Room PH01), the names could be "B123.R0001.CHWP.1. STARTSTOP" or "B123.RPH01.CHWP.1.STARTSTOP". In the case of unitary controllers, for example a VAV box controller, a name might be "B123.R101.VAV". These names should be used for the value of the "Object_Name" property of the BACnet Device objects of the controllers involved so that the BACnet name and the EMCS name are the same.

2.6 BACNET DEVICES

A. All BACnet Devices - controllers, gateways, routers, actuators and sensors shall conform to BACnet Device Profiles and shall be BACnet Testing Laboratories (BTL) -Listed as conforming to those Device Profiles. Protocol Implementation Conformance Statements (PICSs), describing the BACnet capabilities of the Devices shall be published and available of the Devices through links in the BTL website.

1. BACnet Building Controllers, historically referred to as NACs, shall conform to the BACnet B-BC Device Profile, and shall be BTL-Listed as conforming to the B-BC Device Profile. The Device’s PICS shall be submitted.

2. BACnet Advanced Application Controllers shall conform to the BACnet B-AAC Device Profile, and shall be BTL-Listed as conforming to the B-AAC Device Profile. The Device's PICS shall be submitted.

3. BACnet Application Specific Controllers shall conform to the BACnet B-ASC Device Profile, and shall be BTL-Listed as conforming to the B-ASC Device Profile. The Device's PICS shall be submitted.

4. BACnet Smart Actuators shall conform to the BACnet B-SA Device Profile, and shall be BTL-Listed as conforming to the B-SA Device Profile. The Device's PICS shall be submitted.

5. BACnet Smart Sensors shall conform to the BACnet B-SS Device Profile, and shall be BTL-Listed as conforming to the B-SS Device Profile. The Device's PICS shall be submitted.

6. BACnet routers and gateways shall conform to the BACnet B-OTH Device Profile, and shall be BTL-Listed as conforming to the B-OTH Device Profile. The Device's PICS shall be submitted.

2.7 CONTROLLERS

A. General. Provide an adequate number of BTL-Listed B-BC building controllers and an adequate number of BTL-Listed B-AAC advanced application controllers to achieve the performance specified in the Part 1 Article on "System Performance." Each of these controllers shall meet the following requirements.

1. The controller shall have sufficient memory to support its operating system, database, and programming requirements.

2. The building controller shall share data with the ECC and the other networked building controllers. The advanced application controller shall share data with its building controller and the other networked advanced application controllers.

3. The operating system of the controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.

4. Controllers that perform scheduling shall have a real-time clock.

5. The controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:

   a. assume a predetermined failure mode, and

   b. generate an alarm notification.

6. The controller shall communicate with other BACnet devices on the internetwork using the BACnet Read (Execute and Initiate) and Write (Execute and Initiate) Property services.

7. Communication.

   a. Each controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications. Each building controller also shall perform

BACnet routing if connected to a network of custom application and application specific controllers.

b. The controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable operator's terminal.

8. Keypad. A local keypad and display shall be provided for each controller. The keypad shall be provided for interrogating and editing data. Provide a system security password shall be available to prevent unauthorized use of the keypad and display.

9. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

10. Memory. The controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

11. The controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Controller operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

B. Provide BTL-Listed B-ASC application specific controllers for each piece of equipment for which they are constructed. Application specific controllers shall communicate with other BACnet devices on the internetwork using the BACnet Read (Execute) Property service.

1. Each B-ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.

2. Each B-ASC will contain sufficient I/O capacity to control the target system.

3. Communication.

a. Each controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications. Each building controller also shall perform BACnet routing if connected to a network of custom application and application specific controllers.

b. Each controller shall have a BACnet Data Link/Physical layer compatible connection for a laptop computer or a portable operator's tool. This connection shall be extended to a space temperature sensor port where shown.

4. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

5. Memory. The application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.

6. Immunity to power and noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

7. Transformer. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type.

C. Direct Digital Controller Software

1. The software programs specified in this section shall be commercially available, concurrent, multi-tasking operating system and support the use of software application that operates under DOS or Microsoft Windows.

2. All points shall be identified by up to 30-character point name and 16-character point descriptor. The same names shall be used at the ECC.

3. All control functions shall execute within the stand-alone control units via DDC algorithms. The VA shall be able to customize control strategies and sequences of operations defining the appropriate control loop algorithms and choosing the optimum loop parameters.

4. All controllers shall be capable of being programmed to utilize stored default values for assured fail-safe operation of critical processes. Default values shall be invoked upon sensor failure or, if the primary value is normally provided by the central or another CU, or by loss of bus communication. Individual application software packages shall be structured to assume a fail-safe condition upon loss of input sensors. Loss of an input sensor shall result in output of a sensor-failed message at the ECC. Each ACU and RCU shall have capability for local readouts of all functions. The UCUs shall be read remotely.

5. All DDC control loops shall be able to utilize any of the following control modes:

   a. Two position (on-off, slow-fast) control.

   b. Proportional control.

   c. Proportional plus integral (PI) control.

   d. Proportional plus integral plus derivative (PID) control. All PID programs shall automatically invoke integral wind up prevention routines whenever the controlled unit is off, under manual control of an automation system or time initiated program.

   e. Automatic tuning of control loops.

6. System Security: Operator access shall be secured using individual password and operator’s name. Passwords shall restrict the operator to the level of object, applications, and system functions assigned to him. A minimum of six (6) levels of security for operator access shall be provided.

7. Application Software: The controllers shall provide all programs required to meet the sequence of operations indicated on the drawings. All application software shall reside and run in the system digital controllers. Editing of the application shall occur at the ECC or via a portable operator's terminal, when it is necessary, to access directly the programmable unit.

2.8 SENSORS (AIR)

A. Sensors' measurements shall be read back to the DDC system, and shall be visible by the ECC.

B. Temperature and Humidity Sensors shall be electronic, vibration and corrosion resistant for wall, immersion, and/or duct mounting. Provide all remote sensors as required for the systems.

1. Temperature Sensors: thermistor type for terminal units and Resistance Temperature Device (RTD) with an integral transmitter type for all other sensors.

a. Duct sensors shall be rigid or averaging type as shown on drawings. Averaging sensor shall be a minimum of 1 linear ft of sensing element for each sq ft of cooling coil face area.

b. Space sensors shall be equipped with in-space User set-point adjustment, override switch, numerical temperature display on sensor cover, and communication port. Match room thermostats. Provide a tooled-access cover.

1) Public space sensor: setpoint adjustment shall be only through the ECC or through the DDC system's diagnostic device/laptop. Do not provide in-space User set-point adjustment. Provide an opaque keyed-entry cover if needed to restrict in-space User set-point adjustment.

c. Outdoor air temperature sensors shall have watertight inlet fittings and be shielded from direct sunlight.

d. Room security sensors shall have stainless steel cover plate with insulated back and security screws.

e. Wire: Twisted, shielded-pair cable.

f. Output Signal: 4-20 ma.

2. Humidity Sensors: Bulk polymer sensing element type.

a. Duct and room sensors shall have a sensing range of 20 to 80 percent with accuracy of ± 2 to ± 5 percent RH, including hysteresis, linearity, and repeatability.

b. Outdoor humidity sensors shall be furnished with element guard and mounting plate and have a sensing range of 0 to 100 percent RH.

c. 4-20 ma continuous output signal.

C. Static Pressure Sensors: Non-directional, temperature compensated.

1. 4-20 ma output signal.

2. 0 to 5 inches wg for duct static pressure range.

3. 0 to 0.25 inch wg for Building static pressure range.

D. Current Switches: Current operated switches shall be self powered, solid state with adjustable trip current as well as status, power, and relay command status LED indication. The switches shall be selected to match the current of the application and output requirements of the DDC systems.

2.9 CONTROL CABLES

A. General:

1. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Comply with Sections 27 05 26 and 26 05 26.

2. Cable conductors to provide protection against induction in circuits. Crosstalk attenuation within the System shall be in excess of -80 dB throughout the frequency ranges specified.

3. Minimize the radiation of RF noise generated by the System equipment so as not to interfere with any audio, video, data, computer main distribution frame (MDF), telephone customer service unit (CSU), and electronic private branch exchange (EPBX) equipment the System may service.

4. The as-installed drawings shall identify each cable as labeled, used cable, and bad cable pairs.

5. Label system’s cables on each end. Test and certify cables in writing to the VA before conducting proof-of-performance testing. Minimum cable test requirements are for impedance compliance, inductance, capacitance, signal level compliance, opens, shorts, cross talk, noise, and distortion, and split pairs on all cables in the frequency ranges used. Make available all cable installation and test records at demonstration to the VA. All changes (used pair, failed pair, etc.) shall be posted in these records as the change occurs.

6. Power wiring shall not be run in conduit with communications trunk wiring or signal or control wiring operating at 100 volts or less.

B. Analogue control cabling shall be not less than No. 18 AWG solid, with thermoplastic insulated conductors as specified in Section 26 05 21.

C. Copper digital communication cable between the ECC and the B-BC and B-AAC controllers shall be 100BASE-TX Ethernet, Category 5e or 6, not less than minimum 24 American Wire Gauge (AWG) solid, Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP), with thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, as specified in Section 27 15 00.

1. Other types of media commonly used within IEEE Std 802.3 LANs (e.g., 10Base-T and 10Base-2) shall be used only in cases to interconnect with existing media.

D. Optical digital communication fiber, if used, shall be Multimode or Singlemode fiber, 62.5/125 micron for multimode or 10/125 micron for singlemode micron with SC or ST connectors as specified in TIA-568-C.1. Terminations, patch panels, and other hardware shall be compatible with the specified fiber and shall be as specified in Section 27 15 00. Fiber-optic cable shall be suitable for use with the 100Base-FX or the 100Base-SX standard (as applicable) as defined in IEEE Std 802.3.

2.10 THERMOSTATS AND HUMIDISTATS

A. Room thermostats controlling unitary standalone heating and cooling devices not connected to the DDC system shall have three modes of operation (heating - null or dead band - cooling). Thermostats for patient bedrooms shall have capability of being adjusted to eliminate null or dead band. Wall mounted thermostats shall have polished or brushed aluminum finish, setpoint range and temperature display and external adjustment:

1. Electronic Thermostats: Solid-state, microprocessor based, programmable to daily, weekend, and holiday schedules.

a. Public Space Thermostat: Public space thermostat shall have a thermistor sensor and shall not have a visible means of set point adjustment. Adjustment shall be via the digital controller to which it is connected.

b. Patient Room Thermostats: thermistor with in-space User set point adjustment and an on-casing room temperature numerical temperature display.

c. Psychiatric Patient Room Sensors: Electronic duct sensor as noted under Article 2.4.

d. Battery replacement without program loss.

B. Strap-on thermostats shall be enclosed in a dirt-and-moisture proof housing with fixed temperature switching point and single pole, double throw switch.

C. Freezestats shall have a minimum of 300 mm (one linear foot) of sensing element for each 0.093 square meter (one square foot) of coil area. A freezing condition at any increment of 300 mm (one foot) anywhere along the sensing element shall be sufficient to operate the thermostatic element. Freezestats shall be manually-reset.

D. Room Humidistats: Provide fully proportioning humidistat with adjustable throttling range for accuracy of settings and conservation. The humidistat shall have set point scales shown in percent of relative humidity located on the instrument. Systems showing moist/dry or high/low are not acceptable.

2.11 FINAL CONTROL ELEMENTS AND OPERATORS

A. Fail Safe Operation: Control valves and dampers shall provide "fail safe" operation in either the normally open or normally closed position as required for freeze, moisture, and smoke or fire protection.

B. Spring Ranges: Range as required for system sequencing and to provide tight shut-off.

C. Damper and Valve Operators and Relays:

1. Electric operator shall provide full modulating control of dampers and valves. A linkage and pushrod shall be furnished for mounting the actuator on the damper frame internally in the duct or externally in the duct or externally on the duct wall, or shall be furnished with a direct-coupled design. Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.

   a. Minimum valve close-off pressure shall be equal to the system pump's dead-head pressure, minimum 50 psig for valves smaller than 4 inches.

2. Electronic damper operators: Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.

3. See drawings for required control operation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Examine project plans for control devices and equipment locations; and report any discrepancies, conflicts, or omissions to COR for resolution before proceeding for installation.

2. Install equipment, piping, wiring/conduit parallel to or at right angles to building lines.

3. Install all equipment and piping in readily accessible locations. Do not run tubing and conduit concealed under insulation or inside ducts.

4. Mount control devices, tubing and conduit located on ducts and apparatus with external insulation on standoff support to avoid interference with insulation.

5. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

6. Run tubing and wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing.

7. Install equipment level and plum.

B. Electrical Wiring Installation:

1. All wiring cabling shall be installed in conduits. Install conduits and wiring in accordance with Specification Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS. Conduits carrying control wiring and cabling shall be dedicated to the control wiring and cabling: these conduits shall not carry power wiring. Provide plastic end sleeves at all conduit terminations to protect wiring from burrs.

   a. Minimum conduit size shall be 3/4 inch.

2. Install analog signal and communication cables in conduit and in accordance with Specification Section 26 05 21. Install digital communication cables in conduit and in accordance with Specification Section 27 15 00, Communications Horizontal Cabling.

3. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section.

4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical specifications. Where low voltage (less than 50 volt) power is required, provide suitable Class B transformers.

5. Install all system components in accordance with local Building Code and National Electric Code.

   a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.

   b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long. Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.

   c. Cable Runs: Keep cable runs as short as possible. Allow extra length for connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.

   d. Use vinyl tape, sleeves, or grommets to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.

6. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.

7. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.

8. Grounding: ground electrical systems per manufacturer’s written requirements for proper and safe operation.

C. Install Sensors and Controls:

1. Temperature Sensors:

   a. Install all sensors and instrumentation according to manufacturer's written instructions. Temperature sensor locations shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.

   b. Calibrate sensors to accuracy specified, if not factory calibrated.

   c. Use of sensors shall be limited to its duty, e.g., duct sensor shall not be used in lieu of room sensor.

   d. Install room sensors permanently supported on wall frame. They shall be mounted at 1.5 meter (5.0 feet) above the finished floor.

   e. Mount sensors rigidly and adequately for the environment within which the sensor operates. Separate extended-bulb sensors form contact with metal casings and coils using insulated standoffs.

   f. Sensors used in mixing plenum, and hot and cold decks shall be of the averaging of type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.

   g. All pipe mounted temperature sensors shall be installed in wells.

   h. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.

   i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.

2. Pressure Sensors:

   a. Install duct static pressure sensor tips facing directly downstream of airflow.

   b. Install high-pressure side of the differential switch between the pump discharge and the check valve.

   c. Install snubbers and isolation valves on steam pressure sensing devices.

3. Actuators:

   a. Mount and link damper and valve actuators according to manufacturer's written instructions.

   b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.

c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.

4. Flow Switches:

a. Install flow switch according to manufacturer's written instructions.

b. Assure correct flow direction and alignment.

D. Installation of network:

1. Ethernet:

a. The network shall employ Ethernet LAN architecture, as defined by IEEE 802.3. The Network Interface shall be fully Internet Protocol (IP) compliant allowing connection to currently installed IEEE 802.3, Compliant Ethernet Networks.

b. The network shall directly support connectivity to a variety of cabling types. As a minimum provide the following connectivity: 100 Base TX (Category 5e cabling) for the communications between the ECC and the B-BC and the B-AAC controllers.

2. Third party interfaces: Contractor shall integrate real-time data from building systems by other trades and databases originating from other manufacturers as specified and required to make the system work as one system.

E. Installation of digital controllers and programming:

1. Provide a separate digital control panel for each major piece of equipment, such as air handling units, etc. Points used for control loop reset such as outdoor air, outdoor humidity, or space temperature could be located on any of the remote control units.

2. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25 percent of available memory free for future use.

3. System point names shall be modular in design, permitting easy operator interface without the use of a written point index.

4. Provide software programming for the applications intended for the systems specified, and adhere to the strategy algorithms provided.

5. Provide graphics for each piece of equipment and floor plan in the building. This includes each air handling unit, etc. These graphics shall show all points dynamically as specified in the point list.

3.2 SYSTEM VALIDATION AND DEMONSTRATION

A. As part of final system acceptance, a system demonstration is required (see below). Prior to start of this demonstration, the contractor is to perform a complete validation of all aspects of the controls and instrumentation system.

B. Validation

1. Prepare and submit for approval a validation test plan including test procedures for the performance verification tests. Test Plan shall address all specified functions of the ECC and all specified sequences of operation. Explain in detail actions and expected results used to demonstrate compliance with the requirements of this specification. Explain the method for simulating the necessary conditions of operation used to demonstrate performance of the system. Test plan shall include a test check list to be used by the Installer's agent to check and initial that each test has been successfully completed. Deliver test plan documentation for the performance verification tests to the owner's representative 30 days prior to start of performance verification tests. Provide draft copy of operation and maintenance manual with performance verification test.

2. After approval of the validation test plan, installer shall carry out all tests and procedures therein. Installer shall completely check out, calibrate, and test all connected hardware and software to insure that system performs in accordance with approved specifications and sequences of operation submitted. Installer shall complete and submit Test Check List.

C. Demonstration

1. System operation and calibration to be demonstrated by the installer in the presence of the Architect or COR on random samples of equipment as dictated by the Architect or VA's representative. Should random sampling indicate improper commissioning, the owner reserves the right to subsequently witness complete calibration of the system at no addition cost to the VA.

2. Demonstrate to authorities that all required safeties and life safety functions are fully functional and complete.

3. Make accessible, personnel to provide necessary adjustments and corrections to systems as directed by balancing agency.

4. The following witnessed demonstrations of field control equipment shall be included:

   a. Observe HVAC systems in shut down condition. Check dampers and valves for normal position.

   b. Test application software for its ability to communicate with digital controllers, operator workstation, and uploading and downloading of control programs.

   c. Demonstrate the software ability to edit the control program off-line.

   d. Demonstrate reporting of alarm conditions for each alarm and ensure that these alarms are received at the assigned location, including operator workstations.

   e. Demonstrate ability of software program to function for the intended applications-trend reports, change in status etc.

   f. Demonstrate via graphed trends to show the sequence of operation is executed in correct manner, and that the HVAC systems operate

properly through the complete sequence of operation, e.g., seasonal change, occupied/unoccupied mode, and warm-up condition.

g. Demonstrate hardware interlocks and safeties functions, and that the control systems perform the correct sequence of operation after power loss and resumption of power loss.

h. Prepare and deliver to the VA graphed trends of all control loops to demonstrate that each control loop is stable and the set points are maintained.

i. Demonstrate that each control loop responds to set point adjustment and stabilizes within one (1) minute. Control loop trend data shall be instantaneous and the time between data points shall not be greater than one (1) minute.

5. Witnessed demonstration of ECC functions shall consist of:

a. Running each specified report.

b. Display and demonstrate each data entry to show site specific customizing capability. Demonstrate parameter changes.

c. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.

d. Execute digital and analog commands in graphic mode.

e. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs (6 loops minimum).

f. Demonstrate EMS performance via trend logs and command trace.

g. Demonstrate scan, update, and alarm responsiveness.

h. Demonstrate spreadsheet/curve plot software, and its integration with database.

i. Demonstrate on-line user guide, and help function and mail facility.

j. Demonstrate digital system configuration graphics with interactive upline and downline load, and demonstrate specified diagnostics.

k. Demonstrate multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.

l. Demonstrate class programming with point options of beep duration, beep rate, alarm archiving, and color banding.

3.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00,

COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

- - - E N D - - -

SECTION 23 10 00
FACILITY FUEL OIL SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION

A. Diesel fuel oil tanks, piping, pumps, and accessories located aboveground as shown on contract drawings. Refer to contract drawings for type of fuel and for tank capacities.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Civil Engineers (ASCE):

1. ASCE-7-2016 Minimum Design Loads and Associated Criteria for Buildings and Other Structures.

C. American Society of Mechanical Engineers (ASME):

1. B16.5-2020 Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.

2. B16.9-2018 Factory Made Wrought Buttwelding Fittings

3. B16.11-2016 Forged Fittings, Socket-Welding and Threaded

4. B31.1-2020 Power Piping

D. American Society for Testing and Materials (ASTM):

1. A36/A36M-2019 Standard Specification for Carbon Structural Steel

2. A53/A53M-2020 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

3. A105/A105M-2021 Standard Specification for Carbon Steel Forgings for Piping Applications

4. A106/A106M-2019A Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

5. A126-04-2019 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

6. A234/A234M-08-2019 Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

7. B62-2017 Standard Specification for Composition Bronze or Ounce Metal Castings

E. NACE International (NACE):

1. SSPC–SP6-2007 Commercial Blast Cleaning

2. SSPC-SP7-2007 Brush-off Blast Cleaning

F. National Electrical Manufacturers Association (NEMA):

1. 250-2020 Enclosures for Electrical Equipment (1000 Volts Maximum)

G. National Fire Protection Association (NFPA):

1. 30-2021 Flammable and Combustible Liquids Code

2. 31-2020 Standard for the Installation of Oil-Burning Equipment

3. 70-2020 National Electrical Code (NEC)

H. Underwriters Laboratories Inc. (UL):

1. 142-2019 Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids

2. 2085-2010 Standard for Protected Aboveground Tanks for Flammable and Combustible Liquids

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 23 10 00, FACILITY FUEL OIL SYSTEMS”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

D. Fuel Piping:

1. ASTM and UL compliance.
2. Grade, class or type, schedule number.
3. Manufacturer.

E. Pipe Fittings, Unions, Flanges:

1. ASTM and UL compliance.
2. ASTM standards number.
3. Catalog cuts.
4. Pressure and temperature rating.

F. Foot Valves, Check Valves, and Overfill Prevention Valves:

1. Catalog cuts showing design and construction.
2. Pressure and temperature ratings.
3. Pressure loss and flow rate data.
4. Materials of construction.
5. Accessories.

G. Tank and Piping Accessories: Design, construction, and dimensions of vent caps, fill boxes, fill caps, spill containers and other accessories.

H. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

I. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

J. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. Approval by COR is required of products or services of proposed manufacturers, suppliers and installers, and will be based on Contractor's certification that:

1. Manufacturers regularly and currently manufacture tanks, tank and piping accessories, tank fluid level monitoring and leak detection systems, and fuel quality management systems.

2. Manufacturers of steel tanks participate in the Quality Assurance Program of the Steel Tank Institute (STI).

3. The design and size of each item of equipment provided for this project is of current production and has been in satisfactory operation on at least three installations for approximately three years. Current models of fluid level and leak detection systems with less than three years' service experience are acceptable if similar previous models from the same manufacturer have at least three years' service experience.

B. Apply and install materials, equipment and specialties in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract drawings and specifications shall be referred to the COR for resolution. Provide copies of installation instructions to the COR two weeks prior to commencing installation of any item.

C. All equipment shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components or overall assembly.

D. Tank and piping installation contractor shall be certified as acceptable by local and state pollution control authorities.

E. Entire installation shall conform to requirements of local and state pollution control authorities.

F. Pipe Welding: Conform to requirements of ASME B31.1. Welders shall show evidence of qualification. Welders shall utilize a stamp to identify their work. Unqualified personnel will be rejected.

G. Where specified codes or standards conflict, consult the COR.

H. Label of Conformance (definition): Labels of accredited testing laboratories showing conformance to the standards specified.

I. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a safe, complete and fully operational system which conforms to contract requirements and in which no item is subject to conditions beyond its design capabilities.

1.6 AS-BUILT DOCUMENTATION

A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:

   1. As-built drawings are to be provided, with a copy of them on AutoCAD version 2017 or newer provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and

calibration data to include equipment serial numbers or individual identifications, etc.

1.7 PERMITS

A. Contractor shall obtain and complete all tank permit and registration forms required by governmental authorities for demolition or installation of fuel tanks and piping.

PART 2 PRODUCTS

2.1 PIPING, VALVES, FITTINGS

A. Steel Pipe and Fittings:

1. Piping: Steel, seamless or electric resistance welded (ERW), ASTM A53/A53M Grade B or ASTM A106/A106M Grade B, Schedule 40. Aboveground piping shall be painted. Refer to Section 09 91 00, PAINTING.

2. Joints: Socket or butt-welded. Threaded joints are prohibited except at valves, unions and tank connections.

3. Fittings:

a. Butt-welded joints: Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe.

b. Socket-welded joints: Forged steel, ASME B16.11, 13,790 kPa (2000 psig) class.

4. Unions: Malleable iron, 2070 kPa (300 psig) class.

5. Companion flanges: Flanges and bolting, ASME B16.5.

6. Welding flanges: Weld neck, ASME B16.5, forged steel ASTM A105/A105M, 1034 kPa (150 psig).

B. Ball Valves:

C. Check Valves - Fuel Pump Suction.

1. Pipe Sizes 50 mm (2 inches) and under: Rated for 1375 kPa (200 psig) water-oil-gas, swing-type, threaded ends, ASTM B62 bronze body. Provide union adjacent to valve.

2. Pipe Sizes 65 mm (2-1/2 inches) and above: Rated for 1380 kPa (200 psig) water-oil-gas, swing-type, 861 kPa (125 pounds) ASME flanged ends, ASTM A126 class B cast iron body.

D. Foot Valves - Fuel Pump Suction: Double poppet, lapped-in metal-to-metal seats, double-guided stems, 20 mesh inlet screen, same size as fuel suction piping. Foot valve shall be removable to above grade through the tank manhole enclosure or through extractor fitting.

2.2 DAY TANKS

A. General

1. The day tank shall be designed and supplied as an engineered system by the manufacturer. Each tank shall be of packaged design to include all inlet flow control devices, other valves, level controls, remote pump activation, indicators, alarms and all other devices as required to form an integrated, functional system such that field installation is restricted largely to external piping, wiring and such intermediate devices that are required by code and/or good engineering practice to interconnect the bulk source of supply to the day tank, the day tank to the prime mover and to provide for external vents as per local codes and UL 142, NFPA 31 and NFPA 37.

2. The system shall be for use with fuel oil as described by NFPA 321, "Basic Classification of Flammable and Combustible Liquids". As defined by this standard, the fuel supply system shall be for use with "combustible liquids", those having a flash point at or above 100°F and further defined as class II or class III liquids. In no case shall a liquid defined as "flammable", or as "class I" or as having a flash point less than 100°F be used. In every case, the system shall not be used or applied at a temperature in excess of the flash point of the contents. Electrical equipment used in the system shall be in accordance with NFPA 30, Section 5-7, wherein it states "For areas where class II or class III liquids only are stored or handled at a temperature below their flash points, the electrical equipment may be installed in accordance with provisions of NFPA 70, National Electric Code, for ordinary locations."

3. Day tank shall be for use with a main fuel tank and remote fuel delivery system in order to provide an automatic, self-refilling fuel supply system.

4. The system shall be designed and installed in accordance with applicable sections of NFPA 30, NFPA 31, NFPA 37, UL 80 and UL 142. The day tank shall bear the label of Underwriters Laboratories standards 142 and 508A.

5. The day tank system, shall be designed and manufactured by a single supplier and be a standard product in serial production.

6. The manufacturer shall have at least 10 years experience in the design and manufacture of these products.

7. The day tank shall be supplied with manufacturer's test certificates as below:

a. Tank test: pressure test, leak proof test and structural integrity/appearance test.

b. Level controller: operational test with liquid of level sensors, level indicator, level control, alarms, backup devices.

c. Pump: vacuum test, flow test, pressure test, leak proof test, ampere/voltage test, load test, overload test.

8. Provide day tank assembly with manufacturer's two-year parts and labor warranty.

B. Tank Construction

1. All welded steel atmospheric tank of rectangular construction built in accordance with codes and standards noted above for indoor use with fuel oil.

2. Threaded pipe connections shall be provided for:

a. Fuel oil supply from remote pump set.

b. Supply to prime mover.

c. Return from genset.

d. Overflow port.

e. Vent.

f. Emergency vent.

g. Drain, with drain valve

3. The tank shall be equipped with a welded steel channel base suitable for bolt attachment to a concrete pad

4. The tank shall have interior corrosion protection

5. The exterior of the day tank shall receive a heavy duty industrial anti-corrosion coating and be finish painted

6. All day tank pump/motors shall be protected by a removable steel equipment cover.

7. Day tank shall be factory leak tested at 3 PSI.

8. The tank shall be steel double-wall construction bearing the UL 142 label and having a containment rating of 110% of the primary day tank. The containment shall be equipped with a leak detector that shall activate the "Leak" alarm described below. A drain with ball valve is to be supplied. The containment shall be equipped with a separate e-vent as required by UL 142.

C. Fuel Delivery System

1. Provide installed upon the day tank, a fuel oil pump and pump controller for supply of fuel from the main tank to the day tank. This is a suction-lift application: adequate pipe sizes must be used in the system and a foot valve must be installed in the main tank. Manual priming of the system is required.

2. The system shall include:

a. Direct drive, motor driven pump coupled via flexible coupling.

b. Pumps to be directly driven, positive displacement, internal gear type. Pump shall be a high pressure, hydraulic type consisting of two intermeshing, hardened steel, precision ground gear assemblies enclosed by a high strength, die cast aluminum housing, hardened drive shaft.

c. Motors to be open drip proof construction.

d. Shutoff ball valve on pump inlet.

e. Pump check valve, spring-type, bronze construction, 600 PSI rated, installed, with priming tee, on pump inlet.

f. Suction strainer, simplex type fuel oil strainer on the pump suction.

D. Controls

1. A UL Listed, integrated design level controller package shall be supplied which provides differential level control for activation of remote pumps, tank level indication, system alarms and manual operating controls. Level controller shall be self-contained as a unit within a Type 1 box mounted to the day tank. The controller shall utilize discrete level sensors and circuit paths for level alarms, primary pump control and backup pump control. Failure in one sensor or circuit path shall not necessarily disable the entire controller. All indicators are to be long life light emitting diodes.

2. The level controller shall have an intrinsic overflow cutout backup control which, upon sensing an overflow, will stop the pump, activate an alarm and cause the controller to revert to an emergency backup level control mode which allows the tank to continue operating automatically but which inhibits overflow.

3. The level controller shall provide the following control functions:
   a. "Auto-off-manual" pump control mode switch
   b. "Press to test" pump push-button
   c. Pump start-stop automatic level control
   d. Pump overflow control backup
4. The level controller shall provide the following indication functions:
   a. Fuel level
   b. Power available
   c. Switch not in auto
   d. Pump running
   e. Low level alarm
   f. High level alarm
   g. Not in Auto alarm
   h. Day Tank leak
5. The level controller shall provide the following outputs:
   a. Remote pump lead pump start, lag pump start
   b. Low level alarm
   c. High level alarm
   d. Day tank leak
   e. Not in Auto

2.3 CONCRETE FOUNDATIONS

A. Refer to Structural drawings and Section 03 30 00, CAST-IN-PLACE CONCRETE.

PART 3 EXECUTION

3.1 GENERAL

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 DAY TANKS

A. General

1. The day tank shall be installed adjacent or near the genset fed by the day tank.

2. Install the day tank on a concrete housekeeping pad. Day tank shall be anchored to the housekeeping pad as directed by the Manufacturer.

B. Connections

1. Provide schedule 40, ASTM A 53, black iron pipe connections to the day tank.

2. Make all connections to fixed installed pipe with pipe unions to facilitate tank service/removal.

3. Vent pipe & connection sizes shall be provided as shown and as required by local codes and by UL 142, NFPA-31 and NFPA-37 requirements.

3.3 CONTROLS

A. Integrate new system components into existing fuel oil system controls. Fuel oil system shall be configured to operate as required to automatically circulated fuel oil between the main tank, day tank, and connected genset unit.

3.4 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer's technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Field installed refrigerant piping for direct expansion HVAC systems, including required pipe insulation.

B. Refrigerant piping shall be sized, selected, and designed either by the equipment manufacturer or in strict accordance with the manufacturer's published instructions. The schematic piping diagram shall show all accessories such as, stop valves, level indicators, liquid receivers, oil separator, gauges, thermostatic expansion valves, solenoid valves, moisture separators and driers to make a complete installation.

1.2 DEFINITIONS:

A. Refrigerating system: Combination of interconnected refrigerant-containing parts constituting one closed refrigeration circuit in which a refrigerant is circulated for the purpose of extracting heat.

1. Low side means the parts of a refrigerating system subjected to evaporator pressure.

2. High side means the parts of a refrigerating system subjected to condenser pressure.

B. Brazed joint: A gas-tight joint obtained by the joining of metal parts with alloys which melt at temperatures higher than 449 degrees C (840 degrees F) but less than the melting temperatures of the joined parts.

1.3 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

D. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

E. Section 23 81 23, COMPUTER-ROOM AIR CONDITIONERS.

1.4 QUALITY ASSURANCE

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Comply with ASHRAE Standard 15, Safety Code for Mechanical Refrigeration. The application of this Code is intended to assure the safe design, construction, installation, operation, and inspection of every refrigerating system employing a fluid which normally is vaporized and liquefied in its refrigerating cycle.

C. Comply with ASME B31.5: Refrigerant Piping and Heat Transfer Components.

D. Products shall comply with UL 207 "Refrigerant-Containing Components and Accessories, "Nonelectrical"; or UL 429 "Electrical Operated Valves."

1.5 SUBMITTALS

A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Shop Drawings:

1. Complete information for components noted, including valves and refrigerant piping accessories, clearly presented, shall be included to determine compliance with drawings and specifications for components noted below:

a. Tubing and fittings

b. Valves

c. Strainers

d. Moisture-liquid indicators

e. Filter-driers

f. Flexible metal hose

g. Liquid-suction interchanges

h. Gages

i. Pipe and equipment supports

j. Refrigerant and oil

k. Pipe/conduit roof penetration cover

l. Soldering and brazing materials

2. Layout of refrigerant piping and accessories, including flow capacities, valves locations, and oil traps slopes of horizontal runs, floor/wall penetrations, and equipment connection details.

3. Location of all access panels shall be indicated on shop drawings.

C. Certification: Copies of certificates for welding procedure, performance qualification record and list of welders' names and symbols.

1.6 APPLICABLE PUBLICATIONS

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

B. American National Standards Institute (ANSI):

A13.1-2015	Scheme for Identification of Piping Systems
Z535.1-2017	Safety Color Code

C. American Welding Society, Inc. (AWS):

Brazing Handbook

A5.8/A5.8M-2011 Standard Specification for Filler Metals for Brazing and Braze Welding

D. Underwriters Laboratories (U.L.):

U.L.207-2018 Standard for Refrigerant-Containing Components and Accessories, Nonelectrical

U.L.429-2013 Standard for Electrically Operated Valves

PART 2 - PRODUCTS

2.1 PIPING AND FITTINGS

A. Refrigerant Piping:

1. For piping up to 100 mm (4 inch) use Copper refrigerant tube, ASTM B280, cleaned, dehydrated and sealed, marked ACR on hard temper straight lengths.

a. Coils shall be tagged ASTM B280 by the manufacturer.

B. Refrigerant Piping Kits for Mini-Split Systems:

1. All refrigerant lines between outdoor and indoor units shall be of annealed, refrigeration grade copper tubing, ACR Type, meeting ASTM B280 requirements, individually insulated in twin-tube, flexible, closed-cell, CFC-free (ozone depletion potential of zero), elastomeric material for the insulation of refrigerant pipes and tubes with thermal conductivity equal to or better than 0.27 BTU-inch/hour per Sq Ft / °F, a water vapor transmission equal to or better than 0.08 Perm-inch and superior fire ratings such that insulation will not contribute significantly to fire and up to 1” thick insulation shall have a Flame-Spread Index of less than 25 and a Smoke-development Index of less than 50 as tested by ASTM E 84 and CAN / ULC S-102.

C. Water and Drain Piping: Copper water tube, ASTM B88M, Type B or C (ASTM B88, Type L or M).

D. Fittings, Valves and Accessories:

1. Copper fittings: Wrought copper fittings, ASME B16.22.

a. Brazed Joints, refrigerant tubing: Cadmium free, AWS A5.8/A5.8M, 45 percent silver brazing alloy, Class BAg-5.

b. Solder Joints, water and drain: 95-5 tin-antimony, ASTM B32 (95TA).

2. Flanges and flanged fittings: ASME B16.24.

3. Refrigeration Valves:

a. Stop Valves: Brass or bronze alloy, packless, or packed type with gas tight cap, frost proof, back seating.

b. Pressure Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; UL listed. Forged brass with nonferrous, corrosion

resistant internal working parts of high strength, cast iron bodies conforming to ASTM A126, Grade B. Set valves in accordance with ASHRAE Standard 15.

c. Solenoid Valves: Comply with ARI 760 and UL 429, UL-listed, two-position, direct acting or pilot-operated, moisture and vapor-proof type of corrosion resisting materials, designed for intended service, and solder-end connections. Fitted with suitable NEMA 250 enclosure of type required by location and normally open or closed holding coil.

d. Thermostatic Expansion Valves: Comply with ARI 750. Brass body with stainless-steel or non-corrosive non-ferrous internal parts, diaphragm and spring-loaded (direct-operated) type with sensing bulb and distributor having side connection for hot-gas bypass and external equalizer. Size and operating characteristics as recommended by manufacturer of evaporator and factory set for superheat requirements. Solder-end connections. Testing and rating in accordance with ASHRAE Standard 17.

e. Check Valves: Brass or bronze alloy with swing or lift type, with tight closing resilient seals for silent operation; designed for low pressure drop, and with solder-end connections. Direction of flow shall be legibly and permanently indicated on the valve body.

4. Strainers: Designed to permit removing screen without removing strainer from piping system, and provided with screens 80 to 100 mesh in liquid lines DN 25 (NPS 1) and smaller, 60 mesh in liquid lines larger than DN 25 (NPS 1), and 40 mesh in suction lines. Provide strainers in liquid line serving each thermostatic expansion valve, and in suction line serving each refrigerant compressor not equipped with integral strainer.

5. Refrigerant Moisture/Liquid Indicators: Double-ported type having heavy sight glasses sealed into forged bronze body and incorporating means of indicating refrigerant charge and moisture indication. Provide screwed brass seal caps.

6. Refrigerant Filter-Dryers: UL listed, angle or inline type, as shown on drawings. Conform to ARI Standard 730 and ASHRAE Standard 63.1. Heavy gage steel shell protected with corrosion-resistant paint; perforated baffle plates to prevent desiccant bypass. Size as recommended by manufacturer for service and capacity of system with connection not less than the line size in which installed. Filter driers with replaceable filters shall be furnished with one spare element of each type and size.

7. Flexible Metal Hose: Seamless bronze corrugated hose, covered with bronze wire braid, with standard copper tube ends. Provide in suction and discharge piping of each compressor.

2.2 GAGES

A. Temperature Gages: Comply with ASME B40.200. Industrial-duty type and in required temperature range for service in which installed. Gages shall have Celsius scale in 1-degree (Fahrenheit scale in 2-degree) graduations and with black number on a white face. The pointer shall be

adjustable. Rigid stem type temperature gages shall be provided in thermal wells located within 1525 mm (5 feet) of the finished floor. Universal adjustable angle type or remote element type temperature gages shall be provided in thermal wells located 1525 to 2135 mm (5 to 7 feet) above the finished floor. Remote element type temperature gages shall be provided in thermal wells located 2135 mm (7 feet) above the finished floor.

B. Vacuum and Pressure Gages: Comply with ASME B40.100 and provide with throttling type needle valve or a pulsation dampener and shut-off valve. Gage shall be a minimum of 90 mm (3-1/2 inches) in diameter with a range from 0 kPa (0 psig) to approximately 1.5 times the maximum system working pressure. Each gage range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

1. Suction: 101 kPa (30 inches Hg) vacuum to 1723 kPa (gage) (250 psig).

2. Discharge: 0 to 3445 kPa (gage) (0 to 500 psig).

2.3 PIPE SUPPORTS

A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.4 REFRIGERANTS AND OIL

A. Provide EPA approved refrigerant and oil for proper system operation.

2.5 PIPE/CONDUIT ROOF PENETRATION COVER

A. Penetration Cover: Galvanized sheet metal with flanged removable top. Provide 38 mm (1-1/2 inch) thick mineral fiber board insulation.

B. Flashing Sleeves: Provide sheet metal sleeves for conduit and pipe penetrations of the penetration cover. Seal watertight penetrations.

2.6 PIPE INSULATION FOR DX HVAC SYSTEMS

A. Refer to specification Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install refrigerant piping and refrigerant containing parts in accordance with ASHRAE Standard 15 and ASME B31.5

1. Install piping as short as possible, with a minimum number of joints, elbow and fittings.

2. Install piping with adequate clearance between pipe and adjacent walls and hangers to allow for service and inspection. Space piping, including insulation, to provide 25 mm (1 inch) minimum clearance between adjacent piping or other surface. Use pipe sleeves through walls, floors, and ceilings, sized to permit installation of pipes with full thickness insulation.

3. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent

to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing.

4. Use copper tubing in protective conduit when installed below ground.

5. Install hangers and supports per ASME B31.5 and the refrigerant piping manufacturer's recommendations.

B. Joint Construction:

1. Brazed Joints: Comply with AWS "Brazing Handbook" and with filler materials complying with AWS A5.8/A5.8M.

a. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper tubing.

b. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

c. Swab fittings and valves with manufacturer's recommended cleaning fluid to remove oil and other compounds prior to installation.

d. Pass nitrogen gas through the pipe or tubing to prevent oxidation as each joint is brazed. Cap the system with a reusable plug after each brazing operation to retain the nitrogen and prevent entrance of air and moisture.

C. Protect refrigerant system during construction against entrance of foreign matter, dirt and moisture; have open ends of piping and connections to compressors, condensers, evaporators and other equipment tightly capped until assembly.

D. Pipe relief valve discharge to outdoors for systems containing more than 45 kg (100 lbs) of refrigerant.

E. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

F. Seismic Bracing: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS, for bracing of piping & equipment in seismic areas.

G. Provide access panels for all field-made refrigerant piping joints. Where possible, group multiple field-made joints in locations where a single access panel can be used for access.

3.2 PIPE AND TUBING INSULATION

A. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

3.3 SIGNS AND IDENTIFICATION

A. Each refrigerating system erected on the premises shall be provided with an easily legible permanent sign securely attached and easily accessible, indicating thereon the name and address of the installer, the kind and total number of pounds of refrigerant required in the system for normal operations, and the field test pressure applied.

3.4 FIELD QUALITY CONTROL

Prior to initial operation examine and inspect piping system for conformance to plans and specifications and ASME B31.5. Correct equipment, material, or work rejected because of defects or nonconformance with plans and specifications, and ANSI codes for pressure piping.

A. After completion of piping installation and prior to initial operation, conduct test on piping system according to ASME B31.5. Furnish materials and equipment required for tests. Perform tests in the presence of COR. If the test fails, correct defects and perform the test again until it is satisfactorily done and all joints are proved tight.

1. Every refrigerant-containing parts of the system that is erected on the premises, except compressors, condensers, evaporators, safety devices, pressure gages, control mechanisms and systems that are factory tested, shall be tested and proved tight after complete installation, and before operation.

2. The high and low side of each system shall be tested and proved tight at not less than the lower of the design pressure or the setting of the pressure-relief device protecting the high or low side of the system, respectively, except systems erected on the premises using non-toxic and non-flammable Group A1 refrigerants with copper tubing not exceeding DN 18 (NPS 5/8). This may be tested by means of the refrigerant charged into the system at the saturated vapor pressure of the refrigerant at 20 degrees C (68 degrees F) minimum.

B. Test Medium: A suitable dry gas such as nitrogen or shall be used for pressure testing. The means used to build up test pressure shall have either a pressure-limiting device or pressure-reducing device with a pressure-relief device and a gage on the outlet side. The pressure relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system components.

3.5 SYSTEM TEST AND CHARGING

A. System Test and Charging: As recommended by the equipment manufacturer or as follows:

1. Connect a drum of refrigerant to charging connection and introduce enough refrigerant into system to raise the pressure to 70 kPa (10 psi) gage. Close valves and disconnect refrigerant drum. Test system for leaks with halide test torch or other approved method suitable for the test gas used. Repair all leaking joints and retest.

2. Connect a drum of dry nitrogen to charging valve and bring test pressure to design pressure for low side and for high side. Test entire system again for leaks.

3. Evacuate the entire refrigerant system by the triplicate evacuation method with a vacuum pump equipped with an electronic gage reading in mPa (microns). Pull the system down to 665 mPa (500 microns) 665 mPa (2245.6 inches of mercury at 60 degrees F) and hold for four hours then break the vacuum with dry nitrogen (or refrigerant). Repeat the evacuation two more times breaking the third vacuum with

the refrigeration to be charged and charge with the proper volume of refrigerant.

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SECTION 23 31 00
HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Ductwork and accessories for HVAC including the following:

1. Supply Air, Return Air, and Exhaust systems.

2. Duct cleaning.

B. Definitions:

1. SMACNA Standards as used in this specification means the HVAC Duct Construction Standards, Metal and Flexible.

2. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.

3. Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.

4. Exposed Duct: Exposed to view in a finished room.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 07 84 00, FIRESTOPPING.

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

D. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

E. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

F. Section 23 37 00, AIR INLETS AND OUTLETS.

1.3 QUALITY ASSURANCE

A. Refer to article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Fire Safety Code: Comply with NFPA 90A.

C. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.

D. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA HVAC Air Duct Leakage Test Manual for duct pressure classes shown on the drawings.

E. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturer's Literature and Data:

1. Rectangular ducts:

a. Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, gage and reinforcement.

b. Duct liner.

c. Sealants and gaskets.

d. Access doors.

2. Round and flat oval duct construction details:

a. Manufacturer's details for duct fittings.

b. Duct liner.

c. Sealants and gaskets.

d. Access sections.

e. Installation instructions.

3. Volume dampers, back draft dampers.

4. Upper hanger attachments.

5. Flexible ducts and clamps, with manufacturer's installation instructions.

6. Flexible connections.

7. Instrument test fittings.

8. Details and design analysis of alternate or optional duct systems.

C. Coordination Drawings: Refer to article, SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

D. Test results.

1.5 APPLICABLE PUBLICATIONS

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

B. American Society of Civil Engineers (ASCE):

1. ASCE7-2017 Minimum Design Loads for Buildings and Other Structures

C. American Society for Testing and Materials (ASTM):

1. A167-2009 Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

2. A653-2019 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process

3. A1011-2018 Standard Specification for Steel, Sheet and Strip, Hot rolled, Carbon, structural, High-Strength Low-Alloy, High Strength Low-Alloy with Improved Formability, and Ultra-High Strength

4. B209-2014 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

5. C1071-2019 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

6. E84-2014 Standard Test Method for Surface Burning Characteristics of Building Materials

D. National Fire Protection Association (NFPA):

1. 90A-2018 Standard for the Installation of Air Conditioning and Ventilating Systems

2. 96-2018 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1. 3rd Edition - 2006 HVAC Duct Construction Standards, Metal and Flexible

2. 2nd Edition - 2012 HVAC Air Duct Leakage Test Manual

3. 6th Edition - 2016 Fibrous Glass Duct Construction Standards

F. Underwriters Laboratories, Inc. (UL):

1. 181-2013 Factory-Made Air Ducts and Air Connectors

PART 2 - PRODUCTS

2.1 DUCT MATERIALS AND SEALANTS

A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A653, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.

B. Joint Sealing: Refer to SMACNA HVAC Duct Construction Standards.

1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.

2. Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used on bare metal or on dry sealant.

3. Gaskets in Flanged Joints: Soft neoprene.

C. Approved factory-made joints may be used.

2.2 DUCT CONSTRUCTION AND INSTALLATION

A. Regardless of the pressure classifications outlined in the SMACNA Standards, fabricate and seal all ductwork in accordance with the following minimum pressure and sealing classifications (except where specifically noted otherwise on the drawings): 0 to 50 mm (2 inch) pressure rating, Class A sealing.

B. Round Ducts: Furnish duct and fittings made by the same manufacturer to insure good fit of slip joints. When submitted and approved in advance, round and flat oval duct, with size converted on the basis of equal pressure drop, may be furnished in lieu of rectangular duct design shown on the drawings.

1. Elbows: Diameters 80 through 200 mm (3 through 8 inches) shall be two sections die stamped, all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.

2. Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA HVAC Duct Construction Standards.

3. Ribbed Duct Option: Lighter gage round/oval duct and fittings may be furnished provided certified tests indicating that the rigidity and performance is equivalent to SMACNA standard gage ducts are submitted.

a. Ducts: Manufacturer's published standard gage, G90 coating, spiral lock seam construction with an intermediate standing rib.

b. Fittings: May be manufacturer's standard as shown in published catalogs, fabricated by spot welding and bonding with neoprene base cement or machine formed seam in lieu of continuous welded seams.

4. Provide flat side reinforcement of oval ducts as recommended by the manufacturer and SMACNA HVAC Duct Construction Standard S3.13. Because of high pressure loss, do not use internal tie-rod reinforcement unless approved by the COR.

C. Volume Dampers: Single blade or opposed blade, multi-louver type as detailed in SMACNA Standards. Refer to SMACNA Duct Construction Standards Figure 2-12 for Single Blade and Figure 2.13 for Multi-blade Volume Dampers.

D. Duct Hangers and Supports: Refer to SMACNA Standards Section IV. Avoid use of trapeze hangers for round duct.

2.3 DUCT LINER

A. Duct sizes shown on drawings for lined duct are clear opening inside lining.

B. Duct lining shall be applied with mechanical fasteners and 100 percent coverage of adhesive in conformance with SMACNA Duct Liner Application Standard.

2.4 DUCT ACCESS DOORS, PANELS AND SECTIONS

A. Provide access doors, sized and located for maintenance work, upstream, in the following locations:

1. Each duct mounted coil and humidifier.

2. Each automatic control damper.

B. Openings shall be as large as feasible in small ducts, 300 mm by 300 mm (12 inch by 12 inch) minimum where possible. Access sections in insulated ducts shall be double-wall, insulated. Transparent shatterproof covers are preferred for uninsulated ducts.

1. For rectangular ducts: Refer to SMACNA HVAC Duct Construction Standards (Figure 2-12).

2. For round duct: Refer to SMACNA HVAC duct Construction Standards (Figure 2-11).

2.5 FLEXIBLE AIR DUCT

A. General: Factory fabricated, complying with NFPA 90A for connectors not passing through floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance rating of one hour or more. Flexible duct length shall not exceed 1.5 m (5 feet). Provide insulated acoustical air duct connectors in supply air duct systems and elsewhere as shown.

B. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181. Ducts larger than 200 mm (8 inches) in diameter shall be Class 1. Ducts 200 mm (8 inches) in diameter and smaller may be Class 1 or Class 2.

C. Insulated Flexible Air Duct: Factory made including mineral fiber insulation with maximum C factor of 0.25 at 24 degrees C (75 degrees F) mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units. Acoustic insertion loss shall not be less than 3 dB per 300 mm (foot) of straight duct, at 500 Hz, based on 150 mm (6 inch) duct, of 750 m/min (2500 fpm).

D. Application Criteria:

1. Temperature range: -18 to 93 degrees C (0 to 200 degrees F) internal.

2. Maximum working velocity: 1200 m/min (4000 feet per minute).

3. Minimum working pressure, inches of water gage: 2500 Pa (10 inches) positive, 500 Pa (2 inches) negative.

E. Duct Clamps: 100 percent nylon strap, 80 kg (175 pounds) minimum loop tensile strength manufactured for this purpose or stainless steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.

2.6 FLEXIBLE DUCT CONNECTIONS

Where duct connections are made to fans, air terminal units, and air handling units, install a non-combustible flexible connection of 822 g (29 ounce) neoprene coated fiberglass fabric approximately 150 mm (6 inches) wide. For connections exposed to sun and weather provide hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A. Securely fasten flexible connections to round ducts with stainless steel or zinc-coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws 50 mm (2 inches) on center. Fabric shall not be stressed other than by air pressure. Allow at least 25 mm (one inch) slack to ensure that no vibration is transmitted.

2.7 FIRESTOPPING MATERIAL

A. Refer to Section 07 84 00, FIRESTOPPING.

2.8 SEISMIC RESTRAINT FOR DUCTWORK

A. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.

B. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:

1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.

2. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards. Provide streamliner, when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.

3. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA Standards.

4. Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.

C. Install duct hangers and supports in accordance with SMACNA Standards.

D. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.

E. Flexible duct installation:

1. Refer to SMACNA Standards, Chapter 3.

2. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long (NFPA 90A), adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with clamps as recommended by SMACNA. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket.

3. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including one-hour or two-hour fire-rated corridor partitions.

4. Support ducts per SMACNA Standards.

5. Provide 5' of flexible duct for each connection to air inlets & outlets in hard lid or T-bar ceilings in offices, consultation rooms, treatment rooms, and all acoustically sensitive spacesoffices, consultation rooms, treatment rooms, and all acoustically sensitive spaces. Flexible duct shall be installed coiled or with multiple bends to discourage sound transmission through the duct system.

F. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.

G. Control Damper Installation:

1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.

2. Assemble multiple sections dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.

3. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.

4. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.

H. Low Pressure Duct Liner: Install in accordance with SMACNA, Duct Liner Application Standard.

I. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition or return to source of supply for repair or replacement, as determined by COR. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to

existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2 TESTING, ADJUSTING AND BALANCING (TAB)

A. Refer to Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.3 OPERATING AND PERFORMANCE TESTS

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for two hours to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

- - - END - - -

SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Air Outlets and Inlets: Diffusers, Registers, and Grilles.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

D. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

E. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

1.3 QUALITY ASSURANCE

A. Refer to Article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Fire Safety Code: Comply with NFPA 90A.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer's Literature and Data:

1. Air intake/exhaust hoods.

2. Diffusers, registers, grilles and accessories.

C. Coordination Drawings: Refer to Article, SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.5 APPLICABLE PUBLICATIONS

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

B. Air Diffusion Council Test Code:

1. 1062 GRD-2015 Certification, Rating, and Test Manual 4th Edition

C. American Society of Civil Engineers (ASCE):

1. ASCE7-2017 Minimum Design Loads for Buildings and Other Structures

D. American Society for Testing and Materials (ASTM):

1. B209-2014 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

E. National Fire Protection Association (NFPA):

1. 90A-2018 Standard for the Installation of Air Conditioning and Ventilating Systems

F. Underwriters Laboratories, Inc. (UL):

1. 181-2013 UL Standard for Safety Factory-Made Air Ducts and Connectors

PART 2 - PRODUCTS

2.1 EQUIPMENT SUPPORTS

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.1 AIR OUTLETS AND INLETS

A. Materials:

1. Aluminum, Extruded: ASTM B221M (B221).

2. Aluminum, Plate and Sheet: ASTM B209M (B209); alloy 3003 or 5005 with temper as required for forming.

3. Provide all air inlets & outlets with manufacturer's standard gasket.

B. Fasteners

1. Exposed Fastenings:

a. Fasteners for aluminum inlets & outlets shall be stainless steel.

C. Contractor shall review all ceiling drawings and details and provide all ceiling mounted devices with appropriate dimensions and trim for the specific locations.

D. Performance Test Data: In accordance with Air Diffusion Council Code 1062GRD. Refer to Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT for NC criteria.

E. Air Supply Outlets:

1. Linear Bar Grilles and Diffusers: Extruded aluminum, manufacturer's standard finish, and positive holding concealed fasteners.

a. Margin Frame: Flat, 20 mm (3/4 inch) wide.

b. Bars: Minimum 5 mm (3/16 inch) wide by 20 mm (3/4 inch) deep, zero deflection unless otherwise shown. Bar spacing shall be a minimum of 3 mm (1/8 inch) on center. Reinforce bars on 450 mm (18 inch) center for sidewall units and on 150 mm (6 inch) center for units installed in floor or sills.

c. Provide opposed blade damper and equalizing or control grid where shown on drawings, drawing schedules, or where required elsewhere in the project documents.

F. Return and Exhaust Registers and Grilles:

1. Provide opposed blade damper without removable key operator for registers.

2. Finish

   a. Manufacturer's standard aluminum finish for duct-mounted units.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION, particularly regarding coordination with other trades and work in existing buildings.

B. Protection and Cleaning: Protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as determined by COR. Protect equipment during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.

3.2 TESTING, ADJUSTING AND BALANCING (TAB)

A. Refer to Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.3 OPERATING AND PERFORMANCE TESTS

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

3.4 START-UP AND INSTRUCTIONS

A. Check vibration and correct as necessary for air balance work.

B. After air balancing is complete and permanent sheaves are in place perform necessary field mechanical balancing to meet vibration tolerance in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

3.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for four hours to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

- - - END - - -

SECTION 23 81 23

COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies process cooling split systems air conditioning unit.

B. Definitions:

1. Energy Efficiency Ratio (EER): A ratio calculated by dividing the cooling capacity in Btuh by the power input in watts at any given set of rating conditions, expressed in Watts (Btu/h) per watt.

2. Coefficient of Performance (COP): A ratio calculated by dividing the change in heating or cooling capacity (Btu/h) to the energy consumed by the system (kW), expressed in Btu/kWh.

3. Unitary (AHRI): Consists of one or more factory-made assemblies, which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function.

4. CRAC Units: Computer Room Air Conditioning Units.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

D. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

E. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

F. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

G. Section 23 23 00, REFRIGERANT PIPING.

H. Section 23 31 00, HVAC DUCTS and CASINGS.

1.3 QUALITY ASSURANCE

A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.4 SUBMITTALS

A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer’s Literature and Data rated capacities (at design indoor and outdoor conditions), EER/COP, operating characteristics, required specialties and accessories. Submit published catalog selection data showing equipment ratings and compliance with required sensible ratio.

1. Indoor Air Conditioning Unit

2. Air Cooled Condensing Unit

3. Accessories

C. Submit detailed equipment assemblies with dimensions, operating weights, required clearances.

D. Submit wiring diagrams for power, alarm and controls.

E. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 GUARANTEE

A. The unit shall be guaranteed against all mechanical defects in material, parts or workmanship and shall be repaired or replaced at the Contractor's expense within the period of one year from final acceptance. Contractor shall adhere to a four-hour service response time to troubles during the guarantee period.

B. Provide the following manufacturer's extended warranties for all CRAC systems:

1. 1-Year labor warranty covering labor to replace components that fail during 1st year of standard parts-only warranty.

2. 5-Year parts-only warranty for all components (other than compressors).

3. 5-Year parts-only warranty for compressors.

1.6 APPLICABLE PUBLICATIONS

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

B. Federal Specifications (Fed Spec):

1. 00-A-374C-1999 Air-Conditioners with Remote Condensing Units or Remote Air-cooled and Water-Cooled Condenser Units, Unitary

2. TT-C-490D-1993 Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings

C. Air-Conditioning, Heating and Refrigeration Institute (AHRI) Standards:

1. 210/240-2017 Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment

2. 340/360-2015 Performance Rating of Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment

3. 410-2001 Forced-Circulation Air-Cooling and Air-Heating Coils

4. 460-2005 Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers

5. 520-2004 Performance Rating of Positive Displacement Condensing Units

6. DCPP-2008 Directory of Certified Product Performance - Applied Directory of Certified Products

D. Air Movement and Control Association (AMCA):

1. 210-2016 Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating (ANSI)

2. 410-1996 Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

E. American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc. (ASHRAE):

1. 15-2019 Safety Standard for Refrigeration Systems (ANSI)

2. Handbook 2016 HVAC Systems and Equipment

3. Handbook 2018 Refrigeration

4. 52.1-1992 Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices used in General Ventilation for Removing Particulate Matter

5. 62-1-2016 Ventilation for Acceptable Indoor Air Quality (ANSI)

6. 90.1-2016 Energy Standard for Buildings except Low-Rise Residential Buildings (ANSI Approved; IESNA Co-sponsored)

F. American Society of Testing and Materials (ASTM):

1. B117-2017 Standard Practice for Operating Salt Spray (Fog) Apparatus

G. National Electrical Manufacturer's Association (NEMA):

1. MG 1-2019 Motors and Generators (ANSI)

H. National Fire Protection Association (NFPA) Publications:

1. 70-2020 National Electrical Code

2. 90A-2018 Standard for the Installation of Air-Conditioning and Ventilating Systems

PART 2 - PRODUCTS

2.1 CEILING-MOUNTED UNITS (2-3 TON) (TR'S)

A. Evaporator Cabinet Construction

1. The cabinet and chassis shall be constructed of heavy gauge galvanized steel, and shall be serviceable from one side. Mounting brackets shall be integral to the cabinet design. Internal cabinet insulation shall meet ASHRAE 62.1 requirements for Mold Growth, Humidity & Erosion, tested per UL 181 and ASTM 1338 standards.

B. Air Distribution

1. The air distribution system shall be constructed with a quiet, direct-drive fan assembly equipped with double-inlet blower, self-aligning ball bearings and lifetime lubrication. Fan motor shall be permanent-split capacitor, high-efficiency type, equipped with two speeds for airflow modulation. The microprocessor controller shall use the lower fan speed for precise dehumidification control. Fan speed shall also be user selectable from the wall controller.

2. System shall be suitable for supply and return air plenum or ducted supply and return air distribution.

C. Microprocessor Control

1. The control system shall be microprocessor-based, factory-wired into the system and tested prior to shipment. The wall-mounted controller shall include a 2-line by 16-character character liquid crystal display (LCD) providing continuous display of operating status and alarm condition and shall be capable of displaying values in °F or °C. An 8-key membrane keypad for setpoint/ program control, fan speed selection and unit On/Off shall be located below the display. Controller shall be password protected to prevent unauthorized set point adjustments. Field-supplied 4-conductor thermostat wire shall be used to connect the wall-mounted controller to the unit control board.

2. Temperature and humidity sensors shall be located in the wall controller, which shall be capable of being located up to 300 ft (91.4m) from the evaporator unit when using a remote temperature/humidity sensor in the conditioned space.

3. Monitoring

a. The LCD shall provide On/Off indication, operating mode indication (cooling, heating, humidifying, dehumidifying), fan speed indication and current day, time, temperature and humidity (if applicable) indication. The monitoring system shall be capable of relaying unit operating parameters and alarms to the Liebert IS-UNITY-DP, Liebert iCOM-CMS or Liebert® SiteScan monitoring systems.

4. Unit Controls

a. Compressor Short-Cycle Control

1) The control system shall prevent compressor short-cycling by a 3-minute timer from compressor stop to the next start.

b. Common Alarm and Remote On/Off

1) A common alarm relay shall provide a contact closure to a remote alarm device. Two (2) terminals shall also be provided for remote On/Off control. Individual alarms shall be “enabled” or “disabled” from reporting to the common alarm.

c. Setback Control

1) The control shall be user-configurable to use a manual setpoint control or a programmable, time-based setback control. The setback control will be based on a 5 day/2 day

programmed weekly schedule with capability of accepting 2 events per program day.

d. Temperature Calibration

1) The control shall include the capabilities to calibrate the temperature and humidity sensors and adjust the sensor response delay time from 0 to 90 seconds. The control shall be capable of displaying temperature values in ˚F or ˚C.

e. System Auto Restart

1) For startup after power failure, the system shall provide automatic restart with a programmable (up to 9.9 minutes in 6-second increments) time delay. Programming can be performed either at the wall-mounted controller or from the central, site-monitoring system.

D. Electrical Switches and Sensors

1. Disconnect Switch, Non-Locking

a. The non-automatic, non-locking, molded case circuit interrupter shall be factory mounted in the high-voltage section of the electrical panel. The switch handle shall be accessible from the unit front.

2. High-Temperature Sensor

a. The high-temperature sensor shall immediately shut down the system when high temperatures (125˚F, 51.7˚C) are detected. The high-temperature sensor shall be mounted with the sensing element in the return air.

3. Filter Clog Switch

a. The filter clog switch senses pressure drop across the filters and shall annunciate the controller upon exceeding the adjustable setpoint.

E. Alarms

1. Unit Alarm

a. The control system shall monitor unit operation and activate an audible and visual alarm in the event of the following factory preset alarm conditions:

1) High Temperature

2) Low Temperature

3) High Humidity

4) Low Humidity

5) High Water Alarm - Lockout Unit Operation

6) High Head Pressure

7) Loss of Power

8) Compressor Short Cycle

2. Custom Alarms

a. Humidifier Problem

b. Filter Clog

c. Water Detected

d. Smoke Detected

e. Custom 1

f. Custom 2

g. User-customized text can be entered for the two (2) custom alarms.

3. Alarm Controls

a. Each alarm (unit and custom) shall be individually enabled or disabled (except for high head pressure and high water in condensate pan) and can be programmed for a time delay of 0 to 255 seconds of continuous alarm condition to be recognized as an alarm. Each alarm can also be enabled or disabled to activate the common alarm (except high head pressure and high water in condensate pan).

4. Audible Alarm

a. The audible alarm shall annunciate at the wall-mounted controller any alarm that is enabled by the operator.

5. Common Alarm

a. A programmable common alarm shall be provided to interface user selected alarms with a remote alarm device. Alarms shall be enabled or disabled from reporting to the common alarm.

6. Remote Monitoring

a. All alarms shall be communicated to the Liebert® remote monitoring system with the following information: date and time of occurrence, unit number and present temperature and humidity.

F. Direct Expansion System Evaporator Components

1. Direct Expansion Coil

a. The evaporator section shall include evaporator coil, thermostatic expansion valve and filter drier.

b. The evaporator coil shall be constructed of copper tubes and aluminum fins. An externally equalized thermostatic expansion valve shall control refrigerant flow. The refrigerant piping shall be spun-closed and filled with a nitrogen holding charge. Field relief of the Schrader valves shall indicate a leak-free system. Evaporator and condensing unit shall be field piped using copper lines, brazed, evacuated and field charged with R-407C

refrigerant. The evaporator unit can be coupled directly with the condensing unit or mounted remote to the condensing unit.

c. The coil assembly shall be mounted in a condensate drain pan with an internally trapped drain line. The evaporator drain pan shall include a factory-installed float switch to shut down the evaporator upon high water condition

G. Indoor Air-Cooled Centrifugal Fan Condensing Unit

1. Condensing unit components shall include condenser coil, scroll compressor, high-pressure switch, refrigerant receiver, head pressure control valve, hot gas bypass system and liquid line solenoid valve. A non-automatic, non-locking, molded case disconnect switch shall be factory mounted in the high voltage section of the electrical panel. The switch handle shall be accessible form the unit front. The cabinet and chassis shall be constructed of heavy gauge galvanized steel, and shall be serviceable from one side. Mounting brackets shall be integral to the cabinet design and be designed for ceiling mounting.

2. The hot gas bypass circuit shall be provided to reduce compressor cycling and improve operation under low-load conditions. The hot gas bypass shall be completely contained in the condensing unit. Field installed third refrigerant line shall not be acceptable. Hot gas bypass shall be automatically deactivated upon a call for dehumidification.

3. High pressure switch shall protect the unit from abnormal refrigerant pressure conditions and shall deactivate the compressor and annunciate an alarm at the wall controller. The blower shall continue to circulate air. The wall controller shall be used to manually restart the compressor function after the automatic pressure switch resets. Three high head pressure alarms in a rolling 12-hour period shall lock out the manual restart feature until power is cycled to the evaporator unit.

4. A pressure balancing valve shall be factory installed to reduce the chance of high pressure cut-out due to excessive refrigerant migration to the receiver due to changing outdoor temperatures during off-cycles.

5. The refrigerant piping shall be spun-closed and filled with a nitrogen holding charge. Field relief of the Schrader valves shall indicate a leak-free system. Evaporator and condensing unit shall be field piped using copper lines, brazed, evacuated and field charged with R-407C refrigerant. Condensing unit shall be designed for 95°F (35°C) ambient and be capable of operation to -30°F (-34°C). The condensing unit can be mounted directly to the evaporator or can be mounted remote to the evaporator.

6. The condensing coil shall be constructed of copper tubes and aluminum fins. The condenser fan shall be centrifugal type, double inlet, direct drive and shall operate at 1050 RPM (890 RPM @ 50 Hz).

H. Outdoor Air-Cooled Prop Fan Condensing Unit

1. The condensing unit shall be designed for outdoor use with either roof or ground level mounting. The condensing unit is constructed

of galvanized and galvanneal painted steel for corrosion resistance. Removable exterior panels shall allow access to the electric panel or refrigeration components for service or maintenance. Both inlet and outlet air grilles shall be heavy duty steel with a durable polyester coating.

2. Condensing unit components shall include a condenser coil, a direct-drive propeller-type fan, a scroll compressor, high-pressure switch, refrigerant receiver and head pressure control valve, hot gas bypass system and liquid line solenoid valve. The condensing coil shall be constructed of copper tubes and aluminum fins.

3. The hot gas bypass circuit shall be provided to reduce compressor cycling and improve operation under low-load conditions. In split systems, the hot gas bypass shall be completely contained in the condensing unit. Field installed third refrigerant line shall not be acceptable. Hot gas bypass shall be automatically deactivated upon a call for dehumidification.

4. High pressure switch shall protect the unit from abnormal refrigerant pressure conditions and shall deactivate the compressor and annunciate an alarm at the wall controller. The blower shall continue to circulate air. The wall controller shall be used to manually restart the compressor function after the automatic pressure switch resets. Three high head pressure alarms in a rolling 12-hour period shall lock out the manual restart feature until power is cycled to the evaporator unit.

5. A pressure balancing valve shall be factory installed to reduce the chance of high pressure cut-out due to excessive refrigerant migration to the receiver due to changing outdoor temperatures during off-cycles.

6. The refrigerant piping shall be spun-closed and filled with a nitrogen holding charge. Field relief of the Schrader valves shall indicate a leak-free system. Evaporator and condensing unit shall be field piped using copper lines, brazed, evacuated and field charged with R-407C refrigerant. Condensing unit shall be designed for 95˚F (35˚C) ambient and be capable of operation to -30˚F (-34.4˚C).

7. The condenser coil shall be constructed of copper tubes and aluminum fins.

I. Factory-Installed Options

1. Steam Generating Humidifier

a. The Thermal Management system shall be equipped with a steam generating humidifier that is controlled by the microprocessor control system. It shall be complete with disposable canister, all supply and drain valves, 1" (25.4mm) air gap on fill line, inlet strainer, steam distributor and electronic controls. The need to change canister shall be annunciated on the wall-mounted controller. The humidifier shall have a capacity of 4.3 lb/hr (2.0 kg/h). An LED light on the humidifier assembly shall indicate cylinder full, overcurrent detection, fill system fault and end of cylinder life conditions. The canister flush water

shall not drain into the coil drain pan, due to risk of aggressive corrosion of the evaporator coil. The humidifier wand shall be mounted over the coil drain pan.

2. Electric Reheat

a. The electric reheat shall be low-watt density, 304/304 stainless steel, finned-tubular and shall be capable of maintaining room dry bulb temperature conditions when the system is calling for dehumidification. The reheat section shall include a UL-approved safety switch to protect the system from overheating. A ground current detector shall be factory installed to shut-down the entire unit if a ground fault in the reheat system is detected.

b. The capacity of the reheat coils shall be controlled in one stage.

3. Smoke Sensor

a. The smoke sensor shall immediately shut down the Thermal Management system and activate the alarm system when activated. The sensing element shall be located in the return air compartment. This smoke sensor shall not function or replace any room smoke detection system that may be required by local or national codes.

4. Remote Monitoring and Control - DDC Connections

a. The IS-UNITY-DP BMS Monitoring Solution shall provide SNMP v1/v2c/v3, BACnet IP, BACnet MSTP, Modbus TCP/IP, and Modbus RTU monitoring capability to the CRAC system. Card shall employ Ethernet and RS-485 networks to monitor and manage a wide range of operating parameters pertaining to the cooling system. The Unity card shall provide access to the CRAC unit remotely via a web interface and shall support Liebert Nform™ connectivity. The adapter card shall be factory mounted inside an enclosure on the outside of the CRAC unit and shall be factory wired for power and unit communications. Ethernet cable providing network access to the world-wide web or to a BMS shall be field wired.

J. Factory-Supplied, Field-Installed Accessories

1. Remote Sensors

a. The unit shall be supplied with remote temperature and humidity sensors. The sensors shall be connected to the unit by a shielded cable.

2. Air Filter Box

a. The evaporator section shall be supplied with an air filter box for use with ducted installations. One (1) filter shall be included 4" x 20" x 20" (102 mm x 508mm x 508mm), deep-pleated type, with a MERV 8 rating, based on ASHRAE 52.2-2007.

3. Air Distribution Plenum

a. The evaporator section shall be supplied with an air distribution plenum with integral filter. The plenum shall be 24" x 48" (610mm

x 1219mm) in size and shall provide 3-way air distribution, for installation into a standard 24" x 48" (610mm x 1219mm) ceiling grid. Filter size shall be 4" x 16" x 25" (102 mm x 406mm x 535 mm), deep pleated type with MERV 8 rating, based on ASHRAE 52.2-2007.

4. High Static Blower Assembly

   a. A blower box shall be field attached to the evaporator to provide up to 2.0" (51mm) of external static pressure on the discharge side of the evaporator. The blower box shall contain a centrifugal type, double inlet blower, with belt drive and single speed motor, mounted to an adjustable motor base.

5. Condensate Pump

   a. The condensate pump shall be complete with integral float switch, pump, motor assembly and reservoir. A secondary float switch on the condensate pump shall tie into the unit to provide an alarm on the wall-mounted controller and shut down the unit upon high water in the basin of the pump. Condensate pump shall be powered from the CRAC unit. A separate electrical feed is not acceptable.

2.2 FLOOR MOUNTED, DOWNFLOW UNITS (20-30 TONS) (MCR)

A. XXX

2.3 SPECIAL TOOLS

A. If any part of equipment furnished under these specifications requires a special tool for assembly, adjustment, setting, or maintenance and the tool is not readily available from the commercial tool market, furnish the necessary tools with equipment as a standard accessory.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Handle and install refrigeration units and accessories in accordance with the instructions and recommendations of the manufacturer.

B. Coordinate installation of Computer room Air Conditioning Units with Computer room access flooring installer.

C. Field Refrigerant Piping: As specified in specification Section 23 23 00, REFRIGERANT PIPING.

D. Electrical System Connections and Equipment Ground: As specified in Division 26 Sections.

3.2 CONNECTIONS

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

B. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Install piping adjacent to machine to allow service and maintenance.

D. Water and Drainage Connections: Comply with applicable requirements in Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING and Section 22 11 00, FACILITY WATER DISTRIBUTION. Provide adequate connections for condensate drain and humidifier flushing system.

E. Refrigerant Piping: Comply with applicable requirements in Section 23 23 00, REFRIGERANT PIPING. Provide shutoff valves and piping.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.

2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. After startup service and performance test, change filters and flush humidifier.

3.4 STARTUP AND TESTING

A. Manufacturer's field service technician shall provide warranty start-up supervision and assist in programming of unit(s) controls and ancillary panels supplied as part of the manufacturer's computer room air conditioning system.

B. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum of seven days prior notice.

C. Provide services of manufacturer’s technical representative for four hours to instruct VA personnel in operation and maintenance of computer room air conditioning equipment.

3.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for four hours to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

- - - END - - -

SECTION 26 05 11
REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section applies to all sections of Division 26.

B. Furnish and install electrical systems, materials, equipment, and accessories in accordance with the specifications and drawings. Capacities and ratings of motors, conductors and cable, panelboards, and other items and arrangements for the specified items are shown on the drawings.

C. Conductor ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways sized per NEC. Aluminum conductors are prohibited.

1.2 MINIMUM REQUIREMENTS

A. The latest International Building Code (IBC), Underwriters Laboratories, Inc. (UL), Institute of Electrical and Electronics Engineers (IEEE), and National Fire Protection Association (NFPA) codes and standards are the minimum requirements for materials and installation.

B. The drawings and specifications shall govern in those instances where requirements are greater than those stated in the above codes and standards.

1.3 TEST STANDARDS

A. All materials and equipment shall be listed, labeled, or certified by a Nationally Recognized Testing Laboratory (NRTL) to meet Underwriters Laboratories, Inc. (UL), standards where test standards have been established. Materials and equipment which are not covered by UL standards will be accepted, providing that materials and equipment are listed, labeled, certified or otherwise determined to meet the safety requirements of a NRTL. Materials and equipment which no NRTL accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial

standards, such as ANSI, NEMA, and NETA. Evidence of compliance shall include certified test reports and definitive shop drawings.

B. Definitions:

1. Listed: Materials and equipment included in a list published by an organization that is acceptable to the Authority Having Jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production or listed materials and equipment or periodic evaluation of services, and whose listing states that the materials and equipment either meets appropriate designated standards or has been tested and found suitable for a specified purpose.

2. Labeled: Materials and equipment to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the Authority Having Jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled materials and equipment, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3. Certified: Materials and equipment which:

a. Have been tested and found by a NRTL to meet nationally recognized standards or to be safe for use in a specified manner.

b. Are periodically inspected by a NRTL.

c. Bear a label, tag, or other record of certification.

4. Nationally Recognized Testing Laboratory: Testing laboratory which is recognized and approved by the Secretary of Labor in accordance with OSHA regulations.

1.4 QUALIFICATIONS (PRODUCTS AND SERVICES)

A. Manufacturer’s Qualifications: The manufacturer shall regularly and currently produce, as one of the manufacturer's principal products, the materials and equipment specified for this project, and shall have manufactured the materials and equipment for at least three years.

B. Product Qualification:

1. Manufacturer's materials and equipment shall have been in satisfactory operation, on three installations of similar size and type as this project, for at least three years.

2. The Government reserves the right to require the Contractor to submit a list of installations where the materials and equipment have been in operation before approval.

C. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within eight hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.5 APPLICABLE PUBLICATIONS

A. Applicable publications listed in all Sections of Division 26 shall be the latest issue, unless otherwise noted.

B. Products specified in all sections of Division 26 shall comply with the applicable publications listed in each section.

1.6 MANUFACTURED PRODUCTS

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, and for which replacement parts shall be available. Materials and equipment furnished shall be new and shall have superior quality and freshness.

B. When more than one unit of the same class or type of materials and equipment is required, such units shall be the product of a single manufacturer.

C. Equipment Assemblies and Components:

1. Components of an assembled unit need not be products of the same manufacturer.

2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.

3. Components shall be compatible with each other and with the total assembly for the intended service.

4. Constituent parts which are similar shall be the product of a single manufacturer.

D. Factory wiring and terminals shall be identified on the equipment being furnished and on all wiring diagrams.

E. When Factory Tests are specified, Factory Tests shall be performed in the factory by the equipment manufacturer and witnessed by the contractor. In addition, the following requirements shall be complied with:

1. The Government shall have the option of witnessing factory tests. The Contractor shall notify the Government through the COR a minimum of thirty (30) days prior to the manufacturer’s performing of the factory tests.

2. When factory tests are successful, contractor shall furnish four (4) copies of the equipment manufacturer’s certified test reports to the COR fourteen (14) days prior to shipment of the equipment, and not more than ninety (90) days after completion of the factory tests.

3. When factory tests are not successful, factory tests shall be repeated in the factory by the equipment manufacturer and witnessed by the Contractor. The Contractor shall be liable for all additional expenses for the Government to witness factory re-testing.

1.7 VARIATIONS FROM CONTRACT REQUIREMENTS

A. Where the Government or the Contractor requests variations from the contract requirements, the connecting work and related components shall include, but not be limited to additions or changes to branch circuits, circuit protective devices, conduits, wire, feeders, controls, panels and installation methods.

1.8 MATERIALS AND EQUIPMENT PROTECTION

A. Materials and equipment shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.

1. Store materials and equipment indoors in clean dry space with uniform temperature to prevent condensation.

2. During installation, equipment shall be protected against entry of foreign matter, and be vacuum cleaned both inside and outside before testing and operating. Compressed air shall not be used to clean equipment. Remove loose packing and flammable materials from inside equipment.

3. Damaged equipment shall be repaired or replaced, as determined by the COR.

4. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.

5. Damaged paint on equipment shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

1.9 WORK PERFORMANCE

A. All electrical work shall comply with requirements of the latest NFPA 70 (NEC), NFPA 70B, NFPA 70E, NFPA 99, NFPA 110, OSHA Part 1910 subpart J – General Environmental Controls, OSHA Part 1910 subpart K – Medical and First Aid, and OSHA Part 1910 subpart S – Electrical, in addition to other references required by contract.

B. Job site safety and worker safety is the responsibility of the Contractor.

C. Electrical work shall be accomplished with all affected circuits or equipment de-energized. However, energized electrical work may be performed only for the non-destructive and non-invasive diagnostic testing(s), or when scheduled outage poses an imminent hazard to patient care, safety, or physical security. In such case, all aspects of energized electrical work, such as the availability of

appropriate/correct personal protective equipment (PPE) and the use of PPE, shall comply with the latest NFPA 70E, as well as the following requirements:

1. Only Qualified Person(s) shall perform energized electrical work. Supervisor of Qualified Person(s) shall witness the work of its entirety to ensure compliance with safety requirements and approved work plan.

2. At least two weeks before initiating any energized electrical work, the Contractor and the Qualified Person(s) who is designated to perform the work shall visually inspect, verify and confirm that the work area and electrical equipment can safely accommodate the work involved.

3. At least two weeks before initiating any energized electrical work, the Contractor shall develop and submit a job specific work plan, and energized electrical work request to the COR, and Medical Center's Chief Engineer or his/her designee. At the minimum, the work plan must include relevant information such as proposed work schedule, area of work, description of work, name(s) of Supervisor and Qualified Person(s) performing the work, equipment to be used, procedures to be used on and near the live electrical equipment, barriers to be installed, safety equipment to be used, and exit pathways.

4. Energized electrical work shall begin only after the Contractor has obtained written approval of the work plan, and the energized electrical work request from the COR, and Medical Center's Chief Engineer or his/her designee. The Contractor shall make these approved documents present and available at the time and place of energized electrical work.

5. Energized electrical work shall begin only after the Contractor has invited and received acknowledgment from the COR, and Medical Center's Chief Engineer or his/her designee to witness the work.

D. For work that affects existing electrical systems, arrange, phase and perform work to assure minimal interference with normal functioning of

the facility. Refer to Article OPERATIONS AND STORAGE AREAS under Section 01 00 00, GENERAL REQUIREMENTS.

E. New work shall be installed and connected to existing work neatly, safely and professionally. Disturbed or damaged work shall be replaced or repaired to its prior conditions, as required by Section 01 00 00, GENERAL REQUIREMENTS.

F. Coordinate location of equipment and conduit with other trades to minimize interference.

1.10 EQUIPMENT INSTALLATION AND REQUIREMENTS

A. Equipment location shall be as close as practical to locations shown on the drawings.

B. Working clearances shall not be less than specified in the NEC.

C. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not readily accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Government.

2. "Readily accessible” is defined as being capable of being reached quickly for operation, maintenance, or inspections without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.

1.11 EQUIPMENT IDENTIFICATION

A. In addition to the requirements of the NEC, install an identification sign which clearly indicates information required for use and maintenance of items such as panelboards, cabinets, fused and non-fused safety switches, separately enclosed circuit breakers, control devices and other significant equipment.

B. Identification signs for Normal Power System equipment shall be laminated black phenolic resin with a white core with engraved lettering. Identification signs for Essential Electrical System (EES) equipment, as defined in the NEC, shall be laminated red phenolic resin

with a white core with engraved lettering. Lettering shall be a minimum of 12 mm (1/2 inch) high. Identification signs shall indicate equipment designation, rated bus amperage, voltage, number of phases, number of wires, and type of EES power branch as applicable. Secure nameplates with screws.

C. Install adhesive arc flash warning labels on all equipment as required by the latest NFPA 70E. Label shall show specific and correct information for specific equipment based on its arc flash calculations. Label shall show the followings:

1. Nominal system voltage.
2. Equipment/bus name, date prepared, and manufacturer name and address.
3. Arc flash boundary.
4. Available arc flash incident energy and the corresponding working distance.
5. Minimum arc rating of clothing.
6. Site-specific level of PPE.

1.12 SUBMITTALS

A. Submit to the COR in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. The Government's approval shall be obtained for all materials and equipment before delivery to the job site. Delivery, storage or installation of materials and equipment which has not had prior approval will not be permitted.

C. All submittals shall include six copies of adequate descriptive literature, catalog cuts, shop drawings, test reports, certifications, samples, and other data necessary for the Government to ascertain that the proposed materials and equipment comply with drawing and specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify specific materials and equipment being submitted.

D. Submittals for individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.

1. Mark the submittals, "SUBMITTED UNDER SECTION 26 05 11 ".

2. Submittals shall be marked to show specification reference including the section and paragraph numbers.

3. Submit each section separately.

E. The submittals shall include the following:

1. Information that confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, manuals, pictures, nameplate data, and test reports as required.

2. Submittals are required for all equipment anchors and supports. Submittals shall include weights, dimensions, center of gravity, standard connections, manufacturer's recommendations and behavior problems (e.g., vibration, thermal expansion, etc.) associated with equipment or piping so that the proposed installation can be properly reviewed. Include sufficient fabrication information so that appropriate mounting and securing provisions may be designed and attached to the equipment.

3. Elementary and interconnection wiring diagrams for communication and signal systems, control systems, and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams.

4. Parts list which shall include information for replacement parts and ordering instructions, as recommended by the equipment manufacturer.

F. Maintenance and Operation Manuals:

1. Submit as required for systems and equipment specified in the technical sections. Furnish in hardcover binders or an approved equivalent.

2. Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the

system, material, equipment, building, name of Contractor, and contract name and number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the material or equipment.

3. Provide a table of contents and assemble the manual to conform to the table of contents, with tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in.

4. The manuals shall include:

   a. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.

   b. A control sequence describing start-up, operation, and shutdown.

   c. Description of the function of each principal item of equipment.

   d. Installation instructions.

   e. Safety precautions for operation and maintenance.

   f. Diagrams and illustrations.

   g. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers.

   h. Performance data.

   i. Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare and replacement parts, and name of servicing organization.

   j. List of factory approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.

G. Approvals will be based on complete submission of shop drawings, manuals, test reports, certifications, and samples as applicable.

H. After approval and prior to installation, furnish the COR with one sample of each of the following:

1. A minimum 300 mm (12 inches) length of each type and size of wire and cable along with the tag from the coils or reels from which the sample was taken. The length of the sample shall be sufficient to show all markings provided by the manufacturer.

2. Each type of conduit coupling, bushing, and termination fitting.

3. Conduit hangers, clamps, and supports.

4. Duct sealing compound.

5. Each type of receptacle, toggle switch, lighting control sensor, outlet box, manual motor starter, device wall plate, engraved nameplate, wire and cable splicing and terminating material, and branch circuit single pole molded case circuit breaker.

1.13 SINGULAR NUMBER

A. Where any device or part of equipment is referred to in these specifications in the singular number (e.g., "the switch"), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

1.14 ACCEPTANCE CHECKS AND TESTS

A. The Contractor shall furnish the instruments, materials, and labor for tests.

B. Where systems are comprised of components specified in more than one section of Division 26, the Contractor shall coordinate the installation, testing, and adjustment of all components between various manufacturer’s representatives and technicians so that a complete, functional, and operational system is delivered to the Government.

C. When test results indicate any defects, the Contractor shall repair or replace the defective materials or equipment and repeat the tests for the equipment. Repair, replacement, and re-testing shall be accomplished at no additional cost to the Government.

1.15 WARRANTY

A. All work performed and all equipment and material furnished under this Division shall be free from defects and shall remain so for a period of one year from the date of acceptance of the entire installation by the Contracting Officer for the Government.

1.16 INSTRUCTION

A. Instruction to designated Government personnel shall be provided for the particular equipment or system as required in each associated technical specification section.

B. Furnish the services of competent and factory-trained instructors to give full instruction in the adjustment, operation, and maintenance of the specified equipment and system, including pertinent safety requirements. Instructors shall be thoroughly familiar with all aspects of the installation and shall be factory-trained in operating theory as well as practical operation and maintenance procedures.

C. A training schedule shall be developed and submitted by the Contractor and approved by the COR at least 30 days prior to the planned training.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

- - - END - - -

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of the electrical conductors and cables for use in electrical systems rated 600 V and below, indicated as cable(s), conductor(s), wire, or wiring in this section.

1.2 RELATED WORK

A. Section 07 84 13, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire-resistant rated construction.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for conductors and cables.

E. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Installation of conductors and cables in manholes and ducts.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES and the following requirements:

1. Shop Drawings:

a. Submit sufficient information to demonstrate compliance with drawings and specifications.

b. Submit the following data for approval:

1) Electrical ratings and insulation type for each conductor and cable.

2) Splicing materials and pulling lubricant.

2. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the manufacturer that the conductors and cables conform to the requirements of the drawings and specifications.

b. Certification by the Contractor that the conductors and cables have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are reference in the text by designation only.

B. American Society of Testing Material (ASTM):

D2301-10 .....Standard Specification for Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape

D2304-10 .....Test Method for Thermal Endurance of Rigid Electrical Insulating Materials

D3005-10 .....Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape

C. National Electrical Manufacturers Association (NEMA):

WC 70-09 .....Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy

D. National Fire Protection Association (NFPA):

70-17 .....National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL):

44-14 .....Thermoset-Insulated Wires and Cables

83-14 .....Thermoplastic-Insulated Wires and Cables

467-13 .....Grounding and Bonding Equipment

486A-486B-13 .....Wire Connectors

486C-13 .....Splicing Wire Connectors

486D-15 .....Sealed Wire Connector Systems

486E-15 .....Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors

493-07 .....Thermoplastic-Insulated Underground Feeder and Branch Circuit Cables

514B-12 .....Conduit, Tubing, and Cable Fittings

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Conductors and cables shall be in accordance with ASTM, NEMA, NFPA, UL, as specified herein, and as shown on the drawings.

B. All conductors shall be copper.

C. Single Conductor and Cable:

1. No. 12 AWG: Minimum size, except where smaller sizes are specified herein or shown on the drawings.

2. No. 8 AWG and larger: Stranded.

3. No. 10 AWG and smaller: Solid OR stranded; use stranded for final connection to motors, transformers, and vibrating equipment.

4. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.

D. Color Code:

1. No. 10 AWG and smaller: Solid color insulation or solid color coating.

2. No. 8 AWG and larger: Color-coded using one of the following methods:

   a. Solid color insulation or solid color coating.

   b. Stripes, bands, or hash marks of color specified.

   c. Color using 19 mm (0.75 inches) wide tape.

4. For modifications and additions to existing wiring systems, color coding shall conform to the existing wiring system.

5. Conductors shall be color-coded as follows:

208/120 V	Phase	480/277 V
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray *
* or white with colored (other than green) tracer.		

6. Lighting circuit “switch legs”, and 3-way and 4-way switch “traveling wires”, shall have color coding that is unique and distinct (e.g., pink and purple) from the color coding indicated above. The unique color codes shall be solid and in accordance with the NEC. Coordinate color coding in the field with the COR.

7. Color code for isolated power system wiring shall be in accordance with the NEC.

2.2 SPLICES

A. Splices shall be in accordance with NEC and UL.

B. Above Ground Splices for No. 10 AWG and Smaller:

1. Solderless, screw-on, reusable pressure cable type, with integral insulation, approved for copper and aluminum conductors.

2. The integral insulator shall have a skirt to completely cover the stripped conductors.

3. The number, size, and combination of conductors used with the connector, as listed on the manufacturer's packaging, shall be strictly followed.

C. Above Ground Splices for No. 8 AWG to No. 4/0 AWG:

1. Compression, hex screw, or bolt clamp-type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.

2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.

3. Splice and insulation shall be product of the same manufacturer.

4. All bolts, nuts, and washers used with splices shall be zinc plated steel.

D. Above Ground Splices for 250 kcmil and Larger:

1. Long barrel “butt-splice” or “sleeve” type compression connectors, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.

2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.

3. Splice and insulation shall be product of the same manufacturer.

E. Plastic electrical insulating tape: Per ASTM D2304, flame-retardant, cold and weather resistant.

2.3 CONNECTORS AND TERMINATIONS

A. Mechanical type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.

B. Long barrel compression type of high conductivity and corrosion-resistant material, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.

C. All bolts, nuts, and washers used to connect connections and terminations to bus bars or other termination points shall be zinc plated steel.

2.4 CONTROL WIRING

A. Unless otherwise specified elsewhere in these specifications, control wiring shall be as specified herein, except that the minimum size shall be not less than No. 14 AWG.

B. Control wiring shall be sized such that the voltage drop under in-rush conditions does not adversely affect operation of the controls.

2.5 WIRE LUBRICATING COMPOUND

A. Lubricating compound shall be suitable for the wire insulation and conduit, and shall not harden or become adhesive.

B. Shall not be used on conductors for isolated power systems.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.

B. Install all conductors in raceway systems.

C. Splice conductors only in outlet boxes, junction boxes, or pullboxes.

D. Conductors of different systems (e.g., 120 V and 277 V) shall not be installed in the same raceway.

E. Install cable supports for all vertical feeders in accordance with the NEC. Provide split wedge type which firmly clamps each individual cable and tightens due to cable weight.

F. In panelboards, cabinets, wireways, switches, enclosures, and equipment assemblies, neatly form, train, and tie the conductors with non-metallic ties.

G. For connections to motors, and vibrating equipment, stranded conductors shall be used only from the last fixed point of connection to the motors, or vibrating equipment.

H. Use expanding foam or non-hardening duct-seal to seal conduits entering a building, after installation of conductors.

I. Conductor and Cable Pulling:

1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling. Use lubricants approved for the cable.

2. Use nonmetallic pull ropes.

3. Attach pull ropes by means of either woven basket grips or pulling eyes attached directly to the conductors.

4. All conductors in a single conduit shall be pulled simultaneously.

5. Do not exceed manufacturer’s recommended maximum pulling tensions and sidewall pressure values.

J. No more than three branch circuits shall be installed in any one conduit.

K. When stripping stranded conductors, use a tool that does not damage the conductor or remove conductor strands.

3.2 SPLICE AND TERMINATION INSTALLATION

A. Splices and terminations shall be mechanically and electrically secure, and tightened to manufacturer’s published torque values using a torque screwdriver or wrench.

B. Where the Government determines that unsatisfactory splices or terminations have been installed, replace the splices or terminations at no additional cost to the Government.

3.3 CONDUCTOR IDENTIFICATION

A. When using colored tape to identify phase, neutral, and ground conductors larger than No. 8 AWG, apply tape in half-overlapping turns for a minimum of 75 mm (3 inches) from terminal points, and in junction boxes and pullboxes. Apply the last two laps of tape with no tension to prevent possible unwinding. Where cable markings are covered by tape, apply tags to cable, stating size and insulation type.

3.4 FEEDER CONDUCTOR IDENTIFICATION

A. In each interior pullbox install brass tags on all feeder conductors to clearly designate their circuit identification and voltage. The tags shall be the embossed type, 40 mm (1-1/2 inches) in diameter and 40 mils thick. Attach tags with plastic ties.

3.5 EXISTING CONDUCTORS

A. Unless specifically indicated on the plans, existing conductors shall not be reused.

3.6 CONTROL WIRING INSTALLATION

A. Unless otherwise specified in other sections, install control wiring and connect to equipment to perform the required functions as specified or as shown on the drawings. Each separate system shall have a dedicated power supply circuit.

B. Install a separate power supply circuit for each system, except where otherwise shown on the drawings.

3.7 CONTROL WIRING IDENTIFICATION

A. Install a permanent wire marker on each wire at each termination.

B. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.

C. Wire markers shall retain their markings after cleaning.

D. In each manhole and handhole, install embossed brass tags to identify the system served and function.

3.8 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests: Inspect physical condition.

2. Electrical tests:

a. After installation but before connection to utilization devices, such as fixtures, motors, or appliances, test conductors phase-to-phase and phase-to-ground resistance with an insulation

resistance tester. Existing conductors to be reused shall also be tested.

b. Applied voltage shall be 500 V DC for 300 V rated cable, and 1000 V DC for 600 V rated cable. Apply test for one minute or until reading is constant for 15 seconds, whichever is longer. Minimum insulation resistance values shall not be less than 25 megohms for 300 V rated cable and 100 megohms for 600 V rated cable.

c. Perform phase rotation test on all three-phase circuits.

- - - END - - -

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of grounding and bonding equipment, indicated as grounding equipment in this section.

B. "Grounding electrode system" refers to grounding electrode conductors and all electrodes required or allowed by NEC, as well as made, supplementary, and lightning protection system grounding electrodes.

C. The terms "connect" and "bond" are used interchangeably in this section and have the same meaning.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and boxes.

D. Section 26 24 16, PANELBOARDS: Low-voltage panelboards.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES and the following requirements:

1. Shop Drawings:

a. Submit sufficient information to demonstrate compliance with drawings and specifications.

b. Submit plans showing the location of system grounding electrodes and connections, and the routing of aboveground and underground grounding electrode conductors.

2. Test Reports:

a. Two weeks prior to the final inspection, submit ground resistance field test reports to the COR.

3. Certifications:

a. Certification by the Contractor that the grounding equipment has been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Society for Testing and Materials (ASTM):

B1-13 .....Standard Specification for Hard-Drawn Copper Wire

B3-13 .....Standard Specification for Soft or Annealed Copper Wire

B8-11 .....Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

81-12 .....IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements

D. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

70E-21 .....National Electrical Safety Code

99-20 .....Health Care Facilities

E. Underwriters Laboratories, Inc. (UL):

44-14 .....Thermoset-Insulated Wires and Cables

83-14 .....Thermoplastic-Insulated Wires and Cables

467-13 .....Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

A. Equipment grounding conductors shall be insulated stranded copper, except that sizes No. 10 AWG and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG and larger shall be identified per NEC.

B. Bonding conductors shall be bare stranded copper, except that sizes No. 10 AWG and smaller shall be bare solid copper. Bonding conductors shall be stranded for final connection to motors, transformers, and vibrating equipment.

C. Conductor sizes shall not be less than shown on the drawings, or not less than required by the NEC, whichever is greater.

D. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.

2.2 GROUND RODS

A. Steel or copper clad steel, 19 mm (0.75 inch) diameter by 3 M (10 feet) long.

B. Quantity of rods shall be as shown on the drawings, and as required to obtain the specified ground resistance.

2.3 CONCRETE ENCASED ELECTRODE

A. Concrete encased electrode shall be No. 4 AWG bare copper wire, installed per NEC.

2.4 GROUND CONNECTIONS

A. Below Grade and Inaccessible Locations: Exothermic-welded type connectors.

B. Above Grade:

1. Bonding Jumpers: Listed for use with aluminum and copper conductors. For wire sizes No. 8 AWG and larger, use compression-type connectors. For wire sizes smaller than No. 8 AWG, use mechanical type lugs. Connectors or lugs shall use zinc plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2. Connection to Building Steel: Exothermic-welded type connectors.

3. Connection to Grounding Bus Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with zinc plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

4. Connection to Equipment Rack and Cabinet Ground Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with zinc plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.5 EQUIPMENT RACK AND CABINET GROUND BARS

A. Provide solid copper ground bars designed for mounting on the framework of open or cabinet-enclosed equipment racks. Ground bars shall have minimum dimensions of 6.3 mm (0.25 inch) thick x 19 mm (0.75 inch) wide, with length as required or as shown on the drawings. Provide insulators and mounting brackets.

2.6 GROUND TERMINAL BLOCKS

A. At any equipment mounting location (e.g., backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide

mechanical type lugs, with zinc plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.7 GROUNDING BUS BAR

A. Pre-drilled rectangular copper bar with stand-off insulators, minimum 6.3 mm (0.25 inch) thick x 100 mm (4 inches) high in cross-section, length as shown on the drawings, with hole size, quantity, and spacing per detail shown on the drawings. Provide insulators and mounting brackets.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.

B. System Grounding:

1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformer.

2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.

C. Equipment Grounding: Metallic piping, building structural steel, electrical enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits, shall be bonded and grounded.

D. For patient care area electrical power system grounding, conform to the latest NFPA 70 and 99.

3.2 INACCESSIBLE GROUNDING CONNECTIONS

A. Make grounding connections, which are normally buried or otherwise inaccessible, by exothermic weld.

3.3 SECONDARY VOLTAGE EQUIPMENT AND CIRCUITS

A. Metallic Piping, Building Structural Steel, and Supplemental Electrode(s):

1. Provide jumpers across insulating joints in the metallic piping.

2. Provide a supplemental ground electrode as shown on the drawings and bond to the grounding electrode system.

C. Panelboards, Engine Generators and other electrical equipment:

1. Connect the equipment grounding conductors to the ground bus.

2. Connect metallic conduits by grounding bushings and equipment grounding conductor to the equipment ground bus.

3.4 RACEWAY

A. Conduit Systems:

1. Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor.

2. Non-metallic conduit systems, except non-metallic feeder conduits that carry a grounded conductor from exterior transformers to interior or building-mounted service entrance equipment, shall contain an equipment grounding conductor.

3. Metallic conduit that only contains a grounding conductor, and is provided for its mechanical protection, shall be bonded to that conductor at the entrance and exit from the conduit.

4. Metallic conduits which terminate without mechanical connection to an electrical equipment housing by means of locknut and bushings or adapters, shall be provided with grounding bushings. Connect bushings with a equipment grounding conductor to the equipment ground bus.

B. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders, and power and lighting branch circuits.

C. Boxes, Cabinets, Enclosures, and Panelboards:

1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes (except for special grounding systems for intensive care units and other critical units shown).

2. Provide lugs in each box and enclosure for equipment grounding conductor termination.

D. Wireway Systems:

1. Bond the metallic structures of wireway to provide electrical continuity throughout the wireway system, by connecting a No. 6 AWG bonding jumper at all intermediate metallic enclosures and across all section junctions.

2. Install insulated No. 6 AWG bonding jumpers between the wireway system, bonded as required above, and the closest building ground at each end and approximately every 16 M (50 feet).

3. Use insulated No. 6 AWG bonding jumpers to ground or bond metallic wireway at each end for all intermediate metallic enclosures and across all section junctions.

4. Use insulated No. 6 AWG bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 15 M (49 feet).

E. Receptacles shall not be grounded through their mounting screws. Ground receptacles with a jumper from the receptacle green ground terminal to the device box ground screw and a jumper to the branch circuit equipment grounding conductor.

F. Ground lighting fixtures to the equipment grounding conductor of the wiring system. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.

G. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.

H. Panelboard Bonding in Patient Care Areas: The equipment grounding terminal buses of the normal and essential branch circuit panel boards serving the same individual patient vicinity shall be bonded together with an insulated continuous copper conductor not less than No. 10 AWG, installed in rigid metal conduit.

3.5 CORROSION INHIBITORS

A. When making grounding and bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.6 CONDUCTIVE PIPING

A. Bond all conductive piping systems, interior and exterior, to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.

3.7 GROUND RESISTANCE

A. Grounding system resistance to ground shall not exceed 5 ohms. Make any modifications or additions to the grounding electrode system necessary for compliance without additional cost to the Government. Final tests shall ensure that this requirement is met.

B. Grounding system resistance shall comply with the electric utility company ground resistance requirements.

3.8 GROUND ROD INSTALLATION

A. For outdoor installations, drive each rod vertically in the earth, until top of rod is 610 mm (24 inches) below final grade.

B. For indoor installations, leave 100 mm (4 inches) of each rod exposed.

C. Where buried or permanently concealed ground connections are required, make the connections by the exothermic process, to form solid metal joints. Make accessible ground connections with mechanical pressure-type ground connectors.

D. Where rock or impenetrable soil prevents the driving of vertical ground rods, install angled ground rods or grounding electrodes in horizontal trenches to achieve the specified ground resistance.

3.9 ACCEPTANCE CHECKS AND TESTS

A. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 82. Ground resistance measurements shall be made before the electrical

distribution system is energized or connected to the electric utility company ground system and shall be made in normally dry conditions not fewer than 48 hours after the last rainfall.

B. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

C. Below-grade connections shall be visually inspected by the COR prior to backfilling. The Contractor shall notify the COR 24 hours before the connections are ready for inspection.

- - - END - - -

SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of conduit, fittings, and boxes, to form complete, coordinated, grounded raceway systems. Raceways are required for all wiring unless shown or specified otherwise.

B. Definitions: The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

1.2 RELATED WORK

A. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire rated construction.

B. Section 07 92 00, JOINT SEALANTS: Sealing around conduit penetrations through the building envelope to prevent moisture migration into the building.

C. Section 09 91 00, PAINTING: Identification and painting of conduit and other devices.

D. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Conduits bracing.

E. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.

F. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

I. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Underground conduits.

J. Section 31 20 00, EARTHWORK: Bedding of conduits.

1.3 QUALITY ASSURANCE

A. Refer to paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS and 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1. Shop Drawings:

a. Size and location of main feeders.

b. Size and location of panels and pull-boxes.

c. Layout of required conduit penetrations through structural elements.

d. Submit the following data for approval:

1) Raceway types and sizes.

2) Conduit bodies, connectors and fittings.

3) Junction and pull boxes, types and sizes.

2. Certifications: Two weeks prior to final inspection, submit the following:

a. Certification by the manufacturer that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment conform to the requirements of the drawings and specifications.

b. Certification by the Contractor that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment have been properly installed.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the

extent referenced. Publications are referenced in the text by designation only.

B. American National Standards Institute (ANSI):

C80.1-05 .....Electrical Rigid Steel Conduit

C80.3-05 .....Steel Electrical Metal Tubing

C80.6-05 .....Electrical Intermediate Metal Conduit

FB1-14 .....Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable

FB2.10-13 .....Selection and Installation Guidelines for Fittings for use with Non-Flexible Conduit or Tubing (Rigid Metal Conduit, Intermediate Metallic Conduit, and Electrical Metallic Tubing)

TC-2-13 .....Electrical Polyvinyl Chloride (PVC) Tubing and Conduit

TC-3-13 .....PVC Fittings for Use with Rigid PVC Conduit and Tubing

C. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):

1-05 .....Flexible Metal Conduit

5-11 .....Surface Metal Raceway and Fittings

6-07 .....Electrical Rigid Metal Conduit - Steel

50-95 .....Enclosures for Electrical Equipment

360-13 .....Liquid-Tight Flexible Steel Conduit

467-13 .....Grounding and Bonding Equipment

514A-13 .....Metallic Outlet Boxes

514B-12 .....Conduit, Tubing, and Cable Fittings

514C-07 .....Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers

651-11 .....Schedule 40 and 80 Rigid PVC Conduit and Fittings

651A-11 .....Type EB and A Rigid PVC Conduit and HDPE Conduit

797-07 .....Electrical Metallic Tubing

1242-06 .....Electrical Intermediate Metal Conduit - Steel

E. National Electrical Manufacturers Association (NEMA):

TC-2-13 .....Electrical Polyvinyl Chloride (PVC) Tubing and Conduit

TC-3-13 .....PVC Fittings for Use with Rigid PVC Conduit and Tubing

FB1-12 .....Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable

FB2.10-13 .....Selection and Installation Guidelines for Fittings for use with Non-Flexible Conduit or Tubing (Rigid Metal Conduit, Intermediate Metallic Conduit, and Electrical Metallic Tubing)

FB2.20-12 .....Selection and Installation Guidelines for Fittings for use with Flexible Electrical Conduit and Cable

F. American Iron and Steel Institute (AISI):

S100-2007-52-10 .....North American Specification for the Design of Cold-Formed Steel Structural Members

PART 2 – PRODUCTS

2.1 MATERIAL

A. Conduit Size: In accordance with the NEC, but not less than 19 mm (0.75-inch) unless otherwise shown. Where permitted by the NEC, 13 mm (0.5-inch) flexible conduit may be used for tap connections to recessed lighting fixtures.

B. Conduit:

1. Size: In accordance with the NEC, but not less than 19 mm (0.75-inch).

2. Rigid Steel Conduit (RMC): Shall conform to UL 6 and ANSI C80.1.

3. Rigid Intermediate Steel Conduit (IMC): Shall conform to UL 1242 and ANSI C80.6.

4. Electrical Metallic Tubing (EMT): Shall conform to UL 797 and ANSI C80.3. Maximum size not to exceed 105 mm (4 inches) and shall be permitted only with cable rated 600 V or less.

5. Flexible Metal Conduit: Shall conform to UL 1.

6. Direct Burial Plastic Conduit: Shall conform to UL 651 and UL 651A, heavy wall PVC or high-density polyethylene (PE).

9. Surface Metal Raceway: Shall conform to UL 1.

C. Conduit Fittings:

1. Rigid Steel and Intermediate Metallic Conduit Fittings:

a. Fittings shall meet the requirements of UL 514B and NEMA FB1.

b. Standard threaded couplings, locknuts, bushings, conduit bodies, and elbows: Only steel or malleable iron materials are acceptable. Integral retractable type IMC couplings are also acceptable.

c. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.

d. Bushings: Metallic insulating type, consisting of an insulating insert, molded or locked into the metallic body of the fitting.

Bushings made entirely of metal or nonmetallic material are not permitted.

e. Erickson (Union-Type) and Set Screw Type Couplings: Approved for use in concrete are permitted for use to complete a conduit run where conduit is installed in concrete. Use set screws of case-hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.

f. Sealing Fittings: Threaded cast iron type. Use continuous drain-type sealing fittings to prevent passage of water vapor. In concealed work, install fittings in flush steel boxes with blank cover plates having the same finishes as that of other electrical plates in the room.

2. Electrical Metallic Tubing Fittings:

a. Fittings and conduit bodies shall meet the requirements of UL 514B, ANSI C80.3, and NEMA FB1.

b. Only steel or malleable iron materials are acceptable.

c. Compression Couplings and Connectors: Concrete-tight and rain-tight, with connectors having insulated throats.

d. Indent-type connectors or couplings are prohibited.

e. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.

3. Flexible Metal Conduit Fittings:

a. Conform to UL 514B. Only steel or malleable iron materials are acceptable.

b. Clamp-type, with insulated throat.

4. Expansion and Deflection Couplings:

a. Conform to UL 467 and UL 514B.

b. Accommodate a 19 mm (0.75-inch) deflection, expansion, or contraction in any direction, and allow 30-degree angular deflections.

c. Include internal flexible metal braid, sized to guarantee conduit ground continuity and a low-impedance path for fault currents, in accordance with UL 467 and the NEC tables for equipment grounding conductors.

d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat-resistant molded rubber material with stainless steel jacket clamps.

D. Conduit Supports:

1. Parts and Hardware: Zinc-coat or provide equivalent corrosion protection.

2. Individual Conduit Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.

3. Multiple Conduit (Trapeze) Hangers: Not less than 38 mm x 38 mm (1.5 x 1.5 inches), 12-gauge steel, cold-formed, lipped channels; with not less than 9 mm (0.375-inch) diameter steel hanger rods.

4. Solid Masonry and Concrete Anchors: Self-drilling expansion shields, or machine bolt expansion.

E. Outlet, Junction, and Pull Boxes:

1. Comply with UL-50 and UL-514A.

2. Rustproof cast metal where required by the NEC or shown on drawings.

3. Sheet Metal Boxes: Galvanized steel, except where shown on drawings.

F. Metal Wireways: Equip with hinged covers, except as shown on drawings. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.

PART 3 - EXECUTION

3.1 PENETRATIONS

A. Cutting or Holes:

1. Cut holes in advance where they should be placed in the structural elements, such as ribs or beams. Obtain the approval of the COR prior to drilling through structural elements.

2. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammers, impact electric, hand, or manual hammer-type drills are not allowed, except when permitted by the COR where working space is limited.

B. Firestop: Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or rated floor assemblies, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING.

C. Waterproofing: At exterior wall and roof conduit penetrations, completely seal the gap around conduit to render it watertight, as specified in Section 07 92 00, JOINT SEALANTS.

3.2 INSTALLATION, GENERAL

A. In accordance with UL, NEC, NEMA, as shown on drawings, and as specified herein.

B. Raceway systems used for Essential Electrical Systems (EES) shall be entirely independent of other raceway systems.

C. Install conduit as follows:

1. In complete mechanically and electrically continuous runs before pulling in cables or wires.

2. Unless otherwise indicated on the drawings or specified herein, installation of all conduits shall be concealed within finished walls, floors, and ceilings.

3. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new conduits.

4. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.

5. Cut conduits square, ream, remove burrs, and draw up tight.

6. Independently support conduit at 2.4 M (8 feet) on centers with specified materials and as shown on drawings.

7. Do not use suspended ceilings, suspended ceiling supporting members, lighting fixtures, other conduits, cable tray, boxes, piping, or ducts to support conduits and conduit runs.

8. Support within 300 mm (12 inches) of changes of direction, and within 300 mm (12 inches) of each enclosure to which connected.

9. Close ends of empty conduits with plugs or caps at the rough-in stage until wires are pulled in, to prevent entry of debris.

10. Conduit installations under fume and vent hoods are prohibited.

11. Secure conduits to cabinets, junction boxes, pull-boxes, and outlet boxes with bonding type locknuts. For rigid steel and IMC conduit installations, provide a locknut on the inside of the enclosure, made up wrench tight. Do not make conduit connections to junction box covers.

12. Flashing of penetrations of the roof membrane is specified in Section 07 60 00, FLASHING AND SHEET METAL and Section 07 92 00 JOINT SEALANTS.

13. Conduit bodies shall only be used for changes in direction and shall not contain splices.

D. Conduit Bends:

1. Make bends with standard conduit bending machines.

2. Conduit hickey or hand bender may be used for slight offsets and for straightening stubbed out conduits.

3. Bending of conduits with a pipe tee or vise is prohibited.

E. Layout and Homeruns:

1. Install conduit with wiring, including homeruns, as shown on drawings.

2. Deviations: Make only where necessary to avoid interferences and only after drawings showing the proposed deviations have been submitted and approved by the COR.

3.3 CONCEALED WORK INSTALLATION

A. In Concrete:

1. Conduit: Rigid steel, IMC, or EMT. Do not install EMT in concrete slabs that are in contact with soil, gravel, or vapor barriers.

2. Align and run conduit in direct lines.

3. Install conduit through concrete beams only:

a. Where shown on the structural drawings.

b. As approved by the COR prior to construction, and after submittal of drawing showing location, size, and position of each penetration.

4. Installation of conduit in concrete that is less than 75 mm (3 inches) thick is prohibited.

a. Conduit outside diameter larger than one-third of the slab thickness is prohibited.

b. Space between conduits in slabs: Approximately six conduit diameters apart, and one conduit diameter at conduit crossings.

c. Install conduits approximately in the center of the slab so that there will be a minimum of 19 mm (0.75-inch) of concrete around the conduits.

5. Make couplings and connections watertight. Use thread compounds that are UL approved conductive type to ensure low resistance ground continuity through the conduits. Tightening setscrews with pliers is prohibited.

B. Above Furred or Suspended Ceilings and in Walls:

1. Conduit for Conductors Above 600 V: Rigid steel. Mixing different types of conduits in the same system is prohibited.

2. Conduit for Conductors 600 V and Below: Rigid steel, IMC or EMT. Mixing different types of conduits in the same system is prohibited.

3. Align and run conduit parallel or perpendicular to the building lines.

4. Tightening set screws with pliers is prohibited.

5. For conduits running through metal studs, limit field cut holes to no more than 70% of web depth. Spacing between holes shall be at least 457 mm (18 inches). Cuts or notches in flanges or return lips shall not be permitted.

3.4 EXPOSED WORK INSTALLATION

A. Unless otherwise indicated on drawings, exposed conduit is only permitted in mechanical and electrical rooms.

B. Conduit for Conductors Above 600 V: Rigid steel. Mixing different types of conduits in the system is prohibited.

C. Conduit for Conductors 600 V and Below: Rigid steel, IMC or EMT. Mixing different types of conduits in the system is prohibited.

D. Align and run conduit parallel or perpendicular to the building lines.

E. Install horizontal runs close to the ceiling or beams and secure with conduit straps.

F. Support horizontal or vertical runs at not over 2.4 M (8 feet) intervals.

G. Surface Metal Raceways: Use only where shown on drawings.

H. Painting:

1. Paint exposed conduit as specified in Section 09 91 00, PAINTING.

2. Paint all conduits containing cables rated over 600 V safety orange. Refer to Section 09 91 00, PAINTING for preparation, paint type, and exact color. In addition, paint legends, using 50 mm (2 inch) high black numerals and letters, showing the cable voltage rating.

Provide legends where conduits pass through walls and floors and at maximum 6 M (20 feet) intervals in between.

3.5 DIRECT BURIAL INSTALLATION

Refer to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

3.6 HAZARDOUS LOCATIONS

A. Use rigid steel conduit only.

B. Install UL approved sealing fittings that prevent passage of explosive vapors in hazardous areas equipped with explosion-proof lighting fixtures, switches, and receptacles, as required by the NEC.

3.7 WET OR DAMP LOCATIONS

A. Use rigid steel or IMC conduits unless as shown on drawings.

B. Provide sealing fittings to prevent passage of water vapor where conduits pass from warm to cold locations, i.e., refrigerated spaces, constant-temperature rooms, air-conditioned spaces, building exterior walls, roofs, or similar spaces.

C. Use rigid steel or IMC conduit within 1.5 M (5 feet) of the exterior and below concrete building slabs in contact with soil, gravel, or vapor barriers, unless as shown on drawings. Conduit shall be half-lapped with 10 mil PVC tape before installation. After installation, completely recoat or retape any damaged areas of coating.

D. Conduits run on roof shall be supported with integral galvanized lipped steel channel, attached to UV-inhibited polycarbonate or polypropylene blocks every 2.4 M (8 feet) with 9 mm (3/8-inch) galvanized threaded rods, square washer and locknut. Conduits shall be attached to steel channel with conduit clamps.

3.8 MOTORS AND VIBRATING EQUIPMENT

A. Use flexible metal conduit for connections to motors and other electrical equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission.

B. Use liquid-tight flexible metal conduit for installation in exterior locations, moisture or humidity laden atmosphere, corrosive atmosphere,

water or spray wash-down operations, inside airstream of HVAC units, and locations subject to seepage or dripping of oil, grease, or water.

C. Provide a green equipment grounding conductor with flexible and liquid-tight flexible metal conduit.

3.9 EXPANSION JOINTS

A. Conduits 75 mm (3 inch) and larger that are secured to the building structure on opposite sides of a building expansion joint require expansion and deflection couplings. Install the couplings in accordance with the manufacturer's recommendations.

B. Provide conduits smaller than 75 mm (3 inch) with junction boxes on both sides of the expansion joint. Connect flexible metal conduits to junction boxes with sufficient slack to produce a 125 mm (5 inch) vertical drop midway between the ends of the flexible metal conduit. Flexible metal conduit shall have a green insulated copper bonding jumper installed. In lieu of this flexible metal conduit, expansion and deflection couplings as specified above are acceptable.

C. Install expansion and deflection couplings where shown.

D. Seismic: Provide conduits rigidly secured to the building structure on opposite sides of a building expansion joint with junction boxes on both sides of the joint. Connect conduits to junction boxes with 375 mm (15 inches) of slack flexible conduit. Flexible conduit shall have a copper bonding jumper installed.

3.10 CONDUIT SUPPORTS

A. Safe working load shall not exceed one-quarter of proof test load of fastening devices.

B. Use pipe straps or individual conduit hangers for supporting individual conduits.

C. Support multiple conduit runs with trapeze hangers. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits, wires, hanger itself, and an additional 90 kg (200 lbs). Attach each conduit with U-bolts or other approved fasteners.

D. Support conduit independently of junction boxes, pull-boxes, fixtures, suspended ceiling T-bars, angle supports, and similar items.

E. Fasteners and Supports in Solid Masonry and Concrete:

1. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing the concrete.

2. Existing Construction:

a. Steel expansion anchors not less than 6 mm (0.25-inch) bolt size and not less than 28 mm (1.125 inch) in embedment.

b. Power set fasteners not less than 6 mm (0.25-inch) diameter with depth of penetration not less than 75 mm (3 inch).

c. Use vibration and shock-resistant anchors and fasteners for attaching to concrete ceilings.

F. Hollow Masonry: Toggle bolts.

G. Bolts supported only by plaster or gypsum wallboard are not acceptable.

H. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.

I. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.

J. Chain, wire, or perforated strap shall not be used to support or fasten conduit.

K. Spring steel type supports or fasteners are prohibited for all uses except horizontal and vertical supports/fasteners within walls.

L. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

3.11 BOX INSTALLATION

A. Boxes for Concealed Conduits:

1. Flush-mounted.

2. Provide raised covers for boxes to suit the wall or ceiling, construction, and finish.

B. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operations or where more than the equivalent of 4-90 degree bends are necessary.

C. Locate pullboxes so that covers are accessible and easily removed. Coordinate locations with piping and ductwork where installed above ceilings.

D. Remove only knockouts as required. Plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.

E. Outlet boxes mounted back-to-back in the same wall are prohibited. A minimum 600 mm (24 inch) center-to-center lateral spacing shall be maintained between boxes.

F. Flush-mounted wall or ceiling boxes shall be installed with raised covers so that the front face of raised cover is flush with the wall. Surface-mounted wall or ceiling boxes shall be installed with surface-style flat or raised covers.

G. Minimum size of outlet boxes for ground fault circuit interrupter (GFCI) receptacles is 100 mm (4 inches) square x 55 mm (2.125 inches) deep, with device covers for the wall material and thickness involved.

H. Stencil or install phenolic nameplates on covers of the boxes identified on riser diagrams; for example "SIG-FA JB No. 1."

I. On all branch circuit junction box covers, identify the circuits with black marker.

- - - END - - -

SECTION 26 05 41
UNDERGROUND ELECTRICAL CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of underground ducts and raceways, and precast manholes and pullboxes to form a complete underground electrical raceway system.

B. The terms "duct" and "conduit" are used interchangeably in this section.

1.2 RELATED WORK

A. Section 07 92 00, JOINT SEALANTS: Sealing of conduit penetrations.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

D. Section 31 22 00, EARTHWORK.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. Coordinate layout and installation of ducts, manholes, and pullboxes with final arrangement of other utilities, site grading, and surface features.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:

a. Submit sufficient information to demonstrate compliance with drawings and specifications.

b. Submit information on manholes, pullboxes, ducts, and hardware. Submit manhole plan and elevation drawings, showing openings, pulling irons, cable supports, cover, ladder, sump, and other accessories.

c. Proposed deviations from the drawings shall be clearly marked on the submittals. If it is necessary to locate manholes, pullboxes, or duct banks at locations other than shown on the drawings, show the proposed locations accurately on scaled site drawings, and submit to the COR for approval prior to construction.

2. Certifications: Two weeks prior to the final inspection, submit the following.
   a. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the materials have been properly installed, connected, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Concrete Institute (ACI):
Building Code Requirements for Structural Concrete
318-14/318M-14 .....Building Code Requirements for Structural Concrete & Commentary
SP-66-04 .....ACI Detailing Manual

C. American National Standards Institute (ANSI):
77-14 .....Underground Enclosure Integrity

D. American Society for Testing and Materials (ASTM):
C478 REV A-15 .....Standard Specification for Precast Reinforced Concrete Manhole Sections
C858-10 .....Underground Precast Concrete Utility Structures
C990-09 .....Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants.

E. National Electrical Manufacturers Association (NEMA):
TC 2-13 .....Electrical Polyvinyl Chloride (PVC) Conduit
TC 3-15 .....Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit And Tubing
TC 6 & 8-13 .....Polyvinyl Chloride (PVC) Plastic Utilities Duct For Underground Installations

TC 9-04 .....Fittings For Polyvinyl Chloride (PVC) Plastic Utilities Duct For Underground Installation

F. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

70E-21 .....National Electrical Safety Code

G. Underwriters Laboratories, Inc. (UL):

6-07 .....Electrical Rigid Metal Conduit-Steel

467-13 .....Grounding and Bonding Equipment

651-11 .....Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings

651A-11 .....Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit

PART 2 - PRODUCTS

2.1 PRE-CAST CONCRETE MANHOLES AND HARDWARE

A. Structure: Factory-fabricated, reinforced-concrete, monolithically-poured walls and bottom. Frame and cover shall form top of manhole.

B. Cable Supports:

1. Cable stanchions shall be hot-rolled, heavy duty, hot-dipped galvanized "T" section steel, 56 mm (2.25 inches) x 6 mm (0.25 inch) in size, and punched with 14 holes on 38 mm (1.5 inches) centers for attaching cable arms.
2. Cable arms shall be 5 mm (0.1875 inch) gauge, hot-rolled, hot-dipped galvanized sheet steel, pressed to channel shape. Arms shall be approximately 63 mm (2.5 inches) wide x 350 mm (14 inches) long.
3. Insulators for cable supports shall be porcelain, and shall be saddle type or type that completely encircles the cable.
4. Equip each cable stanchion with one spare cable arm, with three spare insulators for future use.

C. Ladder: Aluminum with 400 mm (16 inches) rung spacing. Provide securely-mounted ladder for every manhole over 1.2 M (4 feet) deep.

D. Ground Rod Sleeve: Provide a 75 mm (3 inches) PVC sleeve in manhole floors so that a driven ground rod may be installed.

E. Sump: Provide 305 mm x 305 mm (12 inches x 12 inches) covered sump frame and grated cover.

2.2 PULLBOXES

A. General: Size as indicated on the drawings. Provide pullboxes with weatherproof, non-skid covers with recessed hook eyes, secured with

corrosion- and tamper-resistant hardware. Cover material shall be identical to pullbox material. Covers shall have molded lettering, ELECTRIC or SIGNAL as applicable. Pullboxes shall comply with the requirements of ANSI 77 Tier 5, Tier 8, Tier 15 and Tier 22 loading as required for locations. Provide pulling irons, 22 mm (0.875 inch) diameter galvanized steel bar with exposed triangular-shaped opening.

2.3 DUCTS

A. Number and sizes shall be as shown on the drawings.

B. Ducts (concrete-encased):

1. Plastic Duct:

a. UL 651 and 651A Schedule 40 PVC conduit.

b. Duct shall be suitable for use with 90˚ C (194˚ F) rated conductors.

2. Conduit Spacers: Prefabricated plastic.

C. Ducts (direct-burial):

1. Plastic duct:

a. Schedule 80 PVC or HDPE conduit.

b. Duct shall be suitable for use with 75˚ C (167˚ F) rated conductors.

2. Rigid metal conduit: UL 6 and NEMA RN1 galvanized rigid metal, half-lap wrapped with 10 mil PVC tape.

2.4 GROUNDING

A. Ground Rods and Ground Wire: Per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

2.5 WARNING TAPE

A. 4-mil polyethylene 75 mm (3 inches) wide detectable tape, red with black letters, imprinted with “CAUTION - BURIED ELECTRIC CABLE BELOW” or similar.

2.6 PULL ROPE FOR SPARE DUCTS

A. Plastic with 890 N (200 lb) minimum tensile strength.

PART 3 - EXECUTION

3.1 MANHOLE AND PULLBOX INSTALLATION

A. Assembly and installation shall be per the requirements of the manufacturer.

1. Install manholes and pullboxes level and plumb.

2. Units shall be installed on a 300 mm (12 inches) thick level bed of 90% compacted granular fill, well-graded from the 25 mm (1 inch)

sieve to the No. 4 sieve. Granular fill shall be compacted with a minimum of four passes with a plate compactor.

B. Access: Ensure the top of frames and covers are flush with finished grade.

C. Grounding in Manholes:

1. Ground Rods in Manholes: Drive a ground rod into the earth, through the floor sleeve, after the manhole is set in place. Fill the sleeve with sealant to make a watertight seal. Rods shall protrude approximately 100 mm (4 inches) above the manhole floor.
2. Install a No. 3/0 AWG bare copper ring grounding conductor around the inside perimeter of the manhole and anchor to the walls with metallic cable clips.
3. Connect the ring grounding conductor to the ground rod by an exothermic welding process.
4. Bond the ring grounding conductor to the duct bank equipment grounding conductors, the exposed non-current carrying metal parts of racks, sump covers, and like items in the manholes with a minimum No. 6 AWG bare copper jumper using an exothermic welding process.

3.2 TRENCHING

A. Refer to Section 31 22 00, EARTHWORK for trenching, backfilling, and compaction.

B. Before performing trenching work at existing facilities, a Ground Penetrating Radar Survey shall be carefully performed by a certified technician to reveal all existing underground ducts, conduits, cables, and other utility systems.

C. Work with extreme care near existing ducts, conduits, and other utilities to avoid damaging them.

D. Cut the trenches neatly and uniformly.

E. For Concrete-Encased Ducts:

1. After excavation of the trench, stakes shall be driven in the bottom of the trench at 1.2 M (4 feet) intervals to establish the grade and route of the duct bank.
2. Pitch the trenches uniformly toward manholes or both ways from high points between manholes for the required duct line drainage. Avoid pitching the ducts toward buildings wherever possible.
3. The walls of the trench may be used to form the side walls of the duct bank, provided that the soil is self-supporting and that the

concrete envelope can be poured without soil inclusions. Forms are required where the soil is not self-supporting.

4. After the concrete-encased duct has sufficiently cured, the trench shall be backfilled to grade with earth, and appropriate warning tape installed.

F. Individual conduits to be installed under existing paved areas and roads that cannot be disturbed shall be jacked into place using rigid metal conduit, or bored using plastic utilities duct or PVC conduit, as approved by the COR.

3.3 DUCT INSTALLATION

A. General Requirements:

1. Ducts shall be in accordance with the NEC, as shown on the drawings, and as specified.
2. Join and terminate ducts with fittings recommended by the manufacturer.
3. Slope ducts to drain towards manholes and pullboxes, and away from building and equipment entrances. Pitch not less than 100 mm (4 inches) in 30 M (100 feet).
4. Underground conduit stub-ups and sweeps to equipment inside of buildings shall be galvanized rigid metal conduit half-lap wrapped with PVC tape, and shall extend a minimum of 1.5 M (5 feet) outside the building foundation. Tops of conduits below building slab shall be minimum 610 mm (24 inches) below bottom of slab.
5. Stub-ups and sweeps to equipment mounted on outdoor concrete slabs shall be galvanized rigid metal conduit half-lap wrapped with PVC tape, and shall extend a minimum of 1.5 M (5 feet) away from the edge of slab.
6. Install insulated grounding bushings on the conduit terminations.
7. Radius for sweeps shall be sufficient to accomplish pulls without damage. Minimum radius shall be six times conduit diameter.
8. All multiple conduit runs shall have conduit spacers. Spacers shall securely support and maintain uniform spacing of the duct assembly a minimum of 75 mm (3 inches) above the bottom of the trench during the concrete pour. Spacer spacing shall not exceed 1.5 M (5 feet). Secure spacers to ducts and earth to prevent floating during concrete pour. Provide nonferrous tie wires to prevent displacement

of the ducts during concrete pour. Tie wires shall not act as substitute for spacers.

9. Duct lines shall be installed no less than 300 mm (12 inches) from other utility systems, such as water, sewer, chilled water.
10. Clearances between individual ducts:
    a. For similar services, not less than 75 mm (3 inches).
    b. For power and signal services, not less than 150 mm (6 inches).
11. Duct lines shall terminate at window openings in manhole walls as shown on the drawings. All ducts shall be fitted with end bells.
12. Couple the ducts with proper couplings. Stagger couplings in rows and layers to ensure maximum strength and rigidity of the duct bank.
13. Keep ducts clean of earth, sand, or gravel, and seal with tapered plugs upon completion of each portion of the work.
14. Spare Ducts: Where spare ducts are shown, they shall have a nylon pull rope installed. They shall be capped at each end and labeled as to location of the other end.
15. Duct Identification: Place continuous strip of warning tape approximately 300 mm (12 inches) above ducts before backfilling trenches. Warning tape shall be preprinted with proper identification.
16. Duct Sealing: Seal ducts, including spare ducts, at building entrances and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of foreign objects and material, moisture, and gases.
17. Use plastic ties to secure cables to insulators on cable arms. Use minimum two ties per cable per insulator.

B. Concrete-Encased Ducts:

1. Install concrete-encased ducts for medium-voltage systems, low-voltage systems, and signal systems, unless otherwise shown on the drawings.
2. Duct banks shall be single or multiple duct assemblies encased in concrete. Ducts shall be uniform in size and material throughout the installation.
3. Tops of concrete-encased ducts shall be:
    a. Not less than 600 mm (24 inches) and not less than shown on the drawings, below finished grade.

b. Not less than 750 mm (30 inches) and not less than shown on the drawings, below roads and other paved surfaces.
c. Additional burial depth shall be required in order to accomplish NEC-required minimum bend radius of ducts.
d. Conduits crossing under grade slab construction joints shall be installed a minimum of 1.2 M (4 feet) below slab.

4. Extend the concrete envelope encasing the ducts not less than 75 mm (3 inches) beyond the outside walls of the outer ducts.
5. Within 3 M (10 feet} of building and manhole wall penetrations, install reinforcing steel bars at the top and bottom of each concrete envelope to provide protection against vertical shearing.
6. Install reinforcing steel bars at the top and bottom of each concrete envelope of all ducts underneath roadways and parking areas.
7. Where new ducts and concrete envelopes are to be joined to existing manholes, pullboxes, ducts, and concrete envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions.
8. Duct joints in concrete may be placed side by side horizontally, but shall be staggered at least 150 mm (6 inches) vertically.
9. Pour each run of concrete envelope between manholes or other terminations in one continuous pour. If more than one pour is necessary, terminate each pour in a vertical plane and install 19 mm (0.75 inch) reinforcing rod dowels extending 450 mm (18 inches) into concrete on both sides of joint near corners of envelope.
10. Pour concrete so that open spaces are uniformly filled. Do not agitate with power equipment unless approved by COR.

D. Connections to Manholes: Ducts connecting to manholes shall be flared to have an enlarged cross-section to provide additional shear strength. Dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 300 mm (12 inches) in each direction. Perimeter of the duct bank opening in the manhole shall be flared toward the inside or keyed to provide a positive interlock between the duct and the wall of the manhole. Use vibrators when this portion of the encasement is poured to ensure a seal between the envelope and the wall of the structure.

E. Connections to Existing Manholes: For duct connections to existing manholes, break the structure wall out to the dimensions required and preserve the 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.

F. Connections to Existing Ducts: Where connections to existing ducts are indicated, excavate around the ducts as necessary. Cut off the ducts and remove loose concrete from inside before installing new ducts. Provide a reinforced-concrete collar, poured monolithically with the new ducts, to take the shear at the joint of the duct banks.

G. Partially-Completed Ducts: During construction, wherever a construction joint is necessary in a duct bank, prevent debris such as mud and dirt from entering ducts by providing suitable plugs. Fit concrete envelope of a partially completed ducts with reinforcing steel extending a minimum of 600 mm (2 feet) back into the envelope and a minimum of 600 mm (2 feet) beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm (3 inches) from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 300 mm (12 inches) apart. Restrain reinforcing assembly from moving during pouring of concrete.

3.4 ACCEPTANCE CHECKS AND TESTS

A. Duct Testing and Cleaning:

1. Upon completion of the duct installation, a standard flexible mandrel shall be pulled through each duct to loosen particles of earth, sand, or foreign material left in the duct, and to test for out-of-round conditions.
2. The mandrel shall be not less than 300 mm (12 inches) long, and shall have a diameter not less than 13 mm (0.5 inch) less than the inside diameter of the duct. A brush with stiff bristles shall then be pulled through each duct to remove the loosened particles. The diameter of the brush shall be the same as, or slightly larger than, the diameter of the duct.
3. If testing reveals obstructions or out-of-round conditions, the Contractor shall replace affected section(s) of duct and retest to the satisfaction of the COR.
4. Mandrel pulls shall be witnessed by the COR.

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SECTION 26 05 73
OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the overcurrent protective device coordination study, related calculations and analysis, indicated as the study in this section.

B. A short-circuit and selective coordination study, and arc flash calculations and analysis shall be prepared for the electrical overcurrent devices to be installed under this project.

C. The study shall present a well-coordinated time-current analysis of each overcurrent protective device from the individual device up to the utility source and the on-site generator sources.

D Study is permitted by a licensed electrical engineering consultant paid by the general contractor or electrical contractor sub-contractor.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.

B. Section 26 24 16, PANELBOARDS: Low-voltage panelboards.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. The study shall be prepared by the equipment manufacturer and performed by the equipment manufacturer’s licensed electrical engineer, unless as noted above.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES and the following requirements:

1. Product data on the software program to be used for the study. Software shall be in mainstream use in the industry, shall provide device settings and ratings, and shall show selective coordination by time-current drawings.

2. Complete study as described in paragraph 1.6. Submittal of the study shall be well-coordinated with submittals of the shop drawings for equipment in related specification sections.
3. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the Contractor that the overcurrent protective devices have been set in accordance with the approved study.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. Institute of Electrical and Electronics Engineers (IEEE):

241-90 .....Recommended Practice Electrical Systems in Commercial Buildings

242-03 .....Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

399-97 .....Recommended Practice for Industrial and Commercial Power Systems Analysis

1584-18 .....Performing Arc-Flash Hazards Calculations

1584A-04 .....Performing Arc-Flash Hazards Calculations – Amendment 1

1584B-11 .....Performing Arc-Flash Hazards Calculations – Amendment 2

C. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

70E-21 .....Standard for Electrical Safety in the Workplace

99-20 .....Health Care Facilities Code

1.6 STUDY REQUIREMENTS

A. The study shall be in accordance with IEEE and NFPA standards.

B. The study shall include one line diagram, short-circuit and ground fault analysis, protective coordination plots for all overcurrent protective devices, and arc flash calculations and analysis.

C. One Line Diagram:

1. Show all electrical equipment and wiring to be protected by the overcurrent devices.

2. Show the following specific information:
   a. Calculated fault impedance, X/R ratios, and short-circuit values at each feeder and branch circuit bus.
   b. Relay, circuit breaker, and fuse ratings.
   c. Generator kW/kVA and transformer kVA and voltage ratings, percent impedance, X/R ratios, and wiring connections.
   d. Voltage at each bus.
   e. Identification of each bus, matching the identification on the drawings.
   f. Conduit, conductor, and busway material, size, length, and X/R ratios.

D. Short-Circuit Study:
   1. The study shall be performed using computer software designed for this purpose. Pertinent data and the rationale employed in developing the calculations shall be described in the introductory remarks of the study.
   2. Calculate the fault impedance to determine the available short-circuit and ground fault currents at each bus. Incorporate applicable motor and/or generator contribution in determining the momentary and interrupting ratings of the overcurrent protective devices.
   3. Present the results of the short-circuit study in a table. Include the following:
      a. Device identification.
      b. Operating voltage.
      c. Overcurrent protective device type and rating.
      d. Calculated short-circuit current.

E. Coordination Study:
   1. Prepare the coordination curves to determine the required settings of overcurrent protective devices to demonstrate selective coordination. Graphically illustrate on log-log paper that adequate time separation exists between devices, including the utility company upstream device if applicable. Plot the specific time-current characteristics of each overcurrent protective device in such a manner that all devices are clearly depicted.
   2. The following specific information shall also be shown on the coordination curves:

a. Device identification.
b. Potential transformer and current transformer ratios.
c. Three-phase and single-phase ANSI damage points or curves for each cable, transformer, or generator.
d. Applicable circuit breaker or protective relay characteristic curves.
e. No-damage, melting, and clearing curves for fuses.
f. Transformer in-rush points.

3. Develop a table to summarize the settings selected for the overcurrent protective devices. Include the following in the table:
a. Device identification.
b. Protective relay or circuit breaker potential and current transformer ratios, sensor rating, and available and suggested pickup and delay settings for each available trip characteristic.
c. Fuse rating and type.

F. Arc Flash Calculations and Analysis:
1. Arc flash warning labels shall comply with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
2. Arc flash calculations shall be based on actual over-current protective device clearing time. Maximum clearing time shall be in accordance with IEEE 1584.
3. Arc flash analysis shall be based on the lowest clearing time setting of the over-current protective device to minimize the incident energy level without compromising selective coordination.
4. Arc flash boundary and available arc flash incident energy at the corresponding working distance shall be calculated for all electrical power distribution equipment specified in the project, and as shown on the drawings.
5. Required arc-rated clothing and other PPE shall be selected and specified in accordance with NFPA 70E.

1.7 ANALYSIS

A. Analyze the short-circuit calculations, and highlight any equipment determined to be underrated as specified. Propose solutions to effectively protect the underrated equipment.

1.8 ADJUSTMENTS, SETTINGS, AND MODIFICATIONS

A. Final field settings and minor modifications of the overcurrent protective devices shall be made to conform with the study, without additional cost to the Government.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

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SECTION 26 12 19
PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of the pad-mounted, liquid-filled, medium-voltage transformers, indicated as transformers in this section.

1.2 RELATED WORK

A. Section 09 06 00, SCHEDULE FOR FINISHES: Finishes for electrical equipment.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground currents.

D. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Manholes, pull-boxes, and ducts for underground raceway systems.

E. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

A. Factory Tests shall be required.

B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirement:

1. Transformers shall be thoroughly tested at the factory to ensure that there are no electrical or mechanical defects. Tests shall be conducted as per IEEE Standards. Factory tests shall be certified. The following tests shall be performed:
   a. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground.
   b. Perform turns-ratio tests at all tap positions.

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Include electrical ratings, nameplate data, impedance, outline drawing with dimensions and front, top, and side views, weight, mounting details, decibel rating, termination information, temperature rise, no-load and full-load losses, regulation, overcurrent protection, connection diagrams, and accessories.
   c. Complete nameplate data, including manufacturer’s name and catalog number.
2. Manuals:
   a. When submitting the shop drawings, submit companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
      1) Identify terminals on wiring diagrams to facilitate installation, maintenance, and operation.
      2) Indicate on wiring diagrams the internal wiring for each piece of equipment and interconnections between the pieces of equipment.
      3) Approvals will be based on complete submissions of manuals, together with shop drawings.
   b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
      1) Update the manual to include any information necessitated by shop drawing approval.
      2) Show all terminal identification.
      3) Include information for testing, repair, troubleshooting, assembly, disassembly, and recommended maintenance intervals.
      4) Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.

B. Certifications:

1. Two weeks prior to the final inspection, submit the following certifications.
   a. Certification by the manufacturer that the transformers conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the transformers have been properly installed, connected, and tested.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Society for Testing and Materials (ASTM):

D3487-16 .....Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus

C. Institute of Electrical and Electronic Engineers (IEEE):

48-09 .....Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5kV Through 765kV or Extruded Insulation Rated 2.5kV Through 500kV

386-16 .....Separable Insulated Connector Systems for Power Distribution Systems Above 600 V

592-07 .....Exposed Semiconducting Shields on High-Voltage Cable Joints and Separable Connectors

C2-17 .....National Electrical Safety Code

C37.47-11 .....Specification for High Voltage (>1000V) Distribution Class Current-Limiting Fuses and Fuse Disconnecting Switches

C57.12.00-15 .....Liquid-Immersed Distribution, Power and Regulating Transformers

C57.12.10-13 .....Liquid-Immersed Power Transformers

C57.12.25-90 .....Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution-Transformers with Separable Insulated High Voltage Connectors; High Voltage, 34500 Grd Y/19920 Volts and Below; Low-Voltage 240/120 Volts; 167 kVA and Smaller Requirements

C57.12.28-14 .....Pad-Mounted Equipment - Enclosure Integrity
C57.12.29-14 .....Pad-Mounted Equipment – Enclosure Integrity for Coastal Environments
C57.12.34-15 .....Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15kV Nominal System Voltage and Below
C57.12.90-15 .....Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
C62.11-12 .....Metal-Oxide Surge Arresters for AC Power Circuits

D. International Code Council (ICC):
IBC-15 .....International Building Code

E. National Electrical Manufacturers Association (NEMA):
TR 1-13 .....Transformers, Regulators, and Reactors

F. National Fire Protection Association (NFPA):
70-17 .....National Electrical Code (NEC)

G. Underwriters Laboratories Inc. (UL):
467-13 .....Grounding and Bonding Equipment

H. United States Department of Energy (DOE):
10 CFR Part 431 .....Energy Efficiency Program for Certain Commercial and Industrial Equipment

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Transformers shall be in accordance with ASTM, IEEE, NFPA, UL, as shown on the drawings, and as specified herein. Each transformer shall be assembled as an integral unit by a single manufacturer.

B. Transformers shall be complete, outdoor type, continuous duty, integral assembly, grounded, tamper-resistant, and with liquid-immersed windings.

C. Ratings shall not be less than shown on the drawings.

D. Completely fabricate transformers at the factory so that only the external cable connections are required at the project site.

E. Thoroughly clean, phosphatize, and finish all the metal surfaces at the factory with a rust-resistant primer and dark green enamel finish coat, except where a different color is specified in Section 09 06 00, SCHEDULE FOR FINISHES. All surfaces of the transformer that will be in contact

with the concrete pad shall be treated with corrosion-resistant compounds and epoxy resin or a rubberized sealing compound.

2.2 COMPARTMENTS

A. Construction:

1. Enclosures shall be weatherproof and in accordance with IEEE C57.12.28.
2. The medium- and low-voltage compartments shall be separated with a steel barrier that extends the full height and depth of the compartments.
3. The compartments shall be constructed of sheet steel (gauge to meet ANSI requirements) with bracing and with reinforcing gussets using jig welds to assure rectangular rigidity.
4. All bolts, nuts, and washers shall be zinc-plated steel.
5. Sufficient space shall be provided for equipment, cabling, and terminations within the compartments.
6. Affix transformer nameplate permanently within the low-voltage compartment. Voltage and kVA rating, connection configuration, impedance, date of manufacture, and serial number shall be shown on the nameplate.

B. Doors:

1. Provide a separate door for each compartment with provisions for a single padlock to secure all doors. Provide each compartment door with open-position doorstops and corrosion-resistant tamperproof hinges welded in place. The medium-voltage compartment door shall be mechanically prevented from opening unless the low-voltage compartment door is open.
2. The secondary compartment door shall have a one-piece steel handle and incorporate three-point locking mechanisms.

2.3 BILL RATING

A. 5 kV class equipment shall have a minimum 60 kV BIL rating.

2.4 TRANSFORMER FUSE ASSEMBLY

A. The primary fuse assembly shall be load-break combination fuse and dry-well fuse holder rated for system voltage, rated for 10 load makes and 10 load breaks, with rated 200 amp load current at 75% power factor, 10,000 symmetrical A close-in on fault duty, and 95 kV BIL. The entire fuse assembly shall be removable through the use of hot stick.

1. The fuses shall be concealed, hot stick removable, 50,000 A symmetrical interrupting, non-expulsion, current-limiting primary distribution

type, of the size and voltage class as shown on the drawings. The fuses shall operate within the fuse holder as a unit disconnecting means. Fuses shall be in accordance with ANSI C37.47.

2. Transformers shall not have internal "weak link" fuses that require transformer tank cover removal for replacement.

2.5 PRIMARY CONNECTIONS

A. Primary connections shall be 200 A dead-front loadbreak.

B. Surge Arresters: Distribution class, one for each primary phase, complying with IEEE C62.11, supported from tank wall.

2.6 MEDIUM-VOLTAGE TERMINATIONS

A. Terminate the medium-voltage cables in the primary compartment with 200 A loadbreak premolded rubber elbow connectors, suitable for submersible applications. Elbow connectors shall have a semi-conductive shield material covering the housing. The separable connector system shall include the loadbreak elbow, the bushing insert, and the bushing well. Separable connectors shall comply with the requirements of IEEE 386, and shall be interchangeable between suppliers. Allow sufficient slack in medium-voltage cable, ground, and drain wires to permit elbow connectors to be moved to their respective parking stands.

B. Ground metallic cable shield with a cable shield grounding adapter, consisting of a solderless connector enclosed in watertight rubber housing covering the entire assembly, bleeder wire, and ground braid.

2.7 LOW-VOLTAGE EQUIPMENT

A. The low-voltage leads shall be brought out of the tank by epoxy pressure tight bushings, and shall be standard arrangement.

B. Tin-plate the low-voltage neutral terminal and isolate from the transformer tank. Provide a removable ground strap sized in accordance with the NEC and connect between the secondary neutral and ground pad.

2.8 TRANSFORMERS

A. Transformer ratings shall be as shown on drawings. kVA ratings shown on the drawings are for continuous duty without the use of cooling fans.

B. Temperature rises shall not exceed the NEMA TR 1 of 65˚ C (149˚ F) by resistance.

C. Transformer insulating material shall be mineral oil in accordance with ASTM D 3487.

D. Transformer impedance shall be not less than 4-1/2% for sizes 150 kVA and larger. Impedance shall be as shown on the drawings.

E. Sound levels shall conform to NEMA TR 1 standards.

F. Primary and Secondary Windings for Three-Phase Transformers:

1. Primary windings shall be delta-connected.
2. Secondary windings shall be wye-connected, except where otherwise indicated on the drawings. Provide isolated neutral bushings for secondary wye-connected transformers.
3. Secondary leads shall be brought out through pressure-tight epoxy bushings.

G. Primary windings shall have four 2-1/2% full-capacity voltage taps; two taps above and two taps below rated voltage.

H. Core and Coil Assemblies:

1. Cores shall be grain-oriented, non-aging, silicon steel to minimize losses.
2. Core and coil assemblies shall be rigidly braced to withstand the stresses caused by rough handling during shipment, and stresses caused by any possible short-circuit currents.
3. Coils shall be continuous-winding type without splices except for taps. Material shall be copper.
4. Coil and core losses shall be optimum for efficient operation.
5. Primary, secondary, and tap connections shall be brazed or pressure type.
6. Provide end fillers or tie-downs for coil windings.

I. The transformer tank, cover, and radiator gauge thickness shall not be less than that required by ANSI.

J. Accessories:

1. Provide standard NEMA features, accessories, and the following:
   a. No-load tap changer. Provide warning sign.
   b. Lifting, pulling, and jacking facilities.
   c. Globe-type valve for oil filtering and draining, including sampling device.
   d. Pressure relief valve.
   e. Liquid level gauge and filling plug.
   f. A grounding pad in the medium- and low-voltage compartments.
   g. A diagrammatic nameplate.
   h. Dial-type liquid thermometer with a maximum reading pointer and an external reset.

i. Hot stick. Securely fasten hot stick within low-voltage compartment.

2. The accessories shall be made accessible within the compartments without disassembling trims and covers.

K. Transformers shall meet the energy conservation standards for transformers per the United States Department of Energy 10 CFR Part 431.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install transformers outdoors, as shown on the drawings, in accordance with the NEC, and as recommended by the manufacturer.

B. Anchor transformers with rustproof bolts, nuts, and washers not less than 12 mm (1/2 inch) diameter, in accordance with manufacturer’s instructions, and as shown on drawings.

C. Mount transformers on existing concrete slab.

D. Grounding:

1. Ground each transformer in accordance with the requirements of the NEC. Install ground rods per the requirements of Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS, to maintain a maximum resistance of 5 ohms to ground.

2. Connect the ground rod to the ground pads in the medium- and low-voltage compartments.

3. Install and connect the cable shield grounding adapter per the manufacturer’s instructions. Connect the bleeder wire of the cable shield grounding adapter to the loadbreak or deadbreak elbow grounding point with minimum No. 14 AWG wire, and connect the ground braid to the grounding system with minimum No. 6 AWG bare copper wire. Use soldered or mechanical grounding connectors listed for this purpose.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform manufacturer’s required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

a. Compare equipment nameplate data with specifications and approved shop drawings.

b. Inspect physical and mechanical condition. Check for damaged or cracked bushings and liquid leaks.

c. Verify that control and alarm settings on temperature indicators are as specified.

d. Inspect all field-installed bolted electrical connections, using the calibrated torque-wrench method to verify tightness of accessible bolted electrical connections, and perform thermographic survey after energization under load.
e. Vacuum-clean transformer interior. Clean transformer enclosure exterior.
f. Verify correct liquid level in transformer tank.
g. Verify correct equipment grounding per the requirements of Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
h. Verify the presence and connection of transformer surge arresters, if provided.
i. Verify that the tap-changer is set at rated system voltage.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the transformers are in good operating condition and properly performing the intended function.

3.4 SPARE PARTS

A. Deliver the following spare parts for the project to the COR two weeks prior to final inspection:
1. Six insulated protective caps.
2. One spare set of medium-voltage fuses for each size and type of fuse used in the project.

----- END -----

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of panelboards.

1.2 RELATED WORK

A. Section 09 91 00, PAINTING: Painting of panelboards.

B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirements for seismic restraint of non-structural components.

C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

D. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

F. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.

G. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

H. Section 26 09 23, LIGHTING CONTROLS: Lighting controls integral to panelboards.

I. Section 26 43 13, SURGE PROTECTIVE DEVICES: Surge protective devices integral to panelboards.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:

a. Submit sufficient information to demonstrate compliance with drawings and specifications.

b. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, circuit breakers, wiring and connection diagrams, accessories, and nameplate data.

c. Certification from the manufacturer that a representative panelboard has been seismically tested to International Building Code requirements. Certification shall be based upon simulated seismic forces on a shake table or by analytical methods, but not by experience data or other methods.

2. Manuals:

a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering circuit breakers and replacement parts.

1) Include schematic diagrams, with all terminals identified, matching terminal identification in the panelboards.

2) Include information for testing, repair, troubleshooting, assembly, and disassembly.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the manufacturer that the panelboards conform to the requirements of the drawings and specifications.

b. Certification by the Contractor that the panelboards have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. International Code Council (ICC):

IBC-21 .....International Building Code

C. National Electrical Manufacturers Association (NEMA):

PB 1-11 .....Panelboards

250-14 .....Enclosures for Electrical Equipment (1,000V Maximum)

D. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

70E-21 .....Standard for Electrical Safety in the Workplace

E. Underwriters Laboratories, Inc. (UL):

50-15 .....Enclosures for Electrical Equipment

67-09 .....Panelboards

489-16 .....Molded Case Circuit Breakers and Circuit Breaker Enclosures

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Panelboards shall be in accordance with NEC, NEMA, UL, as specified, and as shown on the drawings.

B. Panelboards shall have main breaker or main lugs, bus size, voltage, phases, number of circuit breaker mounting spaces, top or bottom feed, flush or surface mounting, branch circuit breakers, and accessories as shown on the drawings.

C. Panelboards shall be completely factory-assembled with molded case circuit breakers and integral accessories as shown on the drawings or specified herein.

D. Non-reduced size copper bus bars, rigidly supported on molded insulators, and fabricated for bolt-on type circuit breakers.

E. Bus bar connections to the branch circuit breakers shall be the “distributed phase” or “phase sequence” type.

F. Mechanical lugs furnished with panelboards shall be cast, stamped, or machined metal alloys listed for use with the conductors to which they will be connected.

G. Neutral bus shall be 200% rated, mounted on insulated supports.

H. Grounding bus bar shall be equipped with screws or lugs for the connection of equipment grounding conductors.

I. Bus bars shall be braced for the available short-circuit current as shown on the drawings, but not be less than 10,000 A symmetrical for 120/208 V and 120/240 V panelboards, and 14,000 A symmetrical for 277/480 V panelboards.

J. In two-section panelboards, the main bus in each section shall be full size. The first section shall be furnished with subfeed lugs on the

line side of main lugs only, or through-feed lugs for main breaker type panelboards, and have field-installed cable connections to the second section as shown on the drawings. Panelboard sections with tapped bus or crossover bus are not acceptable.

K. Series-rated panelboards are not permitted.

2.2 ENCLOSURES AND TRIMS

A. Enclosures:

1. Provide galvanized steel enclosures, with NEMA rating as shown on the drawings or as required for the environmental conditions in which installed.
2. Enclosures shall not have ventilating openings.
3. Enclosures may be of one-piece formed steel or of formed sheet steel with end and side panels welded, riveted, or bolted as required.
4. Provide manufacturer’s standard option for prepunched knockouts on top and bottom endwalls.
5. Include removable inner dead front cover, independent of the panelboard cover.

B. Trims:

1. Hinged “door-in-door” type.
2. Interior hinged door with hand-operated latch or latches, as required to provide access only to circuit breaker operating handles, not to energized parts.
3. Outer hinged door shall be securely mounted to the panelboard enclosure with factory bolts, screws, clips, or other fasteners, requiring a key or tool for entry. Hand-operated latches are not acceptable.
4. Inner and outer doors shall open left to right.
5. Trims shall be flush or surface type as shown on the drawings.

2.3 MOLDED CASE CIRCUIT BREAKERS

A. Circuit breakers shall be per UL, NEC, as shown on the drawings, and as specified.

B. Circuit breakers shall be bolt-on type.

C. Circuit breakers shall have minimum interrupting rating as required to withstand the available fault current, but not less than:

1. 120/208 V Panelboard: 10,000 A symmetrical.
2. 120/240 V Panelboard: 10,000 A symmetrical.
3. 277/480 V Panelboard: 14,000 A symmetrical.

D. Circuit breakers shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for less than 400 A frame. Circuit breakers with 400 A frames and above shall have magnetic trip, adjustable from 5x to 10x. Breaker trip setting shall be set in the field, based on the approved protective device study as specified in Section 26 05 73 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY, as applicable.

E. Circuit breaker features shall be as follows:

1. A rugged, integral housing of molded insulating material.
2. Silver alloy contacts.
3. Arc quenchers and phase barriers for each pole.
4. Quick-make, quick-break, operating mechanisms.
5. A trip element for each pole, thermal magnetic type with long time delay and instantaneous characteristics, a common trip bar for all poles and a single operator.
6. Electrically and mechanically trip free.
7. An operating handle which indicates closed, tripped, and open positions.
8. An overload on one pole of a multi-pole breaker shall automatically cause all the poles of the breaker to open.
9. Ground fault current interrupting breakers, shunt trip breakers, lighting control breakers (including accessories to switch line currents), or other accessory devices or functions shall be provided where shown on the drawings.
10. For circuit breakers being added to existing panelboards, coordinate the breaker type with existing panelboards. Modify the panel directory accordingly.

2.4 SURGE PROTECTIVE DEVICES

A. Where shown on the drawings, furnish panelboards with integral surge protective devices. Refer to Section 26 43 13, SURGE PROTECTIVE DEVICES.

PART 3 - EXECUTION

3.1 INSTALLATION

B. Installation shall be in accordance with the manufacturer’s instructions, the NEC, as shown on the drawings, and as specified.

C. Locate panelboards so that the present and future conduits can be conveniently connected.

D. In seismic areas, panelboards shall be adequately anchored and braced per details on structural contract drawings to withstand the seismic forces at the location where installed.

E. Install a printed schedule of circuits in each panelboard after approval by the COR. Schedules shall reflect final load descriptions, room numbers, and room names connected to each circuit breaker. Schedules shall be printed on the panelboard directory cards and be installed in the appropriate panelboards

F. Mount panelboards such that the maximum height of the top circuit breaker above the finished floor shall not exceed 1980 mm (78 inches).

G. Provide blank cover for each unused circuit breaker mounting space.

H. For panelboards located in areas accessible to the public, paint the exposed surfaces of the trims with finishes to match surrounding surfaces after the panelboards have been installed. Do not paint nameplates.

I. Rust and scale shall be removed from the inside of existing enclosures where new interior components are to be installed. Paint inside of enclosures with rust-preventive paint before the new interior components are installed. Provide new trim. Trim shall fit tight to the enclosure.

J. Panelboard enclosures shall not be used for conductors feeding through, spliced, or tapping off to other enclosures or devices.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

a. Compare equipment nameplate data with specifications and approved shop drawings.

b. Inspect physical, electrical, and mechanical condition.

c. Verify appropriate anchorage and required area clearances.

d. Verify that circuit breaker sizes and types correspond to approved shop drawings.

e. To verify tightness of accessible bolted electrical connections, use the calibrated torque-wrench method or perform thermographic survey after energization.

f. Vacuum-clean enclosure interior. Clean enclosure exterior.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the panelboards are in good operating condition and properly performing the intended function.

---END---

SECTION 26 25 11
BUSWAYS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of busways for use in electrical systems rated 600 V and below.

1.2 RELATED WORK

A. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirement for seismic restraint for nonstructural components.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

D. Section 26 24 16, PANELBOARDS: Circuit breakers for use in plug-in busway.

E. Section 26 29 21, ENCLOSED SWITCHES AND CIRCUIT BREAKERS: Switches and fuses for use in plug-in busway.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Submit the following data for approval:
      1) Electrical ratings, dimensions, mounting details and position, mounting method, vertical supports, materials, fire stops, and weatherproofing.
      2) Detailed coordinated connections to equipment terminations such as switchgear, switchboards, and transformers.

3) Coordination Drawings: Submit floor plans and sections, drawn to scale. Include bus assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Indicate vertical and horizontal enclosed busway runs, offsets, transitions, and clearances for access above and to the side of enclosed busways. Indicate vertical elevation of busway above the floor or bottom of structure. Indicate support locations, type of support, and weight on each support.

c. Certification from the manufacturer that representative busway has been seismically tested to International Building Code requirements. Certification shall be based upon simulated seismic forces on a shake table or by analytical methods, but not by experience data or other methods.

2. Manuals:

a. Submit complete maintenance and operating manuals including technical data sheets, and information for ordering replacement parts.

1) Include information for testing, repair, troubleshooting, assembly, and disassembly.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the manufacturer that the busway conforms to the requirements of the drawings and specifications.

b. Certification by the Contractor that the busway has been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplement and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

B. International Code Council (ICC):

IBC-21 .....International Building Code

C. National Electrical Manufacturers Association (NEMA):

BU 1.1-10 .....General Instructions for Handling, Installation, Operation and Maintenance of Busway Rated 600 Volts or Less

BU 1.2-13 .....Application Information for Busway Rated 600 Volts or Less

D. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

E. Underwriters Laboratories Inc. (UL):

857-09 .....Busways

PART 2 - PRODUCTS

2.1 MATERIAL

A. Busway shall be in accordance with NEMA and UL.

B. Busway shall be rated as shown on the drawings.

C. Busway shall have the following features:

1. For indoor locations; plug-in type, totally enclosed and moisture resistant.
2. Short circuit current rating shall not be less than 42,000 A, or as required to withstand the available fault current shown on the drawings, whichever is higher.
3. 3-phase, 4-wire, with 200% neutral, except where 3-phase, 3-wire is shown on the drawings.
4. Internal 50%-rated ground bus bar. Busway housing is not allowed to serve as the equipment grounding conductor.
5. All bus bars, phase, neutral, and ground, for each busway shall be within a single housing.
6. Bus Bars:
   a. Shall be full round edge rectangular copper of sufficient cross-section to provide full current rating without exceeding a temperature rise of 55° C above a 40° C ambient.
   b. Interconnection joints shall be tin or silver plated, with steel bolts, nuts, and Belleville washers.
   c. Shall be completely insulated with flame-retardant, track-resistant, self-extinguishing insulation.
7. Housings:
   a. Shall be steel or aluminum, with continuous mounting rails.
   b. Shall be thoroughly cleaned and painted at the factory with primer and the manufacturer's standard finish.

c. Shall have rustproof metal hardware.

d. Provide external flanges and weatherproofing at busway entrances to buildings.

e. Install expansion fittings in the busway runs in compliance with the manufacturer's standard recommendations.

f. The temperature rise at any point on the housing shall not exceed 30° C above an ambient temperature of 40° C.

8. Busway shall not be reduced in size at any point.

9. Provide manufacturer’s fittings and accessories, including but not limited to elbows, tees, tap boxes, transformer taps, end boxes, expansion fittings, offsets, adapters, hangers, and mounting hardware.

D. Dimensions and Configuration:

1. Configure within the space designated for busway installation.

2. Coordinate busway routing with equipment installation by other trades to avoid conflicts.

3. Make final field measurements and check them with the busway coordination drawings prior to authorization of fabrication of the busways.

2.2 PLUG-IN TYPE BUSWAY

A. Plug-in busway shall be available in standard trade lengths, with plug-in openings provided on both sides of the busway sections. Plug-in covers shall prohibit dirt and debris from entering contact plug-in openings in the busway. The contact surfaces for bus plug stabs shall be tin- or silver-plated and of the same material, thickness, and rating as the phase bars. A standard housing ground connection shall be supplied in each plug-in opening.

B. Plug-in units of the types and ratings indicated on the drawings and specifications shall be supplied. Plug-in units shall be mechanically interlocked with the busway housing to prevent their installation or removal while the switch is in the “ON” position. The enclosure of any plug-in unit shall make positive ground connection to the duct housing before the stabs make contact with the bus bars. All plug-in units shall be equipped with an interlock that can be defeated to prevent the cover from being opened while the plug-in unit is in the “ON” position, and to prevent accidental closing while the cover is open. The plug-in units shall be provided with a means for padlocking. The operating

handle and mechanism shall remain in control of the plug-in unit at all times, permitting easy operation by means of a hook stick or chain. All plug-in units shall be interchangeable without alteration or modification of plug-in busway.

C. Fusible-type plug-in units shall have a quick-make/quick-break disconnect switch and positive pressure fuse clips. Provide fuses as specified in Section 26 29 21, ENCLOSED SWITCHES AND CIRCUIT BREAKERS, and as shown on the drawings.

D. Circuit breaker-type plug-in units shall have an interrupting rating as shown on the drawings. All circuit breaker plug-in devices shall be of the same manufacturer as the busway. Circuit breakers shall be as specified in Section 26 24 16, PANELBOARDS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.

B. Support busways as required by the NEC and as required by manufacturer’s shop drawings.

C. In seismic areas, busway shall be adequately anchored and braced per details on structural contract drawings to withstand the seismic forces at the location where installed.

D. Coordinate all of the busway terminations to equipment to ensure proper phasing.

E. Tighten bolted connections with a torque wrench to values as required by the manufacturer.

F. Install expansion fittings at locations where busways cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform manufacturer’s required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

a. Compare equipment nameplate data with specifications and approved shop drawings.

b. Inspect physical, electrical, and mechanical condition.

c. Verify appropriate anchorage, required area clearances, and correct alignment.

d. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.

e. Verify appropriate equipment grounding.

f. Examine outdoor busways for removal of weep-hole plugs, if applicable, and the correct installation of joint shield.

2. Electrical Tests:

a. After installation, test busway phase-to-phase and phase-to-ground resistance with an insulation resistance tester. Resulting values shall not be less than one megohm.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the busway is in good operating condition and properly performing the intended function.

B. After the busways have been energized for a minimum of 30 days, repeat the torque wrench tightening of all bolt connections.

---END---

SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of wiring devices.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.

B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Cables and wiring.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and boxes.

E. Section 26 51 00, INTERIOR LIGHTING: LED drivers for use with manual dimming controls.

1.3 QUALITY ASSURANCE

A. Refer to paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS and 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1. Shop Drawings:

a. Submit sufficient information to demonstrate compliance with drawings and specifications.

b. Include electrical ratings, dimensions, mounting details, construction materials, grade, and termination information.

2. Manuals:

a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets and information for ordering replacement parts.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the manufacturer that the wiring devices conform to the requirements of the drawings and specifications.

b. Certification by the Contractor that the wiring devices have been properly installed and adjusted.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.

B. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

99-21 .....Health Care Facilities

C. National Electrical Manufacturers Association (NEMA):

WD 1-10 .....General Color Requirements for Wiring Devices

WD 6-12 .....Wiring Devices – Dimensional Specifications

D. Underwriter’s Laboratories, Inc. (UL):

5-11 .....Surface Metal Raceways and Fittings

20-10 .....General-Use Snap Switches

231-08 .....Power Outlets

467-13 .....Grounding and Bonding Equipment

498-12 .....Attachment Plugs and Receptacles

943-15 .....Ground-Fault Circuit-Interrupters

1449-14 .....Surge Protective Devices

1472-15 .....Solid State Dimming Controls

PART 2 - PRODUCTS

2.1 RECEPTACLES

A. General: All receptacles shall comply with NEMA, NFPA, UL, and as shown on the drawings.

1. Mounting straps shall be nickel plated brass, brass, nickel plated steel or galvanize steel with break-off plaster ears and shall include a self-grounding feature. Terminal screws shall be brass, brass plated or a copper alloy metal.

2. Receptacles shall have provisions for back wiring with separate metal clamp type terminals (four minimum) and side wiring from four captively held binding screws.

B. Duplex Receptacles - Hospital-grade: shall be listed for hospital grade, single phase, 20 ampere, 120 volts, 2-pole, 3-wire, NEMA 5-20R, with break-off feature for two-circuit operation.

1. Bodies shall be white in color.

2. Switched duplex receptacles shall be wired so that only the top receptacle is switched. The lower receptacle shall be unswitched.

3. Duplex Receptacles on Emergency Circuit:

a. In rooms without emergency powered general lighting, the emergency receptacles shall be of the self-illuminated type.

4. Ground Fault Current Interrupter (GFCI) Duplex Receptacles: Shall be an integral unit, hospital-grade, suitable for mounting in a

standard outlet box, with end-of-life indication and provisions to isolate the face due to improper wiring. GFCI receptacles shall be self-test receptacles in accordance with UL 943.

a. Ground fault interrupter shall consist of a differential current transformer, self-test, solid state sensing circuitry and a circuit interrupter switch. Device shall have nominal sensitivity to ground leakage current of 4-6 milliamperes and shall function to interrupt the current supply for any value of ground leakage current above five milliamperes (+ or – 1 milliampere) on the load side of the device. Device shall have a minimum nominal tripping time of 0.025 second.

b. Self-test function shall be automatically initiated within 5 seconds after power is activated to the receptacles. Self-test function shall be periodically and automatically performed every 3 hours or less.

c. End-of-life indicator light shall be a persistent flashing or blinking light to indicate that the GFCI receptacle is no longer in service.

5. Tamper-Resistant Duplex Receptacles:

a. Bodies shall be gray in color.

1) Shall permit current to flow only while a standard plug is in the proper position in the receptacle.

2) Screws exposed while the wall plates are in place shall be the tamperproof type.

C. Duplex Receptacles – Non-hospital Grade: shall be the same as duplex receptacles – hospital grade in accordance with sections 2.1A and 2.1B of this specification, except for the hospital grade listing.

a. Bodies shall be brown nylon.

D. Receptacles - 20, 30, and 50 ampere, 250 Volts: Shall be complete with appropriate cord grip plug.

E. Weatherproof Receptacles: Shall consist of a duplex receptacle, mounted in box with a gasketed, weatherproof, cast metal cover plate and cap

over each receptacle opening. The cap shall be permanently attached to the cover plate by a spring-hinged flap. The weatherproof integrity shall not be affected when heavy duty specification or hospital grade attachment plug caps are inserted. Cover plates on outlet boxes mounted flush in the wall shall be gasketed to the wall in a watertight manner.

F. Surge Protective (TVSS) Receptacles shall have integral surge suppression in line to ground, line to neutral, and neutral to ground modes.

1. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 Volts, and minimum single transient pulse energy dissipation of 210 Joules.

2. Active TVSS Indication: LED, visible in face of device to indicate device is active or no longer in service.

2.2 TOGGLE SWITCHES

A. Toggle switches shall be totally enclosed tumbler type with nylon bodies. Handles shall be white in color unless otherwise specified or shown on the drawings.

1. Switches installed in hazardous areas shall be explosion-proof type in accordance with the NEC and as shown on the drawings.

2. Shall be single unit toggle, butt contact, quiet AC type, heavy-duty general-purpose use with an integral self-grounding mounting strap with break-off plasters ears and provisions for back wiring with separate metal wiring clamps and side wiring with captively held binding screws.

3. Switches shall be rated 20 amperes at 120-277 Volts AC.

2.3 MANUAL DIMMING CONTROL

A. Electronic full-wave manual slide dimmer with on/off switch and audible frequency and EMI/RFI suppression filters.

B. Manual dimming controls shall be fully compatible with LED dimming driver and be approved by the driver manufacturer, shall operate over full specified dimming range.

C. Provide single-pole, three-way or four-way, as shown on the drawings.

D. Manual dimming control and faceplates shall be white in color unless otherwise specified.

2.4 WALL PLATES

A. Wall plates for switches and receptacles shall be type smooth nylon. Oversize plates are not acceptable.

B. Color shall be white unless otherwise specified.

C. For receptacles or switches mounted adjacent to each other, wall plates shall be common for each group of receptacles or switches.

D. In areas requiring tamperproof wiring devices, wall plates shall be type 302 stainless steel, and shall have tamperproof screws and beveled edges.

E. Duplex Receptacles on Emergency Circuit: Wall plates shall be red nylon with the word "EMERGENCY" engraved in 6 mm (1/4 inch) white letters.

2.5 SURFACE MULTIPLE-OUTLET ASSEMBLIES

A. Shall have the following features:

1. Enclosures:

a. Thickness of steel shall be not less than 1 mm (0.040 inch) for base and cover. Nominal dimensions shall be 40 mm x 70 mm (1-1/2 inches by 2-3/4 inches) with inside cross sectional area not less than 2250 square mm (3-1/2 square inches). The enclosures shall be thoroughly cleaned, phosphatized, and painted at the factory with primer and the manufacturer's standard baked enamel finish.

2. Receptacles shall be duplex, hospital grade. See paragraph 'RECEPTACLES' in this Section. Device cover plates shall be the manufacturer's standard corrosion resistant finish and shall not exceed the dimensions of the enclosure.

3. Unless otherwise shown on drawings, receptacle spacing shall be 600 mm (24 inches) on centers.

4. Conductors shall be as specified in Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE.

5. Installation fittings shall be the manufacturer's standard bends, offsets, device brackets, inside couplings, wire clips, elbows, and other components as required for a complete system.

6. Bond the assemblies to the branch circuit conduit system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC and as shown as on the drawings.

B. Install wiring devices after wall construction and painting is complete.

C. The ground terminal of each wiring device shall be bonded to the outlet box with an approved green bonding jumper, and also connected to the branch circuit equipment grounding conductor.

D. Outlet boxes for toggle switches and manual dimming controls shall be mounted on the strike side of doors.

E. Provide barriers in multi-gang outlet boxes to comply with the NEC.

F. Coordinate the electrical work with the work of other trades to ensure that wiring device flush outlets are positioned with box openings aligned with the face of the surrounding finish material. Pay special attention to installations in cabinet work, and in connection with laboratory equipment.

G. Exact field locations of floors, walls, partitions, doors, windows, and equipment may vary from locations shown on the drawings. Prior to locating sleeves, boxes and chases for roughing-in of conduit and equipment, the Contractor shall coordinate exact field location of the above items with other trades.

H. Install wall switches 1.2 M (48 inches) above floor, with the toggle OFF position down.

I. Install wall dimmers 1.2 M (48 inches) above floor.

J. Install receptacles 450 mm (18 inches) above floor, and 152 mm (6 inches) above counter backsplash or workbenches. Install specific-use

receptacles at heights shown on the drawings.

K. Install horizontally mounted receptacles with the ground pin to the right.

L. When required or recommended by the manufacturer, use a torque screwdriver. Tighten unused terminal screws.

M. Label device plates with a permanent adhesive label listing panel and circuit feeding the wiring device.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform manufacturer’s required field checks in accordance with the manufacturer's recommendations, and the latest NFPA 99. In addition, include the following:

1. Visual Inspection and Tests:

a. Inspect physical and electrical conditions.

b. Vacuum-clean surface metal raceway interior. Clean metal raceway exterior.

c. Test wiring devices for damaged conductors, high circuit resistance, poor connections, inadequate fault current path, defective devices, or similar problems using a portable receptacle tester. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.

d. Test GFCI receptacles.

2. Receptacle testing in the Patient Care Spaces, such as retention force of the grounding blade of each receptacle, shall comply with the latest NFPA 99.

- - - END - - -

SECTION 26 29 21
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of fused and unfused disconnect switches (indicated as switches in this section), and separately-enclosed circuit breakers for use in electrical systems rated 600 V and below.

1.2 RELATED WORK

A. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirements for seismic restraint of non-structural components.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground faults.

E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.

F. Section 26 24 16, PANELBOARDS: Molded-case circuit breakers.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES and the following requirements:

1. Shop Drawings:

a. Submit sufficient information to demonstrate compliance with drawings and specifications.

b. Submit the following data for approval:

1) Electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, fuses, circuit breakers, wiring and connection diagrams, accessories, and device nameplate data.

c. Certification from the manufacturer that representative enclosed switches and circuit breakers have been seismically tested to International Building Code requirements. Certification shall be based upon simulated seismic forces on a shake table or by analytical methods, but not by experience data or other methods.

2. Manuals:

a. Submit complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering fuses, circuit breakers, and replacement parts.

1) Include schematic diagrams, with all terminals identified, matching terminal identification in the enclosed switches and circuit breakers.

2) Include information for testing, repair, troubleshooting, assembly, and disassembly.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the manufacturer that the enclosed switches and circuit breakers conform to the requirements of the drawings and specifications.

b. Certification by the Contractor that the enclosed switches and circuit breakers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. International Code Council (ICC):

IBC-21 .....International Building Code

C. National Electrical Manufacturers Association (NEMA):

FU l-12 .....Low Voltage Cartridge Fuses

KS l-13 .....Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum)

D. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL):

98-16 .....Enclosed and Dead-Front Switches

248 1-11 .....Low Voltage Fuses

489-13 .....Molded Case Circuit Breakers and Circuit Breaker Enclosures

PART 2 - PRODUCTS

2.1 FUSED SWITCHES RATED 600 AMPERES AND LESS

A. Switches shall be in accordance with NEMA, NEC, UL, as specified, and as shown on the drawings.

B. Shall be NEMA classified General Duty (GD) for 240 V switches, and NEMA classified Heavy Duty (HD) for 480 V switches.

C. Shall be horsepower (HP) rated.

D. Shall have the following features:

1. Switch mechanism shall be the quick-make, quick-break type.

2. Copper blades, visible in the open position.

3. An arc chute for each pole.

4. External operating handle shall indicate open and closed positions and have lock-open padlocking provisions.

5. Mechanical interlock shall permit opening of the door only when the switch is in the open position, defeatable to permit inspection.

6. Fuse holders for the sizes and types of fuses specified.

7. Solid neutral for each switch being installed in a circuit which includes a neutral conductor.

8. Ground lugs for each ground conductor.

9. Enclosures:

   a. Shall be the NEMA types shown on the drawings.

   b. Where the types of switch enclosures are not shown, they shall be the NEMA types most suitable for the ambient environmental conditions.

   c. Shall be finished with manufacturer’s standard gray baked enamel paint over pretreated steel.

10. Electrically operated switches shall only be installed where shown on the drawings.

2.2 UNFUSED SWITCHES RATED 600 AMPERES AND LESS

A. Shall be the same as fused switches, but without provisions for fuses.

2.3 FUSED SWITCHES RATED OVER 600 AMPERES TO 1200 AMPERES

A. Shall be the same as fused switches, and shall be NEMA classified Heavy Duty (HD).

2.4 MOTOR RATED TOGGLE SWITCHES

A. Type 1, general purpose for single-phase motors rated up to 1 horsepower.

B. Quick-make, quick-break toggle switch with external reset button and thermal overload protection matched to nameplate full-load current of actual protected motor.

2.5 CARTRIDGE FUSES

A. Shall be in accordance with NEMA FU 1.

B. Feeders: Class L, time delay.

C. Motor Branch Circuits: time delay.

D. Other Branch Circuits: Class RK1.

E. Control Circuits: Class CC.

2.6 SEPARATELY-ENCLOSED CIRCUIT BREAKERS

A. Provide circuit breakers in accordance with the applicable requirements in Section 26 24 16, PANELBOARDS.

B. Enclosures shall be the NEMA types shown on the drawings. Where the types are not shown, they shall be the NEMA type most suitable for the ambient environmental conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.

B. Enclosed switches and circuit breakers shall be adequately anchored and braced per details on structural contract drawings to withstand the seismic forces at the location where installed.

C. Fused switches shall be furnished complete with fuses. Arrange fuses such that rating information is readable without removing the fuses.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

a. Compare equipment nameplate data with specifications and approved shop drawings.

b. Inspect physical, electrical, and mechanical condition.

c. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.

d. Vacuum-clean enclosure interior. Clean enclosure exterior.

3.3 SPARE PARTS

A. Two weeks prior to the final inspection, furnish one complete set of spare fuses for each fused disconnect switch installed on the project. Deliver the spare fuses to the Resident Engineer OR COR.

- - - END - - -

SECTION 26 33 53
STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of the static uninterruptible power supply, indicated in this section as UPS.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible fault currents.

D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

A. UPS shall be thoroughly tested at the factory to assure that there are no electrical or mechanical defects.

B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. UPS shall be factory full-load tested to meet the requirements specified using a test battery (not the battery to be supplied with the system) with AC input power and with battery power for a minimum of 8 hours, with meter readings taken every 30 minutes. Should a malfunction occur, the problem shall be corrected and the test shall be repeated. The tests shall encompass all aspects of operation, such as module failure, static bypass operation, battery failure, input power failure and overload ratings.

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, plan, front, side, and rear elevations, accessories, and device nameplate data.
   c. Provide detailed and project-specific system diagram, showing maintenance bypass, UPS module(s), battery cabinet(s) and batteries, major circuit protective devices, interconnecting power and control wiring, key-type mechanical interlocks, and connections to power sources and loads, as applicable. Indicate whether interconnections are factory-provided/factory-installed, factory-provided/field-installed, or field-provided/field installed.
2. Manuals:
   a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.
      1) Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.
      2) Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnection between the items of equipment.
      3) Provide a clear and concise description of operation, which gives, in detail, the information required to properly operate the UPS, including but not limited to bypass switchboard, UPS, key-type mechanical interlocks, remote devices, emergency power off buttons, fire alarm interface, and other components as applicable.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
   1) Include complete "As Installed" diagrams that indicate all pieces of equipment and their interconnecting wiring.
   2) Include complete diagrams of the internal wiring for each piece of equipment, including "As Installed" revisions of the diagrams.
   3) The wiring diagrams shall identify the terminals to facilitate installation, maintenance, operation, and testing.

3. Test Reports:
   a. Submit certified factory design and production test reports for approval.
   b. Two weeks prior to the final inspection, submit certified field test reports and data sheets to the COR.
4. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the UPS conforms to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the UPS has been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata), form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.

B. Institute of Engineering and Electronic Engineers (IEEE):

C57.110-08 .....Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents

C62.41.1-02 .....Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits

C62.41.2-02 .....Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

450-10 .....Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications

485-10 .....Sizing Lead-Acid Batteries for Stationary Applications

C. International Code Council (ICC):

IBC-21 .....International Building Code

D. National Electrical Manufacturers Association (NEMA):

PE 1-12 .....Uninterruptible Power Systems - Specification and Performance Verification

E. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. System Capacity: Unless stated otherwise, the parameters listed are under full rated output load at a minimum of 0.9 power factor, with batteries fully charged and floating on the DC bus and with nominal input voltage. Overall 5kVA at 40 °C.

B. Battery Capacity: Discharge time to end voltage: 10 minutes, at 25 °C (77 °F). Battery shall be capable of delivering 125 percent of full rated output load at initial start-up.

C. System Bus Bracing: Braced for amperes symmetrical interrupting capacity as shown on drawings.

D. AC Input:

1. Voltage 208 volts line-to-line.
2. Number of phases: 3-phase, 4-wire, plus ground.
3. Voltage Range: Plus 10 percent, minus 15 percent, without affecting battery float voltage or output voltage.
4. Frequency: 60 Hz, plus or minus 5 percent.
5. Total harmonic current distortion (THD) reflected into the primary line: 5 percent maximum.

E. AC Output

1. Voltage 208 volts line-to-line, 120 volts line-to-neutral.
2. Number of phases: 3-phase, 4-wire, plus ground.
3. Voltage regulation:
   a. Balanced load: Plus or minus 1.0 percent.
   b. 100 percent load imbalance, phase-to-phase: Plus or minus 3 percent.
4. Frequency: 60 Hz.

5. Frequency regulation: Plus or minus 0.05 percent.
6. Harmonic content (RMS voltage): 5 percent maximum total harmonic distortion with 100% nonlinear load.
7. Load power factor operating range: 1.0 to 0.8 lagging.
8. Phase displacement:
   a. Balanced load: Plus or minus 1 degree of bypass input.
9. Overload capability (at full voltage) (excluding battery):
   a. 125 percent load for 10 minutes.
   b. 150 percent load for 1 minute.

F. Voltage Transient Response:
1. 100 percent load step: Plus or minus 5 percent.

2.2 100KVA UPS - MCR

A. General Description: The UPS system shall consist of an IGBT power factor-corrected rectifier, DC-DC converter and three-phase, transformer-free inverter, bypass static transfer switch, bypass synchronizing circuitry, protective devices and accessories as specified. The specified system shall also include a battery disconnect breaker and battery system.

B. Rectifier/Charger Unit: Rectifier/charger unit shall be solid state and shall provide direct current to the DC bus.
1. Input Circuit Breaker: Rectifier/charger unit shall be provided with an input circuit breaker. The circuit breaker shall be sized to accept simultaneously the full-rated load and the battery recharge current.
2. 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.

C. 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.
1. Output Overload: The inverter shall be able to sustain an overload as specified across its output terminals.
2. Synchronism: The inverter shall normally operate in phase-lock and synchronism with the bypass source.

3. 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.
4. Output Circuit Breaker: The output circuit breaker shall be capable of shunt tripping and shall have interrupting capacity as specified. Circuit breaker shall have provision for locking in the "off" position.
5. Output Transformer: The inverter output transformer shall be similar to the input transformer and shall be capable of handling up to nonlinear loads as described in IEEE C57.110.

D. 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.

E. 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.

2.3 STATIC BYPASS TRANSFER SWITCH

A. When maintenance is required or when the inverter cannot maintain voltage to the load due to sustained overload or malfunction, a bypass circuit shall be provided to isolate the inverter output from the load and provide a path for power directly from an alternate AC (bypass) source. The UPS control system shall constantly monitor the availability of the inverter bypass circuit to perform a transfer. The inverter bypass circuit shall consist of a continuous duty bypass static switch and an overcurrent protection device to isolate the static bypass switch from the bypass utility source. The bypass static

switch shall denote the solid-state device incorporating SCRs (silicon controlled rectifiers) that can automatically and instantaneously connect the alternate AC source to the load.

1. Static Bypass Transfer Switch Disconnect: A disconnect shall be incorporated to isolate the static bypass transfer switch assembly so it can be removed for servicing. The disconnect shall be equipped with auxiliary contacts and provision for padlocking in either the "on" or "off" position.

2.4 MAINTENANCE BYPASS - SINGLE-MODULE UPS

A. A maintenance bypass switch shall be provided as an integral part of the UPS and located within the UPS module. The maintenance bypass switch shall provide the capability to continuously support the 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. Switch shall contain a maintenance bypass protective device and a module isolation protective device.

B. The maintenance bypass switch shall provide the capability of transferring the 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 load

2.6 MODULE CONTROL PANEL – SINGLE-MODULE UPS

A. UPS Control Panel—The UPS shall be provided with a microprocessor-based control panel for operator interface (may also be referred to as User Interface, or UI) to configure and monitor the UPS. The control panel shall be located on the front of the unit where it can be operated without opening the hinged front door. A backlit, menu-driven, full-graphics, color touchscreen liquid crystal display shall be used to enter setpoints for the battery test (duration and end voltage), display system information, metering information, a one-line diagram of the UPS and battery, active events, event history, startup instructions and transfer and shutdown screens.

No mechanical push buttons shall be used.

1. **Module Meters:**

a. Meters shall have 1 percent accuracy.

b. The following functions shall be monitored and displayed:

1) Input voltage, phase-to-phase (all three phases).
2) Input current, all three phases.
3) Input frequency.
4) Battery voltage.
5) Battery current (charge/discharge).
6) Output voltage, phase-to-phase and phase-to-neutral (all three phases).
7) Output current, all three phases.
8) Output frequency.
9) Output kilowatts.
10) Elapsed time meter to indicate hours of operation, 6 digits.
11) Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).
12) Output kilovars.
13) Output kilowatt hours, with 15-minute interval.

2. **Module Controls:**

a. Module shall have the following controls:

1) Alarm test/reset function.
2) Module input protective device trip function.
3) Module output protective device trip function.
4) Battery protective device trip function.
5) Emergency Power Off (EPO) pushbutton, with guard.
6) Control power off switch.
7) Static bypass transfer switch enable/disable selector switch.

3. **Module Alarm Indicators:**

a. 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.

1) Input AC power source failure.
2) Input protective device open.
3) Output protective device open.
4) Overload.
5) Overload shutdown.
6) DC overvoltage.
7) DC ground fault.
8) Low battery.

9) Battery discharged.
10) Battery protective device open.
11) Cooling fan failure.
12) Equipment overtemperature.
13) Control power failure.
14) Charger off.
15) Inverter off.
16) Emergency off.
17) UPS on battery.
18) Load on static bypass.
19) Static bypass transfer switch disabled.
20) Inverter output overvoltage, undervoltage, overfrequency, and underfrequency.
21) Bypass source overvoltage, undervoltage, overfrequency, and underfrequency.
22) Bypass source to inverter out of synchronization.

2.9 BATTERY SYSTEM

A. 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.
B. Battery Type: Lead calcium.
C. Battery Construction: The battery shall be of the valve-regulated, sealed, non-gassing, recombinant type.
D. Battery Cabinet: The batteries shall be furnished in a battery cabinet matching the UPS. The battery cabinet shall be provided with smoke and high temperature alarms
E. Battery Cables: Battery-to-battery connections shall be stranded cable with proper cable supports.
F. Battery Disconnect: The battery cabinet shall have a properly rated circuit breaker (600VDC) to isolate it from the Liebert EXM UPS. This breaker shall be in a separate NEMA-1 enclosure or in a matching battery cabinet. When this breaker is open, there shall be no battery voltage in the UPS enclosure. The UPS shall be automatically disconnected from the battery by a shunt trip of the battery cabinet breaker when signaled by other control functions.

2.10 5KVA UPS – TELECOMMUNICATIONS ROOMS (TR)

2.11 PART 1 GENERAL UPS

2.12 SUMMARY UPS

This specification describes the operation and functionality of a continuous duty, three- phase, solid-state, static Uninterruptible Power Supply (UPS) hereafter referred to as the UPS. Any system deployment shall comprise of hot swappable / user replaceable 5kVA/5kW electronics modules. Each replaceable 5kVA/5kW electronics module contains individual UPS system logic controls, a power factor corrected input power converter/rectifier, PWM inverter, continuous duty bypass static switch module and battery charging circuit. Each 5kW system shall also comprise of hot swappable / user replaceable battery modules, individual user replaceable LCD interface display, intelligent automated maintenance bypass contactor, battery breaker, individual system input breaker, and output distribution breaker. Each 5kW UPS shall contain two battery strings in parallel enhancing system reliability.

2.13 STANDARDS

A. UL 1778 (Underwriters Laboratories) – Standard for Uninterruptible Power Supply Equipment. Product safety requirements for the United States.

B. CSA C22.2 No 107.1(Canadian Standards Association) – Commercial and Industrial Power Supplies. Product safety requirements for Canada.

C. IEC 62040-1-1 (International Electrotechnical Commission) – Uninterruptible power systems (UPS) – Part 1-1: General and safety requirements for UPS used in operator access areas.

D. IEC 62040-1-2 (International Electrotechnical Commission) – Uninterruptible power systems (UPS) – Part 1-2: General and safety requirements for UPS used in restricted access locations.

E. IEC 62040-3 (International Electrotechnical Commission) – Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements.

F. CISPR 22: FCC Rules and Regulations 47, Part 15, Class A (Federal Communications Commission) – Radio Frequency Devices.

G. Where applicable, the UPS shall also be designed in accordance with publications from the following organizations and committees

1. IEEE 587 (ANSI C62.41) Category A & B (International Electrical and Electronics Engineers) – Recommended practices on surge voltages in low voltage power circuits.

2. NFPA 70E®: Standard for Electrical Safety in the Workplace®

3. NEMA - National Electrical Manufacturers Association

4. MIL-HDBK-217E (Military Handbook) – Reliability prediction of electronics equipment

5. IEEE 519-1992 Standard Practices and Requirements for Harmonic Control in Electrical Power Systems.

6. ISO 9001

(8) ISO

14001

2.14 UPS MODES OF OPERATION

A. Standard: Power strategy set for High Efficiency: Utilizing commercial AC power, the critical load shall be continuously supplied regulated and protected AC power. The system shall power the load while regulating both voltage and frequency in compliance with the UPS output specifications. The system shall derive power from the commercial AC source if the input source is within the specifications for the UPS input. Upon loss of AC power or an event where the input AC source is not is tolerance the UPS shall supply DC power to the Inverter which will supply an output voltage in compliance with the output voltage specifications. System efficiency will be 96% or greater, over the range of 40% to 100% load. System efficiency will be 95% or better from 20 to 40% load. The UPS shall be able to distinguish between upstream (utility) faults and downstream (load) faults, and react appropriately to protect and support the critical load, without interruption. When High Efficiency is utilized, the UPS must attenuate ANSI C62.41-type line transients to within IEC and ITIC limits. During standard operation the AC source shall provide power for the loads in conjunction with charging the battery.

B. Normal: Power strategy set for Normal: Utilizing commercial AC power, the critical load shall be continuously supplied regulated and protected AC power. The system shall power the load while regulating both voltage and frequency in compliance with the UPS output specifications . The system shall operate in double conversion mode of operation unless forced or commanded to battery mode, bypass mode, high efficiency more or system off. The system shall derive power from the commercial AC source and shall supply DC power to the Inverter in conjunction with charging the battery.

C. Battery: Upon failure of the commercial AC power, the critical load shall continue to be supplied AC power by the system, which shall obtain power from the batteries without any operator intervention. Continuous operation of the critical load shall never be jeopardized during the failure or restoration of the commercial AC source.

D. Charger: Upon restoration of the commercial AC or back-up generation source, the charger shall recharge the batteries and simultaneously supply power to the input power converter (rectifier) which provides power to the Inverter. This shall be an automatic function and shall cause no interruption to the critical load.

2.15 PRODUCT

2.15.1 DESIGN REQUIREMENTS

A. The UPS shall be sized for 5kW / 5kVA load
B. The UPS battery shall be sized for 10 minutes runtime at a Power Factor of .9 for a 5kW load.

2.15.2 SYSTEM CHARACTERISTICS

A. System Capacity: The system shall be rated for full 5kW output .

B. Input Specifications:

AC Input Nominal Voltage: 208Y/120V, 3 Phase, 4 wire plus ground 60 Hz.

AC Input Voltage Window (range before re-transfer from battery):

- System loading less than 85% or 4.2kW per 5kW module: 157vac to 246vac, line to line, (-24/+18%), without using stored energy mode.
- System loading greater than 85% or 4.2kW per module: 187 to 229 vac, line to line, (+10/-10%) without using stored energy mode.
- Transfer to stored energy window is 3 % wider that re-transfer to AC line to compensate for hysteresis.

Maximum Frequency Range: (automatically set upon start-up)

- 60 Hz operation: 55-65 Hz before switching to battery operation
- 50 Hz operation: 45 to 55 Hz before switching to battery operation

Input Power Factor:

- While operating in Normal: > .97 operating from IGBT based input power converter

Input Current Distortion (*with no additional passive filter)*

- While operating in Normal: < 5% operating from input power converter, with PFC and Non-PFC loads.

Current inrush: No transformer magnetizing inrush in standard UPS

- From start or retransfer from battery: Shall not exceed connected load inrush
- Programmable delay: Upon retransfer from battery each UPS module shall be capable of being programmed from 0 to a maximum of 50 second delay before attempting transfer to the alternate source. This delay is programmable in 10 groups at maximum of five seconds per group .

C. Output Specifications:

- AC Output: 208Y/120V, 3 Phase, 4 wire plus ground, 60 Hz.
- AC Output Voltage Distortion: Max. 3% @ 100% Linear Load.
- Output Voltage Window: Selectable
  - Conformance to ITIC curve, 187 vac to 229 vac L to L
  - Wide window option, typical per ITE Power supply regulation window: 180 vac to 229 vac L to L

- Voltage Transient Response:
  - HE operation: Dependent upon input mains source, however typically maintains voltage within output specification window +/- 1% maximum for 0-100% or 100% to 0 load step
  - Normal operation: +/- 6% RMS maximum for 0-100% or 100% to 0 load step
  - rve energy mode: +/- 6% RMS maximum for 0-100% or 100% to 0 load step

- Voltage Transient Recovery within <50 milliseconds

- Static transfer duration
  - With mode set to high efficiency: typical 3-5 ms
  - With mode set to normal, bypass mode back to normal mode: 1-2 ms

- Output Voltage Harmonic Distortion: Stored energy or inverter operation
  - <3% THD maximum and 1% single harmonic for a 100% linear load
  - <5% THD maximum for non-linear load described in IEC 62040-3

- Phase Angle Displacement:
- 120 degrees $^{+}$/- 1 degree for balanced load
  - 120 degrees $^{+}$/- 1 degrees for 50% imbalanced load
  - 120 degrees $^{+}$/- 3 degrees for 100% imbalanced load

- Overload Rating
  - With mode set to Normal Operation
    - >150% - three hundred milliseconds (300mS)
    - 126% to 150% - five (5) seconds
    - 111% to 125% - one (1) minute
    - 106% to 110% - ten (10) minutes
    - 105% continuous

- Bypass Operation
  - 125% continuous
  - 1000% for 500 milliseconds (OCP dependent)

- System AC-AC Efficiency: Power Strategy set to High Efficiency >97.5% at 100% load, with nominal input voltage and frequency.

- System AC-AC Efficiency: Power Strategy set to Normal >89.5% at 83% load, with nominal input voltage and frequency.

- Output Power Factor Rating: 0.9 lead to 0.7 lag

  - The UPS output shall not require derating for purely resistive or power factor corrected loads (PF of 1). The output kW and kVA ratings of the UPS shall be equal. For loads exhibiting a power factor of .9 leading to .7 lagging no derating of the UPS shall be required.

- Environmental
  - Storage Ambient Temperature: -40□F to 158□F (-40□C to 70□C)
  - Operating Ambient Temperature: +32□F to 104□F (0□C to 40□C). (25□C is ideal for most battery types)
  - Relative Humidity: 5 to 95% Non-condensing
  - Altitude: Maximum installation with no derating of the UPS output shall be 3300 feet (1000m) above sea level.

D. INPUT POWER CONVERTER

1. The input power converter for each 5kW system is housed within the removable electronics module. This electronics module shall also contain the system control logic, continuous duty static switch and continuous duty inverter. The input power converter shall constantly receive power from the mains input to the system, to provide the necessary UPS power for precise regulation of the DC link voltage to the inverter and battery charger, therefore maintaining regulated output power.

2. Input Current Total Harmonic Distortion: The input current ITHD shall be actively controlled by the input power converter while operating from the converter in normal operational mode. The input ITHD shall be less than 5% at full system load.

3. Magnetization Inrush Current: If provided with an optional isolation transformer or PDU/System Bypass, system inrush shall be limited to 10 times the nominal input current of the transformer.

4. Input Current Limit:

   a. The input converter shall control and limit the input current

draw from utility to 130% of the UPS output. With mains deviation of up to +18%/ -10% of the nominal input voltage the UPS shall be able to support 100% load, charge batteries at up to 10% of the UPS output rating, and provide voltage regulation per the output voltage specification.

b. When installed in a parallel configuration the UPS systems shall adjust charge levels to ensure batteries are properly charged, without compromising the parallel bus bar capacity rating, or upstream breaker ratings.

5. Battery management system: The UPS shall contain a battery management system with the following features:

a. Battery Recharge: The battery management system shall provide a three-step charging process. These periods shall be recognized as constant current, constant voltage and rest. After recharging batteries to full capacity, UPS shall isolate the charging circuit from the battery. Continual float charging of the battery shall not be allowed, therefore reducing the possibility of positive grid corrosion, and increasing expected battery life.

b. Battery Runtime Monitoring: The battery management system shall monitor battery and provide status to end user of battery run time via front panel, serial/network communications, or both. Run time calculations to be based on load demand and analysis of battery health.

c. Battery Health Monitoring: UPS shall continuously monitor battery health and the UPS will provide warnings visually, audibly and/or via serial/network communications when battery capability falls below 80% of original capacity. Battery testing may also be user initiated via the front panel or serial communications.

d. The battery charging circuit shall remain active when in any normal mode of operation or while in static bypass mode.

6. Back-feed Protection: Each UPS shall provide a UL1778 approved back-feed protection scheme.

E. OUTPUT INVERTER

1. The UPS output inverter shall be used to regulate the output voltage to operate in conjunction with the connected IT load equipment. The output inverter shall use IGBT driven power converters, operating at high frequency to limit the effects of step loads and reduce the operating audible noise from the system. In both double conversion operation and battery operation, the output inverters shall create an output voltage independent of the mains input voltage. Input voltage anomalies such as brown-outs, spikes, surges, sags, and

outages shall not affect the continued operation of the critical load.

2. Overload Capability: The output inverter shall be capable of supporting 300% overload for a short period, in attempt to clear any short-circuit on the output. The UPS inverter shall remain operational for one (1) minute if a steady-state overload condition of up to 125% is seen on the output of the system. If the overload persists past the outlined time limitation, the critical load will be automatically switched to the static bypass output of the UPS. In the event the static switch exceeds its overload capability, the UPS shall activate the automated maintenance bypass to continue to support the overload until activation of an overcurrent protection device, or the overload condition is removed from the system.
3. Inverter Output Isolation: The output inverter shall be provided with a semi conductor fuse and output mechanical contactor to provide overcurrent protection and physical isolation of the inverter from the critical bus. This feature allows a failed inverter to remove itself from the critical bus while not affecting the operation of other parallel systems supporting the loads. Battery Protection: Each UPS shall be capable of controlling battery discharge depth, with the additional feature of removing all DC power draw from the battery in case of an extended input power outage. This will ensure that the batteries will not be deeply discharged which could cause damage to the battery.

F. SYSTEM PROTECTION

1. Back-feed protection: As a requirement of UL1778, back-feed protection in the static bypass circuit shall also be incorporated in the system design. Back-feed protection shall be a function of a mechanical contactor in series with the bypass SCR(s). The back-feed contactor shall open immediately upon sensing a condition where back-feeding of the static switch by any source connected to the critical output bus of the system is occurring. Shorted SCRs in the static bypass assembly will cause the back-feed protection to activate.

G. OUTPUT POWER DISTIBUTION

1. Each 5kW UPS module shall provide power to an output connector on the rear of the UPS chassis. This connector shall be protected by a properly sized breaker (50A), limiting the output of each UPS module to its rating. The connector shall be capable of supporting loads connected to it even in event the electronics and battery modules are removed. This connector shall also be designed so that the internal UPS electronics module will support the loads on the output connector in event of a parallel bus failure. The output connector shall be monitored by the UPS controls.

H. DISPLAY AND CONTROLS

1. System control and information network interconnections

   a. Cabling for the UPS monitoring network shall consist of interconnecting cable (ANSI/TIA/EIA-568-A, Category 5e) segments secured at each UPS with an interlocked 8P8C modular plug (RJ45). All information network interconnections shall be made on independent control area network (CAN) cards, which are inserted in an independently controlled and powered communication slot on each UPS module. Each of these interconnection cables shall serve as the physical layer for the UPS information network. This network cable shall be included by the manufacturer with every control area network card purchased. And shall not require tools to install.

2. Front Panel Display: The UPS shall include a front panel display consisting of a graphical LCD display with backlight, four status LED's, and a four-key keypad. The LCD shall display a mimic screen of power flow through the UPS system when programmed for this function. The keypad keys shall be menu driven per the function being performed.

   a. Graphical LCD display: Includes basic language (English and local selectable languages), display of unit function and operating parameters. It shall be used to signify the operating state of the UPS, for indicating alarms, for changing operations control parameters and set points. The graphical display shall have a real time clock which will stamp events with event type and time information, reviewable in the logged data menus.

      i. Four status LED's, which indicate:

         1. Alarms, with a red LED
         2. On Battery, with a yellow LED
         3. On Bypass, with a yellow LED
         4. Power On, with a green LED

      ii. Four-Key Multifunction Keypad: UPS shall have keypad to allow user to:

         1. Adjust UPS parameters
         2. View UPS metered data
         3. View all parallel UPS systems metered data
         4. View alarm and inverter logs
         5. Change UPS operational modes of the individual module
         6. Change operational modes of all

parallel connected systems
7. Turn individual UPS systems on and off
8. Turn all parallel connected systems on or off

iii. Metered Data: The following metered data, shall be available on the alphanumeric display:

1. Input:

a. Voltage Line to Neutral
b. Voltage Line to Line
c. Frequency

2. Battery:

a. Voltage
b. Current
c. Runtime

3. Output:

a. Voltage Line to Neutral
b. Voltage Line to Line
c. Current
d. Frequency
e. Power kW
f. Power kVA
g. Power factor (pf)

4. Parallel System:

a. kW [by unit]
b. kW [Parallel total]

5. Load Receptacle:

a. Voltage Line to Line
b. Frequency
c. Power kW
d. Power kVA
e. Current

iv. Event log: The display unit shall allow the user to display a time and date stamped log of the 100 most recent status and alarm events. Each event will be time stamped with Year, Month, Day, Hour, Minute, Second of occurring event.

v. The system shall be capable of displaying the following system status information:

1. System Normal
2. High Efficiency Power: %
3. Battery Resting
4. Battery Floating
5. UPS in Parallel mode
6. Parallel Unit Number
7. Units on Parallel Bus
8. Units on Load

vi. The system control functions shall have the following capability

1. Go to Normal Mode
2. Go to Bypass Mode
3. Turn UPS On/Off
4. Turn system UPS On/Off
5. Start Battery Test
6. Start Display Test

vii. The following system information shall be available from the front display

1. UPS Type
2. UPS Part Number
3. UPS Serial Number
4. UPS Firmware Revision
5. UPS Display Firmware Revision
6. UPS CAN Bridge Firmware Revision

viii. Alarms and system information: The display unit shall allow the user to display a log of all active alarms. The following minimum set of alarm conditions shall be available:

1. On Battery
2. Battery Low
3. On Bypass
4. Bypass Unavailable
5. Battery Breaker Open
6. Battery Connection
7. Overload
8. Over-temperature
9. Site Wiring Fault
10. The UPS does not provide the expected backup time
11. Power is not available at the UPS

output receptacle
12. The UPS does not start
13. The UPS does not turn off
14. The UPS operates normally, but some or all of the protected equipment is not on
15. Battery test failed
16. Battery test pending
17. Battery test did not run
18. Battery test aborted
19. The UPS does not transfer to Bypass mode
20. Check Parallel Board
21. Abnormal output voltage at startup
22. Selective Trip
23. Redundancy Loss Due to Overload
24. Configuration Error and the UPS does not start.

ix. System Configuration: The following shall be configurable from the display unit:

1. Set Date and Time
2. Display Contrast
3. Change Language
4. Relay Configuration
5. Signal Inputs
6. Serial Port Configuration
7. Parallel Operation Settings
8. Modem Configuration
9. Battery Setup
10. Power Strategy (normal or high efficiency)
11. Start Screen
12. User Password
13. Audible Alarms
14. Unsynchronized Transfer to Bypass
15. Transfer to Bypass When Overload
16. Automatic Start Delay
17. Control Commands from X-Slot 1
18. Control Commands from X-Slot2
19. X-Slot Signal Input Activation Delay
20. Site Wiring Fault Notice
21. Input Range
22. Reset Custom Event Settings

x. Communication Interface Board: A communication interface board shall

provide the following communication port:

1. Communication Card Slot:

    a. Each UPS shall provide a communication slot in the back of the system allowing for additional connectivity options, including SNMP/Web, AS/400 relays, Modbus, etc

2. Serial communications (via RS-232) with manufacturer-supplied power management software package.

I. BATTERY

1. The UPS battery shall be of modular construction made up of user replaceable, hot swappable, battery modules with approved over-current protection. Each UPS module shall contain a minimum of two (2) parallel battery strings therefore reducing the chance of a single battery failure causing complete loss of runtime.

2. The battery jars housed within each removable battery tray shall be of the Valve Regulated Lead Acid (VRLA) type. Each hot swappable battery module shall hold 10 batteries and shall not exceed recommended OSHA weight limits (50 lbs for men) for a single person to lift repetitively. Each battery tray assembly shall be constructed so that leakage of battery electrolyte from a single battery, due to a damaged battery case, will be contained within the battery tray. Internal batteries shall be of 5AH capacity at 20 hour rate (23 to 27 w/cell).

3. The UPS shall incorporate a battery management system to automatically monitor the health of the battery system. This UPS shall notify the user via the front panel and serial/network communications in the event that a failed or weak battery string is found.

4. Each 5kW UPS module shall have an independent 70A DC breaker for isolation of all internal and external battery modules to the DC bus. The UPS module shall notify the user if the DC breaker is in the off position.

PART 2 ACCESSORIES

A. POWER DISTRIBUTION SYSTEM

1. The UPS module output connector on the rear of the UPS chassis shall be designed to interface to a rack mounted power distributions system.

B. EXTENDED RUNTIME BATTERY

1. Extended runtime for the UPS shall be available as an option. These extended battery runtime modules (EBM) will come in a standard rack mount design, with capability to go into any EIA-310-D, or EIA-310-E four post 19” IT enclosure, with minimum depth of 30 inches. Each EBM shall come with a standard four post rail mounting kit to ensure easy slide in installation into the rack or enclosure. EBMs shall be capable of mounting into the same enclose that houses the UPS modules. Each EBM will include a cord assembly that allows plug in capability to the rear of the UPS system or other like EBMs. Each EBM shall include a matching input connector that allows easy tool-less “daisy chaining” of additional EBM modules by plugging them together. The DC output of each EBM shall be protected by an over-current protection device (breaker) with capability of being reset without tools. The cord length of the EBM will be 36” to allow easy installation above or below any UPS. Up to four (4) Extended Battery Modules shall be capable to be added to the standard UPS system for increased battery runtime greater than 30 minutes.

C. SOFTWARE AND CONNECTIVITY

UPS monitoring and management

1 Network management: An Ethernet WEB/SNMP, BACnet IP and ModBus TCP network communication adaptor shall be available to allow one or more network management systems (NMS) to monitor and manage the UPS in TCP/IP and/or ModBus or BACnet network environments. SNMP information shall be available in the standard management information base (MIB) data, which can be used by network management software programs. SNMP information shall be provided in DOS and UNIX "tar" formats. The WEB/SNMP interface adaptor shall be a hot swappable card capable of being inserted into any open UPS communication slot.

2 A single network management card shall have the capability of interfacing and delivering WEB/SNMP, BACnet IP or ModBus TCP information concurrently

3 Each UPS system shall also be capable of using an RS232 port to communicate by means of serial communications to gracefully shut down one or more operating systems during operation on battery. This serial port will also be used for UPS system firmware upgrades.

4 UPS communications shall be compatible with APC StruxureWare

D. STANDARD EQUIPMENT WARRANTY

1 Standard equipment warranty shall be eighteen (18) months from the date of purchase

E. MANUFACTURER FIELD SERVICE

1 The UPS manufacturer shall have a worldwide service organization, consisting of factory trained field service

personnel to perform start-up, preventative maintenance, and service of the UPS system and power equipment. The service organization shall offer 24 hours a day, 7 days a week, 365 days a year service support

2 Replacement parts: Parts shall be available through the worldwide service organization 24 hours a day, 7 days a week, and 365 days a year. The worldwide service organization shall be capable of shipping parts within 4 working hours or on the next available flight, so that the parts may be delivered to the customer site within 24 hours

F. **MAINTENANCE CONTRACTS**

1 A complete offering of preventative and full service maintenance contracts for the UPS system and the battery system shall be available. All contract work shall be performed by Eaton authorized trained service personnel

2 Contracts shall be available for both Monday through Friday, normal business hours next day response, and seven days a week, any hour with up to two (2) hour response time

G. TRAINING

1 UPS service training: A UPS service training first responder course shall be available from the UPS manufacturer. The service training workshop shall include a combination of lecture and practical instruction with hands-on laboratory sessions. The service training workshop shall include instruction about safety procedures, UPS operational theory, sub-assembly identification and operation, system controls and adjustment, preventative maintenance, and troubleshooting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The UPS shall be set in place, wired, and connected in accordance with the approved shop drawings and manufacturer's instructions.

3.2 ACCEPTANCE CHECKS AND TESTS

A. An authorized representative of the UPS manufacturer shall technically supervise and participate during all of the field adjustments and tests. Major adjustments and field tests shall be witnessed by the COR. The manufacturer’s representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer’s recommendations.

B. Perform manufacturer’s required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

a. Compare equipment nameplate data with specifications and approved shop drawings.
b. Inspect physical, electrical, and mechanical condition.
c. Verify appropriate anchorage, required area clearances, and correct alignment.
d. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
e. Verify grounding connections.
f. Vacuum-clean enclosure interior. Clean enclosure exterior.
g. Verify the correct operation of all alarms and indicating devices.
h. Attach a phase rotation meter to the UPS input, output, and bypass buses, and observe proper phase sequences.
i. Check and test controls for proper operation.
j. Check doors for proper alignment and operation.
k. Check and test each protective device for proper mechanical and electrical operation.

2. Load Test: The UPS shall be load tested for a continuous 24 hour period by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. The UPS shall be continuously tested at 1/2 load for 8 hours, 3/4 load for 8 hours and full load for 8 hours. If a failure occurs during the burn-in period, the tests shall be repeated. Instrument readings shall be recorded every half hour for the following:
   a. Input voltage and current (all three phases, for each module).
   b. Input and output frequency.
   c. Battery voltage for each module.
   d. Output voltage and current (all three phases, for each module).
   e. Output kilowatts for each module.
   f. Output voltage and current (all three phases).
   g. Output kilowatts.
3. Full Load Burn In Test: The UPS shall undergo an additional full load burn-in period of 24 continuous hours by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. If a failure occurs during the burn-in period, the

tests shall be repeated. Instrument readings shall be recorded every half hour as above. The following tests shall be performed:

a. With the UPS carrying full rated output load and supplied from the normal source, switch 100 percent of load bank capacity 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 above.

4. Full Load Battery Burn In Test: The UPS shall undergo a full load battery test by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. If a failure occurs during the battery discharge time, the tests shall be repeated. Instrument readings shall be recorded every half hour as above.

a. With the UPS carrying full rated output load and operating on battery power, switch 100 percent of load bank capacity on and off a minimum of five times within the battery discharge time.

5. Battery Discharge and Recharge Test: With the battery fully charged, the UPS shall undergo a complete battery discharge test to full depletion followed by a full recharge. Instrument readings shall be recorded every minute during discharge for the following:

a. Battery voltage and current.

b. Output voltage and current (all three phases).

c. Output kilowatts.

d. Output voltage and current (all three phases).

e. Output kilowatts (system).

f. Output frequency.

3.3 FOLLOW-UP VERIFICATION

A. After completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the UPS is in good operating condition and properly performing the intended function.

3.4 ONE LINE DIAGRAM AND SEQUENCE OF OPERATION

A. At final inspection, an as-built one line diagram shall be laminated or mounted under acrylic glass, and installed in a frame mounted near the UPS.

B. Furnish a written sequence of operation for the UPS and connected line side/load side electrical distribution equipment. The sequence of

operation shall be laminated or mounted under acrylic glass, and installed in a frame mounted near the UPS.

C. Deliver an additional four copies of the as-built one line diagram and sequence of operation to the COR.

3.5 INSTRUCTION

A. Furnish the services of a factory-trained technician for one 4-hour training period for instructing personnel in the maintenance and operation of the UPS, on the dates requested by the COR.

---END---

SECTION 26 41 00
FACILITY LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing and installation of a complete UL master labeled lightning protection system.

1.2 RELATED WORK

A. Section 07 60 00, FLASHING AND SHEET METAL: Penetrations through the roof.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground faults.

D. Section 26 42 00 CATHODIC PROTECTION: Requirements for protection of buried ferrous equipment from galvanic corrosion.

E. Section 26 43 13, SURGE PROTECTIVE DEVICES: Surge protective device installed at the electrical service entrance.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Show locations of air terminals, connections to required metal surfaces, down conductors, and grounding means.
   c. Show the mounting hardware and materials used to attach air terminals and conductors to the structure.
2. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the manufacturer that the lightning protection system conforms to the requirements of the drawings and specifications.
b. Certification by the Contractor that the lightning protection system has been properly installed and inspected.
c. Certification that the lightning protection system has been inspected by a UL representative and has been approved by UL without variation.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

780-20 .....Standard for the Installation of Lightning Protection Systems

C. Underwriters Laboratories, Inc. (UL):

96-16 .....Lightning Protection Components

96A-16 .....Installation Requirements for Lightning Protection Systems

467-13 .....Standard for Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Lightning protection components shall conform to NFPA 780 and UL 96, for use on Class I structures. Aluminum materials are not allowed.

1. Class I conductors: Copper.
2. Class I air terminals: Solid copper, 460 mm (18 inches) long, not less than 9.5 mm (3/8 inch) diameter, with sharp nickel-plated points.
3. Ground rods: Copper-clad steel, 0.75 in (19 mm) diameter by 3 m (10 feet) long.
4. Ground plates: Solid copper, not less than 20 gauge.
5. Bonding plates: Bronze, 50 square cm (8 square inches).
6. Through roof connectors: Solid copper riser bar, length and type as required to accommodate roof structure and flashing requirements.

7. Down conductor guards: Stiff copper or brass.
8. Anchors and fasteners: Bronze bolt and clamp type shall be used for all applications except for membrane roof. Adhesive type are allowed only for attachment to membrane roof materials, using adhesive that is compatible with the membrane material.
9. Connectors: Bronze clamp-type connectors shall be used for roof conductor splices, and the connection of the roof conductor to air terminals and bonding plates. Crimp-type connectors are not allowed.
10. Exothermic welds: Exothermic welds shall be used for splicing the roof conductor to the down conductors, splices of the down conductors, and for connection of the down conductors to ground rods, ground plates, and the ground ring.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.
B. Coordinate installation with the roofing manufacturer and roofing installer.
C. Install the conductors as inconspicuously as practical.
D. Install the down conductors within the concealed cavity of exterior walls where practical. Run the down conductors to the exterior at elevations below the finished grade.
E. Where down conductors are subject to damage or are accessible near grade, protect with down conductor guards to 2.4 m (8 feet) above grade. Bond down conductors guards to down conductor at both ends.
F. Make connections of dissimilar metal with bimetallic type fittings to prevent electrolytic action.
G. Install ground rods and ground plates not less than 600 mm (2 feet) deep and a distance not less than 900 mm (3 feet) nor more than 2.5 m (8 feet) from the nearest point of the structure. Exothermically weld the down conductors to ground rods and ground plates in the presence of the COR.
H. Bond down conductors to metal main water piping where applicable.
I. Bond down conductors to building structural steel.
J. Connect roof conductors to all metallic projections and equipment above the roof as indicated on the drawings.

K. Connect exterior metal surfaces, located within 900 mm (3 feet) of the conductors, to the conductors to prevent flashovers.

L. Maintain horizontal or downward coursing of main conductor and insure that all bends have at least an 200 mm (8 inches) radius and do not exceed 90 degrees.

M. Conductors shall be rigidly fastened every 900 mm (3 feet) along the roof and down to the building to ground.

N. Air terminals shall be secured against overturning either by attachment to the object to be protected or by means of a substantial tripod or other braces permanently and rigidly attached to the building or structure.

O. Install air terminal bases, cable holders and other roof-system supporting means without piercing membrane or metal roofs.

P. Use through-roof connectors for penetration of the roof system. Flashing shall be provided by roofing contractor in accordance with Section 07 60 00, FLASHING AND SHEET METAL.

Q. Down conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel or the structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 30 M (100 feet).

R. A counterpoise or ground ring, where shown, shall be of No. 1/0 copper cable having suitable resistance to corrosion and shall be laid around the perimeter of the structure in a trench not less than 600 mm (2 feet) deep at a distance not less than 900 mm (3 feet) nor more than 2.5 M (8 feet) from the nearest point of the structure.

S. On construction utilizing post tensioning systems to secure precast concrete sections, the post tension rods shall not be used as a path for lightning to ground.

T. Where shown, use the structural steel framework or reinforcing steel as the down conductor.

1. Weld or bond the non-electrically-continuous sections together and make them electrically continuous.
2. Verify the electrical continuity by measuring the ground resistances to earth at the ground level, at the top of the building or stack, and at intermediate points with a sensitive ohmmeter. Compare the resistance readings.

3. Connect the air terminals together with an exterior conductor connected to the structural steel framework at not more than 18 M (60 feet) intervals.
4. Install ground connections to earth at not more than 18 M (60 feet) intervals around the perimeter of the building.
5. Weld or braze bonding plates to cleaned sections of the steel and connect the conductors to the plates.
6. Do not pierce the structural steel in any manner. Connections to the structural steel shall conform to UL 96A.

U. For obstruction lights, the following additional requirements shall apply:
1. Extend air terminals 300 mm (1 foot) above the top of the light fixtures and securely clamp to the light fixture supports.
2. Install 600 volt class lightning arresters. Connect the arresters to the lightning circuit conductors at suitable locations, and ground and bond them to the lightning protection system.

V. Where the drawings show the new lightning protection system connected to an existing lightning protection system with or without a UL master label, the new portion of the lightning protection system requires UL inspection and a Letter of Findings.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Test the ground resistance to earth by standard methods, and conform to the ground resistance requirements specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

B. A UL representative shall inspect the lightning protection system. Obtain and install a UL numbered master label for each of the lightning protection systems at the location directed by the UL representative and the COR.

---END---

SECTION 26 43 13
SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of Type 2 Surge Protective Devices, as defined in NFPA 70, and indicated as SPD in this section.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

B. Section 26 24 16, PANELBOARDS: For factory-installed or external SPD.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Include electrical ratings and device nameplate data.
2. Manuals:
   a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.
   b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the SPD conforms to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the SPD has been properly installed.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplement and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

B. Institute of Engineering and Electronic Engineers (IEEE):

IEEE C62.41.2-02 .....Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.45-08 .....Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits

C. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):

UL 1283-15 .....Electromagnetic Interference Filters

UL 1449-14 .....Surge Protective Devices

PART 2 - PRODUCTS

2.1 PANELBOARD SPD

A. General Requirements:

1. Comply with UL 1449 and IEEE C62.41.2.
2. Modular design with field-replaceable modules, or non-modular design.
3. Fuses, rated at 200 kA interrupting capacity.
4. Bolted compression lugs for internal wiring.
5. Integral disconnect switch.
6. Redundant suppression circuits.
7. LED indicator lights for power and protection status.
8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
10. Four-digit transient-event counter.

B. Surge Current per Phase: Minimum 120kA per phase.

2.3 ENCLOSURES

A. Enclosures: NEMA 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.

B. Factory-installed SPD: Panelboard manufacturer shall install SPD at the factory.

C. Do not perform insulation resistance tests on panelboards or feeders with the SPD connected. Disconnect SPD before conducting insulation resistance tests, and reconnect SPD immediately after insulation resistance tests are complete.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

a. Compare equipment nameplate data with specifications and approved shop drawings.

b. Inspect physical, electrical, and mechanical condition.

c. Verify that disconnecting means and feeder size and maximum length to SPD corresponds to approved shop drawings.

d. Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.

e. Vacuum-clean enclosure interior. Clean enclosure exterior.

f. Verify the correct operation of all sensing devices, alarms, and indicating devices.

3.3 FOLLOW-UP VERIFICATION

A. After completion of acceptance checks and tests, the Contractor shall show by demonstration in service that SPD are in good operating condition and properly performing the intended function.

3.4 INSTRUCTION

A. Provide the services of a factory-trained technician for one 2-hour training period for instructing personnel in the maintenance and operation of the SPD, on the date requested by the COR.

`---END---

SECTION 26 51 00
INTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of the interior lighting systems. The terms "lighting fixture," "fixture," and "luminaire" are used interchangeably.

1.2 RELATED WORK

A. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT: Disposal of lamps.

B. Section 02 41 00, DEMOLITION: Removal and disposal of lamps and ballasts.

C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Requirement for seismic restraint for nonstructural components.

D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

E. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

F. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

G. Section 26 27 26, WIRING DEVICES: Wiring devices used for control of the lighting systems.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:

a. Submit the following information for each type of lighting fixture designated on the LIGHTING FIXTURE SCHEDULE, arranged in order of lighting fixture designation.

b. Material and construction details, include information on housing and optics system.

c. Physical dimensions and description.

d. Wiring schematic and connection diagram.

e. Installation details.

f. Energy efficiency data.

g. Photometric data based on laboratory tests complying with IES Lighting Measurements testing and calculation guides.

h. Lamp data including lumen output (initial and mean), color rendition index (CRI), rated life (hours), and color temperature (degrees Kelvin).

i. Driver data including driver type, starting method, ambient temperature, sound rating, system watts, and total harmonic distortion (THD).

j. For LED lighting fixtures, submit US DOE LED Lighting Facts label, and IES L70 rated life.

2. Manuals:

a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the Contractor that the interior lighting systems have been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Society for Testing and Materials (ASTM):

C635/C635M REV A-13 ....Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings

C. Environmental Protection Agency (EPA):

40 CFR 261 .....Identification and Listing of Hazardous Waste

D. Federal Communications Commission (FCC):

CFR Title 47, Part 18 ..Industrial, Scientific, and Medical Equipment

E. Illuminating Engineering Society (IES):

LM-79-08 .....Electrical and Photometric Measurements of Solid-State Lighting Products

LM-80-15 .....Measuring Lumen Maintenance of LED Light Sources

LM-82-12 .....Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a Function of Temperature

F. Institute of Electrical and Electronic Engineers (IEEE):

C62.41-91(R1995) .....Surge Voltages in Low Voltage AC Power Circuits

G. International Code Council (ICC):

IBC-21 .....International Building Code

H. National Electrical Manufacturer's Association (NEMA):

SSL 1-16 .....Electronic Drivers for LED Devices, Arrays, or Systems

I. National Fire Protection Association (NFPA):

70-20 .....National Electrical Code (NEC)

101-21 .....Life Safety Code

J. Underwriters Laboratories, Inc. (UL):

496-17 .....Lampholders

924-16 .....Emergency Lighting and Power Equipment

1598-08 .....Luminaires

8750-15.....Light Emitting Diode (LED) Light Sources for Use in Lighting Products

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES

A. Shall be in accordance with NFPA, UL, as shown on drawings, and as specified.

B. Sheet Metal:

1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved), and parallel to each other as designed.

2. Wireways and fittings shall be free of burrs and sharp edges, and shall accommodate internal and branch circuit wiring without damage to the wiring.
3. When installed, any exposed fixture housing surface, trim frame, door frame, and lens frame shall be free of light leaks.
4. Hinged door frames shall operate smoothly without binding. Latches shall function easily by finger action without the use of tools.

C. Drivers and lamps shall be serviceable while the fixture is in its normally installed position. Drivers shall not be mounted to removable reflectors or wireway covers unless so specified.

D. Recessed fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.

E. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, aircraft cable, captive hinges, or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.

F. Metal Finishes:
1. The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion-resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking, and shall be applied after fabrication.
2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise shown on the drawing.
3. Exterior finishes shall be as shown on the drawings.

G. Lighting fixtures shall have a specific means for grounding metallic wireways and housings to an equipment grounding conductor.

2.2 EMERGENCY LIGHTING UNIT

A. Complete, self-contained unit with batteries, battery charger, one or more local or remote lamp heads with lamps, under-voltage relay, and test switch.

1. Enclosure: Shall be impact-resistant thermoplastic. Enclosure shall be suitable for the environmental conditions in which installed.
2. Lamp Heads: Horizontally and vertically adjustable, mounted on the face of the unit, except where otherwise indicated.
3. Lamps: Shall be sealed-beam MR-16 halogen, rated not less than 12 watts at the specified DC voltage.
4. Battery: Shall be maintenance-free nickel-cadmium. Minimum normal life shall be minimum of 10 years.
5. Battery Charger: Dry-type full-wave rectifier with charging rates to maintain the battery in fully-charged condition during normal operation, and to automatically recharge the battery within 12 hours following a 1-1/2 hour continuous discharge.
6. Integral Self-Test: Automatically initiates test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing LED.

2.3 LED EXIT LIGHT FIXTURES

A. Exit light fixtures shall meet applicable requirements of NFPA and UL.
B. Housing and door shall be die-cast aluminum.
C. For general purpose exit light fixtures, door frame shall be hinged, with latch. For vandal-resistant exit light fixtures, door frame shall be secured with tamper-resistant screws.
D. Finish shall be satin or fine-grain brushed aluminum.
E. There shall be no radioactive material used in the fixtures.
F. Fixtures:
   1. Inscription panels shall be cast or stamped aluminum a minimum of 2.25 mm (0.090 inch) thick, stenciled with 150 mm (6 inch) high letters, baked with red color stable plastic or fiberglass. Lamps shall be luminous Light Emitting Diodes (LED) mounted in center of letters on red color stable plastic or fiberglass.
   2. Double-Faced Fixtures: Provide double-faced fixtures where required or as shown on drawings.
   3. Directional Arrows: Provide directional arrows as part of the inscription panel where required or as shown on drawings. Directional arrows shall be the "chevron-type" of similar size and width as the letters and meet the requirements of NFPA 101.
G. Voltage: Multi-voltage (120 – 277V).

2.4 LED LIGHT FIXTURES

A. General:

1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.
2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.
3. LED drivers shall include the following features unless otherwise indicated:
   a. Minimum efficiency: 85% at full load.
   b. Minimum Operating Ambient Temperature: -20˚ C. (-4˚ F.)
   c. Input Voltage: 120 - 277V (±10%) at 60 Hz.
   d. Integral short circuit, open circuit, and overload protection.
   e. Power Factor: ≥ 0.95.
   f. Total Harmonic Distortion: ≤ 20%.
   g. Comply with FCC 47 CFR Part 15.
4. LED modules shall include the following features unless otherwise indicated:
   a. Comply with IES LM-79 and LM-80 requirements.
   b. Minimum CRI 80 and color temperature 3000˚ K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
   c. Minimum Rated Life: 50,000 hours per IES L70.
   d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.

B. LED Downlights:

1. Housing, LED driver, and LED module shall be products of the same manufacturer.

C. LED Troffers:

1. LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling.
2. Housing, LED driver, and LED module shall be products of the same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, manufacturer's instructions, and as shown on the drawings or specified.

B. Align, mount, and level the lighting fixtures uniformly.

C. Wall-mounted fixtures shall be attached to the studs in the walls, or to a 20 gauge metal backing plate that is attached to the studs in the walls. Lighting fixtures shall not be attached directly to gypsum board.

D. Lighting Fixture Supports:

1. Shall provide support for all of the fixtures. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
2. Shall maintain the fixture positions after cleaning and relamping.
3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.
4. Hardware for recessed fixtures:
   a. Where the suspended ceiling system is supported at the four corners of the fixture opening, hardware devices shall clamp the fixture to the ceiling system structural members, or plaster frame at not less than four points in such a manner as to resist spreading of the support members and safely lock the fixture into the ceiling system.
   b. Where the suspended ceiling system is not supported at the four corners of the fixture opening, hardware devices shall independently support the fixture from the building structure at four points.
5. Hardware for surface mounting fixtures to suspended ceilings:
   a. In addition to being secured to any required outlet box, fixtures shall be bolted to a grid ceiling system at four points spaced near the corners of each fixture. The bolts shall be not less than 6 mm (1/4 inch) secured to channel members attached to and spanning the tops of the ceiling structural grid members. Non-turning studs may be attached to the ceiling structural grid members or spanning channels by special clips designed for the purpose, provided they lock into place and require simple tools for removal.
   b. In addition to being secured to any required outlet box, fixtures shall be bolted to ceiling structural members at four points spaced near the corners of each fixture. Pre-positioned 6 mm (1/4 inch) studs or threaded plaster inserts secured to ceiling

structural members shall be used to bolt the fixtures to the ceiling. In lieu of the above, 6 mm (1/4 inch) toggle bolts may be used on new or existing ceiling provided the plaster and lath can safely support the fixtures without sagging or cracking.//

6. Surface mounted lighting fixtures:
   a. Fixtures shall be bolted against the ceiling independent of the outlet box at four points spaced near the corners of each unit. The bolts (or stud-clips) shall be minimum 6 mm (1/4 inch) bolt, secured to main ceiling runners and/or secured to cross runners. Non-turning studs may be attached to the main ceiling runners and cross runners with special non-friction clip devices designed for the purpose, provided they bolt through the runner, or are also secured to the building structure by 12 gauge safety hangers. Studs or bolts securing fixtures weighing in excess of 25 kg (56 pounds) shall be supported directly from the building structure.
   b. Where ceiling cross runners are installed for support of lighting fixtures, they must have a carrying capacity equal to that of the main ceiling runners and be rigidly secured to the main runners.
   c. Fixtures less than 6.8 kg (15 pounds) in weight and occupying less than 3715 sq cm (two square feet) of ceiling area may, when designed for the purpose, be supported directly from the outlet box when all the following conditions are met.
      1) Screws attaching the fixture to the outlet box pass through round holes (not key-hole slots) in the fixture body.
      2) The outlet box is attached to a main ceiling runner (or cross runner) with approved hardware.
      3) The outlet box is supported vertically from the building structure.
   d. Fixtures mounted in open construction shall be secured directly to the building structure with approved bolting and clamping devices.
7. Single or double pendant-mounted lighting fixtures:
   a. Each stem shall be supported by an approved outlet box mounted swivel joint and canopy which holds the stem captive and provides spring load (or approved equivalent) dampening of fixture oscillations. Outlet box shall be supported vertically from the building structure.

8. Outlet boxes for support of lighting fixtures (where permitted) shall be secured directly to the building structure with approved devices or supported vertically in a hung ceiling from the building structure with a nine gauge wire hanger, and be secured by an approved device to a main ceiling runner or cross runner to prevent any horizontal movement relative to the ceiling.

E. Furnish and install the new lamps as specified for all lighting fixtures installed under this project, and for all existing lighting fixtures reused under this project.

F. The electrical and ceiling trades shall coordinate to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges, etc.), to match the ceiling system being installed.

G. Bond lighting fixtures to the grounding system as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

H. At completion of project, replace all defective components of the lighting fixtures at no cost to the Government.

I. Dispose of lamps per requirements of Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT, and Section 02 41 00, DEMOLITION.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform the following:

1. Visual Inspection:

a. Verify proper operation by operating the lighting controls.

b. Visually inspect for damage to fixtures, lenses, reflectors, diffusers, and louvers. Clean fixtures, lenses, reflectors, diffusers, and louvers that have accumulated dust, dirt, or fingerprints during construction.

2. Electrical tests:

a. Exercise dimming components of the lighting fixtures over full range of dimming capability by operating the control devices(s) in the presence of the COTR. Observe for visually detectable flicker over full dimming range, and replace defective components at no cost to the Government.

b. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Government. Burn-in period to be 40 hours minimum, unless specifically recommended otherwise by

the lamp manufacturer. Replace any lamps and drivers which fail during burn-in.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the lighting systems are in good operating condition and properly performing the intended function.

---END---

SECTION 27 05 26
GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies grounding and bonding requirements of communications installations based on the requirements of ANSI/TIA-607-D, Telecommunications Bonding and Grounding (Earthing) for Customer Premises. Work covered by this Section shall consist of furnishing supplies, labor, materials, equipment, labeling, and tools. Testing is required unless otherwise specified. An operable grounding and bonding infrastructure is required as described on the Drawings and/or required by these specifications. All materials shall be listed by a nationally recognized testing laboratory (NRTL).

1.2 SUMMARY

Section Includes:

A. Required Bonding Busbars.

B. Supplemental Bonding Networks.

C. Telecommunications Bonding Conductors.

D. Joining Requirements.

E. Overvoltage Surge Protectors.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

B. ANSI/TIA-607-D, Telecommunications Bonding and Grounding (Earthing) for Customer Premises.

C. NFPA 70, National Electrical Code (NEC).

D. International Annealed Copper Standard (IACS).

E. BICSI Information Technology Systems Installation Methods Manual (ITSIMM), Recommended Testing Procedures and Criteria.

F. UL 497 & UL 497A, UL Standards for Primary & Secondary Safety Protectors for Paired-Conductor Communications Circuits.

1.4 RELATED WORK

A. Facility grounding and bonding requirements: Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

B. Information Technology equipment enclosures: Section 27 11 16, COMMUNICATION CABINETS, RACKS, FRAMES, AND ENCLOSURES.

C. Cable trays: Section 27 05 36, CABLE TRAYS FOR COMMUNICATIONS SYSTEMS.

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

B. Provide riser diagram indicating location of communications grounding system connections indicating routing of grounding conductors.

C. Closeout Submittals: Provide test reports of ground resistance to each primary or secondary bonding busbar (PBB/SBB) located in each telecommunications space impacted by the work.

PART 2 - PRODUCTS

2.1 BONDING BUSBARS

Bonding busbars are located in each telecommunications space and in each network rack/cabinet. Bonding busbars provide common locations in the telecommunications space for the connection of the telecommunications bonding conductors.

A. Common Requirements.

1. Provided with holes for use with correctly-matched UL Listed two-hole lugs and hardware.
2. Constructed of copper or copper alloy with a minimum of 95% conductivity when annealed.
3. Annealed as specified by the International Annealed Copper Standard (IACS).
4. Installation resulting in a maximum 4.0Ω to ground resistance measured from any point in the system.
5. Installation is insulated from the mounting surface through the use of appropriate insulators.
6. UL Listed.

B. Primary Bonding Busbar (PBB). The PBB is a dedicated extension of the building grounding electrode system for the telecommunications infrastructure. The PBB also serves as the central attachment point for Secondary Bonding Busbars (SBB) via Telecommunications Bonding Backbone (TBB).

1. Pre-drilled copper with holes to accommodate lug mounting holes.
2. Sized for current applications and future growth.
3. Insulated from its supports.
4. Electro-tin plated is acceptable.
5. Maintain a 2” min clearance between busbar and finished wall.

6. Size must be 0.25” thick by 4” wide by 20” length.

C. Secondary Bonding Busbar (SBB). The SBB is a common point of connection for telecommunications system and equipment bonding to a ground located in each Telecommunications Room.
   1. Pre-drilled holes to accommodate dual-lug mounting holes.
   2. 0.25” thick x 2” wide with varying length to be sized for current applications and future growth.
   3. Maintain a 2” min clearance between the finished wall and busbar.
   4. Copper or tin annealed copper.

D. Rack Bonding Busbar (RBB). The RBB is a busbar located in a cabinet, rack, or frame.
   1. Mounting. Horizontal mounting to an EIA-310-D 19” equipment rack is specified.
   2. Capacity: 10 Double-hole lugs.
   3. Size & material 0.75” wide x 19” length x 0.25” thick – Copper or tin annealed copper.

2.2 SUPPLEMENTAL BONDING NETWORKS.

Also known as Signal Reference Grids (SRGs), Mesh Bonding Networks (Mesh-BN), or Isolated Bonding Networks (IBNs), the requirements for supplemental bonding networks are not specified in this document. Supplemental bonding networks may not be used to replace a standards-compliant bonding infrastructure.

2.3 TELECOMMUNICATIONS BONDING BACKBONE (TBB).

The TBB bonds the facility Primary Bonding Busbar (PBB) to telecommunications space Secondary Bonding Busbars (SBBs).

A. Material. Stranded copper wire with a green jacket (or per NEC depending on size), run as a continuous conductor.

B. Size. The TBB shall be sized to meet the requirements of ANSI/TIA-607-D and will be as straight as practicable avoiding bends.

C. Bonding the TBB to the PBB and each SBB will require a UL Listed irreversible compression (crimp) dual-lug connector.

2.4 BONDING CONDUCTORS.

A. Telecommunications Equipment Bonding Conductor (TEBC). The TEBC connects the cabinets and racks in the telecommunications space to the space’s bonding busbar (PBB or SBB).
   1. Material. Stranded copper wire with a green jacket (or per NEC depending on size), run as a continuous conductor.

2. Size. The TBB shall be sized to meet the requirements of ANSI/TIA-607-D. The minimum size for the TEBC shall be AWG 6.

3. Bonding. Bonded to the telecommunications space bonding busbar (PBB or SBB) via a UL Listed two-hole compression lug. Rack Bonding Conductors (RBCs) are connected to the TEBC using UL Listed irreversible compression (crimp) connectors.

B. Rack Bonding Conductor (RBC). The RBC is a bonding conductor from the cabinet or Rack Bonding Busbar (RBB) to the Telecommunications Equipment Bonding Conductor (TEBC).

1. Material. Stranded copper wire with a green jacket run as a continuous conductor.

2. Size. The minimum size for the RBC shall be AWG 6.

3. Bonding. Bonded to the Telecommunications Equipment Bonding Conductor (TEBC) using UL Listed irreversible compression (crimp) connectors.

a. Where connected to a server cabinet, the RBC extends to the bottom of the server cabinet allowing Equipment Bonding Conductors to be attached at any point in the cabinet.

b. Where connected to a network rack/cabinet, the Rack Bonding Conductor (RBC) is bonded to the Rack Bonding Busbar (RBB) via a UL Listed two-hole compression lug.

C. Equipment/Unit Bonding Conductor (EBC/UBC). The Equipment/Unit Bonding Conductor connects individual equipment in a cabinet or rack to the Rack Bonding Conductor (RBC) or Rack Bonding Busbar (RBB). Equipment Bonding conductors are also used as cable tray bonding conductors to bond cable tray sections to the Telecommunications Equipment Bonding Conductor (TEBC).

1. Material. Stranded copper wire with a green jacket run as a continuous conductor.

2. Size. The minimum size for the RBC shall be AWG 6.

3. Bonding.

a. Where used in a server cabinet, bonded to the Rack Bonding Connector (RBC) using UL Listed irreversible compression (crimp) connectors and to IT equipment via a UL Listed two-hole compression lug. (Some IT equipment may require one-hole lugs.)

b. Where used in a network cabinet/rack, bonded to the Rack Bonding Busbar (RBB) via a UL Listed two-hole compression lug and

to IT equipment via a UL Listed two-hole compression lug. (Some IT equipment may require one-hole lugs.)

c. Where used as a cable tray bonding conductor connecting cable tray sections, bonded to each adjoining section of the cable tray using UL Listed two-hole compression lugs.

d. Where used as a cable tray bonding conductor connecting cable tray sections to the Telecommunications Equipment Bonding Conductor (TEBC), bonded to the TEBC using UL Listed irreversible compression (crimp) connectors and to the cable tray via a UL Listed two-hole compression lug.

4. Contractor shall furnish a minimum of ten (10) EBCs for each RBB. Five (5) EBCs shall be outfitted as described here and shall be six (6) feet in length. Five (5) EBCs shall be outfitted as decried here and shall be nine (9) feet in length. Contractor shall use field measurements to determine EBC cable length when directed by VA project managers.

2.5 OVERVOLTAGE SURGE PROTECTORS.

A. Protectors are voltage-limiting devices intended to protect equipment, wiring, and personnel against the effects of excessive potentials and currents in communications lines caused by lightning, contacts with power conductors, power induction, and rises in ground potential.

1. Compliance. Protectors shall be compliant with UL 497 and/or UL 497A, as applicable.

2. Performance. Protectors shall be rated to support copper UTP performance Category 5e at 100MHz.

3. Protection. Voltage suppression shall be via low capacitance solid state protectors only, rated at 18V for copper backbone applications or 65V for VOIP or PoE applications.

4. Construction. Provide protection for each pair.

5. Termination shall be insulation-displacement contact.

6. Mounting. Protectors shall be wall-mounted.

PART 3 - EXECUTION

3.1 IMPLEMENTATION

A. Components of the telecommunications bonding system will be installed and connected using materials and techniques required by ANSI/TIA-607-D. The use

of antioxidant joint compound is required for all connections excluding protector 110 block connections.

B. Testing.

1. Perform tests per BICSI Information Technology Systems Installation Methods Manual (ITSIMM), Recommended Testing Procedures and Criteria.
2. Perform two-point bond test using trained installers qualified to use test equipment.
3. Conduct continuity tests to verify that metallic pathways in telecommunications spaces are bonded to PBB or SBB.
4. Conduct electrical continuity test to verify that PBB is effectively bonded to the facility grounding electrode conductor.
5. Perform resistance tests to ensure rack and cabinet bonding connection resistance measures less than 4Ω to PBB or SBB.

- - - E N D - - -

SECTION 27 05 33
CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies conduit, fittings, and boxes to form raceway systems for communications cabling.

1.2 RELATED WORK

A. Bedding of conduits: Section 31 20 00, EARTH MOVING.

B. Sealing around penetrations to maintain integrity of fire rated construction: Section 07 84 00, FIRESTOPPING.

C. Fabrications for deflection of water away from building envelope at penetrations: Section 07 60 00, FLASHING AND SHEET METAL.

D. Sealing around conduit penetrations through building envelope to prevent moisture migration into building: Section 07 92 00, JOINT SEALANTS.

E. Identification and painting of conduit and other devices: Section 09 91 00, PAINTING.

F. Requirements for personnel safety and to provide a low impedance path for possible ground fault currents: Section 27 05 26, GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS.

1.3 SUBMITTALS

A. In accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS, submit the following:

1. Size and location of cabinets, splice boxes, and pull boxes.
2. Layout of required conduit penetrations through structural elements.
3. Catalog cuts marked with specific item proposed and area of application identified.

B. Certification: Provide letter prior to final inspection, certifying material is in accordance with construction documents and properly installed.

PART 2 - PRODUCTS

2.1 MATERIAL

A. Minimum Conduit Size: 19 mm (3/4 inch).

B. Conduit:

1. Rigid Galvanized Steel: Conform to UL 6, ANSI C80.1.
2. Rigid Aluminum: Conform to UL 6A, ANSI C80.5.

3. Rigid Intermediate Steel Conduit (IMC): Conform to UL 1242, ANSI C80.6.
4. Electrical Metallic Tubing (EMT):
   a. Maximum Size: 105 mm (4 inches).
   b. Install only for cable rated 600 volts or less.
   c. Conform to UL 797, ANSI C80.3.
5. Flexible Galvanized Steel Conduit: Conform to UL 1.
6. Liquid-tight Flexible Metal Conduit: Conform to UL 360.
7. Direct Burial Plastic Conduit: Conform to UL 651 and UL 651A, heavy wall PVC, or high density polyethylene (HDPE).
8. Surface Metal Raceway: Conform to UL 5.

C. Conduit Fittings:
1. Rigid Galvanized Steel and Rigid Intermediate Steel Conduit Fittings:
   a. Provide fittings meeting requirements of UL 514B and ANSI/ NEMA FB 1.
   b. Sealing: Provide threaded cast iron type. Use continuous drain type sealing fittings to prevent passage of water and vapor. In concealed work, install sealing fittings in flush steel boxes with blank cover plates having same finishes as other electrical plates in room.
   c. Standard Threaded Couplings, Locknuts, Bushings, and Elbows: Only steel or malleable iron materials are acceptable. Integral retractable type IMC couplings are also acceptable.
   d. Locknuts: Bonding type with sharp edges for digging into metal wall of an enclosure.
   e. Bushings: Metallic insulating type, consisting of an insulating insert molded or locked into metallic body of fitting. Bushings made entirely of metal or nonmetallic material are not permitted.
   f. Erickson (union-type) and Set Screw Type Couplings:
      1) Couplings listed for use in concrete are permitted for use to complete a conduit run where conduit is installed in concrete.
      2) Use set screws of case hardened steel with hex head and cup point to seat in conduit wall for positive ground.
   g. Provide OEM approved fittings.
2. Rigid Aluminum Conduit Fittings:

a. Standard Threaded Couplings, Locknuts, Bushings, and Elbows: Malleable iron, steel or aluminum alloy materials; Zinc or cadmium plate iron or steel fittings. Aluminum fittings containing more than 0.4 percent copper are not permitted.
b. Locknuts and Bushings: As specified for rigid steel and IMC conduit.
c. Set Screw Fittings: Not permitted for use with aluminum conduit.

3. Electrical Metallic Tubing Fittings:
   a. Conform to UL 514B and ANSI/ NEMA FB1; only steel or malleable iron materials are acceptable.
   b. Couplings and Connectors: Concrete tight and rain tight, with connectors having insulated throats.
      1) Use gland and ring compression type couplings and connectors for conduit sizes 50 mm (2 inches) and smaller.
      2) Use set screw type couplings with four set screws each for conduit sizes over 50 mm (2 inches).
      3) Use set screws of case-hardened steel with hex head and cup point to seat in wall of conduit for positive grounding.
   c. Indent type connectors or couplings are not permitted.
   d. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are not permitted.
   e. Provide OEM approved fittings.
4. Flexible Steel Conduit Fittings:
   a. Conform to UL 514B; only steel or malleable iron materials are acceptable.
   b. Provide clamp type, with insulated throat.
   c. Provide OEM approved fittings.
5. Liquid-tight Flexible Metal Conduit Fittings:
   a. Conform to UL 514B and ANSI/ NEMA FB1; only steel or malleable iron materials are acceptable.
   b. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening.
   c. Provide connectors with insulated throats to prevent damage to cable jacket.
   d. Provide OEM approved fittings.

6. Direct Burial Plastic Conduit Fittings: Provide fittings meeting requirements of UL 514C and NEMA TC3, and as recommended by conduit manufacturer.
7. Expansion and Deflection Couplings:
   a. Conform to UL 467 and UL 514B.
   b. Accommodate 19 mm (3/4 inch) deflection, expansion, or contraction in any direction, and allow 30-degree angular deflections.
   c. Include internal flexible metal braid sized to ensure conduit ground continuity and fault currents in accordance with UL 467, and NEC code tables for ground conductors.
   d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat resistant molded rubber material with stainless steel jacket clamps.
8. Rigid Aluminum Fittings:
   a. Provide malleable iron, steel or aluminum alloy materials; zinc or cadmium plate iron or steel fittings. Aluminum fittings containing more than 0.4 percent copper are prohibited.
   b. Locknuts and Bushings: As specified for rigid steel and IMC conduit.
   c. Set Screw Fittings: Not permitted for use with aluminum conduit.
   d. Indent type connectors or couplings are prohibited.
   e. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are not permitted.
   f. Provide OEM approved fittings.

D. Conduit Supports:
1. Parts and Hardware: Provide zinc-coat or equivalent corrosion protection.
2. Individual Conduit Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.
3. Multiple Conduit (Trapeze) Hangers: Minimum 38 mm by 38 mm (1-1/2 by 1-1/2 inch), 2.78 mm (12 gage) steel, cold formed, lipped channels; with minimum 9 mm (3/8 inch) diameter steel hanger rods.
4. Solid Masonry and Concrete Anchors: Self-drilling expansion shields, or machine bolt expansion.

E. Outlet, Splice, and Pull Boxes:

1. Conform to UL-50 and UL-514A.
2. Cast metal where required by NEC or shown, and equipped with rustproof boxes.
3. Sheet Metal Boxes: Galvanized steel, except where otherwise shown.
4. Install flush mounted wall or ceiling boxes with raised covers so that front face of raised cover is flush with wall.
5. Install surface mounted wall or ceiling boxes with surface style flat or raised covers.

F. Warning Tape: Standard, 4-Mil polyethylene 76 mm (3 inch) wide tape detectable type, red with black letters, and imprinted with "CAUTION BURIED COMMUNICATIONS CABLE BELOW".

G. Flexible Nonmetallic Communications Raceway (Innerduct) and Fittings:
1. General: Provide UL 910 listed plenum, riser, and general purpose corrugated pliable communications raceway.
2. Provide Communications Raceway with a factory installed 567 kg (1250 lb.) tensile pre-lubricated pull tape.
3. Use only metallic straps, hangers and fittings to support raceway from building structure. Cable ties are not permitted for securing raceway to building structure.
4. Provide fittings to be installed in spaces used for environmental air made of materials that do not exceed flammability, smoke generation, ignitibility, and toxicity requirements of environmental air space.
5. Size: Metric Designator 53 (trade size 2) or smaller.
6. Outside Plant: Plenum-rated where each innerduct is 75 mm (3 inches) and larger.
7. Inside Plant: Listed and marked for installation in plenum airspaces and minimum 25 mm (1 inch) inside diameter.
8. Plenum: Non-metallic communications raceway.
   a. Constructed of low smoke emission, flame retardant PVC with corrugated construction.
   b. UL 94 V-O rating for flame spreading limitation.
9. Provide innerduct reel lengths as necessary to ensure ducts are continuous.
10. Provide pulling accessories used for innerduct including but not limited to, inner duct lubricants, spreaders, applicators, grips,

swivels, harnesses, and line missiles (blown air) compatible with materials being pulled.

H. Outlet Boxes:

1. Flush wall mounted minimum 11.9 cm (4-11/16 inches) square, 9.2 cm (3-5/8 inches) deep pressed galvanized steel.
2. 2-Gang Tile Box:
   a. Flush backbox type for installation in block walls.
   b. Minimum 92 mm (3-5/8 inches) deep.

I. Weatherproof Outlet Boxes: Surface mount two gang, 67 mm (2-5/8 inches) deep weatherproof cast aluminum with powder coated finish internal threads on hubs 19 mm (3/4 inch) minimum.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION AND REQUIREMENTS

A. Penetrations:

1. Cutting or Holes:
   a. Locate holes in advance of installation. Where proposed in structural sections, obtain approval of structural engineer and COR prior to drilling through structural sections.
   b. Make holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammer, impact electric, hand or manual hammer type drills are not permitted; COR may grant limited permission by request, in condition of limited working space.
   c. Fire Stop: Where conduits, wireways, and other communications raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING.
      1) Fill and seal clearances between raceways and openings with fire stop material.
      2) Install only retrofittable, non-hardening, and reusable firestop material that can be removed and reinstalled to seal around cables inside conduits.
   d. Waterproofing at Floor, Exterior Wall, and Roof Conduit Penetrations: Seal clearances around conduit and make watertight

as specified in Section 07 92 00, JOINT SEALANTS or directed by waterproofing manufacturer.

B. Conduit Installation:

1. Minimum conduit size of 19 mm (3/4 inch), but not less than size required for 40 percent fill.
2. Install insulated bushings on all conduit ends.
3. Install pull boxes after every 180 degrees of bends (two 90-degree bends) or every 100ft. Size boxes per TIA 569.
4. Extend vertical conduits/sleeves through floors minimum 75 mm (3 inches) above floor and minimum 75 mm (3 inches) below ceiling of floor below.
5. Terminate conduit runs to and from a backboard in a TR or interstitial space at top or bottom of backboard. Install conduits to enter telecommunication rooms next to wall and flush with backboard.
6. Where drilling is necessary for vertical conduits, locate holes so as not to affect structural sections.
7. Seal empty conduits located in telecommunications rooms or on backboards to prevent entrance of moisture and gases and to meet fire resistance requirements.
8. Provide pull wire in all empty conduits; sleeves through floor are exceptions.
9. Complete each entire conduit run installation before pulling in cables.
10. Flattened, dented, or deformed conduit is not permitted.
11. Ensure conduit installation does not encroach into ceiling height head room, walkways, or doorways.
12. Cut conduit square with a hacksaw, ream, remove burrs, and draw tight.
13. Install conduit mechanically continuous.
14. Independently support conduit at 2.44 m (8 feet) on center; do not use other supports (i.e., suspended ceilings, suspended ceiling supporting members, luminaires, conduits, mechanical piping, or mechanical ducts).
15. Support conduit within 300 mm (1 foot) of changes of direction, and within 300 mm (1 foot) of each enclosure to which connected.

16. Close ends of empty conduit with plugs or caps to prevent entry of debris, until cables are pulled in.
17. Attach conduits to cabinets, splice cases, pull boxes and outlet boxes with bonding type locknuts. For rigid and IMC conduit installations, provide a locknut on inside of enclosure, made up wrench tight. Do not make conduit connections to box covers.
18. Do not use aluminum conduits in wet locations.
19. Unless otherwise indicated on drawings or specified herein, conceal conduits within finished walls, floors and ceilings.
20. Conduit Bends:
    a. Make bends with standard conduit bending machines; observe minimum bend radius for cable type and outside diameter.
    b. Conduit hickey is permitted only for slight offsets, and for straightening stubbed conduits.
    c. Bending of conduits with a pipe tee or vise is not permitted.
    d. Minimum radius of communication conduit bends:

Sizes of Conduit Trade Size	Radius of Conduit Bends mm, Inches
3/4	150 (6)
1	230 (9)
1-1/4	350 (14)
1-1/2	430 (17)
2	525 (21)
2-1/2	635 (25)
3	775 (31)
3-1/2	900 (36)
4	1125 (45)

21. Layout and Homeruns - Deviations: Make only where necessary to avoid interferences and only after drawings showing proposed deviations have been submitted and approved by COR.

C. Concealed Work Installation:
1. In Concrete:
    a. Conduit: Rigid steel or IMC.
    b. Align and run conduit in direct lines.
    c. Install conduit through concrete beams only when the following occurs:

1) Where shown on structural drawings.
2) As accepted by COR prior to construction, and after submittal of drawing showing location, size, and position of each penetration.

d. Installation of conduit in concrete that is less than 75 mm (3 inches) thick is prohibited.
1) Conduit outside diameter larger than 1/3 of slab thickness is prohibited.
2) Space between Conduits in Slabs: Approximately six conduit diameters apart, except one conduit diameter at conduit crossings.
3) Install conduits approximately in center of slab to ensure a minimum of 19 mm (3/4 inch) of concrete around conduits.

e. Make couplings and connections watertight. Use thread compounds that are NRTL listed conductive type to ensure low resistance ground continuity through conduits. Tightening set screws with pliers is not permitted.

D. Furred or Suspended Ceilings and in Walls:
1. Rigid steel, IMC, or rigid aluminum. Different type conduits mixed indiscriminately in same system is not permitted.
2. Align and run conduit parallel or perpendicular to building lines.
3. Tightening set screws with pliers is not permitted.

E. Exposed Work Installation:
1. Unless otherwise indicated on drawings, exposed conduit is only permitted in telecommunications rooms.
a. Provide rigid steel, IMC or rigid aluminum.
b. Different type of conduits mixed indiscriminately in system is not permitted.
2. Align and run conduit parallel or perpendicular to building lines.
3. Install horizontal runs close to ceiling or beams and secure with conduit straps.
4. Support horizontal or vertical runs at not over 2400 mm (96 inches) intervals.
5. Painting:
a. Paint exposed conduit as specified in Section 09 91 00, PAINTING.
b. Refer to Section 09 91 00, PAINTING for preparation, paint type, and exact color.

c. Provide labels where conduits pass through walls and floors and at maximum 6000 mm (20 foot) intervals in between.

F. Expansion Joints:

1. Conduits 75 mm (3 inches) and larger, that are secured to building structure on opposite sides of a building expansion joint, require expansion and deflection couplings. Install couplings in accordance with manufacturer's recommendations.
2. Provide conduits smaller than 75 mm (3 inches) with pull boxes on both sides of expansion joint. Connect conduits to expansion and deflection couplings as specified.
3. Install expansion and deflection couplings where shown.

G. Seismic Areas:

1. In seismic areas, follow H-18-8 Seismic Design Requirements.
2. Rigidly secure conduit to building structure on opposite sides of a building expansion joint with pull boxes on both sides of joint.
3. Connect conduits to pull boxes with 375 mm (15 inches) of slack flexible conduit.
4. Install green copper wire minimum #6 AWG in flexible conduit for bonding jumper.

H. Conduit Supports, Installation:

1. Select AC193 code listed mechanical anchors or fastening devices with safe working load not to exceed 1/4 of proof test load.
2. Use pipe straps or individual conduit hangers for supporting individual conduits. Maximum distance between supports is 2.5 m (8 foot) on center.
3. Support multiple conduit runs with trapeze hangers. Use trapeze hangers designed to support a load equal or greater than sum of the weights of the conduits, wires, hanger itself, and 90 kg (200 pounds). Attach each conduit with U-bolts or other accepted fasteners.
4. Support conduit independent of pull boxes, luminaires, suspended ceiling components, angle supports, duct work, and similar items.
5. Fastenings and Supports in Solid Masonry and Concrete:
   a. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing concrete.
   b. Existing Construction:

1) Code AC193 listed wedge type steel expansion anchors minimum 6 mm (1/4 inch) bolt size and minimum 28 mm (1-1/8 inch) embedment.
2) Power set fasteners minimum 6 mm (1/4 inch) diameter with depth of penetration minimum 75 mm (3 inches).
3) Use vibration and shock resistant anchors and fasteners for attaching to concrete ceilings.

6. Fastening to Hollow Masonry: Toggle bolts are permitted.
7. Fastening to Metal Structures: Use machine screw fasteners or other devices designed and accepted for application.
8. Bolts supported only by plaster or gypsum wallboard are not acceptable.
9. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.
10. Do not support conduit from chain, wire, or perforated strap.
11. Spring steel type supports or fasteners are not permitted except horizontal and vertical supports/fasteners within walls.
12. Vertical Supports:
    a. Install riser clamps and supports for vertical conduit runs in accordance with NEC.
    b. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

I. Box Installation:
1. Boxes for Concealed Conduits:
    a. Flush mounted.
    b. Provide raised covers for boxes to suit wall or ceiling, construction and finish. In spaces not controlled by VA (i.e., common hallways) covers must be lockable.
2. In addition to boxes shown, install additional boxes where needed to prevent damage to cables during pulling.
3. Remove only knockouts as required and plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.
4. Stencil or install phenolic nameplates on covers of boxes identified on riser diagrams; for example "SIG-FA JB No. 1".

5. Outlet boxes mounted back-to-back in same wall are not permitted. A minimum 600 mm (24 inches) center-to-center lateral spacing must be maintained between boxes.

J. Flexible Nonmetallic Communications Raceway (Innerduct), Installation:
1. Install Innerduct in cable tray. Innerduct may not be free-hung.
2. Install only in accessible spaces not subject to physical damage or corrosive influences.
3. Make bends manually to assure internal diameter of tubing is not effectively reduced.
4. Extend each segment of innerduct minimum 300 mm (12 inches) beyond end of service conduit tie or cable tray. Restrain innerduct ends with wall mount clamps and seal when cable is installed.

3.2 TESTING

A. Examine fittings and locknuts for secureness.
B. Test RMC, IMC and EMT systems for electrical continuity and resistance to ground.

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SECTION 27 05 36
CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies requirements for telecommunications cabling cable tray and raceway equipment.

1.2 SUMMARY

Section Includes:

A. Cable Tray.

B. Fiber Optic Cable Raceway.

C. Ladder Rack.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. Grounding and bonding: Section 27 05 26, GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS.

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 CABLE TRAY.

A. Design. Wire basket with tray insert. Maximum 2” x 4” wire mesh construction. Constructed of round, smooth wire with continuous top side to minimize cable sheath damage.

B. Finish. Coated to prevent rust.

C. Size. Cable tray shall be sized to hold the maximum expected cable load at not more than 40% fill and not more than 6” maximum cable depth.

D. Accessories. Provide and install the following components and accessories as necessary to achieve the design:

1. Overhead mounting equipment (thread-rod, unistrut, nuts, washers, etc.) suitable for the supporting structural elements.

2. Tray section splicing hardware.

3. Tray insert.

4. Cable waterfalls.

5. Ground strap kits.

6. Bend radius limiters.

2.2 FIBER OPTIC CABLE RACEWAY.

A. Design. Raceway system shall be a modular system of channels, fittings, and brackets, able to be assembled with couplers. Fittings for cable spillout shall maintain a minimum 2” bend radius.

B. Materials. Raceway shall be constructed of rigid PVC and ABS plastics.

C. Size. Raceway shall be nominally sized 4”x4”.

D. Accessories. Provide and install the following components and accessories as necessary to achieve the design:

1. Overhead mounting equipment (thread-rod, unistrut, nuts, washers, etc.) suitable for the supporting structural elements.

2. Hinged channel covers.

3. Raceway section couplers.

4. Channel corners and intersections.

5. Spillway fittings.

2.3 LADDER RACK.

A. Design. Ladder rack system shall be a modular system of ladder, turns, splices, supports, and accessories able to be assembled with couplers.

B. Finish. Coated to prevent rust.

C. Materials. Ladder rack shall be manufactured from tubular steel and extruded aluminum. Stringers will be 3/8” by 1-1/2” tubular steel. Cross members will be 1” x 1/2". Steel elements shall have a minimum 0.065” wall thickness.

D. Size. Ladder rack shall be nominally sized 12” width.

E. Accessories. Provide and install the following components and accessories as necessary to achieve the design:

1. Overhead mounting equipment (thread-rod, unistrut, nuts, washers, etc.) suitable for the supporting structural elements.

2. Ladder rack section couplers (splices).

3. Ladder rack radius bends.

4. Ground strap kits.

PART 3 - EXECUTION

3.1 IMPLEMENTION:

A. Cable tray shall be used in horizontal applications. Ladder rack is used in vertical applications.

B. Cable tray and ladder rack sections shall be bonded together with bonding conductors and the system bonded to the bonding busbar in the space.

C. Support horizontal cable tray not less than every 5’ (shorter spans if recommended by the equipment manufacturer).

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SECTION 27 05 53
IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies labeling and identification requirements for information technology (IT) equipment cabinets, racks, and cabling.

1.2 SUMMARY

Section Includes:

A. Equipment and component labels.

B. Labeling implementation requirements.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. Server cabinets and network racks: Section 27 11 16, COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES.

B. Cable management equipment: Section 27 11 23, COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK.

C. Copper UTP cabling: Section 27 13 13, COMMUNICATIONS COPPER BACKBONE CABLING.

D. Fiber optic cabling: Section 27 13 23, COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING.

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND COMPONENT LABELS

A. Materials. Materials used for labeling equipment, components, and telecommunications cabling shall be appropriate for the installation environment, durable and permanent, and heat-resistant if necessary for labeling in high-temperature environments.

PART 3 - EXECUTION

3.1 IMPLEMENTION

A. Governing Standard. Labeling and identification of equipment, components, and telecommunications cabling shall be based on ANSI/TIA-

606-C, Administration Standard for Telecommunications Infrastructure, and NFPA 70, National Electrical Code, as modified by guidance in the VA Infrastructure Standard for Telecommunications Spaces.

B. All passive infrastructure equipment, components, and telecommunications cabling installed shall be labeled at the time of installation.

C. Telecommunications cable labeling shall include delivery of complete and accurate connection documentation (where each cable terminates at each end) matching the installed labels.

D. Label locations shall be as specified in the VA Infrastructure Standard for Telecommunications Spaces.

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SECTION 27 10 00
STRUCTURED CABLING

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies requirements for telecommunications structured cabling systems.

1.2 SUMMARY

Section Includes:

A. Computer Room Backbone Structured Cabling.

B. Computer Room Horizontal Structured Cabling.

C. Facility Backbone Structured Cabling.

D. Facility Horizontal Structured Cabling.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. Cabling labeling and identification: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.

B. Cable termination locations and equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 COMPUTER ROOM BACKBONE STRUCTURED CABLING.

Backbone structured cabling in the computer room environment (first level backbone) connects the Main Distribution Areas (MDAs) to the Horizontal Distribution Areas (HDAs).

A. Install first level backbone structured cabling in overhead cable tray and fiber raceway systems following diverse path routing.

B. All cabling used shall be pre-terminated and procured to the specific length required by the design (horizontal and vertical paths) with no more than 1 meter of excess length on each end.

C. Terminate first level backbone structured cabling in the top RU positions of each network rack or cabinet, working downward, with patch panel equipment mounted on the front rails.

D. Mirror distribution on the A-side and B-side MDA and HDA elements.
   1. In MDA network racks or cabinets:
      a. Install angled UTP patch panel(s) for each backbone UTP patch panel in the same-side HDA in the computer room beginning in RU45.
      b. Install an angled panel cover on the lowest UTP patch panel.
      c. Install a blanking panel in the RU below the UTP patch panels.
      d. Install fiber optic distribution cabinets to support the backbone fiber distribution from each HDA.
      e. Install a blanking panel in the RU below the fiber optic distribution cabinet(s).
   2. In HDA network racks or cabinets:
      a. Install fiber optic distribution cabinet(s) and populate with fiber optic distribution cassettes starting in RU45.
      b. Install a blanking panel in the RU below the last fiber cabinet.
      c. Install UTP patch panel(s) below the blanking panel.
      d. Install a blanking panel in the RU below the last UTP patch panel.
E. Install UTP cables between the same-side MDAs and HDAs.
F. Install 12- or 24-strand multimode fiber optic cables between each fiber cassette in the HDA to either the same-side MDA or the opposite side MDA as appropriate.

2.2 COMPUTER ROOM HORIZONTAL STRUCTURED CABLING

Horizontal structured cabling in the computer room environment connects the Equipment Distributors (EDs) in the server cabinets to each supported Horizontal Distribution Area (HDA).

A. Install horizontal structured cabling in overhead cable tray and fiber raceway systems following diverse path routing.
B. All cabling used shall be pre-terminated and procured to the specific length required by the design (horizontal and vertical paths) with no more than 1 meter of excess length on each end.
C. In the server cabinets, terminate horizontal structured cabling in EDs located in the top 5U of each cabinet, with patch panel equipment mounted on the rear rails.

1. Install fiber optic distribution cabinet(s) starting in RU45 and populate with fiber optic distribution cassettes to support the requirement.
2. Install a blanking panel in the RU below the last fiber cabinet.
3. Install copper UTP patch panel(s) below the blanking panel.

D. In the HDAs, terminate horizontal structured cabling in the RU positions immediately below the first level backbone structured cabling equipment of each network rack or cabinet, working downward, with patch panel equipment mounted on the front rails.
   1. Install fiber optic distribution cabinet(s) and populate with fiber optic distribution cassettes to support each server cabinet.
   2. Install a blanking panel in the RU below the fiber optic distribution cabinet(s).
E. Install 12- or 24-strand multimode fiber optic cables between the server cabinet ED and both HDAs.
F. Install UTP cables between the server cabinet ED and both HDAs.

2.3 FACILITY BACKBONE STRUCTURED CABLING

Backbone structured cabling (inter-building and intra-building first level backbone) connects the Entrance Rooms to the Main Distribution Areas (MDAs) in the computer room, and connects the Main Distribution Areas to each Telecommunications Room (TR). This specification describes facility backbone structured cabling when the Entrance Rooms and computer room are in the same building, connected entirely by environmentally conditioned pathways (no outside plant pathways are transited).

A. Interior to each telecommunications space, install facility backbone structured cabling in overhead cable tray and fiber raceway systems.
B. All facility backbone structured cabling shall be redundant and follow diverse path routing.
C. Facility backbone cabling shall be field-terminated (fusion spliced).
D. In the Entrance Room, MDA, and TR network racks designated for facility backbone distribution, install fiber optic distribution cabinets as required for the quantity of fibers installed.
E. Between each Entrance Room and the computer room:

1. Provide 2 diversely routed paths of backbone cabling from each Entrance Room. One path will terminate on the A-side MDA and one path will terminate on the B-side MDA.
2. Install a minimum of 24 strands of multimode fiber optic cabling and 12 strands of single-mode fiber optic cabling per path.
3. Populate the fiber optic distribution cabinets on each end with a sufficient quantity of multimode OM4 and single-mode OS1 fiber optic splice cassettes per path.

F. Between each MDA and each TR:

1. No zone/intermediate distribution areas (ZDAs/IDAs) intermediate cross-connects (ICCs) shall be used. All facility backbone cabling between the MDAs and TRs shall be run directly and continuously.
2. Provide 2 diversely routed paths of backbone cabling, one from the A-side MDA and one from the B-side MDA.
3. Where the TR is located in the same building as the computer room MDAs (does not transit outside plant pathways) and the path distance is less than 400 meters, install a minimum of 24 strands of multimode fiber optic cabling and 12 strands of single-mode fiber optic cabling per path.
   a. Populate the fiber optic distribution cabinets on each end with a sufficient quantity of multimode OM4 and single-mode OS1 fiber optic splice cassettes per path.
4. Where the TR is located in a different building as the computer room (transits outside plant pathways) or the path distance is greater than 400m, install a minimum of 24 strands of single-mode fiber optic cabling per path.
   a. Populate the fiber optic distribution cabinets on each end with a sufficient quantity of single-mode OS2 fiber optic splice cassettes per path.

2.4 FACILITY HORIZONTAL STRUCTURED CABLING

Facility horizontal structured cabling (horizontal distribution) connects the Telecommunications Room (TR) to each end-user Work Area Outlet (WAO).

A. Interior to each TR, install horizontal distribution structured cabling in overhead cable tray systems.

B. All horizontal distribution structured cabling shall have a minimum of 2 cables per WAO.

C. Horizontal distribution structured cabling may be field-terminated.

D. In each TR install sufficient UTP patch panels to support the quantity of WAOs in the TR's serving zone.

1. Plan network racks such that patch panels and horizontal cable managers are located in the top 1/3 (RU31-45), switching equipment in the middle 1/3 (RU16-30), and power distribution and other services in the bottom 1/3 (RU1-15).

E. Install a minimum of 2 UTP cables between the TR UTP patch panels and each work area faceplate.

F. Each typical end-user receptacle shall be constructed of a single-gang workbox with one connector chassis, a minimum of two non-proprietary Category 6A 8P8C media interface connectors (RJ-45), and a four-position keystone faceplate.

1. Modular plug terminated links (MPTL) are permitted to service wireless access points (WAPs), cameras, and other Power over Ethernet (PoE) devices where mating will be very infrequent.

PART 3 - EXECUTION

3.1 IMPLEMENTION

A. 100% construction drawing sets shall include drawings detailing the computer room and facility/campus structured cabling systems, including:

1. Cable media performance categories for each type of run.
2. Cabling and equipment quantities.
3. Elevation drawings showing equipment placement in individual enclosures.
4. Full interconnection diagram for all structured cabling.
5. Port map and cable label matrices.

B. All cabling and equipment shall be labeled per the requirements of the VA Infrastructure Standard for Telecommunications Spaces.

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SECTION 27 11 16
COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies Information Technology (IT) equipment enclosures for use in VA telecommunications spaces. Note that 2-post racks are not acceptable for new installation.

1.2 SUMMARY

Section Includes:

A. Server Cabinets.

B. Network Channel Racks.

C. Network Cabinets.

D. Telecommunications Enclosures.

E. Pathway Racks.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. Cabling termination equipment, rack-mounted: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.

B. Cable management equipment: Section 27 11 23, COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK.

C. Power distribution equipment: Section 27 11 26, COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS.

D. Grounding and bonding equipment: Section 27 05 26, GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS.

E. Labeling and identification requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.

F. Seismic bracing: Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 SERVER CABINETS

A. Height. Cabinets shall provide 45 standard rack units (RU) of space (45U) for mounting equipment.

B. Dimensions. Nominal dimensions for server cabinets are 84” (2134mm) tall, 23.6” (600mm) wide, and 48” (1220mm) deep, including side panels and doors. Minimum depth is 46” (1168mm). Maximum width is 30” (762 mm).

C. Doors and Panels.

1. Front Door. Provide a single locking, latched, hinged metal front door for the server cabinet with minimum 75% open perforated design for airflow.

2. Rear Door. Provide a single locking, latched, hinged metal rear door for the server cabinet.

a. If a vertical exhaust duct (VED, “chimney”) is specified for the server cabinet, the rear door shall be solid.

b. If no VED is specified, the rear door shall be perforated with a minimum of 75% open design for airflow.

3. Side Panels. Provide removable, locking solid metal side panels. Side panels shall have cable pass-through cut-outs protected with brushed grommets on each side, aligned on each side to allow Rack PDU cables to pass between enclosures to Zone PDUs.

D. Locks. All locks on a server cabinet shall be keyed the same. Provide two keys per cabinet.

E. Color. The cabinet and all components shall be white in color.

F. Equipment Mounting Rack. The cabinet shall provide an EIA-310-E compliant 19” racking system with front and rear rails using standard 3/8” x 3/8” square hole mounting.

1. Rear Rails. Position rear rails with a minimum of 6” of clearance between the rails and the rear doors to accommodate rear-mounted angled patch panels and up to four (4) vertical rack PDUs.

G. Components. The cabinet shall be supplied with the following standard equipment:

a. Air dams for left and right of the front rails.

b. Finger cable managers.

c. Bottom panel with brushed grommets.

d. Top panel with brushed grommets.

e. Toolless mounting brackets for vertical Rack PDUs.

f. 45U of 1RU blanking panels.

2.2 NETWORK CHANNEL RACKS

A. Height. Racks shall provide 45 standard rack units (RU) of space (45U) for mounting equipment.

B. Dimensions. Nominal dimensions for network racks are 86” (2184mm) tall, 24” (610mm) wide, and 40” (1220mm) deep (30”/762mm between front and rear mounting rails).

C. Side Panels. The rack shall have integral metal side panels (a “channel” rack) constructed with a cable management pattern of staggered shapes (circles, hexagons, etc.) to allow for connection points for cable management accessories.

D. Security Doors. Provide locking, latched, hinged metal doors and mounting hardware for the network rack. Doors shall be perforated with a minimum of 50% open design for airflow.

1. Locks. All locks on a network rack shall be keyed the same. Provide two keys per cabinet.

E. Color. The rack and all components shall be white in color.

F. Equipment Mounting Rack. The rack shall provide an EIA-310-E compliant 19” racking system with front and rear rails using standard 3/8” x 3/8” square hole mounting.

G. Components. The rack shall be supplied with the following standard equipment:

a. Toolless mounting brackets for vertical Rack PDUs.

b. 30U of 1RU blanking panels.

c. Vertical cable managers with doors on both left and right of the rack (size commensurate with the requirement).

d. Cable management accessories as necessary to maintain cable bend radii, uniformity, and neatness (e.g. d-rings, spools, bend radius limiters, finger cable managers, waterfalls, etc.).

2.3 NETWORK CABINETS

A. Height. Cabinets shall provide 45 standard rack units (RU) of space (45U) for mounting equipment.

B. Dimensions. Nominal dimensions for server cabinets are 84” (2134mm) tall, 40” (1016mm) and 48” (1220mm) deep, including side panels and doors.

C. Doors and Panels.

1. Front Door. Provide a single locking, latched, hinged metal front door for the server cabinet with minimum 75% open perforated design for airflow.

2. Rear Door. Provide a single locking, latched, hinged metal rear door for the server cabinet.

a. If a vertical exhaust duct (VED, “chimney”) is specified for the server cabinet, the rear door shall be solid.

b. If no VED is specified, the rear door shall be perforated with a minimum of 75% open design for airflow.

3. Side Panels. Provide removable, locking solid metal side panels. Side panels shall have cable pass-through cut-outs protected with brushed grommets on each side, aligned on each side to allow Rack PDU and communications cables to pass between enclosures to Zone PDUs.

D. Locks. All locks on a server cabinet shall be keyed the same. Provide two keys per cabinet.

E. Color. The cabinet and all components shall be white in color.

F. Equipment Mounting Rack. The cabinet shall provide an EIA-310-E compliant 19” racking system with front and rear rails using standard 3/8” x 3/8” square hole mounting.

G. Components. The cabinet shall be supplied with the following standard equipment:

a. Air dams for left and right of the front rails.

b. Bottom panel with brushed grommets.

c. Top panel with brushed grommets.

d. Toolless mounting brackets for vertical Rack PDUs.

e. 45U of 1RU blanking panels.

f. Cable management accessories as necessary to maintain cable bend radii, uniformity, and neatness (e.g. d-rings, spools, bend radius limiters, finger cable managers, waterfalls, etc.).

2.4 TELECOMMUNICATIONS ENCLOSURES (TE)

Telecommunications Enclosures (TEs) are swing-out wall-mounted enclosures.

A. Height. TEs shall provide 12 standard rack units (RU) of space for mounting equipment.

B. Dimensions. Nominal dimensions for cabinets are 24” (610mm) tall, 24” (610mm) wide, and 30” (760mm) deep.

C. Doors and Panels.

1. Front Door. TEs shall have a single locking, latched, hinged metal front door with a tempered glass front.

2. Rear Panel. TEs shall have a latched, hinged metal rear door that mounts to the wall, allowing the body of the TE to be swung open for rear equipment access. If latched exterior to the body of the TE, the latch shall be locking.

a. Cabling Cutouts. The top and bottom surfaces of the rear panel shall have cabling cutouts to accommodate telecommunications cabling entering the TE. Edge-protection grommets for the cabling cutouts shall be provided.

b. Power Cutout. The rear panel shall have a cutout on the rear mounting surface allowing power to be installed internal to the TE.

3. Locks. All locks on a TE shall be keyed the same. Provide two keys per TE.

D. Load Rating. The TE shall support 300lb (136kg) of total weight.

E. Color. The cabinet and all components shall be white in color.

F. Equipment Mounting Rack. The cabinet shall provide an EIA-310-E compliant 19” racking system with front and rear rails using standard threaded #12-24 hole mounting.

G. Components. The cabinet shall be supplied with the following standard equipment:

a. 1U shelf (two per TE).

b. Vertical cable management kits (one per each full 12U of TE height).

c. Fan kit to evacuate heat generated by active equipment (two per TE).

d. Filter kit for fans (two per TE).

2.5 PATHWAY RACKS

A. Height. Pathway racks shall provide a minimum of 5 standard rack units (RU) of space (5U) for mounting Equipment Distributor equipment.

B. Dimensions. Nominal dimensions for pathway racks are 12.6” tall, 23.6” wide, and 9” deep.

C. Mounting. Pathway racks shall mount to standard basket-style cable tray.

E. Color. Pathway racks shall be white in color.

F. Equipment Mounting Rack. The cabinet shall provide an EIA-310-E compliant 19” racking system with rails using EIA-tapped 10-32 holes.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Where to be installed in structures assigned to Seismic Design Category C, D, E, or F, seismic bracing equivalent to that for other storage racks per VA Master Specification 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS section 3.7 (“Install… to withstand earthquake forces and anchored to the floor or laterally braced from the top to the structural elements”) is required.

B. Casters on floor-mounted enclosures shall be retracted and the enclosures leveled and stabilized.

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SECTION 27 11 19
COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies cable termination and management equipment to be mounted in information technology (IT) equipment cabinets and racks.

1.2 SUMMARY

Section Includes:

A. Copper UTP Patch Panels.

B. Fiber Optic Distribution Cabinets.

C. Fiber Optic Distribution Cassettes.

D. Fiber Optic Splice Cassettes.

E. Horizontal Cable Managers.

F. Blanking Panels.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. Server cabinets and network racks: Section 27 11 16, COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES.

B. Cable management equipment: Section 27 11 23, COMMUNICATIONS CABLE MANAGEMENT AND LADDER RACK.

C. Labeling and identification requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.

D. Copper UTP cabling: Section 27 13 13, COMMUNICATIONS COPPER BACKBONE CABLING.

E. Copper UTP cabling termination: Section 27 13 13.13, COMMUNICATIONS COPPER CABLE SPLICING AND TERMINATIONS.

F. Fiber optic cabling: Section 27 13 23, COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING.

G. Fiber optic cabling termination: Section 27 13 23.13, COMMUNICATIONS OPTICAL FIBER SPLICING AND TERMINATIONS.

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 COPPER (UTP) PATCH PANELS

A. Form Factor. 1U, 19" rack-mountable. Default form factor for patch panels shall be angled to extend not less than 4" (104mm) forward from the mounting rail.

B. Capacity. 48 copper 8P8C ports in groupings of 6.

C. Interface. Copper (UTP) patch panels shall accept pre-terminated single 8P8C keystone jacks and 6-jack cassettes.

D. Accessories. Provide each patch panel installation with the following accessories.

1. Angled panel cover. Specify angled panel covers at the top and bottom of each stack of angled patch panels. Covers shall mount to the same RU rail positions as the top and bottom patch panels.

2. Rear cable manager tray. Specify one rear cable manager tray per patch panel. Trays shall mount to the same RU rail positions as the patch panel.

2.2 FIBER OPTIC DISTRIBUTION CABINETS

A. Form Factor. 1U, 19" rack-mountable, angled to extend not less than 4" (104mm) forward from the mounting rail.

B. Capacity. 192 fibers in a variety of distribution and/or splice cassettes.

C. Door. Cabinets shall be supplied with a locking front cover.

D. Accessories. Provide each distribution cabinet with the following accessories.

1. Rear cable manager. Specify one rear cable manager with fiber storage rings per distribution cabinet. Trays shall mount to the same RU rail positions as the distribution cabinet.

2. 0RU patch cord managers. Specify one pair of patch cord managers per distribution cabinet. Managers shall mount to the same RU rail positions as the distribution cabinet and rear cable manager.

2.3 FIBER OPTIC DISTRIBUTION CASSETTES

Fiber optic distribution cassettes are used in structured cabling in the computer room to connect Main Distribution Areas (MDAs), Horizontal Distribution Areas (HDAs), and Equipment Distributors (EDs) where pre-terminated cable is used.

A. Form Factor. Designed to install in rack-mounted fiber optic distribution cabinet.

B. Connections. The rear connection shall accept 12-strand multi-fiber push-on (MPO) connectors or 24-strand multi-fiber push-on (MPO) connectors. Adapters on the front of the cassette shall accept 6 duplex Lucent connector (LC) fiber pairs or 3 sets of 8-strand multi-fiber push-on (MPO) connectors.

C. Polarity. Provide type universal polarity cassettes.

2.4 FIBER OPTIC SPLICE CASSETTES

Fiber optic splice cassettes are used in backbone structured cabling connecting the Entrance Rooms to the Main Distribution Areas (MDAs) in the computer room, and the MDAs to Telecommunications Rooms (TRs) where field-terminated (fusion spliced) cable is used.

A. Form Factor. Designed to install in rack-mounted fiber optic distribution cabinet.

B. Connections. Adapters on the front of the cassette shall accept 6 duplex Lucent connector (LC) fiber pairs or 3 sets of 8-strand multi-fiber push-on (MPO) connectors.

C. Design. Splice cassette modules shall be self-contained to integrate fiber adapter bulkhead and splice holders. No additional splice trays shall be necessary. Each module shall provide 24 fiber splice connections.

D. Fiber Type. Provide multimode OM4 and single-mode OS2 splice cassettes as required by the quantity of each type of fiber installed.

2.5 HORIZONTAL CABLE MANAGERS

A. Form Factor. 1U, 19” rack-mountable.

B. Door. Horizontal cable managers shall have a double-hinged front cover to protect installed cables.

C. Fingers. 6-port spacing (five fingers).

2.6 BLANKING PANELS

A. Form Factor. 1U, 19” rack-mountable, angled to extend 4” (104mm) forward from the mounting rail.

B. Transition. Blanking panel shall have a transition cover from angled front to flat front.

C. Quantity. Provide blanking panels to fill 75% of all RUs in all server cabinets and network cabinets.

PART 3 - EXECUTION

3.1 INSTALLATION

Not used.

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SECTION 27 11 26
COMMUNICATIONS RACK MOUNTED POWER PROTECTION AND POWER STRIPS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies power distribution equipment and interconnections supporting equipment deployed in telecommunications spaces (entrance rooms, computer rooms, and telecommunications rooms).

1.2 SUMMARY

Section Includes:

A. Zone Power Distribution Units (zPDUs).

B. Rack-Mounted Uninterruptible Power Supply (UPS) Units.

C. Rack Power Distribution Units (rPDUs).

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. General electrical requirements that are common to more than one section in Division 27: Section 27 05 11, REQUIREMENTS FOR COMMUNICATIONS INSTALLATIONS.

B. IT equipment enclosures: Section 27 11 16, COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

B. For each type of product:

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for rack-mounted power protection and power strips.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

PART 2 - PRODUCTS

2.1 ZONE POWER DISTRIBUTION UNITS (ZONE PDU)

A. Provide components from a single manufacturer.

B. 60 Amp Zone PDU:

1. Description: Zone PDU with A/B redundant 3-phase 60A input circuits and three (3) pairs of A/B redundant L21-20R outlets allowing each supported Standard Density (5kW) enclosure to operate at full density rating.
2. Input Connection: Dual 60A three-phase 208V hard-wired, with junction box and five-wire (L+L+L+N+G) DIN copper terminal blocks accommodating 4AWG conductors. Power cord 10’ (3m) length.
3. Output Connection: Three (3) pairs of A/B (redundant) L21-20R outlets.
4. Power Capacity: 43.2kW (21.6kW redundant at full load); 5.7kW fully-rated at each L21-20R outlet.
5. Enclosure: Fully self-contained.
6. Mounting: 1” rack-mount.

C. 30 Amp Zone PDU:

1. Description: Zone PDU with A/B redundant 3-phase 30A input circuits and two (2) pairs of A/B redundant L21-20R outlets allowing each supported Standard Density (5kW) enclosure to operate at partial density rating.
2. Input Connection: Dual 30A three-phase 208V L21-30P. Power cord 10’ (3m) length.
3. Output Connection: Two (2) pairs of A/B (redundant) L21-20P outlets.
4. Power Capacity: 21.6kW (10.8kW redundant at full load); combined 8.6kW rated output through each A/B pair of L21-20R outlets.
5. Enclosure: Fully self-contained.
6. Mounting: 1” rack-mount.

2.2 RACK-MOUNTED UNINTERRUPTIBLE POWER SUPPLY (UPS) UNITS

A. Provide components from a single manufacturer.

B. Description: 5kW three-phase 208V 20A rack-mounted UPS with L21-20 input and output connections.

C. Input Connection: Single input NEMA L21-20P plug (twistlock three-phase five wire L+L+L+N+G). Power cord minimum 3’ (1m) length.

D. Output Connection: Single output NEMA L21-20R receptacle.

E. Power Capacity: 5kW

F. Enclosure: Fully self-contained.

G. Mounting: 19” rack mount.

H. Battery Capacity: Ten minutes at 70% load (3.5kW).

I. Cooling: Fan-cooled, front air entry, rear exhaust.

2.3 RACK POWER DISTRIBUTION UNITS (RACK PDUS)

A. Provide components from a single manufacturer.

B. Description: Metered/monitored three-phase 208V 20A vertical Rack Power Distribution Unit (Rack PDU), 5.7kW, with IEC60320 outlets.

C. Input Connection: Single input NEMA L21-20P plug (twistlock three-phase five wire L+L+L+N+G). Power cord 10’ (3m) length.

D. Output Connections.

1. For Computer Room applications: Minimum 30 each C13 and 6 each C19. Outlets grouped in phase-grouping banks (A-B, B-C, C-A) or alternating to assist with phase balancing. Outlets labelled with associated phase-grouping bank.

2. For Telecommunications Room (TR) and entrance room applications: Minimum 30 each C13, 6 each C19, 2 each L5-20. Outlets grouped in phase-grouping banks (A-B, B-C, C-A) or alternating to assist with phase balancing. Outlets labelled with associated phase-grouping bank.

E. Power Capacity: 5.7kW rated.

F. Enclosure: Fully self-contained.

G. Mounting: Toolless mounting, orientation vertical at rear of enclosure, taking up zero RU spaces. Up to two Rack PDUs must be able to be installed on each side for High Density (10kW) enclosures.

H. Mounting Hardware: As required to connect to the specific enclosure make/model.

I. Number of RPDUs: 2 for Standard Density (up to 5kW) enclosures, 4 for High Density (10kW) enclosures.

J. Metering: Local display provides input line currents (Amperage). Additional metering items (voltage, power, energy, power factor) across the unit or at individual outlets, is acceptable.

K. Monitoring: RJ45 Ethernet port allows connection to an external monitoring system. Supports SNMP v3 with SSL Encryption.

PART 3 - EXECUTION

3.1 INSTALLATION

A. DEFINITION: Sides (left/right) of the enclosure are as when

viewed from the rear (hot aisle) of the enclosure for the purposes of this section.

B. Zone PDUs.

1. Install Zone PDUs only in enclosures that require them.
2. Zone PDUs shall not be installed in enclosures supported by busbar power distribution.
3. Install Zone PDUs beginning in RU position 1 or the first open RU position above any rack-mounted UPS unit, at the bottom of the 19” rack, on the rear rails of the enclosure.
4. Connect the Zone PDU power cords to the upstream branch circuit supporting the enclosures.

C. Rack-Mounted UPS Units.

1. Install rack-mounted UPS units only in enclosures that require them. Rack-mounted UPS units shall not be installed downstream of another UPS system (cascaded).
2. Where non-redundant UPS power is required to support the enclosure, install the rack-mounted UPS unit in the A side power distribution.
3. Install rack-mounted UPS units beginning in RU position 1, at the bottom of the 19” rack, with the exhaust ports facing the rear of the enclosure. No other equipment should be installed below the rack-mounted UPS units.
4. Connect the rack-mounted UPS unit power cord to the appropriate (A side) power receptacle on the upstream Zone PDU.

D. Rack PDUs.

1. Install Rack PDUs in matched A/B pairs only.
2. Install A side Rack PDUs on the left side of the enclosure and B side Rack PDUs on the right side of the enclosure, interior to the rear enclosure door.
3. Connect the Rack PDU power cord to the upstream rack-mounted UPS unit (where present) or the appropriate power receptacle on the upstream Zone PDU.

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SECTION 27 13 13
COMMUNICATIONS COPPER BACKBONE CABLING

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies requirements for telecommunications copper (UTP) backbone and horizontal cabling in structured cabling systems in computer rooms.

1.2 SUMMARY

Section Includes:

A. Copper (UTP) Backbone Cables.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. Computer room structured cabling: Section 27 10 00, STRUCTURED CABLING.

B. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.

B. Cable labeling requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 COPPER (UTP) BACKBONE CABLES

Copper (UTP) backbone and horizontal cables are used in computer room structured cabling to connect Main Distribution Areas (MDAs), Horizontal Distribution Areas (HDAs), and server cabinet Equipment Distributors (EDs).

A. Performance Category. Copper (UTP) backbone cables shall meet the Category 6A performance requirements. Category 6A connectors are required.

B. Performance Specifications. Meets or exceeds TIA-EIA-568-C.2-10 and TSB-155.

C. Limited Power (LP) Certification. UL Listed as x-LP (0.5A).

D. Termination. Factory pre-terminated TIA 568B.

E. Testing. Factory certified to meet performance category requirements per TIA 568-C.2.

F. Conductor Size. 22-24AWG.

G. Jacket Rating. Communications Multipurpose Cable, Plenum (CMP) shall be specified if any portion of the cable passes through an NEC-defined plenum. Communications Multipurpose Cable, Riser (CMR) shall be specified for all other applications. CMP may be used as a substitute for CMR.

H. Bundling and Construction. Copper (UTP) backbone cables shall be provided in 6-cable bundles with individual 8P8C media interface connectors (RJ-45 'jacks') or 6-jack cassettes designed to fit in copper (UTP) patch panels.

I. Color. A-side 8P8C media interface connectors (RJ-45) shall be blue. B-side 8P8C connectors shall be yellow.

J. Length. Backbone cabling used shall be procured to the specific length required by the design (horizontal and vertical paths) with no more than 2 feet of excess length.

PART 3 - EXECUTION

3.1 IMPLEMENTATION

A. A. All cabling and equipment shall be labeled per the requirements of the VA Infrastructure Standard for Telecommunications Spaces.

B. Install first level backbone and horizontal structured cabling in the computer room in cable tray and fiber raceway systems following diverse path routing.

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SECTION 27 13 13.13
COMMUNICATIONS COPPER CABLE SPLICING AND TERMINATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies requirements for terminations of copper (UTP) cabling.

1.2 SUMMARY

Section Includes:

A. Termination Requirements.

B. Splicing.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.

B. Copper (UTP) cabling requirements: Section 27 13 13, COMMUNICATIONS COPPER BACKBONE CABLING.

C. Copper (UTP) cabling requirements: Section 27 15 13, COMMUNICATIONS COPPER HORIZONTAL CABLING.

1.5 SUBMITTALS:

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 TERMINATION REQUIREMENTS

A. Terminate copper (UTP) cabling used for data communications per TIA 568B.

B. Connections shall be made to equipment certified to performance category 6a.

C. Pre-terminated connections are preferred for computer room structured cabling applications. Field termination for non-computer room applications is acceptable.

3.2 SPLICING

Splicing of copper (UTP) cabling is prohibited.

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SECTION 27 13 23
COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies requirements for telecommunications optical fiber backbone cabling.

1.2 SUMMARY

Section Includes:

A. Multimode Optical Fiber Backbone Cables.

B. Single Mode Optical Fiber Backbone Cables.

C. Hybrid Optical Fiber Backbone Cables.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. Computer room structured cabling: Section 27 10 00, STRUCTURED CABLING.

B. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.

B. Cable labeling requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 MULTIMODE OPTICAL FIBER BACKBONE CABLES.

Multimode fiber optic backbone cables are specified for inside plant use, for data center backbone use as well as for intrabuilding campus backbone.

A. Performance Category. Laser-optimized OM4 or OM5 cables are specified.

B. Testing. All fiber optic backbone media shall pass all Tier 1 requirements (attenuation with an Optical Loss Test Set or OLTS, verification of cable length and polarity) and all Tier 2 requirements (characterization by an Optical Time Domain Reflectometer or OTDR resulting in indication of the uniformity of cable attenuation and connector insertion loss).

C. Termination. For computer room first level backbone usage, factory pre-terminated cables with MPO connectors are required. Fiber will be field terminated (fusion spliced) when used to connect the computer room to Telecommunications Rooms (TRs) and other telecommunications spaces.

1. Polarity. For pre-terminated MPO-MPO cables, the polarity of the cables shall be matched to the type of fiber optic distribution cassettes specified.

D. Jacket Color.

1. OM4. Aqua.

2. OM5. Lime.

E. Jacket Rating. Communications Multipurpose Cable, Plenum (CMP) shall be specified if any portion of the cable passes through an NEC-defined plenum. Communications Multipurpose Cable, Riser (CMR) shall be specified for all other applications. CMP may be used as a substitute for CMR.

F. Bundling and Construction. Bundles consisting of multiples of sub-bundles (subunits) of 24 strands of fiber are specified. Cables shall be dielectric and tight-buffered. Construction shall match the rear entry requirements of the fiber optic distribution or splice cassette such that the sub-bundle (subunit) remains jacketed into the cassette.

G. Length. Backbone cabling for computer room first level backbone use (pre-terminated) shall be procured to the specific length required by the design (horizontal and vertical paths) with no more than 1 meter of excess length on each end.

2.2 SINGLE MODE OPTICAL FIBER BACKBONE CABLES

Single mode fiber optic backbone cables are specified for inside and outside plant use, for campus backbone (interbuilding and intrabuilding) use.

A. Performance Category. OS1 is specified for inside plant applications. Inside/outside rated OS2 is specified for applications where the pathway transits an outside plant path.

B. Testing. All fiber optic backbone media shall pass all Tier 1 requirements (attenuation with an Optical Loss Test Set or OLTS, verification of cable length and polarity) and all Tier 2 requirements (characterization by an Optical Time Domain Reflectometer or OTDR

resulting in indication of the uniformity of cable attenuation and connector insertion loss).

C. Termination. Fiber will be field terminated (fusion spliced) when used to connect the computer room to Telecommunications Rooms (TRs) and other telecommunications spaces.

D. Jacket Color. Yellow.

E. Jacket Rating. Communications Multipurpose Cable, Plenum (CMP) shall be specified if any portion of the cable passes through an NEC-defined plenum. Communications Multipurpose Cable, Riser (CMR) shall be specified for all other applications. CMP may be used as a substitute for CMR.

F. Bundling and Construction. Bundles consisting of multiples of sub-bundles (subunits) of 12 or 24 strands of fiber are specified. Cables shall be dielectric and tight-buffered for OS1, and loose-tube gel-filled for OS2.

2.3 HYBRID OPTICAL FIBER BACKBONE CABLES

Hybrid cables containing multiple 12 strand bundles (subunits) of multimode and/or single mode fiber are acceptable.

PART 3 - EXECUTION

3.1 IMPLEMENTATION

A. A. All cabling and equipment shall be labeled per the requirements of the VA Infrastructure Standard for Telecommunications Spaces.

B. Interior to telecommunications spaces, install fiber optic backbone cabling in overhead cable tray and fiber raceway systems.

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SECTION 27 15 13
COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies requirements for telecommunications copper (UTP) horizontal distribution cabling outside of the computer room. For copper (UTP) horizontal cabling in structured cabling systems in the computer room, see Section 27 13 13 Communications Copper Backbone Cabling.

1.2 SUMMARY

Section Includes:

A. Copper (UTP) Horizontal Cables.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. Computer room structured cabling: Section 27 10 00, STRUCTURED CABLING.

B. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.

B. Cable labeling requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 COPPER (UTP) HORIZONTAL CABLES

Copper (UTP) horizontal cables connect the Telecommunications Room (TR) to each end-user Work Area Outlet (WAO) (horizontal distribution).

A. Performance Category. Copper (UTP) horizontal cables shall meet the Category 6A performance requirements. Category 6A connectors are required.

B. Performance Specifications. Meets or exceeds TIA-EIA-568-C.2-10 and TSB-155.

C. Limited Power (LP) Certification. UL Listed as x-LP (0.5A).

D. Termination. Field terminated TIA 568B.

E. Testing. Following installation, each cable shall be field certified to meet performance category requirements per TIA 568-C.2.

F. Conductor Size. 22-24AWG.

G. Jacket Rating. Communications Multipurpose Cable, Plenum (CMP) shall be specified if any portion of the cable passes through an NEC-defined plenum. Communications Multipurpose Cable, Riser (CMR) shall be specified for all other applications. CMP may be used as a substitute for CMR.

H. Construction. Copper Clad Aluminum (CCA) cable is not permitted.

J. Length. The maximum distance for UTP horizontal cables is limited to 295 feet.

PART 3 - EXECUTION

3.1 IMPLEMENTATION

A. A. All cabling and equipment shall be labeled per the requirements of the VA Infrastructure Standard for Telecommunications Spaces.

B. Interior to the TR, install horizontal copper (UTP) structured cabling in overhead cable tray.

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SECTION 27 15 13.13
COMMUNICATIONS OPTICAL FIBER SPLICING AND TERMINATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies requirements for terminations of fiber optic cabling.

1.2 SUMMARY

Section Includes:

A. Termination Requirements.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.

B. Fiber optic cabling requirements: Section 27 13 23, COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING.

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 TERMINATION REQUIREMENTS

A. Terminate fiber optic cabling with duplex Lucent connector (LC) adapters, 12-fiber multi-fiber push on (MPO) connectors, or 24-fiber multi-fiber push on (MPO) connectors as required for the application.

B. Pre-terminated connections are preferred for computer room structured cabling applications. Field termination (fusion splicing) for non-computer room applications where cable lengths cannot be determined in advance is acceptable.

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SECTION 27 16 19
COMMUNICATIONS PATCH CORDS, STATION CORDS, AND CROSS CONNECT WIRE

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies requirements for telecommunications patch cords.

1.2 SUMMARY

Section Includes:

A. Copper (UTP) Patch Cables.

B. Fiber Optic Patch Cables.

1.3 REFERENCES

A. VA Infrastructure Standard for Telecommunications Spaces.

1.4 RELATED WORK

A. Termination equipment: Section 27 11 19, COMMUNICATIONS TERMINATION BLOCKS AND PATCH PANELS.

B. Cable labeling requirements: Section 27 05 53, IDENTIFICATION FOR COMMUNICATIONS SYSTEMS.

1.5 SUBMITTALS

A. Submit in accordance with Section 27 05 00, COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS.

PART 2 - PRODUCTS

2.1 COPPER (UTP) PATCH CABLES

A. Performance Category. Patch cables shall meet the Category 6A performance requirements. Category 6A connectors are required.

B. Termination Method. Factory pre-terminated TIA 568B.

C. Conductor Size. 22-28AWG. Where 28AWG patch cords are specified, the overall horizontal channel distance is reduced.

D. Length. Patch cords of the shortest appropriate length shall be used.

2.2 FIBER OPTIC PATCH CABLES

A. Construction. Fiber patch cords shall be constructed of pairs (2-strands) of multimode laser-enhanced 50/125µm or single mode laser-optimized 9/125µm fiber.

B. Performance Category. Multimode patch cords shall meet the OM4 performance requirements.

C. Connectors. Duplex Lucent connector (LC) connectors are required. Where polarity requirements are not known, reversible polarity duplex LC connectors are specified on one end.

D. Termination Method. Factory pre-terminated.

E. Length. Patch cords of the shortest appropriate length shall be used.

PART 3 - EXECUTION

3.1 IMPLEMENTATION

A. Patch cords shall not be used to connect equipment in different server cabinets.

B. Patch cords shall be neatly installed using cable management equipment and following cable management principles.

C. Upon installation patch cords shall be labeled in accordance with the requirements of the VA Infrastructure Standard for Telecommunications Spaces.

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SECTION 28 31 00
FIRE DETECTION AND ALARM

PART 1 – GENERAL

1.1 DESCRIPTION

A. This section of the specifications includes the furnishing, installation, and connection of the fire alarm equipment to form a complete coordinated system ready for operation. It shall include, but not be limited to, alarm initiating devices, alarm notification appliances, and wiring as shown on the drawings and specified. The fire alarm system shall not be combined with other systems such as building automation, energy management, security, etc. Devices shall be compatible with the existing fire alarm system.

B. Building 145, Data Center – Room 132 is protected with a clean agent system. Smoke detection to be coordinated with clean agent system and provided as required for adequate protection in accordance with NFPA 2001 and coordinated with the cold aisle containment system. Clean agent releasing panel to be monitored as required by the fire alarm system as required by NFPA 2001 and NFPA 72.

C. Building 145, Data Center – Room 132 is protected by a separately valved wet-pipe suppression system and shall be integrated with the fire alarm system as required by NFPA 13 and NFPA 72.

D. Fire alarm systems shall comply with requirements of the most recent VA FIRE PROTECTION DESIGN MANUAL and NFPA 72 unless variations to NFPA 72 are specifically identified within these contract documents by the following notation: "variation". The design, system layout, document submittal preparation, and supervision of installation and testing shall be provided by a technician that is certified NICET level III or a registered fire protection engineer. The NICET certified technician shall be on site for the supervision and testing of the system. Factory engineers from the equipment manufacturer, thoroughly familiar and knowledgeable with all equipment utilized, shall provide additional technical support at the site as required by the Contracting Officer's Representative (COR) or their authorized representative. Installers shall have a minimum of 2 years experience installing fire alarm systems.

E. Fire alarm signals:

1. Alarm signals (by device), supervisory signals (by device) and system trouble signals (by device not reporting) shall be distinctly transmitted to the main fire alarm system control unit.

1.2 SCOPE

A. Provide fire alarm devices as indicated on plans and all cables, conduits, programming, I/O points as required to create a fully functioning alarm system within the area defined by the scope of work. The HVAC controls contractor will install all smoke detectors in the ducts.

B. Coordinate system integration as required, including, but not limited to, new and existing devices for the wet-pipe fire suppression system and clean agent fire suppression system.

C. All existing fire alarm equipment, wiring, devices, and sub-systems within the area of the scope of work that are not shown to be reused shall be removed. All existing fire alarm conduit not reused shall be removed.

D. Basic Performance:

1. Response time between alarm initiation (contact closure) and recording at the main fire alarm control unit (appearance on alphanumeric read out) shall not exceed 5 seconds.
2. Existing pathway classifications shall be maintained. New circuits shall have pathway classifications in accordance with NFPA 72.

1.3 RELATED WORK

A. Section 01 33 23 – SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 07 84 00 – FIRESTOPPING.

C. Section 21 13 13 – WET-PIPE SPRINKLER SYSTEMS

D. Section 21 22 00 – CLEAN AGENT FIRE SUPPRESSION SYSTEM

E. Section 26 05 11 – REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

F. Section 26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

G. Section 26 05 26 – GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY.

H. Section 26 05 33 – RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

I. Section 26 27 26 – WIRING DEVICES

J. Section 27 11 00.10 – COLD AISLE CONTAINMENT SYSTEM

1.4 SUBMITTALS

A. General: Submit 5 copies in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, and Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. Drawings:

1. Prepare drawings using AutoCAD version 2020 and include all contractor's information. Layering shall be by VA criteria as provided by the COR. The contractor shall be responsible for verifying all critical dimensions shown on the drawings provided by VA.
2. Floor plans: Provide locations of all new devices (with device number at each addressable device corresponding to control unit programming), appliances, panels, equipment, junction/terminal cabinets/boxes, risers, electrical power connections, individual circuits and raceway routing, system zoning; number, size, and type of raceways and conductors in each raceway; conduit fill calculations with cross section area percent fill for each type and size of conductor and raceway. Only those new devices connected and incorporated into the final system needs to be on these floor plans. Do not show any removed devices on the floor plans. Show all interfaces for adjacent fire safety functions.
3. Riser diagrams: Provide, for the new devices, the number, size and type of riser raceways and conductors in each riser raceway and number of each type of device per floor and zone. Show new HVAC shutdown interface and all other fire safety interfaces. Show wiring classifications on the riser diagram for all new circuits. Provide diagrams both on aper building and campus wide basis.
4. Detailed wiring diagrams: Provide for control panels, modules, power supplies, electrical power connections, auxiliary relays and annunciators showing termination identifications, size and type conductors, circuit boards, LED lamps, indicators, adjustable controls, switches, ribbon connectors, wiring harnesses, terminal strips and connectors, spare zones/circuits. Diagrams shall be drawn to a scale sufficient to show spatial relationships between components, enclosures, and equipment configuration.
5. Two weeks prior to final inspection, the Contractor shall deliver to the COR 3 sets of as-built drawings and one set of the as-built

drawing computer files (using AutoCAD 2010). As-built drawings (floor plans) shall show all new and/or existing conduit used for the fire alarm system.

C. Manuals:

1. Submit simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets for all items used in the system, power requirements, device wiring diagrams, dimensions, and information for ordering replacement parts.
   a. Wiring diagrams shall have their terminals identified to facilitate installation, operation, expansion, and maintenance.
   b. Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnections between the items of equipment.
   c. Include complete listing of all software used and installation and operation instructions including the input/output matrix chart.
   d. Provide a clear and concise description of operation that gives, in detail, the information required to properly operate, inspect, test and maintain the equipment and system. Provide all manufacturer's installation limitations including but not limited to circuit length limitations.
   e. Complete listing of all digitized voice messages.
   f. Provide standby battery calculations under normal operating and alarm modes. Battery calculations shall include the magnets for holding the doors open for one minute.
   g. Include information indicating who will provide emergency service and perform post contract maintenance.
   h. Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.
   i. A computerized preventive maintenance schedule for all equipment. The schedule shall be provided on disk in a computer format acceptable to the VAMC and shall describe the protocol for preventive maintenance of all equipment. The schedule shall include the required times for systematic examination, adjustment, and cleaning of all equipment. A printout of the

schedule shall also be provided in the manual. Provide the disk in a pocket within the manual.

j. Furnish manuals in 3 ring loose-leaf binder or manufacturer's standard binder.

k. A printout for all devices proposed on each signaling line circuit with spare capacity indicated.

2. Two weeks prior to final inspection, deliver 4 copies of the final updated maintenance and operating manual to the COR.

a. The manual shall be updated to include any information necessitated by the maintenance and operating manual approval.

b. Complete "As installed" wiring and schematic diagrams shall be included that shows all items of equipment and their interconnecting wiring. Show all final terminal identifications.

c. Complete listing of all programming information, including all control events per device including an updated input/output matrix.

d. Certificate of Installation as required by NFPA 72 for each building. The certificate shall identify any variations from the National Fire Alarm Code.

e. Certificate from equipment manufacturer assuring compliance with all manufacturers installation requirements and satisfactory system operation.

D. Certifications:

1. Together with the shop drawing submittal, submit the technician's NICET level III fire alarm certification as well as certification from the control unit manufacturer that the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer. Include in the certification the names and addresses of the proposed supervisor of installation and the proposed performer of contract maintenance. Also include the name and title of the manufacturer’s representative who makes the certification.

2. Together with the shop drawing submittal, submit a certification from either the control unit manufacturer or the manufacturer of each component (e.g., smoke detector) that the components being furnished are compatible with the control unit.

3. Together with the shop drawing submittal, submit a certification from the major equipment manufacturer that the wiring and connection diagrams meet this specification, UL and NFPA 72 requirements.

1.5 WARRANTY

All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of one year from the date of acceptance of the entire installation by the Contracting Officer.

1.6 APPLICABLE PUBLICATIONS

A. The publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. The publications are referenced in text by the basic designation only and the latest editions of these publications shall be applicable.

B. National Fire Protection Association (NFPA):

NFPA 13 .....Standard for the Installation of Sprinkler Systems, 2022 edition

NFPA 70.....National Electrical Code (NEC), 2020 edition

NFPA 72.....National Fire Alarm Code, 2022 edition

NFPA 90A.....Standard for the Installation of Air Conditioning and Ventilating Systems, 2021 edition

NFPA 101.....Life Safety Code, 2021 edition

NFPA 2001..... Standard on Clean Agent Fire Extinguishing Systems, 2022

C. Underwriters Laboratories, Inc. (UL): Fire Protection Equipment Directory (2011)

D. Factory Mutual Research Corp (FM): Approval Guide, 2021

E. American National Standards Institute (ANSI):

S3.41.....Audible Emergency Evacuation Signal, 2015 edition, reaffirmed 2020

F. International Code Council, International Building Code (IBC), 2021 edition

PART 2 – PRODUCTS

2.1 EQUIPMENT AND MATERIALS, GENERAL

A. Existing equipment may be reused only where indicated on the drawings.

B. Except as indicated in paragraph A above, all equipment and components shall be new and the manufacturer's current model. All equipment shall be tested and listed by Underwriters Laboratories, Inc. or Factory Mutual Research Corporation for use as part of a fire alarm system. The authorized representative of the manufacturer of the major equipment shall certify that the installation complies with all manufacturer's requirements and that satisfactory total system operation has been achieved.

2.2 CONDUIT, BOXES, AND WIRE

A. Conduit shall be in accordance with Section 28 05 28.33 CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY and as follows:
   1. All new conduits shall be installed in accordance with NFPA 70.
   2. Conduit fill shall not exceed 40 percent of interior cross-sectional area.
   3. All new conduits shall be 3/4-inch (19 mm) minimum.

B. Wire:
   1. Wiring shall be in accordance with NEC article 760, Section 28 05 13, CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY, and as recommended by the manufacturer of the fire alarm system. All wires shall be color coded. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 18 AWG for initiating device circuits and 14 AWG for notification device circuits.
   2. Addressable circuits and wiring used for the multiplex communication loop shall be twisted and shielded unless specifically excepted by the fire alarm equipment manufacturer in writing.
   3. Any fire alarm system wiring that extends outside of a building shall have additional power surge protection to protect equipment from physical damage and false signals due to lightning, voltage and current induced transients. Protection devices shall be shown on the submittal drawings and shall be UL listed or in accordance with written manufacturer's requirements.
   4. All wire or cable used in underground conduits including those in concrete shall be listed for wet locations.

C. Terminal Boxes, Junction Boxes, and Cabinets:
   1. Shall be galvanized steel in accordance with UL requirements.
   2. All boxes shall be sized and installed in accordance with NFPA 70.

3. covers shall be repainted red in accordance with Section 09 91 00, PAINTING and shall be identified with white markings as "FA" for junction boxes and as "FIRE ALARM SYSTEM" for cabinets and terminal boxes. Lettering shall be a minimum of 3/4 inch (19 mm) high.
4. Terminal boxes and cabinets shall have a volume 50 percent greater than required by the NFPA 70. Minimum sized wire shall be considered as 14 AWG for calculation purposes.
5. Terminal boxes and cabinets shall have identified pressure type terminal strips and shall be located at the base of each riser. Terminal strips shall be labeled as specified or as approved by the COR.

2.3 ALARM NOTIFICATION APPLIANCES

A. Speakers:

1. Shall operate on either 25 VRMS or 70.7 VRMS with field selectable output taps from 0.5 to 2.0W and originally installed at the 1/2-watt tap. Speakers shall provide a minimum sound output of 80 dBA at 10 feet (3,000 mm) with the 1/2-watt tap.
2. Frequency response shall be a minimum of 400 HZ to 4,000 HZ.
3. Four inches (100 mm) or 8 inches (200 mm) cone type speakers ceiling mounted with white colored baffles in areas with suspended ceilings and wall mounted in areas without ceilings.

B. Strobes:

1. Xenon flash tube type minimum 15 candela in toilet rooms and 75 candela in all other areas with a flash rate of 1 HZ. Strobes shall be synchronized where required by the National Fire Alarm Code (NFPA 72).
2. Backplate shall be red with 1/2 inch (13 mm) permanent red letters. Lettering to read "Fire", be oriented on the wall or ceiling properly, and be visible from all viewing directions.
3. Each strobe circuit shall have a minimum of 20 percent spare capacity.
4. Strobes may be combined with the audible notification appliances specified herein.

2.4 ALARM INITIATING DEVICES

A. Manual Fire Alarm Stations:

1. Shall be non-break glass, address reporting type.

2. Station front shall be constructed of a durable material such as cast or extruded metal or high impact plastic. Stations shall be semi-flush type.
3. Stations shall be of single action pull down type with suitable operating instructions provided on front in raised or depressed letters, and clearly labeled "FIRE."
4. Operating handles shall be constructed of a durable material. On operation, the lever shall lock in alarm position and remain so until reset. A key shall be required to gain front access for resetting or conducting tests and drills.
5. Unless otherwise specified, all exposed parts shall be red in color and have a smooth, hard, durable finish.
6. Stations identified as key operated only shall have a single standardized lock and key separate from the control equipment.

B. Smoke Detectors:

1. Smoke detectors shall be photoelectric type and UL listed for use with the fire alarm control unit being furnished.
2. Smoke detectors shall be addressable type complying with applicable UL Standards for system type detectors. Smoke detectors shall be installed in accordance with the manufacturer's recommendations and NFPA 72.
3. Detectors shall have an indication lamp to denote an alarm condition. Provide remote indicator lamps and identification plates where detectors are concealed from view. Locate the remote indicator lamps and identification plates flush mounted on walls so they can be observed from a normal standing position.
4. All spot type and duct type detectors installed shall be of the photoelectric type.
5. Photoelectric detectors shall be factory calibrated and readily field adjustable. The sensitivity of any photoelectric detector shall be factory set at 3.0 plus or minus 0.25 percent obscuration per foot.
6. Detectors shall provide a visual trouble indication if they drift out of sensitivity range or fail internal diagnostics. Detectors shall also provide visual indication of sensitivity level upon testing. Detectors, along with the fire alarm control units shall be UL listed for testing the sensitivity of the detectors.

2.5 SUPERVISORY DEVICES

A. Duct Smoke Detectors:

1. Duct smoke detectors shall be provided and connected by way of an address reporting interface device. Detectors shall be provided with an approved duct housing mounted exterior to the duct and shall have perforated sampling tubes extending across the full width of the duct (wall to wall). Detector placement shall be such that there is uniform airflow in the cross section of the duct.
2. Interlocking with fans shall be provided in accordance with NFPA 90A and as specified hereinafter under Part 3.2, "TYPICAL OPERATION".
3. Provide remote indicator lamps, key test stations and identification nameplates (e.g. "DUCT SMOKE DETECTOR AHU-X") for all duct detectors. Locate key test stations in plain view on walls or ceilings so that they can be observed and operated from a normal standing position.

2.6 ADDRESS REPORTING INTERFACE DEVICE

A. Shall have unique addresses that reports directly to the building fire alarm panel.

B. Shall be configurable to monitor normally open or normally closed devices for both alarm and trouble conditions.

C. Shall have terminal designations clearly differentiating between the circuit to which they are reporting from and the device that they are monitoring.

D. Shall be UL listed for fire alarm use and compatibility with the panel to which they are connected.

E. Shall be mounted in weatherproof housings if mounted exterior to a building.

2.7 INSTRUCTION CHART:

Provide typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame with a backplate. Install the frame in a conspicuous location observable from each control unit where operations are performed. The card shall show those steps to be taken by an operator when a signal is received under all conditions, normal, alarm, supervisory, and trouble. Provide an additional copy with the binder for the input output matrix for the sequence of operation. The instructions shall be approved by the COR before being posted.

PART 3 – EXECUTION

3.1 INSTALLATION:

A. Installation shall be in accordance with NFPA 70, 72, 90A, and 101 as shown on the drawings, and as recommended by the major equipment manufacturer. Fire alarm wiring shall be installed in conduit. All conduit and wire shall be installed in accordance with, Section 28 05 13 CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY, Section 28 05 26 GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY, Section 28 05 28.33 CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY, and all penetrations of smoke and fire barriers shall be protected as required by Section 07 84 00, FIRESTOPPING.

B. All conduits, junction boxes, conduit supports, and hangers shall be concealed in finished areas and may be exposed in unfinished areas.

C. All fire detection and alarm system devices shall be flush mounted when located in finished areas and may be surface mounted when located in unfinished areas. Exact locations are to be approved by the COR.

D. Speakers shall be ceiling mounted and fully recessed in areas with suspended ceilings. Speakers shall be wall mounted and recessed in finished areas without suspended ceilings. Speakers may be surface mounted in unfinished areas.

E. Strobes shall be flush wall mounted with the bottom of the unit located 80 inches (2,000 mm) above the floor or 6 inches (150 mm) below ceiling, whichever is lower. Locate and mount to maintain a minimum 36 inches (900 mm) clearance from side obstructions.

F. Manual pull stations shall be installed not less than 42 inches (1,050 mm) or more than 48 inches (1,200 mm) from finished floor to bottom of device and within 60 inches (1,500 mm) of a stairway or an exit door.

3.2 TYPICAL OPERATION

A. Activation of any manual pull station, heat detector, or smoke detector shall cause the following operations to occur:

1. Continuously sound a temporal pattern general alarm and flash all strobes in the building in alarm until reset at the local fire alarm control unit in the cleanroom.
2. Transmit a separate alarm signal, via the main fire alarm control unit to the fire department.
3. Unlock the electrically locked exit doors within the zone of alarm.

B. Operation of duct smoke detectors shall cause a system supervisory condition and shut down the ventilation system and close the associated smoke dampers as appropriate.

C. Alarm verification shall not be used for smoke detectors installed for the purpose of early warning.

3.3 TESTS

A. Provide the service of a NICET level III, competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all of the adjustments and tests for the system. Make all adjustments and tests in the presence of the COR.

B. When the systems have been completed and prior to the scheduling of the final inspection, furnish testing equipment and perform the following tests in the presence of the COR. When any defects are detected, make repairs or install replacement components, and repeat the tests until such time that the complete fire alarm systems meets all contract requirements. After the system has passed the initial test and been approved by the COR, the contractor may request a final inspection.

1. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
2. Test the insulation on all installed cable and wiring by standard methods as recommended by the equipment manufacturer.
3. Open each alarm initiating and notification circuit to see if trouble signal actuates.
4. Ground each alarm initiation and notification circuit and verify response of trouble signals.
5. Write a sequence of operations for a testing protocol which under no circumstances causes the cleanroom to lose negative pressure whether occupied or unoccupied.

3.4 FINAL INSPECTION AND ACCEPTANCE

A. Prior to final acceptance a minimum 30 day "burn-in" period shall be provided. The purpose shall be to allow equipment to stabilize and potential installation and software problems and equipment malfunctions to be identified and corrected. During this diagnostic period, all system operations and malfunctions shall be recorded. Final acceptance

will be made upon successful completion of the "burn-in" period and where the last 14 days is without a system or equipment malfunction.

B. At the final inspection a factory trained representative of the manufacturer of the major equipment shall repeat the tests in Article 3.3 TESTS and those required by NFPA 72. In addition, the representative shall demonstrate that the systems function properly in every respect. The demonstration shall be made in the presence of a VA representative. Provide four hours of Owner's training as part of testing and demonstration.

- - END - -

SECTION 31 20 11 EARTHWORK

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies the requirements for furnishing all equipment, materials, labor and techniques for earthwork including excavation, fill, backfill and site restoration utilizing fertilizer, seed and/or sod.

1.2 DEFINITIONS:

A. Unsuitable Materials:

1. Fills: Topsoil, frozen materials; construction materials and materials subject to decomposition; clods of clay and stones larger than 75 mm (3 inches); organic materials, including silts, which are unstable; and inorganic materials, including silts, too wet to be stable.
2. Existing Subgrade (except footings): Same materials as above paragraph, that are not capable of direct support of slabs, pavement, and similar items, with the possible exception of improvement by compaction, proof rolling with a compactive effort of 4 passes using a 35-ton sheepsfoot roller - Caterpillar C825 or equivalent - shall be made on each 8-inch lift of loose soil spread, or similar methods of improvement.
3. Existing Subgrade (footings only): Same as Paragraph 1, but no fill or backfill. If materials differ from design requirements, excavate to acceptable strata subject to Contracting Officer’s Representative (COR)approval.

B. Earthwork: Earthwork operations required within the new construction area. It also includes earthwork and falsework required for auxiliary structures, utilities, concrete pads, and buildings and sewer and other trenchwork throughout the job site.

C. Degree of Compaction: Degree of compaction is expressed as a percentage of maximum density obtained by the test procedure presented in ASTM D698.

D. The term fill means fill or backfill as appropriate.

1.3 RELATED WORK:

A. Materials testing and inspection during construction: Section 01 45 29, TESTING LABORATORY SERVICES.

B. Safety Requirements: Section 01 35 26, SAFETY REQUIREMENTS.

C. Protection of existing utilities, fire protection services, existing equipment, roads, and pavements: Section 01 00 00, GENERAL REQUIREMENTS.

D. Subsurface Investigation: Section 01 00 00, GENERAL REQUIREMENTS, Article, PHYSICAL DATA.

1.4 CLASSIFICATION OF EXCAVATION:

A. Unclassified Excavation: Removal and disposal of pavements and other man-made obstructions visible on the surface; utilities, and other items including underground structures indicated to be demolished and removed; together with any type of materials regardless of character of material and obstructions encountered.

B. Classified Excavation: Removal and disposal of all material not defined as rock.

C. Rock Excavation:

1. Solid ledge rock (igneous, metamorphic, and sedimentary rock).
2. Bedded or conglomerate deposits so cemented as to present characteristics of solid rock which cannot be excavated without blasting; or the use of a modern power excavator (shovel, backhoe, or similar power excavators) of no less than 0.75 m3 (1 cubic yard) capacity, properly used, having adequate power and in good running condition.
3. Boulders or other detached stones each having a volume of 0.4 m3 (1/2 cubic yard) or more.

1.5 MEASUREMENT AND PAYMENT FOR EXCAVATION:

Measurement: The unit of measurement for excavation and borrow will be the cubic yard, computed by the average end area method from cross sections taken before and after the excavation and borrow operations, including the excavation for ditches, gutters,

and channel changes, when the material is acceptably utilized or disposed of as herein specified. Quantities should be computed by a Registered Professional Land Surveyor or Registered Civil Engineer, specified in Section 01 00 00, GENERAL REQUIREMENTS. The measurement will include authorized excavation for rock, authorized excavation of satisfactory subgrade soil, and the volume of loose, scattered rocks and boulders collected within the limits of the work; allowance will be made on the same basis for selected backfill ordered as replacement. The measurement will not include the volume of subgrade material or other material used for purposes other than directed. The volume of overburden stripped from borrow pits and the volume of excavation for ditches to drain borrow its, unless used as borrow material, will not be measured for payment. The measurement will not include the volume of any excavation performed prior to taking of elevations and measurements of the undisturbed grade. All payment will be based on maximum dry density.

1.6 MEASUREMENT AND PAYMENT FOR ROCK EXCAVATION:

A. Measurement: Cross section and measure the uncovered and separated materials, and compute quantities by the Registered Professional Land Surveyor or Registered Civil Engineer, specified in Section 01 00 00, GENERAL REQUIREMENTS. Do not measure quantities beyond the following limits:

1. 300 mm (12 inches) outside of the perimeter of formed footings.
2. 600 mm (24 inches) outside the face of concrete work for which forms are required, except for footings.
3. 150 mm (6 inches) below the bottom of pipe and not more than the pipe diameter plus 600 mm (24 inches) in width for pipe trenches.
4. The outside dimensions of concrete work for which no forms are required (trenches, conduits, and similar items not requiring forms).

B. Payment for Differing Site Conditions: When rock excavation, as classified, is encountered, the contract price and time will be adjusted in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable.

1.7 SUBMITTALS:

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Rock Excavation Report:

1. Certification of rock quantities excavated.
2. Excavation method.
3. Labor.
4. Equipment.
5. Land Surveyor's or Civil Engineer's name and official registration stamp.
6. Plot plan showing elevations.

C. Contractor shall submit procedure and location for disposal of unused satisfactory material. Proposed source of borrow material. Notification of encountering rock in the project. Advance notice on the opening of excavation or borrow areas. Advance notice on shoulder construction for rigid pavements.

D. Furnish to Contracting Officer’s Representative (COR), soil samples, suitable for laboratory tests, of proposed off site or on site fill material.

E. Qualifications of the commercial testing laboratory or Contractor’s Testing facility shall be submitted.

1.8 APPLICABLE PUBLICATIONS:

A. Publications listed below form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

B. American Nursery and Landscape Association (ANLA):

2004 .....American Standard for Nursery Stock

C. American Association of State Highway and Transportation Officials (AASHTO):

T99-10 .....Moisture-Density Relations of Soils Using a 2.5 kg (5.5 lb) Rammer and a 305 mm (12 inch) Drop

T180-10 .....Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg [10 lb] Rammer and a 457 mm (18 inch) Drop

D. American Society for Testing and Materials (ASTM):

C33-03 .....Concrete Aggregate

D698-e1 .....Laboratory Compaction Characteristics of Soil Using Standard Effort

D1140-00 .....Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve

D1556-00 .....Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

D1557-09 .....Laboratory Compaction Characteristics of Soil Using Modified Effort

D2167-94 (2001) .....Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

D2487-06 .....Standard Classification of Soil for Engineering Purposes (Unified Soil Classification System)

D6938-10 .....Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

E. Standard Specifications of Michigan Department of Transportation, latest revision.

PART 2 - PRODUCTS

2.1 MATERIALS:

A. Fills: Materials approved from on site and off site sources having a minimum dry density of 1760 kg/m3 (110 pcf), a maximum Plasticity Index of 6, and a maximum Liquid Limit of 30.

B. Granular Fill:

1. Under concrete slab, granular fill shall consist 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. Fine aggregate grading shall conform to ASTM C33 with a maximum of 3 percent by weight passing ASTM D1140.
2. Bedding for sanitary and storm sewer pipe, crushed stone or gravel graded from 13 mm (1/2 inch) to 4.75 mm (No. 4).

C. Fertilizer: (5-10-5) delivered to site in unopened containers that clearly display the manufacturer's label, indicating the analysis of the contents.

D. Seed: Grass mixture comparable to existing turf delivered to site in unopened containers that clearly display the manufacturer's label, indicating the analysis of the contents.

E. Sod: Comparable species with existing turf. Use State Certified or State Approved sod when available. Deliver sod to site immediately after cutting and in a moist condition. Thickness of cut must be 19 mm to 32 mm (3/4 inch to 1 1/4 inches) excluding top growth. There shall be no broken pads and torn or uneven ends

F. Requirements For Offsite Soils: Offsite soils brought in for use as backfill shall be tested for TPH, BTEX and full TCLP including ignitability, corrosivity and reactivity. Backfill shall contain less than 100 parts per million (ppm) of total hydrocarbons (TPH) and less than 10 ppm of the sum of Benzene, Toleune, Ethyl

Benzene, and Xylene (BTEX)and shall not fail the TCLP test. TPH concentrations shall be determined by using EPA 600/4-79/020 Method 418.1. BTEX concentrations shall be determined by using EPA SW-846.3-3a Method5030/8020. TCLP shall be performed in accordance with EPA SW-846.3-3a 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. Material shall not be brought on site until tests have been approved by the Contracting Officer's Representative (COR).

G. Buried Warning and Identification Tape: Polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inch minimum width, color coded as specific 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. Color and printing shall be permanent, 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

H. Warning Tape for Metallic Piping: Acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above. Minimum thickness of tape shall be 0.076 mm (0.003 inch). Tape shall have a minimum strength of 10.3 MPa (1500 psi) lengthwise, and 8.6 MPa (1250 psi) crosswise, with a maximum 350 percent elongation.

I. Detectable Warning Tape for Non-Metallic Piping: Polyethylene plastic tape conforming to the width, color, and printing requirements specified above. Minimum thickness of the tape shall be 0.102 mm (0.004 inch). Tape shall have a minimum strength of 10.3 MPa (1500 psi) lengthwise and 8.6 MPa (1250 psi) crosswise. Tape shall be manufactured with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 0.9 m(3 feet) deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

J. Detection Wire For Non-Metallic Piping: Detection wire shall be Insulated single strand, solid copper with a minimum of 12 AWG.

PART 3 - EXECUTION

3.1 SITE PREPARATION:

A. Clearing: Clearing within the limits of earthwork operations as described or designated by the Contracting Officer’s Representative (COR). Work includes removal of trees, shrubs, fences, foundations, incidental structures, paving, debris, trash and any other obstructions. Remove materials from the // Medical Center.

B. Grubbing: Remove stumps and roots 75 mm (3 inches) and larger diameter. Undisturbed sound stumps, roots up to 75 mm (3 inches) diameter, and nonperishable solid objects which will be a minimum of 900 mm (3 feet) below subgrade or finished embankment may be left.

C. Trees and Shrubs: Trees and shrubs, not shown for removal, may be removed from the areas within 4500 mm (15 feet) of new construction and 2250 mm (7’-6”) of utility lines if such removal is approved in advance by the Contracting Officer’s Representative (COR). Remove materials from the Medical Center. Trees and shrubs, shown to be transplanted, shall be dug with a ball of earth and burlapped in accordance with the latest issue

of the, "American Standard for Nursery Stock", of the American Association of Nurserymen, Inc. Transplant trees and shrubs to a permanent or temporary position within two hours after digging. Maintain trees and shrubs held in temporary locations by watering as necessary and feeding semi-annually with liquid fertilizer with a minimum analysis of 5 percent nitrogen, 10 percent phosphorus and 5 percent potash. Maintain plants moved to permanent positions as specified for plants in temporary locations until the conclusion of the contract. // Box, and otherwise protect from damage, existing trees and shrubs which are not shown to be removed in the construction area. Repair immediately damage to existing trees and shrubs by trimming, cleaning and painting damaged areas, including the roots, in accordance with standard industry horticultural practice for the geographic area and plant species. Building materials shall not be stored closer to trees and shrubs that are to remain, than the farthest extension of their limbs.

D. Stripping Topsoil: Unless otherwise indicated on the drawings, the limits of earthwork operations shall extend anywhere the existing grade is filled or cut or where construction operations have compacted or otherwise disturbed the existing grade or turf. Strip topsoil as defined herein, or as indicated in the geotechnical report, from within the limits of earthwork operations as specified above unless specifically indicated or specified elsewhere in the specifications or shown on the drawings. Topsoil shall be fertile, friable, natural topsoil of loamy character and characteristic of the locality. Topsoil shall be capable of growing healthy horticultural crops of grasses. Stockpile topsoil and protect as directed by the Contracting Officer’s Representative (COR). Eliminate foreign material, such as weeds, roots, stones, subsoil, frozen clods, and similar foreign materials, larger than 0.014 m3 (1/2 cubic foot) in volume, from soil as it is stockpiled. Retain topsoil on the

station. Remove foreign materials larger than 50 mm (2 inches) in any dimension from topsoil used in final grading. Topsoil work, such as stripping, stockpiling, and similar topsoil work, shall not, under any circumstances, be carried out when the soil is wet so that the tilth of the soil will be destroyed.

2. Concrete Slabs and Paving: Score deeply or saw cut to insure a neat, straight cut, sections of existing concrete slabs and paving to be removed where excavation or trenching occurs. Extend pavement section to be removed a minimum of 300 mm (12 inches) on each side of widest part of trench excavation and insure final score lines are approximately parallel unless otherwise indicated. Remove material from the Medical Center.

E. Disposal: All materials removed from the property shall be disposed of at a legally approved site, for the specific materials, and all removals shall be in accordance with all applicable Federal, State and local regulations. No burning of materials is permitted onsite.

3.2 EXCAVATION:

A. Shoring, Sheeting and Bracing: Shore, brace, or slope to it's angle of repose banks of excavations to protect workmen, banks, adjacent paving, structures, and utilities, in compliance with OSHA requirements.

1. Extend shoring and bracing to the bottom of the excavation. Shore excavations that are carried below the elevations of adjacent existing foundations.
2. If the bearing of any foundation is disturbed by excavating, improper shoring or removal of shoring, placing of backfill, and similar operations, provide a concrete fill support in compliance with Specification Section 31 23 23.33, FLOWABLE FILL, under disturbed foundations, as directed by Contracting Officer’s Representative (COR), at no additional cost to the Government. Do not remove shoring until permanent work in

excavation has been inspected and approved by Contracting Officer's Representative (COR).

B. Excavation Drainage: Operate pumping equipment and/or provide other materials, means and equipment as required, to keep excavations free of water and subgrades dry, firm, and undisturbed until approval of permanent work has been received from Contracting Officer's Representative (COR). Approval by the Contracting Officer's Representative (COR) is also required before placement of the permanent work on all subgrades. When subgrade for foundations has been disturbed by water, remove the disturbed material to firm undisturbed material after the water is brought under control. Replace disturbed subgrade in trenches by mechanically tamped sand or gravel. When removed disturbed material is located where it is not possible to install and properly compact disturbed subgrade material with mechanically compacted sand or gravel, the Contracting Officer's Representative (COR) should be contacted to consider the use of flowable fill. Groundwater flowing toward or into excavations shall be controlled to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 0.9 m (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. Control measures shall be taken 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, the water level shall be maintained continuously, at least three feet below the working level. Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly. Measure and record performance of dewatering system at same time each day by use of observation

wells or piezometers installed in conjunction with the dewatering system. Relieve hydrostatic head in pervious zones below subgrade elevation in layered soils to prevent uplift. Provide redundancy is dewatering system such as is necessary to prevent work stoppage in the event of any system component failure.

C. Blasting:. Blasting shall not be permitted.

D. Building Earthwork:

1. Excavation shall be accomplished as required by drawings and specifications.
2. Excavate foundation excavations to solid undisturbed subgrade.
3. Remove loose or soft material to solid bottom.
4. Fill excess cut under footings or foundations with 25 MPa (3000 psi) concrete, poured separately from the footings.
3. Do not tamp earth for backfilling in footing bottoms, except as specified.

E. Trench Earthwork:

1. Utility trenches (except sanitary and storm sewer):
   a. Excavate to a width as necessary for sheeting and bracing and proper performance of the work.
   b. Grade bottom of trenches with bell-holes, scooped-out to provide a uniform bearing.
   c. Support piping on suitable undisturbed earth unless a mechanical support is shown. Unstable material removed from the bottom of the trench or excavation shall be replaced with select granular material placed in layers not exceeding 150 mm (6 inches) loose thickness.
   d. The length of open trench in advance of pipe laying shall not be greater than is authorized by the Contracting Officer’s Representative (COR).
   e. Provide buried utility lines with utility identification tape. Bury tape 300 mm (12 inches) below finished grade;

under pavements and slabs, bury tape 150 mm (6 inches) below top of subgrade

f. Bury detection wire directly above non-metallic piping at a distance not to exceed 300 mm (12 inches) above the top of pipe. The wire shall extend continuously and unbroken, from manhole to manhole. The ends of the wire shall terminate inside the manholes at each end of the pipe, with a minimum of 0.9 m (3 feet) of wire, coiled, remaining accessible in each manhole. The wire shall remain insulated over it's entire length. The wire shall enter 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, the wire shall terminate in the valve pit at the pump station end of the pipe.

g. Initial backfill material shall be placed and compacted with approved tampers to a height of at least one foot above the utility pipe or conduit. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken 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. Backfill to top of pipe shall be compacted to 95 percent of ASTM D 698maximum density. Plastic piping shall have bedding to spring line of pipe. Provide materials as follows:

1) Class I: Angular, 6 to 40 mm (0.25 to 1.5 inches), graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

2) Class II: Coarse sands and gravels with maximum particle size of 40 mm (1.5 inches), 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 D 2487.
3) Clean, coarse-grained sand classified as SP by the ENR Method.
4) Clean, coarsely graded natural gravel, crushed stone or a combination thereof identified GW by ASTM D 2487. Maximum particle size shall not exceed 75 mm (3 inches).

2. Sanitary and storm sewer trenches:
   a. Trench width below a point 150 mm (6 inches) above top of the pipe shall be 600 mm (24 inches) for up to and including 300 mm (12 inches) diameter and four-thirds diameter of pipe plus 200 mm (8 inches) for pipe larger than 300 mm (l2 inches). Width of trench above that level shall be as necessary for sheeting and bracing and proper performance of the work.
   b. The bottom quadrant of the pipe shall be bedded on suitable undisturbed soil or granular fill. Unstable material removed from the bottom of the trench or excavation shall be replaced with select granular material placed in layers not exceeding 150 mm (6 inches) loose thickness.
      1) Undisturbed: Bell holes shall be no larger than necessary for jointing. Backfill up to a point 300 mm (12 inches) above top of pipe shall be clean earth placed and tamped by hand.
      2) Granular Fill: Depth of fill shall be a minimum of 75 mm (3 inches) plus one-sixth of pipe diameter below the pipe of 300 mm (12 inches) above top of pipe. Place and tamp fill material by hand.

c. Place and compact as specified the remainder of backfill using acceptable excavated materials. Do not use unsuitable materials.
d. Use granular fill for bedding where rock or rocky materials are excavated.
e. Provide buried utility lines with utility identification tape. Bury tape 300 mm (12 inches) below finished grade; under pavements and slabs, bury tape 150 mm (6 inches) below top of subgrade
f. Bury detection wire directly above non-metallic piping at a distance not to exceed 300 mm (12 inches) above the top of pipe. The wire shall extend continuously and unbroken, from manhole to manhole. The ends of the wire shall terminate inside the manholes at each end of the pipe, with a minimum of 0.9 m (3 feet) of wire, coiled, remaining accessible in each manhole. The wire shall remain insulated over its entire length. The wire shall enter 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, the wire shall terminate in the valve pit at the pump station end of the pipe.
g. Initial backfill material shall be placed and compacted with approved tampers to a height of at least one foot above the utility pipe or conduit. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken 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. Backfill to top of pipe shall be compacted to 95 percent of ASTM D698 maximum density. Plastic piping shall have

bedding to spring line of pipe. Provide materials as follows:

1) Class I: Angular, 6 to 40 mm (0.25 to 1.5 inches), graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.
2) Class II: Coarse sands and gravels with maximum particle size of 40 mm (1.5 inches), 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) Clean, coarse-grained sand classified as SW per ASTM D 2487
4) Clean, coarsely graded natural gravel, crushed stone or a combination thereof identified as GP per ASTM D 2487.

F. Site Earthwork: Excavation shall be accomplished as required by drawings and specifications. Remove subgrade materials that are determined by the Contracting Officer’s Representative (COR) as unsuitable, and replace with acceptable material. When unsuitable material is encountered and removed, the contract price and time will be adjusted in accordance with Articles, DIFFERING SITE CONDITIONS, CHANGES and CHANGES-SUPPLEMENT of the GENERAL CONDITIONS as applicable. Adjustments to be based on meters (yardage) in cut section only.

G. Finished elevation of subgrade shall be as follows:
   1. Pavement Areas - bottom of the pavement or base course as applicable.
   2. Planting and Lawn Areas - 100 mm (4 inches) below the finished grade, unless otherwise specified or indicated on the drawings.

3.3 FILLING AND BACKFILLING:

A. General: Do not fill or backfill until all debris, unsatisfactory soil materials, obstructions, and deleterious materials have been removed from the excavation. Proof-roll exposed subgrades with a fully loaded dump truck. Use excavated materials or borrow for fill and backfill, as applicable. Do not use unsuitable excavated materials. Do not backfill until foundation walls have been completed above grade and adequately braced, waterproofing or dampproofing applied, and pipes coming in contact with backfill have been installed, and inspected and approved by Contracting Officer’s Representative (COR).

B. Proof-rolling Existing Subgrade: - Proof rolling shall be done per ODOT 204.

C. Placing: Place material in horizontal layers not exceeding 200 mm (8 inches) in loose depth and then compacted. Do not place material on surfaces that are muddy, frozen, or contain frost. wherever possible.

D. Compaction: Use approved equipment (hand or mechanical) well suited to the type of material being compacted. Do not operate mechanized vibratory compaction equipment within 3000 mm (10 feet) of new or existing building walls without the prior approval of the Contracting Officer’s Representative (COR). Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Compact each layer until there is no evidence of further compaction and to not less than 95 percent of the maximum density determined in accordance with the following test method ASTM D698 and D1557 Method A. Backfill adjacent to any and all types of structures shall be placed and compacted 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.

E. Borrow Material: Borrow material shall be selected to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Borrow material shall be obtained from the from approved private sources. Unless otherwise provided in the contract, the Contractor shall obtain from the owners 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. Borrow material from approved sources on Government-controlled land may be obtained without payment of royalties. Unless specifically provided, no borrow shall be obtained within the limits of the project site without prior written approval. Necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon shall be considered related operations to the borrow excavation.

F. Opening and Drainage of Excavation and Borrow Pits: The Contractor shall notify the Contracting Officer's Representative (COR) sufficiently in advance of the opening of any excavation or borrow pit to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, borrow pits and other excavation areas shall be excavated providing adequate drainage. Overburden and other spoil material shall be transported to designated spoil areas or otherwise disposed of as directed. Borrow pits shall be neatly trimmed and drained after the excavation is completed. The Contractor shall ensure that excavation of any area, operation of borrow pits, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

3.4 GRADING:

A. General: Uniformly grade the areas within the limits of this section, including adjacent transition areas. Smooth the finished surface within specified tolerance. Provide uniform levels or slopes between points where elevations are indicated, or between

such points and existing finished grades. Provide a smooth transition between abrupt changes in slope.

B. Cut rough or sloping rock to level beds for foundations. In unfinished areas fill low spots and level off with coarse sand or fine gravel.

C. Slope backfill outside the building away from the building walls for a minimum distance of 3048 mm (10 feet)at a minimum five percent (5%) slope.

D. The finished grade shall be 150 mm (6 inches) below bottom line of windows or other building wall openings unless greater depth is shown.

E. Place crushed stone or gravel fill under concrete slabs on grade tamped and leveled. The thickness of the fill shall be 150 mm (6 inches), unless otherwise indicated.

F. Finish subgrade in a condition acceptable to the Contracting Officer’s Representative (COR) at least one day in advance of the paving operations. Maintain finished subgrade in a smooth and compacted condition until the succeeding operation has been accomplished. Scarify, compact, and grade the subgrade prior to further construction when approved compacted subgrade is disturbed by contractor's subsequent operations or adverse weather.

G. Grading for Paved Areas: Provide final grades for both subgrade and base course to +/- 6 mm (0.25 inches) of indicated grades.

3.5 LAWN AREAS:

A. General: Harrow and till to a depth of 100 mm (4 inches), new or existing lawn areas to remain, which are disturbed during construction. Establish existing or design grades by dragging or similar operations. Do not carry out lawn areas earthwork out when the soil is wet so that the tilth of the soil will be destroyed. Plant bed must be approved by Contracting Officer’s Representative (COR) before seeding or sodding operation begins.

B. Finished Grading: Begin finish grading after rough grading has had sufficient time for settlement. Scarify subgrade surface in lawn areas to a depth of 100 mm (4 inches). Apply topsoil so that after normal compaction, dragging and raking operations (to bring surface to indicated finish grades) there will be a minimum of 100 mm (4 inches) of topsoil over all lawn areas; make smooth, even surface and true grades, which will not allow water to stand at any point. Shape top and bottom of banks to form reverse curves in section; make junctions with undisturbed areas to conform to existing topography. Solid lines within grading limits indicate finished contours. Existing contours, indicated by broken lines are believed approximately correct but are not guaranteed.

C. Fertilizing: Incorporate fertilizer into the soil to a depth of 100 mm (4 inches) at a rate of 12 kg/100 m2 (25 pounds per 1000 square feet).

D. Seeding: Seed at a rate of 2 kg/100 m2 (4 pounds per 1000 square feet) and accomplished only during periods when uniform distribution may be assured. Lightly rake seed into bed immediately after seeding. Roll seeded area immediately with a roller not to exceed 225 kg/m (150 pounds per foot) of roller width.

E. Sodding: Topsoil shall be firmed by rolling and during periods of high temperature the topsoil shall be watered lightly immediately prior to laying sod. Sod strips shall be tightly butted at the ends and staggered in a running bond fashion. Placement on slopes shall be from the bottom to top of slope with sod strips running across slope. Secure sodded slopes by pegging or other approved methods. Roll sodded area with a roller not to exceed 225 kg/m (150 pounds per foot) of the roller width to improve contact of sod with the soil.

F. Watering: The Contracting Officer’s Representative (COR) is responsible for having adequate water available at the site. As

sodding is completed in any one section, the entire sodded area shall be thoroughly irrigated by the contractor, to a sufficient depth, that the underside of the new sod pad and soil, immediately below sod, is thoroughly wet. Contracting Officer's Representative (COR) will be responsible for sod after installation and acceptance.

3.6 DISPOSAL OF UNSUITABLE AND EXCESS EXCAVATED MATERIAL:

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Medical Center.

B. Place excess excavated materials suitable for fill and/or backfill on site where directed.

C. Remove from site and dispose of any excess excavated materials after all fill and backfill operations have been completed.

D. Segregate all excavated contaminated soil designated by the Contracting Officer's Representative (COR) from all other excavated soils, and stockpile on site on two 0.15 mm (6 mil) polyethylene sheets with a polyethylene cover. A designated area shall be selected for this purpose. Dispose of excavated contaminated material in accordance with State and Local requirements.

3.7 CLEAN-UP:

Upon completion of earthwork operations, clean areas within contract limits, remove tools, and equipment. Provide site clear, clean, free of debris, and suitable for subsequent construction operations. Remove debris, rubbish, and excess material from the Medical Center.

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SECTION 32 05 23
CEMENT AND CONCRETE FOR EXTERIOR IMPROVEMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Subbase for concrete pavements.
2. Curbs, gutters, and combination curbs and gutters.
3. Pedestrian Pavement: All
4. Vehicular Pavement: All
5. Equipment Pads: All

1.2 RELATED REQUIREMENTS

A. Field Testing: Section 01 45 29, TESTING LABORATORY SERVICES.

B. Subgrade Preparation and Subbase Compaction: Section 31 20 00, EARTHWORK.

1.3 APPLICABLE PUBLICATIONS

A. Comply with references to extent specified in this section.

B. American Association of State Highway and Transportation Officials (AASHTO):

1. M147-65-UL-04 - Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses.
2. M233-86 - Boiled Linseed Oil Mixture for Treatment of Portland Cement Concrete.

C. American Concrete Institute (ACI):

1. 305R-10 - Guide to Hot Weather Concreting.
2. 306R-10 - Guide to Cold Weather Concreting.

D. American National Standards Institute (ANSI):

1. B101.3 - Wet DOCF of Common Hard Surface Floor Materials (Including Action and Limit Thresholds for the Suitable Assessment of the Measured Values).

E. ASTM International (ASTM):

1. A615/A615M-16 - Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.

2. A996/A996M-15 - Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.
3. A1064/A1064M-16 - Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
4. C33/C33M-16 - Concrete Aggregates.
5. C94/C94M-16 - Ready Mixed Concrete.
6. C143/C143M-15a - Slump of Hydraulic Cement Concrete.
7. C150/C150M-16 - Portland Cement.
8. C171-16 - Sheet Materials for Curing Concrete.
9. C260/C260M-10a - Air Entraining Admixtures for Concrete.
10. C309-11 - Liquid Membrane Forming Compounds for Curing Concrete.
11. C494/C494M-15a - Chemical Admixtures for Concrete.
12. C618-15 - Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
13. C979/C979M-16 - Pigments for Integrally Colored Concrete.
14. C989/C989M-14 - Slag Cement for Use in Concrete and Mortars.
15. C1240-15 - Silica Fume Used in Cementitious Mixtures.
16. D1751-04(2013)e1 - Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
17. D5893/D5893M-10 - Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.
18. D6690-15 - Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

1.4 PREINSTALLATION MEETINGS

A. Conduct preinstallation meeting at project site minimum 30 days before beginning Work of this section.
   1. Required Participants:
      a. Contracting Officer's Representative.
      b. Contractor.
      c. Installer.

2. Meeting Agenda: Distribute agenda to participants minimum 3 days before meeting.
   a. Installation schedule.
   b. Installation sequence.
   c. Preparatory work.
   d. Protection before, during, and after installation during cold, temperate, inclement, and hot weather conditions
   e. Installation.
   f. Terminations.
   g. Transitions and connections to other work.
   h. Inspecting and testing.
   i. Other items affecting successful completion.
3. Document and distribute meeting minutes to participants to record decisions affecting installation.

1.5 SUBMITTALS

A. Submittal Procedures: Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Submittal Drawings:
   1. Show size, configuration, and fabrication and installation details.
   2. Show reinforcing.
   3. Include jointing plan for concrete pavements, curbs and gutters.

C. Manufacturer's Literature and Data:
   1. Description of each product.
   2. Installation instructions.

D. Samples:
   1. Exposed Aggregate Concrete Panel: 0.4 sq. m by 50 mm (4 sq. ft. by 2 inches) thick, 2 required, each color and finish.
   2. Colored Concrete Panel: As specified in Section 09 06 00, SCHEDULE FOR FINISHES, with mix data.

E. Test reports: Certify products comply with specifications.
   1. Concrete materials.

2. Select subbase materials.
3. Field test reports.

F. Certificates: Certify products comply with specifications.
1. Expansion joint filler.
2. Reinforcement.
3. Curing materials.
4. Concrete protective coating.

G. Qualifications: Substantiate qualifications comply with specifications.
1. Installer with project experience list.
2. Land surveyor.

H. Concrete mix design.

I. Select subbase job-mix design.

J. Proposed hot and cold weather concreting methods.

K. Land surveyor's construction staking notes, before placing concrete.
1. Identify discrepancies between field conditions and Drawings.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:
1. Regularly installs specified products.
2. Installed specified products with satisfactory service on five similar installations.
a. Project Experience List: Provide contact names and addresses for completed projects.

B. Land Surveyor: Professional land surveyor or engineer registered to provide land surveys in jurisdiction where project is located.

C. Preconstruction Testing:
1. Engage independent testing laboratory to perform tests and submit reports.
a. Deliver samples to laboratory in number and quantity required for testing.
2. Concrete mix design.
3. Select subbase job-mix design. Report the following:

a. Material sources.
b. Gradation.
c. Plasticity index.
d. Liquid limit.
e. Laboratory compaction curves indicating maximum density at optimum moisture content.

1.7 DELIVERY

A. Deliver steel reinforcement to prevent damage.
B. Before installation, return or dispose of distorted or damaged steel reinforcement.
C. Bulk Products: Deliver bulk products away from buildings, utilities, pavement, and existing turf and planted areas. Maintain dry bulk product storage away from contaminants.

1.8 STORAGE AND HANDLING

A. Store products indoors in dry, weathertight facility.
B. Protect products from damage during handling and construction operations.

1.9 FIELD CONDITIONS

A. Hot Weather Concreting Procedures: ACI 305R.
B. Cold Weather Concreting Procedures: ACI 306R.
   1. Use non-corrosive, non-chloride accelerator admixture.
   2. Do not use calcium chloride, thiocyanates or admixtures containing more than 0.05 percent chloride ions.

1.10 WARRANTY

A. Construction Warranty: FAR clause 52.246-21, "Warranty of Construction."

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I or II.
B. Pozzolans:

1. Fly Ash: ASTM C618, Class C or F including supplementary optional physical requirements.
2. Slag: ASTM C989/C989, Grade 80,
3. Silica Fume: ASTM C1240.

C. Coarse Aggregate: ASTM C33/C33M;

D. Fine Aggregate: ASTM C33/C33M.

E. Mixing Water: Fresh, clean, and potable.

F. Air-Entraining Admixture: ASTM C260/C260M.

G. Chemical Admixtures: ASTM C494/C494M.

H. Reinforcing Steel: ASTM A615/A615M or ASTM A996/A996M, // Grade 280 (40) deformed.

I. Welded Wire Fabric: ASTM A1064/A1064M, deformed; Grade 385 (56); sized as indicated.

J. Expansion Joint Filler: ASTM D1751.

K. Sheet Materials for Curing Concrete: ASTM C171.

2.2 SELECT SUBBASE

A. Subbase: AASHTO M147; Grade A

1. Select granular material composed of sand, sand-gravel, crushed stone, crushed or granulated slag, with or without soil binder, or combinations of these materials.

SUBBASE GRADING REQUIREMENTS							
Sieve Size		Percentage Passing by Mass					
		Grades					
(mm)	(in)	A	B	C	D	E	F
50	2	100	100				
25	1		75-95	100	100	100	100
9.5	3/8	30-65	40-75	50-85	60-100		
4.47	No. 4	25-55	30-60	35-65	50-85	55-100	70-100
2.00	No. 10	15-40	20-45	25-50	40-70	40-100	55-100
0.425	No. 40	8-20	15-30	15-30	25-45	20-50	30-70
0.075	No. 200	2-8	5-20	5-15	5-20	6-20	8-25

B. Other Acceptable Gradations: Materials within three to five percent, plus or minus, of specified gradation, or as recommended by the geotechnical engineer and approved by the Contracting Officer's Representative.

2.3 FORMS

A. Forms: Wood, plywood, metal, or other materials, approved by Contracting Officer's Representative, of grade or type suitable to obtain type of finish specified.
   1. Plywood: Exterior grade, free of defects and patches on contact surface.
   2. Lumber: Sound, grade-marked, S4S stress graded softwood, minimum 50 mm (2 inches) thick, free from warp, twist, loose knots, splits, or other defects.
   3. Form Coating: As recommended by Architect/Engineer.

B. Provide forms suitable in cross-section, depth, and strength to resist springing during depositing and consolidating concrete.
   1. Do not use forms varying from straight line more than 3 mm in 3000 mm (1/8 inch in 10 feet), horizontally and vertically.

C. Provide flexible or curved forms for forming radii.

2.4 CONCRETE CURING MATERIALS

A. Concrete curing materials, conform to one of the following:
   1. Burlap: Minimum 233 g/sq. m (7 ounces/sq. yd.) dry.
   2. Sheet Materials for Curing Concrete: ASTM C171.
   3. Curing Compound: ASTM C309, // Type 1 clear

2.5 CONCRETE MIXES

A. Design concrete mixes according to ASTM C94/C94M, Option C.

B. Concrete Type: Air-entrained. See Table I.

TABLE I - CONCRETE TYPES

Concrete Type	Minimum 28 Day Compressive Strength f'c MPa (psi)	Non-Air-Entrained		Air-Entrained	
		Min. Cement kg/cu. m	Max. Water	Min. Cement kg/cu. m	Max. Water

		(lbs./cu. yd.)	Cement Ratio	(lbs./cu. yd.)	Cement Ratio
A	35 (5000)1,3	375 (630)	0.45	385 (650)	0.40
B	30 (4000)1,3	325 (550)	0.55	340 (570)	0.50
C	25 (3000)1,3	280 (470)	0.65	290 (490)	0.55
D	25 (3000)1,2	300 (500)	*	310 (520)	*

Footnotes:
1. If trial mixes are used, achieve compressive strength 8.3 MPa (1,200 psi) in excess of f'c. For concrete strengths greater than 35 MPa (5,000 psi), achieve compressive strength 9.7 MPa (1,400 psi) in excess of f'c.
2. For Concrete Exposed to High Sulfate Content Soils: Maximum water cement ratio is 0.44.
3. Laboratory Determined according to ACI 211.1 for normal weight concrete.

C. Maximum Slump: ASTM C143/C143M. See Table II.

TABLE II - MAXIMUM SLUMP	
APPLICATION	MAXIMUM SLUMP
Curb & Gutter	75 mm (3 inches)
Pedestrian Pavement	75 mm (3 inches)
Vehicular Pavement	50 mm (2 inches) Machine Finished 100 mm (4 inches) Hand Finished
Equipment Pad	75 to 100 mm (3 to 4 inches)

2.6 ACCESSORIES

A. Equipment and Tools: Obtain Contracting Officer's Representative's, approval of equipment and tools needed for handling materials and performing work before work begins.

B. Maintain equipment and tools in satisfactory working condition.

C. Sealants:

1. Concrete Paving Expansion Joints: ASTM D5893/D5893M, Type SL, single component, self-leveling, silicone joint sealant.
2. Concrete Paving Joints: ASTM D6690, Type IV, hot-applied, single component joint sealant.

D. Concrete Protective Coating: AASHTO M233 linseed oil mixture.

PART 3 - EXECUTION

3.1 PREPARATION

A. Examine and verify substrate suitability for product installation.

B. Protect existing construction and completed work from damage.

C. Prepare, construct, and finish subgrade. See Section 31 20 00, EARTHWORK.

D. Maintain subgrade in smooth, compacted condition, in conformance with the required section and established grade until the succeeding operation has been accomplished.

3.2 SELECT SUBBASE

A. Placing:

1. Place subbase material on prepared subgrade in uniform layer to required contour and grades, and to maximum 200 mm (8 inches) loose depth.
2. When required compacted thickness exceeds 150 mm (6 inches), place subbase material in equal thickness layers.
3. When subbase elevation is 13 mm (1/2 inch) or more below required grade, excavate subbase minimum 75 mm (3 inches) deep. Place and compact subbase to required grade.

B. Compaction:

1. Perform compaction with approved hand or mechanical equipment well suited to the material being compacted.
2. Maintain subbase at optimum moisture content for compaction.
3. Compact each subbase layer to minimum 95 percent or 100 percent of maximum density as specified in Section 31 20 00, EARTHWORK.

C. Subbase Tolerances:
   1. Variation from Indicated Grade: Maximum 9 mm (3/8 inch).
   2. Variation from Indicated Thickness: Maximum 13 mm (1/2 inch).

D. Protection:
   1. Protect subbase from damage until concrete is placed.
   2. Reconstruct damaged subbase before placing concrete.

3.3 SETTING FORMS

A. Form Substrate:
   1. Compact form substrate to uniformly support forms along entire length.
   2. Correct substrate imperfections and variations by cutting, filling, and compacting.

B. Form Setting:
   1. Set forms to indicated line and grade with tight joints. Rigidly brace forms preventing movement.
   2. Remove forms when removal will not damage concrete and when required for finishing.
   3. Clean and oil forms before each use.
   4. Correct forms, when required, immediately before placing concrete.

C. Land Surveyor: Establish control, alignment, and grade for forms and slip forming machine operations.
   1. Notify Contracting Officer's Representative immediately when discrepancies exist between field conditions and drawings.
   2. Correct discrepancies greater than 25 mm (1 inch) before placing concrete.

D. Form Tolerances:
   1. Variation from Indicated Line: Maximum 6 mm (1/4 inch).
   2. Variation from Indicated Grade: Maximum 3 mm in 3000 mm (1/8 inch in 10 feet).

3.4 PLACING REINFORCEMENT

A. Keep reinforcement clean from contamination preventing concrete bond.

B. Install reinforcement shown on drawings.

C. Support and securely tie reinforcing steel to prevent displacement during concrete placement.

D. Obtain Contracting Officer's Representative's reinforcement placement approval before placing concrete.

3.5 JOINTS - GENERAL

A. Place joints, where shown on approved submittal Drawings.

1. Conform to details shown.
2. Install joints perpendicular to finished concrete surface.

B. Make joints straight and continuous from edge to edge of pavement.

3.6 CONSTRUCTION JOINTS

A. Locate longitudinal and transverse construction joints between slabs of vehicular pavement as shown on approved submittal Drawings.

B. Place transverse construction joints of type shown, where indicated, and whenever concrete placement is suspended for more than 30 minutes.

C. Provide butt-type joint with dowels in curb and gutter at planned joint locations.

D. Provide keyed joints with tie bars when joint occurs in middle third of planned curb and gutter joint interval.

3.7 CONTRACTION JOINTS

A. Tool or cut joints to width, depth, and radius edge shown on drawings using grooving tool, jointer, or saw.

B. Construct joints in curbs and gutters by inserting 3 mm (1/8 inch) steel plates conforming to curb and gutter cross sections.

1. Keep plates in place until concrete can hold its shape.

C. Finish joint edges with edging tool.

D. Score pedestrian pavement with grooving tool or jointer.

3.8 EXPANSION JOINTS

A. Form expansion joints with expansion joint filler of thickness shown on drawings.

1. Locate joints around perimeter of structures and features abutting site work concrete.
2. Create complete, uniform separation between structure and site work concrete.

B. Extend expansion joint material full depth of concrete with top edge of joint filler below finished concrete surface where sealant is indicated on Drawings.

C. Cut and shape material matching cross section.

D. Anchor with approved devices to prevent displacing during placing and finishing operations.

E. Round joint edges with edging tool.

3.9 PLACING CONCRETE - GENERAL

A. Preparation before Placing Concrete:

1. Obtain Contracting Officer's Representative approval.
2. Remove debris and other foreign material.
3. Uniformly moisten substrate, without standing water.

B. Convey concrete from mixer to final location without segregation or loss of ingredients. Deposit concrete to minimize handling.

C. During placement, consolidate concrete by spading or vibrating to minimize voids, honeycomb, and rock pockets.

1. Vibrate concrete against forms and along joints.
2. Avoid excess vibration and handling causing segregation.

D. Place concrete continuously between joints without bulkheads.

E. Install construction joint in concrete placement suspended for more than 30 minutes.

F. Replace concrete with cracks, chips, bird baths, and other defects to nearest joints, approved by Contracting Officer's Representative.

3.10 PLACING CONCRETE FOR CURB AND GUTTER, PEDESTRIAN PAVEMENT, AND EQUIPMENT PADS

A. Place concrete in one layer conforming to cross section shown on Drawings after consolidating and finishing.
B. Deposit concrete near joints without disturbing joints. Do not place concrete directly onto joint assemblies.
C. Strike concrete surface to proper section ready for consolidation.
D. Consolidate concrete by tamping and spading or with approved mechanical finishing equipment.
E. Finish concrete surface with wood or metal float.
F. Construct concrete pads and pavements with sufficient slope to drain, preventing standing water.

3.11 PLACING CONCRETE FOR VEHICULAR PAVEMENT

A. Deposit concrete as close as possible to its final position.
B. Place concrete continuously between construction joints without cold joints.
C. Strike and consolidate concrete with finishing machine, vibrating screed, or by hand-finishing.
D. Finish concrete surface to elevation and crown shown on drawings.
E. Deposit concrete near joints without disturbing joints. Do not place concrete directly onto joint assemblies.
F. Obtain Contracting Officer's Representative's approval before placing adjacent lanes.

3.12 FORM REMOVAL

A. Keep forms in place minimum 12 hours after concrete placement. Remove forms without damaging concrete.
B. Do not use bars or heavy tools against concrete to remove forms. Repair damage concrete found after form removal.

3.13 CONCRETE FINISHING - GENERAL

A. Follow operation sequence below, unless otherwise indicated on Drawings:
   1. Consolidating, floating, striking, troweling, texturing, and joint edging.

B. Use edging tool with 6 mm (1/4 inch) radius, unless otherwise shown on Drawings.

C. Keep finishing equipment and tools clean and suitable for use.

3.14 CONCRETE FINISHING - PEDESTRIAN PAVEMENT

A. Walks, Grade Slabs, Lawn Mower Crossings, Wheelchair Curb Ramps, Terraces, Healing Gardens :
   1. Finish concrete surfaces with metal float, troweled smooth, and finished with a broom moistened with clear water.
   2. Finish slab edges and formed transverse joints with edger.
   3. Broom surfaces transverse to traffic direction.
      a. Use brooming to eliminate flat surface produced by edger.
      b. Produce uniform corrugations, maximum 1.5 mm (1/16 inch) deep profile.
   4. Provide surface uniform in color and free of surface blemishes, form marks, and tool marks.
   5. Paving Tolerances:
      a. Variation from Indicated Plane: Maximum 5 mm in 3000 mm (3/16 inch in 10 feet).
      b. Variation from Indicated Thickness: Maximum 6 mm (1/4 inch).
   6. Replace paving within joint boundary when paving exceeds specified tolerances.

B. Step Treads, Risers and Sidewalls: Finish as specified for pedestrian pavement, except as follows:
   1. Remove riser forms sequentially, starting with top riser.
   2. Rub riser face with wood or concrete rubbing block and water. Remove blemishes, form marks, and tool marks. Use outside

edger to round nosing; use inside edger to finish bottom of riser.

3. Apply uniform brush finish to treads, risers, and sidewall.
   a. Apply stiff brush finish to treads to provide slip resistant surface complying with ANSI B101.3.
4. Step Tolerance:
   a. Variation from Indicated Plane: Maximum 5 mm in 3000 mm (3/16 inch in 10 feet).

3.15 CONCRETE FINISHING - VEHICULAR PAVEMENT

A. Align finish surfaces where new and existing pavements abut.
B. Longitudinally float pavement surface to profile and grade indicated on drawings.
C. Straighten surface removing irregularities and maintaining specified tolerances while concrete is plastic.
D. Finish pavement edges and joints with edging tool.
E. Broom finish concrete surface after bleed water dissipates and before concrete hardens.
   1. Broom surface transverse to traffic direction.
      a. Use brooming to eliminate flat surface produced by edger.
      b. Produce uniform corrugations, maximum 3 mm (1/8 inch) deep profile.
F. Pavement Tolerances:
   1. Variation from Indicated Plane: Maximum 6 mm in 3000 mm (1/4 inch in 10 feet) tested parallel and perpendicular to traffic direction at maximum 1500 mm (5 feet) intervals.
   2. Variation from Indicated Thickness: Maximum 6 mm (1/4 inch).
G. Replace paving within joint boundary when paving exceeds specified tolerances.

3.16 CONCRETE FINISHING - CURBS AND GUTTERS

A. Round edges of gutter and top of curb with edging tool.
B. Gutter and Curb Top:

1. Float surfaces and finish with smooth wood or metal float until true to grade and section and uniform color.
2. Finish surfaces, while still plastic, longitudinally with bristle brush.

C. Curb Face:
1. Remove curb form and immediately rub curb face with wood or concrete rubbing block removing blemishes, form marks, and tool marks and providing uniform color.
2. Brush curb face, while still plastic, matching gutter and curb top.

D. Curb and Gutter Tolerances: Except at grade changes or curves.
1. Variation from Indicated Plane and Grade:
a. Gutter: Maximum 3 mm in 3000 mm (1/8 inch in 10 feet).
b. Curb Top and Face: Maximum 6 mm in 3000 mm (1/4 inch in 10 feet).

E. Replace curbs and gutters within joint boundary when curbs and gutters exceed specified tolerances.

F. Correct depressions causing standing water.

3.17 CONCRETE FINISHING - EQUIPMENT PADS

A. Strike pad surface to elevation shown on Drawings.

B. Provide smooth, dense float finish, free from depressions or irregularities.

C. Finish pad edges with edger.

D. After removing forms, rub pad edge faces with wood or concrete rubbing block, removing blemishes, form marks, and tool marks and providing uniform color.

E. Pad Tolerances:
1. Variation from Indicated Plane: Maximum 3 mm in 3000 mm (1/8 inch in 10 feet).
2. Variation from Indicated Elevation: Maximum 6 mm (1/4 inch).
3. Variation from Indicated Thickness: Maximum 6 mm (1/4 inch).

F. Replace pads when pads exceed specified tolerances.

3.18 CONCRETE CURING

A. Concrete Protection:
   1. Protect unhardened concrete from rain and flowing water.
   2. Provide sufficient curing and protection materials available and ready for use before concrete placement begins.
   3. Protect concrete to prevent pavement cracking from ambient temperature changes during curing period.
      a. Replace pavement damaged by curing method allowing concrete cracking.
      b. Employ another curing method as directed by Contracting Officer's Representative.

B. Cure concrete for minimum 7 days by one of the following methods appropriate to weather conditions preventing moisture loss and rapid temperature change:
   1. Burlap Mat: Provide minimum two layers kept saturated with water during curing period. Overlap Mats at least 150 mm (6 inches).
   2. Sheet Materials:
      a. Wet exposed concrete surface with fine water spray and cover with sheet materials.
      b. Overlap sheets minimum 300 mm (12 inches).
      c. Securely anchor sheet materials preventing displacement.
   3. Curing Compound:
      a. Protect joints indicated to receive sealants preventing contamination from curing compound.
      b. Insert moistened paper or fiber rope into joint or cover joint with waterproof paper.
      c. Apply curing compound before concrete dries.
      d. Apply curing compound in two coats at right angles to each other.
      e. Application Rate: Maximum 5 sq. m/L (200 sq. ft./gallon), both coats.

f. Immediately reapply curing compound to surfaces damaged during curing period.

3.19 CONCRETE PROTECTIVE COATING

A. Apply protective coating of linseed oil mixture to exposed-to-view concrete surfaces, drainage structures, and features that project through, into, or against concrete exterior improvements to protect the concrete against deicing materials.

B. Complete backfilling and curing operation before applying protective coating.

C. Dry and thoroughly clean concrete before each application.

D. Apply two coats, with maximum coverage of 11 sq. m/L (50 sq. yds./gal.); first coat, and maximum 16 sq. m/L (70 sq. yds./gal.); second coat, except apply commercially prepared mixture according to manufacturer's instructions.

E. Protect coated surfaces from vehicular and pedestrian traffic until dry.

F. Do not heat protective coating, and do not expose protective coating to open flame, sparks, or fire adjacent to open containers or applicators. Do not apply material at temperatures lower than 10 degrees C (50 degrees F).

3.20 FIELD QUALITY CONTROL

A. Field Tests: Performed by testing laboratory specified in Section 01 45 29, TESTING LABORATORY SERVICES.

1. Compaction.
   a. Pavement subgrade.
   b. Curb, gutter, and sidewalk.
2. Concrete:
   a. Delivery samples.
   b. Field samples.
3. Slip Resistance: Steps and pedestrian paving.

3.21 CLEANING

A. After completing curing:

1. Remove burlap and sheet curing materials.
2. Sweep concrete clean, removing foreign matter from the joints.
3. Seal joints as specified.

3.22 PROTECTION

A. Protect exterior improvements from traffic and construction operations.
   1. Prohibit traffic on paving for minimum seven days after placement, or longer as directed by Contracting Officer's Representative.

B. Remove protective materials immediately before acceptance.

C. Repair damage.
   1. Replace concrete containing excessive cracking, fractures, spalling, and other defects within joint boundary, when directed by Contracting Officer's Representative, and at no additional cost to the Government.

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END OF VOLUME TWO