



WORK ORDER NO.

CONTRACT NO. N40085-20-C-0059

**P1338 II MEF SIMULATION/TRAINING
CENTER REPLACEMENT**

At the
**Marine Corps Base Camp Lejeune,
North Carolina**

Volume 1 - Divisions 21 thru 33

PREPARED BY:

Michael Baker International in association with
100 Airside Drive,
Airside Business Park
Moon Township, PA 15108

RQ-WM Jordan JV
1620 Faraday Ave,
Carlsbad, CA 92008

Architectural: Pawel Paszczuk, R.A.
Civil: William D. Neider, P.E.
Structural: David Carter, P.E.
Interior Design: Pawel Paszczuk, R.A.

Mechanical: Dennis E. Myer, P.E.
Electrical: Senol Durur, P.E.
Fire Protection: Kevin B. Spangler, P.E.
Landscape Arch. John C Fennell, PLA

Submitted By:

Date: 09/20/2021

APPROVED BY:

Specifications:

For Commander, NAVFAC:
Date:

UNCLASSIFIED/FOR OFFICIAL USE ONLY



PROJECT TABLE OF CONTENTS**DIVISION 01 - GENERAL REQUIREMENTS**

01 14 00	11/11	WORK RESTRICTIONS
01 20 00.05 20	01/12	PRICE AND PAYMENT PROCEDURES FOR DESIGN-BUILD
01 30 00.05 20	03/13	ADMINISTRATIVE REQUIREMENTS FOR DESIGN-BUILD
01 30 01.00 22	09/15	DESIGN, PROCUREMENT, AND INSTALLATION OF FURNITURE, FIXTURES, AND EQUIPMENT
01 31 19.05 20	09/15	POST AWARD MEETINGS
01 31 23.13 20	05/17	ELECTRONIC CONSTRUCTION AND FACILITY SUPPORT CONTRACT MANAGEMENT SYSTEM
01 32 17.00 20	05/18	COST-LOADED NETWORK ANALYSIS SCHEDULES (NAS)
01 33 00.05 20	05/14	CONSTRUCTION SUBMITTAL PROCEDURES
01 33 10.05 20	05/17	DESIGN SUBMITTAL PROCEDURES
01 33 29.05 20	02/17	SUSTAINABILITY REPORTING FOR DESIGN-BUILD
01 35 13.05 20	11/07	SPECIAL PROJECT PROCEDURES FOR DESIGN-BUILD
01 35 26.05 20	12/15	GOVERNMENT SAFETY REQUIREMENTS FOR DESIGN-BUILD
01 42 00	02/19	SOURCES FOR REFERENCE PUBLICATIONS
01 45 00.05 20	06/15	DESIGN AND CONSTRUCTION QUALITY CONTROL
01 45 35.05 20	09/15	SPECIAL INSPECTIONS FOR DESIGN-BUILD
01 50 00.05 20	11/07	TEMPORARY FACILITIES AND CONTROLS FOR DESIGN-BUILD
01 57 19	11/15	TEMPORARY ENVIRONMENTAL CONTROLS
01 57 19.01 20	08/18	SUPPLEMENTAL TEMPORARY ENVIRONMENTAL CONTROLS
01 60 00.00 22	08/19	REQUIREMENTS FOR PESTICIDE AND HERBICIDE COORDINATION
01 74 19.05 20	03/15	CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT FOR DESIGN-BUILD
01 78 00	08/11	CLOSEOUT SUBMITTALS
01 78 23	08/15	OPERATION AND MAINTENANCE DATA
01 78 24.00 20	02/15	FACILITY ELECTRONIC OPERATION AND MAINTENANCE SUPPORT INFORMATION (eOMSI)
01 78 30.00 22	11/18	GIS DATA DELIVERABLES
01 91 00.15 38	11/19	TOTAL BUILDING COMMISSIONING FOR PROJECT P-1338

DIVISION 02 - EXISTING CONDITIONS

02 82 16	03/10	REMOVAL AND DISPOSAL OF ASBESTOS MATERIALS
02 82 33.12	01/07	PREPARATION OF SURFACES COATED WITH CONTAMINATED PAINT
02 82 33.13	01/07	REMOVAL AND DISPOSAL OF MATERIALS COATED WITH LEAD-CONTAINING PAINT
02 84 16	05/20	HANDLING OF LIGHTING BALLASTS AND LAMPS CONTAINING PCBs AND MERCURY
02 84 33	05/20	REMOVAL AND DISPOSAL OF POLYCHLORINATED BIPHENYLS (PCBs)
02 85 00	11/18	MOLD REMEDIATION

DIVISION 03 - CONCRETE

03 30 00	02/19	CAST-IN-PLACE CONCRETE
03 47 13	08/16	TILT-UP CONCRETE

DIVISION 04 - MASONRY

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

DIVISION 05 - METALS

05 12 00	08/18, CHG 1: 11/18	STRUCTURAL STEEL
05 30 00	05/15, CHG 2: 08/18	STEEL DECKS
05 40 00	05/15, CHG 1: 08/18	COLD-FORMED METAL FRAMING
05 50 13	05/17, CHG 1: 08/18	MISCELLANEOUS METAL FABRICATIONS
05 52 00	02/18	METAL RAILINGS
05 72 00	05/18	DECORATIVE METAL SPECIALTIES

DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

06 10 00	08/16, CHG 2: 11/18	ROUGH CARPENTRY
06 20 00	08/16, CHG 2: 11/18	FINISH CARPENTRY
06 41 16.00 10	08/10, CHG 1: 11/18	PLASTIC-LAMINATE-CLAD ARCHITECTURAL CABINETS
06 61 16	08/20	SOLID SURFACING FABRICATIONS

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

07 05 23	08/19	PRESSURE TESTING AN AIR BARRIER SYSTEM FOR AIR TIGHTNESS
07 19 00	05/11, CHG 1: 08/17	WATER REPELLENTS
07 21 13	02/16, CHG 2: 08/20	BOARD AND BLOCK INSULATION
07 21 16	11/11, CHG 4: 08/18	MINERAL FIBER BLANKET INSULATION
07 22 00	02/16, CHG 3: 11/18	ROOF AND DECK INSULATION
07 27 10.00 10	08/19, CHG 1: 02/20	BUILDING AIR BARRIER SYSTEM
07 27 36	05/17, CHG 2: 08/20	SPRAY FOAM AIR BARRIERS
07 60 00	05/17, CHG 2: 11/18	FLASHING AND SHEET METAL
07 61 15.00 20	08/16, CHG 2: 11/18	ALUMINUM STANDING SEAM ROOFING
07 84 00	05/10, CHG 1: 08/13	FIRESTOPPING
07 92 00	08/16, CHG 3: 11/18	JOINT SEALANTS

DIVISION 08 - OPENINGS

08 11 13	02/10	STEEL DOORS AND FRAMES
08 11 16	05/17, CHG 2: 11/18	ALUMINUM DOORS AND FRAMES
08 14 00	08/16, CHG 1: 08/18	WOOD DOORS
08 31 00	05/17, CHG 1: 08/18	ACCESS DOORS AND PANELS
08 34 73	11/19, CHG 1: 02/21	SOUND CONTROL DOOR ASSEMBLIES
08 41 13	08/18, CHG 1: 08/18	ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS
08 51 13	05/19	ALUMINUM WINDOWS
08 71 00	02/16	DOOR HARDWARE
08 81 00	05/19	GLAZING
08 91 00	05/11	METAL WALL LOUVERS

DIVISION 09 - FINISHES

09 22 00	02/10, CHG 2: 08/18	SUPPORTS FOR PLASTER AND GYPSUM BOARD
09 29 00	08/16, CHG 4: 02/20	GYPSUM BOARD
09 30 10	08/20	PORCELAIN AND GLASS TILING

09 51 00	08/20	ACOUSTICAL CEILINGS
09 62 38	08/17, CHG 1: 08/18	STATIC-CONTROL FLOORING
09 65 00	08/10	RESILIENT FLOORING
09 66 23	08/16	RESINOUS MATRIX TERRAZZO FLOORING
09 68 00	11/17	CARPETING
09 69 13	11/15, CHG 1: 08/18	RIGID GRID ACCESS FLOORING
09 72 00	08/17	WALLCOVERINGS
09 84 20	08/16	ACOUSTICAL WALL PANELS
09 90 00	02/21	PAINTS AND COATINGS
09 96 00	11/14	HIGH-PERFORMANCE COATINGS

DIVISION 10 - SPECIALTIES

10 11 00	08/20	VISUAL DISPLAY UNITS
10 14 00.10	08/17	EXTERIOR SIGNAGE
10 14 00.20	19FEB2019	INTERIOR SIGNAGE
10 21 13	08/20	TOILET COMPARTMENTS
10 22 39	08/20	FOLDING PANEL PARTITIONS
10 26 00	08/20	WALL PROTECTION
10 28 13	08/20	TOILET ACCESSORIES
10 44 16	11/19	FIRE EXTINGUISHERS
10 51 13	05/11	PLASTIC LOCKERS

DIVISION 12 - FURNISHINGS

12 24 13	08/20	ROLLER WINDOW SHADES
12 48 13	08/17	ENTRANCE FLOOR MATS AND FRAMES
12 61 13	08/20	UPHOLSTERED AUDIENCE SEATING
12 93 00	08/17	SITE FURNISHINGS

DIVISION 21 - FIRE SUPPRESSION

21 13 13	08/20	WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION

DIVISION 22 - PLUMBING

22 00 00	11/15	PLUMBING, GENERAL PURPOSE
22 05 48.00 20	04/06, CHG 1: 05/15	MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

23 03 00.00 20	08/10, CHG 3: 08/18	BASIC MECHANICAL MATERIALS AND METHODS
23 05 93.00 22	09/19	TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS
23 07 00	02/13	THERMAL INSULATION FOR MECHANICAL SYSTEMS
23 09 23.13 22	06/21	BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC
23 11 20	05/20	FACILITY GAS PIPING
23 24 00	08/10	HYDRONIC PIPE CLEANING AND FLUSHING PROCEDURES
23 30 00	05/20	HVAC AIR DISTRIBUTION
23 52 43.00 20	05/15, CHG 2: 08/18	LOW PRESSURE WATER HEATING BOILERS (UNDER 800,000 BTU/HR OUTPUT)
23 64 10	11/16	WATER CHILLERS, VAPOR COMPRESSION TYPE
23 64 26	08/09, CHG 5: 11/19	HYDRONIC CHILLED AND HOT WATER PIPING SYSTEMS

23 81 00	05/18	DECENTRALIZED UNITARY HVAC EQUIPMENT
23 81 23	11/20	COMPUTER ROOM AIR CONDITIONING UNITS
23 82 00.00 20	02/16, CHG 1: 08/18	TERMINAL HEATING UNITS

DIVISION 25 - INTEGRATED AUTOMATION

25 05 11	11/17	CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS

DIVISION 26 - ELECTRICAL

26 08 00	08/08, CHG 1: 02/15	APPARATUS INSPECTION AND TESTING
26 12 19.10	05/19	THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS
26 20 00	08/19	INTERIOR DISTRIBUTION SYSTEM
26 24 13	05/15	SWITCHBOARDS
26 27 14.00 20	02/11	ELECTRICITY METERING
26 28 01.00 10	10/07	COORDINATED POWER SYSTEM PROTECTION
26 29 23	02/20	ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS
26 32 15.00	05/20	ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES
26 36 23	05/20	AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH
26 41 00	11/13	LIGHTNING PROTECTION SYSTEM
26 51 00	05/20	INTERIOR LIGHTING
26 56 00	05/20	EXTERIOR LIGHTING

DIVISION 27 - COMMUNICATIONS

27 05 29.00 10	08/11	PROTECTIVE DISTRIBUTION SYSTEM (PDS) FOR SIPRNET COMMUNICATION SYSTEMS
27 10 00	06/17	BUILDING TELECOMMUNICATIONS CABLING SYSTEM
27 51 16	05/20	PUBLIC ADDRESS SYSTEMS

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

28 31 76	08/20	INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE

DIVISION 31 - EARTHWORK

31 05 19	08/08	GEOTEXTILE
31 11 00	11/18	CLEARING AND GRUBBING
31 23 00.00 20	02/11	EXCAVATION AND FILL
31 62 19	11/20	TIMBER PILES

DIVISION 32 - EXTERIOR IMPROVEMENTS

32 05 33	08/17	LANDSCAPE ESTABLISHMENT
32 11 20	08/17	SUBBASES FOR FLEXIBLE PAVING
32 11 23	08/17	AGGREGATE BASE COURSES
32 12 13	05/17	BITUMINOUS TACK AND PRIME COATS
32 12 16	08/09	HOT-MIX ASPHALT (HMA) FOR ROADS
32 13 13.06	05/20	PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES
32 16 19	05/18	CONCRETE CURBS, GUTTERS AND SIDEWALKS
32 17 23	08/16	PAVEMENT MARKINGS

32 31 13.53	02/20	HIGH-SECURITY FENCES AND GATES
32 92 19	08/17	TEMPORARY SEEDING
32 92 23	04/06	SODDING
32 93 00	08/17	EXTERIOR PLANTS

DIVISION 33 - UTILITIES

33 01 30.16	08/16	TV INSPECTION OF SEWER PIPELINES
33 05 23	08/15	TRENCHLESS UTILITY INSTALLATION
33 11 00	02/18	WATER UTILITY DISTRIBUTION PIPING
33 11 23	11/09	NATURAL GAS AND LIQUID PETROLEUM PIPING
33 30 00	05/18	SANITARY SEWERAGE
33 40 00	02/10	STORM DRAINAGE UTILITIES
33 61 14	02/10	EXTERIOR BURIED PREINSULATED WATER PIPING
33 71 01	01/07	OVERHEAD TRANSMISSION AND DISTRIBUTION
33 71 02	12/10	UNDERGROUND ELECTRICAL DISTRIBUTION
33 82 00.00 22	06/17	TELECOMMUNICATIONS OUTSIDE PLANT (OSP)

-- End of Project Table of Contents --

SECTION 21 13 13

WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION
08/20

PART 1 GENERAL

1.1 REFERENCES

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

ASME INTERNATIONAL (ASME)

- ASME B16.1 (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
- ASME B16.3 (2016) Malleable Iron Threaded Fittings, Classes 150 and 300
- ASME B16.4 (2016) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
- ASME B16.21 (2016) Nonmetallic Flat Gaskets for Pipe Flanges

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

- ASSE 1013 (2011) Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers - (ANSI approved 2010)
- ASSE 1015 (2011) Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies - (ANSI approved 2010)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

- AWWA C104/A21.4 (2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
- AWWA C110/A21.10 (2012) Ductile-Iron and Gray-Iron Fittings for Water
- AWWA C111/A21.11 (2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
- AWWA C203 (2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
- AWWA M14 (2015) Manual: Recommended Practice for

Backflow Prevention and Cross-Connection Control

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A135/A135M	(2009; R2014) Standard Specification for Electric-Resistance-Welded Steel Pipe
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings

FM GLOBAL (FM)

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

INTELLIGENCE COMMUNITY STANDARD (ICS)

ICS 705-1	(2010) Physical and Technical Security Standard for Sensitive Compartmented Information Facilities

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13	(2019; Errata 19-1; Errata 19-2; TIA 19-1; TIA 19-2; TIA 19-3; TIA 19-4; Errata 19-3; Errata 20-4; TIA 19-5; TIA 19-6) Standard for the Installation of Sprinkler Systems
NFPA 13R	(2013) Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height
NFPA 24	(2019; TIA 19-1) Standard for the Installation of Private Fire Service Mains and Their Appurtenances

NFPA 101	(2021) Life Safety Code
NFPA 291	(2016) Recommended Practice for Fire Flow Testing and Marking of Hydrants
NATIONAL INSTITUTE FOR CERTIFICATION IN ENGINEERING TECHNOLOGIES (NICET)	
NICET 1014-7	(2012) Program Detail Manual for Certification in the Field of Fire Protection Engineering Technology (Field Code 003) Subfield of Automatic Sprinkler System Layout
UNDERWRITERS LABORATORIES (UL)	
UL 199	(2020) UL Standard for Safety Automatic Sprinklers for Fire-Protection Service
UL 262	(2004; Reprint Oct 2011) Gate Valves for Fire-Protection Service
UL 312	(2010; Reprint Mar 2018) UL Standard for Safety Check Valves for Fire-Protection Service
UL 405	(2013; Bul. 2020) UL Standard for Safety Fire Department Connection Devices
UL 668	(2004; Reprint Jul 2016) UL Standard for Safety Hose Valves for Fire-Protection Service
UL 789	(2004; Reprint May 2017) UL Standard for Safety Indicator Posts for Fire-Protection Service
UL Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.2 SYSTEM DESCRIPTION

Provide wet pipe sprinkler system(s) in all areas of the building . Except as modified herein, the system must meet the requirements of NFPA 13. Pipe sizes which are not indicated on the Contract drawings must be determined by hydraulic calculations.

1.2.1 Hydraulic Design

1.2.1.1 Basis for Calculations

A waterflow test was performed on December 3, 2020 at McHugh Boulevard and Birch Street and resulted in a static pressure of 72 psi with a residual pressure of 66 psi while flowing 8446 gpm. Perform a fire hydrant flow test prior to shop drawing submittal in accordance with NFPA 291. Results must include hydrant elevations relative to the building and hydrant number/identifiers for the tested hydrants, including which were flowed, which had a gauge. This information must be presented in a tabular form if multiple hydrants were flowed. The results must be included with the hydraulic calculations. Hydraulic calculations must be based on flow test

noted in this paragraph, unless verified by the Fire Protection Engineer and approved by Contracting Officer. Hydraulic calculations must be based upon the Hazen-Williams formula with a "C" value noted in NFPA 13 for piping, . .

1.2.1.2 Hydraulic Calculations

- a. Water supply curves and system requirements must be plotted on semi-logarithmic graph ($N^{1.85}$) paper so as to present a summary of the complete hydraulic calculation.
- b. Provide a summary sheet listing sprinklers in the design area and their respective hydraulic reference points, elevations, minimum discharge pressures and minimum flows. Elevations of hydraulic reference points (nodes) must be indicated.
- c. Documentation must identify each pipe individually and the nodes connected thereto. Indicate the diameter, length, flow, velocity, friction loss, number and type fittings, total friction loss in the pipe, equivalent pipe length and Hazen-Williams coefficient for each pipe.
- d. Where the sprinkler system is supplied by interconnected risers, the sprinkler system must be hydraulically calculated using the hydraulically most demanding single riser. The calculations must not assume the simultaneous use of more than one riser.
- e. All calculations must include the backflow preventer manufacturer's stated friction loss at the design flow or 12 psi for reduced pressure backflow preventer, whichever is greater.
- f. All calculations must be performed back to the actual location of the flow test, taking into account the direction of flow in the service main at the test location.
- g. For gridded systems, calculations must show peaking of demand area friction loss to verify that the hydraulically most demanding area is being used. A flow diagram indicating the quantity and direction of flows must be included.

1.2.1.3 Design Criteria

Hydraulically design the system to discharge a minimum density as indicated on the drawings. Hydraulic calculations must be in accordance with the Area/Density Method of NFPA 13. Add an allowance for exterior hose streams of 250 gpm to the sprinkler system demand at the point of connection to the existing water system.

1.2.2 Sprinkler Coverage

Sprinklers must be uniformly spaced on branch lines. Provide coverage throughout 100 percent of the building. This includes, but is not limited to, telephone rooms, electrical equipment rooms (regardless of the fire resistance rating of the enclosure), boiler rooms, switchgear rooms, transformer rooms, attached electrical vaults and other electrical and mechanical spaces. Coverage per sprinkler must be in accordance with NFPA 13. Provide sprinklers below all obstructions in accordance with NFPA 13. Exceptions are as follows:

- a. Sprinklers may be omitted from small rooms which are exempted for specific occupancies in accordance with NFPA 101.
- b. Facilities that are designed in accordance with NFPA 13R.

1.2.3 Qualified Fire Protection Engineer (QFPE)

An individual who is a licensed professional engineer (P.E.) who has passed the fire protection engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and has relevant fire protection engineering experience. Services of the QFPE must include:

- a. Reviewing SD-02, SD-03, and SD-05 submittal packages for completeness and compliance with the provisions of this specification. Working (shop) drawings and calculations must be prepared by, or prepared under the immediate supervision of, the QFPE. The QFPE must affix their professional engineering stamp with signature to the shop drawings, calculations, and material data sheets, indicating approval prior to submitting the shop drawings to the DFPE.
- b. Provide a letter documenting that the SD-02, SD-03, and SD-05 submittal package has been reviewed and noting all outstanding comments.
- c. Performing in-progress construction surveillance prior to installation of ceilings (rough-in inspection).
- d. Witnessing pre-Government and final Government functional performance testing and performing a final installation review.
- e. Signing applicable certificates under SD-07.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Partial submittals and submittals not fully complying with NFPA 13 and this specification section must be returned disapproved without review. SD-02, SD-03 and SD-05 must be submitted simultaneously.

Shop drawings (SD-02), product data (SD-03) and calculations (SD-05) must be prepared by the designer and combined and submitted as one complete package. The QFPE must review the SD-02/SD-03/SD-05 submittal package for completeness and compliance with the Contract provisions prior to submission to the Government. The QFPE must provide a Letter of Confirmation that they have reviewed the submittal package for compliance with the contract provisions. This letter must include their professional engineer stamp and signature. Partial submittals and submittals not reviewed by the QFPE must be returned disapproved without review.

Submit the following in accordance with Section 01 33 00.05 20
CONSTRUCTION SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualified Fire Protection Engineer (QFPE); G

Sprinkler System Designer; G

Sprinkler System Installer; G

SD-02 Shop Drawings

Shop Drawing; G

SD-03 Product Data

Pipe; G

Fittings; G

Valves, including gate, check, butterfly, and globe; G

Alarm Valves; G

Relief Valves; G

Sprinklers; G

Pipe Hangers and Supports; G

Sprinkler Alarm Switch; G

Valve Supervisory (Tamper) Switch; G

Fire Department Connection; G

Backflow Prevention Assembly; G

Air Vent; G

Hose Valve; G

Seismic Bracing; G

Nameplates; G

SD-05 Design Data

Seismic Bracing; G

Load calculations for sizing of seismic bracing

Hydraulic Calculations; G

SD-06 Test Reports

Test Procedures; G

SD-07 Certificates

Verification of Compliant Installation; G

Request for Government Final Test; G

SD-10 Operation and Maintenance Data

Operating and Maintenance (O&M) Instructions; G

Spare Parts Data; G

SD-11 Closeout Submittals

As-built drawings

1.4 QUALITY ASSURANCE

1.4.1 Preconstruction Submittals

Within 36 days of contract award but no less than 14 days prior to commencing work on site, the prime Contractor must submit the following for review and approval. SD-02, SD-03 and SD-05 submittals received prior to the review and approval of the qualifications will be returned Disapproved Without Review.

1.4.1.1 Shop Drawing

Six copies of the shop drawings, no later than 28 days prior to the start of system installation. Working drawings conforming to the requirements prescribed in NFPA 13 and must be no smaller than the Contract Drawings. Each set of drawings must include the following:

1. A descriptive index with drawings listed in sequence by number. A legend sheet identifying device symbols, nomenclature, and conventions used in the package.
2. Floor plans drawn to a scale not less than 1/8-inch equals 1-foot clearly showing locations of devices, equipment, risers, and other details required to clearly describe the proposed arrangement.
3. Actual center-to-center dimensions between sprinklers on branch lines and between branch lines; from end sprinklers to adjacent walls; from walls to branch lines; from sprinkler feed mains, cross mains and branch lines to finished floor and roof or ceiling. A detail must show the dimension from the sprinkler and sprinkler deflector to the ceiling in finished areas.
4. Longitudinal and transverse building sections showing typical branch line and cross main pipe routing, elevation of each typical sprinkler above finished floor and elevation of "cloud" or false ceilings in relation to the building ceilings.
5. Plan and elevation views which establish that the equipment will fit the allotted spaces with clearance for installation and maintenance.
6. Riser layout drawings drawn to a scale of not less than 1/2-inch equals 1-foot to show details of each system component, clearances between each other and from other equipment and construction in the room.
7. Details of each type of riser assembly, pipe hanger, and restraint of underground water main at point-of-entry into the building, and electrical devices and interconnecting wiring. The dimension from the edge of vertical piping to the nearest adjacent wall(s) must be indicated on the drawings when vertical piping is located in stairs or other portions of

the means of egress.

8. Details of each type of pipe hanger and related components.

1.4.1.2 Product Data

Six copies of annotated catalog data to show the specific model, type, and size of each item. Catalog cuts must also indicate the NRTL listing. The data must be highlighted to show model, size, options, and other pertinent information, that are intended for consideration. Data must be adequate to demonstrate compliance with all contract requirements. Product data for all equipment must be combined into a single submittal.

1.4.1.3 Hydraulic Calculations

Calculations must be as outlined in NFPA 13 except that calculations must be performed by computer using software intended specifically for fire protection system design using the design data shown on the drawings. Calculations must include isometric diagram indicating hydraulic nodes and pipe segments.

1.4.1.4 Operating and Maintenance (O&M) Instructions

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA as supplemented and modified by this specification section.

Provide six manuals and one pdf version on electronic media. The manuals must include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment.

Submit spare parts data for each different item of material and equipment specified. The data must include a complete list of parts and supplies, and a list of parts recommended by the manufacturer to be replaced after 1-year and 3 years of service. Include a list of special tools and test equipment required for maintenance and testing of the products supplied.

1.4.2 Qualifications

1.4.2.1 Sprinkler System Designer

The sprinkler system designer must be certified as a Level III Technician by National Institute for Certification in Engineering Technologies (NICET) in the Water-Based Systems Layout subfield of Fire Protection Engineering Technology in accordance with NICET 1014-7.

1.4.2.2 Sprinkler System Installer

The sprinkler system installer must be regularly engaged in the installation of the type and complexity of system specified in the contract documents, and must have served in a similar capacity for at least three systems that have performed in the manner intended for a period of not less than 6 months.

1.4.3 Regulatory Requirements

Equipment and material must be listed or approved. Listed or approved, as used in this Section, means listed, labeled or approved by a Nationally Recognized Testing Laboratory (NRTL) such as [UL Fire Prot Dir](#) or [FM APP GUIDE](#). The omission of these terms under the description of an item or equipment described must not be construed as waiving this requirement. All listings or approvals by testing laboratories must be from an existing ANSI or UL published standard. The recommended practices stated in the manufacturer's literature or documentation are mandatory requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity and temperature variations, dirt and dust, or other contaminants. All pipes must be either capped or plugged until installed.

1.6 EXTRA MATERIALS

Spare sprinklers and wrench(es) must be provided as [spare parts](#) in accordance with [NFPA 13](#).

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials, equipment, and devices listed for fire protection service when so required by [NFPA 13](#) or this specification. Select material from one manufacturer, where possible, and not a combination of manufacturers, for a classification of material. Material and equipment must be standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid.

2.1.2 [Nameplates](#)

Major components of equipment must have the manufacturer's name, address, type or style, model or serial number, catalog number, date of installation, installing Contractor's name and address, and the contract number provided on a new name plate permanently affixed to the item or equipment. Nameplates must be etched metal or plastic, permanently attached by screws to control units, panels or adjacent walls.

2.1.3 Identification and Marking

Pipe and fitting markings must include name or identifying symbol of manufacturer and nominal size. Pipe must be marked with ASTM designation. Valves and equipment markings must have name or identifying symbol of manufacturer, specific model number, nominal size, name of device, arrow indicating direction of flow, and position of installation (horizontal or vertical), except if valve can be installed in either position. Markings must be included on the body casting or on an etched or stamped metal nameplate permanently on the valve or cover plate.

2.1.4 Pressure Ratings

Valves, fittings, couplings, alarm switches, and similar devices must be

rated for the maximum working pressures that can be experienced in the system, but in no case less than 175 psi.

2.2 UNDERGROUND PIPING COMPONENTS

2.2.1 Pipe

Pipe must comply with NFPA 24. Minimum pipe size is 4 inches. Piping more than 5 feet outside the building walls must comply with Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING. A continuous section of welded stainless steel fire water service piping from a point outside the building perimeter to a flanged fitting at least 1-foot above the finished floor within the building is acceptable.

2.2.2 Fittings and Gaskets

Fittings must be ductile-iron conforming to AWWA C110/A21.10 with cement mortar lining conforming to AWWA C104/A21.4. Gaskets must be suitable in design and size for the pipe with which such gaskets are to be used. Gaskets for ductile-iron pipe joints must conform to AWWA C111/A21.11.

2.2.3 Gate Valve and Indicator Posts

Installation must comply with NFPA 24. Gate valves for use with indicator post must conform to UL 262. Indicator posts must conform to UL 789. Provide each indicator post with one coat of primer and two coats of red enamel paint.

2.2.4 Buried Utility Warning and Identification Tape

Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape must be detectable by an electronic detection instrument. Provide tape, 3 inches minimum width, color coded for the utility involved with warning and identification imprinted in bold block letters continuously and repeatedly over the entire tape length. Warning and identification must read "CAUTION BURIED WATER PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

2.3 ABOVEGROUND PIPING COMPONENTS

2.3.1 Steel Piping Components

2.3.1.1 Steel Pipe

Except as modified herein, steel pipe must be black as permitted by NFPA 13 and conform to the applicable provisions of ASTM A53/A53M, ASTM A135/A135M or ASTM A153/A153M.

Steel piping with wall thickness less than Schedule 40 must not be threaded.

2.3.1.2 Fittings

Fittings must be welded, threaded, or grooved-end type. Threaded fittings must be cast-iron conforming to ASME B16.4, malleable-iron conforming to ASME B16.3 or ductile-iron conforming to ASTM A536. Plain-end fittings with mechanical couplings, fittings that use steel gripping devices to

bite into the pipe, steel press fittings and field welded fittings are not permitted. Fittings, mechanical couplings, and rubber gaskets must be supplied by the same manufacturer. Threaded fittings must use Teflon tape or manufacturer's approved joint compound. Reducing couplings are not permitted except as allowed by NFPA 13.

2.3.1.3 Grooved Mechanical Joints and Fittings

Joints and fittings must be designed for not less than 175 psi service and the product of the same manufacturer. Field welded fittings must not be used. Fitting and coupling housing must be malleable-iron conforming to ASTM A47/A47M, Grade 32510; ductile-iron conforming to ASTM A536, Grade 65-45-12. Rubber gasketed grooved-end pipe and fittings with mechanical couplings are permitted in pipe sizes 2 inches and larger. Gasket must be the flush type that fills the entire cavity between the fitting and the pipe. Nuts and bolts must be heat-treated steel conforming to ASTM A183 and must be cadmium-plated or zinc-electroplated.

2.3.1.4 Flanges

Flanges must conform to NFPA 13 and ASME B16.1. Gaskets must be non-asbestos compressed material in accordance with ASME B16.21, 1/16-inch thick, and full face or self-centering flat ring type.

2.3.2 Flexible Sprinkler Hose

The use of flexible hose is not permitted.

2.3.3 Pipe Hangers and Supports

Provide galvanized pipe hangers and supports in accordance with NFPA 13..

2.3.4 Valves

Provide valves of types approved for fire service. Valves must open by counterclockwise rotation.

2.3.4.1 Control Valve

Manually operated sprinkler control/gate valve must be butterfly type and must be listed.

2.3.4.2 Check Valves

Check valves must comply with UL 312. Check valves 4 inches and larger must be of the swing type, have a clear waterway and meet the requirements of MSS SP-71, for Type 3 or 4. Inspection plate must be provided on valves larger than 6 inches.

2.3.4.3 Hose Valve

Valve must comply with UL 668.

2.3.5 Riser Check Valves

Provide riser check valve, pressure gauges and main drain.

2.4 ALARM INITIATING AND SUPERVISORY DEVICES

2.4.1 Sprinkler Alarm Switch

Vane or pressure-type flow switch(es). Connection of switch must be by the fire alarm installer. Vane type alarm actuating devices must have mechanical diaphragm controlled retard device adjustable from 10 to 60 seconds and must instantly recycle.

2.4.2 Valve Supervisory (Tamper) Switch

Switch must be integral to the control valve or suitable for mounting to the type of control valve to be supervised open. The switch must be tamper resistant and contain SPDT (Form C) contacts arranged to transfer upon removal of the housing cover or closure of the valve of more than two rotations of the valve stem.

2.5 BACKFLOW PREVENTION ASSEMBLY

Reduced-pressure principle valve assembly backflow preventer complying with ASSE 1013, ASSE 1015 and AWWA M14. Each check valve must have a drain. Backflow prevention assemblies must have current "Certificate of Approval from the Foundation for Cross-Connection Control and Hydraulic Research, FCCCHR List" and be listed for fire protection use. Listing of the specific make, model, design, and size in the FCCCHR List is acceptable as the required documentation.

2.5.1 Backflow Preventer Test Connection

Test connection must consist of a series of listed hose valves with 2 1/2-inch National Standard male hose threads with cap and chain.

2.6 FIRE DEPARTMENT CONNECTION

Fire department connection must be freestanding type with cast-brass body, matching escutcheon lettered "Auto Spkr" with a polished-brass finish. The connection must have individual self-closing clappers, caps with drip drains and chains. Female inlets must have 5-inch diameter Storz. Comply with UL 405.

2.7 SPRINKLERS

Sprinklers must comply with UL 199 and NFPA 13. Sprinklers with internal O-rings are not acceptable. Sprinklers in high heat areas including attic spaces or in close proximity to unit heaters must have temperature classification in accordance with NFPA 13. Extended coverage sprinklers are permitted for loading docks, residential occupancies and high-piled storage applications only.

2.7.1 Pendent Sprinkler

Pendent sprinkler must be quick-response type with nominal K-factor of 5.6. Pendent sprinklers must have a polished chrome finish. Assembly must include an integral escutcheon.

2.7.2 Upright Sprinkler

Upright sprinkler must be quick-response type and have a nominal K-factor of 5.6.

2.7.3 Sidewall Sprinkler

Sidewall sprinkler must be the quick-response type. Sidewall sprinkler must have a nominal K-factor of 5.6. Sidewall sprinkler must have a polished-chrome finish.

2.7.4 Concealed Sprinkler

Concealed sprinkler must be quick-response type and have a nominal K-factor of 5.6. Coverplate must be chrome.

2.8 ACCESSORIES

2.8.1 Sprinkler Cabinet

Provide spare sprinklers in accordance with NFPA 13 and must be placed in a suitable metal or plastic cabinet of sufficient size to accommodate all the spare sprinklers and wrenches in designated locations. Spare sprinklers must be representative of, and in proportion to, the number of each type and temperature rating of the sprinklers installed as required by NFPA 13. At least one wrench of each type required must be provided.

2.8.2 Pendent Sprinkler Escutcheon

Escutcheon must be one-piece metallic type with a depth of less than 3/4-inch and suitable for installation on pendent sprinklers. The escutcheon must have a factory finish that matches the pendent sprinkler.

2.8.3 Pipe Escutcheon

Provide split hinge metal plates for piping entering walls, floors, and ceilings in exposed spaces. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.8.4 Sprinkler Guard

Listed guard must be a steel wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards must be provided on sprinklers located within 7 feet of the floor.

2.8.5 Relief Valve

Relief valves must be listed and installed at their riser in accordance with NFPA 13.

2.8.6 Air Vent

Air vents must be of the automatic type and piped to drain to the building exterior.

2.8.7 Identification Sign

Valve identification sign must be minimum 6 inches wide by 2 inches high with enamel baked finish on minimum 18 gage steel or 0.024-inch aluminum with red letters on a white background or white letters on red background. Wording of sign must include, but not be limited to "main drain", "auxiliary drain", "inspector's test", "alarm test", "alarm line",

and similar wording as required to identify operational components. Where there is more than one sprinkler system, signage must include specific details as to the respective system.

PART 3 EXECUTION

3.1 VERIFYING ACTUAL FIELD CONDITIONS

Before commencing work, examine all adjoining work on which the contractor's work that is dependent for perfect workmanship according to the intent of this specification section, and report to the Contracting Officer's Representative a condition that prevents performance of first class work. No "waiver of responsibility" for incomplete, inadequate or defective adjoining work will be considered unless notice has been filed before submittal of a proposal.

3.2 INSTALLATION

The installation must be in accordance with the applicable provisions of [NFPA 13](#), [NFPA 24](#) and publications referenced therein. Locate sprinklers in a consistent pattern with ceiling grid, lights, and air supply diffusers. Install sprinkler system over and under ducts, piping and platforms when such equipment can negatively affect or disrupt the sprinkler discharge pattern and coverage.

- a. Piping offsets, fittings, and other accessories required must be furnished to provide a complete installation and to eliminate interference with other construction.
- b. Wherever the contractor's work interconnects with work of other trades the Contractor must coordinate with other Contractors to insure all Contractors have the information necessary so that they may properly install all necessary connections and equipment. Identify all work items needing access (dampers and similar equipment) that are concealed above hung ceilings by permanent color coded pins/tabs in the ceiling directly below the item.
- c. Provide required supports and hangers for piping, conduit, and equipment so that loading will not exceed allowable loadings of structure. Submittal of a bid must be a deemed representation that the contractor submitting such bid has ascertained allowable loadings and has included in his estimates the costs associated in furnishing required supports.

3.2.1 Waste Removal

At the conclusion of each day's work, clean up and stockpile on site all waste, debris, and trash which may have accumulated during the day as a result of work by the contractor and of his presence on the job. Sidewalks and streets adjoining the property must be kept broom clean and free of waste, debris, trash and obstructions caused by work of the contractor, which will affect the condition and safety of streets, walks, utilities, and property.

3.3 UNDERGROUND PIPING INSTALLATION

The fire protection water main must be laid, and joints anchored, in accordance with [NFPA 24](#). Minimum depth of cover must be [3 feet](#) or the frost line, whichever is deeper. The supply line must terminate inside

the building with a flanged piece, the bottom of which must be set not less than 1-foot above the finished floor. A blind flange must be installed temporarily on top of the flanged piece to prevent the entrance of foreign matter into the supply line. A concrete thrust block must be provided at the elbow where the pipe turns up toward the floor. In addition, joints must be anchored in accordance with NFPA 24. Buried steel components must be provided with a corrosion protective coating in accordance with AWWA C203. Piping more than 5 feet outside the building walls must meet the requirements of Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

3.4 ABOVEGROUND PIPING INSTALLATION

The methods of fabrication and installation of the aboveground piping must fully comply with the requirements and recommended practices of NFPA 13 and this specification section.

3.4.1 Protection of Piping Against Earthquake Damage

Seismic restraint is not required.

3.4.2 Piping in Exposed Areas

Install exposed piping without diminishing exit access widths, corridors or equipment access. Exposed horizontal piping, including drain piping, must be installed to provide maximum headroom.

3.4.3 Piping in Finished Areas

In areas with suspended or dropped ceilings and in areas with concealed spaces above the ceiling, piping must be concealed above ceilings. Piping must be inspected, hydrostatically tested and approved before being concealed. Risers and similar vertical runs of piping in finished areas must be concealed.

3.4.4 Pendent Sprinklers

- a. Drop nipples to pendent sprinklers must consist of minimum 1-inch pipe with a reducing coupling into which the sprinkler must be threaded.
- b. Where sprinklers are installed below suspended or dropped ceilings, drop nipples must be cut such that sprinkler ceiling plates or escutcheons are of a uniform depth throughout the finished space. The outlet of the reducing coupling must not extend below the underside of the ceiling.
- c. Recessed pendent sprinklers must be installed such that the distance from the sprinkler deflector to the underside of the ceiling must not exceed the manufacturer's listed range and must be of uniform depth throughout the finished area.
- d. Pendent sprinklers in suspended ceilings must be located in the center of the tile (+/- 2 inches).

3.4.5 Upright Sprinklers

Riser nipples or "sprigs" to upright sprinklers must contain no fittings between the branch line tee and the reducing coupling at the sprinkler.

3.4.6 Pipe Joints

Pipe joints must conform to NFPA 13, except as modified herein. Not more than four threads must show after joint is made up. Welded joints will be permitted, only if welding operations are performed as required by NFPA 13 at the Contractor's fabrication shop, not at the project construction site. Flanged joints must be provided where indicated or required by NFPA 13. Grooved pipe and fittings must be prepared in accordance with the manufacturer's latest published specification according to pipe material, wall thickness and size. Grooved couplings, fittings and grooving tools must be products of the same manufacturer. For copper tubing, pipe and groove dimensions must comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field must be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe must be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances.

3.4.7 Reducers

Reductions in pipe sizes must be made with one-piece tapered reducing fittings. When standard fittings of the required size are not manufactured, single bushings of the face or hex type will be permitted. Where used, face bushings must be installed with the outer face flush with the face of the fitting opening being reduced. Bushings cannot be used in elbow fittings, in more than one outlet of a tee, in more than two outlets of a cross, or where the reduction in size is less than 1/2-inch.

3.4.8 Pipe Penetrations

- a. Cutting structural members for passage of pipes or for pipe-hanger fastenings will not be permitted. Pipes that must penetrate concrete or masonry walls or concrete floors must be core-drilled and provided with pipe sleeves. Each sleeve must be Schedule 40 galvanized steel, ductile-iron or cast-iron pipe and extend through its respective wall or floor and be cut flush with each wall surface. Sleeves must provide required clearance between the pipe and the sleeve per NFPA 13. The space between the sleeve and the pipe must be firmly packed with mineral wool insulation.
- b. Where pipes and sleeves penetrate fire walls, fire partitions, or floors, pipes/sleeves must be firestopped in accordance with Section 07 84 00 FIRESTOPPING.
- c. In penetrations that are not fire-rated or not a floor penetration, the space between the sleeve and the pipe must be sealed at both ends with plastic waterproof cement that will dry to a firm but pliable mass or with a mechanically adjustable segmented elastomer seal.
- d. All penetrations through the boundary of rooms/areas identified as secure space area must meet ICS 705-1.

3.4.9 Escutcheons

Escutcheons must be provided for pipe penetration in finished areas of ceilings, floors and walls. Escutcheons must be securely fastened to the pipe at surfaces through which piping passes.

3.4.10 Inspector's Test Connection

Unless otherwise indicated, the test connection must consist of **1-inch** pipe connected at the riser as a combination test and drain valve; a test valve located approximately **7 feet** above the floor; a smooth bore brass outlet equivalent to the smallest orifice sprinkler used in the system; and a painted metal identification sign affixed to the valve with the words "Inspector's Test". All test connection piping must be inside of the building and penetrate the exterior wall at the location of the discharge orifice only. The discharge orifice must be located outside the building wall no more than **2 feet** above finished grade, directed so as not to cause damage to adjacent construction or landscaping during full flow discharge, or to the sanitary sewer. Discharge to the exterior must not interfere with exiting from the facility. Water discharge or runoff must not cross the path of egress from the building. Do not discharge to the roof. Discharge to floor drains, janitor sinks or similar fixtures is not permitted.

Provide concrete splash blocks at all drain and inspector's test connection discharge locations if not discharging to a concrete surface. Splash blocks must be large enough to mitigate erosion and not become dislodged during a full flow of the drain. Ensure all discharged water drains away from the facility and does not cause property damage.

3.4.11 Backflow Preventer

Locate within the building or in a heated enclosure in locations subject to freezing. For heated enclosures, provide a low temperature supervisory alarm connected to the facility fire alarm system. Heat trace is not permitted to be used.

Install backflow preventers so that the bottom of the assembly is a minimum of **6 inches** above the finished floor/grade. Install horizontal backflow preventers so that the bottom of the assembly is no greater than **24 inches** above the finished floor/grade. Install vertical backflow preventers so that the upper operating handwheel is no more than **6 feet** above the finished floor/grade. Clearance around control valve handles must be minimum **6 inches** above grade/finished floor and away from walls.

3.4.11.1 Test Connection

Provide downstream of the backflow prevention assembly **UL 668** hose valves with **2.5-inch** National Standard male hose threads with cap and chain. Provide one valve for each **250 gpm** of system demand or fraction thereof. Provide a permanent sign in accordance with paragraph entitled "Identification Signs" which reads, "Test Valve". Indicate location of test header. If an exterior connection, provide a control valve inside a heated mechanical room to prevent freezing.

3.4.12 Drains

- a. Main drain piping must be provided to discharge at a safe point outside the building, no more than **2 feet** above finished grade. Provide a concrete splash block at drain outlet. Discharge to the exterior must not interfere with exiting from the facility. Water discharge or runoff must not cross the path of egress from the building.

- b. Auxiliary drains must be provided as required by NFPA 13. Auxiliary drains are permitted to discharge to a floor drain if the drain is sized to accommodate full flow (min 40 gpm). Discharge to service sinks or similar plumbing fixtures is not permitted.

3.4.13 Installation of Fire Department Connection

Connection must be mounted adjacent to and on the sprinkler system side of the backflow preventer. The piping between the connection and the check valve must be provided with an automatic drip in accordance with NFPA 13 and piped to drain to the outside or a floor drain within the same room.

3.4.14 Identification Signs

Signs must be affixed to each control valve, inspector test valve, main drain, auxiliary drain, test valve, and similar valves as appropriate or as required by NFPA 13. Main drain test results must be etched into main drain identification sign. Hydraulic design data must be etched into the nameplates and permanently affixed to each sprinkler riser as specified in NFPA 13. Provide labeling on the surfaces of all feed and cross mains to show the pipe function (e.g., "Sprinkler System", "Fire Department Connection", "Standpipe") and normal valve position (e.g. "Normally Open", "Normally Closed"). For pipe sizes 4-inch and larger provide white painted stenciled letters and arrows, a minimum of 2 inches in height and visible from at least two sides when viewed from the floor. For pipe sizes less than 4-inch, provide white painted stenciled letters and arrows, a minimum of 0.75-inch in height and visible from the floor.

3.5 ELECTRICAL

Except as modified herein, electric equipment and wiring must be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Alarm signal wiring connected to the building fire alarm control system must be by the fire alarm installer.

3.6 PAINTING

Color code mark piping as specified in Section 09 90 00 PAINTS AND COATINGS.

3.7 FIELD QUALITY CONTROL

3.7.1 Test Procedures

Submit detailed test procedures, prepared and signed by the NICET Level III Fire Sprinkler Technician, and the representative of the installing company, and reviewed by the QFPE 60 days prior to performing system tests. Detailed test procedures must list all components of the installed system. Test procedures must include sequence of testing, time estimate for each test, and sample test data forms. The test data forms must be in a check-off format (pass/fail with space to add applicable test data; similar to the forms in NFPA 13 .) The test procedures and accompanying test data forms must be used for the pre-Government testing and the Government final testing.

- a. Provide space to identify the date and time of each test. Provide space to identify the names and signatures of the individuals conducting and witnessing each test.

3.7.2 Pre-Government Testing

3.7.2.1 Verification of Compliant Installation

Conduct inspections and tests to ensure that equipment is functioning properly. Tests must meet the requirements of paragraph entitled "Minimum System Tests" and "System Acceptance" as noted in NFPA 13. The Contractor and QFPE must be in attendance at the pre-Government testing to make necessary adjustments. After inspection and testing is complete, provide a signed Verification of Compliant Installation letter by the QFPE that the installation is complete, compliant with the specification and fully operable. The letter must include the names and titles of the witnesses to the pre-Government tests. Provide all completion documentation as required by NFPA 13 and the test reports noted below.

- a. NFPA 13 Aboveground Material and Test Certificate
- b. NFPA 13 Underground Material and Test Certificate

3.7.2.2 Request for Government Final Test

When the verification of compliant installation has been completed, submit a formal request for Government final test to the Designated Fire Protection Engineer (DFPE). Government final testing will not be scheduled until the DFPE has received copies of the request for Government final testing and Verification of Compliant Installation letter with all required reports. Government final testing will not be performed until after the connections to the building fire alarm system have been completed and tested to confirm communications are fully functional. Submit request for test at least 15 calendar days prior to the requested test date.

3.7.3 Correction of Deficiencies

If equipment was found to be defective or non-compliant with contract requirements, perform corrective actions and repeat the tests. Tests must be conducted and repeated if necessary until the system has been demonstrated to comply with all contract requirements.

3.7.4 Government Final Tests

The tests must be performed in accordance with the approved test procedures in the presence of the DFPE. Furnish instruments and personnel required for the tests. The following must be provided at the job site for Government Final Testing:

- a. The manufacturer's technical representative.
- b. The contractor's Qualified Fire Protection Engineer (QFPE).
- c. Marked-up red line drawings of the system as actually installed.

Government Final Tests will be witnessed by the , Designated Fire Protection Engineer Contracting Officer, Qualified Fire Protection Engineer (QFPE). At this time, all required tests noted in the paragraph "Minimum System Tests" must be repeated at their discretion.

3.8 MINIMUM SYSTEM TESTS

The system, including the underground water mains, and the aboveground piping and system components, must be tested to ensure that equipment and components function as intended. The underground and aboveground interior piping systems and attached appurtenances subjected to system working pressure must be tested in accordance with NFPA 13 and NFPA 24.

3.8.1 Underground Piping

3.8.1.1 Flushing

Underground piping must be flushed at a minimum of 10 fps in accordance with NFPA 24.

3.8.1.2 Hydrostatic Test

New underground piping must be hydrostatically tested in accordance with NFPA 24.

3.8.2 Aboveground Piping

3.8.2.1 Hydrostatic Test

Aboveground piping must be hydrostatically tested in accordance with NFPA 13. There must be no drop in gauge pressure or visible leakage when the system is subjected to the hydrostatic test. The test pressure must be read from a gauge located at the low elevation point of the system or portion being tested.

3.8.2.2 Backflow Prevention Assembly Forward Flow Test

Each backflow prevention assembly must be tested at system flow demand, including all applicable hose streams, as specified in NFPA 13. The Contractor must provide all equipment and instruments necessary to conduct a complete forward flow test, including 2.5-inch diameter hoses, playpipe nozzles or flow diffusers, calibrated pressure gauges, and pitot tube gauge. The Contractor must provide all necessary supports to safely secure hoses and nozzles during the test. At the system demand flow, the pressure readings and pressure drop (friction loss) across the assembly must be recorded. A metal placard must be provided on the backflow prevention assembly that lists the pressure readings both upstream and downstream of the assembly, total pressure drop, and the system test flow rate determined during the preliminary testing. The pressure drop must be compared to the manufacturer's data and the readings observed during the final inspections and tests.

3.8.3 Main Drain Flow Test

Following flushing of the underground piping, a main drain test must be made to verify the adequacy of the water supply. Static and residual pressures must be recorded on the certificate specified in paragraph SUBMITTALS.

3.9 SYSTEM ACCEPTANCE

Following acceptance of the system, as-built drawings and O&M manuals must be delivered to the Contracting Officer for review and acceptance. Submit six sets of detailed as-built drawings. The drawings must show the system

as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final acceptance test of the system. At least one set of as-built (marked-up) drawings must be provided at the time of, or prior to the final acceptance test.

- a. Provide one set of full size paper as-built drawings and schematics. The drawings must be prepared electronically and sized no less than the contract drawings. Furnish one set of CDs or DVDs containing software back-up and CAD based drawings in latest version of AutoCAD, DXF and portable document formats of as-built drawings and schematics.
- b. Provide [operating and maintenance \(O&M\) instructions](#).

3.10 ONSITE TRAINING

Conduct a training course for the responding fire department and operating and maintenance personnel as designated by the Contracting Officer. Training must be performed on two separate days (to accommodate different shifts of Fire Department personnel) for a period of 4 hours of normal working time and must start after the system is functionally complete and after the final acceptance test. The on-site training must cover all of the items contained in the approved Operating and Maintenance Instructions.

-- End of Section --

SECTION 22 00 00

PLUMBING, GENERAL PURPOSE
11/15

PART 1 GENERAL

1.1 REFERENCES

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

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 1010 (2002) Self-Contained, Mechanically Refrigerated Drinking-Water Coolers

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.10.1/CSA 4.1 (2019) Gas Water Heaters Vol. I, Storage Water Heaters with Input Ratings of 75,000 Btu Per Hour or Less

ANSI Z21.10.3/CSA 4.3 (2019) Gas-Fired Water Heaters Vol.III, Storage Water Heaters With Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous

ANSI Z21.22/CSA 4.4 (2015; R 2020) Relief Valves for Hot Water Supply Systems

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

ASHRAE 90.1 - IP (2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

ASME INTERNATIONAL (ASME)

ASME A112.1.2 (2012; R 2017) Air Gaps in Plumbing Systems (For Plumbing Fixtures and Water-Connected Receptors)

ASME A112.6.1M (1997; R 2017) Floor Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use

ASME A112.6.3 (2019) Standard for Floor and Trench Drains

ASME A112.14.1 (2003; R 2017) Backwater Valves

ASME A112.19.2/CSA B45.1 (2018; ERTA 2018) Standard for Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals

ASME A112.19.3/CSA B45.4 (2017; Errata 2017) Stainless Steel Plumbing Fixtures

ASME A112.19.5	(2017) Flush Valves and Spuds for Water Closets, Urinals, and Tanks
ASME A112.36.2M	(1991; R 2017) Cleanouts
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2018) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2016) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.24	(2016) Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B16.50	(2013) Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings
ASME B31.1	(2020) Power Piping
ASME B31.5	(2020) Refrigeration Piping and Heat Transfer Components
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IV	(2017) BPVC Section IV-Rules for Construction of Heating Boilers
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME CSD-1	(2016) Control and Safety Devices for Automatically Fired Boilers

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1001	(2016) Performance Requirements for Atmospheric Type Vacuum Breakers
ASSE 1003	(2009) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)
ASSE 1010	(2004) Performance Requirements for Water Hammer Arresters (ANSI approved 2004)
ASSE 1011	(2004; Errata 2004) Performance Requirements for Hose Connection Vacuum Breakers (ANSI approved 2004)
ASSE 1012	(2009) Performance Requirements for Backflow Preventer with an Intermediate Atmospheric Vent - (ANSI approved 2009)
ASSE 1013	(2011) Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers - (ANSI approved 2010)
ASSE 1018	(2001) Performance Requirements for Trap Seal Primer Valves - Potable Water Supplied (ANSI Approved 2002)
ASSE 1019	(2011; R 2016) Performance Requirements for Wall Hydrant with Backflow Protection and Freeze Resistance
ASSE 1020	(2020) Performance Requirements for Pressure Vacuum Breaker Assemblies
ASSE 1037	(2015; R 2020) Performance Requirements for Pressurized Flushing Devices for Plumbing Fixtures

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2017) Standard Methods for the Examination of Water and Wastewater
AWWA B300	(2018) Hypochlorites
AWWA B301	(2010) Liquid Chlorine
AWWA C203	(2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C606	(2015) Grooved and Shouldered Joints
AWWA C651	(2014) Standard for Disinfecting Water Mains

AWWA C652	(2019) Disinfection of Water-Storage Facilities
AWWA D100	(2011) Welded Steel Tanks for Water Storage
AMERICAN WELDING SOCIETY (AWS)	
AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.2/B2.2M	(2016) Specification for Brazing Procedure and Performance Qualification
ASTM INTERNATIONAL (ASTM)	
ASTM A74	(20207) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM A105/A105M	(2018) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A515/A515M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A733	(2016) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM A888	(2020) Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B42	(2020) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM B370	(2012; R 2019) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM B584	(2014) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM B828	(2016) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM C564	(2020a) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics
ASTM D1004	(2013) Initial Tear Resistance of Plastic Film and Sheeting
ASTM D2235	(2004; R 2016) Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2657	(2007; R 2015) Heat Fusion Joining Polyolefin Pipe and Fittings
ASTM D2665	(2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D2822/D2822M	(2005; R 2011; E 2011) Standard Specification for Asphalt Roof Cement, Asbestos-Containing
ASTM D2855	(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3138	(2004; R 2016) Standard Specification for Solvent Cements for Transition Joints Between Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Non-Pressure Piping Components

ASTM D3139	(2019) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3212	(2007; R 2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3311	(2017) Standard Specification for Drain, Waste, and Vent (DWV) Plastic Fittings Patterns
ASTM D4551	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM E96/E96M	(2016) Standard Test Methods for Water Vapor Transmission of Materials
ASTM F409	(2017) Standard Specification for Thermoplastic Accessible and Replaceable Plastic Tube and Tubular Fittings
ASTM F477	(2014) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F493	(2020) Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
ASTM F891	(2016) Standard Specification for Coextruded Poly (Vinyl Chloride) (PVC) Plastic Pipe with a Cellular Core
ASTM F1290	(2019) Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings
ASTM F1760	(2016; R 2020) Standard Specification for Coextruded Poly(Vinyl Chloride) (PVC) Non-Pressure Plastic Pipe Having Reprocessed-Recycled Content
ASTM F2389	(2019) Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

CAST IRON SOIL PIPE INSTITUTE (CISPI)

CISPI 301	(2018) Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
CISPI 310	(2012) Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings

for Sanitary and Storm Drain, Waste, and
Vent Piping Applications

COPPER DEVELOPMENT ASSOCIATION (CDA)

CDA A4015 (2016; 14/17) Copper Tube Handbook

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1 COMM (2017) Standard And Commentary Accessible
and Usable Buildings and Facilities

ICC IPC (2018) International Plumbing Code

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS
INDUSTRY (MSS)

MSS SP-25 (2018) Standard Marking System for Valves,
Fittings, Flanges and Unions

MSS SP-58 (2018) Pipe Hangers and Supports -
Materials, Design and Manufacture,
Selection, Application, and Installation

MSS SP-67 (2017; Errata 1 2017) Butterfly Valves

MSS SP-70 (2011) Gray Iron Gate Valves, Flanged and
Threaded Ends

MSS SP-71 (2018) Gray Iron Swing Check Valves,
Flanged and Threaded Ends

MSS SP-72 (2010a) Ball Valves with Flanged or
Butt-Welding Ends for General Service

MSS SP-78 (2011) Cast Iron Plug Valves, Flanged and
Threaded Ends

MSS SP-80 (2019) Bronze Gate, Globe, Angle and Check
Valves

MSS SP-83 (2014) Class 3000 Steel Pipe Unions Socket
Welding and Threaded

MSS SP-85 (2011) Gray Iron Globe & Angle Valves
Flanged and Threaded Ends

MSS SP-110 (2010) Ball Valves Threaded,
Socket-Welding, Solder Joint, Grooved and
Flared Ends

NACE INTERNATIONAL (NACE)

NACE SP0169 (2013) Control of External Corrosion on
Underground or Submerged Metallic Piping
Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- NEMA 250 (2018) Enclosures for Electrical Equipment
(1000 Volts Maximum)
- NEMA MG 1 (2018) Motors and Generators
- NEMA MG 11 (1977; R 2012) Energy Management Guide for
Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 31 (2020) Standard for the Installation of
Oil-Burning Equipment
- NFPA 54 (2021) National Fuel Gas Code
- NFPA 90A (2021) Standard for the Installation of
Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

- NSF 372 (2016) Drinking Water System Components -
Lead Content
- NSF/ANSI 14 (2019) Plastics Piping System Components
and Related Materials
- NSF/ANSI 61 (2020) Drinking Water System Components -
Health Effects

PLASTIC PIPE AND FITTINGS ASSOCIATION (PPFA)

- PPFA Fire Man (2016) Firestopping: Plastic Pipe in Fire
Resistive Construction

PLUMBING AND DRAINAGE INSTITUTE (PDI)

- PDI WH 201 (2010) Water Hammer Arresters Standard

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

- SAE J1508 (2009) Hose Clamp Specifications

U.S. DEPARTMENT OF ENERGY (DOE)

- Energy Star (1992; R 2006) Energy Star Energy
Efficiency Labeling System (FEMP)

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

- PL 93-523 (1974; A 1999) Safe Drinking Water Act

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

- 10 CFR 430 Energy Conservation Program for Consumer
Products
- 21 CFR 175 Indirect Food Additives: Adhesives and

Components of Coatings

40 CFR 141.80

National Primary Drinking Water
Regulations; Control of Lead and Copper;
General Requirements

UNDERWRITERS LABORATORIES (UL)

UL 1951

(2011; Reprint Jun 2020) UL Standard for
Safety Electric Plumbing Accessories

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 10.05 20 DESIGN SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Plumbing System;

Detail drawings consisting of schedules, performance charts, instructions, diagrams, and other information to illustrate the requirements and operations of systems that are not covered by the Plumbing Code. Detail drawings for the complete plumbing system including piping layouts and locations of connections; dimensions for roughing-in, foundation, and support points; schematic diagrams and wiring diagrams or connection and interconnection diagrams. Detail drawings shall indicate clearances required for maintenance and operation. Where piping and equipment are to be supported other than as indicated, details shall include loadings and proposed support methods. Mechanical drawing plans, elevations, views, and details, shall be drawn to scale.

SD-03 Product Data

Recycled Content for Steel Pipe; S

Fixtures

List of installed fixtures with manufacturer, model, and flow rate.

Flush Valve Water Closets

WaterSense Label for Flush Valve Water Closet; S

Flush Valve Urinals

WaterSense Label for Urinal; S

Wall Hung Lavatories

Countertop Lavatories

WaterSense Label for Lavatory Faucet; S

Kitchen Sinks

Drinking-Water Coolers;

Energy Star Label for Electric Water Cooler; S

Energy Star Label for Wheelchair Electric Water Cooler; S

WaterSense Label for Showerhead; S

Water Heaters; G

Energy Star Label for Gas Storage Water Heater; S

Pumps; G

Backflow Prevention Assemblies; G

Shower Faucets;

Welding

A copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators.

Vibration-Absorbing Features;

Details of vibration-absorbing features, including arrangement, foundation plan, dimensions and specifications.

Plumbing System

Diagrams, instructions, and other sheets proposed for posting. Manufacturer's recommendations for the installation of bell and spigot and hubless joints for cast iron soil pipe.

SD-06 Test Reports

Tests, Flushing and Disinfection

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, completion and testing of the installed system. Each test report shall indicate the final position of controls.

Test of Backflow Prevention Assemblies;

Certification of proper operation shall be as accomplished in accordance with state regulations by an individual certified by the state to perform such tests. If no state requirement exists, the Contractor shall have the manufacturer's representative test the device, to ensure the unit is properly installed and performing as intended. The Contractor shall provide written documentation of the tests performed and signed by the individual performing the tests.

SD-07 Certificates

Materials and Equipment

Where equipment is specified to conform to requirements of the ASME Boiler and Pressure Vessel Code, the design, fabrication, and installation shall conform to the code.

Bolts

Written certification by the bolt manufacturer that the bolts furnished comply with the specified requirements.

SD-10 Operation and Maintenance Data

Plumbing System;

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.3 STANDARD PRODUCTS

Specified materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products. Specified equipment shall essentially duplicate equipment that has performed satisfactorily at least two years prior to bid opening. Standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.3.1 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.3.2 Service Support

The equipment items shall be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3.3 Manufacturer's Nameplate

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

1.3.4 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been

substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.3.4.1 Definitions

For the International Code Council (ICC) 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" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.3.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.5 PERFORMANCE REQUIREMENTS

1.5.1 Welding

Piping shall be welded in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer, may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests, and the tests shall be performed at the work site if practicable. Welders or welding operators shall apply their assigned symbols near each weld they make as a permanent record. Structural members shall be welded in accordance with Section 05 12 00 STRUCTURAL STEEL. .

1.6 REGULATORY REQUIREMENTS

Unless otherwise required herein, plumbing work shall be in accordance with ICC IPC.

1.7 PROJECT/SITE CONDITIONS

The Contractor shall become familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.8 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.9 ACCESSIBILITY OF EQUIPMENT

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

2.1 MATERIALS

Materials for various services shall be in accordance with TABLES I and II. Cement pipe shall contain recycled content as specified in Section 03 47 13 TILT-UP CONCRETE. Steel pipe shall contain a minimum of 25 percent recycled content, with a minimum of 16 percent post-consumer recycled content. Provide data identifying percentage of recycled content for steel pipe. Pipe schedules shall be selected based on service requirements. Pipe fittings shall be compatible with the applicable pipe materials. Plastic pipe, fittings, and solvent cement shall meet NSF/ANSI 14 and shall be NSF listed for the service intended. Plastic pipe, fittings, and solvent cement used for potable hot and cold water service shall bear the NSF seal "NSF-PW." Polypropylene pipe and fittings shall conform to dimensional requirements of Schedule 40, Iron Pipe size and shall comply with NSF/ANSI 14, NSF/ANSI 61 and ASTM F2389. Polypropylene piping that will be exposed to UV light shall be provided with a Factory applied UV resistant coating. Pipe threads (except dry seal) shall conform to ASME B1.20.1. Grooved pipe couplings and fittings shall be from the same manufacturer. 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, Annex G or NSF 372. In line devices such as water meters, building valves, check valves, meter stops, valves, fittings and back flow preventers shall comply with PL 93-523 and NSF/ANSI 61, Section 8. End point devices such as drinking water fountains, lavatory faucets, kitchen and bar faucets, residential ice makers, supply stops and end point control valves used to dispense water for drinking must meet the requirements of NSF/ANSI 61, Section 9.

Hubless cast-iron soil pipe shall not be installed underground, under concrete floor slabs, or in crawl spaces below kitchen floors. Plastic pipe shall not be installed in air plenums. Plastic pipe shall not be installed in a pressure piping system in buildings greater than three stories including any basement levels.

2.1.1 Pipe Joint Materials

Grooved pipe and hubless cast-iron soil pipe shall not be used underground. Solder containing lead shall not be used with copper pipe. Cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Institute. Joints and gasket materials shall conform to the following:

- a. Coupling for Cast-Iron Pipe: for hub and spigot type [ASTM A74](#), [AWWA C606](#). For hubless type: [CISPI 310](#)
- b. Coupling for Steel Pipe: [AWWA C606](#).
- d. Flange Gaskets: Gaskets shall be made of non-asbestos material in accordance with [ASME B16.21](#). Gaskets shall be flat, 1/16 inch thick, and contain Aramid fibers bonded with Styrene Butadiene Rubber (SBR) or Nitro Butadiene Rubber (NBR). Gaskets shall be the full face or self centering flat ring type. Gaskets used for hydrocarbon service shall be bonded with NBR.
- e. Brazing Material: Brazing material shall conform to [AWS A5.8/A5.8M](#), BCuP-5.
- f. Brazing Flux: Flux shall be in paste or liquid form appropriate for use with brazing material. Flux shall be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides; and contain fluorides.
- g. Solder Material: Solder metal shall conform to [ASTM B32](#).
- h. Solder Flux: Flux shall be liquid form, non-corrosive, and conform to [ASTM B813](#), Standard Test 1.
- i. PTFE Tape: PTFE Tape, for use with Threaded Metal or Plastic Pipe.
- j. Rubber Gaskets for Cast-Iron Soil-Pipe and Fittings (hub and spigot type and hubless type): [ASTM C564](#).
- l. Flexible Elastomeric Seals: [ASTM D3139](#), [ASTM D3212](#) or [ASTM F477](#).
- n. Solvent Cement for Transition Joints between ABS and PVC Nonpressure Piping Components: [ASTM D3138](#).
- o. Plastic Solvent Cement for ABS Plastic Pipe: [ASTM D2235](#).
- p. Plastic Solvent Cement for PVC Plastic Pipe: [ASTM D2564](#) and [ASTM D2855](#).

- q. Plastic Solvent Cement for CPVC Plastic Pipe: **ASTM F493**.
- r. Flanged fittings including, but not limited to, flanges, bolts, nuts and bolt patterns shall be in accordance with **ASME B16.5** class 150 and shall have the manufacturer's trademark affixed in accordance with **MSS SP-25**. Flange material shall conform to **ASTM A105/A105M**. Blind flange material shall conform to **ASTM A516/A516M** cold service and **ASTM A515/A515M** for hot service. Bolts shall be high strength or intermediate strength with material conforming to **ASTM A193/A193M**.
- u. Copper tubing shall conform to **ASTM B88**, Type K, L or M.
- v. Heat-fusion joints for polypropylene piping: **ASTM F2389**.

2.1.2 Miscellaneous Materials

Miscellaneous materials shall conform to the following:

- a. Water Hammer Arrestor: **PDI WH 201**. Water hammer arrester shall be diaphragm or piston type.
- b. Copper, Sheet and Strip for Building Construction: **ASTM B370**.
- c. Asphalt Roof Cement: **ASTM D2822/D2822M**.
- d. Hose Clamps: **SAE J1508**.
- e. Supports for Off-The-Floor Plumbing Fixtures: **ASME A112.6.1M**.
- f. Metallic Cleanouts: **ASME A112.36.2M**.
- g. Plumbing Fixture Setting Compound: A preformed flexible ring seal molded from hydrocarbon wax material. The seal material shall be nonvolatile nonasphaltic and contain germicide and provide watertight, gastight, odorproof and verminproof properties.
- h. Coal-Tar Protective Coatings and Linings for Steel Water Pipelines: **AWWA C203**.
- i. Hypochlorites: **AWWA B300**.
- j. Liquid Chlorine: **AWWA B301**.
- k. Gauges - Pressure and Vacuum Indicating Dial Type - Elastic Element: **ASME B40.100**.
- l. Thermometers: **ASTM E1**. Mercury shall not be used in thermometers.

2.1.3 Pipe Insulation Material

Insulation shall be as specified in Section **23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS**.

2.2 PIPE HANGERS, INSERTS, AND SUPPORTS

Pipe hangers, inserts, and supports shall conform to **MSS SP-58**.

2.3 VALVES

Valves shall be provided on supplies to equipment and fixtures. Valves 2-1/2 inches and smaller shall be bronze with threaded bodies for pipe and solder-type connections for tubing. Valves 3 inches and larger shall have flanged iron bodies and bronze trim. Pressure ratings shall be based upon the application. Valves shall conform to the following standards:

Description	Standard
Butterfly Valves	MSS SP-67
Cast-Iron Gate Valves, Flanged and Threaded Ends	MSS SP-70
Cast-Iron Swing Check Valves, Flanged and Threaded Ends	MSS SP-71
Ball Valves with Flanged Butt-Welding Ends for General Service	MSS SP-72
Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends	MSS SP-110
Cast-Iron Plug Valves, Flanged and Threaded Ends	MSS SP-78
Bronze Gate, Globe, Angle, and Check Valves	MSS SP-80
Steel Valves, Socket Welding and Threaded Ends	ASME B16.34
Cast-Iron Globe and Angle Valves, Flanged and Threaded Ends	MSS SP-85
Backwater Valves	ASME A112.14.1
Vacuum Relief Valves	ANSI Z21.22/CSA 4.4
Water Pressure Reducing Valves	ASSE 1003
Water Heater Drain Valves	ASME BPVC SEC IV, Part HLW-810: Requirements for Potable-Water Heaters Bottom Drain Valve
Trap Seal Primer Valves	ASSE 1018

Temperature and Pressure Relief Valves for Hot Water Supply Systems	ANSI Z21.22/CSA 4.4
Temperature and Pressure Relief Valves for Automatically Fired Hot Water Boilers	ASME CSD-1 Safety Code No., Part CW, Article 5

2.3.1 Wall Faucets

Wall faucets with vacuum-breaker backflow preventer shall be brass with 3/4 inch male inlet threads, hexagon shoulder, and 3/4 inch hose connection. Faucet handle shall be securely attached to stem.

2.3.2 Wall Hydrants (Frostproof)

ASSE 1019 with vacuum-breaker backflow preventer shall have a nickel-brass or nickel-bronze wall plate or flange with nozzle and detachable key handle. A brass or bronze operating rod shall be provided within a galvanized iron casing of sufficient length to extend through the wall so that the valve is inside the building, and the portion of the hydrant between the outlet and valve is self-draining. A brass or bronze valve with coupling and union elbow having metal-to-metal seat shall be provided. Valve rod and seat washer shall be removable through the face of the hydrant. The hydrant shall have 3/4 inch exposed hose thread on spout and 3/4 inch male pipe thread on inlet.

2.3.3 Yard Hydrants

Yard box or post hydrants shall have valve housings located below frost lines. Water from the casing shall be drained after valve is shut off. Hydrant shall be bronze with cast-iron box or casing guard. "T" handle key shall be provided.

2.3.4 Relief Valves

Water heaters and hot water storage tanks shall have a combination pressure and temperature (P&T) relief valve. The pressure relief element of a P&T relief valve shall have adequate capacity to prevent excessive pressure buildup in the system when the system is operating at the maximum rate of heat input. The temperature element of a P&T relief valve shall have a relieving capacity which is at least equal to the total input of the heaters when operating at their maximum capacity. Relief valves shall be rated according to ANSI Z21.22/CSA 4.4. Relief valves for systems where the maximum rate of heat input is less than 200,000 Btuh shall have 3/4 inch minimum inlets, and 3/4 inch outlets. Relief valves for systems where the maximum rate of heat input is greater than 200,000 Btuh shall have 1 inch minimum inlets, and 1 inch outlets. The discharge pipe from the relief valve shall be the size of the valve outlet.

2.3.5 Thermostatic Mixing Valves

Provide thermostatic mixing valve for lavatory faucets. Mixing valves, thermostatic type, pressure-balanced or combination thermostatic and pressure-balanced shall be line size and shall be constructed with rough or finish bodies either with or without plating. Each valve shall be constructed to control the mixing of hot and cold water and to deliver

water at a desired temperature regardless of pressure or input temperature changes. The control element shall be of an approved type. The body shall be of heavy cast bronze, and interior parts shall be brass, bronze, corrosion-resisting steel or copper. The valve shall be equipped with necessary stops, check valves, unions, and sediment strainers on the inlets. Mixing valves shall maintain water temperature within 5 degrees F of any setting.

2.4 FIXTURES

Water closet replacements in major renovations may have a flush valve of up to 1.6 GPF to accommodate existing plumbing capacity. Fixtures for use by the physically handicapped shall be in accordance with ICC A117.1 COMM. Vitreous China, nonabsorbent, hard-burned, and vitrified throughout the body shall be provided. Porcelain enameled ware shall have specially selected, clear white, acid-resisting enamel coating evenly applied on surfaces. No fixture will be accepted that shows cracks, crazes, blisters, thin spots, or other flaws. Fixtures shall be equipped with appurtenances such as traps, faucets, stop valves, and drain fittings. Each fixture and piece of equipment requiring connections to the drainage system, except grease interceptors, shall be equipped with a trap. Brass expansion or toggle bolts capped with acorn nuts shall be provided for supports, and polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Fixtures with the supply discharge below the rim shall be equipped with backflow preventers. Internal parts of flush valves and flushometer valves, shower mixing valves, shower head face plates, pop-up stoppers of lavatory waste drains, and pop-up stoppers and overflow tees and shoes of bathtub waste drains may contain acetal resin, fluorocarbon, nylon, acrylonitrile-butadiene-styrene (ABS) or other plastic material, if the material has provided satisfactory service under actual commercial or industrial operating conditions for not less than 2 years. Plastic in contact with hot water shall be suitable for 180 degrees F water temperature.

2.4.1 Lavatories

Provide WaterSense labeled faucet with a maximum flow rate of 0.5 gpm at a flowing pressure of 60 psi. Water volume must be limited to 0.25 gal per metering cycle. Provide data identifying WaterSense label for lavatory faucet.

2.4.2 Automatic Controls

Provide automatic, sensor operated faucets and flush valves to comply with ASSE 1037 and UL 1951 for lavatory faucets, urinals, and water closets. Flushing and faucet systems shall consist of solenoid-activated valves with light beam sensors. Flush valve for water closet shall include an override pushbutton. Flushing devices shall be provided as described in paragraph FIXTURES AND FIXTURE TRIMMINGS.

2.4.3 Flush Valve Water Closets

ASME A112.19.2/CSA B45.1, white vitreous china, siphon jet, elongated bowl, floor-mounted, floor outlet. Top of toilet seat height above floor shall be 14 to 15 inches, except 17 to 19 inches for wheelchair water closets. Provide wax bowl ring including plastic sleeve. Provide white solid plastic elongated open-front seat.

Water flushing volume of the water closet and flush valve combination shall not exceed 1.28 gallons per flush. Water closets must meet the EPA WaterSense product definition specified in http://www.epa.gov/watersense/partners/product_program_specs.html and must be EPA WaterSense labeled products. Provide data identifying WaterSense label for flush valve water closet.

Provide large diameter flush valve including angle control-stop valve, vacuum breaker, tail pieces, slip nuts, and wall plates; exposed to view components shall be chromium-plated or polished stainless steel. Flush valves shall be nonhold-open type. Mount flush valves not less than 11 inches above the fixture. Mounted height of flush valve shall not interfere with the hand rail in ADA stalls. Provide solenoid-activated flush valves including electrical-operated light-beam-sensor to energize the solenoid.

2.4.4 Flush Valve Urinals

ASME A112.19.2/CSA B45.1, white vitreous china, wall-mounted, wall outlet, siphon jet, integral trap, and extended side shields. Provide urinal with the rim 17 inches above the floor. Provide urinal with the rim 24 inches above the floor. Water flushing volume of the urinal and flush valve combination shall not exceed 0.5 gallons per flush. Urinals must meet the specifications of http://www.epa.gov/watersense/partners/product_program_specs.html and must be EPA WaterSense labeled products. Provide data identifying WaterSense label for urinal. Provide ASME A112.6.1M concealed chair carriers with vertical steel pipe supports. Provide large diameter flush valve including angle control-stop valve, vacuum breaker, tail pieces, slip nuts, and wall plates; exposed to view components shall be chromium-plated or polished stainless steel. Flush valves shall be nonhold-open type. Mount flush valves not less than 11 inches above the fixture. Provide solenoid-activated flush valves including electrical-operated light-beam-sensor to energize the solenoid.

2.4.5 Wheelchair Flush Valve Type Urinals

ASME A112.19.2/CSA B45.1, white vitreous china, wall-mounted, wall outlet, blowout action, integral trap, elongated projecting bowl, 20 inches long from wall to front of flare, and ASME A112.19.5 trim. Provide large diaphragm (not less than 2.625 inches upper chamber inside diameter at the point where the diaphragm is sealed between the upper and lower chambers), nonhold-open flush valve of chrome plated cast brass conforming to ASTM B584, including vacuum breaker and angle (control-stop) valve with back check. The water flushing volume of the flush valve and urinal combination shall not exceed 0.5 gallon per flush. Urinals must meet the specifications of http://www.epa.gov/watersense/partners/product_program_specs.html and must be EPA WaterSense labeled products. Provide data identifying WaterSense label for wheelchair flush valve urinal. Furnish urinal manufacturer's certification of conformance. Provide ASME A112.6.1M concealed chair carriers. Mount urinal with front rim a maximum of 17 inches above floor and flush valve handle a maximum of 44 inches above floor for use by handicapped on wheelchair. Provide solenoid-activated flush valves including electrical-operated light-beam-sensor to energize the solenoid.

2.4.6 Wall Hung Lavatories

ASME A112.19.2/CSA B45.1, white vitreous china, ,straight back type,

minimum dimensions of 19 inches, wide by 17 inches front to rear, with supply openings for use with top mounted centerset faucets, and openings for concealed arm carrier installation. Provide aerator with faucet. Provide lavatory faucets and accessories meeting the flow rate and product requirements of the paragraph LAVATORIES. Provide ASME A112.6.1M concealed chair carriers with vertical steel pipe supports and concealed arms for the lavatory. Mount lavatory with the front rim 34 inches above floor and with 29 inches minimum clearance from bottom of the front rim to floor. Provide top-mounted solenoid-activated lavatory faucets including electrical-operated light-beam-sensor to energize the solenoid.

2.4.7 Countertop Lavatories

Solid Surface lavatories shall be in accordance with Section 06 61 16 SOLID SURFACING FABRICATIONS. Supply openings for use with top mounted centerset faucets. Furnish template and mounting kit by lavatory manufacturer. Provide aerator with faucet. Provide lavatory faucets and accessories meeting the flow rate and product requirements of the paragraph LAVATORIES. Mount counter with the top surface 34 inches above floor and with 29 inches minimum clearance from bottom of the counter face to floor. Provide top-mounted solenoid-activated lavatory faucets including electrical-operated light-beam-sensor to energize the solenoid.

2.4.8 Kitchen Sinks

ASME A112.19.3/CSA B45.4, 20 gage stainless steel with integral mounting rim for flush installation, minimum dimensions of 33 inches wide by 21 inches front to rear, two compartments, with undersides fully sound deadened, with supply openings for use with top mounted washerless sink faucets with hose spray, and with 3.5 inch drain outlet. Provide aerator with faucet. Water flow rate shall not exceed 2.2 gpm when measured at a flowing water pressure of 60 psi. Provide stainless steel drain outlets and stainless steel cup strainers. Provide separate 1.5 inch P-trap and drain piping to vertical vent piping from each compartment. Provide top mounted washerless sink faucets with hose spray.

2.4.9 Drinking-Water Coolers

AHRI 1010 with more than a single thickness of metal between the potable water and the refrigerant in the heat exchanger, wall-hung, bubbler style, air-cooled condensing unit, 4.75 gph minimum capacity, stainless steel splash receptor and basin, bottle filler and stainless steel cabinet. Bubblers shall be controlled by push levers or push bars, front mounted or side mounted near the front edge of the cabinet. Bubbler spouts shall be mounted at maximum of 36 inches above floor and at front of unit basin. Spouts shall direct water flow at least 4 inches above unit basin and trajectory parallel or nearly parallel to the front of unit. Provide filters for chlorine in supply piping to faucets. Provide ASME A112.6.1M concealed steel pipe chair carriers. Provide electric water cooler that is Energy Star labeled. Provide data identifying Energy Star label for electric water cooler.

2.4.10 Wheelchair Drinking Water cooler

AHRI 1010, wall-mounted bubbler style with ASME A112.6.1M concealed chair carrier, air-cooled condensing unit, 4.75 gph minimum capacity, stainless steel splash receptor, and all stainless steel cabinet, with 27 inch minimum knee clearance from front bottom of unit to floor and 36 inch maximum spout height above floor and bottle filler. Bubblers shall also

be controlled by push levers, by push bars, or touch pads one on each side or one on front and both sides of the cabinet. Provide filters for chlorine in supply piping to faucets. Provide electric water cooler that is Energy Star labeled. Provide data identifying Energy Star label for wheelchair electric water cooler.

2.4.11 Solid Surface Shower Stalls

Solid Surface shower walls and base shall be in accordance with Section 06 61 16 SOLID SURFACING FABRICATIONS. Provide showerheads meeting the requirements of the paragraph BATHTUB AND SHOWER FAUCETS AND DRAIN FITTINGS. Provide flow restrictor in handshower to flow 1.75 gpm. Provide recessed type shower stalls, dimensions as indicated on the drawings, with shower stall bottom or feet firmly supported by a smooth level floor. Provide PVC shower floor drains and stainless steel strainers. Install shower stall in accordance with the manufacturer's written instructions. Provide smooth 100 percent silicone rubber white bathtub caulk between the top, sides, and bottom of shower stalls and bathroom walls and floors.

2.4.12 Precast Terrazzo Mop Sinks

Terrazzo shall be made of marble chips cast in white portland cement to produce 3000 psi minimum compressive strength 7 days after casting. Provide floor or wall outlet copper alloy body drain cast integral with terrazzo, with polished stainless steel strainers.

2.5 BACKFLOW PREVENTERS

Backflow prevention devices must be approved by the State or local regulatory agencies. If there is no State or local regulatory agency requirements, the backflow prevention devices must be listed by the Foundation for Cross-Connection Control & Hydraulic Research, or any other approved testing laboratory having equivalent capabilities for both laboratory and field evaluation of backflow prevention devices and assemblies.

Reduced pressure principle assemblies, double check valve assemblies, atmospheric (nonpressure) type vacuum breakers, and pressure type vacuum breakers shall be meet the above requirements.

Backflow preventers with intermediate atmospheric vent shall conform to ASSE 1012. Reduced pressure principle backflow preventers shall conform to ASSE 1013. Hose connection vacuum breakers shall conform to ASSE 1011. Pipe applied atmospheric type vacuum breakers shall conform to ASSE 1001. Pressure vacuum breaker assembly shall conform to ASSE 1020. Air gaps in plumbing systems shall conform to ASME A112.1.2.

2.6 DRAINS

2.6.1 Floor and Shower Drains

Floor and shower drains shall consist of a galvanized body, integral seepage pan, and adjustable perforated or slotted chromium-plated bronze, nickel-bronze, or nickel-brass strainer, consisting of grate and threaded collar. Floor drains shall be cast iron except where metallic waterproofing membrane is installed. Drains shall be of double drainage pattern for embedding in the floor construction. The seepage pan shall have weep holes or channels for drainage to the drainpipe. The strainer

shall be adjustable to floor thickness. A clamping device for attaching flashing or waterproofing membrane to the seepage pan without damaging the flashing or waterproofing membrane shall be provided when required. Drains shall be provided with threaded connection. Between the drain outlet and waste pipe, a neoprene rubber gasket conforming to [ASTM C564](#) may be installed, provided that the drain is specifically designed for the rubber gasket compression type joint. Floor and shower drains shall conform to [ASME A112.6.3](#). Provide drain with trap primer connection, trap primer, and connection piping. Primer shall meet [ASSE 1018](#).

2.6.1.1 Drains and Backwater Valves

Drains and backwater valves installed in connection with waterproofed floors or shower pans shall be equipped with bolted-type device to securely clamp flashing.

2.6.2 Shower Faucets and Drain Fittings

Provide single control pressure equalizing shower faucets with body mounted from behind the wall with threaded connections. Provide [stainless steel institutional bracket](#). Provide [stationary](#) shower heads. Provide WaterSense labeled showerhead with a maximum flow rate of (1.75 gpm). Provide data identifying [WaterSense label for showerhead](#). Provide separate globe valves or angle valves with union connections in each supply to faucet. Provide bathtub and shower valve with ball type control handle.

2.6.3 Area Drains

Area drains shall be plain pattern with polished stainless steel perforated or slotted grate and bottom outlet. The drain shall be circular or square with a [12 inch](#) nominal overall width or diameter and [10 inch](#) nominal overall depth. Drains shall be cast iron with manufacturer's standard coating. Grate shall be easily lifted out for cleaning. Outlet shall be suitable for inside caulked connection to drain pipe. Drains shall conform to [ASME A112.6.3](#).

2.6.4 Floor Sinks

Floor sinks shall be square, with [12 inch](#) nominal overall width or diameter and [10 inch](#) nominal overall depth. Floor sink shall have an acid-resistant enamel interior finish with cast-iron body, ABS sediment bucket, and perforated grate of cast iron in industrial areas and stainless steel in finished areas. The outlet pipe size shall be as indicated or of the same size as the connecting pipe.

2.7 SHOWER PAN

Shower pan may be copper, or nonmetallic material.

2.7.1 Sheet Copper

Sheet copper shall be [16 ounce](#) weight.

2.7.2 Plasticized Polyvinyl Chloride Shower Pan Material

Material shall be sheet form. The material shall be [0.040 inch](#) minimum thickness of plasticized polyvinyl chloride or chlorinated polyethylene and shall be in accordance with [ASTM D4551](#).

2.7.3 Nonplasticized Polyvinyl Chloride (PVC) Shower Pan Material

Material shall consist of a plastic waterproofing membrane in sheet form. The material shall be 0.040 inch minimum thickness of nonplasticized PVC and shall have the following minimum properties:

a. or ASTM D638:

Ultimate Tensile Strength:	2600 psi
Ultimate Elongation:	398 percent
100 Percent Modulus:	445 psi

b. ASTM D1004:

Tear Strength:	300 pounds per inch

c. ASTM E96/E96M:

Permeance:	0.008 perms

d. Other Properties:

Specific Gravity:	1.29
PVC Solvent:	Weldable
Cold Crack:	minus 53 degrees F
Dimensional stability	212 degrees F minus 2.5 percent
Hardness, Shore A:	89

2.8 TRAPS

Unless otherwise specified, traps shall be plastic per ASTM F409. Traps shall be without a cleanout. Provide traps with removable access panels for easy clean-out at sinks and lavatories. Tubes shall be copper alloy with walls not less than 0.032 inch thick within commercial tolerances, except on the outside of bends where the thickness may be reduced slightly in manufacture by usual commercial methods. Inlets shall have rubber washer and copper alloy nuts for slip joints above the discharge level. Swivel joints shall be below the discharge level and shall be of metal-to-metal or metal-to-plastic type as required for the application. Nuts shall have flats for wrench grip. Outlets shall have internal pipe thread, except that when required for the application, the outlets shall have sockets for solder-joint connections. The depth of the water seal shall be not less than 2 inches. The interior diameter shall be not more than 1/8 inch over or under the nominal size, and interior surfaces shall be reasonably smooth throughout. A copper alloy "P" trap assembly consisting of an adjustable "P" trap and threaded trap wall nipple with cast brass wall flange shall be provided for lavatories. The assembly shall be a standard manufactured unit and may have a rubber-gasketed swivel joint.

2.9 WATER HEATERS

Water heater types and capacities shall be as indicated. Each water heater shall have replaceable anodes. Each primary water heater shall have controls with an adjustable range that includes 90 to 160 degrees F. Each gas-fired water heater and booster water heater shall have controls with an adjustable range that includes 120 to 180 degrees F. Hot water systems utilizing recirculation systems shall be tied into building

off-hour controls. The thermal efficiencies and standby heat losses shall conform to TABLE III in PART 3 of this Section for each type of water heater specified. The only exception is that storage water heaters and hot water storage tanks having more than 500 gallons storage capacity need not meet the standard loss requirement if the tank surface area is insulated to R-12.5 and if a standing light is not used. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. A factory pre-charged expansion tank shall be installed on the cold water supply to each water heater. Expansion tanks shall be specifically designed for use on potable water systems and shall be rated for 200 degrees F water temperature and 150 psi working pressure. The expansion tank size and acceptance volume shall be as indicated.

2.9.1 Automatic Storage Type

Heaters shall be complete with control system, temperature gauge, and pressure gauge, and shall have ASME rated combination pressure and temperature relief valve.

2.9.1.1 Gas-Fired Type

Gas-fired water heaters shall conform to ANSI Z21.10.1/CSA 4.1 when input is 75,000 BTU per hour or less or ANSI Z21.10.3/CSA 4.3 for heaters with input greater than 75,000 BTU per hour. Provide Energy Star labeled gas storage water heater. Provide data identifying Energy Star label for gas storage water heater.

2.9.2 Phenolic Resin Coatings for Heater Tubes

The phenolic resin coating system shall be applied at either the coil or coating manufacturer's factory in accordance with manufacturer's standard proven production process. The coating system shall be a product specifically intended for use on the material the water heating tubes/coils are made of and shall be acceptable for use in potable water systems. The coating system shall be capable of withstanding temperatures up to 400 degrees F dry bulb; and meet the requirements of 21 CFR 175.

The entire exterior surface and the first 5 to 8 inches inside the tubes of each coil shall be coated with phenolic resin coating system.

2.9.2.1 Standard Product

Provide a phenolic resin coating system that is a standard product of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship.

Standard products are defined as components and equipment that have been in satisfactory commercial or industrial use in similar applications of similar size for at least two years before bid opening.

Prior to this two year period, these standard products were sold on the commercial market using advertisements in manufacturers' catalogs or brochures. These manufacturers' catalogs, or brochures shall have been copyrighted documents or be identified with a manufacturer's document number.

2.10 HOT-WATER STORAGE TANKS

Hot-water storage tanks shall be constructed by one manufacturer, ASME stamped for the working pressure, and shall have the National Board (ASME) registration. The tank shall be cement-lined or glass-lined steel type in accordance with AWWA D100. The heat loss shall conform to TABLE III in PART 3 of this Section as determined by the requirements of ASHRAE 90.1 - IP. Each tank shall be equipped with a thermometer, conforming to ASTM E1, Type I, Class 3, Range C, style and form as required for the installation, and with 7 inch scale. Thermometer shall have a separable socket suitable for a 3/4 inch tapped opening. Tanks shall be equipped with a pressure gauge 6 inch minimum diameter face. Insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Storage tank capacity shall be as shown.

2.11 PUMPS

2.11.1 Circulating Pumps

Domestic hot water circulating pumps shall be electrically driven, single-stage, centrifugal, with mechanical seals, suitable for the intended service. Pump and motor shall be supported by the piping on which it is installed. The shaft shall be one-piece, heat-treated, corrosion-resisting steel with impeller and smooth-surfaced housing of bronze.

Motor shall be totally enclosed, fan-cooled and shall have sufficient horsepower for the service required. Each pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in cover.

Integral size motors shall be premium efficiency type in accordance with NEMA MG 1. Pump motors smaller than 1 hp Fractional horsepower pump motors shall have integral thermal overload protection in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Guards shall shield exposed moving parts.

2.11.2 Flexible Connectors

Flexible connectors shall be provided at the suction and discharge of each pump that is 1 hp or larger. Connectors shall be constructed of neoprene, rubber, or braided bronze, with Class 150 standard flanges. Flexible connectors shall be line size and suitable for the pressure and temperature of the intended service.

2.12 DOMESTIC WATER SERVICE METER

The requirements for metering and submetering are specified in Section 33 11 00 WATER UTILITY DISTRIBUTION PIPING.

2.13 ELECTRICAL WORK

Provide electrical motor driven equipment specified complete with motors, motor starters, and controls as specified herein and in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, corresponding to the applications in accordance with NEMA MG 11. In addition to the

requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide polyphase, squirrel-cage medium induction motors with continuous ratings, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

Controllers and contactors shall have auxiliary contacts for use with the controls provided. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers, including the required monitors and timed restart.

Power wiring and conduit for field installed equipment shall be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.14 MISCELLANEOUS PIPING ITEMS

2.14.1 Escutcheon Plates

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Provide chromium-plated on copper alloy plates or polished stainless steel finish in finished spaces. Provide paint finish on plates in unfinished spaces.

2.14.2 Pipe Sleeves

Provide where piping passes entirely through walls, ceilings, roofs, and floors. Sleeves are not required where supply drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade, except where penetrating a membrane waterproof floor.

2.14.2.1 Sleeves in Masonry and Concrete

Provide steel pipe sleeves or schedule 40 PVC plastic pipe sleeves. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth.

2.14.2.2 Sleeves Not in Masonry and Concrete

Provide 26 gage galvanized steel sheet or PVC plastic pipe sleeves.

2.14.3 Pipe Hangers (Supports)

Provide MSS SP-58 Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19

or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor. Provide Type 40 insulation protection shield for insulated piping.

2.14.4 Nameplates

Provide 0.125 inch thick melamine laminated plastic nameplates, black matte finish with white center core, for equipment, gages, thermometers, and valves; valves in supplies to faucets will not require nameplates. Accurately align lettering and engrave minimum of 0.25 inch high normal block lettering into the white core. Minimum size of nameplates shall be 1.0 by 2.5 inches. Key nameplates to a chart and schedule for each system. Frame charts and schedules under glass and place where directed near each system. Furnish two copies of each chart and schedule.

2.14.5 Labels

Provide labels for sensor operators at flush valves and faucets. Include the following information on each label:

- a. Identification of the sensor and its operation with written description.
- b. Range of the sensor.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Piping located in air plenums shall conform to NFPA 90A requirements. Piping located in shafts that constitute air ducts or that enclose air ducts shall be noncombustible in accordance with NFPA 90A. Installation of plastic pipe where in compliance with NFPA may be installed in accordance with PPFA Fire Man. The plumbing system shall be installed complete with necessary fixtures, fittings, traps, valves, and accessories. Water and drainage piping shall be extended 5 feet outside the building, unless otherwise indicated. A full port ball valve and drain shall be installed on the water service line inside the building approximately 6 inches above the floor from point of entry. Piping shall be connected to the exterior service lines or capped or plugged if the exterior service is not in place. Sewer and water pipes shall be laid in separate trenches, except when otherwise shown. Exterior underground utilities shall be at least 12 inches below the average local frost depth or as indicated on the drawings. If trenches are closed or the pipes are otherwise covered before being connected to the service lines, the location of the end of each plumbing utility shall be marked with a stake or other acceptable means. Valves shall be installed with control no lower than the valve body.

3.1.1 Water Pipe, Fittings, and Connections

3.1.1.1 Utilities

The piping shall be extended to fixtures, outlets, and equipment. The

hot-water and cold-water piping system shall be arranged and installed to permit draining. The supply line to each item of equipment or fixture, except faucets, flush valves, or other control valves which are supplied with integral stops, shall be equipped with a shutoff valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures. Supply piping to fixtures, faucets, hydrants, shower heads, and flushing devices shall be anchored to prevent movement.

3.1.1.2 Cutting and Repairing

The work shall be carefully laid out in advance, and unnecessary cutting of construction shall be avoided. Damage to building, piping, wiring, or equipment as a result of cutting shall be repaired by mechanics skilled in the trade involved.

3.1.1.3 Protection of Fixtures, Materials, and Equipment

Pipe openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water, chemicals, and mechanical injury. Upon completion of the work, the fixtures, materials, and equipment shall be thoroughly cleaned, adjusted, and operated. Safety guards shall be provided for exposed rotating equipment.

3.1.1.4 Mains, Branches, and Runouts

Piping shall be installed as indicated. Pipe shall be accurately cut and worked into place without springing or forcing. Structural portions of the building shall not be weakened. Aboveground piping shall run parallel with the lines of the building, unless otherwise indicated. Branch pipes from service lines may be taken from top, bottom, or side of main, using crossover fittings required by structural or installation conditions. Supply pipes, valves, and fittings shall be kept a sufficient distance from other work and other services to permit not less than $\frac{1}{2}$ inch between finished covering on the different services. Bare and insulated water lines shall not bear directly against building structural elements so as to transmit sound to the structure or to prevent flexible movement of the lines. Water pipe shall not be buried in or under floors unless specifically indicated or approved. Changes in pipe sizes shall be made with reducing fittings. Use of bushings will not be permitted except for use in situations in which standard factory fabricated components are furnished to accommodate specific accepted installation practice. Change in direction shall be made with fittings, except that bending of pipe $\frac{1}{4}$ inches and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center-line radius of bends shall be not less than six diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be acceptable.

3.1.1.5 Pipe Drains

Pipe drains indicated shall consist of $\frac{3}{4}$ inch hose bibb with renewable seat and full port ball valve ahead of hose bibb. At other low points, $\frac{3}{4}$ inch brass plugs or caps shall be provided. Disconnection of the supply piping at the fixture is an acceptable drain.

3.1.1.6 Expansion and Contraction of Piping

Allowance shall be made throughout for expansion and contraction of water

pipe. Each hot-water and hot-water circulation riser shall have expansion loops or other provisions such as offsets and changes in direction where indicated and required. Risers shall be securely anchored as required or where indicated to force expansion to loops. Branch connections from risers shall be made with ample swing or offset to avoid undue strain on fittings or short pipe lengths. Horizontal runs of pipe over 50 feet in length shall be anchored to the wall or the supporting construction about midway on the run to force expansion, evenly divided, toward the ends. Sufficient flexibility shall be provided on branch runouts from mains and risers to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that piping will spring enough to allow for expansion without straining. If mechanical grooved pipe coupling systems are provided, the deviation from design requirements for expansion and contraction may be allowed pending approval of Contracting Officer.

3.1.1.7 Thrust Restraint

Plugs, caps, tees, valves and bends deflecting 11.25 degrees or more, either vertically or horizontally, in waterlines 4 inches in diameter or larger shall be provided with thrust blocks, where indicated, to prevent movement. Thrust blocking shall be concrete of a mix not leaner than: 1 cement, 2-1/2 sand, 5 gravel; and having a compressive strength of not less than 2000 psi after 28 days. Blocking shall be placed between solid ground and the fitting to be anchored. Unless otherwise indicated or directed, the base and thrust bearing sides of the thrust block shall be poured against undisturbed earth. The side of the thrust block not subject to thrust shall be poured against forms. The area of bearing will be as shown. Blocking shall be placed so that the joints of the fitting are accessible for repair. Steel rods and clamps, protected by galvanizing or by coating with bituminous paint, shall be used to anchor vertical down bends into gravity thrust blocks.

3.1.1.8 Commercial-Type Water Hammer Arresters

Commercial-type water hammer arresters shall be provided on hot- and cold-water supplies and shall be located as generally indicated, with precise location and sizing to be in accordance with PDI WH 201. Water hammer arresters, where concealed, shall be accessible by means of access doors or removable panels. Commercial-type water hammer arresters shall conform to ASSE 1010. Vertical capped pipe columns will not be permitted.

3.1.2 Joints

Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints shall be made up with fittings of compatible material and made for the specific purpose intended.

3.1.2.1 Threaded

Threaded joints shall have American Standard taper pipe threads conforming to ASME B1.20.1. Only male pipe threads shall be coated with graphite or with an approved graphite compound, or with an inert filler and oil, or shall have a polytetrafluoroethylene tape applied.

3.1.2.2 Unions and Flanges

Unions, flanges and mechanical couplings shall not be concealed in walls, ceilings, or partitions. Unions shall be used on pipe sizes 2-1/2 inches and smaller; flanges shall be used on pipe sizes 3 inches and larger.

3.1.2.3 Cast Iron Soil, Waste and Vent Pipe

Bell and spigot compression and hubless gasketed clamp joints for soil, waste and vent piping shall be installed per the manufacturer's recommendations.

3.1.2.4 Copper Tube and Pipe

- a. Brazed. Brazed joints shall be made in conformance with AWS B2.2/B2.2M, ASME B16.50, and CDA A4015 with flux and are acceptable for all pipe sizes. Copper to copper joints shall include the use of copper-phosphorus or copper-phosphorus-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorus, copper-phosphorus-silver or a silver brazing filler metal.
- b. Soldered. Soldered joints shall be made with flux and are only acceptable for piping 2 inches and smaller. Soldered joints shall conform to ASME B31.5 and CDA A4015. Soldered joints shall not be used in compressed air piping between the air compressor and the receiver.
- c. Copper Tube Extracted Joint. Mechanically extracted joints shall be made in accordance with ICC IPC.

3.1.2.5 Plastic Pipe

Acrylonitrile-Butadiene-Styrene (ABS) pipe shall have joints made with solvent cement. PVC and CPVC pipe shall have joints made with solvent cement elastomeric, threading, (threading of Schedule 80 Pipe is allowed only where required for disconnection and inspection; threading of Schedule 40 Pipe is not allowed), or mated flanged.

3.1.2.6 Glass Pipe

Joints for corrosive waste glass pipe and fittings shall be made with corrosion-resisting steel compression-type couplings with acrylonitrile rubber gaskets lined with polytetrafluoroethylene.

3.1.2.7 Corrosive Waste Plastic Pipe

Joints for polyolefin pipe and fittings shall be made by mechanical joint or electrical fusion coil method in accordance with ASTM D2657 and ASTM F1290. Joints for filament-wound reinforced thermosetting resin pipe shall be made in accordance with manufacturer's instructions. Unions or flanges shall be used where required for disconnection and inspection.

3.1.2.8 Polypropylene Pipe

Joints for polypropylene pipe and fittings shall be made by heat fusion welding socket-type or butt-fusion type fittings and shall comply with ASTM F2389.

3.1.2.9 Other Joint Methods

3.1.3 Dissimilar Pipe Materials

Connections between ferrous and non-ferrous copper water pipe shall be made with dielectric unions or flange waterways. Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways. Connecting joints between plastic and metallic pipe shall be made with transition fitting for the specific purpose.

3.1.4 Corrosion Protection for Buried Pipe and Fittings

Ductile iron, cast iron, and steel pipe, fittings, and joints shall have a protective coating. Additionally, ductile iron, cast iron, and steel pressure pipe shall have a cathodic protection system and joint bonding.

Coatings shall be selected, applied, and inspected in accordance with [NACE SP0169](#) and as otherwise specified. The pipe shall be cleaned and the coating system applied prior to pipe tightness testing. Joints and fittings shall be cleaned and the coating system applied after pipe tightness testing. For tape coating systems, the tape shall conform to [AWWA C203](#) and shall be applied with a 50 percent overlap. Primer utilized with tape type coating systems shall be as recommended by the tape manufacturer.

3.1.5 Pipe Sleeves and Flashing

Pipe sleeves shall be furnished and set in their proper and permanent location.

3.1.5.1 Sleeve Requirements

Unless indicated otherwise, provide pipe sleeves meeting the following requirements:

Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors.

A modular mechanical type sealing assembly may be installed in lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve. The seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and sleeve using galvanized steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe and sleeve involved.

Sleeves shall not be installed in structural members, except where indicated or approved. Rectangular and square openings shall be as

detailed. Each sleeve shall extend through its respective floor, or roof, and shall be cut flush with each surface, except for special circumstances. Pipe sleeves passing through floors in wet areas such as mechanical equipment rooms, lavatories, kitchens, and other plumbing fixture areas shall extend a minimum of 4 inches above the finished floor.

Unless otherwise indicated, sleeves shall be of a size to provide a minimum of 1/4 inch clearance between bare pipe or insulation and inside of sleeve or between insulation and inside of sleeve. Sleeves in bearing walls and concrete slab on grade floors shall be steel pipe or cast-iron pipe. Sleeves in nonbearing walls or ceilings may be steel pipe, cast-iron pipe, galvanized sheet metal with lock-type longitudinal seam, or plastic.

Except as otherwise specified, the annular space between pipe and sleeve, or between jacket over insulation and sleeve, shall be sealed as indicated with sealants conforming to ASTM C920 and with a primer, backstop material and surface preparation as specified in Section 07 92 00 JOINT SEALANTS. The annular space between pipe and sleeve, between bare insulation and sleeve or between jacket over insulation and sleeve shall not be sealed for interior walls which are not designated as fire rated.

Sleeves through below-grade walls in contact with earth shall be recessed 1/2 inch from wall surfaces on both sides. Annular space between pipe and sleeve shall be filled with backing material and sealants in the joint between the pipe and concrete wall as specified above. Sealant selected for the earth side of the wall shall be compatible with dampproofing/waterproofing materials that are to be applied over the joint sealant. Pipe sleeves in fire-rated walls shall conform to the requirements in Section 07 84 00 FIRESTOPPING.

3.1.5.2 Flashing Requirements

Pipes passing through roof shall be installed through a 16 ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall be set over the roof or floor membrane in a solid coating of bituminous cement. The flashing shall extend up the pipe a minimum of 10 inches. For cleanouts, the flashing shall be turned down into the hub and caulked after placing the ferrule. Pipes passing through pitched roofs shall be flashed, using lead or copper flashing, with an adjustable integral flange of adequate size to extend not less than 8 inches from the pipe in all directions and lapped into the roofing to provide a watertight seal. The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Flashing for dry vents shall be turned down into the pipe to form a waterproof joint. Pipes, up to and including 10 inches in diameter, passing through roof or floor waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing-clamp device, and pressure ring with brass bolts. Flashing shield shall be fitted into the sleeve clamping device. Pipes passing through wall waterproofing membrane shall be sleeved as described above. A waterproofing clamping flange shall be installed.

3.1.5.3 Waterproofing

Waterproofing at floor-mounted water closets shall be accomplished by forming a flashing guard from soft-tempered sheet copper. The center of the sheet shall be perforated and turned down approximately 1-1/2 inches

to fit between the outside diameter of the drainpipe and the inside diameter of the cast-iron or steel pipe sleeve. The turned-down portion of the flashing guard shall be embedded in sealant to a depth of approximately 1-1/2 inches; then the sealant shall be finished off flush to floor level between the flashing guard and drainpipe. The flashing guard of sheet copper shall extend not less than 8 inches from the drainpipe and shall be lapped between the floor membrane in a solid coating of bituminous cement. If cast-iron water closet floor flanges are used, the space between the pipe sleeve and drainpipe shall be sealed with sealant and the flashing guard shall be upturned approximately 1-1/2 inches to fit the outside diameter of the drainpipe and the inside diameter of the water closet floor flange. The upturned portion of the sheet fitted into the floor flange shall be sealed.

3.1.5.4 Optional Counterflashing

Instead of turning the flashing down into a dry vent pipe, or caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may be accomplished by utilizing the following:

- a. A standard roof coupling for threaded pipe up to 6 inches in diameter.
- b. A tack-welded or banded-metal rain shield around the pipe.

3.1.5.5 Pipe Penetrations of Slab on Grade Floors

Where pipes, fixture drains, floor drains, cleanouts or similar items penetrate slab on grade floors, except at penetrations of floors with waterproofing membrane as specified in paragraphs FLASHING REQUIREMENTS and WATERPROOFING, a groove 1/4 to 1/2 inch wide by 1/4 to 3/8 inch deep shall be formed around the pipe, fitting or drain. The groove shall be filled with a sealant as specified in Section 07 92 00 JOINT SEALANTS.

3.1.5.6 Pipe Penetrations

Provide sealants for all pipe penetrations. All pipe penetrations shall be sealed to prevent infiltration of air, insects, and vermin.

3.1.6 Fire Seal

Where pipes pass through fire walls, fire-partitions, fire-rated pipe chase walls or floors above grade, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.1.7 Supports

3.1.7.1 General

Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger

and support spacing required for an individual pipe in the multiple pipe run. Threaded sections of rods shall not be formed or bent.

3.1.7.2 Pipe Hangers, Inserts, and Supports

Installation of pipe hangers, inserts and supports shall conform to **MSS SP-58** except as modified herein.

- a. Types 5, 12, and 26 shall not be used.
- b. Type 3 shall not be used on insulated pipe.
- c. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for type 18 inserts.
- d. Type 19 and 23 C-clamps shall be torqued per **MSS SP-58** and shall have both locknuts and retaining devices furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.
- e. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.
- f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.
- g. Type 39 saddles shall be used on insulated pipe **4 inches** and larger when the temperature of the medium is **60 degrees F** or higher. Type 39 saddles shall be welded to the pipe.
- h. Type 40 shields shall:
 - (1) Be used on insulated pipe less than **4 inches**.
 - (2) Be used on insulated pipe **4 inches** and larger when the temperature of the medium is **60 degrees F** or less.
 - (3) Have a high density insert for all pipe sizes. High density inserts shall have a density of **8 pcf** or greater.
- i. Horizontal pipe supports shall be spaced as specified in **MSS SP-58** and a support shall be installed not over **1 foot** from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over **5 feet** apart at valves. Operating temperatures in determining hanger spacing for PVC or CPVC pipe shall be **120 degrees F** for PVC and **180 degrees F** for CPVC. Horizontal pipe runs shall include allowances for expansion and contraction.
- j. Vertical pipe shall be supported at each floor, except at slab-on-grade, at intervals of not more than **15 feet** nor more than **8 feet** from end of risers, and at vent terminations. Vertical pipe risers shall include allowances for expansion and contraction.
- k. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided to allow longitudinal pipe movement. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered. Lateral restraints shall be provided as needed. Where steel slides do

not require provisions for lateral restraint the following may be used:

- (1) On pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher, a Type 39 saddle, welded to the pipe, may freely rest on a steel plate.
 - (2) On pipe less than 4 inches a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.
 - (3) On pipe 4 inches and larger carrying medium less than 60 degrees F a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.
- l. Pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation. The insulation shall be continuous through the hanger on all pipe sizes and applications.
 - m. Where there are high system temperatures and welding to piping is not desirable, the type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 4 inches or by an amount adequate for the insulation, whichever is greater.
 - n. Hangers and supports for plastic pipe shall not compress, distort, cut or abrade the piping, and shall allow free movement of pipe except where otherwise required in the control of expansion/contraction.

3.1.7.3 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Supports shall not be attached to the underside of concrete filled floor or concrete roof decks unless approved by the Contracting Officer. Masonry anchors for overhead applications shall be constructed of ferrous materials only.

3.1.8 Welded Installation

Plumbing pipe weldments shall be as indicated. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connection may be made with either welding tees or forged branch outlet fittings. Branch outlet fittings shall be forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Beveling, alignment, heat treatment, and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded. After filler metal has been removed from its original package, it shall be protected or stored so that its characteristics or welding properties are not affected. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.9 Pipe Cleanouts

Pipe cleanouts shall be the same size as the pipe except that cleanout plugs larger than 4 inches will not be required. A cleanout installed in connection with cast-iron soil pipe shall consist of a long-sweep 1/4 bend or one or two 1/8 bends extended to the place shown. An extra-heavy

cast-brass or cast-iron ferrule with countersunk cast-brass head screw plug shall be caulked into the hub of the fitting and shall be flush with the floor. Cleanouts in connection with other pipe, where indicated, shall be T-pattern, 90-degree branch drainage fittings with cast-brass screw plugs, except plastic plugs shall be installed in plastic pipe. Plugs shall be the same size as the pipe up to and including 4 inches. Cleanout tee branches with screw plug shall be installed at the foot of soil and waste stacks, at the foot of interior downspouts, on each connection to building storm drain where interior downspouts are indicated, and on each building drain outside the building. Cleanout tee branches may be omitted on stacks in single story buildings with slab-on-grade construction or where less than 18 inches of crawl space is provided under the floor. Cleanouts on pipe concealed in partitions shall be provided with chromium plated bronze, nickel bronze, nickel brass or stainless steel flush type access cover plates. Round access covers shall be provided and secured to plugs with securing screw. Square access covers may be provided with matching frames, anchoring lugs and cover screws. Cleanouts in finished walls shall have access covers and frames installed flush with the finished wall. Cleanouts installed in finished floors subject to foot traffic shall be provided with a chrome-plated cast brass, nickel brass, or nickel bronze cover secured to the plug or cover frame and set flush with the finished floor. Heads of fastening screws shall not project above the cover surface. Where cleanouts are provided with adjustable heads, the heads shall be cast iron or plastic.

3.2 WATER HEATERS AND HOT WATER STORAGE TANKS

3.2.1 Relief Valves

No valves shall be installed between a relief valve and its water heater or storage tank. The P&T relief valve shall be installed where the valve actuator comes in contact with the hottest water in the heater. Whenever possible, the relief valve shall be installed directly in a tapping in the tank or heater; otherwise, the P&T valve shall be installed in the hot-water outlet piping. A vacuum relief valve shall be provided on the cold water supply line to the hot-water storage tank or water heater and mounted above and within 6 inches above the top of the tank or water heater.

3.2.2 Installation of Gas- and Oil-Fired Water Heater

Installation shall conform to NFPA 54 for gas fired and NFPA 31 for oil fired. Storage water heaters that are not equipped with integral heat traps and having vertical pipe risers shall be installed with heat traps directly on both the inlet and outlet. Circulating systems need not have heat traps installed. An acceptable heat trap may be a piping arrangement such as elbows connected so that the inlet and outlet piping make vertically upward runs of not less than 24 inches just before turning downward or directly horizontal into the water heater's inlet and outlet fittings. Commercially available heat traps, specifically designed by the manufacturer for the purpose of effectively restricting the natural tendency of hot water to rise through vertical inlet and outlet piping during standby periods may also be approved.

3.2.3 Heat Traps

Piping to and from each water heater and hot water storage tank shall be routed horizontally and downward a minimum of 2 feet before turning in an upward direction.

3.2.4 Connections to Water Heaters

Connections of metallic pipe to water heaters shall be made with dielectric unions or flanges.

3.2.5 Expansion Tank

A pre-charged expansion tank shall be installed on the cold water supply between the water heater inlet and the cold water supply shut-off valve. The Contractor shall adjust the expansion tank air pressure, as recommended by the tank manufacturer, to match incoming water pressure.

3.2.6 Direct Fired and Domestic Water Heaters

Notify the Contracting Officer when any direct fired domestic water heater over 400,000 BTU/hour is operational and ready to be inspected and certified.

3.3 FIXTURES AND FIXTURE TRIMMINGS

Polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Angle stops, straight stops, stops integral with the faucets, or concealed type of lock-shield, and loose-key pattern stops for supplies with threaded, sweat or solvent weld inlets shall be furnished and installed with fixtures. Where connections between copper tubing and faucets are made by rubber compression fittings, a beading tool shall be used to mechanically deform the tubing above the compression fitting. Exposed traps and supply pipes for fixtures and equipment shall be connected to the rough piping systems at the wall, unless otherwise specified under the item. Floor and wall escutcheons shall be as specified. Drain lines and hot water lines of fixtures for handicapped personnel shall be insulated and do not require polished chrome finish. Plumbing fixtures and accessories shall be installed within the space shown.

3.3.1 Fixture Connections

Where space limitations prohibit standard fittings in conjunction with the cast-iron floor flange, special short-radius fittings shall be provided. Connections between earthenware fixtures and flanges on soil pipe shall be made gastight and watertight with a closet-setting compound or neoprene gasket and seal. Use of natural rubber gaskets or putty will not be permitted. Fixtures with outlet flanges shall be set the proper distance from floor or wall to make a first-class joint with the closet-setting compound or gasket and fixture used.

3.3.2 Flushometer Valves

Flushometer valves shall be secured to prevent movement by anchoring the long finished top spud connecting tube to wall adjacent to valve with approved metal bracket. Flushometer valves for water closets shall be installed 39 inches above the floor, except at water closets intended for use by the physically handicapped where flushometer valves shall be mounted at approximately 30 inches above the floor and arranged to avoid interference with grab bars. In addition, for water closets intended for handicap use, the flush valve handle shall be installed on the wide side of the enclosure.

3.3.3 Height of Fixture Rims Above Floor

Lavatories shall be mounted with rim 31 inches above finished floor. Wall-hung drinking fountains and water coolers shall be installed with rim 42 inches above floor. Wall-hung service sinks shall be mounted with rim 28 inches above the floor. Installation of fixtures for use by the physically handicapped shall be in accordance with ICC A117.1 COMM.

3.3.4 Shower Bath Outfits

The area around the water supply piping to the mixing valves and behind the escutcheon plate shall be made watertight by caulking or gasketing.

3.3.5 Fixture Supports

Fixture supports for off-the-floor lavatories, urinals, water closets, and other fixtures of similar size, design, and use, shall be of the chair-carrier type. The carrier shall provide the necessary means of mounting the fixture, with a foot or feet to anchor the assembly to the floor slab. Adjustability shall be provided to locate the fixture at the desired height and in proper relation to the wall. Support plates, in lieu of chair carrier, shall be fastened to the wall structure only where it is not possible to anchor a floor-mounted chair carrier to the floor slab.

3.3.5.1 Support for Solid Masonry Construction

Chair carrier shall be anchored to the floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be imbedded in the masonry wall.

3.3.5.2 Support for Concrete-Masonry Wall Construction

Chair carrier shall be anchored to floor slab. Where a floor-anchored chair carrier cannot be used, a suitable wall plate shall be fastened to the concrete wall using through bolts and a back-up plate.

3.3.5.3 Support for Steel Stud Frame Partitions

Chair carrier shall be used. The anchor feet and tubular uprights shall be of the heavy duty design; and feet (bases) shall be steel and welded to a square or rectangular steel tube upright. Wall plates, in lieu of floor-anchored chair carriers, shall be used only if adjoining steel partition studs are suitably reinforced to support a wall plate bolted to these studs.

3.3.5.4 Support for Wood Stud Construction

Where floor is a concrete slab, a floor-anchored chair carrier shall be used. Where entire construction is wood, wood crosspieces shall be installed. Fixture hanger plates, supports, brackets, or mounting lugs shall be fastened with not less than No. 10 wood screws, 1/4 inch thick minimum steel hanger, or toggle bolts with nut. The wood crosspieces shall extend the full width of the fixture and shall be securely supported.

3.3.5.5 Wall-Mounted Water Closet Gaskets

Where wall-mounted water closets are provided, reinforced wax, treated felt, or neoprene gaskets shall be provided. The type of gasket furnished

shall be as recommended by the chair-carrier manufacturer.

3.3.6 Backflow Prevention Devices

Plumbing fixtures, equipment, and pipe connections shall not cross connect or interconnect between a potable water supply and any source of nonpotable water. Backflow preventers shall be installed where indicated and in accordance with ICC IPC at all other locations necessary to preclude a cross-connect or interconnect between a potable water supply and any nonpotable substance. In addition backflow preventers shall be installed at all locations where the potable water outlet is below the flood level of the equipment, or where the potable water outlet will be located below the level of the nonpotable substance. Backflow preventers shall be located so that no part of the device will be submerged. Backflow preventers shall be of sufficient size to allow unrestricted flow of water to the equipment, and preclude the backflow of any nonpotable substance into the potable water system. Bypass piping shall not be provided around backflow preventers. Access shall be provided for maintenance and testing. Each device shall be a standard commercial unit.

3.3.7 Access Panels

Access panels shall be provided for concealed valves and controls, or any item requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced, maintained, or replaced. Access panels shall be as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.3.8 Sight Drains

Sight drains shall be installed so that the indirect waste will terminate 2 inches above the flood rim of the funnel to provide an acceptable air gap.

3.3.9 Traps

Each trap shall be placed as near the fixture as possible, and no fixture shall be double-trapped. Traps installed on cast-iron soil pipe shall be cast iron. Traps installed on steel pipe or copper tubing shall be recess-drainage pattern, or brass-tube type. Traps installed on plastic pipe may be plastic conforming to ASTM D3311. Traps for acid-resisting waste shall be of the same material as the pipe.

3.3.10 Shower Pans

Before installing shower pan, subfloor shall be free of projections such as nail heads or rough edges of aggregate. Drain shall be a bolt-down, clamping-ring type with weepholes, installed so the lip of the subdrain is flush with subfloor.

3.3.10.1 General

The floor of each individual shower, the shower-area portion of combination shower and drying room, and the entire shower and drying room where the two are not separated by curb or partition, shall be made watertight with a shower pan fabricated in place. The shower pan material shall be cut to size and shape of the area indicated, in one piece to the maximum extent practicable, allowing a minimum of 6 inches for turnup on walls or partitions, and shall be folded over the curb with an approximate

return of 1/4 of curb height. The upstands shall be placed behind any wall or partition finish. Subflooring shall be smooth and clean, with nailheads driven flush with surface, and shall be sloped to drain. Shower pans shall be clamped to drains with the drain clamping ring.

3.3.10.2 Metal Shower Pans

When a shower pan of required size cannot be furnished in one piece, metal pieces shall be joined with a flintlock seam and soldered or burned. The corners shall be folded, not cut, and the corner seam shall be soldered or burned. Pans, including upstands, shall be coated on all surfaces with one brush coat of asphalt. Asphalt shall be applied evenly at not less than 1 gallon per 50 square feet. A layer of felt covered with building paper shall be placed between shower pans and wood floors. The joining surfaces of metal pan and drain shall be given a brush coat of asphalt after the pan is connected to the drain.

3.3.10.3 Plasticized Chlorinated Polyethylene Shower Pans

Corners of plasticized chlorinated polyethylene shower pans shall be folded against the upstand by making a pig-ear fold. Hot-air gun or heat lamp shall be used in making corner folds. Each pig-ear corner fold shall be nailed or stapled 1/2 inch from the upper edge to hold it in place. Nails shall be galvanized large-head roofing nails. On metal framing or studs, approved duct tape shall be used to secure pig-ear fold and membrane. Where no backing is provided between the studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding 1/2 inch from upper edge. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it will be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after which the membrane shall be pressed into place. Surfaces to be solvent-welded shall be clean. Surfaces to be joined with xylene shall be initially sprayed and vigorously cleaned with a cotton cloth, followed by final coating of xylene and the joining of the surfaces by roller or equivalent means. If ambient or membrane temperatures are below 40 degrees F the membrane and the joint shall be heated prior to application of xylene. Heat may be applied with hot-air gun or heat lamp, taking precautions not to scorch the membrane. Adequate ventilation and wearing of gloves are required when working with xylene. Membrane shall be pressed into position on the drain body, and shall be cut and fit to match so that membrane can be properly clamped and an effective gasket-type seal provided. On wood subflooring, two layers of 15 pound dry felt shall be installed prior to installation of shower pan to ensure a smooth surface for installation.

3.3.10.4 Nonplasticized Polyvinyl Chloride (PVC) Shower Pans

Nonplasticized PVC shall be turned up behind walls or wall surfaces a distance of not less than 6 inches in room areas and 3 inches above curb level in curbed spaces with sufficient material to fold over and fasten to outside face of curb. Corners shall be pig-ear type and folded between pan and studs. Only top 1 inch of upstand shall be nailed to hold in place. Nails shall be galvanized large-head roofing type. Approved duct tape shall be used on metal framing or studs to secure pig-ear fold and membrane. Where no backing is provided between studs, the membrane slack shall be taken up by pleating and stapling or nailing to studding at top inch of upstand. To adhere the membrane to vertical surfaces, the back of the membrane and the surface to which it is to be applied shall be coated with adhesive that becomes dry to the touch in 5 to 10 minutes, after

which the membrane shall be pressed into place. Trim for drain shall be exactly the size of drain opening. Bolt holes shall be pierced to accommodate bolts with a tight fit. Adhesive shall be used between pan and subdrain. Clamping ring shall be bolted firmly. A small amount of gravel or porous materials shall be placed at weepholes so that holes remain clear when setting bed is poured. Membrane shall be solvent welded with PVC solvent cement. Surfaces to be solvent welded shall be clean (free of grease and grime). Sheets shall be laid on a flat surface with an overlap of about 2 inches. Top edge shall be folded back and surface primed with a PVC primer. PVC cement shall be applied and surfaces immediately placed together, while still wet. Joint shall be lightly rolled with a paint roller, then as the joint sets shall be rolled firmly but not so hard as to distort the material. In long lengths, about 2 or 3 feet at a time shall be welded. On wood subflooring, two layers of 15 pound felt shall be installed prior to installation of shower pan to ensure a smooth surface installation.

3.4 VIBRATION-ABSORBING FEATURES

Mechanical equipment, including compressors and pumps, shall be isolated from the building structure by approved vibration-absorbing features, unless otherwise shown. Each foundation shall include an adequate number of standard isolation units. Each unit shall consist of machine and floor or foundation fastening, together with intermediate isolation material, and shall be a standard product with printed load rating. Piping connected to mechanical equipment shall be provided with flexible connectors. Isolation unit installation shall limit vibration to 90 percent of the lowest equipment rpm.

3.5 WATER METER REMOTE READOUT REGISTER

The remote readout register shall be mounted at the location indicated or as directed by the Contracting Officer.

3.6 IDENTIFICATION SYSTEMS

3.6.1 Identification Tags

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and valve number shall be installed on valves, except those valves installed on supplies at plumbing fixtures. Tags shall be 1-3/8 inch minimum diameter, and marking shall be stamped or engraved. Indentations shall be black, for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain, or plastic straps designed for that purpose.

3.6.2 Pipe Color Code Marking

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6.3 Color Coding Scheme for Locating Hidden Utility Components

Scheme shall be provided in buildings having suspended grid ceilings. The color coding scheme shall identify points of access for maintenance and operation of operable components which are not visible from the finished space and installed in the space directly above the suspended grid ceiling. The operable components shall include valves, dampers, switches, linkages and thermostats. The color coding scheme shall consist of a

color code board and colored metal disks. Each colored metal disk shall be approximately $\frac{3}{8}$ inch in diameter and secured to removable ceiling panels with fasteners. The fasteners shall be inserted into the ceiling panels so that the fasteners will be concealed from view. The fasteners shall be manually removable without tools and shall not separate from the ceiling panels when panels are dropped from ceiling height. Installation of colored metal disks shall follow completion of the finished surface on which the disks are to be fastened. The color code board shall have the approximate dimensions of 3 foot width, 30 inches height, and $\frac{1}{2}$ inch thickness. The board shall be made of wood fiberboard and framed under glass or $\frac{1}{16}$ inch transparent plastic cover. Unless otherwise directed, the color code symbols shall be approximately $\frac{3}{4}$ inch in diameter and the related lettering in $\frac{1}{2}$ inch high capital letters. The color code board shall be mounted and located in the mechanical or equipment room.

3.7 ESCUTCHEONS

Escutcheons shall be provided at finished surfaces where bare or insulated piping, exposed to view, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

3.8 PAINTING

Painting of pipes, hangers, supports, and other iron work, either in concealed spaces or exposed spaces, is specified in Section 09 90 00 PAINTS AND COATINGS.

3.8.1 Painting of New Equipment

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

3.8.1.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test. Salt-spray fog test shall be in accordance with ASTM B117, and for that test the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond $\frac{0.125}{16}$ inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system shall be designed for the temperature service.

3.8.1.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F shall be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

- a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.
- b. Temperatures Between 120 and 400 Degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.
- c. Temperatures Greater Than 400 Degrees F: Metal surfaces subject to temperatures greater than 400 degrees F shall receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

3.9 TESTS, FLUSHING AND DISINFECTION

3.9.1 Plumbing System

The following tests shall be performed on the plumbing system in accordance with ICC IPC, except that the drainage and vent system final test shall include the smoke test. The Contractor has the option to perform a peppermint test in lieu of the smoke test. If a peppermint test is chosen, the Contractor must submit a testing procedure and reasons for choosing this option in lieu of the smoke test to the Contracting Officer for approval.

- a. Drainage and Vent Systems Test. The final test shall include a smoke test.
- b. Building Sewers Tests.
- c. Water Supply Systems Tests.

3.9.1.1 Test of Backflow Prevention Assemblies

Backflow prevention assembly shall be tested using gauges specifically designed for the testing of backflow prevention assemblies.

Backflow prevention assembly test gauges shall be tested annually for accuracy in accordance with the requirements of State or local regulatory

agencies. If there is no State or local regulatory agency requirements, gauges shall be tested annually for accuracy in accordance with the requirements of University of Southern California's Foundation of Cross Connection Control and Hydraulic Research or the American Water Works Association Manual of Cross Connection (Manual M-14), or any other approved testing laboratory having equivalent capabilities for both laboratory and field evaluation of backflow prevention assembly test gauges. Report form for each assembly shall include, as a minimum, the following:

Data on Device	Data on Testing Firm
Type of Assembly	Name
Manufacturer	Address
Model Number	Certified Tester
Serial Number	Certified Tester No.
Size	Date of Test
Location	
Test Pressure Readings	Serial Number and Test Data of Gauges

If the unit fails to meet specified requirements, the unit shall be repaired and retested.

3.9.1.2 Shower Pans

After installation of the pan and finished floor, the drain shall be temporarily plugged below the weep holes. The floor area shall be flooded with water to a minimum depth of 1 inch for a period of 24 hours. Any drop in the water level during test, except for evaporation, will be reason for rejection, repair, and retest.

3.9.2 Defective Work

If inspection or test shows defects, such defective work or material shall be replaced or repaired as necessary and inspection and tests shall be repeated. Repairs to piping shall be made with new materials. Caulking of screwed joints or holes will not be acceptable.

3.9.3 System Flushing

3.9.3.1 During Flushing

Before operational tests or disinfection, potable water piping system shall be flushed with hot potable water. Sufficient water shall be used to produce a water velocity that is capable of entraining and removing debris in all portions of the piping system. This requires simultaneous operation of all fixtures on a common branch or main in order to produce a flushing velocity of approximately 4 fps through all portions of the piping system. In the event that this is impossible due to size of system, the Contracting Officer (or the designated representative) shall specify the number of fixtures to be operated during flushing. Contractor

shall provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the facility. Contractor shall be responsible for any flood damage resulting from flushing of the system. Flushing shall be continued until entrained dirt and other foreign materials have been removed and until discharge water shows no discoloration. All faucets and drinking water fountains, to include any device considered as an end point device by NSF/ANSI 61, Section 9, shall be flushed a minimum of 0.25 gallons per 24 hour period, ten times over a 14 day period.

3.9.3.2 After Flushing

System shall be drained at low points. Strainer screens shall be removed, cleaned, and replaced. After flushing and cleaning, systems shall be prepared for testing by immediately filling water piping with clean, fresh potable water. Any stoppage, discoloration, or other damage to the finish, furnishings, or parts of the building due to the Contractor's failure to properly clean the piping system shall be repaired by the Contractor. When the system flushing is complete, the hot-water system shall be adjusted for uniform circulation. Flushing devices and automatic control systems shall be adjusted for proper operation according to manufacturer's instructions. Flow rates on fixtures must not exceed those stated in PART 2 of this Section. Unless more stringent local requirements exist, lead levels shall not exceed limits established by 40 CFR 141.80 (c)(1). The water supply to the building shall be tested separately to ensure that any lead contamination found during potable water system testing is due to work being performed inside the building.

3.9.4 Operational Test

Upon completion of flushing and prior to disinfection procedures, the Contractor shall subject the plumbing system to operating tests to demonstrate satisfactory installation, connections, adjustments, and functional and operational efficiency. Such operating tests shall cover a period of not less than 8 hours for each system and shall include the following information in a report with conclusion as to the adequacy of the system:

- a. Time, date, and duration of test.
- b. Water pressures at the most remote and the highest fixtures.
- c. Operation of each fixture and fixture trim.
- d. Operation of each valve, hydrant, and faucet.
- e. Pump suction and discharge pressures.
- f. Temperature of each domestic hot-water supply.
- g. Operation of each floor and roof drain by flooding with water.
- h. Operation of each vacuum breaker and backflow preventer.
- i. Complete operation of each water pressure booster system, including pump start pressure and stop pressure.
- j. Compressed air readings at each compressor and at each outlet. Each indicating instrument shall be read at 1/2 hour intervals. The report

of the test shall be submitted in quadruplicate. The Contractor shall furnish instruments, equipment, and personnel required for the tests; the Government will furnish the necessary water and electricity.

3.9.5 Disinfection

After all system components are provided and operational tests are complete, the entire domestic hot- and cold-water distribution system shall be disinfected. Before introducing disinfecting chlorination material, entire system shall be flushed with potable water until any entrained dirt and other foreign materials have been removed.

Water chlorination procedure shall be in accordance with AWWA C651 and AWWA C652 as modified and supplemented by this specification. The chlorinating material shall be hypochlorites or liquid chlorine. The chlorinating material shall be fed into the water piping system at a constant rate at a concentration of at least 50 parts per million (ppm). Feed a properly adjusted hypochlorite solution injected into the system with a hypochlorinator, or inject liquid chlorine into the system through a solution-feed chlorinator and booster pump until the entire system is completely filled.

Test the chlorine residual level in the water at 6 hour intervals for a continuous period of 24 hours. If at the end of a 6 hour interval, the chlorine residual has dropped to less than 25 ppm, flush the piping including tanks with potable water, and repeat the above chlorination procedures. During the chlorination period, each valve and faucet shall be opened and closed several times.

After the second 24 hour period, verify that no less than 25 ppm chlorine residual remains in the treated system. The 24 hour chlorination procedure must be repeated until no less than 25 ppm chlorine residual remains in the treated system.

Upon the specified verification, the system including tanks shall then be flushed with potable water until the residual chlorine level is reduced to less than one part per million. During the flushing period, each valve and faucet shall be opened and closed several times.

Take additional samples of water in disinfected containers, for bacterial examination, at locations specified by the Contracting Officer

Test these samples for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA 10084. The testing method used shall be EPA approved for drinking water systems and shall comply with applicable local and state requirements.

Disinfection shall be repeated until bacterial tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

3.10 POSTED INSTRUCTIONS

Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system,

shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

3.11 PERFORMANCE OF WATER HEATING EQUIPMENT

Standard rating condition terms are as follows:

EF = Energy factor, minimum overall efficiency.

ET = Minimum thermal efficiency with 70 degrees F delta T.

SL = Standby loss is maximum (Btu/h) based on a 70 degrees F temperature difference between stored water and ambient requirements.

V = Rated volume in gallons

Q = Nameplate input rate in kW (Btu/h)

3.11.1 Storage Water Heaters

3.11.1.1 Gas

- a. Storage capacity of 50 gallons or less shall have a minimum energy factor (EF) of 0.67 or higher per FEMP requirements.
- b. Storage capacity of 20 gallons - or more and input rating of 75,000 Btu/h or less: minimum EF shall be 0.62 - 0.0019V per 10 CFR 430.
- c. Rating of less than 22980 W: (75,000 Btu/h) ET shall be 80 percent; maximum SL shall be $(Q/800+110 \times (V^{1/2}))$, per ANSI Z21.10.3/CSA 4.3

3.11.2 Unfired Hot Water Storage

All volumes and inputs: shall meet or exceed R-12.5.

3.12 TABLES

TABLE I						
PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS						
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE G
1	Cast iron soil pipe and fittings, hub and spigot, ASTM A74 with compression gaskets. Pipe and fittings shall be marked with the CISPI trademark.	X		X		
2	Cast iron soil pipe and fittings hubless, CISPI 301 and ASTM A888 . Pipe and fittings shall be marked with the CISPI trademark.		X		X	

TABLE I						
PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS						
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE G

TABLE I						
PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS						
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE G
20	Polyvinyl Chloride plastic drain, waste and vent pipe and fittings, ASTM D2665, ASTM F891, (Sch 40) ASTM F1760	X	X	X	X	X
21						
22						

TABLE I						
PIPE AND FITTING MATERIALS FOR DRAINAGE, WASTE, VENT AND CONDENSATE DRAIN PIPING SYSTEMS						
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE C	SERVICE D	SERVICE G
23						
24						
SERVICE: A - Underground Building Soil, Waste and Storm Drain B - Aboveground Soil, Waste, Drain In Buildings C - Underground Vent D - Aboveground Vent G - Condensate Drain Aboveground * - Hard Temper						

TABLE II				
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS				
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE D
1	Malleable-iron threaded fittings:			
	a. Galvanized, ASME B16.3 for use with Item 4a	X	X	X
	b. Same as "a" but not galvanized for use with Item 4b			

TABLE II				
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS				
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE D
6	Bronze flanged fittings, ASME B16.24 for use with Items 5 and 7	X	X	X
7	Seamless copper pipe, ASTM B42	X	X	X
8	Seamless copper water tube, ASTM B88, ASTM B88M	X**	X**	X***
9	Cast bronze threaded fittings, ASME B16.15 for use with Items 5 and 7	X	X	X
10	Wrought copper and bronze solder-joint pressure fittings, ASME B16.22 for use with Items 5, 7 and 8	X	X	X
11	Cast copper alloy solder-joint pressure fittings, ASME B16.18 for use with Item 8	X	X	X

TABLE II				
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS				
<u>Item #</u>	<u>Pipe and Fitting Materials</u>	<u>SERVICE A</u>	<u>SERVICE B</u>	<u>SERVICE D</u>

TABLE II				
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS				
<u>Item #</u>	<u>Pipe and Fitting Materials</u>	<u>SERVICE A</u>	<u>SERVICE B</u>	<u>SERVICE D</u>

TABLE II				
PIPE AND FITTING MATERIALS FOR PRESSURE PIPING SYSTEMS				
Item #	Pipe and Fitting Materials	SERVICE A	SERVICE B	SERVICE D
33	Fittings: brass or bronze; ASME B16.15, and ASME B16.18 ASTM B828	X	X	
34	Carbon steel pipe unions, socket-welding and threaded, MSS SP-83	X	X	
35	Malleable-iron threaded pipe unions ASME B16.39	X	X	
36	Nipples, pipe threaded ASTM A733	X	X	
	SERVICE: A - Cold Water Service Aboveground B - Hot and Cold Water Distribution 180 degrees F Maximum Aboveground D - Cold Water Service Belowground Indicated types are minimum wall thicknesses. ** - Type L - Hard *** - Type K - Hard temper with brazed joints only or type K-soft temper without joints in or under floors **** - In or under slab floors only brazed joints			

TABLE III				
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT				
<u>FUEL</u>	<u>STORAGE CAPACITY GALLONS</u>	<u>INPUT RATING</u>	<u>TEST PROCEDURE</u>	<u>REQUIRED PERFORMANCE</u>
A. STORAGE WATER HEATERS				
Gas	50 max.		10 CFR 430	EF = 0.67
Gas	20 min.	75,000 Btu/h max.	10 CFR 430	EF = 0.67-0.0019V min.
Gas	1,000 (Btu/h)/gal max.	75,000 Btu/h	ANSI Z21.10.3/C	ET = 80 percent min. SL = 1.3+38/V max.
B. Unfired Hot Water Storage, R-12.5 min.				

TABLE III				
STANDARD RATING CONDITIONS AND MINIMUM PERFORMANCE RATINGS FOR WATER HEATING EQUIPMENT				
<u>FUEL</u>	<u>STORAGE CAPACITY GALLONS</u>	<u>INPUT RATING</u>	<u>TEST PROCEDURE</u>	<u>REQUIRED PERFORMANCE</u>

TERMS:

EF = Energy factor, minimum overall efficiency.

ET = Minimum thermal efficiency with 70 degrees F delta T.

SL = Standby loss is maximum Btu/h based on a 70 degree F temperature difference between stored water and ambient requirements.

V = Rated storage volume in gallons

Q = Nameplate input rate in Btu/h

```
-- End of Section --
```

SECTION 22 05 48.00 20

MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL

04/06, CHG 1: 05/15

PART 1 GENERAL

1.1 REFERENCES

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

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 575 (2008) Method of Measuring Machinery Sound Within an Equipment Space

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M (2019) Standard Specification for Carbon Structural Steel

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A653/A653M (2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM C94/C94M (2020) Standard Specification for Ready-Mixed Concrete

ASTM D471 (2016a) Standard Test Method for Rubber Property - Effect of Liquids

ASTM D2240 (2015; E 2017) Standard Test Method for Rubber Property - Durometer Hardness

ASTM E84 (2020) Standard Test Method for Surface Burning Characteristics of Building Materials

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1966 (2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition

1.2 RELATED REQUIREMENTS

The provisions of Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND

METHODS apply to this section.

1.3 DEFINITIONS

1.3.1 Decibels dB

Measure of sound level. Decibels are referenced to either 20 uPa for sound pressure levels or one pW for sound power levels. dBA is the overall "A" weighted sound level.

1.3.2 Machinery

The vibration or noise producing equipment that must be isolated.

1.3.3 Manufacturer

The fabricator or supplier of vibration-isolation or seismic-protection materials and equipment. For mechanical equipment and machinery the term machinery manufacturer will be used.

1.3.4 Micropascal uPa

10 to the minus 6 power newtons per square meter.

1.3.5 Picowatt pW

10 to the minus 12 power watts.

1.4 SYSTEM DESCRIPTION

1.4.1 Spring Isolator Data

For each type and size of spring isolator, submit the spring outside diameter, deflection, operating spring height, unloaded spring height, solid spring height, the ratio of the outside diameter to the operating spring height, the load to deflection ratio of the springs, and weight and sizes of structural steel members.

1.4.2 Machinery Manufacturer's Sound Data

For each piece of indicated machinery to be vibration isolated, the calculated sound power test data or sound pressure test data as levels in dB in the eight octave bands between 63 and 8,000 Hz. Refer sound power levels to one pW and sound pressure levels to 20 uPa. Submit the overall "A" weighted scale sound pressure level in dB. Submit the standard test procedure used to obtain the sound power or pressure data for the applicable vibration isolation equipment size.

1.4.3 Machinery

For each item of machinery, compare spring static deflections with the specified minimum static deflection, to show that the calculated spring static deflections are not less than the minimum static deflections specified. Rated spring static deflections are not acceptable in lieu of calculated spring static deflections.

1.4.4 Machinery Over 300 Pounds

For machinery items over 300 pounds, provide calculations for shear,

pull-up, primary overturning, and secondary overturning.

1.4.5 Machinery Vibration Criteria

TABLE 1A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
Centrifugal Chillers or Heat Pumps						
Hermetic Type	SV-B	1.75	SV-B	2.5	SV-B	3.5
Reciprocating Air or Refrigeration Compressors						
500 to 750 rpm	S-R	1.75	S-R	2.5	S-R	3.5
751 rpm and up	S-R	1.5	S-R	2.5	S-R	3.5
Closed Coupled Pumps						
Up to 7-1/2 hp	S-I	1.0	S-I	1.0	S-I	1.0
Over 7-1/2 hp	S-I	1.5	S-I	2.5	S-I	2.5
Floor Mounted Units						
Up to 5 hp	S	1.0	S	1.0	S	1.0
Over 5 hp						
Up to 400 rpm	S-R	1.75	S-R	1.75	S-R	2.5
Over 401 rpm	S-R	1.0	S-R	1.5	S-R	2.5
Centrifugal Blowers						
175 - 224 rpm	S-B	4.75	S-B	4.75	S-B	4.75

TABLE 1A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
225 - 299 rpm	S-B	3.75	S-B	4.75	S-B	4.75
300 - 374 rpm	S-B	2.75	S-B	4.5	S-B	4.75
375 - 499 rpm	S-B	2.5	S-B	3.5	S-B	4.5
Over 500 rpm	S-B	1.75	S-B	2.5	S-B	3.5
Tubular Centrifugal and Axial Fans (Note (2))						
Suspended		H with deflection specified for centrifugal blowers				
Floor Mounted Arrangements 1 & 9		S-B with deflections specified for centrifugal blowers				
Utility Fans (Note (2))						
Suspended		H with deflections specified for centrifugal blowers but not to exceed 2.75 inches				
Floor-Mounted		S-R with deflections not specified for centrifugal blowers but not to exceed 2.75 inches				
Internal Combustion Engines and Engine Driven Equip						
750 rpm and over	S	1.5	S	2.5	S	3.5
Dimmer Banks and Transformers						
Up to 1000 lbs.	NM	0.35	NM	0.35	NM	3.5
Over 1000 lbs.	SV	1.0	SV	1.0	SV	1.0
NOTES:						
(1) Equipment Vibration Isolation Schedule Designations (Hyphenated designations are combinations of the following:)						

TABLE 1A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
B - Welded structural steel bases.						
H - Spring isolators (suspended equipment and piping). Where required, provide with adjustable preloading devices.						
HR - Thrust restraints						
I - Concrete inertia bases with steel forms.						
NM - Neoprene mounts.						
NP - Neoprene pads.						
R - Structural steel rail for equipment mounts.						
S - Freestanding spring isolators (floor-mounted equipment).						
SV - Freestanding spring isolators (floor-mounted equipment).						
SX - Freestanding spring isolators with adjustable cushioned vertical stops and cushioned horizontal stops (floor-mounted equipment). Protected spring isolators SX may be substituted wherever S or SV is specified and shall meet all requirements.						
(2) Fans						
a. When fan motors are 75 hp or larger, use the deflection requirements for the next wider column spacing. Except for building slab on grade a minimum of 2.5 inches should be used unless larger deflections are specified in the centrifugal blower table.						
b. Provide sway brace isolators for tubular centrifugal and axial fans when the fan pressure exceeds 4 inches water column.						
c. Provide inertia bases for all fans in lieu of structural steel bases or rails specified above when the fan pressure exceeds 4 inches water column.						

TABLE 1A						
Vibration Isolator Types and Minimum Static Deflection						
(MSD, inches) for 4-8 inch slab on grade and column supported.						
Column Spacing	Slab on earth and 0-30 feet		31-40 feet		41-50 feet	
Equipment	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))	Type (Note (1))	MSD (Note (1))
d. With attaching brackets, suspension spring isolators bridge between the structure and the thrust-producing machinery such as high-pressure fan. Both types H and HR normally provide reaction in tension, while types S, SV, and SX normally provide reaction in compression. Thrust restraints are low-cost and effective components available from manufacturers. Use thrust restraints to eliminate the need for or reduce the magnitude of inertia mass when the mass is only used to reduce the displacement effects of the thrust.						

TABLE 1B		
Class II Vibration Isolator Types and Minimum Static Deflection		
(MSD, inches) for basements below grade and floor slabs on earth		
Equipment	Type (Note (1))	MSD
Centrifugal Chillers or Heat Pumps		
Hermetic Type	NP	0.25
	NM	0.35
Reciprocating Air or Refrigeration Compressors		
500 to 750 rpm	S	1.0
751 rpm and up	S	1.0
Reciprocating Chillers or Heat Pumps		
500 to 750 rpm	SV	1.0
751 rpm and up	SV	1.0
Packaged Boilers	NP	0.25
	NM	0.35
Pumps		
Closed Coupled	NP	0.25
Up to 7 1/2 hp	NM	0.35

TABLE 1B		
Class II Vibration Isolator Types and Minimum Static Deflection		
(MSD, inches) for basements below grade and floor slabs on earth		
Equipment	Type (Note (1))	MSD
Over 7 1/2 hp	S-I	1.0
Base Mounted		
Up to 20 hp	S-I	1.0
20 to 75 hp	S-I	1.0
Over 75 hp	S-I	1.0
Cooling Towers and Evaporative Condensers	NP	0.25
	NM	0.35
Factory Assembled Air Handling Equipment AH, AC and HV Units (Note (2))		
Suspended Units		
Up to 5 hp	H	1.0
Over 5 hp		
Up to 400 rpm	H	1.75
Over 401 rpm	H	1.0
Floor Mounted Units		
Up to 5 hp	NP	0.25
	NM	0.35
Over 5 hp		
Up to 400 rpm	NM	0.35
Over 401 rpm	NM	0.35
Centrifugal Blowers		
175 - 224 rpm	NM-B	0.35
225 - 299 rpm	NM-B	0.35
300 - 374 rpm	NM-B	0.35
375 - 499 rpm	NM-B	0.35
Over 500 rpm	NM-B	0.35
Tubular Centrifugal and Axial Fans (Note (2))		
Suspended	H with deflections specified for centrifugal blowers	
Floor Mounted Arrangements 1 & 9	NM	0.35
Utility Fans (Note (2))		
Suspended and centrifugal	H with deflections specified for	

TABLE 1B		
Class II Vibration Isolator Types and Minimum Static Deflection		
(MSD, inches) for basements below grade and floor slabs on earth		
Equipment	Type (Note (1))	MSD
Floor-Mounted	NM	0.35
Internal Combustion Engines and Engine Driven Equip		
750 rpm and over	S	1.0
Dimmer Banks and Transformers		
Up to 1000 lbs.	NP	0.25
	NM	0.35
Over 1000 lbs.	SV	1.0
NOTES: Note (1) and Note (2) are same as for TABLE 1A.		

Provide vibration isolators for mechanical and electrical machinery and associated piping and ductwork, to minimize transmission of vibrations and structure borne noise to the building structure or spaces or from the building structure to the machinery. Comply with the following vibration schedule.

1.4.6 Machinery Airborne Sound Level Criteria

TABLE 2A								
Sound Data Schedule								
Equipment	Maximum Sound Power Level (dB)							
	Octave Band Level Center Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Air Handling Unit	94	90	89	89	89	84	82	79
Make-Up Air Fan	91	91	80	84	82	76	71	65
Air Conditioning Unit	100	96	90	89	86	80	75	72
Boiler	75	72	72	75	76	63	55	50
Chiller	98	98	96	95	93	94	88	81

TABLE 2A								
Sound Data Schedule								
Equipment	Maximum Sound Power Level (dB)							
	Octave Band Level Center Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Cooling Tower	110	110	105	102	98	95	92	87
Air Compressor	90	89	92	93	92	92	90	81
Pump	85	80	82	82	80	77	74	72
Fan	55	50	48	47	48	46	42	37

1.4.6.1 Basic Criteria

For each piece of machinery in the human work environment, do not exceed the maximum airborne sound levels 84 dB A-weighted scale, continuous or intermittent, or 140 dB peak sound pressure-level, impact or impulse, noise.

1.4.6.2 Sound Data Schedule

TABLE 2A								
Sound Data Schedule								
Equipment	Maximum Sound Power Level (dB)							
	Octave Band Level Center Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Air Handling Unit	94	90	89	89	89	84	82	79
Make-Up Air Fan	91	91	80	84	82	76	71	65
Air Conditioning Unit	100	96	90	89	86	80	75	72
Boiler	75	72	72	75	76	63	55	50
Chiller	98	98	96	95	93	94	88	81
Cooling Tower	110	110	105	102	98	95	92	87
Air Compressor	90	89	92	93	92	92	90	81

TABLE 2A								
Sound Data Schedule								
Equipment	Maximum Sound Power Level (dB)							
	Octave Band Level Center Frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Pump	85	80	82	82	80	77	74	72
Fan	55	50	48	47	48	46	42	37

1.4.7 Welding

AWS D1.1/D1.1M.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Inertia Bases

SD-03 Product Data

Isolators

Flexible Connectors

Flexible Duct Connectors

Pipe Guides

Vertical Stops

Thrust Restraints

Inertia Bases

Machinery Manufacturer's Sound Data

SD-05 Design Data

Inertia Bases

SD-06 Test Reports

Equipment Vibration Tests

Equipment Sound Level Tests

SD-08 Manufacturer's Instructions

Vibration and Noise Isolation Components

1.6 QUALITY ASSURANCE

1.6.1 Vibration Isolator Procurement

For each piece of machinery to be isolated from vibration, supply the vibration isolators, seismic snubbers, and other associated materials and equipment as a coordinated package by a single manufacturer or by the machinery manufacturer. Select isolators that provide uniform deflection even when machinery weight is not evenly distributed. This requirement does not include the flexible connectors or the hangers for the associated piping and ductwork.

1.6.2 Unitized Machinery Assemblies

Mounting of unitized assemblies directly on vibration isolation springs is acceptable if machinery manufacturer certifies that the end supports of the assemblies have been designed for such installation.

PART 2 PRODUCTS

2.1 CORROSION PROTECTION FOR STEEL PARTS

ASTM A123/A123M or ASTM A653/A653M hot-dipped galvanized, or equivalent manufacturer standard coatings. Where steel parts are exposed to the weather, provide galvanized coating of at least 2 ounces of zinc per square foot of surface. Coat springs with neoprene.

2.2 NEOPRENE

ASTM D471 and ASTM D2240, Grade Durometer 40, 50, or 60, and oil resistant.

2.3 FLOOR-MOUNTED ISOLATORS

2.3.1 Neoprene Isolation Pads

Provide pads at least 1/4 inch thick with cross-ribbed or waffle design. For concentrated loads, provide steel bearing plates bonded or cold cemented to the pads.

2.3.2 Neoprene Isolators

Provide molded neoprene isolators having steel base plates with mounting holes and, at the top, steel mounting plates with mounting holes or

threaded inserts. Provide elements of type and size coded with molded letters or color-coded for capacity identification. Embed metal parts completely in neoprene.

2.4 SPRING ISOLATORS AND PROTECTED SPRING ISOLATORS

Provide spring isolators or protected spring isolators that are adjustable and laterally stable with free-standing springs of horizontal stiffness at minimum 80 percent of the vertical (axial) stiffness. For machine-attached and floor-attached restraining elements, separate from metal-to-metal contact by neoprene cushions $\frac{1}{8}$ inch thick minimum. Provide neoprene acoustic friction pads at least $\frac{1}{4}$ inch thick.

2.4.1 Springs

Provide springs with base and compression plates, to keep spring ends parallel during and after deflection to operating height. Provide outside coil diameters at least 0.8 of the operating height. At operating height, springs shall have additional travel to complete (solid) compression equal to at least 50 percent of the operating deflection.

2.4.2 Mounting and Adjustment

Provide base and compression plates with mounting holes or threaded fittings. Bolt leveling adjustment bolts to machinery or base.

2.5 SUSPENSION ISOLATORS

Provide hangers with suspension isolators encased in open steel brackets. Isolate hanger rods from isolator steel brackets with neoprene-lined opening.

2.5.1 Suspension Neoprene Isolators

Provide double-deflection elements with minimum $\frac{3}{8}$ inch deflection.

2.5.2 Suspension Spring Isolators

Provide hangers with springs and molded neoprene elements in series. Provide isolators with adjustable spring-preloading devices where required to maintain constant pipe elevations during installation and when pipe operational loads are transferred to the springs.

2.6 INERTIA BASES

ASTM A36/A36M steel, ASTM C94/C94M (2,500 psi) concrete.

2.7 FLEXIBLE CONNECTORS FOR PIPING

Straight or elbow flexible connectors rated for temperatures, pressures, and fluids to be conveyed. Provide flexible connectors with the strength 4 times operating pressure at highest system operating temperature. Provide elbow flexible connectors with a permanently set angle.

2.7.1 Elastomeric Flexible Connectors

Fabricated of multiple plies of tire cord fabric and elastomeric materials with integral reinforced elastomeric flanges with galvanized malleable iron back up rings.

2.7.2 Metal Flexible Connectors

Fabricated of Grade E phosphor bronze, monel or corrugated stainless steel tube covered with comparable bronze or stainless steel braid restraining and pressure cover.

2.8 FLEXIBLE DUCT CONNECTORS

Provide flexible duct connectors fabricated in accordance with SMACNA 1966.

2.9 PIPE GUIDES

Factory-fabricated. Weld steel bar guides to the pipe at a maximum radial spacing of 60 degrees. The outside diameter around the guide bars shall be smaller than the inside diameter of the guide sleeve in accordance with standard field construction practice. For pipe temperatures below 60 degrees F, provide metal sleeve, minimum one pound per cubic foot density insulation.

2.10 THRUST RESTRAINTS

Adjustable spring thrust restraints, able to resist the thrust force with at least 25 percent unused capacity. The operating spring deflection shall be not less than 50 percent of the static deflection of the isolation supporting the machinery.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Vibration and Noise Isolation Components

Install vibration-and-noise isolation materials and equipment as indicated and in accordance with machinery manufacturer's instructions.

3.1.2 Suspension Vibration Isolators

Provide suspension isolation hangers for piping, suspended equipment, and suspended equipment platforms in mechanical equipment rooms, as indicated and as specified. For operating load static deflections of 1/4 inch or less, provide neoprene pads or single deflection neoprene isolators. For operating load static deflections over 5/16 to 3/8 inch, provide double-deflection neoprene element isolators. For operating load static deflections over 3/8 inch, provide isolators with spring and neoprene elements in series.

3.1.3 Vertical Stops

For machinery affected by wind pressure or having an operational weight different from installed weight, provide resilient vertical limit stops which prevent spring extension when weight is removed. Provide vertical stops for machinery containing liquid, such as water chillers, evaporative coolers, boilers, and cooling towers. Spring isolated or protected spring isolated machinery must rock and move freely within limits of stops or seismic restraint devices.

3.1.4 Thrust Restraints

Where required, provide pairs of thrust restraints, symmetrically installed on both sides of the steady state line of thrust.

3.1.5 Flexible Pipe and Duct Connectors

Install flexible connectors in accordance with the manufacturer's instructions. When liquid pulsation dampening is required, flexible connectors with spherical configuration may be used.

3.1.6 Water and Steam Distribution Piping Application

Resiliently support piping with combination spring and neoprene isolation hangers. Provide spring elements with $5/8$ inch static deflection; install the hanger with spacing so that the first harmonic natural frequency is not less than 360 Hz. Provide double-deflection neoprene elements. For the first two isolation hangers from the rotating equipment of $3\ 1/2$ inch and smaller piping systems, ensure a deflection equal to the equipment-isolation static deflection. For the first four piping isolation hanger supports from rotating equipment of 4 inch and larger piping systems, use resilient hanger-rod isolators at a fixed elevation regardless of load changes. Incorporate an adjustable preloading device to transfer the load to the spring element within the hanger mounting after the piping system has been filled with water.

3.1.7 Pipe Hanger and Support Installation

3.1.7.1 Pipe Hangers

Provide eye-bolts or swivel joints for pipe hangers to permit pipe thermal or mechanical movement without angular misalignment of hanger vibration isolator.

3.1.7.2 Valves

Provide vibration isolation hangers and supports at modulating, pressure reducing, or control valves which will induce fluid pulsations. When required or indicated, isolate valves with flexible connectors.

3.1.7.3 Machinery Without Flexible Connections

When piping is not connected to vibrating machinery with flexible connectors, provide the first four hangers with isolation elements designed for deflections equal to equipment vibration isolator deflections (including static, operating, and start-up).

3.1.7.4 Pipe Risers

Provide pipe riser supports with bearing plates and two layers of $1/4$ inch thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with $1/4$ inch steel plate. Weld pipe riser clamps at anchor points to the pipe and to pairs of vertical acoustical pipe anchor mountings which shall be rigidly fastened to the steel framing.

3.1.7.5 Supports at Base of Pipe Risers

Piping isolation supports at the base of risers shall be two layers of $1/2$ inch thick heavy-duty neoprene pad separated by $1/4$ inch thick steel plate. Use bearing plates sized to provide a pad loading of not more than

500 psi. Weld the stanchion between the pipe and isolation support to the pipe and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support piping, provide a maximum deflection of 0.08 inches at the mid-span of this steel under the load. Rigidly support piping from the supplementary steel with the supplementary steel isolated from the building structure with isolators.

3.1.7.6 Pipe Anchors

Attach each end of the pipe anchor to an omni-directional pipe isolator which in turn shall be rigidly fastened to the steel framing or structural concrete. Provide a telescoping pipe isolator of two sizes of steel tubing separated by a minimum 1/2 inch thick pad of heavy-duty neoprene or heavy-duty neoprene and canvas. Provide vertical restraints by similar material to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.1.8 Equipment Room Sound Isolation

Do not allow direct contact between pipe or ducts and walls, floor slabs, roofs, ceilings or partitions of equipment rooms.

3.1.8.1 Pipe Penetrations

Provide galvanized Schedule 40 pipe sleeves and tightly pack annular space between sleeves and pipe with insulation having a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E84, maximum effective temperature 1000 degrees F, bulk density 6 pounds/cu. ft. minimum. Provide uninsulated pipe with a one inch thick mineral fiber sleeve the full length of the penetration and seal each end with an interior or exterior and weather resistant non-hardening compound. Provide sealant and mineral-fiber sleeve of a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E84.

3.1.8.2 Duct Penetrations

Pack openings around ducts with mineral fiber insulation the full length of the penetration having a flame spread rating not more than 25 and a smoke developed rating not more than 50 when tested in accordance with ASTM E84. At each end of duct opening provide sealing collars and seal with an interior or exterior and weather resistant non-hardening compound.

3.1.8.3 Ducts Passing Through Equipment Rooms

Provide with sound insulation equal to the sound attenuation value of the wall, floor, or ceiling penetrated.

3.1.9 Machinery Foundations and Subbases

Provide cast in place anchor bolts as recommended by the machinery manufacturer.

3.1.9.1 Machinery Subbases

Provide concrete subbases at least 4 inches high for floor mounted equipment. Rest subbases on structural floor and reinforce with steel rods interconnected with floor reinforcing bars by tie bars hooked at both

ends. Provide at least 2 inch clearance between subbases and inertia bases, steel bases, and steel saddles with machinery in operation.

3.1.9.2 Common Machinery Foundations

Mount electrical motors on the same foundations as driven machinery. Support piping connections, strainers, valves, and risers on the same foundation as the pumps.

3.1.9.3 Foundation and Subbase Concrete

Cast concrete foundations and subbases of ASTM C94/C94M 2500 psi concrete reinforced with steel bars as indicated or recommended by machinery manufacturer.

3.1.9.4 Anchor Bolts and Grout

Secure machinery to foundations and inertia bases with anchor bolts. Grout equipment with baseplates, the full area under baseplates with premixed non-shrinking grout. After grout has set, remove wedges, shims, and jack bolts and fill spaces with grout.

3.1.10 Inertia Bases

Install inertia bases in accordance with the recommendations of the machinery manufacturer or inertia base manufacturer, as applicable.

3.1.11 Suspended Machinery Platforms

Provide with vibration-isolation hangers.

3.1.12 Electrical Connections

Provide flexible conduit or multiple conductor cable connections for machinery with sufficient extra length to permit 2 inch minimum displacement in any direction without damage.

3.1.13 Systems Not To Be Vibration Isolated

Do not provide vibration isolation for electrical raceways and conduits or for fire protection, storm, sanitary, and domestic water piping systems which do not include pumps or other vibrating, rotating, or pulsating equipment including control and pressure reducing valves.

3.2 FIELD QUALITY CONTROL

Provide equipment and apparatus required for performing inspections and tests. Notify Contracting Officer 14 days prior to machinery sound & vibration testing. Rebalance, adjust, or replace machinery with noise or vibration levels in excess of those given in the machinery specifications, or machinery manufacturer's data.

3.2.1 Field Inspections

Prior to initial operation, inspect the vibration isolators for conformance to drawings, specifications, and manufacturer's data and instructions. Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Check connector alignment before and after filling of system and during operation.

Correct misalignment without damage to connector and in accordance with manufacturer's recommendations.

3.2.2 Spring Isolator Inspection

After installation of spring isolators or protected spring isolators, and seismic restraint devices, the machinery shall rock freely on its spring isolators within limits of stops or seismic restraint devices. Eliminate or correct interferences.

3.2.3 Tests

Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.

3.2.3.1 Equipment Vibration Tests

Perform vibration tests to determine conformance with vibration isolation schedule specified indicated.

3.2.3.2 Equipment Sound Level Tests

Measure continuous or intermittent steady state noise with a sound level meter set for low response. Measure impact or impulse noise as dB peak sound pressure level (20 uPa) with an impact noise analyzer. Measure work distance from person to machinery noise center. Perform sound level tests to determine conformance with sound level schedule specified .

a. Interior Machinery Sound

In accordance with [AHRI 575](#), measure the sound data for air conditioning and refrigeration machinery, such as fans, boilers, valves, engines, turbines, or transformers. Measure the sound pressure levels around mechanical and electrical machinery located in equipment spaces, [3 feet](#) horizontally from the edge closest to the acoustical center of the machinery at points [3 feet](#) and [5.5 feet](#) above floor. Take measurements at the center of each side of the machinery. Locate the microphone at least [3 feet](#) from the observer and measuring instruments. Observer shall not be between the machinery and the measuring instrument.

b. Exterior Machinery Sound

Measure sound data for machinery radiating noise outside the building in such applications as grade installations, area-ways, wall and roof installations for cooling towers, refrigerant condensers, engine driven generator sets, fans, air conditioning machinery, heat pumps, evaporative coolers, exhaust silencers, and air intakes.

-- End of Section --

SECTION 23 03 00.00 20

BASIC MECHANICAL MATERIALS AND METHODS

08/10, CHG 3: 08/18

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM B117 (2019) Standard Practice for Operating
Salt Spray (Fog) Apparatus

INTERNATIONAL CODE COUNCIL (ICC)

ICC IFGC (2018) International Fuel Gas Code

ICC IMC (2018) International Mechanical Code

ICC IPC (2018) International Plumbing Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2018) Motors and Generators

NEMA MG 10 (2017) Energy Management Guide for
Selection and Use of Fixed Frequency
Medium AC Squirrel-Cage Polyphase
Induction Motors

1.2 RELATED REQUIREMENTS

This section applies to all sections of Divisions: 21, FIRE SUPPRESSION; 22, PLUMBING; and 23, HEATING, VENTILATING, AND AIR CONDITIONING of this project specification, unless specified otherwise in the individual section.

1.3 QUALITY ASSURANCE

1.3.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Standard products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.3.2 Alternative Qualifications

Products having less than a two-year field service record will be

acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.3.3 Service Support

The equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3.4 Manufacturer's Nameplate

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

1.3.5 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.3.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions must be considered mandatory, the word "should" is interpreted as "must." Reference to the "code official" must be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" must be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" must be interpreted to mean the "lessor." References to the "permit holder" must be interpreted to mean the "Contractor."

1.3.5.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, must be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.5 ELECTRICAL REQUIREMENTS

Furnish motors, controllers, disconnects and contactors with their respective pieces of equipment. Motors, controllers, disconnects and contactors must conform to and have electrical connections provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Furnish internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors will not be permitted. Controllers and contactors shall have a maximum of 120 volt control circuits, and must have auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of additional electrical service and related work must be included under the section that specified that motor or equipment. Power wiring and conduit for field installed equipment must be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

1.5.1 Motor Voltage

Provide motors rated for the voltage supplied. Motors shall be suitable for use at 90% to 110% of the nominal voltage and shall have a service factor of at least 1.1 at that nominal voltage.

1.5.2 Single Phase Motor Efficiency

Unless otherwise specified, single-phase fractional-horsepower alternating-current motors must be high efficiency types corresponding to the applications listed in NEMA MG 11.

1.5.3 Poly Phase Motor Efficiency

Unless other specified polyphase squirrel-cage induction motors must be premium efficiency with continuous ratings that meet or exceed energy efficient ratings in accordance with Table 12-12 of NEMA MG 1 and corresponding to the applications listed in NEMA MG 10

1.5.4 Three-Phase Motor Protection

Provide controllers for motors rated three horsepower and larger with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

1.6 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors must be thoroughly familiar with all parts of the installation and must be trained in operating theory as well as practical operation and maintenance work.

Instruction must be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished must be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for

instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.7 ACCESSIBILITY

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 Manufacturer's Recommendations

All material and equipment shall be installed in accordance with the manufacturer's recommendations for the intended purpose. Use the more stringent methods when manufacturer's recommendations, and plan & specification requirements differ. The contractor shall notify the government of any conflicts between manufacturer's recommendations and plans & specification requirements.

3.2 International Construction Codes

All material, equipment and installation shall be in accordance with the ICC IFGC, ICC IPC, and ICC IMC unless noted otherwise on the drawings and/or specifications. The contractor shall notify the government of any conflicts between ICC code requirements and contract requirements.

3.3 PAINTING OF NEW EQUIPMENT

New equipment painting must be factory applied or shop applied, and must be as specified herein, and provided under each individual section.

3.3.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with [ASTM B117](#), and for that test the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond [0.125 inch](#) on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above [120 degrees F](#), the factory painting system must be designed for the temperature service.

3.3.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F must be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat must be aluminum or light gray.

- a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F must receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of 1 mil; and two coats of enamel applied to a minimum dry film thickness of 1 mil per coat.
- b. Temperatures Between 120 and 400 Degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F must receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.
- c. Temperatures Greater Than 400 Degrees F: Metal surfaces subject to temperatures greater than 400 degrees F must receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

-- End of Section --

SECTION 23 05 93.00 22

TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS

09/19

PART 1 GENERAL

1.1 REFERENCES

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

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.11 PART 1 (2014) American National Standard
Electroacoustics - Octave-Band and
Fractional-Octave-Band Filters - Part 1:
Specifications

ASA S1.4 (1983; Amendment 1985; R 2006)
Specification for Sound Level Meters (ASA
47)

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 203 (1990; R 2011) Field Performance
Measurements of Fan Systems

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

ASHRAE 62.1 (2010) Ventilation for Acceptable Indoor
Air Quality

ASHRAE HVAC APP IP HDBK (2016) HVAC Applications Handbook, I-P
Edition

ASSOCIATED AIR BALANCE COUNCIL (AABC)

AABC MN-1 (2016; 7th ed) National Standards for
Total System Balance

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB MASV (2006) Procedural Standards for
Measurements and Assessment of Sound and
Vibration

NEBB PROCEDURAL STANDARDS (2015) Procedural Standards for TAB
(Testing, Adjusting and Balancing)
Environmental Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION
(SMACNA)

SMACNA 1780 (2002) HVAC Systems - Testing, Adjusting
and Balancing, 3rd Edition

SMACNA 1858

(2004) HVAC Sound And Vibration Manual -
First Edition

SMACNA 1972 CD

(2012) HVAC Air Duct Leakage Test Manual -
2nd Edition

1.2 DEFINITIONS

- a. AABC: Associated Air Balance Council
- b. COTR: Contracting Officer's Technical Representative
- c. DALT: Duct air leakage test
- d. DALT'd: Duct air leakage tested
- e. Duct System: When applied to DALT, this phrase means "complete duct system", inclusive of all ductwork, plenums, mains, branches, fittings and duct-mounted components and appurtenances, e.g. manual balancing dampers, control dampers, access doors, fire dampers, duct-mounted coils, etc. up to, but excluding air-handling equipment (e.g. AHUs, DOAUs, ERUs, VAVs) and flexible duct.
- f. HVAC: Heating, ventilating, and air conditioning; or heating, ventilating, and cooling
- g. NEBB: National Environmental Balancing Bureau
- h. Out-of-tolerance data: Pertains only to field acceptance testing of Final DALT or TAB report. When applied to DALT work, this phrase means "a leakage rate measured during DALT field acceptance testing which exceeds the leakage rate allowed by Appendix D REQUIREMENTS FOR DUCT AIR LEAK TESTING." When applied to TAB work this phrase means "a measurement taken during TAB field acceptance testing which does not comply with the requirements indicated in the paragraph WORKMANSHIP."
- i. Season of maximum heating load: The time of year when the outdoor temperature at the project site remains within **plus or minus 20 degrees Fahrenheit** of the project site's winter outdoor design temperature, throughout the period of TAB data recording.
- j. Season of maximum cooling load: The time of year when the outdoor temperature at the project site remains within **plus or minus 5 degrees Fahrenheit** of the project site's summer outdoor design temperature, throughout the period of TAB data recording.
- k. Season 1, Season 2: Depending upon when the project HVAC is completed and ready for TAB, Season 1 is defined, thereby defining Season 2. Season 1 could be the season of maximum heating load, or the season of maximum cooling load.
- l. Sound measurements terminology: Defined in **AABC MN-1**, **NEBB MASV**, or **SMACNA 1858** (TABB).
- m. TAB: Testing, adjusting, and balancing
- n. TAB'd: Testing/Adjusting/Balancing procedures performed

- o. TAB Agency: TAB Firm
- p. TABB: Testing Adjusting and Balancing Bureau

1.2.1 Similar Terms

In some instances, terminology differs between the Contract and the TAB Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results.

The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding AABC, NEBB, or TABB requirements where differences exist.

SIMILAR TERMS			
Contract Term	AABC Term	NEBB Term	TABB Term
TAB Standard	National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems	Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems	HVAC Systems Testing, Adjusting, and Balancing
TAB supervisor or Team Supervisor	TAB Engineer	TAB Supervisor	TAB Supervisor
Systems Readiness Check	Construction Phase Inspection	Field Readiness Check & Preliminary Field Procedures	Field Readiness Check & Prelim. Field Procedures

1.3 WORK DESCRIPTION

The work includes duct air leakage testing (DALT) and testing, adjusting, and balancing (TAB) of new heating, ventilating, and cooling (HVAC) air and water distribution systems including equipment and performance data, ducts, and piping which are located within, on, under, between, and adjacent to buildings.

Perform TAB in accordance with the requirements of the TAB procedural standard recommended by the TAB trade association that approved the TAB Firm's qualifications. Comply with requirements of [AABC MN-1](#), [NEBB PROCEDURAL STANDARDS](#), or [SMACNA 1780](#) (TABB) as supplemented and modified by this specification section. All recommendations and suggested practices contained in the TAB procedural standards are considered mandatory.

Conduct DALT and TAB of the indicated existing systems and equipment and submit the specified DALT and TAB reports for approval. Conduct DALT testing in compliance with the requirements specified in [SMACNA 1972 CD](#), except as supplemented and modified by this section. Conduct DALT and TAB work in accordance with the requirements of this section.

1.3.1 Air Distribution Systems

Test, adjust, and balance (TAB) systems in compliance with this section. Obtain Contracting Officer's written approval before applying insulation to exterior of air distribution systems as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

1.3.2 Water Distribution Systems

TAB systems in compliance with this section. Obtain Contracting Officer's written approval before applying insulation to water distribution systems as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. At Contractor's option and with Contracting Officer's written approval, the piping systems may be insulated before systems are TAB'd.

Terminate piping insulation immediately adjacent to each flow control valve, automatic control valve, or device. Seal the ends of pipe insulation and the space between ends of pipe insulation and piping, with waterproof vapor barrier coating.

After completion of work under this section, insulate the flow control valves and devices as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

1.3.3 Domestic Hot Water Distribution Systems

TAB systems in compliance with this section. Obtain Contracting Officer's written approval before applying insulation to water distribution systems as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. At Contractor's option and with Contracting Officer's written approval, the piping systems may be insulated before systems are TAB'd.

Terminate piping insulation immediately adjacent to each flow control valve, automatic control valve, or device. Seal the ends of pipe insulation and the space between ends of pipe insulation and piping, with waterproof vapor barrier coating.

After completion of work under this section, insulate the flow control valves and devices as specified under Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

1.3.4 Related Requirements

Requirements for price breakdown of HVAC TAB work are specified in Section 01 20 00.05 20 PRICE AND PAYMENT PROCEDURES FOR DESIGN-BUILD.

Requirements for construction scheduling related to HVAC TAB work are specified in Section 01 32 17.00 20 COST LOADED NETWORK ANALYSIS SCHEDULES (NAS).

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Independent TAB Agency and Personnel Qualifications; G

Pre-Field Engineering Report; G

SD-06 Test Reports

Completed Pre-Final DALT Report; G

Certified Final DALT Report; G

Certified Final TAB Report for Proportional Balancing; G

Certified Final TAB Report for Season 1; G

Certified Final TAB Report for Season 2; G

SD-07 Certificates

Independent TAB Agency and Personnel Qualifications; G

Advance Notice of Pre-Final DALT Field Work; G

Advance Notice of TAB Field Work for Proportional Balancing; G

Advance Notice of TAB Field Work for Season 1; G

Advance Notice of TAB Field Work for Season 2 G

1.5 QUALITY ASSURANCE

1.5.1 Independent TAB Agency and Personnel Qualifications

To secure approval for the proposed agency, submit information certifying that the TAB agency is a first tier subcontractor who is not affiliated with any other company participating in work on this contract, including design, furnishing equipment, commissioning, or construction. Further, submit the following, for the agency, to Contracting Officer for approval:

a. Independent AABC or NEBB or TABB TAB agency:

TAB agency: AABC registration number and expiration date of current certification; or NEBB certification number and expiration date of current certification; or TABB certification number and expiration date of current certification.

b. TAB Agency Team Members

TAB agency employees approved to accomplish work on this contract must be permanent employees of the TAB agency. No other personnel are allowed to perform TAB work on this contract.

TAB team supervisor: Name and copy of AABC or NEBB or TABB TAB supervisor certificate and expiration date of current certification.

TAB team field leader: Name and copy of AABC or NEBB or TABB TAB

certificate, and documented evidence, including a list of projects, roles performed, and associated dates, that the team field leader has satisfactorily performed full-time supervision of TAB work in the field for not less than 3 years immediately preceding this contract's bid opening date.

TAB team field technicians: Names and documented evidence, including a list of projects, roles performed, and associated dates, that each field technician has satisfactorily assisted a TAB team field leader in performance of TAB work in the field for not less than one year immediately preceding this contract's bid opening date.

Current certificates: Registrations and certifications are current, and valid for the duration of this contract. Renew Certifications which expire prior to completion of the TAB work, in a timely manner so that there is no lapse in registration or certification. TAB agency or TAB team personnel without a current registration or current certification are not to perform TAB work on this contract.

- c. Replacement of TAB team members: Replacement of members may occur if each new member complies with the applicable personnel qualifications and each is approved by the Contracting Officer.

1.5.2 TAB Standard

Perform TAB in accordance with the requirements of the standard under which the TAB Firm's qualifications are approved, i.e., [AABC MN-1](#), [NEBB PROCEDURAL STANDARDS](#), or [SMACNA 1780](#) unless otherwise specified herein. All recommendations and suggested practices contained in the TAB Standard are considered mandatory. Use the provisions of the TAB Standard, including checklists, report forms, etc., as nearly as practical, to satisfy the Contract requirements. Use the TAB Standard for all aspects of TAB, including qualifications for the TAB Firm and Specialist and calibration of TAB instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the TAB Standard, adhere to the manufacturer's recommendations.

All quality assurance provisions of the TAB Standard such as performance guarantees are part of this contract. For systems or system components not covered in the TAB Standard, TAB procedures must be developed by the TAB Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the TAB Standard used (AABC, NEBB, or TABB), the requirements and recommendations contained in these procedures and requirements are considered mandatory, including the latest requirements of [ASHRAE 62.1](#).

1.5.3 Sequencing and Scheduling

1.5.3.1 Projects with Phased Construction

This specification section is structured as though the HVAC construction, and thereby the TAB work, will be completed in a single phase. When the construction is completed in phases, the DALT work and TAB work must be planned, completed, and accepted for each construction phase.

1.5.3.2 DALT and TAB Submittal and Work Schedule

Comply with requirements specified in Appendix C: DALT AND TAB SUBMITTAL AND WORK SCHEDULE included at the end of this section.

1.5.4 Subcontractor Special Requirements

Perform all work in this section in accordance with the paragraph SUBCONTRACTOR SPECIAL REQUIREMENTS in Section 01 30 00.05 20 ADMINISTRATIVE REQUIREMENTS FOR DESIGN BUILD, stating that all contract requirements of this section must be accomplished directly by a first tier subcontractor. No work may be performed by a second tier subcontractor.

1.5.5 Instrument Calibration Certificates

It is the responsibility of the TAB firm to provide instrumentation that meets the minimum requirements of the standard under which the TAB Firm's qualifications are approved for use on a project. Instrumentation must be in proper operating condition and must be applied in accordance with the instrumentation's manufacturer recommendations.

All instrumentation must bear a valid NIST traceable calibration certificate during field work and during government acceptance testing. All instrumentation must be calibrated within no later than one year of the date of TAB work or government acceptance testing field work.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 WORK DESCRIPTIONS OF PARTICIPANTS

Comply with requirements of this section as specified in Appendix A WORK DESCRIPTIONS OF PARTICIPANTS.

3.1.1 PRE-FIELD ENGINEERING REPORT

Comply with the requirements specified in Appendix B REPORTS - DALT and TAB included at the end of this section.

3.2 PRE-DALT/TAB MEETING

Meet with the Contracting Officer's technical representative (COTR) to develop a mutual understanding relative to the details of the DALT work and TAB work requirements. Ensure that the TAB supervisor is present at this meeting. Requirements to be discussed include required submittals, work schedule, and field quality control.

3.3 DALT PROCEDURES

3.3.1 Prerequisite for DALT Field Work

Complete the following prior to starting DALT field work:

- a. Receive approval of the SD-01 Preconstruction Submittals.
- b. Installation and sealing in conformance with Section 23 30 00 HVAC AIR

DISTRIBUTION, except as supplemented and modified by this section, of those duct systems to be DALT'd.

- c. All work items and inspections indicated by the TAB Team Supervisor that need to be accomplished before DALT field work can be performed.
- d. Furnish the TAB Team Supervisor a copy of the ductwork sheet metal shop or design drawings indicating the completed duct systems available for DALT.

3.3.2 Instruments, Consumables and Personnel

Provide instruments, consumables and personnel required to accomplish the DALT field work. Follow the same basic procedure specified below for TAB Field Work, including maintenance and calibration of instruments, selection of appropriate instruments to meet the accuracy requirements of measurements, accuracy of measurements, preliminary procedures, field work, workmanship and treatment of deficiencies. Calibrate and maintain instruments in accordance with manufacturer's written procedures.

3.3.3 Advance Notice of Pre-Final DALT Field Work

On completion of the installation of each duct system indicated to be DALT'd, notify the Contracting Officer in writing prior to the COTR's duct selection field visit.

3.3.4 Ductwork To Be DALT'd

All duct systems are subject to DALT including supply, return, outside air, exhaust, and relief with exception of transfer air. From each duct system indicated as subject to DALT, the COTR will randomly select sections of each completed duct system for testing by the Contractor's TAB Firm. The sections selected will not exceed 20 percent of the total measured linear footage of duct systems indicated as subject to DALT. Sections of duct systems subject to DALT will include 20 percent of main ducts, sub-main ducts, branch main ducts, branch ducts and plenums.

It is acceptable for an entire duct system to be DALT'd instead of disassembling that system in order to DALT only the 20 percent portion specified above.

It is acceptable to DALT the entire duct systems for 20 percent of the total quantity of similar units (i.e. WSHPs less than 5 tons cooling capacity, VAVs, and FCUs) instead of testing 20 percent of the linear footage of duct systems for each of these units.

Sealing of all selected duct systems is prohibited, with exception of temporary end caps and connection for test apparatus, from time Contractor is notified of selections until DALT measurements are recorded.

3.3.5 DALT Testing

Perform DALT on the duct sections of each duct system as selected by the COTR. Use the duct class, seal class, leakage class and the leak test pressure data indicated on the drawings, to comply with the procedures specified herein and in **SMACNA 1972 CD**.

In spite of specifications of **SMACNA 1972 CD** to the contrary, DALT ductwork of construction class of **3-inch** water gauge static pressure and

below if indicated to be DALT'd. Complete DALT work on the COTR selected ductwork within 48 hours after the particular ductwork was selected for DALT. Separately conduct DALT work for large duct systems to enable the DALT work to be completed in 48 hours.

3.3.6 Completed Pre-Final DALT Report

After completion of the DALT work, prepare a Pre-final DALT Report meeting the additional requirements specified in Appendix B REPORTS - DALT and TAB. Data required by those data report forms shall be furnished by the TAB team. Prepare the report neatly and legibly; the Pre-final DALT report shall provide the basis for the Final DALT Report.

TAB supervisor shall review, approve and sign the Pre-Final DALT Report and submit this report within two days of completion of DALT field work. Verbally notify the COTR that the field check of the Pre-Final DALT Report data can commence.

Further, if any data on the Pre-final DALT report form for a given duct section is out-of-tolerance, report the failure, notify the COTR, and resolve all deficiencies. Repairs shall be applied to similar conditions in all untested duct systems. For each failed duct section, DALT shall be conducted on one additional duct section as selected by the COTR.

3.3.7 Quality Assurance - COTR DALT Field Acceptance Testing

In the presence of the COTR and TAB team field leader, verify for accuracy Pre-final DALT Report data selected by the COTR. For each duct system, this acceptance testing shall be conducted on a maximum of 50 percent of the duct sections DALT'd.

Further, if any Acceptance Testing Measurement for a given duct section is out-of-tolerance, report the failure, and resolve all deficiencies. Repairs shall be applied to similar conditions in all untested duct systems. For each failed duct section, DALT shall be conducted on one additional duct section as selected by the COTR.

3.3.8 Additional COTR Field Acceptance Testing

If any of the duct sections checked for a given system are determined to have a leakage rate measured that exceeds the leakage rate allowed by SMACNA Leak Test Manual for an indicated duct construction class and sealant class, terminate data checking for that section. The associated Pre-final DALT Report data for the given duct system will be disapproved. Make the necessary corrections and prepare a revised Pre-final DALT Report. Reschedule a field check of the revised report data with the COTR.

3.3.9 Certified Final DALT Report

On successful completion of all field checks of the Pre-Final DALT Report data for all systems, the TAB Supervisor shall assemble, review, approve, sign and submit the Final DALT Report in compliance with Appendix B REPORTS - DALT and TAB to the Contracting Officer for approval.

3.4 TAB PROCEDURES

3.4.1 Prerequisite for TAB Field Work

Complete the following prior to starting TAB field work:

- a. All DALT field work and obtain approval of the Certified Final DALT Report.
- b. All work items and inspections indicated by the TAB Team Supervisor that need to be accomplished before TAB field work can be performed.
- c. Enclosure of the building envelope according to the contract documents with final construction completed, the Air Barrier Pressure Test completed, and the Air Leakage Test Reports and Diagnostic Test Reports submitted and approved in accordance with Specification Section 07 05 23 PRESSURE TESTING AN AIR BARRIER SYSTEM FOR AIR TIGHTNESS.
- d. Approval of the manufacturer's equipment start-up forms for each piece of equipment to be TAB'd.
- e. Prerequisite TAB requirements of Section 01 91 00.15 22 TOTAL BUILDING COMMISSIONING.

3.4.2 TAB Field Work

Provide instruments and consumables required to accomplish the TAB work. Calibrate and maintain instruments in accordance with manufacturer's written procedures.

Test, adjust, and balance systems until measured flow rates (air and water flow) are in compliance with the paragraph WORKMANSHIP. Conduct TAB work, including measurement accuracy, and sound measurement work in conformance with the AABC MN-1 and or NEBB PROCEDURAL STANDARDS and NEBB MASV or SMACNA 1780 (used by TABB), and SMACNA 1858 sound measurement procedures, except as supplemented and modified by this section. The only measurement data which can be deferred until Season 1 and Season 2 is that data which would be affected in terms of accuracy due to outside ambient conditions and is reported in TAB Report for Season 1 and for Season 2. TAB Report for Proportional Balancing may include data for Season 1 when measured within seasonal limitations.

3.4.3 Preliminary Procedures

Use the approved pre-field engineering report, in addition to all applicable requirements within this section, as instructions and procedures for accomplishing TAB field work. TAB engineer is to locate, in the field, test ports required for testing. It is the responsibility of the Contractor to provide and install test ports as required by the TAB engineer.

3.4.4 TAB Air Distribution Systems

3.4.4.1 Air Handling Units

Air handling unit systems including fans (air handling unit fans, exhaust fans and winter ventilation fans), coils, ducts, plenums, mixing boxes, terminal units, variable air volume boxes, and air distribution devices for supply air, return air, outside air, mixed air relief air, and makeup air.

3.4.4.2 Heating and Ventilating Units

Heating and ventilating unit systems including fans, coils, ducts, plenums, roof vents, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.

3.4.4.3 Makeup Air, Dedicated Outside Air System and Energy Recovery Units

Makeup air, Dedicated Outside Air System and Energy Recovery unit systems including fans, coils, ducts, plenums, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and exhaust air.

3.4.4.4 Return Air Fans

Return air fan system including fan ducts, plenums, registers, diffusers, grilles, and louvers for supply air, return air, outside air, and mixed air.

3.4.4.5 Fan Coils

Fan coil unit systems including fans, coils, ducts, plenums, and air distribution devices for supply air, return air, and outside air.

3.4.4.6 Exhaust Fans

Exhaust fan systems including fans, ducts, plenums, grilles, and hoods for exhaust air.

3.4.5 TAB Water Distribution Systems

3.4.5.1 Chilled Water

Chilled water systems including chillers, condensers, cooling towers, pumps, coils, system balance valves and flow measuring devices.

For water chillers, report data as required by AABC, NEBB and TABB standard procedures, including refrigeration operational data.

3.4.5.2 Heating Hot Water

Heating hot water systems including boilers, hot water converters (e.g., heat exchangers), pumps, coils, system balancing valves and flow measuring devices.

3.4.5.3 Domestic Hot Water System

Domestic hot water systems including boilers, water heaters, pumps, system balancing valves, and flow measuring devices.

3.4.6 TAB Equipment with Thermal Energy Transfer Components

Perform capacity tests to verify that the thermal energy transfer components, devices, and equipment meet the indicated design capacity. Describe the procedure performed for each test. Water temperatures shall be measured through immersion into fluid stream. Report all design data, actual field measurements, and calculations for all components, devices and equipment below.

3.4.6.1 Units with Coils

Report heating and cooling performance capacity tests for hot water, chilled water, direct-expansion, and steam coils:

- a. For units with capacities greater than 26,370 Watts 7.5 tons (90,000 BTU/H) cooling, such as factory manufactured units, central built-up units and rooftop units, determine the apparent air-side coil capacity by calculations utilizing direct measurement of airflow via Pitot tube duct traverse, single point measurements of entering and leaving wet and dry bulb temperatures for cooling capacity and dry bulb temperature only for heating capacity. Calculate water-side coil capacity utilizing direct measurements of water flow rate, and entering and leaving water temperatures. Measure and record coil water pressure drop.
- b. For units with capacities of 26370 Watts 7.5 tons (90,000 BTU/H) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps, determine the apparent air side coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures for cooling capacity and dry bulb temperature only for heating capacity.

3.4.6.2 Units with Heat Recovery Devices

Report heating and cooling energy recovery performance tests for energy recovery devices (wheels, coils, fixed plate, etc.).

Report total cooling capacity, heating capacity and energy recovery effectiveness. For outside air and exhaust airstreams measure and report airflows, and entering and leaving wet and dry bulb temperatures across heat recovery device. For water-side calculations, utilize direct measurements of water flow rate and entering and leaving water temperatures. Measure and record water pressure drops.

3.4.6.3 Thermal Energy Transfer Equipment

Report heating and/or cooling performance capacity tests for thermal energy transfer equipment (boilers, chillers, cooling towers, etc.) as applicable.

Measure and report water flow rate, water-side pressure drops, and entering and leaving water temperature. Report capacity.

3.4.7 TAB Building Pressure

Record building differential pressure for all sides of the building on each floor where openings exist to obtain differential pressure measurements. Report all system setup parameters affecting building pressure measurement (e.g. exhaust/relief, outdoor air) and indicate wind speed during time of building pressure measurements. Measure in maximum and minimum building systems configuration.

3.4.8 Sound Measurement Work

3.4.8.1 Areas To Be Sound Measured

In the following spaces, measure and record the sound power level for each octave band listed in [ASHRAE HVAC APP IP HDBK](#) Noise Criteria:

- a. All HVAC mechanical rooms, including machinery spaces and other spaces containing HVAC power drivers and power driven equipment.
- b. All spaces sharing a common barrier with each mechanical room, including rooms overhead, rooms on the other side of side walls, and rooms beneath the mechanical room floor.

3.4.8.2 Procedure

Measure sound levels in each room, when unoccupied except for the TAB team, with all HVAC systems that would cause sound readings in the room operating in their noisiest mode. Record the sound level in each octave band. Attempt to mitigate the sound level and bring the level to within the specified [ASHRAE HVAC APP IP HDBK](#) noise criteria goals, if such mitigation is within the TAB team's control. State in the report the [ASHRAE HVAC APP IP HDBK](#) noise criteria goals. If sound level cannot be brought into compliance, provide written notice of the deficiency to the Contractor for resolution or correction.

3.4.8.3 Timing

Measure sound levels at times prescribed by AABC or NEBB or TABB.

3.4.8.4 Meters

Measure sound levels with a sound meter complying with [ASA S1.4](#), Type 1 or 2, and an octave band filter set complying with [ASA S1.11 PART 1](#). Use measurement methods for overall sound levels and for octave band sound levels as prescribed by NEBB.

3.4.8.5 Calibration

Calibrate sound levels as prescribed by AABC or NEBB or TABB, except that calibrators emitting a sound pressure level tone of 94 dB at 1000 hertz (Hz) are also acceptable.

3.4.8.6 Background Noise Correction

Determine background noise component of room sound (noise) levels for each (of eight) octave bands as prescribed by AABC or NEBB or TABB.

3.4.9 TAB Work on Performance Tests With Seasonal Limitations

3.4.9.1 Performance Tests

In addition to the TAB [proportional balancing](#) work on the air distribution systems and the water distribution systems, accomplish TAB work on the HVAC systems which directly transfer thermal energy. TAB the operational performance of the heating systems and cooling systems in accordance with the paragraph TAB EQUIPMENT WITH THERMAL ENERGY TRANSFER COMPONENTS.

3.4.9.2 Season Of Maximum Load

Visit the contract site for at least two TAB work sessions for [Season 1](#) and [Season 2](#) field measures. Visit the contract site during the season of maximum heating load and visit the contract site during the season of maximum cooling load, the goal being to TAB the operational performance of the heating systems and cooling systems under their respective maximum outdoor environment-caused loading. During the seasonal limitations, TAB the operational performance of the heating systems and cooling systems.

3.4.9.3 Ambient Temperatures

On each TAB report form used for recording data, record the outdoor and indoor ambient dry bulb temperature range and the outdoor and indoor ambient wet bulb temperature range within which the report form's data was recorded. Record these temperatures at beginning and at the end of data taking.

3.4.9.4 Sound Measurements

Comply with the paragraph SOUND MEASUREMENT WORK, specifically, the requirement that a room must be operating in its noisiest mode at the time of sound measurements in the room. The maximum noise level measurements could depend on seasonally related heat or cooling transfer equipment.

3.4.10 Workmanship

Conduct TAB work on the HVAC systems until measured flow rates are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. Further, balance air distribution systems until measured outside air flow rates are within plus 10 percent and minus 0 percent of design flow rates and measured exhaust air flow rates are within plus 0 percent and minus 10 percent of design flow rates as specified or indicated on the contract documents, except so not violate code minimum airflow requirements. For air terminals with volumetric flow rates 50 CFM or less, conduct TAB work until measured flow rates are within the greater of: plus 10 or minus 10 percent, or plus 3 CFM or minus 3 CFM. This TAB work includes adjustment of balancing valves, balancing dampers, and sheaves. Further, this TAB work includes changing out fan sheaves and pump impellers if required to obtain air and water flow rates specified or indicated. If, with these adjustments and equipment changes, the specified or indicated design flow rates cannot be attained, contact the Contracting Officer for direction.

Conduct TAB field acceptance testing verifying measured data falls within the range of plus 5 to minus 5 percent of the TAB Report data. Further, verify measured volumetric flow rates for air terminals 50 CFM or less fall within the greater of: plus 10 or minus 10 percent, or plus 3 CFM or minus 3 CFM from design flow rates.

3.4.11 Design/Construction Deficiencies

Strive to meet the intent of this section to maximize the performance of the equipment as designed and installed. However, if deficiencies in equipment design or installation prevent TAB work from being accomplished within the range of design values specified in the paragraph WORKMANSHIP, provide written notice as soon as possible to the Contractor and the Contracting Officer describing the deficiency and recommended correction.

Within 3 working days after the TAB Agency has encountered any design or installation deficiencies, the TAB Supervisor must submit written notification directly to the Contracting Officer, with a separate copy to the Contractor, of all such deficiencies. Provide in this submittal a complete explanation, including supporting documentation, detailing deficiencies. Where deficiencies are encountered that are believed to adversely impact successful completion of:

- a. TAB Field Work: the TAB Agency must issue notice and request direction in the notification submittal.
- b. COTR TAB Field Acceptance Testing or Commissioning: the TAB Agency must issue notice and the Contractor must, within 5 working days of the TAB Agency notice, submit written notification directly to the Contracting Officer, with a separate copy to the TAB Agency, of all such deficiencies, the intended or implemented corrective action, the planned or actual date(s) for completion of each corrective action.

The Contractor must submit notification of construction deficiencies in accordance with the paragraph titled INFORMATION FOR THE CONTRACTING OFFICER in Section 01 45 00.05 20 DESIGN AND CONSTRUCTION QUALITY CONTROL. This notification is in lieu of other notification within this section.

Responsibility for correction of installation deficiencies is the Contractor's. If a deficiency is in equipment design, call the TAB team supervisor for technical assistance. Responsibility for reporting design deficiencies to Contractor is the TAB team supervisor's.

3.4.12 TAB Reports

Additional requirements for TAB Reports are specified in Appendix B REPORTS - DALT and TAB

3.4.13 Quality Assurance - COTR TAB Field Acceptance Testing

3.4.13.1 TAB Field Acceptance Testing

Field acceptance testing of performance capacity data from TAB work with seasonal limitations is to be performed during comparable outdoor conditions as those during the TAB work for the approved Final TAB Report for Season 1 and for Season 2, respectively, as determined by the COTR.

During the field acceptance testing, verify, in the presence of the COTR, random selections of data (water, air quantities, air motion, temperature, pressure, sound level readings) recorded in the TAB Report. Points and areas for field acceptance testing are to be selected by the COTR. Measurement and test procedures are the same as required for TAB work for the TAB Report.

Field acceptance testing includes verification of TAB Report data recorded for the following equipment groups:

Group 1: All chillers, boilers, cooling towers, pumps, return fans, computer room units, energy recovery units, and air handling units (rooftop and central stations).

Group 2: 25 percent of the terminal units (e.g.: VAV boxes, water source heat pumps, fan coil units, etc.) and associated diffusers and

registers.

Group 3: 25 percent of the supply diffusers, registers, grilles associated with air handling equipment (e.g.: AHUs, water source heat pumps, fan coil units, etc.).

Group 4: 25 percent of the return grilles, return registers, exhaust grilles and exhaust registers.

Group 5: 25 percent of the supply fans and exhaust fans.

3.4.13.2 Additional COTR TAB Field Acceptance Testing

If any of the acceptance testing measurements for a given equipment group is found out of tolerance, terminate data verification for all affected data for that group. The affected data for the given group will be disapproved. Make the necessary corrections and prepare a revised TAB Report. Reschedule acceptance testing of the revised report data with the COTR.

3.4.13.3 Prerequisite for Approval

Compliance with the field acceptance testing requirements of this section is a prerequisite for the final Contracting Officer approval of the Final TAB Report submitted and of the acceptance of the facility for occupancy.

3.5 MARKING OF SETTINGS

Upon the final TAB work approval, permanently mark the settings of HVAC adjustment devices including valves, gauges, splitters, and dampers so that adjustment can be restored if disturbed at any time. Label variable frequency drives with final frequency (Hz) and control setpoint. Provide permanent markings clearly indicating the settings on the adjustment devices which result in the data reported on the submitted TAB report.

3.6 MARKING OF TEST PORTS

The TAB team is to permanently and legibly mark and identify the location points of the duct test ports. If the ducts have exterior insulation, make these markings on the exterior side of the duct insulation. Show the location of test ports on the as-built mechanical drawings with dimensions given where the test port is covered by exterior insulation.

3.7 APPENDICES

Appendix A WORK DESCRIPTIONS OF PARTICIPANTS
Appendix B REPORTS - DALT and TAB
Appendix C DALT AND TAB SUBMITTAL AND WORK SCHEDULE
Appendix D REQUIREMENTS FOR DUCT AIR LEAK TESTING

Appendix A

WORK DESCRIPTIONS OF PARTICIPANTS

The Contractor is responsible for ensuring compliance with all requirements of this specification section. However, the following delineation of specific work items is provided to facilitate and co-ordinate execution of the various work efforts by personnel from separate organizations.

1. Contractor

- a. HVAC documentation: Provide pertinent contract documentation to the TAB Firm, to include the following: the contract drawings and specifications; copies of the approved submittal data for all HVAC equipment, air distribution devices, and air/water measuring/balancing devices; the construction work schedule; and other applicable documents requested by the TAB Firm. Provide the TAB Firm copies of contract revisions and modifications as they occur.
- b. Schedules: Ensure the requirements specified in Appendix C "DALT and TAB Submittal and Work Schedule" are met.
- c. Pre-DALT / TAB meeting: Arrange and conduct the Pre-DALT and TAB meeting. Ensure that a representative is present for the sheet metal contractor, the mechanical contractor, the electrical contractor, and the automatic temperature controls contractor.
- d. Advance Notice: Monitor the completion of the duct systems' installation and provide the Advance Notice for Pre-Final DALT field work as specified.
- e. Coordinate Support: Provide and coordinate support personnel required by the TAB Firm in order to accomplish the DALT and TAB field work. Support personnel may include factory representatives, HVAC controls installers, HVAC equipment mechanics, sheet metal workers, pipe fitters, and insulators. Ensure support personnel are present at the work site at the times required.
- f. Correct Deficiencies: Ensure the resolution of Construction Deficiencies are provided as specified herein. Refer to the paragraph DESIGN/CONSTRUCTION DEFICIENCIES. Correct each deficiency as soon as practical with the Contracting Officer, and submit revised schedules and other required documentation.
- g. Pre-TAB Field Work: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as pre-TAB field work items, the deficiencies pointed out by the TAB team supervisor in the design review report.

Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's DALT and TAB Work Procedures Summary.

- h. Give Notice of Testing: Submit advance notice of [proportional](#)

balancing, Season 1, and Season 2 TAB field work.

- i. Insulation work: Insulation must not be installed on ducts to be DALT'd until DALT field acceptance testing on the subject ducts is complete.

Ensure the duct and piping systems are properly insulated and vapor sealed upon the successful completion and acceptance of the DALT and TAB work.

- j. Duct Concealment: Ducts to be DALT'd must not be concealed until DALT field acceptance testing on the subject ducts is complete.

2. TAB Team Supervisor

- a. Overall management: Supervise and manage the overall TAB team work effort, including preliminary and technical DALT and TAB procedures and TAB team field work.
- b. Schedule: Ensure the requirements specified in Appendix C "DALT and TAB Submittal and Work Schedule" are met.
- c. Submittals: Provide the submittals specified herein.
- d. Pre-DALT/TAB meeting: Attend meeting with Contractor. Ensure TAB personnel that will be involved in the TAB work under this contract attend the meeting.
- e. Pre-Field Engineering Report: Submit typed report described in Appendix B "Reports - DALT and TAB".
- f. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency; such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the Pre-Field Engineering Report or during the DALT or TAB field work.

Ensure the Contractor is properly notified and aware of all support personnel needed to perform the TAB work. Maintain communication with the Contractor regarding support personnel throughout the duration of the TAB field work, including the TAB field acceptance testing checking.

Ensure all inspections and verifications necessary to start DALT field work and TAB field work are completely and successfully conducted before DALT and TAB field work is performed.

- g. Technical Assistance: Provide technical assistance to the DALT and TAB field work.
- h. Deficiencies Notification: Ensure the notifications of Construction Deficiencies are provided as specified herein. Comply with requirements of the paragraph DESIGN/CONSTRUCTION DEFICIENCIES.
- i. Procedures: Develop the required TAB procedures for systems or system components not covered in the TAB Standard.

3. TAB Team Field Leader

- a. Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, EXECUTION.
- b. Full time: Be present at the contract site when DALT field work or TAB field work is being performed by the TAB team; ensure day-to-day TAB team work accomplishments are in compliance with this section.
- c. Prerequisite HVAC work: Do not bring the TAB team to the contract site until notification that all work items and inspections identified to the Contractor by the TAB team supervisor are completed, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

Appendix B

REPORTS - DALT and TAB

All submitted documentation must be typed, neat, and organized. All reports must have a title page, a certification page, sequentially numbered pages throughout, and a table of contents. Tables, lists, and diagrams must be titled. Generate and submit for approval the following documentation:

1. Pre-Field Engineering Report

a. DALT and TAB Procedures Summary

Submit a detailed narrative describing all aspects of the DALT and TAB field work to be performed. Clearly distinguish between DALT information and TAB information. Include the following:

- (1) A list of the intended procedural steps for the DALT and TAB field work from start to finish. Indicate how each type of data measurement will be obtained. Include what Contractor support personnel are required for each step, and the tasks they need to perform.
- (2) A list of the project's submittals that are needed by the TAB Firm in order to meet this Contract's requirements.
- (3) The data presentation forms to be used in the report, with the preliminary information and initial design values filled in.
- (4) A list of DALT and TAB instruments to be used, edited for this project, to include the instrument name and description, manufacturer, model number, scale range, published accuracy, most recent calibration date, and what the instrument will be used for on this project.
- (5) A thorough checklist of the work items and inspections that need to be accomplished before DALT field work can be performed.
- (6) A thorough checklist of the work items and inspections that need to be accomplished before the Season 1 TAB field work can be performed.
- (7) A thorough checklist of the work items and inspections that need to be accomplished before the Season 2 TAB field work can be performed.
- (8) The checklists specified above shall be individually developed and tailored specifically for the work under this contract. Refer to **NEBB PROCEDURAL STANDARDS**, Section III, "Preliminary TAB Procedures" under the paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" for examples of items to include in the checklists.

b. Design Review Report:

Review the contract specifications and drawings to verify that the TAB work can be successfully accomplished in compliance with the

requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, manual volume dampers, and required straight duct and pipe runs for accurate measurements.

Submit a typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the DALT work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. If no deficiencies are evident, state so in the report.

c. TAB Schematic Drawings

The schematic drawings to be used in the required reports, may include building floor plans, mechanical room plans, duct system plans, equipment elevations, and diagrams. Indicate intended TAB measurement locations, including where test ports need to be provided by the Contractor.

Show the following information on TAB Schematic Drawings:

- (1) A unique number or mark for each piece of equipment or terminal.
- (2) Air quantities at air terminals.
- (3) Air quantities and temperatures from air handling unit schedules.
- (4) Water quantities and temperatures from thermal energy transfer equipment schedules.
- (5) Water quantities and heads from pump schedules.
- (6) Water flow measurement fittings and balancing fittings.

d. Instrument Calibration Certificates

e. List of TAB Related Submittals

Prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all TAB. Ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.

2. Pre-Final DALT Report

Report the data for the Pre-Final DALT Report meeting the following requirements:

- a. Procedures: Describe how actual field test procedures differed from the previously approved DALT Procedures Summary.
- b. Report format: Submit a comprehensive report for the DALT field work data using data presentation forms equivalent to the "Air Duct Leakage Test Summary Report Forms" located in the [SMACNA 1972 CD](#). All form data must be recorded for each test iteration of each duct section selected. Report forms for each test must indicate either "Pass" or "Fail". In addition, submit in the report, a marked duct shop drawing which identifies each section of duct tested with assigned node

numbers for each section. Node numbers shall be included in the completed report forms to identify each duct section.

- c. Calculations: Include a copy of all calculations prepared in determining the duct surface area and the allowable leakage of each duct test section.
- d. Instruments: Include in the DALT reports copy(s) of the calibration curve for each of the DALT test orifices used for testing. List the types of instruments actually used to measure the data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date. Instruments are to be calibrated within one year of the date of use in the field; instrument calibration is to be traceable to the measuring standards of the National Institute of Standards and Technology.
- e. TAB Supervisor Approval: Include on the submitted report the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

3. Certified Final DALT Report

On successful completion of all COTR field checks of the Pre-final DALT Report data for all systems, the TAB Supervisor shall assemble, review, sign and submit the Final DALT Report containing all Pre-Final DALT Reports to the Contracting Officer for approval.

4. TAB Reports

Submit TAB Reports for Proportional Balancing, Season 1, and Season 2 in the following manner:

- a. Procedure Summary: Submit a copy of the approved DALT and TAB Procedures Summary. When applicable, provide notations describing how actual field procedures differed from the procedures listed.
- b. Report format: Submit the completed data forms approved in the Pre-Field Engineering Report completed by TAB field team, reviewed, approved and signed by the TAB supervisor. Include a table of contents identifying by page number the location of each report. Report forms and report data shall be typewritten. Handwritten report forms or report data are not acceptable.
- c. Schematic Drawings: Provide updated drawings and diagrams with final installed locations of all terminals and devices, any numbering changes, and actual test locations including duct traverse and static pressure measurement locations.
- d. Air Static Pressure Profiles: Report static pressure profiles for air duct systems including: All AHU systems and equipment with duct distribution systems including make-up air units, etc.. Report static pressure data for all supply, return, relief, exhaust and outside air ducts for the systems listed. The static pressure report data shall include, in addition to AABC or NEBB or TABB required data, the following:
 - (1) Report supply fan, return fan, relief fan, and exhaust fan inlet and discharge static pressures.

- (2) Report static pressure drop across chilled water coils, DX coils, hot water coils, steam coils, electric resistance heating coils and heat reclaim devices installed in unit cabinetry or the system ductwork.
- (3) Report static pressure drop across outside air, return air, and supply air automatic control dampers, both proportional and two-position, installed in unit cabinetry.
- (4) Report static pressure drop across air filters, acoustic silencers, moisture eliminators, air flow straighteners, air flow measuring stations or other pressure drop producing specialty items installed in unit cabinetry, or in the system ductwork. Examples of these specialty items are smoke detectors, white sound generators, RF shielding, wave guides, security bars, blast valves, small pipes passing through ductwork, and duct mounted humidifiers.

Do not report static pressure drop across duct fittings provided for the sole purpose of conveying air, such as elbows, transitions, offsets, plenums, manual dampers, and branch takes-offs.

- (5) Report static pressure drop across outside air and relief/exhaust air louvers.
 - (6) Report static pressure readings of supply air, return air, exhaust/relief air, and outside air in duct at the point where these ducts connect to each air moving unit.
- e. Duct Traverses: Report duct traverses for main and branch main supply, return, exhaust, relief and outside air ducts. This shall include all ducts, including those which lack 7 1/2 duct diameters upstream and 2 1/2 duct diameters downstream of straight duct unobstructed by duct fittings/offsets/elbows. Report all individual velocities on the duct traverses taken. Evaluate the suitability of the duct traverse measurement based on satisfying the qualifications for a pitot traverse plane as defined by [AMCA 203](#), "Field Measurements", Section 8, paragraph 8.3, "Location of Traverse Plane". Report duct traverses for all entering and leaving unit airflows for all air handling equipment exceeding 2,000 cfm. Illustrate in an Equipment Diagram representative of the actual installation.
- f. Open Paths: Ensure all required air and hydronic system open paths are identified.
- g. Instruments: List the types of instruments actually used to measure the TAB data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.
- Instrumentation, used for taking wet bulb temperature readings shall provide accuracy of plus or minus 5 percent at the measured face velocities.
- h. Performance Curves: Include in the TAB Reports, factory pump curves and fan curves for pumps and fans TAB'd on the job, and manufacturer equipment data curves or tables correlating pressure drop and water

flow rate.

- i. Calibration Curves: The TAB Supervisor shall include, in the TAB Reports, a factory calibration curve for installed flow control balancing valves, flow venturis and flow orifices TAB'd on the job.
- j. Supporting Documents: Provide copies of any request for information (RFIs) with the RFI responses, summaries of implemented change order(s), meeting minutes with participants, telephone transcripts with participants, electronic mail with addresses, and other documentation substantiating any deviations of the reported data from the initial contract design documents. Include this documentation in an appendix to the TAB report with sequential numbering of each separate document for reference to the data presentation forms.
- k. Data From TAB Field Work: After completion of the TAB field work, prepare the TAB field data for TAB supervisor's review and approval signature, using the reporting forms approved in the Pre-Field Engineering Report. Data required by those approved data report forms shall be furnished by the TAB team. Record final hydronic differential pressure setpoint, hydronic system fill pressure, glycol percentage, pumps and fan motor frequency in maximum, fan motor frequency in minimum, fan brake horsepower, calibration coefficients, and factors, and primary air static pressure setpoint. Except as approved otherwise in writing by the Contracting Officer, the TAB work and thereby the TAB report shall be considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph WORKMANSHIP.
- l. System configuration: Clearly identify system configurations and conditions affecting data for all reported data. Include all system operational parameters such as device positioning, system diversity, modes of operation, and setpoints necessary to setup and duplicate system cconfiguration.

Appendix C

DALT AND TAB SUBMITTAL AND WORK SCHEDULE

Perform the following items of work in the order listed adhering to the dates schedule specified below. Include the major items listed in this schedule in the project network analysis schedule required by Section 01 32 17.00 20 COST-LOADED NETWORK ANALYSIS SCHEDULES (NAS).

Submit Independent TAB Agency and TAB Personnel Qualifications: Within 42 calendar days after issuance of IFC drawings.

Submit the Pre-Field Engineering Report: Within 28 days after receipt of the approved Independent TAB Agency and TAB Personnel Qualifications.

Meet with the COTR at the Pre-DALT/TAB Meeting: Within 14 calendar days.

(1) Prior to commencement of ductwork installation.

(2) Prior to the ductwork installation preparatory meeting per specification section 01 45 00.05 20 DESIGN AND CONSTRUCTION QUALITY CONTROL.

Advance Notice of Pre-Final DALT Field Work: After the completed installation of the HVAC duct system to be DALT'd, submit to the Contracting Officer an Advance Notice of Pre-Final DALT Field Work.

Ductwork Selected for DALT: Within 14 calendar days after receiving an acceptable Advance Notice of Pre-Final DALT Field Work, the Contracting Officer's technical representative (COTR) will select the project ductwork sections to be DALT'd.

DALT Field Work: Within 48 hours of COTR's selection, complete DALT field work on selected project ductwork.

Submit Pre-Final DALT Report: Within two working days after completion of DALT field work, submit Pre-final DALT Report. Separate Pre-final DALT reports may be submitted to allow phased testing from system to system.

Quality Assurance - COTR DALT Field Checks: Upon approval of the Pre-final DALT Report, the COTR's DALT field check work shall be scheduled with the Contracting Officer.

Submit Final DALT Report: Within 14 calendar days after successful completion of all DALT Work Field Checks

TAB field work for Season 1 may be accomplished concurrent with TAB field work for proportional balancing, when the ambient temperature is within Season 1 limits. When accomplished concurrently, Season 1 TAB Report submittal and Season 1 Quality Assurance shall be concurrent with the Proportional Balancing work items.

Advance Notice of TAB Field Work for Proportional Balancing: At a minimum of 14 calendar days prior to TAB Field Work, submit advance notice of TAB field work for proportional balancing.

TAB Field Work for Proportional Balancing: At a minimum of 84 calendar days prior to Beneficial Occupancy Date (BOD), accomplish TAB field work for proportional balancing, and Season 1, if concurrent.

Submit TAB Report for Proportional Balancing: Within 14 calendar days after completion of TAB field work for proportional balancing, and Season 1, if concurrent.

Proportional Balancing Quality Assurance - COTR TAB Field Acceptance Testing: 30 calendar days after TAB report for proportional balancing, and Season 1, if concurrent, is approved by the Contracting Officer, conduct TAB field acceptance testing.

Complete TAB Work for Proportional Balancing: Prior to BOD, complete all TAB work except Season 1 and Season 2 TAB work and submit Final TAB Report for Proportional Balancing.

When not accomplished concurrent with TAB field work for proportional balancing, accomplish the following seasonal items of work:

Advance Notice of Season 1 TAB Field Work: At a minimum of 14 calendar days prior to Season 1 TAB Field Work, submit advance notice of Season 1 TAB field work.

Season 1 TAB Field Work: At a minimum of 84 calendar days prior to BOD, and when the ambient temperature is within Season 1 limits, accomplish Season 1 TAB field work.

Submit Season 1 TAB Report: Within 14 calendar days after completion of Season 1 TAB field work.

Season 1 Quality Assurance - COTR TAB Field Acceptance Testing: 30 calendar days after Season 1 TAB report is approved by the Contracting Officer, conduct Season 1 TAB field acceptance testing.

Advance Notice of Season 2 TAB Field Work: At a minimum of 126 calendar days after CCD, submit Advance Notice of Season 2 TAB Field Work.

Season 2 TAB Field Work: Within 14 calendar days after date of advance notice of Season 2 TAB field work and when the ambient temperature is within Season 2 limits, accomplish Season 2 TAB field work.

Submit Season 2 TAB Report: Within 14 calendar days after completion of Season 2 TAB field work.

Season 2 Quality Assurance - COTR TAB Field Acceptance Testing: 28 calendar days after the Season 2 TAB report is approved by the Contracting Officer, conduct Season 2 field acceptance testing.

Complete Season 2 TAB Work: Within 14 calendar days after the completion of Season 2 TAB field data check, complete all TAB work.

Appendix D

REQUIREMENTS FOR DUCT AIR LEAK TESITNG

Refer to design drawings for the Duct Construction and Leakage Testing
Table

-- End of Section --

SECTION 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS
02/13

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. At the discretion of the Government, the manufacturer of any material supplied will be required to furnish test reports pertaining to any of the tests necessary to assure compliance with the standard or standards referenced in this specification.

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

ASHRAE 90.1 - IP (2013) Energy Standard for Buildings
Except Low-Rise Residential Buildings

ASTM INTERNATIONAL (ASTM)

ASTM A167 (2011) Standard Specification for
Stainless and Heat-Resisting
Chromium-Nickel Steel Plate, Sheet, and
Strip

ASTM A240/A240M (2020a) Standard Specification for
Chromium and Chromium-Nickel Stainless
Steel Plate, Sheet, and Strip for Pressure
Vessels and for General Applications

ASTM A580/A580M (2018) Standard Specification for
Stainless Steel Wire

ASTM B209 (2014) Standard Specification for Aluminum
and Aluminum-Alloy Sheet and Plate

ASTM C1126 (2018) Standard Specification for Faced or
Unfaced Rigid Cellular Phenolic Thermal
Insulation

ASTM C1136 (2017a) Standard Specification for
Flexible, Low Permeance Vapor Retarders
for Thermal Insulation

ASTM C1710 (2011) Standard Guide for Installation of
Flexible Closed Cell Preformed Insulation
in Tube and Sheet Form

ASTM C195 (2007; R 2013) Standard Specification for
Mineral Fiber Thermal Insulating Cement

ASTM C450 (2008) Standard Practice for Fabrication
of Thermal Insulating Fitting Covers for

NPS Piping, and Vessel Lagging

ASTM C534/C534M	(2016) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
ASTM C547	(2017) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2017; E 2018) Standard Specification for Cellular Glass Thermal Insulation
ASTM C647	(2008; R 2013) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM C795	(2008; R 2018) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C916	(2020) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C921	(2010) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM D2863	(2017a) Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
ASTM D5590	(2000; R 2010; E 2012) Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay
ASTM D882	(2012) Tensile Properties of Thin Plastic Sheeting
ASTM E2231	(2018) Standard Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96/E96M	(2016) Standard Test Methods for Water Vapor Transmission of Materials

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350

(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

FM GLOBAL (FM)

FM APP GUIDE

(updated on-line) Approval Guide
<http://www.approvalguide.com/>

GREEN SEAL (GS)

GS-36

(2013) Adhesives for Commercial Use

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58

(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

MIDWEST INSULATION CONTRACTORS ASSOCIATION (MICA)

MICA Insulation Stds

(8th Ed) National Commercial & Industrial Insulation Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A

(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

NFPA 90B

(2021) Standard for the Installation of Warm Air Heating and Air Conditioning Systems

SCIENTIFIC CERTIFICATION SYSTEMS (SCS)

SCS

SCS Global Services (SCS) Indoor Advantage

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168

(2017) Adhesive and Sealant Applications

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY (TAPPI)

TAPPI T403 OM

(2015) Bursting Strength of Paper

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-A-24179

(1969; Rev A; Am 2 1980; Notice 1 1987) Adhesive, Flexible Unicellular-Plastic Thermal Insulation

MIL-A-3316

(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation

MIL-PRF-19565

(1988; Rev C) Coating Compounds, Thermal

Insulation, Fire- and Water-Resistant,
Vapor-Barrier

UNDERWRITERS LABORATORIES (UL)

UL 2818	(2013) GREENGUARD Certification Program For Chemical Emissions For Building Materials, Finishes And Furnishings
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 94	(2013; Reprint Jun 2020) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 SYSTEM DESCRIPTION

1.2.1 General

Provide field-applied insulation and accessories on mechanical systems as specified herein; factory-applied insulation is specified under the piping, duct or equipment to be insulated. Insulation of heat distribution systems and chilled water systems outside of buildings shall be as specified in Section 33 61 14 EXTERIOR BURIED PREINSULATED WATER PIPING. Field applied insulation materials required for use on Government-furnished items as listed in the SPECIAL CONTRACT REQUIREMENTS shall be furnished and installed by the Contractor.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

Submit the three SD types, SD-02 Shop Drawings, SD-03 Product Data, and SD-08 Manufacturer's Instructions at the same time for each system.

SD-02 Shop Drawings

MICA Plates; G

Pipe Insulation Systems and Associated Accessories

Duct Insulation Systems and Associated Accessories

Equipment Insulation Systems and Associated Accessories

Recycled content for insulation materials; S

SD-03 Product Data

Pipe Insulation Systems; G

Duct Insulation Systems; G

Equipment Insulation Systems; G

SD-04 Samples

Thermal Insulation

Display Samples

SD-07 Certificates

Indoor air quality for adhesives; S

SD-08 Manufacturer's Instructions

Pipe Insulation Systems; G

Duct Insulation Systems; G

Equipment Insulation Systems; G

1.4 CERTIFICATIONS

1.4.1 Adhesives and Sealants

Provide products certified to meet indoor air quality requirements by **UL 2818** (Greenguard) Gold, **SCS** Global Services Indoor Advantage Gold or provide certification or validation by other third-party programs that products meet the requirements of this Section. Provide current product certification documentation from certification body. When product does not have certification, provide validation that product meets the indoor air quality product requirements cited herein.

1.5 QUALITY ASSURANCE

1.5.1 Installer Qualification

Qualified installers shall have successfully completed three or more similar type jobs within the last 5 years.

1.6 DELIVERY, STORAGE, AND HANDLING

Materials shall be delivered in the manufacturer's unopened containers. Materials delivered and placed in storage shall be provided with protection from weather, humidity, dirt, dust and other contaminants. The Contracting Officer may reject insulation material and supplies that become dirty, dusty, wet, or contaminated by some other means. Packages or standard containers of insulation, jacket material, cements, adhesives, and coatings delivered for use, and samples required for approval shall have manufacturer's stamp or label attached giving the name of the manufacturer and brand, and a description of the material, date codes, and approximate shelf life (if applicable). Insulation packages and containers shall be asbestos free.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide materials which are the standard products of manufacturers regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Submit a complete list of materials, including manufacturer's descriptive technical literature, performance data, catalog cuts, and installation instructions. The product number, k-value, thickness and furnished accessories including adhesives, sealants and jackets for each mechanical system requiring insulation shall be included. The product data must be copyrighted, have an identifying or publication number, and shall have been published prior to the issuance date of this solicitation. Materials furnished under this section shall be submitted together in a booklet [and in conjunction with the MICA plates booklet \(SD-02\)](#). [Annotate the product data to indicate which MICA plate is applicable.](#)

2.1.1 Insulation System

Provide insulation systems in accordance with the approved MICA National Insulation Standards plates as supplemented by this specification. Provide field-applied insulation for heating, ventilating, and cooling (HVAC) air distribution systems and piping systems that are located within, on, under, and adjacent to buildings; and for plumbing systems. Provide CFC and HCFC free insulation.

2.1.2 Surface Burning Characteristics

Unless otherwise specified, insulation must have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#). Flame spread, and smoke developed indexes, shall be determined by [ASTM E84](#) or [UL 723](#). Test insulation in the same density and installed thickness as the material to be used in the actual construction. Prepare and mount test specimens according to [ASTM E2231](#).

2.2 MATERIALS

Provide insulation that meets or exceed the requirements of [ASHRAE 90.1](#). Insulation exterior shall be cleanable, grease resistant, non-flaking and non-peeling. Materials shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which applied in either wet or dry state. Materials to be used on stainless steel surfaces shall meet [ASTM C795](#) requirements. Calcium silicate shall not be used on chilled or cold water systems. Materials shall be asbestos free. Provide product recognized under [UL 94](#) (if containing plastic) and listed in [FM APP GUIDE](#).

2.2.1 Adhesives

Provide non-aerosol adhesive products used on the interior of the building (defined as inside of the weatherproofing system) that meet either emissions requirements of [CDPH SECTION 01350](#) (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of [SCAQMD Rule 1168](#) (HVAC duct sealants must meet limit requirements of "Other" category within [SCAQMD Rule 1168](#) sealants table). Provide aerosol adhesives used on the interior of the building that meet

either emissions requirements of [CDPH SECTION 01350](#) (use the office or classroom requirements, regardless of space type) or VOC content requirements of [GS-36](#). Provide certification or validation of [indoor air quality for adhesives](#).

2.2.1.1 Acoustical Lining Insulation Adhesive

Adhesive shall be a nonflammable, fire-resistant adhesive conforming to [ASTM C916](#), Type I.

2.2.1.2 Mineral Fiber Insulation Cement

Cement shall be in accordance with [ASTM C195](#).

2.2.1.3 Lagging Adhesive

Lagging is the material used for [thermal insulation](#), especially around a cylindrical object. This may include the insulation as well as the cloth/material covering the insulation. To resist mold/mildew, lagging adhesive shall meet [ASTM D5590](#) with 0 growth rating. Lagging adhesives shall be nonflammable and fire-resistant and shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#). Adhesive shall be [MIL-A-3316](#), Class 1, pigmented [white or red](#) and be suitable for bonding fibrous glass cloth to faced and unfaced fibrous glass insulation board; for bonding cotton brattice cloth to faced and unfaced fibrous glass insulation board; for sealing edges of and bonding glass tape to joints of fibrous glass board; for bonding lagging cloth to thermal insulation; or Class 2 for attaching fibrous glass insulation to metal surfaces. Lagging adhesives shall be applied in strict accordance with the manufacturer's recommendations for pipe and duct insulation.

2.2.1.4 Contact Adhesive

Adhesives may be any of, but not limited to, the neoprene based, rubber based, or elastomeric type that have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#). The adhesive shall not adversely affect, initially or in service, the insulation to which it is applied, nor shall it cause any corrosive effect on metal to which it is applied. Any solvent dispersing medium or volatile component of the adhesive shall have no objectionable odor and shall not contain any benzene or carbon tetrachloride. The dried adhesive shall not emit nauseous, irritating, or toxic volatile matters or aerosols when the adhesive is heated to any temperature up to [212 degrees F](#). The dried adhesive shall be nonflammable and fire resistant. Flexible Elastomeric Adhesive: Comply with [MIL-A-24179](#), Type II, Class I. Provide product listed in [FM APP GUIDE](#).

2.2.2 Caulking

[ASTM C920](#), Type S, Grade NS, Class 25, Use A.

2.2.3 Corner Angles

Nominal [0.016 inch](#) aluminum [1 by 1 inch](#) with factory applied kraft backing. Aluminum shall be [ASTM B209](#), Alloy 3003, 3105, or 5005.

2.2.4 Fittings

Fabricated Fittings are the prefabricated fittings for flexible elastomeric pipe insulation systems in accordance with [ASTM C1710](#). Together with the flexible elastomeric tubes, they provide complete system integrity for retarding heat gain and controlling condensation drip from chilled-water and refrigeration systems. Flexible elastomeric, fabricated fittings provide thermal protection (0.25 k) and condensation resistance (0.05 Water Vapor Transmission factor). For satisfactory performance, properly installed protective vapor retarder/barriers and vapor stops shall be used on high relative humidity and below ambient temperature applications to reduce movement of moisture through or around the insulation to the colder interior surface.

2.2.5 Finishing Cement

[ASTM C450](#): Mineral fiber hydraulic-setting thermal insulating and finishing cement. All cements that may come in contact with Austenitic stainless steel must comply with [ASTM C795](#).

2.2.6 Fibrous Glass Cloth and Glass Tape

Fibrous glass cloth, with 20 X 20 maximum mesh size, and glass tape shall have maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#). Tape shall be [4 inch](#) wide rolls. Class 3 tape shall be [4.5 ounces/square yard](#). Elastomeric Foam Tape: Black vapor-retarder foam tape with acrylic adhesive containing an anti-microbial additive.

2.2.7 Staples

Outward clinching type [monel](#) or [ASTM A167](#), Type 304 or 316 stainless steel.

2.2.8 Jackets

2.2.8.1 Aluminum Jackets

Aluminum jackets shall be corrugated, embossed or smooth sheet, [0.016 inch](#) nominal thickness; [ASTM B209](#), Temper H14, Temper H16, Alloy 3003, 5005, or 3105. Corrugated aluminum jacket shall not be used outdoors. Aluminum jacket securing bands shall be Type 304 stainless steel, [0.015 inch](#) thick, [1/2 inch](#) wide for pipe under [12 inch](#) diameter and [3/4 inch](#) wide for pipe over [12 inch](#) and larger diameter. Aluminum jacket circumferential seam bands shall be [2 by 0.016 inch](#) aluminum matching jacket material. Bands for insulation below ground shall be [3/4 by 0.020 inch](#) thick stainless steel, or fiberglass reinforced tape. The jacket may, at the option of the Contractor, be provided with a factory fabricated Pittsburgh or "Z" type longitudinal joint. When the "Z" joint is used, the bands at the circumferential joints shall be designed by the manufacturer to seal the joints and hold the jacket in place.

2.2.8.2 Polyvinyl Chloride (PVC) Jackets

Polyvinyl chloride (PVC) jacket and fitting covers shall have high impact strength, ultraviolet (UV) resistant rating or treatment and moderate chemical resistance with minimum thickness [0.030 inch](#).

2.2.8.3 Vapor Barrier/Vapor Retarder

Apply the following criteria to determine which system is required.

- a. On ducts, piping and equipment operating below 91 degrees F or located outside shall be equipped with a vapor barrier.
- b. Ducts, pipes and equipment that are located inside and that always operate above 91 degrees F shall be installed with a vapor retarder where required as stated in paragraph VAPOR RETARDER REQUIRED.

2.2.9 Vapor Retarder Required

ASTM C921, Type I, minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork, where a minimum puncture resistance of 25 Beach units is acceptable. Minimum tensile strength, 35 pounds/inch width. ASTM C921, Type II, minimum puncture resistance 25 Beach units, tensile strength minimum 20 pounds/inch width. Jackets used on insulation exposed in finished areas shall have white finish suitable for painting without sizing. Based on the application, insulation materials that require manufacturer or fabricator applied pipe insulation jackets are cellular glass, when all joints are sealed with a vapor barrier mastic, and mineral fiber. All non-metallic jackets shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84. Flexible elastomerics require (in addition to vapor barrier skin) vapor retarder jacketing for high relative humidity and below ambient temperature applications.

2.2.9.1 White Vapor Retarder All Service Jacket (ASJ)

ASJ is for use on hot/cold pipes, ducts, or equipment indoors or outdoors if covered by a suitable protective jacket. The product shall meet all physical property and performance requirements of ASTM C1136, Type I, except the burst strength shall be a minimum of 85 psi. ASTM D2863 Limited Oxygen Index (LOI) shall be a minimum of 31.

In addition, neither the outer exposed surface nor the inner-most surface contacting the insulation shall be paper or other moisture-sensitive material. The outer exposed surface shall be white and have an emittance of not less than 0.80. The outer exposed surface shall be paintable.

2.2.9.2 Vapor Retarder/Vapor Barrier Mastic Coatings

2.2.9.2.1 Vapor Barrier

The vapor barrier shall be self adhesive (minimum 2 mils adhesive, 3 mils embossed) greater than 3 plies standard grade, silver, white, black and embossed white jacket for use on hot/cold pipes. Permeability shall be less than 0.02 when tested in accordance with ASTM E96/E96M. Products shall meet UL 723 or ASTM E84 flame and smoke requirements and shall be UV resistant.

2.2.9.2.2 Vapor Retarder

The vapor retarder coating shall be fire and water resistant and appropriately selected for either outdoor or indoor service. Color shall be white. The water vapor permeance of the compound shall be 0.013 perms or less at 43 mils dry film thickness as determined according to procedure B of ASTM E96/E96M utilizing apparatus described in ASTM E96/E96M. The

coating shall be nonflammable, fire resistant type. To resist mold/mildew, coating shall meet [ASTM D5590](#) with 0 growth rating. Coating shall meet [MIL-PRF-19565](#) Type II (if selected for indoor service) and be Qualified Products Database listed. All other application and service properties shall be in accordance with [ASTM C647](#).

2.2.9.3 Laminated Film Vapor Retarder

[ASTM C1136](#), Type I, maximum moisture vapor transmission 0.02 perms, minimum puncture resistance 50 Beach units on all surfaces except concealed ductwork; where Type II, maximum moisture vapor transmission 0.02 perms, a minimum puncture resistance of 25 Beach units is acceptable. Vapor retarder shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#). Flexible Elastomeric exterior foam with factory applied UV Jacket. Construction of laminate designed to provide UV resistance, high puncture, tear resistance and an excellent WVT rate.

2.2.9.4 Polyvinylidene Chloride (PVDC) Film Vapor Retarder

The PVDC film vapor retarder shall have a maximum moisture vapor transmission of 0.02 perms, minimum puncture resistance of 150 Beach units, a minimum tensile strength in any direction of [30 lb/inch](#) when tested in accordance with [ASTM D882](#), and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#).

2.2.9.5 Polyvinylidene Chloride Vapor Retarder Adhesive Tape

Requirements must meet the same as specified for Laminated Film Vapor Retarder above.

2.2.9.6 Vapor Barrier/Weather Barrier

The vapor barrier shall be greater than 3 ply self adhesive laminate -white vapor barrier jacket- superior performance (less than 0.0000 permeability when tested in accordance with [ASTM E96/E96M](#)). Vapor barrier shall meet [UL 723](#) or [ASTM E84](#) 25 flame and 50 smoke requirements; and UV resistant. Minimum burst strength [185 psi](#) in accordance with [TAPPI T403 OM](#). Tensile strength [68 lb/inch](#) width (PSTC-1000). Tape shall be as specified for laminated film vapor barrier above.

2.2.10 Vapor Retarder Not Required

[ASTM C921](#), Type II, Class D, minimum puncture resistance 50 Beach units on all surfaces except ductwork, where Type IV, maximum moisture vapor transmission 0.10, a minimum puncture resistance of 25 Beach units is acceptable. Jacket shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#).

2.2.11 Wire

Soft annealed [ASTM A580/A580M](#) Type 302, 304 or 316 stainless steel, 16 or 18 gauge.

2.2.12 Insulation Bands

Insulation bands shall be [1/2 inch](#) wide; 26 gauge stainless steel.

2.2.13 Sealants

Sealants shall be chosen from the butyl polymer type, the styrene-butadiene rubber type, or the butyl type of sealants. Sealants shall have a maximum permeance of 0.02 perms based on Procedure B for [ASTM E96/E96M](#), and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with [ASTM E84](#).

2.3 PIPE INSULATION SYSTEMS

Conform insulation materials to Table 1 and minimum insulation thickness as listed in Table 2 and meet or exceed the requirements of [ASHRAE 90.1 - IP](#). Limit pipe insulation materials to those listed herein and meeting the following requirements:

2.3.1 Recycled Materials

Provide insulation materials containing the following minimum percentage of recycled material content by weight:

- Rock Wool: 75 percent slag of weight
- Fiberglass: 20 percent glass cullet
- Rigid Foam: 9 percent recovered material
- Phenolic Rigid Foam: 9 percent recovered material

Provide data identifying percentage of [recycled content for insulation materials](#).

2.3.2 Aboveground Cold Pipeline (-30 to 60 deg. F)

Insulation for outdoor, indoor, exposed or concealed applications, shall be as follows:

2.3.2.1 Cellular Glass

[ASTM C552](#), Type II, and Type III. Supply the insulation from the fabricator with (paragraph WHITE VAPOR RETARDER ALL SERVICE JACKET (ASJ)) ASJ vapor retarder and installed with all longitudinal overlaps sealed and all circumferential joints ASJ taped or supply the insulation unfaced from the fabricator and install with all longitudinal and circumferential joints sealed with vapor barrier mastic.

2.3.2.2 Flexible Elastomeric Cellular Insulation

Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive, complying with [ASTM C534/C534M](#), Grade 1, Type I or II. Type I, Grade 1 for tubular materials. Type II, Grade 1, for sheet materials. Type I and II shall have vapor retarder/vapor barrier skin on one or both sides of the insulation, and require an additional exterior vapor retarder covering for high relative humidity and below ambient temperature applications.

2.3.3 Aboveground Hot Pipeline (Above 60 deg. F)

Insulation for outdoor, indoor, exposed or concealed applications shall meet the following requirements. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.1 Mineral Fiber

ASTM C547, Types I, II or III, supply the insulation with manufacturer's recommended factory-applied jacket.

2.3.3.2 Cellular Glass

ASTM C552, Type II and Type III. Supply the insulation with manufacturer's recommended factory-applied jacket.

2.4 DUCT INSULATION SYSTEMS

2.4.1 Duct Insulation

Provide external thermal insulation for all ductwork. Insulate ductwork in concealed spaces with blanket flexible mineral fiber. Insulate ductwork in Mechanical Rooms and exposed locations with rigid mineral fiber insulation.

Provide insulation with factory applied all-purpose jacket with integral vapor retarder. In exposed locations, provide a jacket with white surface suitable for painting. Flame spread/smoke developed rating for all insulation must not exceed 25/50. Minimum insulation thickness must be the minimum thickness required by ASHRAE 90.1. Insulate the backs of all supply air diffusers with blanket flexible mineral fiber insulation..

2.4.2 Acoustical Duct Lining

2.4.2.1 General

For ductwork indicated or specified in Section **23 30 00 HVAC AIR DISTRIBUTION** to be acoustically lined, provide external insulation in accordance with this specification section and in addition to the acoustical duct lining. Do not use acoustical lining in place of duct wrap or rigid board insulation (insulation on the exterior of the duct).

2.4.2.2 Duct Liner

Flexible Elastomeric Acoustical and Conformable Duct Liner Materials:
Flexible Elastomeric Thermal, Acoustical and Conformable Insulation
Compliance with **ASTM C534/C534M** Grade 1, Type II; and **NFPA 90A** or **NFPA 90B** as applicable.

2.4.3 Duct Insulation Jackets

2.4.3.1 All-Purpose Jacket

Provide insulation with insulation manufacturer's standard reinforced fire-retardant jacket with or without integral vapor barrier as required by the service. In exposed locations, provide jacket with a white surface suitable for field painting.

2.4.3.2 Metal Jackets

2.4.3.2.1 Aluminum Jackets

ASTM B209, Temper H14, minimum thickness of 27 gauge (**0.016 inch**), with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide smooth surface jackets for jacket outside dimension **8 inches** and larger. Provide corrugated surface jackets for jacket outside

dimension 8 inches and larger. Provide stainless steel bands, minimum width of 1/2 inch.

2.4.3.2.2 Stainless Steel Jackets

ASTM A167 or ASTM A240/A240M; Type 304, minimum thickness of 33 gauge (0.010 inch), smooth surface with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide stainless steel bands, minimum width of 1/2 inch.

2.4.3.3 Vapor Barrier/Weatherproofing Jacket

Vapor barrier/weatherproofing jacket shall be laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply (minimum 2.9 mils adhesive), heavy duty white or natural).

2.4.4 Weatherproof Duct Insulation

Provide ASTM C552, cellular glass thermal insulation or ASTM C534/C534M Grade 1, Type II, flexible elastomeric cellular insulation, and weatherproofing as specified in manufacturer's instruction. Multi-ply, Polymeric Blend Laminate Jacketing: Construction of laminate designed to provide UV resistance, high puncture, tear resistance and an excellent WVT rate.

2.5 EQUIPMENT INSULATION SYSTEMS

Insulate equipment and accessories as specified in Tables 5 and 6. In outside locations, provide insulation 1/2 inch thicker than specified. Increase the specified insulation thickness for equipment where necessary to equal the thickness of angles or other structural members to make a smooth, exterior surface. Submit a booklet containing manufacturer's published installation instructions for the insulation systems. The instructions must be copyrighted, have an identifying or publication number, and shall have been published prior to the issuance date of this solicitation. A booklet is also required by paragraphs titled: Pipe Insulation Systems and Duct Insulation Systems.

PART 3 EXECUTION

3.1 APPLICATION - GENERAL

Insulation shall only be applied to unheated and uncooled piping and equipment. Flexible elastomeric cellular insulation shall not be compressed at joists, studs, columns, ducts, hangers, etc. The insulation shall not pull apart after a one hour period; any insulation found to pull apart after one hour, shall be replaced.

3.1.1 Display Samples

Submit and display, after approval of materials, actual sections of installed systems, properly insulated in accordance with the specification requirements. Such actual sections must remain accessible to inspection throughout the job and will be reviewed from time to time for controlling the quality of the work throughout the construction site. Each material used shall be identified, by indicating on an attached sheet the specification requirement for the material and the material by each

manufacturer intended to meet the requirement. The Contracting Officer will inspect display sample sections at the jobsite. Approved display sample sections shall remain on display at the jobsite during the construction period. Upon completion of construction, the display sample sections will be closed and sealed.

3.1.1.1 Pipe Insulation Display Sections

Display sample sections shall include as a minimum an elbow or tee, a valve, dielectric waterways and flanges, a hanger with protection shield and insulation insert, or dowel as required, at support point, method of fastening and sealing insulation at longitudinal lap, circumferential lap, butt joints at fittings and on pipe runs, and terminating points for each type of pipe insulation used on the job, and for hot pipelines and cold pipelines, both interior and exterior, even when the same type of insulation is used for these services.

3.1.1.2 Duct Insulation Display Sections

Display sample sections for rigid and flexible duct insulation used on the job. Use a temporary covering to enclose and protect display sections for duct insulation exposed to weather

3.1.2 Installation

Except as otherwise specified, material shall be installed in accordance with the manufacturer's written instructions. Insulation materials shall not be applied until tests and heat tracing specified in other sections of this specification are completed. Material such as rust, scale, dirt and moisture shall be removed from surfaces to receive insulation. Insulation shall be kept clean and dry. Insulation shall not be removed from its shipping containers until the day it is ready to use and shall be returned to like containers or equally protected from dirt and moisture at the end of each workday. Insulation that becomes dirty shall be thoroughly cleaned prior to use. If insulation becomes wet or if cleaning does not restore the surfaces to like new condition, the insulation will be rejected, and shall be immediately removed from the jobsite. Joints shall be staggered on multi layer insulation. Mineral fiber thermal insulating cement shall be mixed with demineralized water when used on stainless steel surfaces. Insulation, jacketing and accessories shall be installed in accordance with MICA Insulation Stds plates except where modified herein or on the drawings.

3.1.3 Firestopping

Where pipes and ducts pass through fire walls, fire partitions, above grade floors, and fire rated chase walls, the penetration shall be sealed with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING. The protection of ducts at point of passage through firewalls must be in accordance with NFPA 90A and/or NFPA 90B. All other penetrations, such as piping, conduit, and wiring, through firewalls must be protected with a material or system of the same hourly rating that is listed by UL, FM, or a NRTL.

3.1.4 Painting and Finishing

Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.5 Installation of Flexible Elastomeric Cellular Insulation

Install flexible elastomeric cellular insulation with seams and joints sealed with rubberized contact adhesive. Flexible elastomeric cellular insulation shall not be used on surfaces greater than 220 degrees F. Stagger seams when applying multiple layers of insulation. Protect insulation exposed to weather and not shown to have vapor barrier weatherproof jacketing with two coats of UV resistant finish or PVC or metal jacketing as recommended by the manufacturer after the adhesive is dry and cured.

3.1.5.1 Adhesive Application

Apply a brush coating of adhesive to both butt ends to be joined and to both slit surfaces to be sealed. Allow the adhesive to set until dry to touch but tacky under slight pressure before joining the surfaces. Insulation seals at seams and joints shall not be capable of being pulled apart one hour after application. Insulation that can be pulled apart one hour after installation shall be replaced.

3.1.5.2 Adhesive Safety Precautions

Use natural cross-ventilation, local (mechanical) pickup, and/or general area (mechanical) ventilation to prevent an accumulation of solvent vapors, keeping in mind the ventilation pattern must remove any heavier-than-air solvent vapors from lower levels of the workspaces. Gloves and spectacle-type safety glasses are recommended in accordance with safe installation practices.

3.1.6 Welding

No welding shall be done on piping, duct or equipment without written approval of the Contracting Officer. The capacitor discharge welding process may be used for securing metal fasteners to duct.

3.1.7 Pipes/Ducts/Equipment That Require Insulation

Insulation is required on all pipes, ducts, or equipment, except for omitted items as specified.

3.2 PIPE INSULATION SYSTEMS INSTALLATION

3.2.1 Pipe Insulation

3.2.1.1 General

Pipe insulation shall be installed on aboveground hot and cold pipeline systems as specified below to form a continuous thermal retarder/barrier, including straight runs, fittings and appurtenances unless specified otherwise. Installation shall be with full length units of insulation and using a single cut piece to complete a run. Cut pieces or scraps abutting each other shall not be used. Pipe insulation shall be omitted on the following:

- a. Pipe used solely for fire protection.
- b. Chromium plated pipe to plumbing fixtures. However, fixtures for use by the physically handicapped shall have the hot water supply and drain, including the trap, insulated where exposed.

- c. Sanitary drain lines.
- d. Air chambers.
- e. Adjacent insulation.
- f. ASME stamps.
- g. Access plates of fan housings.
- h. Cleanouts or handholes.

3.2.1.2 Pipes Passing Through Walls, Roofs, and Floors

Pipe insulation shall be continuous through the sleeve.

Provide an aluminum jacket or vapor barrier/weatherproofing self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 ply standard grade, silver, white, black and embossed with factory applied moisture retarder over the insulation wherever penetrations require sealing.

3.2.1.2.1 Penetrate Interior Walls

The aluminum jacket or vapor barrier/weatherproofing - self adhesive jacket (minimum 2 mils adhesive, 3 mils embossed) less than 0.0000 permeability, greater than 3 plies standard grade, silver, white, black and embossed shall extend 2 inches beyond either side of the wall and shall be secured on each end with a band.

3.2.1.2.2 Penetrating Floors

Extend the aluminum jacket from a point below the backup material to a point 10 inches above the floor with one band at the floor and one not more than 1 inch from the end of the aluminum jacket.

3.2.1.2.3 Penetrating Waterproofed Floors

Extend the aluminum jacket from below the backup material to a point 2 inches above the flashing with a band 1 inch from the end of the aluminum jacket.

3.2.1.2.4 Penetrating Exterior Walls

Continue the aluminum jacket required for pipe exposed to weather through the sleeve to a point 2 inches beyond the interior surface of the wall.

3.2.1.2.5 Penetrating Roofs

Insulate pipe as required for interior service to a point flush with the top of the flashing and sealed with flashing sealant. Tightly butt the insulation for exterior application to the top of flashing and interior insulation. Extend the exterior aluminum jacket 2 inches down beyond the end of the insulation to form a counter flashing. Seal the flashing and counter flashing underneath with metal jacketing/flashing sealant.

3.2.1.2.6 Hot Water Pipes Supplying Lavatories or Other Similar Heated Service

Terminate the insulation on the backside of the finished wall. Protect the insulation termination with two coats of vapor barrier coating with a minimum total thickness of **1/16 inch** applied with glass tape embedded between coats (if applicable). Extend the coating out onto the insulation **2 inches** and seal the end of the insulation. Overlap glass tape seams **1 inch**. Caulk the annular space between the pipe and wall penetration with approved fire stop material. Cover the pipe and wall penetration with a properly sized (well fitting) escutcheon plate. The escutcheon plate shall overlap the wall penetration at least **3/8 inches**.

3.2.1.2.7 Domestic Cold Water Pipes Supplying Lavatories or Other Similar Cooling Service

Terminate the insulation on the finished side of the wall (i.e., insulation must cover the pipe throughout the wall penetration). Protect the insulation with two coats of weather barrier mastic (breather emulsion type weatherproof mastic impermeable to water and permeable to air) with a minimum total thickness of **1/16 inch**. Extend the mastic out onto the insulation **2 inches** and shall seal the end of the insulation. The annular space between the outer surface of the pipe insulation and caulk the wall penetration with an approved fire stop material having vapor retarder properties. Cover the pipe and wall penetration with a properly sized (well fitting) escutcheon plate. The escutcheon plate shall overlap the wall penetration by at least **3/8 inches**.

3.2.1.3 Pipes Passing Through Hangers

Insulation, whether hot or cold application, shall be continuous through hangers. All horizontal pipes **2 inches** and smaller shall be supported on hangers with the addition of a Type 40 protection shield to protect the insulation in accordance with **MSS SP-58**. Whenever insulation shows signs of being compressed, or when the insulation or jacket shows visible signs of distortion at or near the support shield, insulation inserts as specified below for piping larger than **2 inches** shall be installed, or factory insulated hangers (designed with a load bearing core) can be used.

3.2.1.3.1 Horizontal Pipes Larger Than **2 Inches** at **60 Degrees F** and Above

Supported on hangers in accordance with **MSS SP-58**, and Section **22 00 00 PLUMBING, GENERAL PURPOSE**.

3.2.1.3.2 Horizontal Pipes Larger Than **2 Inches** and Below **60 Degrees F**

Supported on hangers with the addition of a Type 40 protection shield in accordance with **MSS SP-58**. An insulation insert of cellular glass, prefabricated insulation pipe hangers, or perlite above **80 degrees F** shall be installed above each shield. The insert shall cover not less than the bottom 180-degree arc of the pipe. Inserts shall be the same thickness as the insulation, and shall extend **2 inches** on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than **1 inch**, wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the weight of the pipe from crushing the insulation, as an option to installing insulation inserts. The insulation jacket shall be continuous over the wooden dowel, wooden block, or insulation insert.

3.2.1.3.3 Vertical Pipes

Supported with either Type 8 or Type 42 riser clamps with the addition of two Type 40 protection shields in accordance with [MSS SP-58](#) covering the 360-degree arc of the insulation. An insulation insert of cellular glass or calcium silicate shall be installed between each shield and the pipe. The insert shall cover the 360-degree arc of the pipe. Inserts shall be the same thickness as the insulation, and shall extend [2 inches](#) on each end beyond the protection shield. When insulation inserts are required in accordance with the above, and the insulation thickness is less than [1 inch](#), wooden or cork dowels or blocks may be installed between the pipe and the shield to prevent the hanger from crushing the insulation, as an option instead of installing insulation inserts. The insulation jacket shall be continuous over the wooden dowel, wooden block, or insulation insert. The vertical weight of the pipe shall be supported with hangers located in a horizontal section of the pipe. When the pipe riser is longer than [30 feet](#), the weight of the pipe shall be additionally supported with hangers in the vertical run of the pipe that are directly clamped to the pipe, penetrating the pipe insulation. These hangers shall be insulated and the insulation jacket sealed as indicated herein for anchors in a similar service.

3.2.1.3.4 Inserts

Covered with a jacket material of the same appearance and quality as the adjoining pipe insulation jacket, overlap the adjoining pipe jacket [1-1/2 inches](#), and seal as required for the pipe jacket. The jacket material used to cover inserts in flexible elastomeric cellular insulation shall conform to [ASTM C1136](#), Type 1, and is allowed to be of a different material than the adjoining insulation material.

3.2.1.4 Flexible Elastomeric Cellular Pipe Insulation

Flexible elastomeric cellular pipe insulation shall be tubular form for pipe sizes [6 inches](#) and less. Grade 1, Type II sheet insulation used on pipes larger than [6 inches](#) shall not be stretched around the pipe. On pipes larger than [12 inches](#), the insulation shall be adhered directly to the pipe on the lower 1/3 of the pipe. Seams shall be staggered when applying multiple layers of insulation. Sweat fittings shall be insulated with miter-cut pieces the same size as on adjacent piping. Screwed fittings shall be insulated with sleeved fitting covers fabricated from miter-cut pieces and shall be overlapped and sealed to the adjacent pipe insulation. Type II requires an additional exterior vapor retarder/barrier covering for high relative humidity and below ambient temperature applications.

3.2.1.5 Pipes in high abuse areas.

In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, welded PVC, aluminum or flexible laminate cladding (comprised of elastomeric, plastic or metal foil laminate) laminated self-adhesive (minimum [2 mils](#) adhesive, [3 mils](#) embossed) vapor barrier/weatherproofing jacket, - less than 0.0000 permeability; (greater than 3 ply, standard grade, silver, white, black and embossed) aluminum jackets shall be utilized. Pipe insulation to the [6 foot](#) level shall be protected.

3.2.1.6 Pipe Insulation Material and Thickness

Pipe insulation materials must be as listed in Table 1 and must meet or exceed the requirements of [ASHRAE 90.1](#).

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
Chilled Water (Supply & Return, Dual Temperature Piping, 40 F nominal)					
	Cellular Glass	ASTM C552	II	2	Yes-VB
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		Yes-VB
Heating Hot Water Supply & Return (Max 250 F)					
	Mineral Fiber	ASTM C547	I	1	No
	Cellular Glass	ASTM C552	II	2	No
Cold Domestic Water Piping, Makeup Water & Drinking Fountain Drain Piping					
	Cellular Glass	ASTM C552	II	2	YES-VB
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Hot Domestic Water Supply & Recirculating Piping (Max 200 F)					
	Mineral Fiber	ASTM C547	I	1	No
	Cellular Glass	ASTM C552	II	2	No
Refrigerant Suction Piping (35 degrees F nominal)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Cellular Glass	ASTM C552	II	1	Yes
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicapped Personnel					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Horizontal Roof Drain Leaders (Including Underside of Roof Drain Fittings)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Cellular Glass	ASTM C552	III		Yes
Condensate Drain Located Inside Building					

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Note: VR/VB = Vapor Retarder/Vapor Barrier					

TABLE 2						
Piping Insulation Thickness (inch) Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.						
Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
Chilled Water (Supply & Return 40 Degrees F nominal)						
	Cellular Glass	1.5	2	2	2.5	3
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Heating Hot Water Supply & Return, Heated Oil (Max 250 F)						
	Mineral Fiber	1.5	1.5	2	2	2
	Cellular Glass	2	2.5	3	3	3
Cold Domestic Water Piping, Makeup Water & Drinking Fountain Drain Piping						
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Hot Domestic Water Supply & Recirculating Piping (Max 200 F)						
	Mineral Fiber	1	1	1	1.5	1.5
	Cellular Glass	1.5	1.5	1.5	2	2
Refrigerant Suction Piping (35 degrees F nominal)						

TABLE 2						
Piping Insulation Thickness (inch) Do not use integral wicking material in Chilled water applications exposed to outdoor ambient conditions in climatic zones 1 through 4.						
Service						
	Material	Tube And Pipe Size (inch)				
		<1	1-<1.5	1.5-<4	4-<8	> or = >8
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
Exposed Lavatory Drains, Exposed Domestic Water Piping & Drains to Areas for Handicapped Personnel						
	Flexible Elastomeric Cellular	0.5	0.5	0.5	0.5	0.5
Horizontal Roof Drain Leaders (Including Underside of Roof Drain Fittings)						
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
	Faced Phenolic Foam	1	1	1	1	1
Condensate Drain Located Inside Building						
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A

3.2.2 Aboveground Cold Pipelines

The following cold pipelines for minus 30 to plus 60 degrees F, shall be insulated in accordance with Table 2 except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted. This includes but is not limited to the following:

- a. Make-up water.
- b. Refrigerant suction lines.
- c. Chilled water.
- d. Air conditioner condensate drains.
- e. Exposed lavatory drains and domestic water lines serving plumbing fixtures for handicap persons.
- f. Domestic cold and chilled drinking water.

3.2.2.1 Insulation Material and Thickness

Insulation thickness for cold pipelines shall be determined using Table 2.

3.2.2.2 Factory or Field applied Jacket

Insulation shall be covered with a factory applied vapor retarder jacket/vapor barrier or field applied seal welded PVC jacket or greater than 3 ply laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, standard grade, silver, white, black and embossed for use with Mineral Fiber, Cellular Glass, Insulated Pipe. Insulation inside the building, to be protected with an aluminum jacket or greater than 3 ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, Embossed Silver, White & Black, shall have the insulation and vapor retarder jacket installed as specified herein. The aluminum jacket or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, embossed silver, White & Black, shall be installed as specified for piping exposed to weather, except sealing of the laps of the aluminum jacket is not required. In high abuse areas such as janitor closets and traffic areas in equipment rooms, kitchens, and mechanical rooms, aluminum jackets or greater than 3ply vapor barrier/weatherproofing self-adhesive (minimum 2 mils adhesive, 3 mils embossed) product, less than 0.0000 permeability, standard grade, embossed silver, white & black, shall be provided for pipe insulation to the 6 ft level.

3.2.2.3 Installing Insulation for Straight Runs Hot and Cold Pipe

Apply insulation to the pipe with tight butt joints. Seal all butted joints and ends with joint sealant and seal with a vapor retarder coating, greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or PVDC adhesive tape.

3.2.2.3.1 Longitudinal Laps of the Jacket Material

Overlap not less than 1-1/2 inches. Provide butt strips 3 inches wide for circumferential joints.

3.2.2.3.2 Laps and Butt Strips

Secure with adhesive and staple on 4 inch centers if not factory self-sealing. If staples are used, seal in accordance with paragraph STAPLES below. Note that staples are not required with cellular glass systems.

3.2.2.3.3 Factory Self-Sealing Lap Systems

May be used when the ambient temperature is between 40 and 120 degrees F during installation. Install the lap system in accordance with manufacturer's recommendations. Use a stapler only if specifically recommended by the manufacturer. Where gaps occur, replace the section or repair the gap by applying adhesive under the lap and then stapling.

3.2.2.3.4 Staples

Coat all staples, including those used to repair factory self-seal lap systems, with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. Coat all seams, except those on factory self-seal systems, with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.5 Breaks and Punctures in the Jacket Material

Patch by wrapping a strip of jacket material around the pipe and secure it with adhesive, staple, and coat with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape. Extend the patch not less than 1-1/2 inches past the break.

3.2.2.3.6 Penetrations Such as Thermometers

Fill the voids in the insulation and seal with vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.

3.2.2.3.7 Flexible Elastomeric Cellular Pipe Insulation

Install by slitting the tubular sections and applying them onto the piping or tubing. Alternately, whenever possible slide un-slit sections over the open ends of piping or tubing. Secure all seams and butt joints and seal with adhesive. When using self seal products only the butt joints shall be secured with adhesive. Push insulation on the pipe, never pulled. Stretching of insulation may result in open seams and joints. Clean cut all edges. Rough or jagged edges of the insulation are not be permitted. Use proper tools such as sharp knives. Do not stretch Grade 1, Type II sheet insulation around the pipe when used on pipe larger than 6 inches. On pipes larger than 12 inches, adhere sheet insulation directly to the pipe on the lower 1/3 of the pipe.

3.2.2.4 Insulation for Fittings and Accessories

- a. Pipe insulation shall be tightly butted to the insulation of the fittings and accessories. The butted joints and ends shall be sealed with joint sealant and sealed with a vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape.
- b. Precut or preformed insulation shall be placed around all fittings and accessories and shall conform to MICA plates except as modified herein: 5 for anchors; 10, 11, and 13 for fittings; 14 for valves; and 17 for flanges and unions. Insulation shall be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity. Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Insulation of the same thickness and conductivity as the adjoining pipe insulation shall be used. If nesting size insulation is used, the insulation shall be overlapped 2 inches or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow". Submit a booklet containing completed MICA Insulation Stds plates detailing each insulating system for each pipe, duct, or equipment insulating system, after approval of materials and prior to applying insulation.
 - (1) The MICA plates shall detail the materials to be installed and the specific insulation application. Submit all MICA plates required showing the entire insulating system, including plates required to show insulation penetrations, vessel bottom and top heads, legs, and skirt insulation as applicable. The MICA plates shall present all variations of insulation systems including locations,

materials, vaporproofing, jackets and insulation accessories.

- (2) If the Contractor elects to submit detailed drawings instead of edited MICA Plates, the detail drawings shall be technically equivalent to the edited MICA Plate submittal.
- c. Upon completion of insulation installation on flanges, unions, valves, anchors, fittings and accessories, terminations, seams, joints and insulation not protected by factory vapor retarder jackets or PVC fitting covers shall be protected with PVDC or greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape or two coats of vapor retarder coating with a minimum total thickness of **1/16 inch**, applied with glass tape embedded between coats. Tape seams shall overlap **1 inch**. The coating shall extend out onto the adjoining pipe insulation **2 inches**. Fabricated insulation with a factory vapor retarder jacket shall be protected with either greater than 3 ply laminate jacket - less than 0.0000 perm adhesive tape, standard grade, silver, white, black and embossed or PVDC adhesive tape or two coats of vapor retarder coating with a minimum thickness of **1/16 inch** and with a **2 inch** wide glass tape embedded between coats. Where fitting insulation butts to pipe insulation, the joints shall be sealed with a vapor retarder coating and a **4 inch** wide ASJ tape which matches the jacket of the pipe insulation.
- d. Anchors attached directly to the pipe shall be insulated for a sufficient distance to prevent condensation but not less than **6 inches** from the insulation surface.
- e. Insulation shall be marked showing the location of unions, strainers, and check valves.

3.2.2.5 Optional PVC Fitting Covers

At the option of the Contractor, premolded, one or two piece PVC fitting covers may be used in lieu of the vapor retarder and embedded glass tape. Factory precut or premolded insulation segments shall be used under the fitting covers for elbows. Insulation segments shall be the same insulation as the pipe insulation including same density, thickness, and thermal conductivity. The covers shall be secured by PVC vapor retarder tape, adhesive, seal welding or with tacks made for securing PVC covers. Seams in the cover, and tacks and laps to adjoining pipe insulation jacket, shall be sealed with vapor retarder tape to ensure that the assembly has a continuous vapor seal.

3.2.3 Aboveground Hot Pipelines

3.2.3.1 General Requirements

All hot pipe lines above **60 degrees F**, except those piping listed in subparagraph Pipe Insulation in PART 3 as to be omitted, shall be insulated in accordance with Table 2. This includes but is not limited to the following:

- a. Domestic hot water supply & re-circulating system.
- b. Condensate & compressed air discharge.
- c. Hot water heating.

Insulation shall be covered, in accordance with manufacturer's recommendations, with a factory applied Type I jacket or field applied aluminum where required or seal welded PVC.

3.2.3.2 Insulation for Fittings and Accessories

Pipe insulation shall be tightly butted to the insulation of the fittings and accessories. The butted joints and ends shall be sealed with joint sealant. Insulation shall be marked showing the location of unions, strainers, check valves and other components that would otherwise be hidden from view by the insulation.

3.2.3.2.1 Precut or Preformed

Place precut or preformed insulation around all fittings and accessories. Insulation shall be the same insulation as the pipe insulation, including same density, thickness, and thermal conductivity.

3.2.3.2.2 Rigid Preformed

Where precut/preformed is unavailable, rigid preformed pipe insulation sections may be segmented into the shape required. Insulation of the same thickness and conductivity as the adjoining pipe insulation shall be used. If nesting size insulation is used, the insulation shall be overlapped **2 inches** or one pipe diameter. Elbows insulated using segments shall conform to MICA Tables 12.20 "Mitered Insulation Elbow".

3.2.4 Piping Exposed to Weather

Piping exposed to weather shall be insulated and jacketed as specified for the applicable service inside the building. After this procedure, a laminated self-adhesive (minimum **2 mils** adhesive, **3 mils** embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability (greater than 3 ply, standard grade, silver, white, black and embossed aluminum jacket or PVC jacket shall be applied. PVC jacketing requires no factory-applied jacket beneath it, however an all service jacket shall be applied if factory applied jacketing is not furnished. Flexible elastomeric cellular insulation exposed to weather shall be treated in accordance with paragraph INSTALLATION OF FLEXIBLE ELASTOMERIC CELLULAR INSULATION in PART 3.

3.2.4.1 Aluminum Jacket

The jacket for hot piping may be factory applied. The jacket shall overlap not less than **2 inches** at longitudinal and circumferential joints and shall be secured with bands at not more than **12 inch** centers. Longitudinal joints shall be overlapped down to shed water and located at 4 or 8 o'clock positions. Joints on piping **60 degrees F** and below shall be sealed with metal jacketing/flashing sealant while overlapping to prevent moisture penetration. Where jacketing on piping **60 degrees F** and below abuts an un-insulated surface, joints shall be caulked to prevent moisture penetration. Joints on piping above **60 degrees F** shall be sealed with a moisture retarder.

3.2.4.2 Insulation for Fittings

Flanges, unions, valves, fittings, and accessories shall be insulated and finished as specified for the applicable service. Two coats of breather emulsion type weatherproof mastic (impermeable to water, permeable to air)

recommended by the insulation manufacturer shall be applied with glass tape embedded between coats. Tape overlaps shall be not less than **1 inch** and the adjoining aluminum jacket not less than **2 inches**. Factory preformed aluminum jackets may be used in lieu of the above. Molded PVC fitting covers shall be provided when PVC jackets are used for straight runs of pipe. PVC fitting covers shall have adhesive welded joints and shall be weatherproof laminated self-adhesive (minimum **2 mils** adhesive, **3 mils** embossed) vapor barrier/weatherproofing jacket - less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed, and UV resistant).

3.2.4.3 Stainless Steel Jackets

ASTM A167 or ASTM A240/A240M; Type 304, minimum thickness of 33 gauge (0.010 inch), smooth surface with factory-applied polyethylene and kraft paper moisture barrier on inside surface. Provide stainless steel bands, minimum width of 1/2 inch.

3.3 DUCT INSULATION SYSTEMS INSTALLATION

Corner angles shall be installed on external corners of insulation on ductwork in exposed finished spaces before covering with jacket. Air conditioned spaces shall be defined as those spaces directly supplied with cooled conditioned air (or provided with a cooling device such as a fan-coil unit) and heated conditioned air (or provided with a heating device such as a unit heater, radiator or convector).

3.3.1 Duct Insulation Minimum Thickness

Duct insulation minimum thickness in accordance with Table 4.

Table 4 - Minimum Duct Insulation (inches)	
Cold Air Ducts	2.0
Relief Ducts	1.5
Fresh Air Intake Ducts	1.5
Warm Air Ducts	2.0
Relief Ducts	1.5
Fresh Air Intake Ducts	1.5

3.3.2 Insulation and Vapor Retarder/Vapor Barrier for Cold Air Duct

Insulation and vapor retarder/vapor barrier shall be provided for the following cold air ducts and associated equipment.

- a. Supply ducts.
- b. Return air ducts.
- c. Relief ducts.
- d. Flexible run-outs (field-insulated).

- e. Plenums.
- f. Duct-mounted coil casings.
- g. Coil headers and return bends.
- h. Coil casings.
- i. Fresh air intake ducts.
- j. Filter boxes.
- k. Mixing boxes (field-insulated).
- l. Supply fans (field-insulated).
- m. Site-erected air conditioner casings.
- n. Ducts exposed to weather.
- o. Combustion air intake ducts.

Insulation for rectangular ducts shall be flexible type where concealed, minimum density $3/4$ pcf, and rigid type where exposed, minimum density 3 pcf. Insulation for both concealed or exposed round/oval ducts shall be flexible type, minimum density $3/4$ pcf or a semi rigid board, minimum density 3 pcf, formed or fabricated to a tight fit, edges beveled and joints tightly butted and staggered. Insulation for all exposed ducts shall be provided with either a white, paint-able, factory-applied Type I jacket or a field applied vapor retarder/vapor barrier jacket coating finish as specified, the total field applied dry film thickness shall be approximately $1/16$ inch. Insulation on all concealed duct shall be provided with a factory-applied Type I or II vapor retarder/vapor barrier jacket. Duct insulation shall be continuous through sleeves and prepared openings except firewall penetrations. Duct insulation terminating at fire dampers, shall be continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air and which may be prone to condensate formation. Duct insulation and vapor retarder/vapor barrier shall cover the collar, neck, and any un-insulated surfaces of diffusers, registers and grills. Vapor retarder/vapor barrier materials shall be applied to form a complete unbroken vapor seal over the insulation. Sheet Metal Duct shall be sealed in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.3.2.1 Installation on Concealed Duct

- a. For rectangular, oval or round ducts, flexible insulation shall be attached by applying adhesive around the entire perimeter of the duct in 6 inch wide strips on 12 inch centers.
- b. For rectangular and oval ducts, 24 inches and larger insulation shall be additionally secured to bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on 16 inch centers and not more than 16 inches from duct corners.
- c. For rectangular, oval and round ducts, mechanical fasteners shall be provided on sides of duct risers for all duct sizes. Fasteners shall be spaced on 16 inch centers and not more than 16 inches from duct corners.

- d. Insulation shall be impaled on the mechanical fasteners (self stick pins) where used and shall be pressed thoroughly into the adhesive. Care shall be taken to ensure vapor retarder/vapor barrier jacket joints overlap **2 inches**. The insulation shall not be compressed to a thickness less than that specified. Insulation shall be carried over standing seams and trapeze-type duct hangers.
- e. Where mechanical fasteners are used, self-locking washers shall be installed and the pin trimmed and bent over.
- f. Jacket overlaps shall be secured with staples and tape as necessary to ensure a secure seal. Staples, tape and seams shall be coated with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum **2 mils** adhesive, **3 mils** embossed) - less than 0.0000 perm adhesive tape.
- g. Breaks in the jacket material shall be covered with patches of the same material as the vapor retarder jacket. The patches shall extend not less than **2 inches** beyond the break or penetration in all directions and shall be secured with tape and staples. Staples and tape joints shall be sealed with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum **2 mils** adhesive, **3 mils** embossed) - less than 0.0000 perm adhesive tape.
- h. At jacket penetrations such as hangers, thermometers, and damper operating rods, voids in the insulation shall be filled and the penetration sealed with a brush coat of vapor retarder coating or PVDC adhesive tape greater than 3 ply laminate (minimum **2 mils** adhesive, **3 mils** embossed) - less than 0.0000 perm adhesive tape.
- i. Insulation terminations and pin punctures shall be sealed and flashed with a reinforced vapor retarder coating finish or tape with a brush coat of vapor retarder coating. The coating shall overlap the adjoining insulation and un-insulated surface **2 inches**. Pin puncture coatings shall extend **2 inches** from the puncture in all directions.
- j. Where insulation standoff brackets occur, insulation shall be extended under the bracket and the jacket terminated at the bracket.

3.3.2.2 Installation on Exposed Duct Work

- a. For rectangular ducts, rigid insulation shall be secured to the duct by mechanical fasteners on all four sides of the duct, spaced not more than **12 inches** apart and not more than **3 inches** from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct **12 inches** and larger. One row shall be provided for each side of duct less than **12 inches**. Mechanical fasteners shall be as corrosion resistant as G60 coated galvanized steel, and shall indefinitely sustain a **50 lb** tensile dead load test perpendicular to the duct wall.
- b. Form duct insulation with minimum jacket seams. Fasten each piece of rigid insulation to the duct using mechanical fasteners. When the height of projections is less than the insulation thickness, insulation shall be brought up to standing seams, reinforcing, and other vertical projections and shall not be carried over. Vapor retarder/barrier jacket shall be continuous across seams, reinforcing,

and projections. When height of projections is greater than the insulation thickness, insulation and jacket shall be carried over. Apply insulation with joints tightly butted. Neatly bevel insulation around name plates and access plates and doors.

- c. Impale insulation on the fasteners; self-locking washers shall be installed and the pin trimmed and bent over.
- d. Seal joints in the insulation jacket with a 4 inch wide strip of tape. Seal taped seams with a brush coat of vapor retarder coating.
- e. Breaks and ribs or standing seam penetrations in the jacket material shall be covered with a patch of the same material as the jacket. Patches shall extend not less than 2 inches beyond the break or penetration and shall be secured with tape and stapled. Staples and joints shall be sealed with a brush coat of vapor retarder coating.
- f. At jacket penetrations such as hangers, thermometers, and damper operating rods, the voids in the insulation shall be filled and the penetrations sealed with a flashing sealant.
- g. Insulation terminations and pin punctures shall be sealed and flashed with a reinforced vapor retarder coating finish. The coating shall overlap the adjoining insulation and un-insulated surface 2 inches. Pin puncture coatings shall extend 2 inches from the puncture in all directions.
- h. Oval and round ducts, flexible type, shall be insulated with factory Type I jacket insulation with minimum density of 3/4 pcf, attached as in accordance with MICA standards.

3.3.3 Insulation for Warm Air Duct

Insulation and vapor barrier shall be provided for the following warm air ducts and associated equipment:.

- a. Supply ducts.
- b. Return air ducts.
- c. Relief air ducts
- d. Flexible run-outs (field insulated).
- e. Plenums.
- f. Duct-mounted coil casings.
- g. Coil-headers and return bends.
- h. Coil casings.
- i. Fresh air intake ducts.
- j. Filter boxes.
- k. Mixing boxes.
- l. Supply fans.

- m. Site-erected air conditioner casings.
- n. Ducts exposed to weather.

Insulation for rectangular ducts shall be flexible type where concealed, and rigid type where exposed. Insulation on exposed ducts shall be provided with a white, paint-able, factory-applied Type II jacket, or finished with adhesive finish. Flexible type insulation shall be used for round ducts, with a factory-applied Type II jacket. Insulation on concealed duct shall be provided with a factory-applied Type II jacket. Adhesive finish where indicated to be used shall be accomplished by applying two coats of adhesive with a layer of glass cloth embedded between the coats. The total dry film thickness shall be approximately **1/16 inch**. Duct insulation shall be continuous through sleeves and prepared openings. Duct insulation shall terminate at fire dampers and flexible connections.

3.3.3.1 Installation on Concealed Duct

- a. For rectangular, oval and round ducts, insulation shall be attached by applying adhesive around the entire perimeter of the duct in **6 inch** wide strips on **12 inch** centers.
- b. For rectangular and oval ducts **24 inches** and larger, insulation shall be secured to the bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on **18 inch** centers and not more than **18 inches** from duct corner.
- c. For rectangular, oval and round ducts, mechanical fasteners shall be provided on sides of duct risers for all duct sizes. Fasteners shall be spaced on **18 inch** centers and not more than **18 inches** from duct corners.
- d. The insulation shall be impaled on the mechanical fasteners where used. The insulation shall not be compressed to a thickness less than that specified. Insulation shall be carried over standing seams and trapeze-type hangers.
- e. Self-locking washers shall be installed where mechanical fasteners are used and the pin trimmed and bent over.
- f. Insulation jacket shall overlap not less than **2 inches** at joints and the lap shall be secured and stapled on **4 inch** centers.

3.3.3.2 Installation on Exposed Duct

- a. For rectangular ducts, the rigid insulation shall be secured to the duct by the use of mechanical fasteners on all four sides of the duct, spaced not more than **16 inches** apart and not more than **6 inches** from the edges of the insulation joints. A minimum of two rows of fasteners shall be provided for each side of duct **12 inches** and larger and a minimum of one row for each side of duct less than **12 inches**.
- b. Duct insulation with factory-applied jacket shall be formed with minimum jacket seams, and each piece of rigid insulation shall be fastened to the duct using mechanical fasteners. When the height of projection is less than the insulation thickness, insulation shall be brought up to standing seams, reinforcing, and other vertical

projections and shall not be carried over the projection. Jacket shall be continuous across seams, reinforcing, and projections. Where the height of projections is greater than the insulation thickness, insulation and jacket shall be carried over the projection.

- c. Insulation shall be impaled on the fasteners; self-locking washers shall be installed and pin trimmed and bent over.
- d. Joints on jacketed insulation shall be sealed with a 4 inch wide strip of tape and brushed with vapor retarder coating.
- e. Breaks and penetrations in the jacket material shall be covered with a patch of the same material as the jacket. Patches shall extend not less than 2 inches beyond the break or penetration and shall be secured with adhesive and stapled.
- f. Insulation terminations and pin punctures shall be sealed with tape and brushed with vapor retarder coating.
- g. Oval and round ducts, flexible type, shall be insulated with factory Type I jacket insulation, minimum density of 3/4 pcf attached by staples spaced not more than 16 inches and not more than 6 inches from the degrees of joints. Joints shall be sealed in accordance with item "d." above.

3.3.4 Ducts Handling Air for Dual Purpose

For air handling ducts for dual purpose below and above 60 degrees F, ducts shall be insulated as specified for cold air duct.

3.3.5 Duct Test Holes

After duct systems have been tested, adjusted, and balanced, breaks in the insulation and jacket shall be repaired in accordance with the applicable section of this specification for the type of duct insulation to be repaired.

3.3.6 Duct Exposed to Weather

3.3.6.1 Installation

Ducts exposed to weather shall be insulated and finished as specified for the applicable service for exposed duct inside the building. After the above is accomplished, the insulation shall then be further finished as detailed in the following subparagraphs.

3.3.6.2 Round Duct

Laminated self-adhesive (minimum 2 mils adhesive, 3 mils embossed) vapor barrier/weatherproofing jacket - Less than 0.0000 permeability, (greater than 3 ply, standard grade, silver, white, black and embossed or greater than 8 ply, heavy duty, white and natural) membrane shall be applied overlapping material by 3 inches no bands or caulking needed - see manufacturer's recommended installation instructions. Aluminum jacket with factory applied moisture retarder shall be applied with the joints lapped not less than 3 inches and secured with bands located at circumferential laps and at not more than 12 inch intervals throughout. Horizontal joints shall lap down to shed water and located at 4 or 8 o'clock position. Joints shall be sealed with metal jacketing sealant to

prevent moisture penetration. Where jacketing abuts an un-insulated surface, joints shall be sealed with metal jacketing sealant.

3.3.6.3 Fittings

Fittings and other irregular shapes shall be finished as specified for rectangular ducts.

3.3.6.4 Rectangular Ducts

Two coats of weather barrier mastic reinforced with fabric or mesh for outdoor application shall be applied to the entire surface. Each coat of weatherproof mastic shall be **1/16 inch** minimum thickness. The exterior shall be a metal jacketing applied for mechanical abuse and weather protection, and secured with screws or vapor barrier/weatherproofing jacket less than 0.0000 permeability greater than 3 ply, standard grade, silver, white, black, and embossed or greater than 8 ply, heavy duty white and natural. Membrane shall be applied overlapping material by **3 inches**. No bands or caulking needed-see manufacturing recommend installation instructions.

3.4 EQUIPMENT INSULATION SYSTEMS INSTALLATION

3.4.1 General

Removable insulation sections shall be provided to cover parts of equipment that must be opened periodically for maintenance including vessel covers, fasteners, flanges and accessories. Equipment insulation shall be omitted on the following:

- a. Hand-holes.
- b. Boiler manholes.
- c. Cleanouts.
- d. ASME stamps.
- e. Manufacturer's nameplates.
- f. Duct Test/Balance Test Holes.

3.4.2 Insulation for Cold Equipment

Cold equipment below **60 degrees F**: Insulation shall be furnished on equipment handling media below **60 degrees F** including the following:

- a. Pumps.
- b. Refrigeration equipment parts that are not factory insulated.
- c. Drip pans under chilled equipment.
- d. Cold water storage tanks.
- e. Duct mounted coils.
- f. Cold and chilled water pumps.

- g. Roof drain bodies.
- h. Air handling equipment parts that are not factory insulated.
- i. Expansion and air separation tanks.

3.4.2.1 Insulation Type

Insulation shall be suitable for the temperature encountered. Material and thicknesses shall be as shown in Table 5:

TABLE 5		
Insulation Thickness for Cold Equipment (inches)		
Equipment handling media at indicated temperature		
	Material	Thickness (inches)
35 to 60 degrees F		
	Cellular Glass	1.5
	Flexible Elastomeric Cellular	1
1 to 34 degrees F		
	Cellular Glass	3
	Flexible Elastomeric Cellular	1.5
Minus 30 to 0 degrees F		
	Cellular Glass	3.5
	Flexible Elastomeric Cellular	1.75

3.4.2.2 Pump Insulation

- a. Insulate pumps by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Joints between sides and between sides and bottom shall be joined by adhesive with lap strips for rigid mineral fiber and contact adhesive for flexible elastomeric cellular insulation. The box shall conform to the requirements of MICA Insulation Stds plate No. 49 when using flexible elastomeric cellular insulation. Joints between top cover and sides shall fit tightly forming a female shiplap joint on the side pieces and a male joint on the top cover, thus making the top cover removable.
- b. Exposed insulation corners shall be protected with corner angles.
- c. Upon completion of installation of the insulation, including removable sections, two coats of vapor retarder coating shall be applied with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 1/16 inch. A parting line shall be

provided between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. Flashing sealant shall be applied to parting line, between equipment and removable section insulation, and at all penetrations.

3.4.2.3 Other Equipment

- a. Insulation shall be formed or fabricated to fit the equipment. To ensure a tight fit on round equipment, edges shall be beveled and joints shall be tightly butted and staggered.
- b. Insulation shall be secured in place with bands or wires at intervals as recommended by the manufacturer but not more than 12 inch centers except flexible elastomeric cellular which shall be adhered with contact adhesive. Insulation corners shall be protected under wires and bands with suitable corner angles.
- c. Cellular glass shall be installed in accordance with manufacturer's instructions. Joints and ends shall be sealed with joint sealant, and sealed with a vapor retarder coating.
- d. Insulation on heads of heat exchangers shall be removable. Removable section joints shall be fabricated using a male-female shiplap type joint. The entire surface of the removable section shall be finished by applying two coats of vapor retarder coating with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be 1/16 inch.
- e. Exposed insulation corners shall be protected with corner angles.
- f. Insulation on equipment with ribs shall be applied over 6 by 6 inches by 12 gauge welded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot welded to the equipment over the ribs. Insulation shall be secured to the fabric with J-hooks and 2 by 2 inches washers or shall be securely banded or wired in place on 12 inch centers.

3.4.2.4 Vapor Retarder/Vapor Barrier

Upon completion of installation of insulation, penetrations shall be caulked. Two coats of vapor retarder coating or vapor barrier jacket shall be applied over insulation, including removable sections, with a layer of open mesh synthetic fabric embedded between the coats. The total dry thickness of the finish shall be 1/16 inch. Flashing sealant or vapor barrier tape shall be applied to parting line between equipment and removable section insulation.

3.4.3 Insulation for Hot Equipment

Insulation shall be furnished on equipment handling media above 60 degrees F including the following:

- a. Converters.
- b. Heat exchangers.
- c. Hot water generators.
- d. Water heaters.

- e. Pumps handling media above 130 degrees F.
- f. Hot water storage tanks.
- g. Air separation tanks.
- h. Surge tanks.
- i. Flash tanks.
- l. Unjacketed boilers or parts of boilers.
- m. Boiler flue gas connection from boiler to stack (if inside).
- n. Induced draft fans.

3.4.3.1 Insulation

Insulation shall be suitable for the temperature encountered. Shell and tube-type heat exchangers shall be insulated for the temperature of the shell medium.

Insulation thickness for hot equipment shall be determined using Table 6:

TABLE 6		
Insulation Thickness for Hot Equipment (inches)		
Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (inches)
15 psig or 250 degrees F		
	Rigid Mineral Fiber	2
	Flexible Mineral Fiber	2
	Calcium Silicate/Perlite	4
	Cellular Glass	3
	Faced Phenolic Foam	1.5

3.4.3.2 Insulation of Pumps

Insulate pumps by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Bottom and sides shall be banded to form a rigid housing that does not rest on the pump. Joints between top cover and sides shall fit tightly. The top cover shall have a joint forming a female shiplap joint on the side pieces and a male joint on the top cover, making the top cover removable. Two coats of Class I adhesive shall be applied over insulation, including removable sections, with a layer of glass cloth embedded between the coats. A parting line shall be provided between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. The total dry thickness of the finish shall be $1/16$ inch. Caulking shall be applied to parting line of the removable sections and penetrations.

3.4.3.3 Other Equipment

- a. Insulation shall be formed or fabricated to fit the equipment. To ensure a tight fit on round equipment, edges shall be beveled and joints shall be tightly butted and staggered.
- b. Insulation shall be secured in place with bands or wires at intervals as recommended by the manufacturer but not greater than 12 inch centers except flexible elastomeric cellular which shall be adhered. Insulation corners shall be protected under wires and bands with suitable corner angles.
- c. On high vibration equipment, cellular glass insulation shall be set in a coating of bedding compound as recommended by the manufacturer, and joints shall be sealed with bedding compound. Mineral fiber joints shall be filled with finishing cement.
- d. Insulation on heads of heat exchangers shall be removable. The removable section joint shall be fabricated using a male-female shiplap type joint. Entire surface of the removable section shall be finished as specified.
- e. Exposed insulation corners shall be protected with corner angles.
- f. On equipment with ribs, such as boiler flue gas connection, draft fans, and fly ash or soot collectors, insulation shall be applied over 6 by 6 inch by 12 gaugewelded wire fabric which has been cinched in place, or if approved by the Contracting Officer, spot welded to the equipment over the ribs. Insulation shall be secured to the fabric with J-hooks and 2 by 2 inch washers or shall be securely banded or wired in place on 12 inch (maximum) centers.
- g. On equipment handling media above 600 degrees F, insulation shall be applied in two or more layers with joints staggered.
- h. Upon completion of installation of insulation, penetrations shall be caulked. Two coats of adhesive shall be applied over insulation, including removable sections, with a layer of glass cloth embedded between the coats. The total dry thickness of the finish shall be $1/16$ inch. Caulking shall be applied to parting line between equipment and removable section insulation.

3.4.4 Equipment Handling Dual Temperature Media

Below and above 60 degrees F: equipment handling dual temperature media shall be insulated as specified for cold equipment.

3.4.5 Equipment Exposed to Weather

3.4.5.1 Installation

Equipment exposed to weather shall be insulated and finished in accordance with the requirements for ducts exposed to weather in paragraph DUCT INSULATION INSTALLATION.

3.4.5.2 Optional Panels

At the option of the Contractor, prefabricated metal insulation panels may be used in lieu of the insulation and finish previously specified. Thermal performance shall be equal to or better than that specified for field applied insulation. Panels shall be the standard catalog product of a manufacturer of metal insulation panels. Fastenings, flashing, and support system shall conform to published recommendations of the manufacturer for weatherproof installation and shall prevent moisture from entering the insulation. Panels shall be designed to accommodate thermal expansion and to support a 250 pound walking load without permanent deformation or permanent damage to the insulation. Exterior metal cover sheet shall be aluminum and exposed fastenings shall be stainless steel or aluminum.

-- End of Section --

SECTION 23 09 23.13 22

BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC
06/21

PART 1 GENERAL

1.1 REFERENCES

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

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 500-D (2018) Laboratory Methods of Testing
Dampers for Rating

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

ASHRAE 135 (2016) BACnet—A Data Communication
Protocol for Building Automation and
Control Networks

ARCNET TRADE ASSOCIATION (ATA)

ATA 878.1 (1999) Local Area Network: Token Bus

ASME INTERNATIONAL (ASME)

ASME B16.18 (2018) Cast Copper Alloy Solder Joint
Pressure Fittings

ASME B16.22 (2018) Standard for Wrought Copper and
Copper Alloy Solder Joint Pressure Fittings

ASME B16.26 (2018) Standard for Cast Copper Alloy
Fittings for Flared Copper Tubes

ASME B16.5 (2017) Pipe Flanges and Flanged Fittings
NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B31.1 (2020) Power Piping

ASTM INTERNATIONAL (ASTM)

ASTM A126 (2004; R 2019) Standard Specification for
Gray Iron Castings for Valves, Flanges,
and Pipe Fittings

ASTM B117 (2019) Standard Practice for Operating
Salt Spray (Fog) Apparatus

ASTM B32 (2020) Standard Specification for Solder
Metal

ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM D1238	(2013) Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D1693	(2015) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D635	(2018) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics
ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1-D	(2014) Control Network Protocol Specification

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.45	(2002; R 2008) Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000v and less)AC Power Circuits

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 8802-3	(2000) 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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)

National Electrical Code

NFPA 72

(2019; TIA 19-1; ERTA 1 2019) National Fire Alarm and Signaling Code

NFPA 90A

(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1966

(2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition

UNDERWRITERS LABORATORIES (UL)

UL 1449

(2021) UL Standard for Safety Surge Protective Devices

UL 506

(2017) UL Standard for Safety Specialty Transformers

UL 508A

(2013; Reprint Jan 2014) Industrial Control Panels

UL 916

(2015) Standard for Energy Management Equipment

1.2 DEFINITIONS

1.2.1 ANSI/ASHRAE Standard 135

ANSI/ASHRAE Standard 135: BACnet - A Data Communication Protocol for Building Automation and Control Networks, referred to as "BACnet". ASHRAE developed BACnet to provide a method for diverse building automation devices to communicate and share data over a network.

1.2.2 ARCNET

ATA 878.1 - Attached Resource Computer Network. ARCNET is a deterministic LAN technology; meaning it's possible to determine the maximum delay before a device is able to transmit a message.

1.2.3 BACnet

Building Automation and Control Network; the common name for the communication standard **ASHRAE 135**. The standard defines methods and protocol for cooperating building automation devices to communicate over a variety of LAN technologies.

1.2.4 BACnet/IP

An extension of BACnet, Annex J, defines this mechanism using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number. See also "BACnet Broadcast Management Device".

1.2.5 BACnet Internetwork

Two or more BACnet networks, possibly using different LAN technologies, connected with routers. In a BACnet internetwork, there exists only one message path between devices.

1.2.6 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.

1.2.7 BACnet Segment

One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.

1.2.8 BBMD

BACnet Broadcast Management Device (BBMD). A communications device, typically combined with a BACnet router. A BBMD forwards BACnet broadcast messages to BACnet/IP devices and other BBMDs connected to the same BACnet/IP network. Every IP subnetwork that is part of a BACnet/IP network must have only one BBMD. See also "BACnet/IP".

1.2.9 BAS

Building Automation Systems, including DDC (Direct Digital Controls) used for facility automation and energy management.

1.2.10 BAS Owner

The regional or local user responsible for managing all aspects of the BAS operation, including: network connections, workstation management, technical support, control parameters, and daily operation. The BAS Owner for this project is [Camp Lejeune Public Works](#).

1.2.11 BIBBs

BACnet Interoperability Building Blocks. A collection of BACnet services used to describe supported tasks. BIBBs are often described in terms of "A" (client) and "B" (server) devices. The "A" device uses data provided by the "B" device, or requests an action from the "B" device.

1.2.12 BI

BACnet International, formerly two organizations: the BACnet Manufacturers Association (BMA) and the BACnet Interest Group - North America (BIG-NA).

1.2.13 BI/BTL

BACnet International/BACnet Testing Laboratories (Formerly BMA/BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.

1.2.14 Bridge

Network hardware that connects two or more network (or BACnet internetwork) segments at the physical and data link layers. A bridge may also filter messages.

1.2.15 Broadcast

A message sent to all devices on a network segment.

1.2.16 Device

Any control system component, usually a digital controller, that contains a BACnet Device Object and uses BACnet to communicate with other devices. See also "Digital Controller".

1.2.17 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.

1.2.18 Device Profile

A collection of BIBBs determining minimum BACnet capabilities of a device, defined in ASHRAE Standard 135-2004, 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 BIBBs supported.

1.2.19 Digital Controller

An electronic controller, usually with internal programming logic and digital and analog input/output capability, which performs control functions. In most cases, synonymous with a BACnet device described in this specification. See also "Device".

1.2.19.1 Terminal Device Controllers

Terminal device controllers typically are controllers with less control features, may have integrated actuators, and may be mounted directly on equipment (with enclosures).

1.2.19.2 Field Controllers

Field controllers typically have a greater capability for input/output and customization, do not have integral actuators, are mounted in an enclosure not on the equipment and are used for equipment such as VAV air handlers.

1.2.19.3 Plant Controllers

Plant controllers are typically used to control various equipment in mechanical rooms such as pumps, heat exchangers, and chillers.

1.2.19.4 Supervisory Building Controller (SBC)

The Supervisory Building Controller is used to coordinate all equipment in a building, input scheduling, and is used as a connection point for transferring configuration files to the other controllers. The SBC shall communicate with other controllers and equipment through a BACnet MS/TP bus. Depending on approvals and capabilities, the SBC may be used as a

point of connection between the Camp Lejeune EMCS network (IP) and the building level control network (BACnet MS/TP).

1.2.20 Direct Digital Control (DDC)

Digital controllers performing control logic. Usually the controller directly senses physical values, makes control decisions with internal programs, and outputs control signals to directly operate switches, valves, dampers, and motor controllers.

1.2.21 DDC System

A network of digital controllers, communication architecture, and user interfaces. A DDC system may include programming, sensors, actuators, switches, relays, factory controls, operator workstations, and various other devices, components, and attributes.

1.2.22 Energy Management & Control System (EMCS)

The EMCS at Camp Lejeune is an enterprise system that actively receives energy and building condition information from multiple sources and provides load shedding, electric metering, alarming, trending, scheduling, set point adjustment and device status of all supervisory building controllers for maintenance personnel. The EMCS receives real time electrical utility pricing data and automatically manages to Camp Lejeune's energy target. The existing EMCS consists of two servers, 1) Johnson Controls Incorporated (JCI) Metasys Extended Architecture (ADX server), and 2) Niagara FX N4 supervisor (JCI FX web supervisor). Both of the systems communicate over the MCEN and either may be used to fulfill the requirements of this specification.

1.2.23 Ethernet

A family of local-area-network technologies providing high-speed networking features over various media.

1.2.24 Firmware

Software programmed into read only memory (ROM), flash memory, electrically erasable programmable read only memory (EEPROM), or erasable programmable read only memory (EPROM) chips.

1.2.25 Gateway

Communication hardware and software connecting two or more different protocols, similar to human language translators. The Gateway translates one protocol into equivalent concepts for the other protocol. In BACnet applications, a Gateway has BACnet on one side and non-BACnet protocols on the other side.

1.2.26 Global ID

An identification number assigned to each Supervisory Building Controller. The Global ID includes assigned MSTP Trunk Instance Numbers and a range of BACnet Instance Numbers to be used for the Field Controllers. The Global ID is assigned by Public Works.

1.2.27 Half Router

A device that participates as one partner in a BACnet point-to-point (PTP) connection. Two half-routers in an active PTP connection combine to form a single router.

1.2.28 Hub

A common connection point for devices on a network.

1.2.29 Internet Protocol (IP, TCP/IP, UDP/IP)

A communication method, the most common use is the World Wide Web. At the lowest level, it is based on Internet Protocol (IP), a method for conveying and routing packets of information over various LAN media. Two common protocols using IP are User Datagram Protocol (UDP) and Transmission Control Protocol (TCP). UDP conveys information to well-known "sockets" without confirmation of receipt. TCP establishes "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

1.2.30 Input/Output (I/O)

Physical inputs and outputs to and from a device, although the term sometimes describes software, or "virtual" I/O. See also "Points".

1.2.31 I/O Expansion Unit

An I/O expansion unit provides additional point capacity to a digital controller.

1.2.32 IP subnet

Internet protocol (IP) identifies individual devices with a 32-bit number divided into four groups from 0 to 255. Devices are often grouped and share some portion of this number. For example, one device has IP address 209.185.47.68 and another device has IP address 209.185.47.82. These two devices share Class C subnet 209.185.47.00

1.2.33 Local-Area Network (LAN)

A communication network that spans a limited geographic area and uses the same basic communication technology throughout.

1.2.34 LonTalk

CEA-709.1-D. A communication protocol developed by Echelon Corp. LonTalk is **not permitted**.

1.2.35 MAC Address

Media Access Control address. The physical node address that identifies a device on a Local Area Network.

1.2.36 Master-Slave/Token-Passing (MS/TP)

ISO 8802-3. One of the LAN options for BACnet. MSTP uses twisted-pair wiring for relatively low speed and low cost communication (up to 4,000 ft at 76.8K bps).

1.2.37 Native BACnet Device

A device that uses BACnet as its primary, if not only, 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.

1.2.38 Network

Communication technology for data communications. BACnet approved network types are BACnet over Internet Protocol (IP), Point to Point (PTP) Ethernet, ARCNET, MS/TP, and LonTalk®. *In general, networks within the building, all controllers and equipment will be BACnet MS/TP, unless noted otherwise.*

1.2.39 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.

1.2.40 Object

The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.

1.2.41 Object Identifier

An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.

1.2.42 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.

1.2.43 Peer-to-Peer

Peer-to-peer refers to devices where any device can initiate and respond to communication with other devices. *Peer-to-Peer configurations must be reviewed and approved by Camp Lejeune Public Works Department.*

1.2.44 Performance Verification Test (PVT)

The procedure for determining if the installed BAS meets design criteria prior to final acceptance. The PVT is performed after installation, testing, and balancing of mechanical systems. Typically the PVT is performed by the Contractor in the presence of the Government.

1.2.45 PID

Proportional, integral, and derivative control; three parameters used to control modulating equipment to maintain a setpoint. Derivative control is often not required for HVAC systems (leaving "PI" control).

1.2.46 PICS

Protocol Implementation Conformance Statement (PICS), describing the BACnet capabilities of a device. See BACnet, Annex A for the standard format and content of a PICS statement.

1.2.47 Points

Physical and virtual inputs and outputs. See also "Input/Output".

1.2.48 PTP

Point-to-Point protocol connects individual BACnet devices or networks using serial connections like modem-to-modem links.

1.2.49 Repeater

A network component that connects two or more physical segments at the physical layer.

1.2.50 Router

A BACnet router is 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. If a router is connected directly to the MCEN, it must be listed on the approved DIACAP equipment list and must be Marine Corps DADMS listed and approved.

1.2.51 Stand-Alone Control

Refers to devices performing equipment-specific and small system control without communication to other devices or computers for physical I/O, excluding outside air and other common shared conditions. Devices are located near controlled equipment, with physical input and output points limited to 64 or less per device, except for complex individual equipment or systems. Failure of any single device or communications will not cause other network devices to fail. Internal time clocks and onboard scheduling are required to allow for stand-alone control if not connected to a Supervisory Building Controller. BACnet "Smart" actuators (B-SA profile) and sensors (B-SS profile) communicating on a network with a parent device are exempt from stand-alone requirements. Provide stand-alone control routines to provide for energy saving sequences such as free cooling. Provide stand-alone control routines that operate without connection to the BACnet/IP and MS/TP networks during a loss of communication.

1.2.52 Supervisory Building Controller

Supervisory Controller that is the main interface for the building control system.

1.3 SUBCONTRACTOR SPECIAL REQUIREMENTS

Perform all work in this section in accordance with the paragraph SUBCONTRACTOR SPECIAL REQUIREMENTS in Section 01 30 00.05 00 ADMINISTRATIVE REQUIREMENTS FOR DESIGN-BUILD. The paragraph specifies that all contract requirements of this section shall be accomplished directly by a first tier subcontractor. No work required shall be accomplished by a second tier subcontractor.

1.4 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC DESCRIPTION

- a. All new devices are accessible using a Web browser interface and communicate using ASHRAE 135 BACnet communications without the use of gateways, unless gateways are shown on the design drawings and specifically requested by the Government. Where gateways are allowed, they must support ASHRAE 135, including all object properties and read-write services shown on Government approved interoperability schedules. Manufacturer's products, including design, materials, fabrication, assembly, inspection, and testing shall be in accordance with ASHRAE 135, ASME B31.1, and NFPA 70, except where indicated otherwise.

1.4.1 Design Requirements

1.4.1.1 Control System Drawings Title Sheet

Provide a title sheet for the control system drawing set. Include the project title, project location, contract number, the controls contractor preparing the drawings, an index of the control drawings in the set, and a legend of the symbols and abbreviations used throughout the control system drawings. The Title Block of each drawing must include the Drawing revision, i.e. Submittal, Revision 1, Revision 2, As-Built, etc., including the date.

1.4.1.2 List of I/O Points

Also known as a Point Schedule, provide for each input and output point physically connected to a digital controller: point name, point description, point type (Analog Output (AO), Analog Input (AI), Binary Output (BO), Binary Input (BI)), point sensor range, point actuator range, point address, BACnet object, associated BIBBS (where applicable), and point connection terminal number and cable type (18/2, 18/3, etc). Typical schedules for multiple identical equipment are allowed unless otherwise requested in design or contract criteria. All points shall adhere to the Camp Lejeune Standard naming conventions.

1.4.1.3 Control System Components List

Provide a complete list of control system components installed on this project. Include for each controller and device: control system schematic name, control system schematic designation, device description, manufacturer, model, part number, firmware version, serial number, physical location (e.g. Building 4, room 112 overhead), and power requirements (i.e. AC/DC voltage and power draw). For sensors, include point name, sensor range, and operating limits. For valves, include body style, Cv, design flow rate, pressure drop, valve characteristic (linear or equal percentage), and pipe connection size. For actuators, include point name, spring or non-spring return, modulating or two-position action, normal (power fail) position, nominal control signal operating range (0-10 volts DC or 4-20 milliamps), and operating limits.

1.4.1.4 Control System Schematics

Provide control system schematics. Typical schematics for multiple identical equipment are allowed unless otherwise requested in design or contract criteria. Include the following:

- a. Location of each input and output device, specify room # for remote

devices.

- b. Flow diagram for each piece of HVAC equipment
- c. Name or symbol for each control system component, such as V-1 for a valve
- d. Setpoints, with differential or proportional band values
- e. Written sequence of operation for the HVAC equipment
- f. Valve and Damper Schedules, with normal (power fail) position
- g. Control cabinet general layout, include all devices, point count, cable type (18/2, 18/3, etc), 24VAC VA power requirement for all devices including those powered from the cabinet.

1.4.1.5 HVAC Equipment Control Ladder Diagrams

Provide HVAC equipment control ladder diagrams. Indicate required electrical interlocks. Ladder diagram schematics shall include 120 VAC and low voltage devices in each panel. Ladder diagram schematics shall also include all field devices (sensors, relays, actuators, etc.) and any connection point to controlled equipment or devices.

1.4.1.6 Component Wiring Diagrams

Provide a wiring diagram for each type of input device and output device. Indicate how each device is wired and powered; showing typical connections at the digital controller and power supply. Show for all field connected devices such as control relays, motor starters, actuators, sensors, and transmitters.

1.4.1.7 Terminal Strip Diagrams

Provide a diagram of each terminal strip. Indicate the terminal strip location, termination numbers, and associated point names.

1.4.1.8 BACnet Communication Architecture Schematic (Network Riser)

Provide a schematic showing the project's entire BACnet communication network, including Internet Protocol (IP), Media Access Control (MAC), BACnet network, Device ID, field bus address, BBMDs, any devices using BACnet FDR, and Firmware version / Operating System, LAN devices including routers and bridges, gateways, controllers, workstations, and field interface devices. If applicable, show connection to existing networks and include the existing network in the riser diagram. Include surge protection device locations on the riser when the field controller communication trunk is leaving or entering a building.

1.4.1.9 Control Panel Layout

Provide a detailed panel layout for each control panel, relay panel, etc. The layout shall include all components to be installed in the panel including controllers, terminal strips, transformers, Panduit, etc.

1.5 SUBMITTALS

Submit detailed and annotated manufacturer's data, drawings, and specification sheets for each item listed, that clearly show compliance with the project specifications.

Submit the following in accordance with Section 01 33 00.05 20 SUBMITTAL PROCEDURES FOR DESIGN BUILD:

SD-02 Shop Drawings

Include the following in the project's control system drawing set:

Control System Drawings Title Sheet

List of I/O Points

Control System Components List

Control System Schematics

HVAC Equipment Control Ladder Diagrams

Component Wiring Diagrams

Terminal Strip Diagrams

BACnet Communication Architecture Schematic

Sequence of Operations

Control Panel Layout

SD-03 Product Data

Direct Digital Controllers

Include BACnet PICS for each controller/device type, including smart sensors (B-SS) and smart actuators (B-SA).

BACnet Gateways

Include BACnet and workstation display information; bi-directional communication ability; compliance with interoperability schedule; expansion capacity; handling of alarms, events, scheduling and trend data; and single device capability (not depending on multiple devices for exchanging information from either side of the gateway).

Notebook Computer Software

BACnet Operator Workstation

Include BACnet PICS for Operator Workstation software.

Notebook Computer

Sensors and Input Hardware

Output Hardware

Surge and Transient Protection

Indicators

Pneumatic Tubing

Variable Frequency (Motor) Drives

SD-05 Design Data

Pre-PVT Checklist

Performance Verification Testing Plan

SD-06 Test Reports

Pre-Performance Verification Testing Checklist

Performance Verification Testing Report

Bus Waveform Report

SD-07 Certificates

Contractor's Qualifications

Contractor's Training Certifications

SD-10 Operation and Maintenance Data

Comply with requirements for data packages in Section 01 78 23 OPERATION AND MAINTENANCE DATA and in Section 01 78 24.00 20 FACILITY ELECTRONIC OPERATION AND MAINTENANCE SUPPORT INFORMATION (eOMSI), except as supplemented and modified in this specification.

BACnet Direct Digital Control Systems, Data Package 4

Controls System Operators Manuals, Data Package 4

VFD Service Manuals, Data Package 4

SD-11 Closeout Submittals

Training Documentation

Warranty Information

1.6 QUALITY ASSURANCE

1.6.1 Standard Products

Provide material and equipment that are standard manufacturer's products currently in production and supported by a local service organization.

1.6.2 Delivery, Storage, and Handling

Handle, store, and protect equipment and materials to prevent damage

before and during installation according to manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6.3 Operating Environment

Protect components from humidity and temperature variation, dust, and contaminants. If components are stored before installation, keep them within the manufacturer's limits.

1.6.4 Finish of New Equipment

New equipment finishing shall be factory provided. Manufacturer's standard factory finishing shall be proven to withstand 125 hours in a salt-spray fog test. Equipment located outdoors shall be proven to withstand 500 hours in a salt-spray fog test.

Salt-spray fog test shall be according to [ASTM B117](#), with acceptance criteria as follows: immediately after completion of the test, the finish shall show no signs of degradation or loss of adhesion beyond [0.125 inch](#) on either side of the scratch mark.

1.6.5 Verification of Dimensions

The contractor shall verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing work.

1.6.6 Contractor's Qualifications

Submit documentation certifying the controls Contractor performing the work has completed at least three DDC systems installations of a similar design to this project, and programmed similar sequences of operation for at least two years. [Personnel performing the installation, programming, checkout, commissioning and training shall, at a minimum, have obtained all certifications required by the manufacturer for the tasks they are performing. Tasks include any activity required to execute and complete the contracted work. Contractor's Training Certifications for each person shall be submitted prior to the beginning of the contracted work. Certifications shall be made available at any time upon the request from Camp Lejeune.](#)

1.6.7 Modification of References

The advisory provisions in [ASME B31.1](#), [NFPA 70](#) and the manufacturer's [recommendations](#) are mandatory. Substitute "shall" for "should" wherever it appears and interpret all references to the "authority having jurisdiction" and "owner" to mean the Contracting Officer.

1.6.8 Project Sequence

The control system work for this project shall proceed in the following order:

- a. [Preparatory meeting for controls work.](#)
- b. [Submit and receive approval on the Shop Drawings, Product Data, and Certificates specified under the paragraph SUBMITTALS>](#)
- c. [Submit and receive approval for Performance Verification Testing \(PVT\)](#)

Plan.

- d. DDC Pre-Installation Meeting.
- e. Perform the control system installation work, including all field check-outs and tuning.
- f. Provide support to TAB personnel as specified under the paragraph TEST AND BALANCE SUPPORT.
- g. Submit and receive approval of the Controls System Operators Manual specified under the paragraph CONTROLS SYSTEM OPERATORS MANUALS.
- g. Perform the Performance Verification Testing.
- i. Submit and receive approval on the PVT Report. Submit As-Built Control Drawings
- j. PVT Report Acceptance test for Season 1.
- k. Submit and receive approval on the Training Documentation specified under the paragraph INSTRUCTION TO GOVERNMENT PERSONNEL and VFD Service Support. Submit at least 30 days before training.
- l. Deliver the final Controls System Operators Manuals and VFD Service Manuals.
- m. Conduct the Phase I Training and VFD on-site/hands-on training.
- n. Conduct the Phase II Training.
- o. Submit and receive approval of Closeout Submittals.
- p. PVT Report Acceptance Test for Season 2.

PART 2 PRODUCTS

2.1 DDC SYSTEM

- a. Provide a networked DDC system for stand-alone control in compliance with the latest revision of the ASHRAE 135 BACnet standard. Include all programming, objects, and services required to meet the sequence of control. Provide BACnet MS/TP communications between the DDC system and native BACnet devices furnished with HVAC equipment and plant equipment including boilers, chillers, and variable frequency drives. Devices provided shall be certified in the BACnet Testing Laboratories (BTL) Product Listing and in accordance with ASHRAE 135 Method of Test for Conformance to BACnet. Controls provided integral to equipment shall be part of the DDC system and shall fully comply with this specification. Coordinate integration of integral controls into the system as a whole. BACnet over IP is not permitted within the DDC system.
- b. Assist the Government in interfacing the new DDC system with the site's existing server and operator workstation and software. Create graphics, scheduling, alarming, and trending.

2.1.1 Supervisory Building Controller (SBC)

ASHRAE 135 building controller that is the main interface for the building control system. Provide either a Johnson Controls Incorporated NAE, NCE, SNE or SNC; OR a JACE based on the Niagara N4 platform. The JACE (JAVA Application Control Engine) shall be minimally based on a Tridium 8000 with expanded memory and embedded "Niagara Workbench or Workplace" software.

Any device implementing the Niagara Framework is a Niagara Framework Supervisory Gateway and must meet these requirements. In addition to the general requirements for all DDC Hardware, Niagara Framework Supervisory Gateway Hardware must:

- a. Be direct digital control hardware.
- b. Have an unrestricted interoperability license and its Niagara Compatibility Statement (NiCS) must follow the Tridium Open NiCS Specification.
- c. Manage communications between a field control network and the Niagara Framework Monitoring and Control Software, and between itself and other Niagara Framework Supervisory Gateways. Niagara Framework Supervisory Gateway Hardware must use Fox protocol for communication with other Niagara Framework Components, regardless of the manufacturer of the other components.
- d. Be fully programmable using the Niagara Framework Engineering Tool and must support the following:
 - (1) Time synchronization, Calendar, and Scheduling using Niagara Scheduling Objects
 - (2) Alarm generation and routing using the Niagara Alarm Service
 - (3) Trending using the Niagara History Service and Niagara Trend Log Objects
 - (4) Integration of field control networks using the Niagara Framework Engineering Tool
 - (5) Configuration of integrated field control system using the Niagara Framework Engineering Tool when supported by the field control system
- e. Meet the following minimum hardware requirements:
 - (1) Two 10/100/1000 Mbps Ethernet Port(s)
 - (2) One or more MS/TP ports.
 - (3) Central Processing Unit of 1000 Mhz or higher.
 - (4) Embedded operating system.
- f. Provide access to field control network data and supervisory functions via web interface and support a minimum of 16 simultaneous users.
Note: implementation of this capability may not be required on all projects.

- g. Submit a backup of each Niagara Framework Supervisory Gateway. The backup must be sufficient to restore a Niagara Framework Supervisory Gateway to the final as-built condition such that a new Niagara Framework Supervisory Gateway loaded with the backup is indistinguishable in functionality from the original.

2.1.1.1 Niagara Framework Engineering Tool

The Niagara Framework Engineering Tool must be Niagara Workbench or an equivalent Niagara Framework engineering tool software and must:

- a. Have an unrestricted interoperability license and its Niagara Compatibility Statement (NiCS) must follow the Tridium Open NiCS Specification.
- b. Be capable of performing network configuration for Niagara Framework Supervisory Gateways and Niagara Framework Monitoring and Control Software.
- c. Be capable of programming and configuring of Niagara Framework Supervisory Gateways and Niagara Framework Monitoring and Control Software.
- d. Be capable of discovery of Niagara Framework Supervisory Gateways and all points mapped into each Niagara Framework Supervisory Gateway and making these points accessible to Niagara Framework Monitoring and Control Software.

2.1.1.2 Supervisory Controller MCEN Network Homerun

See UFGS 27 10 00 and CLGS 27 10 00 for requirements

2.1.2 EMCS Interface

The Energy Management & Control System (EMCS) at Camp Lejeune is comprised of two separate systems. Both of the systems communicate over the basewide Marine Corps Enterprise Network (MCEN). One uses the Johnson Controls Network Automation Engine (NAE), Network Control Engine (NCE), Supervisory Network Engine (SNE) or Supervisory Network Control Engine (SNC) to the ADX server. The second system uses a Niagara FX N4 web supervisor with a JACE in the building communicating using Fox protocol. Because of IT security and permissions, only these systems and equipment are permitted as part of the EMCS.

2.1.2.1 Supervisory Building Controller

Provide either a Johnson Controls NAE, NCE, SNE, SNC or a JACE. This will serve as both the Supervisory Building Controller and the connection point between the buildings DDC and the EMCS. Provide a five year service license on all Supervisory Controllers. Provide a reserve of 10% of additional points and additional devices on the Supervisory Controller license at the final project acceptance.

The contractor shall assign Camp Lejeune Public Works Department as the owner and manager of all licenses including 3rd party drivers.

2.1.2.2 Palo Alto Firewall

In addition to the Supervisory controller, for buildings with multiple Supervisory controllers, provide a Palo Alto Firewall Model PAN-PA-220R.

2.1.3 Direct Digital Controllers

Direct digital controllers shall be UL 916 rated.

DDC Field Controllers:

Acceptable DDC field controllers are Facility Explorer, Metasys or Distech.

2.1.3.1 I/O Point Limitation

The total number of I/O hardware points used by a single stand-alone digital controller, including I/O expansion units, shall not exceed 64, except for complex individual equipment or systems. Place I/O expansion units in the same cabinet as the digital controller. The field controller must have one spare Configurable Output and one spare Universal Input available per system upon project completion, i.e. AHU, ERU, DOAS, HW System, CHW System and other building primary systems. VAV controllers and programmable thermostats are excluded

2.1.3.2 Environmental Limits

Controllers shall be suitable for, or placed in protective enclosures suitable for the environment (temperature, humidity, dust, and vibration) where they are located.

2.1.3.3 Stand-Alone Controllers

Provide stand-alone direct digital controllers with internal time clocks if not connected to a Supervisory Building Controller. Each piece of equipment shall be controlled by a single controller to provide stand-alone control in the event of any building communication failure. All I/O points specified for a piece of equipment shall be integral to its controller and serial connected expansion modules. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

2.1.3.4 Internal Clock

Provide internal clocks and scheduling for all Direct Digital Controllers. Provide controllers with BTL listed profiles for all BACnet Building Controllers (B-BC) and BACnet Advanced Application Controllers (B-AAC) using BACnet time synchronization services. This includes but is not limited to VAV Controllers, Fan Coil controllers, Heat Pump controllers and any terminal controllers. BACnet Application specific controllers (B-ASC) will only be accepted for dedicated small exhaust system control such as restroom and mechanical room exhaust fans. Automatically synchronize system clocks daily from an operator-designated controller. The system shall automatically adjust for daylight saving time.

2.1.3.5 Memory

Provide sufficient memory for each controller to support the required control, communication, trends, alarms, and messages. Protect programs residing in memory with EEPROM, flash memory, or by an uninterruptible power source (battery or uninterruptible power supply). The backup power source shall have capacity to maintain the memory during a 72-hour continuous power outage. Rechargeable power sources shall be constantly charged while the controller is operating under normal line power. Batteries shall be replaceable without soldering. Trend and alarm history collected during normal operation shall not be lost during power outages less than 72 hours long.

2.1.3.6 Immunity to Power Fluctuations

Controllers shall operate at 90 percent to 110 percent nominal voltage rating.

2.1.3.7 Transformer

The controller power supply shall be fused or current limiting and rated at 125 percent power consumption. Each transformer must singularly serve the connected load, i.e. do not wire transformers in parallel on the load side.

2.1.3.8 Wiring Terminations

Use screw terminal wiring terminations for all field-installed controllers. Provide field-removable modular terminal strip or a termination card connected by a ribbon cable for all controllers other than terminal units.

2.1.3.9 Input and Output Interface

Provide hard-wired input and output interface for all controllers as follows:

- a. Protection: Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with sources up to 24 volts AC or DC for any duration shall cause no controller damage.
- b. Binary Inputs: Binary inputs shall monitor on and off contacts from a "dry" remote device without external power, and external 5-24 VDC voltage inputs.
- c. Pulse Accumulation Inputs: Pulse accumulation inputs shall conform to binary input requirements and accumulate pulses at a resolution suitable to the application.
- d. Analog Inputs: Analog inputs shall monitor low-voltage (0-10 VDC), current (4-20 mA), or resistance (thermistor or RTD) signals.
- e. Binary Outputs: Binary outputs shall send a pulsed 24 VDC low-voltage signal for modulation control, or provide a maintained open-closed position for on-off control. Where appropriate, provide a method to select normally open or normally closed operation.
- f. Analog Outputs: Analog outputs shall send modulating 0-10 VDC or 4-20

mA signals to control output devices.

- g. Tri-State Outputs: Tri-State outputs shall provide three-point floating control of terminal unit electronic actuators.

2.1.3.10 Digital Controller BACnet Internetwork

Provide intermediate gateways, only when requested by the Government and shown on the contract drawings, to connect existing non-BACnet devices to the BACnet internetwork. Controller and operator interface communication shall conform to [ASHRAE 135](#), BACnet. If a controller becomes non-responsive, the remaining controllers shall continue operating and not be affected by the failed controller.

2.1.3.11 Communications Ports

- a. Direct-Connect Interface Ports: Provide at least one extra communication port at each local BACnet network for direct connecting a notebook computer or BACnet hand-held terminal so all network BACnet objects and properties may be viewed and edited by the operator.
- b. BACnet routers supporting ARCnet shall also be capable of supporting MS/TP.

2.1.3.12 BACnet Gateways

Provide BACnet communication ports, whenever available as a plant equipment OEM standard option, for DDC integration via a single communication cable. Typical BACnet controlled plant equipment includes, but is not limited to, boilers, chillers, and variable frequency motor drives.

Provide gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC controlled plant equipment, only when specifically requested and approved by the Government, and shown on the Government approved [BACnet Communication Architecture Schematic](#). Provide with each gateway an interoperability schedule, showing each point or event on the legacy side that the BACnet "client" will read, and each parameter that the BACnet network will write to. Describe this interoperability in terms of BACnet services, or Interoperability Building Blocks (IBBS), defined in [ASHRAE 135](#) Annex K. Provide two-year minimum warranty for each gateway, including parts and labor.

The following minimum capabilities are required:

- a. [Gateways](#) shall be able to read and view all readable object properties listed in the interoperability schedule on the non-BACnet network to the BACnet network and vice versa where applicable.
- b. [Gateways](#) shall be able to write to all writeable object properties listed in the interoperability schedule on the non-BACnet network from the BACnet network and vice versa where applicable.
- c. [Gateways](#) shall provide single-pass (only one protocol to BACnet without intermediary protocols) translation from the non-BACnet protocol to BACnet and vice versa.
- d. [Gateways](#) shall meet the requirements of Data Sharing Read Property

(DS-RP-B), Data Sharing Write Property (DS-WP-B), Device Management Dynamic Device Binding-B (DM-DDB-B), and Device Management Communication Control (DM-DCC-B) BIBBs, in accordance with [ASHRAE 135](#).

- e. [Gateways](#) shall include all hardware, software, software licenses, and configuration tools for operator-to-gateway communications. Provide backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.1.3.13 Digital Controller Cabinet

Provide each digital controller including gateways, in a factory fabricated [locked](#) cabinet enclosure.

Cabinets located indoors shall protect against dust and have a minimum NEMA 1 rating, except where indicated otherwise. Cabinets located outdoors or in damp environments shall protect against all outdoor conditions and have a minimum NEMA 4 rating. [Mechanical rooms that contain steam service or equipment including new steam boiler rooms are considered damp environments.](#) Outdoor control panels and controllers must be able to withstand extreme ambient conditions, without malfunction or failure, whether or not the controlled equipment is running. If necessary, provide a thermostatically controlled panel heater in freezing locations, and an internal ventilating fan in locations exposed to direct sunlight. Cabinets shall have a hinged lockable door and an offset removable metal back plate, except controllers integral with terminal units, like those mounted on VAV boxes. Provide like-keyed locks for all hinged panels provided and a set of two keys at each panel, with one key inserted in the lock. [All devices must be mounted only to the cabinet backplane with adequate space allowed for serviceability and proper heat dissipation from devices.](#) The Supervisory controller cabinet door position (closed/open) shall be monitored with a door switch and BACnet programmable relay such as the Functional Devices RIBTW2401B-BC. An "open" door status shall initiate an alarm to the EMCS Server.

2.1.3.14 Main Power Switch and Receptacle

Provide each control cabinet with a main external power on/off switch located inside the cabinet. Also provide each cabinet with a separate 120 VAC duplex [convenience](#) receptacle.

2.1.4 DDC Software

2.1.4.1 Programming

Provide programming to execute the sequence of operation indicated. Provide all programming, tools, [interfaces, cables, etc.](#) to configure and program all controllers. [All software shall be licensed to Marine Corps Base, Camp Lejeune Complex for unrestricted use on Camp Lejeune Complex and reproduction for use on Camp Lejeune Complex. Software keys and "dongles" are not permitted.](#) Provide programming routines in simple, easy-to-follow logic with detailed text comments describing what the logic does and how it corresponds to the project's written sequence of operation. All logic programming and control functions shall be closed loop, command and feedback for fault detection and alarming when status != command.

- a. Graphic-based programming shall use a library of function blocks made from pre-programmed code designed for BAS control. Function blocks

shall be assembled with interconnecting lines, depicting the control sequence in a flowchart. If providing a computer with device programming tools as part of the project, graphic programs shall be viewable in real time showing present values and logical results from each function block.

- b. Menu-based programming shall be done by entering parameters, definitions, conditions, requirements, and constraints.
- c. For line-by-line and text-based programming, declare variable types (variable types include but are not limited to the following: local, global, real, and integer) at the beginning of the program. Use descriptive comments frequently to describe the programming.
- d. If providing a computer with device programming tools as part of the project, provide a means for detecting program errors and testing software strategies with a simulation tool. Simulation may be inherent within the programming software suite, or provided by physical controllers mounted in a NEMA 1 test enclosure. The test enclosure shall contain one dedicated controller of each type provided under this contract, complete with power supply and relevant accessories.

2.1.4.2 Parameter Modification

All writeable object properties, and all other programming parameters needed to comply with the project specification shall be adjustable for devices at any network level, including those accessible with web-browser communication, and regardless of programming methods used to create the applications.

2.1.4.3 Short Cycling Prevention

Provide setpoint differentials and minimum on/off times to prevent equipment short cycling.

2.1.4.4 Equipment Status Delay

Provide an adjustable delay from when equipment is commanded on or off and when the control program looks to the status input for confirmation.

2.1.4.5 Run Time Accumulation

Use the Elapsed Time Property to provide re-settable run time accumulation for each Binary Output Object connected to mechanical loads greater than 1 HP, electrical loads greater than 10 KW, or wherever else specified.

2.1.4.6 Timed Local Override

Provide an adjustable override time for each push of a timed local override button.

2.1.4.7 Time Synchronization

Provide time synchronization, including adjustments for leap years, daylight saving time, and operator time adjustments.

2.1.4.8 Scheduling

Provide operating schedules as indicated, with equipment assigned to groups. Changing the schedule of a group shall change the operating schedule of all equipment in the group. Groups shall be capable of operator creation, modification, and deletion. Provide capability to view and modify schedules in a seven-day week format. Provide capability to enter holiday and override schedules one full year at a time.

2.1.4.9 Object Property Override

Allow writeable object property values to accept overrides to any valid value. Where specified or required for the sequence of control, the Out-Of-Service property of Objects shall be modifiable using BACnet's write property service. When documented, exceptions to these requirement are allowed for life, machine, and process safeties.

2.1.4.10 Alarms and Events

Alarms and events shall be capable of having programmed time delays and high-low limits. When a web server is connected to the BACnet internetwork, alarms/events shall report to **web server** as defined by an authorized operator. Otherwise alarms/events shall be stored within a device on the BACnet network until connected to a user interface device and retrieved. Provide alarms/events in agreement with the point schedule, sequence of operation, and the BAS Owner. At a minimum, provide programming to initiate alarms/events any time a piece of equipment fails to operate, a control point is outside normal range or condition shown on schedules, communication to a device is lost, a device has failed, or a controller has lost its memory.

2.1.4.11 Trending

Provide BACnet trending all object present values, set points, and other parameters indicated for trending on project schedules **or at the request of Camp Lejeune or commissioning agents**. Trends may be associated into groups, and a trend report may be set up for each group. Trends are stored within a device on the BACnet network, with operator selectable trend intervals from 10 seconds up to **24 hours**. The minimum number of consecutive trend values stored at one time shall be 100 per variable. When trend memory is full, the most recent data shall overwrite the oldest data.

The BACnet system shall allow for Change-Of-Value (COV) subscription based trending at user defined thresholds.

The **B-BC** shall upload trends automatically upon reaching 3/4 of the device buffer limit (via Notification_Threshold property), by operator request, or by time schedule for archiving. Archived and real-time trend data shall be available for viewing numerically and graphically for at the workstation and connected notebook computers.

Additionally, provide daily trend on geothermal well field supply and return temperatures. Allocate sufficient memory to store 24 months data.

2.1.4.12 Device Diagnostics

Each controller shall have diagnostic LEDs for power, communication, and device fault condition. The DDC system shall recognize and report a

non-responsive controller.

2.1.4.13 Power Loss

Upon restoration of power, the DDC system shall perform an orderly restart and restoration of control.

2.1.5 Notebook Computer

Provide a notebook computer, complete with the project's installed DDC software, applications database, **final archived field controller programs and Supervisory controller database**, and graphics to fully troubleshoot and program the project's devices. Provide the notebook computer with a nylon carrying case with shoulder strap, **or backpack**, and all necessary cables and interface hardware needed for **setup and direct communication with the controllers and control system components**. **Direct communication shall not be through the Supervisory controller.**

At a minimum the notebook computer shall include: **Common Access Card Reader**, Windows **based** operating system, minimum 2.7 GHz processor with 3 MB Cache, discrete switchable graphics card with minimum 1 GB dedicated memory, 1 Terabyte hard drive, **32 GB DDR3 RAM**, 2 USB 3.0 ports, 10/100/1000 network interface card, 802.11 b/g/n WLAN, 17-inch display, keyboard with numeric keypad, 6-hour battery with charger, **internal or external 8X DVD+/-R/RW drive** with double layer support with DVD creator software, and Microsoft Office Home and Business bundled software. Provide all original licenses, installation media, documentation, and recovery CDs capable of restoring the original configuration. Provide a means to connect the notebook computer **directly to the installed field bus**. Provide the manufacturer's 3-year accidental damage protection with 3-day on site response for 2 year warranty with the Government listed as the warranty owner.

2.1.6 Notebook Computer Software

2.1.6.1 Password Protection

System shall support role based access. At a minimum OS administrator, auditor, DDC operator and user roles must be defined. The system must be capable of enforcing role based access by location (e.g., Bob may alter operating parameters for Building 1 but not Building 2. Building 2 is Alice's responsibility).

Workstation shall be capable of DoD Common Access Card (CAC) login in addition to traditional username and password.

The lowest level only allow viewing graphics. The second level allows viewing graphics and changing space temperature setpoints. The third level allows the previous level's capability, plus changing operating schedules. The fourth level allows access to all functions except passwords. The highest level provides all administrator rights and allows full access to all programming, including setting new passwords and access levels. Provide the BAS Owner with the highest level password access. Provide automatic log out if no keyboard or mouse activity is detected after a user-defined time delay.

2.1.6.2 Notebook Computer DDC Software

Provide the workstation software with the manufacturer's installation CDs

and licenses. Configure the software according to the DDC system manufacturer's specifications, cybersecurity requirements, and in agreement with [BACnet Operator Workstation](#) (B-OWS) device standards found in ASHRAE 135, Annex L.

The workstation software shall permit complete monitoring, modification, [archiving, programming](#) and troubleshooting interface with the DDC system [including supervisory controller and field controllers](#). Software shall include, but not limited to, [Niagara Workplace, FX Workbench, JCI SCT, CCT/PCT, Distech EC-gfx or any controls manufacturer Supervisory controller and field controller programming software used to program the system](#). The operator interface with the software shall be menu-driven with appropriate displays and menu commands to manipulate the DDC system's objects, point data, operating schedules, control routines, system configuration, trends, alarms, messages, graphics, and reports. Trends shall be capable of graphic display in real time, with variables plotted as functions of time. Each alarmed point shall be capable of displaying its alarm history, showing when it went into alarm, if and when it was acknowledged, and when it went out of alarm. The modification of DDC system parameters and object properties shall be accomplished with "fill in the blank" and/or "point and drag" methods. Modifications shall download to the appropriate controllers at the operator's request.

2.1.6.3 Web-Based User Interface (UI) and Graphics

Provide web-based graphics fully compatible with Internet Explorer 9+, Safari, Firefox, and Google Chrome. Web-based user interface shall be browser agnostic and shall not rely on proprietary client side scripting to function.

Graphic displays shall have full-screen resolution when viewed on the workstation and notebook computers. Dynamic data on graphics pages shall refresh within 10 seconds using an Internet connection, or 30 seconds using a dial-up modem connection. Web-based user interface shall not rely on additional third-party browser "plug-in" software like Adobe Flash. Java client side applets may be used if appropriately signed. If Java client side runtimes are used they shall not require deprecated or otherwise unsupported Java runtime environments.

The graphics shall show the present value and object name for each of the project's I/O points on at least one graphic page. Arrange point values and names on the graphic displays in their appropriate physical locations with respect to the floor plan or equipment graphic displayed. Graphics shall allow the operator to monitor current status, view zone and equipment summaries, use point-and-click navigation between graphic pages, and edit setpoints and parameters directly from the screens. Items in alarm shall be displayed using a different color or other obvious visual indicator.

Provide graphics with the following:

- a. **Graphic Types:** Provide at least one graphic display for each piece of HVAC equipment, building floor, and controlled zone. Indicate dynamic point values, operating statuses, alarm conditions, and control setpoints on each display. Provide summary pages where appropriate.

- (1) **Building Elevation:** For buildings more than one story, provide an elevation view of the building with links to each of the building's floor plans. Simulate the building's architecture and include the building number and floor numbers. If possible, use

an actual photograph of the building.

- (2) Building Floor Plans: Provide a floor plan graphic for each of the building's floors and roof with dynamic display of space temperature and other important data. If used, indicate and provide links to sub-plan areas. If possible, use the project's electronic drawing files for the graphic backgrounds. Provide clear names for important areas, such as "Main Conference Room." Include room names and numbers where applicable. Include features such as stairwells, elevators, and main entrances. Where applicable, include the mechanical room, HVAC equipment, and control component locations, with corresponding links to the equipment graphics.
 - (3) Sub-plan Areas: Where a building's floor plan is too large to adequately display on the screen, sub-divide the plan into distinct areas, and provide a separate graphic display for each area. Provide same level of detail requested in building floor plan section above.
 - (4) HVAC Equipment: Provide a graphic display for each piece of HVAC equipment, such as a fan coil unit, VAV terminal, or air handling unit. Equipment shall be represented by a two or three-dimensional drawing. Where multiple pieces of equipment combine to form a system, such as a central chiller plant or central heating plant, provide one graphic to depict the entire plant. Indicate the equipment, piping, ductwork, dampers, and control valves in the installed location. Include labels for equipment, piping, ductwork, dampers, and control valves. Show the direction of air and water flow. Include dynamic display of applicable object data with clear names in appropriate locations.
 - (5) Sequence of Operation: Provide a graphic screen displaying the written out full sequence of operation for each piece of HVAC equipment. Provide a link to the sequence of operation displays on their respective equipment graphics. Include dynamic real-time data within the text for setpoints and variables.
- b. Graphic Title: Provide a prominent, descriptive title on each graphic page.
 - c. Dynamic Update: When the workstation is on-line, all graphic I/O object values shall update with change-of-value services, or by operator selected discrete intervals.
 - d. Graphic Linking: Provide forward and backward linking between floor plans, sub-plans, and equipment.
 - e. Graphic Editing: Provide installed software to create, modify, and delete the DDC graphics. Include the ability to store graphic symbols in a symbol directory and import these symbols into the graphics.
 - f. Dynamic Point Editing: Provide full editing capability for deleting, adding, and modifying dynamic points on the graphics.

2.2 SENSORS AND INPUT HARDWARE

Coordinate sensor types with the BAS Owner to keep them consistent with existing installations.

2.2.1 Field-Installed Temperature Sensors

Where feasible, provide the same sensor type throughout the project. Avoid using transmitters unless absolutely necessary.

2.2.1.1 Thermistors

Precision thermistors may be used in applications below 200 degrees F. Sensor accuracy over the application range shall be 0.36 degree F or less between 32 to 150 degrees F. Stability error of the thermistor over five years shall not exceed 0.25 degrees F cumulative. A/D conversion resolution error shall be kept to 0.1 degrees F. Total error for a thermistor circuit shall not exceed 0.5 degrees F.

2.2.1.2 Resistance Temperature Detectors (RTDs)

Provide RTD sensors with platinum elements compatible with the digital controllers. Encapsulate sensors in epoxy, series 300 stainless steel, anodized aluminum, or copper. Temperature sensor accuracy shall be 0.1 percent (1 ohm) of expected ohms (10k ohms) at 32 degrees F. Temperature sensor stability error over five years shall not exceed 0.25 degrees F cumulative. Direct connection of RTDs to digital controllers without transmitters is preferred. When RTDs are connected directly, lead resistance error shall be less than 0.25 degrees F. The total error for a RTD circuit shall not exceed 0.5 degrees F.

2.2.1.3 Temperature Sensor Details

- a. Room Type: Provide the sensing element components within a decorative protective cover suitable for surrounding decor. Provide room temperature sensors with timed override button, setpoint adjustment lever.
- b. Duct Probe Type: Ensure the probe is long enough to properly sense the air stream temperature.
- c. Duct Averaging Type: Continuous averaging sensors shall be one foot in length for each 4 square feet of duct cross-sectional area, and a minimum length of 6 feet.
- d. Pipe Immersion Type: Provide minimum three-inch immersion. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells shall be stainless steel when used in steel piping, and brass when used in copper piping. Provide the sensor well with a heat-sensitive transfer agent between the sensor and the well interior.
- e. Outside Air Type: Provide the sensing element on the building's north side with a protective weather shade that positions the sensor approximately 3 inches off the wall surface, does not inhibit free air flow across the sensing element, and protects the sensor from snow, ice, and rain.

2.2.2 Supervisory Controller MCEN Network Homerun

See UFGS 27 10 00 and CLGS 27 10 00

2.2.3 Transmitters

Provide transmitters with 4 to 20 mA or 0 to 10 VDC linear output scaled to the sensed input. Transmitters shall be matched to the respective sensor, factory calibrated, and sealed. Size transmitters for an output near 50 percent of its full-scale range at normal operating conditions. The total transmitter error shall not exceed 0.1 percent at any point across the measured span. Supply voltage shall be 12 to 24 volts AC or DC. Transmitters shall have non-interactive offset and span adjustments. For temperature sensing, transmitter drift shall not exceed 0.03 degrees F a year.

2.2.3.1 Relative Humidity Transmitters

Provide transmitters with an accuracy equal to plus or minus 3 percent from 0 to 90 percent scale, and less than one percent drift per year. Sensing elements shall be the polymer type.

2.2.3.2 Pressure Transmitters

Provide transmitters integral with the pressure transducer. Size transmitters for an output near 50 percent of its full-scale range at normal operating conditions.

2.2.4 Current Transducers

Provide current transducers to monitor motor amperage, unless current switches are shown on design drawings or point tables. Provide a VFD rated current sensor where applicable.

2.2.5 Motor Run Status

Unless otherwise noted, provide current switches to indicate run status of pumps and fans. Sensitivity of the switch on belt and coupler driven equipment should distinguish between loaded motor and unloaded motor such as a fan with a broken belt.

2.2.6 Air Quality Sensors

Provide power supply for each sensor.

2.2.6.1 CO2 Sensors

Provide photo-acoustic type CO2 sensors with integral transducers and linear output. The devices shall read CO2 concentrations between 0 and 2000 ppm with full scale accuracy of at least plus or minus 100 ppm.

2.2.6.2 Air Quality Sensors

Provide full spectrum air quality sensors using a hot wire element based on the Taguchi principle. The sensor shall monitor a wide range of gaseous volatile organic components common in indoor air contaminants like paint fumes, solvents, cigarette smoke, and vehicle exhaust. The sensor shall automatically compensate for temperature and humidity, have span and calibration potentiometers, operate on 24 VDC power with output of 0-10 VDC, and have a service rating of 32 to 140 degrees F and 5 to 95 percent relative humidity.

2.2.7 Input Switches

2.2.7.1 Timed Local Overrides

Provide buttons or switches to override the DDC occupancy schedule programming for each major building zone during unoccupied periods, and to return HVAC equipment to the occupied mode. This requirement is waived for zones clearly intended for 24 hour continuous operation.

2.2.7.2 Emergency Shut Down Switches (ATFP)

Anti Terrorism Force Protection emergency shut down switches must be two action to prevent accidental initiation, such as a mushroom push button with a cover.

2.2.8 Freeze Protection Thermostats

Provide special purpose thermostats with flexible capillary elements 20 feet minimum length for coil face areas up to 40 square feet. Provide longer elements for larger coils at 1-foot of element for every 4 square feet of coil face area, or provide additional thermostats. Provide switch contacts rated for the respective motor starter's control circuit voltage. Include auxiliary contacts for the switch's status condition. A freezing condition at any 18-inch increment along the sensing element's length shall activate the switch. The thermostat shall be equipped with a manual push-button reset switch so that when tripped, the thermostat requires manual resetting before the HVAC equipment can restart.

2.2.9 Air Flow Measurement Stations

Air flow measurement stations shall have an array of velocity sensing elements and straightening vanes inside a flanged sheet metal casing. The velocity sensing elements shall be the RTD or thermistor type, traversing the ducted air in at least two directions. The air flow pressure drop across the station shall not exceed 0.08 inch water gage at a velocity of 2,000 fpm. The station shall be suitable for air flows up to 5,000 fpm, and a temperature range of 40 to 120 degrees F. The station's measurement accuracy over the range of 125 to 2,500 fpm shall be plus or minus 3 percent of the measured velocity. Station transmitters shall provide a linear, temperature-compensated 4 to 20 mA or 0 to 10 VDC output. The output shall be capable of being accurately converted to a corresponding air flow rate in cubic feet per minute. Transmitters shall be a 2-wire, loop powered device. The output error of the transmitter shall not exceed 0.5 percent of the measurement.

2.2.10 Air Flow Measurement for Terminal Devices

Air flow measurement for terminal devices such as variable air volume boxes, with or without fan power shall have an array of pressure sensing elements than sense total pressure and static pressure. The flow measurement shall be integral to the device controller and shall be by differential pressure sensor. The air flow shall measure flows down to 300 fpm with an accuracy of 5 percent of reading.

2.2.11 Energy Metering

2.2.11.1 Electrical Meters

Provide enhanced power and energy meter with built-in integrator and power

supply for the CTs. Meter shall have onboard data logging capability as well as output to SBC via native BACnet MS/TP. Place meter indoors at building Main Distribution Panel (MDP). This meter shall be provided in addition to any other power meters required by Division 26 (Electrical) or Division 33 (Utilities).

Electrical meter shall monitor and trend the following points:

- Power (3-phase total & per phase): Real (kW), Reactive (kVAR), and Apparent (kVA)
- Power Factor: 3-phase average & per phase
- Present Power Demand: Real (kW), Reactive (kVAR), and Apparent (kVA)
- Peak Power Demand: Real (kW), Reactive (kVAR), and Apparent (kVA)
- Current: 3-phase average and per phase
- Voltage: Line-Line and Line-Neutral (3-phase average & per phase)
- Frequency
- Accumulated Net Energy: Real (kWh), Reactive (kVARh), and Apparent (kVAh)
- Accumulated Real Energy by phase (kWh)

2.3 OUTPUT HARDWARE

2.3.1 Control Dampers

Provide factory manufactured galvanized steel or aluminum dampers where indicated. Dampers shall be opposed blade for rectangular applications 10-inches and taller, and single blade for round dampers and rectangular dampers shorter than 10-inches. Control dampers shall comply with SMACNA 1966 except as modified or supplemented by this specification. Published damper leakage rates and respective pressure drops shall have been verified by tests in compliance with AMCA 500-D requirements.

Provide damper assembly frames constructed of minimum thickness galvanized steel channels with mitered and welded corners. Damper axles shall be 0.5 inches minimum diameter plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings.

Dampers shall be rated for not less than 2000 fpm air velocity. The pressure drop through each damper when full-open shall not exceed 0.04 inches water gage at 1000 fpm face velocity. Damper assemblies in ductwork shall be constructed to meet SMACNA Seal Class "A" construction requirements.

Provide the damper operating linkages outside of the air stream, including crank arms, connecting rods, and other hardware that transmits motion from the damper actuators to the dampers, shall be adjustable. Additionally, operating linkages shall be designed and constructed to have a 2 to 1 safety factor when loaded with the maximum required damper operating force. Linkages shall be brass, bronze, galvanized steel, or stainless steel.

Provide access doors or panels in hard ceilings and walls for access to all concealed damper operators and damper locking setscrews.

For field-installed control dampers, a single damper section shall have blades no longer than 48 inches and no higher than 72 inches. The maximum damper blade width shall be 12 inches. Larger sized dampers shall be built using a combination of sections.

Frames shall be at least 2 inches wide. Flat blades shall have edges folded for rigidity. Blades shall be provided with compressible gasket seals along the full length of the blades to prevent air leakage when closed.

The damper frames shall be provided with jamb seals to minimize air leakage. Seals shall be suitable for an operating temperature range of minus 40 degrees F to 200 degrees F.

The leakage rate of each damper when full-closed shall be no more than 3 cfm per sq. foot of damper face area at 1.0 inches water gage static pressure.

2.3.2 Control Valves

2.3.2.1 Valve Assembly

Valve bodies shall be designed for 125 psig minimum working pressure or 150 percent of the operating pressure, whichever is greater. Valve stems shall be Type 316 stainless steel. Valve leakage ratings shall be 0.01 percent of rated Cv value. Class 125 copper alloy valve bodies and Class 150 steel or stainless steel valves shall meet the requirements of ASME B16.5. Cast iron valve components shall meet the requirements of ASTM A126 Class B or C.

2.3.2.2 Butterfly Valves

Butterfly valves shall be the threaded lug type suitable for dead-end service and for modulation to the fully-closed position, with stainless steel shafts supported by bearings, non-corrosive discs geometrically interlocked with or bolted to the shaft (no pins), and EPDM seats suitable for temperatures from minus 20 degrees F to plus 250 degrees F. Valves shall have a means of manual operation independent of the actuator.

2.3.2.3 Two-Way Valves

Two-way modulating valves shall have an equal percentage characteristic.

2.3.2.4 Three-Way Valves

Three-way valves shall have an equal percentage characteristic.

2.3.2.5 Valves for Chilled Water, Condenser Water, and Glycol Fluid Service

- a. Bodies for valves 1-1/2 inches and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 2 inches to 3 inches inclusive shall be of brass, bronze, or iron. Bodies for 2 inch valves shall have threaded connections. Bodies for valves from 2-1/2 to 3 inches shall have flanged connections.
- b. Internal valve trim shall be brass or bronze, except that valve stems shall be stainless steel.
- c. Unless indicated otherwise, provide modulating valves sized for 2 psi minimum and 4 psi maximum differential across the valve at the design flow rate.
- d. Valves 4 inches and larger shall be butterfly valves, unless indicated otherwise.

2.3.2.6 Valves for Hot Water Service

Valves for hot water service below 250 Degrees F:

- a. Bodies for valves 1-1/2 inches and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 2 inches to 3 inches inclusive shall be of brass, bronze, or iron. Bodies for 2 inch valves shall have threaded connections. Bodies for valves from 2-1/2 to 3 inches shall have flanged connections.
- b. Internal trim (including seats, seat rings, modulation plugs, valve stems, and springs) of valves controlling water above 210 degrees F shall be Type 316 stainless steel.
- c. Internal trim for valves controlling water 210 degrees F or less shall be brass or bronze. Valve stems shall be Type 316 stainless steel.
- d. Non-metallic parts of hot water control valves shall be suitable for a minimum continuous operating temperature of 250 degrees F or 50 degrees F above the system design temperature, whichever is higher.
- e. Unless indicated otherwise, provide modulating valves sized for 2 psi minimum and 4 psi maximum differential across the valve at the design flow rate.
- f. Valves 4 inches and larger shall be butterfly valves, unless indicated otherwise.

2.3.3 Actuators

Provide direct-drive electric actuators for all control applications, except where indicated otherwise. All actuators shall include a feedback loop for detecting actuator faults. The actuator shall report actual position back to the control system. Binary actuators shall provide open/closed status, at a minimum. Modulating actuators and process shall provide position feedback expressed (directly or through span conversion) as percent open/closed. Actuator status shall be derived from actuator position; however, effect may be used in cases where direct feedback is not practical such as VAV coils and dampers.

Use airflow sensors as a feedback loop for damper actuators. Use differential temperature as a feedback mechanism for VAV coil valve actuation.

2.3.3.1 Electric Actuators

Each actuator shall deliver the torque required for continuous uniform motion and shall have internal end switches to limit the travel, or be capable of withstanding continuous stalling without damage. Actuators shall function properly within 85 to 110 percent of rated line voltage. Provide actuators with hardened steel running shafts and gears of steel or copper alloy. Fiber or reinforced nylon gears may be used for torques less than 16 inch-pounds. Provide two-position actuators of single direction, spring return, or reversing type. Provide modulating actuators capable of stopping at any point in the cycle, and starting in either direction from any point. Actuators shall be equipped with a switch for reversing direction, and a button to disengage the clutch to allow manual adjustments. Provide the actuator with a hand crank for manual

adjustments, as applicable. Thermal type actuators may only be used on terminal fan coil units, terminal VAV units, convectors, and unit heaters. Spring return actuators shall be provided on all control dampers and all control valves except terminal fan coil units, terminal VAV units, convectors, and unit heaters; unless indicated otherwise. Each actuator shall have distinct markings indicating the full-open and full-closed position, and the points in-between. **Actuators mounted outdoors shall be outdoor rated so that they do not require a weatherproof enclosure.**

2.3.4 Output Signal Conversion

2.3.5 Output Switches

2.3.5.1 Control Relays

Field installed and DDC panel relays shall be double pole, double throw, UL listed, with contacts rated for the intended application, indicator light, and dust proof enclosure. The indicator light shall be lit when the coil is energized and off when coil is not energized. Relays shall be the socket type, plug into a fixed base, and replaceable without tools or removing wiring. Encapsulated "PAM" type relays may be used for terminal control applications.

2.4 ELECTRICAL POWER AND CONTROL WIRING

2.4.1 Transformers

Transformers shall conform to **UL 506**. For control power other than terminal level equipment, provide a fuse or circuit breaker on the secondary side of each transformer.

2.4.2 Surge and Transient Protection

Provide each control **cabinet** with surge and transient power protection. **Surge protection is not required for small terminal unit controllers such as VAV controllers.** Surge and transient protection shall consist of the following devices, installed externally to the controllers.

2.4.2.1 Power Line Surge Protection

Provide surge suppressors on the incoming power at each direct digital controller or grouped terminal controllers and shall be installed externally to the device or devices being protected. Surge suppressors shall be rated in accordance with **UL 1449**, have a fault indicating light, and conform to the following:

- a. The device shall be a transient voltage surge suppressor, hard-wire type individual equipment protector for 120 VAC/1 phase/2 wire plus ground.
- b. The device shall react within 5 nanoseconds and automatically reset.
- c. The voltage protection threshold, line to neutral, shall be no more than 211 volts.
- d. The device shall have an independent secondary stage equal to or greater than the primary stage joule rating.
- e. The primary suppression system components shall be pure silicon

avalanche diodes.

- f. The secondary suppression system components shall be silicon avalanche diodes or metal oxide varistors.
- g. The device shall have an indication light to indicate the protection components are functioning.
- h. All system functions of the transient suppression system shall be individually fused and not short circuit the AC power line at any time.
- i. The device shall have an EMI/RFI noise filter with a minimum attenuation of 13 dB at 10 kHz to 300 MHz.
- j. The device shall comply with IEEE C62.41.1 and IEEE C62.41.2, Class "B" requirements and be tested according to IEEE C62.45.
- k. The device shall be capable of operating between minus 20 degrees F and plus 122 degrees F.

2.4.2.2 MS/TP Communication Line Surge Protection

Provide surge and transient protection for DDC controllers and DDC network related devices connected to phone lines, network communication lines, lines from exterior equipment, and lines from other buildings including mechanical buildings in accordance with the following:

- a. The device shall provide continuous, non-interrupting protection.
- b. The protection shall react within 5 nanoseconds using only solid-state silicon avalanche technology.
- c. The device shall be installed at the distance recommended by its manufacturer.
- d. Include the location of the surge protection devices on the control drawing network riser.

2.4.3 Wiring

Provide complete electrical wiring for the DDC System, including wiring to transformer primaries. Run all control wiring in rigid or flexible conduit, metallic tubing, or covered metal raceways, unless noted otherwise. Control circuit wiring shall not run in the same conduit as power wiring over 100 volts. Circuits operating at more than 100 volts shall be in accordance with Section 26 20 00, INTERIOR DISTRIBUTION SYSTEM.

Run all circuits over 100 volts in conduit, metallic tubing, covered metal raceways, or armored cable. Follow cable manufacturer's recommendations or requirements based on the cable usage, such as outdoors and/or underground.

2.4.3.1 Power Wiring

The following requirements are for field-installed wiring:

- a. Wiring for 24 V circuits shall be insulated copper 18 AWG minimum and rated for 300 VAC service.

- b. Wiring for 120 V circuits shall be insulated copper 12 AWG minimum and rated for 600 VAC service.

2.4.3.2 Analog Signal Wiring and Binary Wiring

Provide in accordance with control manufacturer's recommendations and the following: Field-installed analog signal wiring shall be 18 AWG single or multiple twisted pair. Each cable shall be 100 percent shielded and have a 20 AWG drain wire. Each wire shall have insulation rated for 300 VAC service. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape. All binary input and output wiring shall be 18 AWG.

2.4.3.3 MS/TP Communication Bus

- a. Provide system manufacturer's recommended or preferred cabling.
- b. Follow cable manufacturer's recommendations or requirements based on the cable usage, such as outdoors and/or underground.
- c. Splices in communication cable are not allowed. Segments of communication cable between field devices shall be solid lengths with no splices.

2.4.3.4 Conduit

Conduit for controls less than 100 volts shall be colored blue. Junction box cover plates, cable/wire trough covers, etc., for controls shall be blue. Fittings and boxes do not need to be blue.

2.5 FIRE PROTECTION DEVICES

2.5.1 Duct Smoke Detectors

Provide duct smoke detectors in HVAC ducts in accordance with NFPA 72 and NFPA 90A, except as indicated otherwise. Provide UL listed or FM approved detectors, designed specifically for duct installation.

Furnish detectors under Section 28 31 76 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE and install under this section. Connect new detectors to the building fire alarm panel.

2.6 INDICATORS

2.7 PNEUMATIC POWER SUPPLY AND TUBING

2.7.1 Pneumatic Tubing

2.7.1.1 Copper Tubing

Provide ASTM B75/B75M or ASTM B88 rated tubing. Tubing 0.375 inch outside diameter and larger shall have minimum wall thickness equal to ASTM B88, Type M. Tubing less than 0.375 inch outside diameter shall have minimum wall thickness of 0.025 inch. Exposed tubing and tubing for working pressures greater than 30 psig shall be hard copper. Fittings shall be ASME B16.18 or ASME B16.22 solder type using ASTM B32 95-5 tin-antimony

solder, or ASME B16.26 compression type.

2.7.1.2 Polyethylene Tubing

Polyethylene tubing may only be used in systems with working pressure of 30 psig or less, this includes tubing used for devices such as air filter status, duct pressure and duct pressure safety limits. Provide flame-resistant, multiple polyethylene tubing in flame-resistant protective sheath with mylar barrier, or unsheathed polyethylene tubing in rigid metal, intermediate metal, or electrical metallic tubing conduit for areas where tubing is exposed. Single, unsheathed, flame-resistant polyethylene tubing may be used where concealed in walls or above ceilings and within control panels. Do not provide polyethylene tubing for systems indicated as critical and smoke removal systems. Provide compression or brass barbed push-on type fittings. Extruded seamless polyethylene tubing shall conform to the following:

- a. Minimum Burst Pressure Requirements: 100 psig at 75 degrees F to 25 psig at 150 degrees F.
- b. Stress Crack Resistance: ASTM D1693, 200 hours minimum.
- c. Tensile Strength (Minimum): ASTM D638, 1100 psi.
- d. Flow Rate (Average): ASTM D1238, 0.30 decigram per minute.
- e. Density (Average): ASTM D792, 57.5 pounds per cubic feet.
- f. Burn rate: ASTM D635

2.8 VARIABLE FREQUENCY (MOTOR) DRIVES

Provide variable frequency drives (VFDs) as indicated. VFDs shall convert 208 or 480 volt (plus or minus 10 percent), three phase, 60 hertz (plus or minus 2Hz), utility grade power to adjustable voltage/frequency, three phase, AC power for stepless motor control from 5 percent to 200 percent of base speed. VFDs shall be UL listed as delivered to the end user. The VFD shall meet the requirements specified in the most current National Electrical Code. Each VFD shall also meet the following:

- a. The VFD shall use sine coded Pulse Width Modulation (PWM) technology. PWM calculations shall be performed by the VFD microprocessor.
- b. The VFD shall be capable of automatic control by a remote 4-20 mA 0 to 10 VDC signal, by network command, or manually by the VFD control panel.

2.8.1 VFD Quality Assurance

VFDs shall be the manufacturer's current standard production unit with at least 10 identical units successfully operating in the field.

2.8.2 VFD Service Support

- a. Warranty: Provide the VFDs with a minimum 24-month full parts and labor warranty. The warranty shall start when the contract's HVAC system is accepted by the Government. Include warranty documentation, dates, and contact information with the VFD on-site service manuals.

- b. **VFD Service Manuals:** Provide the VFDs with all necessary installation, operation, maintenance, troubleshooting, service, and repair manuals in English including related factory technical bulletins. Provide the documents factory bound, in sturdy 3-ring binders, or hard bound covers. Provide a title sheet on the outside of each binder indicating the project title, project location, installing contractor, contract number, and the VFD manufacturer, address, and telephone number. Each binder shall include a table of contents and tabbed dividers, with all material neatly organized. The documentation provided shall be specifically applicable to this project, shall be annotated to reflect the actual project conditions, and shall provide a complete and concise depiction of the installed work. Provide a storage cabinet on or near the VFD large enough to hold all of the documentation. Have the cabinet's proposed installation site approved in advance by the Contracting Officer. Prominently label the cabinet "VFD OPERATION AND MAINTENANCE MANUALS." Clearly label each manual with the wording "MECHANICAL ROOM COPY - DO NOT REMOVE".
- c. **Technical Support:** Provide the VFDs with manufacturer's technical telephone support in English, readily available during normal working hours, and free of charge for the life of the equipment.
- d. **Initial Start-Up:** Provide the VFDs with factory-trained personnel for the on-site start-up of the HVAC equipment and associated VFD. The personnel shall be competent in the complete start-up, operation, and repair of the particular model VFD installed. The factory start-up representative shall perform the factory's complete recommended start-up procedures and check-out tests on the VFD. Include a copy of the start-up test documentation with the VFD on-site service manuals.
- e. Provide the VFDs with on-site/hands-on training for the user and maintenance personnel. Provide a capable and qualified instructor with minimum two years field experience with the operation and maintenance of similar VFDs. The training shall occur during normal working hours and last not less than 2 hours. Coordinate the training time with the Contracting Officer and the end user. The VFD service manuals shall be used during the training. The contractor shall ensure the manuals are on-site before the start of training. The training shall cover all operational aspects of the VFD.

2.8.3 VFD Features

VFDs shall have the following features:

- a. A local operator control keypad capable of:
 - (1) Remote/Local operator selection with password access.
 - (2) Run/Stop and manual speed commands.
 - (3) All programming functions.
 - (4) Scrolling through all display functions.
- b. Digital display capable of indicating:
 - (1) VFD status.

- (2) Frequency.
- (3) Motor RPM.
- (4) Phase current.
- (5) Fault diagnostics in descriptive text.
- (6) All programmed parameters.
- (7) Load power.

- c. Standard PI loop controller with input terminal for controlled variable and parameter settings.
- d. User interface terminals for remote control of VFD speed, speed feedback, and an isolated form C SPDT relay, which energizes on a drive fault condition.
- e. An isolated form C SPDT auxiliary relay which energizes on a run command.
- f. A metal NEMA 1 enclosure for indoors, NEMA 4 with heater for outdoors.
- g. An adjustable carrier frequency with 16 KHz minimum upper limit.
- h. A built in DC buss reactor with 3 percent minimum impedance to protect the VFDs DC buss capacitors and rectifier section diodes.

2.8.4 Programmable Parameters

VFDs shall include the following operator programmable parameters:

- a. Upper and lower limit frequency.
- b. Acceleration and Deceleration rate.
- c. Variable torque volts per Hertz curve.
- d. Starting voltage level.
- e. Starting frequency level.
- f. Display speed scaling.
- g. Enable/disable auto-restart feature.
- h. Enable/disable soft stall feature.
- i. Motor overload level.
- j. Motor stall level.
- k. Jump frequency and hysteresis band.
- l. PWM carrier frequency.

2.8.5 Protective Features

VFDs shall have the following protective features:

- a. An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.
- b. An electronic adjustable soft stall feature, allowing the VFD to lower the frequency to a point where the motor will not exceed the full-load amperage when an overload condition exists at the requested frequency. The VFD will automatically return to the requested frequency when load conditions permit.
- c. A separate electronic stall at 110 percent VFD rated current, and a separate hardware trip at 190 percent current.
- d. Ground fault protection that protects the output cables and motor from grounds during both starting and continuous running conditions.
- e. The ability to restart after the following faults:
 - (1) Overcurrent (drive or motor).
 - (2) Power outage.
 - (3) Phase loss.
 - (4) Over voltage/Under voltage.
- f. The ability shut down if inadvertently started into a rotating load without damaging the VFD or the motor.
- g. The ability to keep a log of a minimum of four previous fault conditions, indicating the fault type and time of occurrence in descriptive text.
- h. The ability to sustain 110 percent rated current for 60 seconds
- i. The ability to shutdown safely or protect against and record the following fault conditions:
 - (1) Over current (and an indication if the over current was during acceleration, deceleration, or running).
 - (2) Over current internal to the drive.
 - (3) Motor overload at start-up.
 - (4) Over voltage from utility power.
 - (5) Motor running overload.
 - (6) Over voltage during deceleration.
 - (7) VFD over heat.
 - (8) Load end ground fault.

(9) Abnormal parameters or data in VFD EEPROM.

2.8.6 Minimum Operating Conditions

VFDs shall be designed and constructed to operate within the following service conditions:

- a. Ambient Temperature Range, 0 to 120 degrees F.
- b. Non-condensing relative humidity to 90 percent.

2.8.7 Additional Features

Provide VFDs with the following additional features:

- a. BACnet communication interface port

PART 3 EXECUTION

3.1 INSTALLATION

Perform the installation under the supervision of competent technicians regularly employed in the installation of DDC systems. All material and equipment shall be installed in accordance with the manufacturer's recommendations for the intended purpose. Maintain a copy of the manufacturer's recommendations on the Construction Site. Use the more stringent methods when manufacturer's recommendations, and plans & specification requirements differ. Use the "Preferred" method when alternative methods are given. The word "should" will be considered to mean "shall". Bring any conflicts between manufacturer's recommendations and plans & specification requirements to the Government's attention. All equipment shall be installed level and plumb.

3.1.1 Pre-Installation Meeting

Prior to starting the installation, meet with the Contracting Officer's Technical Representative (COTR) and the BAS owner to develop a mutual understanding relative to the details of the DDC system requirements. Requirements to be discussed include, but not limited to, required submittals, work schedule, field quality control, BAS Supervisory controller configuration requirements, and project DDC Specification requirements.

3.1.2 Demolition

Remove and/or demolish all existing controls, cabling, conductors, conduit, controllers, power circuits and cabinets that are no longer needed after new work is installed. Any existing systems to remain, must remain functional and operate properly after all demolition is complete.

3.1.3 BACnet Naming and Addressing

Coordinate with the EMCS Owner and provide unique naming and addressing consistent with existing buildings already loaded on the EMCS server. All DDC controllers shall have a Camp Lejeune unique instance number and all Supervisory Building Controllers shall have a Camp Lejeune unique name. Names are managed by the Government.

- a. MAC Address

Every BACnet device shall have an assigned and documented MAC Address unique to its network. For Ethernet networks, document the MAC Address assigned at its creation. For MS/TP networks, assign addresses from 0-127. Do not use the controls manufacturer reserved addresses for field controllers. This is typically 0-3. Also the BACnet Instance ID for MAC Address 127, Trunk 1, is reserved for the Supervisory controller. Supervisory Controller Global ID and instance numbers are to be obtained from Camp Lejeune Public Works Operations to ensure duplicates do not occur. Point of Contact:

Public Works Division/EMCS
1005 Michael Road / Building 1005
MCB Camp Lejeune, NC 28547
(910) 450-7846

For MS/TP, assign from 01 to 127 unless reserved by the manufacturer.

b. Network Numbering

Assign unique numbers to each new network installed on the BACnet internetwork. Provide ability for changing the network number; either by device switches, network computer, or field operator interface. The BACnet internetwork (all possible connected networks) can contain up to 65,534 possible unique networks.

c. Device Object Identifier Property Number

Assign unique Device "Object_Identifier" property numbers or device instances for each device on the BACnet internetwork. Provide for future modification of the device instance number; either by device switches, network computer, or field interface. Instance numbers must be field assignable. BACnet allows up to 4,194,302 possible unique devices per internetwork.

d. Device Object Name Property Text

Each object on the Camp Lejeune EMCS has a unique point name, which is made up of the object or short name stored in the controller and the equipment identifier, which is stored in the supervisory building controller (SBC). The long point name combines this object name with the name stored in the SBC that describes the controller or location of the object. The device object name property field shall support 32 minimum printable characters. The point name follows the general convention:

Building.Equipment.Object Name

Example: HP512.AHU-3.DA-T. See Attachments one through three for equipment names, object names, object groupings, and area names.

e. Object Name Property Text (Other than Device Objects)

The object name identifies the specific point. Only object names on the approved Camp Lejeune list shall be used. From the example above, the point name is: "DA-T". See Attachment for the approved Camp Lejeune list. The object name property field shall support 32 minimum printable characters.

f. Object Description

The controller shall also store an alpha numeric description of the object name. The controller shall support a minimum of 30 printable characters. From the example above the object description is: "Discharge Air Temperature".

g. List of Attachments

Attachment 1 - NOT USED
Attachment 2 - Object Names
Attachment 3 - NOT USED
Attachment 4 - Niagara BAS Alarms Policy
Attachment 5 - Trend (History)

3.1.4 Minimum BACnet Object Requirements

a. Use of Standard BACnet Objects in accordance with existing Camp Lejeune Standards

For the following points and parameters, use standard BACnet objects, where all relevant object properties can be read using BACnet's Read Property Service, and all relevant object properties can be modified using BACnet's Write Property Service:
all device physical inputs and outputs, all set points, all PID tuning parameters, all calculated pressures, flow rates, and consumption values, all alarms, all trends, all schedules, and all equipment and lighting circuit operating status.

b. BACnet Object Description Property

The Object Description property shall support 32 minimum printable characters. For each object, complete the description property field using a brief, narrative, plain English description specific to the object and project application. For example: "HW Pump 1 Proof." Document compliance, length restrictions, and whether the description is writeable in the device PICS.

c. Analog Input, Output, and Value Objects

Support and provide Description and Device_Type text strings matching signal type and engineering units shown on the points list.

d. Binary Input, Output, and Value Objects

Support and provide Inactive_Text and Active_Text property descriptions matching conditions shown on the points list.

e. Calendar Object

For devices with scheduling capability, provide at least one Calendar Object with ten-entry capacity. All operators may view Calendar Objects; authorized operators may make modifications from a workstation. Enable the writeable Date List property and support all calendar entry data types.

f. Schedule Object

Use Schedule Objects for all building system scheduling. All operators may view schedule entries; authorized operators may modify schedules from a workstation.

g. Loop Object or Equal

Use Loop Objects or equivalent BACnet objects in each applicable field device for PID control. Regardless of program method or object used, allow authorized operators to adjust the Update Interval, Setpoint, Proportional Constant, Integral Constant, and Derivative Constant using BACnet read/write services.

h. Setpoints

All setpoints must be BACnet exposed for auto discovery purposes if needed.

3.1.5 Minimum BACnet Service Requirements

a. Command Priorities

Use commandable BACnet objects to control machinery and systems, providing the priority levels listed below. If the sequence of operation requires a different priority, obtain approval from the Contracting Officer.

<u>Priority Level</u>	<u>Application</u>
1	Manual-Life Safety
2	Automatic-Life Safety
3	(User Defined)
4	(User Defined)
5	Critical Equipment Control
6	Minimum On/Off
7	(User Defined)
8	Manual Operator
9	(User Defined)
10	(User Defined)
11	Load Shedding
12	(User Defined)
13	(User Defined)
14	(User Defined)
15	(User Defined)

<u>Priority Level</u>	<u>Application</u>
16	(User Defined)

b. Alarming

- (1) Alarm Priorities - Coordinate alarm and event notification with the BAS Owner.
- (2) Notification Class - Enable writeable Priority, Ack Required, and Recipient List properties of Notification Class objects.
- (3) Event Notification Message Texts - Use condition specific narrative text and numerical references for alarm and event notification.

c. Updating Displayed Property Values

Allow workstations to display property values at discrete polled intervals, or based on receipt of confirmed and unconfirmed Change of Value notifications. The COV increment shall be adjustable by an operator using BACnet services, and polled intervals shall be adjustable at the operator workstation.

3.1.6 Local Area Networks

Obtain Government approval before connecting new networks with existing networks. Network numbers and device instance numbers shall remain unique when joining networks. Do not change existing network addressing without Government approval. See also "BACnet Naming and Addressing".

3.1.7 BACnet Routers and Protocol Gateways

Provide the quantity of BACnet routers necessary for communications shown on the BACnet Communication Architecture schematic. Provide BACnet routers with BACnet Broadcast Message Device (BBMD) capability on each BACnet internetwork communicating across an IP network. Configure BBMD tables to enable unicast forwarding of broadcast messaging across Layer-3 IP subnets.

3.1.8 Plant Controllers

Equipment such as VFD's, chillers, and boilers shall have hardwired enable(start/stop), and status points from the plant controller, VFD's shall also have a hardwired speed command. Additionally, this equipment shall have a BACnet interface for monitoring.

3.1.9 Wiring Criteria

- a. Run circuits operating at more than 100 volts in rigid or flexible conduit, metallic tubing, covered metal raceways, or armored cable.
- b. Run all control wiring in blue rigid or flexible conduit, blue

metallic tubing, or covered metal raceways, unless noted otherwise. All control wiring located inside mechanical rooms shall be in conduit or metallic tubing. All conduit and junction box covers, cable/wire trough covers, etc., shall be blue in color."

- c. Do not run binary control circuit wiring in the same conduit as power wiring over 100 volts. Where analog signal wiring requires conduit, do not run in the same conduit with AC power circuits or control circuits operating at more than 100 volts.
- d. Provide circuit and wiring protection required by NFPA 70.
- e. Minimum conduit size is 3/4-inch, except 1/2-inch may be used from last junction box to the terminal device. Maximum conduit fill is 40% or the cable manufacturer's recommended amount whichever is less. Provide plastic end sleeves at all conduit terminations to protect wiring from burrs.
- f. Do not bury aluminum-sheathed cable or aluminum conduit in concrete.
- g. Input/output identification: Permanently label each field-installed wire and cable at each end with descriptive text using a commercial wire marking system. Labels shall fully encircle the wire or cable. The single line text shall run parallel to the wire or cable and shall be repeated so as to be viewable without twirling or twisting the wire. Locate the markers within 2 inches of each termination. Label shall include type of network and destination of cable (ex. BACnet/AHU-1). Match the names and I/O number to the project's point list. Similarly label all power wiring serving control devices, including the word "power" and panel board and circuit number, or transformer location in the label. Number each pneumatic tube every six feet. Label all terminal blocks with alpha/numeric labels. All wiring and the methods shall be in accordance with UL 508A.
- h. Permanently display controller wiring diagram for each controller on the inside of the control cabinet door. Diagram shall be neatly lettered and taped or adhered with sticky back label.
- i. Conduit identification: All conduits shall be labeled within 36 inches from terminations, boxes, bends or wall penetrations. Labels shall be 3/8 inches black lettering on white background and indicate what system the conduit contains. Apply labels every 12 feet or a distance agreed upon by Camp Lejeune Public Works Department. The agreed upon distance shall be for a single building or project only. Label shall be visible and legible, while standing on the floor, from up to three sides with a minimum dimension of 1.9 inches x 4 inches. Conduit that includes power circuits shall be labeled with source panel and circuit, and destination cabinet or equipment.

Provide a label at each control panel on the 120 VAC conduit. The label shall contain the source panel and circuit identifier.

Label Example: SF-C, SF-S, SF-O (3 cables, Supply Fan Command, Supply Fan Status, Supply Fan Output).

Label Example: ZN-T/ZN-H/ZN-Q (1 cable, Zone Temperature, Zone Humidity, Zone Quality).

- j. Each terminal device shall have its own terminal conduit run. Device

boxes or devices or panels shall not be used as "pass thru" for wiring.

- k. Conduit to equipment and devices shall be run tight to walls, and ceilings. Avoid conduit on the floor, i.e. conduit shall not block access to or past equipment. Flex conduit is to be used only when EMT or rigid conduit is not able to satisfy the application such as a transition to a sensor or equipment. Flex conduit shall be limited to a maximum length of 3 ft.
- l. For controller power, provide new 120 VAC circuits, with ground if not defined on the electrical drawings. Provide each circuit with a dedicated breaker, and run wiring in its own conduit, separate from any control wiring. Connect the controller's ground wire to the electrical panel ground; conduit grounds are not acceptable. Include a label on the 120 VAC circuit conduit at each control panel. The label is to include the source panel and circuit identification. The label size shall be a minimum of 1.9 inches by 4 inches, 3/8 inch black lettering on white background.
- m. Supervisory Building Controllers (SBC) shall be powered from a dedicated transformer for the SBC only. Each control cabinet shall have a dedicated 24 volt transformer. The 120 VAC power branch circuit shall be dedicated to the DDC control system. Factory provided transformers in equipment must be used as a source of power only for the control devices intended by the equipment manufacturer.
- n. Surge Protection: Install surge protection according to manufacturer's instructions. Multiple controllers fed from a common power supply may be protected by a common surge protector, properly sized for the total connected devices.
- o. All terminations in panels shall be made at a terminal block if not connected directly to a panel device, ie Field Controller, Supervisory Controller, relays, transmitters, etc. No wire nuts are allowed in panels, VAV boxes, control panels, relay panels or any other type of enclosure shall follow this requirement. High and low voltage wires must not land on the same terminal block unless they are separated and of a different color and/or clearly identified.
- p. Grounding: Ground controllers and cabinets to a good earth ground as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Conduit grounding is not acceptable; all grounding shall have a direct path to the building earth ground. Ground sensor drain wire shields at the controller end.
- q. The Contractor shall be responsible for correcting all associated MS/TP and SA bus wiring, auxiliary bus wiring, termination, end of line, and ground loop problems.
- r. Run wiring in panel enclosures in covered wire track.
- s. Control cabinets, wiring boxes, cable/wiring troughs, panel enclosures, etc., must be clean of all debris, metal shavings, etc.
- t. Low voltage cable must not be supported directly from "all thread" rod. If cabling/wiring is permitted to be run without conduit/raceway it must be supported using a retaining device such as a bridle ring or J hook, and where appropriate connected to the all thread rod using a standoff device. Openly installed cabling/wiring must be approved by

Camp Lejeune Public Works Department.

- u. For serviceability, allow a minimum of 2 inches of exposed wire or cable from any termination point, i.e. between Panduit and field controller terminations.

3.1.10 Accessibility

Install all equipment so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install digital controllers, data ports, and concealed actuators, valves, dampers, air flow stations and like equipment in locations freely accessible through access doors. Install power surge protection such that it is replaceable without removing other components.

3.1.11 Digital Controllers

- a. Install as stand alone control devices (see definitions).
- b. Locate control cabinets at the locations shown on the drawings. If not shown on the drawings, install in the most accessible space, close to the controlled equipment. Controllers must be installed in a manufacturer's required/recommended enclosure for each type of controller.
- c. Provide a dedicated analog output to each output device, such as variable frequency driven pump motors in an alternating arrangement.
- d. Equipment such as VFD's must have hardwired enable(start/stop), speed command and status points from the controller. Software points are not allowable. Additionally, this equipment shall have a BACnet interface for monitoring

3.1.12 Hand-Off-Auto Switches

Wire safety controls such as smoke detectors, freeze protection thermostats, and emergency shut down switches to protect the equipment during both hand and auto operation.

3.1.13 Emergency Shut Down Switches (ATFP)

Quantity and location as shown on the drawings. Switches must be hardwired such that all fans and dampers that circulate air between rooms, or between inside and outside must shut down/close regardless of equipment HOA switch position. ATFP circuit must be energized to allow equipment to operate; i.e. activation of the emergency shut down switch will de-energize the circuit and open relays at the equipment. Additionally, activation of the switch must signal the DDC system to shut all air moving equipment off/closed and initiate an alarm. Reset of the DDC system must be manual.

3.1.13.1 Safety and Shutdown Circuit Monitoring

All safety or shutdown circuits, or any circuit that can disable a system, shall be monitored by the DDC system as separate inputs for each circuit. This shall include, but is not limited to, Low Temperature Limit, Duct Mounted Smoke Detector, Discharge Air High Pressure Limit, Boiler Emergency Pushbutton, Carbon Monoxide, Gas Detection, ATFP, etc. Supervisory controller alarm reporting shall be configured for each

individual circuit alarm.

3.1.14 Temperature Sensors

Install temperature sensors in locations that are accessible and provide a good representation of sensed media. Installations in dead spaces are not acceptable. Calibrate sensors according to manufacturer's instructions. Do not use sensors designed for one application in a different application.

3.1.14.1 Room Temperature Sensors

Mount the sensors on interior walls to sense the average room temperature at the locations indicated. Avoid locations near heat sources such as copy machines or locations by supply air outlet drafts. Mount the center of the sensor 54 inches above the floor to meet ADA requirements.

3.1.14.2 Duct Temperature Sensors

- a. Probe Type: Provide a gasket between the sensor housing and the duct wall. Seal the duct penetration air tight. Seal the duct insulation penetration vapor tight.
- b. Averaging Type (and coil freeze protection thermostats): Weave the capillary tube sensing element in a serpentine fashion perpendicular to the flow, across the duct or air handler cross-section, using durable non-metal supports. Prevent contact between the capillary and the duct or air handler internals. Provide a duct access door at the sensor location. The access door shall be hinged on the side, factory insulated, have cam type locks, and be as large as the duct will permit, maximum 18 by 18 inches. For sensors inside air handlers, the sensors shall be fully accessible through the air handler's access doors without removing any of the air handler's internals.

3.1.14.3 Immersion Temperature Sensors

Provide thermowells for sensors measuring piping, tank, or pressure vessel temperatures. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to sense flow across entire area of well. Wells shall not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide thermal conductivity material within the well to fully coat the inserted sensor.

3.1.14.4 Outside Air Temperature Sensors

Provide outside air temperature sensors in weatherproof enclosures on the north side of the building, away from exhaust hoods and other areas that may affect the reading. Provide a shield to shade the sensor from direct sunlight.

3.1.15 Energy Meters

Provide and locate energy meters as indicated. Connect each meter output to the DDC system, to measure both instantaneous and accumulated energy usage.

3.1.16 Damper Actuators

Where possible, mount actuators outside the air stream in accessible areas.

3.1.17 Pressure Sensors

Locate pressure sensors as indicated.

3.1.18 Pneumatic Tubing

Run tubing concealed in finished and unfinished areas. Run tubing in conduit, such as EMT. For tubing enclosed in concrete, provide rigid metal conduit. Run tubing parallel and perpendicular to building walls. Use 5 foot maximum spacing between tubing supports. Polyethylene tubing over 2 feet long must be run in conduit such as EMT. Caulking joints is not permitted. Do not run tubing and electrical power conductors, or Class 1, 2 or 3 cables, in the same conduit. All tubing must be terminated with an appropriate fitting designed for that purpose.

3.1.19 Component Identification Labeling

Using an electronic hand-held label maker with white tape and bold black block lettering, provide an identification label on the exterior of each new control panel, control device, actuator, and sensor. Also provide labels on the exterior of each new control actuator indicating the (full) open and (full) closed positions. For labels located outdoors, use exterior grade label tape, and provide labels on both the inside and outside of the panel door or device cover. Acceptable alternatives are white plastic labels with engraved bold black block lettering permanently attached to the control panel, control device, actuator, and sensor. Have the labels and wording approved by the BAS Owner prior to installation. Devices with field adjustable setpoints, such as Air Filter Status, Duct Pressure Safety Limit, etc., must have the field adjusted setpoint and date included on the label. Components mounted above a ceiling or service hatch must also have the component identification visible from below. Examples: "A VAV controller, exhaust fan relay, Differential Pressure Transmitter, etc., identification would be included on the ceiling grid, or service hatch, in the area of the controller or field device." Supervisory Controller: Provide a label with the Global ID(s), IP Address and all login credentials. Niagara JACE should include login credentials for both the Station and Platform.

3.1.20 Network and Telephone Communication Lines

When telephone lines or network connections by the Government are required, provide the Contracting Officer at least 120 days advance notice of need. Provide one inch conduit and two (2) green Cat 6 cables from the point of connection of the BAS to the point of connection to the MCEN (most likely in the telephone equipment room). Cables must be terminated and tested.

3.2 TEST AND BALANCE SUPPORT

The controls contractor shall coordinate with and provide on-site support to the test and balance (TAB) personnel specified under Section 23 05 93.00 22 TESTING, ADJUSTING AND BALANCING FOR MECHANICAL SYSTEMS. This support shall include:

- a. On-site operation and manipulation of control systems during the testing and balancing.
- b. Control setpoint adjustments for balancing all relevant mechanical systems, including VAV boxes.
- c. Tuning control loops with setpoints and adjustments determined by TAB personnel.

3.3 INTERFACE WITH EXISTING EMCS

Provide 16 hours of assistance to the Government with interfacing the BAS to the Base wide EMCS. The Government will make the final connection of the BAS to the MCEN. This 16 hours does not include completion or corrections to the installed BAS as defined in the contract documents. This 16 hours is for assisting the interface and for making revisions to the BAS that may be needed outside of the contract requirements. As-Build control drawings must be available for the EMCS operator performing the interacing.

3.4 CONTROLS SYSTEM OPERATORS MANUALS

Provide two electronic and printed copies of a Controls System Operators Manual. The manual shall be specific to the project, written to actual project conditions, and provide a complete and concise depiction of the installed work. Provide information in detail to clearly explain all operation requirements for the control system.

Provide with each manual: CDs of the project's control system drawings, control programs, data bases, graphics, and all items listed below. Include gateway back-up data and configuration tools where applicable. Provide CDs in jewel case with printed and dated project-specific labels on both the CD and the case. For text and drawings, use Adobe Acrobat or MS Office file types. When approved by the Government, AutoCAD and Visio files are allowed. Give files descriptive English names and organize in folders.

Provide printed manuals in sturdy 3-ring binders with a title sheet on the outside of each binder indicating the project title, project location, contract number, and the controls contractor name, address, and telephone number. Each binder shall include a table of contents and tabbed dividers, with all material neatly organized. Manuals shall include the following:

- a. A copy of the as-built control system (shop) drawings set, with all items specified under the paragraph SUBMITTALS. Indicate all field changes and modifications. As-Built Control Drawings shall be marked "As-Built" on the cover page and in the title block of each page. Revisions must be dated, may be hand or CAD annotated.
- b. A copy of the project's mechanical design drawings, including any official modifications and revisions.
- c. A copy of the project's approved Product Data submittals provided under the paragraph SUBMITTALS.
- d. A copy of the project's approved Performance Verification Testing Plan and Report.

- e. A copy of the project's approved final TAB Report.
- f. Printouts of all control system programs, including controller setup pages if used. Include plain-English narratives of application programs, flowcharts, and source code.
- g. Printouts of all physical input and output object properties, including tuning values, alarm limits, calibration factors, and set points.
- h. A table entitled "AC Power Table" listing the electrical power source for each controller. Include the building electrical panel number, panel location, and circuit breaker number.
- i. The DDC manufacturer's hardware and software manuals in both print and CD format with printed project-specific labels. Include installation and technical manuals for all controller hardware, operator manuals for all controllers, programming manuals for all controllers, operator manuals for all workstation software, installation and technical manuals for the workstation and notebook, and programming manuals for the workstation and notebook software. **Provide all warranty information.**
- j. A list of qualified control system service organizations for the work provided under this contract. Include their addresses and telephone numbers.
- k. A written statement entitled "Technical Support" stating the control system manufacturer or authorized representative will provide toll-free telephone technical support at no additional cost to the Government for a minimum of two years from project acceptance, will be furnished by experienced service technicians, and will be available during normal weekday working hours. Include the toll-free technical support telephone number.
- l. A written statement entitled "Software Upgrades" stating software and firmware patches and updates will be provided upon request at no additional cost to the Government for a minimum of two years from **project** acceptance. Include a table of all DDC system software and firmware provided under this contract, listing the original release dates, version numbers, part numbers, and serial numbers.
- m. **Submit any and all updated field controller files, and BACnet Building Controller data base during the acceptance and warranty periods or as a result of a latent defect.**

3.4.1 Storage Cabinets

In **one** project mechanical room, **typically near the BACnet Building Controller** provide a wall-mounted storage cabinet with hinged doors. In addition to the number of manuals specified above, provide an additional copy of the manuals in **this** mechanical room storage cabinet. Provide cabinets large enough to hold the entire set of Controls System Operators Manuals, and the HVAC operation and maintenance manuals provided under Division **23 Heating, Ventilating, and Air Conditioning**. Locate cabinets adjacent to DDC control panels where applicable. Have each cabinet's proposed installation site approved in advance by the Contracting Officer and the BAS Owner. Prominently label each cabinet with the wording "OPERATION AND MAINTENANCE MANUALS." Prominently label each binder with

the wording "MECHANICAL ROOM COPY - DO NOT REMOVE."

3.5 PERFORMANCE VERIFICATION TESTING (PVT)

3.5.1 General

The PVT shall demonstrate compliance of the control system work with the contract requirements. The PVT shall be performed by the Contractor and **may be** witnessed by the Government. If the project is phased, provide separate testing for each phase. A Pre-PVT meeting to review the **Pre-PVT Checklist** is required to coordinate all aspects of the PVT and shall include the Contractor's QA representative, the Contractor's PVT administrator, the Contracting Officer's representative, and the BAS Owner.

3.5.2 Performance Verification Testing Plan

Submit a detailed PVT Plan of the proposed testing for Government approval. Develop the PVT Plan specifically for the control system in this contract. The PVT Plan shall be a clear list of test items arranged in a logical sequence. **It shall include each and all sequences of all controllers. Include sequence tested, intended test procedure, required assisted personnel (such as the mechanical contractor), the expected response, and the pass/fail criteria for every component tested. Include pass/fail column for test, and space for comments, signature and date lines for Contractor's PVT administrator and Contractor's QA representative. The PVT plan shall include the prescriptive pre-PVT check list in addition to the Contractor generated controller specific testing sequences. The final part of the PVT Report shall be 72 hour trends. Propose criteria for the trends, ie, change of state, change of value with the trigger value, time in the PVT Plan.**

3.5.3 PVT Sample Size

Test all controllers unless otherwise directed. **Trends will be reported on all central plant equipment and primary air handling unit controllers, and 25% of terminal controllers such as VAV boxes and fan coil units. Additional trends shall be provided if requested by Camp Lejeune or a commissioning agent.**

3.5.4 Pre-Performance Verification Testing Checklist

Submit the following as a part of the PVT Plan and the PVT Report. **Each item shall include a column for the Contractor's initial/date. This form may be a general form applicable to all controllers and submitted only once in the PVT Plan. Each controller shall have an individual checklist with controller title and identified in the PVT Report..**

- a. **Verify all mechanical installation work is successfully completed and started up by the appropriate personnel.**
- b. **Verify all required control system components, wiring, and accessories are installed.**
- c. **Verify the installed control system architecture matches approved drawings.**
- d. **Verify all control circuits operate at the proper voltage and are free from grounds or faults.**

- e. Verify all required surge protection is installed.
- f. Verify the A/C Power Table specified in the paragraph CONTROLS SYSTEM OPERATORS MANUALS is accurate.
- g. Verify all DDC network communications function properly, including uploading and downloading programming changes.
- h. Verify each digital controller's programming is backed up.
- i. Verify all wiring, components, and panels are properly labeled.
- j. Verify all required points are programmed into devices.
- k. Verify all valve and actuator zero and span adjustments are set properly. List each device and span for that device. Label device with span setting and adjustment date.
- l. Verify all sensor readings are accurate and calibrated. List each sensor, sensor reading, and measured value. Label device with calibrated value and the calibration date.
- m. Verify each control valve and actuator goes to normal position upon loss of power. List each device and normal position.
- n. Verify each controller works properly in stand-alone mode by disconnecting the BACnet bus.

3.5.5 Conducting Performance Verification Testing

- a. Conduct PVT after approval of the PVT Plan. Notify the Contracting Officer of the planned PVT at least 15 days prior to testing. Provide an estimated time table required to perform the testing. Furnish personnel, equipment, instrumentation, and supplies necessary to perform all aspects of the PVT. Ensure that testing personnel are regularly employed in the testing and calibration of DDC systems. Using the project's as-built control system (shop) drawings, the project's mechanical design drawings, and the approved PVT Plan, conduct the PVT.
- b. During testing, identify any items that do not meet the contract requirements and if time permits, conduct immediate repairs and re-test. Otherwise, deficiencies shall be investigated, corrected, and re-tested later. Document each deficiency and corrective action taken.
- c. If re-testing is required, follow the procedures for the initial PVT. The Government may require re-testing of any control system components affected by the original failed test.

3.5.6 Controller Capability and Labeling

Test the following for each controller:

- a. Memory: Demonstrate that programmed data, parameters, and trend/ alarm history collected during normal operation is not lost during power failure.
- b. Direct Connect Interface: Demonstrate the ability to connect directly

to each type of digital controller with a portable electronic device like a notebook computer or PDA. Show that maintenance personnel interface tools perform as specified in the manufacturer's technical literature.

- c. Stand Alone Ability: Demonstrate controllers provide stable and reliable stand-alone operation using default values for values normally read over the network.
- d. Wiring and AC Power: Demonstrate the ability to disconnect any controller safely from its power source using the AC Power Table. Demonstrate the ability to match wiring labels easily with the control drawings. Demonstrate the ability to locate a controller's location using the BACnet Communication Architecture Schematic and floor plans.
- e. Nameplates and Tags: Show the nameplates and tags are accurate and permanently attached to control panel doors, devices, sensors, and actuators.

3.5.7 Workstation and Software Operation

For every user workstation or notebook provided:

- a. Show points lists agree with naming conventions.
- b. Show that graphics are complete.
- c. Show the UPS operates as specified.

3.5.8 BACnet Communications and Interoperability Areas

- a. Data Presentation: On each BACnet Operator Workstation, demonstrate graphic display capabilities.
- b. Reading of Any Property: Demonstrate the ability to read and display any used readable object property of any device on the network.
- c. Setpoint and Parameter Modifications: Show the ability to modify all setpoints and tuning parameters in the sequence of control or listed on project schedules. Modifications are made with BACnet messages and write services initiated by an operator using workstation graphics, or by completing a field in a menu with instructional text.
- d. Peer-to-Peer Data Exchange: Show all BACnet devices are installed and configured to perform BACnet read/write services directly (without the need for operator or workstation intervention), to implement the project sequence of operation, and to share global data.
- e. Alarm and Event Management: Show that alarms/events are installed and prioritized according to the BAS Owner. Demonstrate time delays and other logic is set up to avoid nuisance tripping, e.g., no status alarms during unoccupied times or high supply air during cold morning start-up. Show that operators with sufficient privilege can read and write alarm/event parameters for all standard BACnet event types. Show that operators with sufficient privilege can change routing (BACnet notification classes) for each alarm/event including the destination, priority, day of week, time of day, and the type of transition involved (types of transition include but are not limited to the following: TO-OFF NORMAL and TO-NORMAL).

- f. Schedule Lists: Show that schedules are configured for start/stop, mode change, occupant overrides, and night setback as defined in the [sequence of operations](#).
- g. Schedule Display and Modification: Show the ability to display any schedule with start and stop times for the calendar year. Show that all calendar entries and schedules are modifiable from any connected workstation by an operator with sufficient privilege.
- h. Archival Storage of Data: Show that data archiving is handled by the operator workstation/server, and local trend archiving and display is accomplished with BACnet Trend Log objects.
- i. Modification of Trend Log Object Parameters: Show that an operator with sufficient privilege can change the logged data points, sampling rate, and trend duration.
- j. Device and Network Management: Show the following capabilities:
 - (1) Display of Device Status Information
 - (2) Display of BACnet Object Information
 - (3) Silencing Devices that are Transmitting Erroneous Data
 - (4) Time Synchronization
 - (5) Remote Device Reinitialization
 - (6) Backup and Restore Device Programming and Master Database(s)
 - (7) Configuration Management of Half-Routers, Routers and BBMDs

3.5.9 Execution of Sequence of Operation

Demonstrate that the HVAC system operates properly through the complete sequence of operation. Use read/write property services to globally read and modify parameters over the internetwork.

3.5.10 Control Loop Stability and Accuracy

For all control loops tested, give the Government trend graphs of the control variable over time, demonstrating that the control loop responds to a 20 percent sudden change of the control variable set point without excessive overshoot and undershoot. If the process does not allow a 20 percent set point change, use the largest change possible. Show that once the new set point is reached, it is stable and maintained. Control loop trend data shall be in real-time with the time between data points 30 seconds or less.

3.5.11 [Performance Verification Testing Report](#)

Upon successful completion of the PVT, submit a PVT Report to the Government and prior to the Government taking use and possession of the facility. Do not submit the report until all problems are corrected and successfully re-tested. The report shall include the annotated PVT Plan used during the PVT. Where problems were identified, explain each problem and the corrective action taken. Include a written certification that the

installation and testing of the control system is complete and meets all of the contract's requirements.

3.5.12 Bus Waveform Report

Provide printed wave form of the MS/TP bus(es). Use an oscilloscope to test and record the wave form of each bus segment. This wave form is useful in identifying and troubleshooting bus problems such as inappropriate taps, grounds, end of line terminations and poor connections. Identify each waveform graphic with bus segment name/number, location/building, date and time, and instrument used. Include the resistor sizes needed at each Bus End of Line (EOL). Include a list of the EOL devices.

3.5.13 Performance Verification Testing Acceptance Testing Season One

After acceptance of the PVT Report, demonstrate proper and stable operation of the DDC System. During the field acceptance testing, verify, in the presence of the COTR and BAS owner, random selections of sequences reported in the PVT Report. Equipment, controllers, devices, and sequences for field acceptance testing are to be selected by the COTR. As-built control drawings must be for use and verification at acceptance testing. Field acceptance testing includes verification of the PVT for the following equipment groups:

Group 1: All pumps, chillers, boilers, return fans, computer room units, and air handling units (rooftop and central stations).

Group 2: 25 percent of terminals such as VAV and fan coil units.

Group 3: 25 percent of supply fans, and exhaust fans.

If any of the acceptance testing is found to not operate correctly, terminate verification for the given group. Make the necessary corrections and prepare a revised PVT Report. Reschedule acceptance testing of the revised report with the COTR. After the PVT has been accepted, submit the revised controller files and BACnet Building Controller database.

3.5.14 Performance Verification Testing Acceptance Testing Season Two

A minimum of 3 months after initial acceptance of the DDC system and in the opposite season of heating and cooling, demonstrate proper and stable operation of the DDC system. During the field acceptance testing, verify, in the presence of the COTR and BAS owner, random selections of sequences reported in the PCT Report. Equipment, controllers, devices, and sequences for field acceptance testing are to be selected by the COTR. Field acceptance testing includes verification of the PVT for the following equipment groups:

Group 1: All pumps, chillers, boilers, return fans, computer room units, and air handling units (rooftop and central stations).

Group 2: 25 percent of terminals such as VAV and fan coil units.

Group 3: 25 percent of supply fans, and exhaust fans.

If any of the acceptance testing is found to not operate correctly, terminate verification for the given group. Make the necessary

corrections and prepare a revised PVT Report. Reschedule acceptance testing of the revised report with the COTR. After the PVT has been accepted, submit the revised controller files and BACnet Building Controller database.

3.6 TRAINING REQUIREMENTS

Provide a qualified instructor (or instructors) with two years minimum field experience with the installation and programming of similar BACnet DDC systems. Orient training to the specific systems installed. Coordinate training times and location with the Contracting Officer and BAS Owner after receiving approval of the training course documentation. Training shall take place at the job site or a nearby Government-furnished location. A training day shall occur during normal working hours, last no longer than 8 hours and include a one-hour break for lunch and two additional 15-minute breaks. The project's approved Controls System Operators Manual shall be used as the training text. The Contractor shall ensure the manuals are submitted, approved, and available to hand out to the trainees before the start of training.

3.6.1 Training Documentation

Submit training documentation for review 30 days minimum before training. Documentation shall include an agenda for each training day, objectives, a synopsis of each lesson, and the instructor's background and qualifications. The training documentation can be submitted at the same time as the project's Controls System Operators Manual.

3.6.2 Phase I Training - Fundamentals

The Phase I training session shall last one day and be conducted in a classroom environment with complete audio-visual aids provided by the contractor. Provide each trainee a printed 8.5 by 11 inch hard-copy of all visual aids used. Upon completion of the Phase I Training, each trainee should fully understand the project's DDC system fundamentals. **As-Built control drawings must be used for training.** The training session shall include the following:

- a. BACnet fundamentals (objects, services, addressing) and how/where they are used on this project
- b. This project's list of control system components
- c. This project's list of points and objects
- d. This project's device and network communication architecture
- e. This project's sequences of control, and:
- f. Alarm capabilities
- g. Trending capabilities
- h. Troubleshooting communication errors
- i. Troubleshooting hardware errors

3.6.3 Phase II Training - Operation

Provide Phase II Training shortly after completing Phase I Training. The Phase II training session shall last one day and be conducted at the DDC system workstation, at a notebook computer connected to the DDC system in the field, and at other site locations as necessary. Upon completion of the Phase II Training, each trainee should fully understand the project's DDC system operation. The training session shall include the following:

- a. A walk-through tour of the mechanical system and the installed DDC components (components include but are not limited to the following: controllers, valves, dampers, surge protection, switches, thermostats, and sensors)
- b. A discussion of the components and functions at each DDC panel
- c. Logging-in and navigating at each operator interface type
- d. Using each operator interface to find, read, and write to specific controllers and objects
- e. Modifying and downloading control program changes
- f. Modifying setpoints
- g. Creating, editing, and viewing trends
- h. Creating, editing, and viewing alarms
- i. Creating, editing, and viewing operating schedules and schedule objects
- j. Backing-up and restoring programming and data bases
- k. Modifying graphic text, backgrounds, dynamic data displays, and links to other graphics
- l. Creating new graphics and adding new dynamic data displays and links
- m. Alarm and Event management
- n. Adding and removing network devices

3.7 ATTACHMENTS

Attachment 1 NOT USED
Attachment 2 Object Names
Attachment 3 NOT USED
Attachment 4 Niagara BAS Alarms Policy
Attachment 5 Trend (History)

Attachment 1

** NOT USED **

Attachment 2**Object Names**

<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
ACSOL-C	Autocalibration Solenoid Command
ALARM-RESET	Alarm Reset
BLDG-L	Building Load
BLDG-P	Building Pressure
BLR1-A	Boiler 1 Alarm
BLR1-C	Boiler 1 Command
BLR1-EN	Boiler 1 Enable
BLR1EW-T	Boiler 1 Entering Water Temperature
BLR1-FS	Boiler 1 Flow Switch
BLR1HT-A	Boiler 1 High Temperature Alarm
BLR1ISOV-C	Boiler 1 Isolation Valve Command
BLR1ISOV-S	Boiler 1 Isolation Valve Status
BLR1-LO	Boiler 1 Lockout Switch
BLR1LW-T	Boiler 1 Leaving Water Temperature
BLR1-MS	Boiler 1 Maintenance Switch
BLR1-O	Boiler 1 Output
BLR1-OL	Boiler 1 Overload
BLR1-S	Boiler 1 Status
BLR1SP-O	Boiler 1 Setpoint Output
BP1-%	Boiler Pump 1 Eff Command
BP1-BYPASS	Boiler Pump 1 Bypass Drive
BP1-C	Boiler Pump 1 Command

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
BP1-DP	Boiler Pump 1 Diff Pressure
BP1-FAULT	Boiler Pump 1 Fault Code
BP1-HOA	Boiler Pump 1 Control Mode
BP1-HZ	Boiler Pump 1 Output Frequency
BP1-KWH	Boiler Pump 1 Kilowatt Hours
BP1-O	Boiler Pump 1 Output
BP1-OL	Boiler Pump 1 Overload
BP1-RESET	Boiler Pump 1 Reset Drive Fault
BP1-RPM	Boiler Pump 1 Motor Speed
BP1-S	Boiler Pump 1 Status
BYPV-CL	Bypass Valve Closed Status
BYPV-O	Bypass Valve Output
BYPV-OP	Bypass Valve Open Status
BYPV-POS	Bypass Valve Position
BYPV-S	Bypass Valve Status
CC-T	Cooling Coil Discharge Temperature
CD-CL	Cold Deck Damper Closed Status
CD-F	Cold Deck Flow
CD-O	Cold Deck Damper Output
CD-OP	Cold Deck Damper Open Status
CD-P	Cold Deck Static Pressure
CD-POS	Cold Deck Damper Effective Position
CD-S	Cold Deck Damper Status
CD-T	Cold Deck Temperature
CD-VP	Cold Deck Velocity Pressure

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
CH1-%FLA	Chiller 1 Percent Full Load Amps
CH1-A	Chiller 1 Alarm
CH1-AMPS	Chiller 1 Amps
CH1CHWE-T	Chiller 1 CHW Entering Temperature
CH1CHW-F	Chiller 1 CHW Flow
CH1CHW-FS	Chiller 1 CHW Flow Switch
CH1CHWISOV-C	Chiller 1 CHW Isolation Valve Command
CH1CHWISOV-CL	Chiller 1 CHW Iso Valve Closed Status
CH1CHWISOV-MS	Chiller 1 CHW Isolation Valve Maint Sw
CH1CHWISOV-O	Chiller 1 CHW Isolation Valve Output
CH1CHWISOV-OP	Chiller 1 CHW Iso Valve Open Status
CH1CHWISOV-POS	Chiller 1 CHW Isolation Valve Position
CH1CHWISOV-S	Chiller 1 CHW Isolation Valve Status
CH1CHWL-T	Chiller 1 CHW Leaving Temperature
CH1CL-O	Chiller 1 Current Limit Output
CH1CWE-T	Chiller 1 CW Entering Temperature
CH1CW-F	Chiller 1 CW Flow
CH1CW-FS	Chiller 1 CW Flow Switch
CH1CWISOV-C	Chiller 1 CW Isolation Valve Command
CH1CWISOV-CL	Chiller 1 CW Iso Valve Closed Status
CH1CWISOV-MS	Chiller 1 CW Isolation Valve Maint Sw
CH1CWISOV-O	Chiller 1 CW Isolation Valve Output
CH1CWISOV-OP	Chiller 1 CW Iso Valve Open Status
CH1CWISOV-POS	Chiller 1 CW Isolation Valve Position
CH1CWISOV-S	Chiller 1 CW Isolation Valve Status

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
CH1CWL-T	Chiller 1 CW Leaving Temperature
CH1-EN	Chiller 1 Enable
CH1-MS	Chiller 1 Maintenance Switch
CH1-S	Chiller 1 Status
CH1SP-O	Chiller 1 Setpoint Output
CHEM-A	Chemical Treatment Alarm
CHLR1-L0	Chiller 1 Lockout Switch
CHLR1-OL	Chiller 1 Overload
CHW1ISOV-S	CHW 1 Isolation Valve Status
CHWBYPV-CL	Chilled Water Bypass Valve Closed Status
CHWBYPV-O	Chilled Water Bypass Valve Output
CHWBYPV-OP	Chilled Water Bypass Valve Open Status
CHWBYPV-POS	Chilled Water Bypass Valve Position
CHWBYPV-S	Chilled Water Bypass Valve Status
CHW-DP	Chilled Water Differential Pressure
CHWE-T	Chilled Water Entering Temperature
CHWET-A	CHW Expansion Tank Alarm
CHWETHP-A	CHW Expansion Tank High Pressure Alarm
CHWETLO-A	CHW Expansion Tank Low Pressure Alarm
CHWET-S	CHW Expansion Tank Status
CHWL-T	Chilled Water Leaving Temperature
CHW-P	Chilled Water System Pressure
CHWR-T	Chilled Water Return Temperature
CHWS-T	Chilled Water Supply Temperature
CLG-%	Cooling Effective Command

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
CLG1-C	Cooling Stage 1 Command
CLG-A	Cooling Alarm
CLG-C	Cooling Command
CLG-CL	Cooling Closed Status
CLG-EC	Cooling Effective Command
CLGFBD-CL	Clg Face & Bypass Damper Closed Status
CLGFBD-O	Cooling Face & Bypass Damper Output
CLGFBD-OP	Clg Face & Bypass Damper Open Status
CLGFBD-POS	Cooling Face & Bypass Damper Position
CLGFBD-S	Cooling Face & Bypass Damper Status
CLGOCC-SP	Cooling Occupied Setpoint
CLGUNOCC-SP	Cooling Unoccupied Setpoint
CLG-O	Cooling Output
CLG-OP	Cooling Open Status
CLG-POS	Cooling Position
CLG-S	Cooling Status
CLR1-T	Cooler 1 Temperature
COMBDPR-C	Combustion Damper Command
COMBDPR-CL	Combustion Damper Closed Status
COMBDPR-OP	Combustion Damper Open Status
COMBDPR-POS	Combustion Damper Position
COMBDPR-S	Combustion Damper Status
COMP1-C	Compressor Stage 1 Command
COMP2-C	Compressor Stage 2 Command
COMP-A	Compressor Alarm

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
COND-A	Condensate Alarm
CP-C	Cooling Pump Command
CP-LO	Cooling Pump Lockout Switch
CP-MS	Cooling Pump Maintenance Switch
CP-OL	Cooling Pump Overload Status
CP-S	Cooling Pump Status
CT1-BA	Tower 1 Belt Alarm
CT1BH-EN	Tower 1 Basin Heater Enable
CT1BSN-T	Tower 1 Basin Temperature
CT1BSN-TS	Tower 1 Basin Temp Status
CT1-BYPASS	Tower 1 Bypass Drive
CT1-C	Tower 1 Command
CT1-EC	Tower 1 Effective Command
CT1-F	Tower 1 Flow
CT1-FAULT	Tower 1 Fault Code
CT1H-C	Tower 1 HI Command
CT1H-EC	Tower 1 HI Effective Command
CT1-HOA	Tower 1 Control Mode
CT1-HZ	Tower 1 Output Frequency
CT1ISOV-C	Tower 1 Isolation Valve Command
CT1ISOV-CL	Tower 1 Isolation Valve Closed Status
CT1ISOV-OP	Tower 1 Isolation Valve Open Status
CT1ISOV-S	Tower 1 Isolation Valve Status
CT1-KWH	Tower 1 Kilowatt Hours
CT1L-C	Tower 1 LO Command

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
CT1L-EC	Tower 1 LO Effective Command
CT1-LO	Tower 1 Lockout Switch
CT1LVL-A	Tower 1 Level Alarm
CT1LVL-S	Tower 1 Level Status
CT1M-C	Tower 1 MED Command
CT1M-EC	Tower 1 MED Effective Command
CT1-MS	Tower 1 Maint Sw
CT1MUV-C	Tower 1 Make Up Valve Command
CT1MUV-CL	Tower 1 Make Up Valve Closed Status
CT1MUV-OP	Tower 1 Make Up Valve Open Status
CT1MUV-S	Tower 1 Make Up Valve Status
CT1-O	Tower 1 Output
CT1-OL	Tower 1 Overload
CT1-RESET	Tower 1 Reset Drive Fault
CT1-RPM	Tower 1 Motor Speed
CT1-S	Tower 1 Status
CT1VIB-A	Tower 1 Vibration Alarm
CTBH-EN	Tower Basin Heater Enable
CTLVL-A	Tower Level Alarm
CTLVL-S	Tower Level Status
CTMUV-C	Tower Make Up Valve Command
CTMUV-CL	Tower Make Up Valve Closed Status
CTMUV-OP	Tower Make Up Valve Open Status
CTMUV-S	Tower Make Up Valve Status
CT-T	Tower Basin Temperature

Attachment 2 - Object Names (Continued)	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
CT-TS	Tower Basin Temperature Switch
CTV-CL	Tower Valve Closed Status
CTV-O	Tower Valve Output
CTV-OP	Tower Valve Open Status
CTV-POS	Tower Valve Position
CTV-S	Tower Valve Status
CW1ISOV-S	CW 1 Isolation Valve Status
CW-DP	Cond Water Differential Pressure
CWET-A	CW Expansion Tank Alarm
CWET-S	CW Expansion Tank Status
CW-F	Condenser Water Flow
CWP1-BA	Condenser Water Pump 1 Belt Alarm
CWP1-BYPASS	Condenser Water Pump 1 Bypass Drive
CWP1-C	Condenser Water Pump 1 Command
CWP1-DO%	Condenser Water Pump 1 Drive Output Pcnt
CWP1-DP	Condenser Water Pump 1 Diff Pressure
CWP1-FAULT	Condenser Water Pump 1 Fault Code
CWP1-HOA	Condenser Water Pump 1 Control Mode
CWP1-HZ	Condenser Water Pump 1 Output Frequency
CWP1-KWH	Condenser Water Pump 1 Kilowatt Hours
CWP1-LO	Condenser Water Pump 1 Lockout Switch
CWP1-MS	Condenser Water Pump 1 Maint Sw
CWP1-O	Condenser Water Pump 1 Output
CWP1-OL	Condenser Water Pump 1 Overload
CWP1-RESET	Condenser Water Pump 1 Reset Drive Fault

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
CWP1-RPM	Condenser Water Pump 1 Motor Speed
CWP1-S	Condenser Water Pump 1 Status
CWR-T	Condenser Water Return Temperature
CWS-T	Condenser Water Supply Temperature
DA1-P	Discharge Air Static Pressure 1
DA2-P	Discharge Air Static Pressure 2
DA-F	Discharge Air Flow
DA-H	Discharge Air Humidity
DAPHI-A	Discharge Air High Duct Pressure
DA-Q	Discharge Air Quality
DA-SD	Discharge Air Smoke Alarm
DA-T	Discharge Air Temperature
DA-VP	Discharge Air Velocity Pressure
DCPL-F	Decouple Loop Flow
DCPL-S	Decouple Loop Direction
DCPL-T	Decouple Loop Temperature
DEW-T	Outdoor Air Dew Point Temperature
DHW-A	Domestic HW Alarm
DHWP-S	Domestic HW Pump Status
DHW-T	Domestic HW Temperature
DHWV-CL	Domestic HW Valve Closed Status
DHWV-O	Domestic HW Valve Output
DHWV-OP	Domestic HW Valve Open Status
DHWV-POS	Domestic HW Valve Position
DHWV-S	Domestic HW Valve Status

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
D00R1-S	Door 1 Status
DPR-CL	Supply Air Damper Closed Status
DPR-O	Supply Air Damper Output
DPR-OP	Supply Air Damper Open Status
DPR-POS	Supply Air Damper Effective Position
DPR-S	Supply Air Damper Status
DUCT1-T	Duct 1 Temperature
DUCT-P	Duct Pressure
DWP-S	Domestic Water Pump Status
EAD2-C	Exhaust Air Damper 2 Command
EAD2-S	Exhaust Air Damper 2 Status
EAD-C	Exhaust Air Damper Command
EAD-CL	Exhaust Air Damper Closed Status
EAD-O	Exhaust Air Damper Output
EAD-OP	Exhaust Air Damper Open Status
EAD-POS	Exhaust Air Damper Position
EAD-S	Exhaust Air Damper Status
EA-F	Exhaust Air Flow
EAFILT-DP	Exhaust Air Filter Differential Pressure
EAFILT-S	Exhaust Air Filter Status
EA-H	Exhaust Air Humidity
EAHR-T	Exhaust Air Heat Recovery Temperature
EA-P	Exhaust Air Static Pressure
EAPHI-A	Exhaust Air Low Duct Pressure
EAPLO-A	Exhaust Air Low Duct Pressure

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
EA-Q	Exhaust Air Quality
EA-SD	Exhaust Air Smoke Alarm
EA-T	Exhaust Air Temperature
EA-VP	Exhaust Air Velocity Pressure
ECON-C	Economizer Enable Command
ECON-EN	Economizer Enable
EF-S	Exhaust Fan Status
EF-A	Exhaust Fan Alarm
EF-BA	Exhaust Fan Belt Alarm
EF-BYPASS	Exhaust Fan Bypass Drive
EF-C	Exhaust Fan Command
EF-D0%	Exhaust Fan Drive Output Percent
EF-F	Exhaust Fan Flow
EF-FAULT	Exhaust Fan Fault Code
EF-H0A	Exhaust Fan Control Mode
EF-HZ	Exhaust Fan Output Frequency
EF-KWH	Exhaust Fan Kilowatt Hours
EF-LO	Exhaust Fan Lockout Switch
EF-MS	Exhaust Fan Maint Sw
EF-O	Exhaust Fan Output
EF-OL	Exhaust Fan Overload
EF-RESET	Exhaust Fan Reset Drive Fault
EF-RPM	Exhaust Fan Motor Speed
EF-RS	Exhaust Fan Remote Speed
EF-S	Exhaust Fan Status

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
EFFCLG-SP	Effective Cooling Setpoint
EFFHTG-SP	Effective Heating Setpoint
EH0-S	Energy Hold Off Toggle Switch
ELEC-A	Electric Fault
ELEC-KW	Electric Kilowatts
ELEC-KWH	Electric Kilowatt Hours
ELEC-S	Electric Status
EMER-STOP	Emergency Shutdown
EMGSD1-A	Emergency Shutdown 1 Alarm
ET-A	Expansion Tank Alarm
ETHP-A	Expansion Tank High Pressure Alarm
ETLO-A	Expansion Tank Low Pressure Alarm
ET-S	Expansion Tank Status
FBD-CL	Face & Bypass Damper Closed Status
FBD-O	Face & Bypass Damper Output
FBD-OP	Face & Bypass Damper Open Status
FBD-POS	Face & Bypass Damper Position
FBD-S	Face & Bypass Damper Status
FCB0-S	Fan Control By Others Status
FCP-A	Fire Control Panel Alarm
FCP-TBL	Fire Control Panel Trouble
FD1-A	Fire Damper 1 Alarm
FFILT-DP	Final Filter Differential Pressure
FFILT-S	Final Filter Status
FILT1-DP	Filter 1 Differential Pressure

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
FILT1-S	Filter 1 Status
FILT-DP	Filter Differential Pressure
FILT-S	Filter Status
FLOW1-S	Flow 1 Status
FRZ-S	Freeze Status
FZR1-T	Freezer 1 Temperature
GAS-A	Gas Detection Alarm
GEF-C	General Exhaust Fan Command
GEF-LO	General Exhaust Fan Lockout Switch
GEF-OL	General Exhaust Fan Overload
GEF-S	General Exhaust Fan Status
GEN-A	Generator Alarm
GEN-LVL	Generator Fuel Level
GEN-S	Generator Status
GEN-TBL	Generator Trouble
GLY-T	Glycol Temperature
HCBYPVLV-0	Htg.Clg Bypass Valve Output
HC-C	Heating/Cooling Command
HCFBD-CL	Htg/Clg Face & Bypass Closed Status
HCFBD-O	Heating/Cooling Face & Bypass Output
HCFBD-OP	Htg/Clg Face & Bypass Open Status
HCFBD-POS	Heating/Cooling Face & Bypass Position
HCFBD-S	Heating/Cooling Face & Bypass Status
HCLoop-DP	Heating Cooling Loop Diff Pressure
HC-O	Heating/Cooling Output

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
HCP1-C	Heating/Cooling Pump 1 Command
HCP1-LO	Heating/Cooling Pump 1 Lockout Status
HCP1-OL	Heating/Cooling Pump 1 Overload Status
HCP1-S	Heating/Cooling Pump 1 Status
HCP-C	Heating/Cooling Pump Command
HCP-LO	Heating/Cooling Pump Lockout Switch
HCP-MS	Heating/Cooling Pump Maint Sw
HCP-OL	Heating/Cooling Pump Overload
HCP-S	Heating/Cooling Pump Status
HCV-CL	Heating/Cooling Valve Closed Status
HCV-OP	Heating/Cooling Valve Open Status
HCV-POS	Heating/Cooling Valve Position
HCV-S	Heating/Cooling Valve Status
HCWE-T	Htg/Clg Entering Water Temperature
HCWL-T	Htg/Clg Leaving Water Temperature
HD-CL	Hot Deck Damper Closed Status
HD-F	Hot Deck Flow
HD-H	Hot Deck Humidity
HD-O	Hot Deck Damper Output
HD-OP	Hot Deck Damper Open Status
HD-P	Hot Deck Static Pressure
HD-POS	Hot Deck Damper Effective Position
HD-S	Hot Deck Damper Status
HD-T	Hot Deck Temperature

Attachment 2 - Object Names (Continued)	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
HDV-C	Humidifier Drain Valve Command

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
HD-VP	Hot Deck Velocity Pressure
HFV-C	Humidifier Fill Valve Command
HGBPVC-C	Hot Gas Bypass Valve Command
HGRHV-C	Hot Gas Reheat Valve Command
HI	TEMP 1-T High Temperature 1
HP-A	High Pressure Alarm
HPRW-T	Heat Pump Return Water Temperature
HPSW-T	Heat Pump Supply Water Temperature
HR-C	Heat Recovery Command
HR-CL	Heat Recovery Closed Status
HREAFBD-C	Heat Recovery EA FBD Command
HREAFBD-CL	Heat Recovery EA FBD Closed Status
HREAFBD-O	Heat Recovery EA FBD Output
HREAFBD-OP	Heat Recovery EA FBD Open Status
HREAFBD-POS	Heat Recovery EA FBD Position
HREAFBD-S	Heat Recovery EA FBD Status
HR-O	Heat Recovery Output
HROAFBD-C	Heat Recovery OA FBD Command
HROAFBD-CL	Heat Recovery OA FBD Closed Status
HROAFBD-O	Heat Recovery OA FBD Output
HROAFBD-OP	Heat Recovery OA FBD Open Status
HROAFBD-POS	Heat Recovery OA FBD Position
HROAFBD-S	Heat Recovery OA FBD Status
HR-OP	Heat Recovery Open Status
HRP-C	Heat Recovery Pump Command

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
HRP-LO	Heat Recovery Pump Lockout Switch
HRP-OL	Heat Recovery Pump Overload
HR-POS	Heat Recovery Position
HRP-S	Heat Recovery Pump Status
HR-S	Heat Recovery Status
HR-T	Heat Recovery Temperature
HRW-A	Heat Recovery Wheel Alarm
HRW-BA	Heat Recovery Wheel Belt Alarm
HRW-C	Heat Recovery Wheel Command
HRW-FAULT	Heat Recovery Wheel VFD Fault
HRW-LO	Heat Recovery Wheel Lockout Switch
HRW-MS	Heat Recovery Wheel Maint Sw
HRW-O	Heat Recovery Wheel Output
HRW-OL	Heat Recovery Wheel Overload
HRW-RS	Heat Recovery Wheel Remote Speed
HRW-S	Heat Recovery Wheel Status
HTG1-C	Heating Stage 1 Command
HTG1-CL	Heating 1 Closed Status
HTG1-EC	Heating Effective Stage 1 Command
HTG1-O	Heating 1 Output
HTG1-OP	Heating 1 Open Status
HTG1-POS	Heating 1 Position
HTG1-S	Heating 1 Status
HTG-A	Heating Alarm
HTG-C	Heating Command

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
HTG-CL	Heating Closed Status
HTG-EC	Heating Effective Command
HTG-EN	Heating Enable
HTG-O	Heating Output
HTG-OP	Heating Open Status
HTG-POS	Heating Position
HTG-S	Heating Status
HTGOCC-SP	Heating Occupied Setpoint
HTGUNOCC-SP	Heating Unoccupied Setpoint
HUM1-C	Humidifier Stage 1 Command
HUM1-EC	Humidifier Effective Stage 1 Command
HUM-A	Humidifier Alarm
HUM-C	Humidifier Command
HUMHI-A	Humidity High Limit
HUM-MS	Humidifier Maint Sw
HUM-O	Humidifier Output
HUM-OL	Humidifier Overload
HUMP-LO	Humidification Pump Lockout Switch
HUMP-OL	Humidification Pump Overload
HUM-S	Humidifier Status
HW-DP	Hot Water Differential Pressure
HW-P	Hot Water System Pressure
HX1-A	Heat Exchanger 1 Alarm
HX1-C	Heat Exchanger 1 Command
HX1CHWE-T	Heat Exchanger 1 CHW Enter Temperature

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
HX1CHW-F	Heat Exchanger 1 CHW Flow
HX1CHW-FA	Heat Exchanger 1 CHW Flow Alarm
HX1CHW-FS	Heat Exchanger 1 CHW Flow Switch
HX1CHWISOV-C	Heat Exchanger 1 CHW Iso Valve Command
HX1CHWISOV-O	Heat Exchanger 1 CHW Iso Valve Output
HX1CHWISOV-S	Heat Exchanger 1 CHW Iso Valve Status
HX1CHWL-T	Heat Exchanger 1 CHW Leaving Temperature
HX1CWE-T	Heat Exchanger 1 CW Entering Temperature
HX1CW-F	Heat Exchanger 1 CW Flow
HX1CW-FA	Heat Exchanger 1 CW Flow Alarm
HX1CW-FS	Heat Exchanger 1 CW Flow Switch
HX1CWISOV-C	Heat Exchanger 1 CW Iso Valve Command
HX1CWISOV-O	Heat Exchanger 1 CW Iso Valve Output
HX1CWISOV-S	Heat Exchanger 1 CW Iso Valve Status
HX1CWL-T	Heat Exchanger 1 CW Leaving Temperature
HX1EW-T	Heat Exchanger 1 Entering Temperature
HX1ISOV-C	Heat Exchanger 1 Isolation Valve Command
HX1ISOV-CL	Heat Exchanger 1 Iso Valve Closed Status
HX1ISOV-OP	Heat Exchanger 1 Iso Valve Open Status
HX1ISOV-S	Heat Exchanger 1 Isolation Valve Status
HX1-LO	Heat Exchanger 1 Lockout Switch
HX1LW-T	Heat Exchanger 1 Leaving Temperature
HX1-MS	Heat Exchanger 1 Maintenance Switch
HX1V1-%	Heat Exchanger 1 Valve 1 Eff Command
HX1V1-CL	Heat Exchanger 1 Valve 1 Closed Status

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
HX1V1-O	Heat Exchanger 1 Valve 1 Output
HX1V1-OP	Heat Exchanger 1 Valve 1 Open Status
HX1V1-POS	Heat Exchanger 1 Valve 1 Position
HX1V1-S	Heat Exchanger 1 Valve 1 Status
HX1V2-%	Heat Exchanger 1 Valve 2 Eff Command
HX1V2-CL	Heat Exchanger 1 Valve 2 Closed Status
HX1V2-O	Heat Exchanger 1 Valve 2 Output
HX1V2-OP	Heat Exchanger 1 Valve 2 Open Status
HX1V2-POS	Heat Exchanger 1 Valve 2 Position
HX1V2-S	Heat Exchanger 1 Valve 2 Status
HX4-LO	Heat Exchanger 4 Lockout Switch
HX-A	Heat Exchanger Alarm
HXBYP-T	Heat Exchanger Bypass Temperature
HXCWP1-BA	Primary Hx CW Pump 1 Belt Alarm
HXCWP1-C	Heat Exchanger CW Pump 1 Command
HXCWP1-FAULT	Primary Hx CW Pump 1 VFD Fault
HXCWP1-LO	Primary Hx CW Pump 1 Lockout Switch
HXCWP1-O	Heat Exchanger CW Pump 1 Output
HXCWP1-OL	Primary Hx CW Pump 1 Overload
HXCWP1-S	Heat Exchanger CW Pump 1 Status
HXINR-T	Heat Exchanger Inlet Return Temperature
HXMV-%	Heat Exchange Mixing Valve Eff Command
HXMV-O	Heat Exchanger Mixing Valve Output
HXPCHWP1-BA	Primary Hx CHW Pump 1 Belt Alarm
HXPCHWP1-C	Primary HX CHW Pump 1 Command

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
HXPCHWP1-FAULT	Primary Hx CHW Pump 1 VFD Fault
HXPCHWP1-L0	Primary Hx CHW Pump 1 Lockout Switch
HXPCHWP1-O	Primary HX CHW Pump 1 Output
HXPCHWP1-OL	Primary Hx CHW Pump 1 Overload
HXPCHWP1-S	Primary HX CHW Pump 1 Status
HXSTM-P	Heat Exchanger Steam Pressure
ISOVLV-C	Isolation Valve Command
ISOVLV-CL	Isolation Valve Closed Status
ISOVLV-OP	Isolation Valve Open Status
ISOVLV-S	Isolation Valve Status
LIGHT-C	Lighting Command
LIGHT-L	Ambient Light Level
LIGHT-S	Ambient Light Status
LP-A	Low Pressure Alarm
LT-A	Low Temperature Alarm
MAD-CL	Mixed Air Damper Closed Status
MAD-O	Mixed Air Damper Output
MAD-OP	Mixed Air Damper Open Status
MAD-POS	Mixed Air Damper Position
MAD-S	Mixed Air Damper Status
MA-H	Mixed Air Humidity
MA-Q	Mixed Air Quality
MA-T	Mixed Air Temperature
MISC1-C	Misc 1 Command
MISC1-S	Miscellaneous 1 Status

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
MISC-A	Miscellaneous Alarm
MISC-ADJ	Miscellaneous Adjust
MISC-C	Miscellaneous Command
MISC-F	Miscellaneous Flow
MISC-H	Miscellaneous Humidity
MISC-MTR	Miscellaneous Metered
MISC-O	Miscellaneous Output
MISC-P	Miscellaneous Pressure
MISC-S	Miscellaneous Status
MISC-SP	Miscellaneous Setpoint
MISC-T	Miscellaneous Temperature
MIX-CL	Mixing Valve Closed Status
MIX-O	Mixing Valve Output
MIX-OP	Mixing Valve Open Status
MIX-POS	Mixing Valve Position
MIX-S	Mixing Valve Status
MOAD-C	Min Outdoor Air Damper Command
MOAD-CL	Min Outdoor Air Damper Closed Status
MOAD-O	Min Outdoor Air Damper Output
MOAD-OP	Min Outdoor Air Damper Open Status
MOAD-POS	Min Outdoor Air Damper Position
MOAD-S	Min Outdoor Air Damper Status
MOA-F	Min Outdoor Air Flow
MOAF-%	Min Outdoor Air Fan Speed Feedback
MOAF-A	Min Outdoor Air Fan Alarm

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
MOAF-BA	Min Outdoor Air Fan Belt Alarm
MOAF-BYPASS	Min Outdoor Air Fan Bypass Drive
MOAF-C	Min Outdoor Air Fan Command
MOAF-F	Min Outdoor Air Fan Flow
MOAF-FAULT	Min Outdoor Air Fan Fault Code
MOAF-HOA	Min Outdoor Air Fan Control Mode
MOAF-HZ	Min Outdoor Air Fan Output Frequency
MOAF-KWH	Min Outdoor Air Fan Kilowatt Hours
MOAF-LO	Min Outdoor Air Fan Lockout Switch
MOAF-MS	Min Outdoor Air Fan Maint Sw
MOAF-O	Min Outdoor Air Fan Output
MOAF-OL	Min Outdoor Air Fan Overload
MOAF-RESET	Min Outdoor Air Fan Reset Drive Fault
MOAF-RPM	Min Outdoor Air Fan Motor Speed
MOAF-RS	Min Outdoor Air Fan Remote Speed
MOAF-S	Min Outdoor Air Fan Status
MOA-VP	Min Outdoor Air Velocity Pressure
MOIST1-A	Moisture Detector 1 Alarm
MOTOR1-C	Motor 1 Command
MOTOR1-S	Motor 1 Status
MOTOR-S	Motor Status
MR-T	Mechanical Room Temperature
MVAC-A	Medical Vacuum Alarm
MVAC-P	Medical Vacuum Pressure
NG-F	Natural Gas Flow

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
NG-P	Natural Gas Pressure
NG-S	Natural Gas Alarm
OAD-C	Outdoor Air Damper Command
OAD-CL	Outdoor Air Damper Closed Status
OAD-O	Outdoor Air Damper Output
OAD-OP	Outdoor Air Damper Open Status
OAD-POS	Outdoor Air Damper Position
OAD-S	Outdoor Air Damper Status
OA-F	Outdoor Air Flow
OA-H	Outdoor Air Humidity
OA-Q	Outdoor Air Quality
OA-T	Outdoor Air Temperature
OA-VP	Outdoor Air Velocity Pressure
OCC-C	Occupancy Command
OCC-SCHEDULE	Occupancy Schedule Command
OCC-MODE	Occupancy Status Display
OCC-MODE1	Occupancy Status Display
OCC-S	Occupancy Status
PANIC1-A	Panic Button 1 Alarm
PCHW-F	Primary CHW Flow
PCHWP1-BA	Primary CHW Pump 1 Belt Alarm
PCHWP1-BYPASS	Primary CHW Pump 1 Bypass Drive
PCHWP1-C	Primary CHW Pump 1 Command
PCHWP1-D0%	Primary CHW Pump 1 Drive Output Percent
PCHWP1-DP	Primary CHW Pump 1 Diff Pressure

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
PCHWP1-FAULT	Primary CHW Pump 1 Fault Code
PCHWP1-H0A	Primary CHW Pump 1 Control Mode
PCHWP1-HZ	Primary CHW Pump 1 Output Frequency
PCHWP1-KWH	Primary CHW Pump 1 Kilowatt Hours
PCHWP1-LO	Primary CHW Pump 1 Lockout Switch
PCHWP1-MS	Primary CHW Pump 1 Maint Sw
PCHWP1-O	Primary CHW Pump 1 Output
PCHWP1-OL	Primary CHW Pump 1 Overload
PCHWP1-RESET	Primary CHW Pump 1 Reset Drive Fault
PCHWP1-RPM	Primary CHW Pump 1 Motor Speed
PCHWP1-S	Primary CHW Pump 1 Status
PCHWR-T	Primary CHW Return Temp
PCHWS-T	Primary CHW Supply Temp
PFILT-DP	PreFilter Differential Pressure
PFILT-S	PreFilter Status
PH1-C	Preheat Stage 1 Command
PH1-CL	Preheat 1 Closed Status
PH1-EC	Preheat Effective Stage 1 Command
PH1-O	Preheat 1 Output
PH1-OP	Preheat 1 Open Status
PH1-POS	Preheat 1 Position
PH1-S	Preheat 1 Status
PH-A	Preheat Alarm
PHA-AMPS	Phase A Current
PHA-PF	Phase A Power Factor

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
PHASE-FAIL	Electric Phase Failure
PHA-VOLTS	Phase A Voltage
PHB-AMPS	Phase B Current
PHB-PF	Phase B Power Factor
PHBS-S	Preheat Bonnet Switch Status
PHB-VOLTS	Phase B Voltage
PH-C	Preheat Command
PHC-AMPS	Phase C Current
PH-CL	Preheat Closed Status
PHC-PF	Phase C Power Factor
PHC-VOLTS	Phase C Voltage
PHCWR-T	Primary Htg/Clg Return Water Temperature
PHCWS-T	Primary Htg/Clg Supply Water Temperature
PH-EC	Preheat Effective Command
PH-EN	Preheat Enable
PHFBD-%	Preheat Face & Bypass Damper Eff Command
PHFBD-CL	Preheat Face & Bypass Dmpr Closed Status
PHFBD-O	Preheat Face & Bypass Damper Output
PHFBD-OP	Preheat Face & Bypass Dmpr Open Status
PHFBD-POS	Preheat Face & Bypass Damper Position
PHFBD-S	Preheat Face & Bypass Damper Status
PH-O	Preheat Output
PH-OP	Preheat Open Status
PHP1-C	Preheat Pump 1 Command
PHP1-LO	Preheat Pump 1 Lockout Status

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
PHP1-OL	Preheat Pump 1 Overload Status
PHP1-S	Preheat Pump 1 Status
PHP-C	Preheat Pump Command
PHP-LO	Preheat Pump Lockout Switch
PHP-MS	Preheat Pump Maint Sw
PHP-OL	Preheat Pump Overload
PH-POS	Preheat Position
PHP-S	Preheat Pump Status
PH-S	Preheat Status
PH-T	Preheat Temperature
PHWE-T	Preheat Entering Water Temperature
PHW-F	Primary HW Flow
PHWL-T	Preheat Leaving Water Temperature
PHWP1-BA	Primary HW Pump 1 Belt Alarm
PHWP1-BYPASS	Primary HW Pump 1 Bypass Drive
PHWP1-C	Primary HW Pump 1 Command
PHWP1-DO%	Primary HW Pump 1 Drive Output Percent
PHWP1-DP	Primary HW Pump 1 Diff Pressure
PHWP1-FAULT	Primary HW Pump 1 Fault Code
PHWP1-HOA	Primary HW Pump 1 Control Mode
PHWP1-HZ	Primary HW Pump 1 Output Frequency
PHWP1-KWH	Primary HW Pump 1 Kilowatt Hours
PHWP1-LO	Primary HW Pump 1 Lockout Switch
PHWP1-MS	Primary HW Pump 1 Maint Sw
PHWP1-O	Primary HW Pump 1 Output

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
PHWP1-OL	Primary HW Pump 1 Overload
PHWP1-RESET	Primary HW Pump 1 Reset Drive Fault
PHWP1-RPM	Primary HW Pump 1 Motor Speed
PHWP1-S	Primary HW Pump 1 Status
PHWR-T	Primary HW Return Temperature
PHWS-T	Primary HW Supply Temperature
PIPE1-F	Pipe 1 Flow
PIPE1-P	Pipe 1 Pressure
PIPE1-T	Pipe 1 Temperature
PLANT-DP	Plant Differential Pressure
POOL-T	Pool Temperature
PW-F	Primary Water Flow
PWP1-%	Primary Water Pump 1 Eff Command
PWP1-BA	Primary Water Pump 1 Belt Alarm
PWP1-BYPASS	Primary Water Pump 1 Bypass Drive
PWP1-C	Primary Water Pump 1 Command
PWP1-D0%	Primary Water Pump 1 Drive Output Pcnt
PWP1-DP	Primary Water Pump 1 Diff Pressure
PWP1-FAULT	Primary Water Pump 1 Fault Code
PWP1-HOA	Primary Water Pump 1 Control Mode
PWP1-HZ	Primary Water Pump 1 Output Frequency
PWP1-KWH	Primary Water Pump 1 Kilowatt Hours
PWP1-LO	Primary Water Pump 1 Lockout Switch
PWP1-MS	Primary Water Pump 1 Maint Sw

Attachment 2 - Object Names (Continued)	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
PWP1-0	Primary Water Pump 1 Output

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
PWP1-OL	Primary Water Pump 1 Overload
PWP1-RESET	Primary Water Pump 1 Reset Drive Fault
PWP1-RPM	Primary Water Pump 1 Motor Speed
PWP1-S	Primary Water Pump 1 Status
RA-CO2	Return Air CO2
RAD-CL	Return Air Damper Closed Status
RAD-O	Return Air Damper Output
RAD-OP	Return Air Damper Open Status
RAD-POS	Return Air Damper Position
RAD-S	Return Air Damper Status
RA-F	Return Air Flow
RAFILT-DP	Return Air Filter Differential Pressure
RAFILT-S	Return Air Filter Status
RA-H	Return Air Humidity
RA-P	Return Air Static Pressure
RAPHI-A	Return Air Low Duct Pressure
RAPLO-A	Return Air Low Duct Pressure
RA-Q	Return Air Quality
RA-SD	Return Air Smoke Alarm
RA-T	Return Air Temperature
RA-VP	Return Air Velocity Pressure
REFRIG-A	Refrigerant Alarm
REV1-C	Reversing Valve 1 Command
REV2-C	Reversing Valve 2 Command
RF2-%	Return Fan 2 Speed Feedback

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
RF2-A	Return Fan 2 Alarm
RF2-BA	Return Fan 2 Belt Alarm
RF2-BYPASS	Return Fan 2 Bypass Drive
RF2-C	Return Fan 2 Command
RF2-D0%	Return Fan 2 Drive Output Percent
RF2-FAULT	Return Fan 2 Fault Code
RF2-H0A	Return Fan 2 Control Mode
RF2-HZ	Return Fan 2 Output Frequency
RF2-KWH	Return Fan 2 Kilowatt Hours
RF2-L0	Return Fan 2 Lockout Switch
RF2-O	Return Fan 2 Output
RF2-OL	Return Fan 2 Overload
RF2-RESET	Return Fan 2 Reset Drive Fault
RF2-RPM	Return Fan 2 Motor Speed
RF2-S	Return Fan 2 Status
RF-A	Return Fan Alarm
RF-BA	Return Fan Belt Alarm
RF-BYPASS	Return Fan Bypass Drive
RF-C	Return Fan Command
RF-D0%	Return Fan Drive Output Percent
RF-F	Return Fan Flow
RF-FAULT	Return Fan Fault Code
RF-H0A	Return Fan Control Mode
RF-HZ	Return Fan Output Frequency
RF-KWH	Return Fan Kilowatt Hours

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
RF-LO	Return Fan Lockout Switch
RF-MS	Return Fan Maint Sw
RF-O	Return Fan Output
RF-OL	Return Fan Overload
RF-RESET	Return Fan Reset Drive Fault
RF-RPM	Return Fan Motor Speed
RF-S	Return Fan Status
RH-%	Reheat Effective Command
RH-A	Reheat Alarm
RHC-T	Reheat Coil Discharge Temperature
RH-EN	Reheat Enable
RH-O	Reheat Output
RHP1-C	Reheat Pump 1 Command
RHP1-LO	Reheat Pump 1 Lockout Status
RHP1-OL	Reheat Pump 1 Overload Status
RHP1-S	Reheat Pump 1 Status
RHP-C	Reheat Pump Command
RHP-LO	Reheat Pump Lockout Switch
RHP-MS	Reheat Pump Maint Sw
RHP-OL	Reheat Pump Overload
RH-POS	Reheat Position
RHP-S	Reheat Pump Status
RH-S	Reheat Status
RHWE-T	Reheat Entering Water Temperature
RHWL-T	Reheat Leaving Water Temperature

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
RLF2-A	Relief Fan 2 Alarm
RLF2-BA	Relief Fan 2 Belt Alarm
RLF2-BYPASS	Relief Fan 2 Bypass Drive
RLF2-C	Relief Fan 2 Command
RLF2-D0%	Relief Fan 2 Drive Output Percent
RLF2-FAULT	Relief Fan 2 Fault Code
RLF2-HOA	Relief Fan 2 Control Mode
RLF2-HZ	Relief Fan 2 Output Frequency
RLF2-KWH	Relief Fan 2 Kilowatt Hours
RLF2-LO	Relief Fan 2 Lockout Switch
RLF2-O	Relief Fan 2 Output
RLF2-RESET	Relief Fan 2 Reset Drive Fault
RLF2-RPM	Relief Fan 2 Motor Speed
RLF2-S	Relief Fan 2 Status
RLF-A	Relief Fan Alarm
RLF-BA	Relief Fan Belt Alarm
RLF-BYPASS	Relief Fan Bypass Drive
RLF-C	Relief Fan Command
RLF-D0%	Relief Fan Drive Output Percent
RLF-F	Relief Air Flow
RLF-FAULT	Relief Fan Fault Code
RLF-HOA	Relief Fan Control Mode
RLF-HZ	Relief Fan Output Frequency
RLF-KWH	Relief Fan Kilowatt Hours
RLF-LO	Relief Fan Lockout Switch

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
RLF-MS	Relief Fan Maint Sw
RLF-O	Relief Fan Output
RLF-OL	Relief Fan Overload
RLF-RESET	Relief Fan Reset Drive Fault
RLF-RPM	Relief Fan Motor Speed
RLF-RS	Relief Fan Remote Speed
RLF-S	Relief Fan Status
RLF-VP	Relief Air Velocity Pressure
SA-T	Supply Air Temperature
SCHW-F	Secondary CHW Flow
SCHWP1-%	Secondary CHW Pump 1 Effective Command
SCHWP1-BA	Secondary CHW Pump 1 Belt Alarm
SCHWP1-BYPASS	Secondary CHW Pump 1 Bypass Drive
SCHWP1-C	Secondary CHW Pump 1 Command
SCHWP1-D0%	Secondary CHW Pump 1 Drive Output Pcnt
SCHWP1-DP	Secondary CHW Pump 1 Diff Pressure
SCHWP1-EC	Secondary CHW Pump 1 Effective Command
SCHWP1-FAULT	Secondary CHW Pump 1 VFD Fault
SCHWP1-HOA	Secondary CHW Pump 1 Control Mode
SCHWP1-HZ	Secondary CHW Pump 1 Output Frequency
SCHWP1-KWH	Secondary CHW Pump 1 Kilowatt Hours
SCHWP1-L0	Secondary CHW Pump 1 Lockout Switch
SCHWP1-MS	Secondary CHW Pump 1 Maint Sw
SCHWP1-O	Secondary CHW Pump 1 Output
SCHWP1-OL	Secondary CHW Pump 1 Overload

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
SCHWP1-RESET	Secondary CHW Pump 1 Reset Drive Fault
SCHWP1-RPM	Secondary CHW Pump 1 Motor Speed
SCHWP1-S	Secondary CHW Pump 1 Status
SCHWR-T	Secondary CHW Return Temperature
SCHWS-T	Secondary CHW Supply Temperature
SEWG1-A	Sewage Pump 1 Alarm
SF2-A	Supply Fan 2 Alarm
SF2-BA	Supply Fan 2 Belt Alarm
SF2-BYPASS	Supply Fan 2 Bypass Drive
SF2-C	Supply Fan 2 Command
SF2-D0%	Supply Fan 2 Drive Output Percent
SF2-FAULT	Supply Fan 2 Fault Code
SF2-H0A	Supply Fan 2 Control Mode
SF2-HZ	Supply Fan 2 Output Frequency
SF2-KWH	Supply Fan 2 Kilowatt Hours
SF2-L0	Supply Fan 2 Lockout Switch
SF2-O	Supply Fan 2 Output
SF2-OL	Supply Fan 2 Overload
SF2-RESET	Supply Fan 2 Reset Drive Fault
SF2-RPM	Supply Fan 2 Motor Speed
SF2-S	Supply Fan 2 Status
SF-A	Supply Fan Alarm
SFA-R	Supply Fan Array Status Resistance
SF-BA	Supply Fan Belt Alarm
SF-BYPASS	Supply Fan Bypass Drive

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
SF-C	Supply Fan Command
SF-D0%	Supply Fan Drive Output Percent
SF-F	Supply Fan Flow
SF-FAULT	Supply Fan Fault Code
SFH-C	Supply Fan HI Command
SF-HOA	Supply Fan Control Mode
SF-HZ	Supply Fan Output Frequency
SF-KWH	Supply Fan Kilowatt Hours
SFL-C	Supply Fan LO Command
SF-LO	Supply Fan Lockout Switch
SFM-C	Supply Fan MED Command
SF-MS	Supply Fan Maint Sw
SF-O	Supply Fan Output
SF-OL	Supply Fan Overload
SFPL0-A	Supply Fan Low Duct Pressure
SF-RESET	Supply Fan Reset Drive Fault
SF-RPM	Supply Fan Motor Speed
SF-RS	Supply Fan Remote Speed
SF-S	Supply Fan Status
SHW-F	Secondary HW Flow
SHWP1-%	Secondary HW Pump 1 Speed Feedback
SHWP1-BA	Secondary HW Pump 1 Belt Alarm
SHWP1-BYPASS	Secondary HW Pump 1 Bypass Drive
SHWP1-C	Secondary HW Pump 1 Command
SHWP1-D0%	Secondary HW Pump 1 Drive Output Percent

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
SHWP1-DP	Secondary HW Pump 1 Diff Pressure
SHWP1-EC	Secondary HW Pump 1 Effective Command
SHWP1-FAULT	Secondary HW Pump 1 Fault Code
SHWP1-HOA	Secondary HW Pump 1 Control Mode
SHWP1-HZ	Secondary HW Pump 1 Output Frequency
SHWP1-KWH	Secondary HW Pump 1 Kilowatt Hours
SHWP1-LO	Secondary HW Pump 1 Lockout Switch
SHWP1-MS	Secondary HW Pump 1 Maint Sw
SHWP1-O	Secondary HW Pump 1 Output
SHWP1-OL	Secondary HW Pump 1 Overload
SHWP1-RESET	Secondary HW Pump 1 Reset Drive Fault
SHWP1-RPM	Secondary HW Pump 1 Motor Speed
SHWP1-S	Secondary HW Pump 1 Status
SHWR-T	Secondary HW Return Temperature
SHWS-T	Secondary HW Supply Temperature
SMK1-S	Smoke Detector 1 Status
SP1-A	Sump Pump 1 Alarm
SP1CHW-F	Secondary Pump 1 CHW Flow
STMISO-C	Steam Isolation Valve Command
STMISO-CL	Steam Isolation Valve Closed Status
STMISO-OP	Steam Isolation Valve Open Status
STMISO-S	Steam Isolation Valve Status
STM-P	Steam Pressure
SUMWIN-S	Summer/Winter Mode Status
SUPHTG-%	Supplemental Heating Effective Command

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
SUPHTG1-C	Supplemental Heating Stage 1 Command
SUPHTG1-EC	Supplemental Heating Eff Stage 1 Command
SUPHTG-A	Supplemental Heating Alarm
SUPHTG-C	Supplemental Heating Command
SUPHTG-CL	Supplemental Heating Closed Status
SUPHTG-EC	Supplemental Heating Effective Command
SUPHTG-EN	Supplemental Heating Enable
SUPHTG-O	Supplemental Heating Output
SUPHTG-OP	Supplemental Heating Open Status
SUPHTGP-C	Supplemental Heating Pump Command
SUPHTGP-MS	Supplemental Heating Pump Maint Sw
SUPHTGP-OL	Supplemental Heating Pump Overload
SUPHTG-POS	Supplemental Heating Position
SUPHTGP-S	Supplemental Heating Pump Status
SUPHTG-S	Supplemental Heating Status
SYS-RESET	System Reset
TANKHI-A	Tank High Level Alarm
TANK-L	Tank Level
TANKLO-A	Tank Low Level Alarm
TEF-C	Toilet Exhaust Fan Command
TEF-LO	Toilet Exhaust Fan Lockout Switch
TEF-OL	Toilet Exhaust Fan Overload
TEF-S	Toilet Exhaust Fan Status
TOT-VP	Total Velocity Pressure
UNITEN-S	Unit Enable Toggle Switch

Attachment 2 - Object Names (Continued)	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
UNIT-RESET	Unit Reset
UNIT-S	Unit Status
WC1-ADJ	Zone 1 Warmer/Cooler Adjust
WC-ADJ	Warmer/Cooler Adjust
WIND-DIR	Wind Direction
WINDOW-S	Window Status
WIND-SPD	Wind Speed
ZHLP1-C	Zone 1 Heating Pump Command
ZN	CLG-SP Zone Cooling Setpoint
ZN	C02 FAULT-S-DISP Zone C02 Fault Status Display
ZN	ENERGY SAVING-S Zone Energy Saving Status
ZN	FAN ONLY-S Zone Fan Only Status
ZN	FAN SPEED-DISP Zone Fan Speed Display
ZN	FAN SPEED-REQ Zone Fan Speed Request
ZN	FAULT-S-DISP Zone Fault Status Display
ZN	HTG CLG-S Zone Heating Cooling Status
ZN	HTG-SP Zone Heating Setpoint
ZN	LOCAL SP-LOC Zone Local Setpoint Location
ZN	OAT-DISP Zone OA Temperature Display
ZN	OCC-DISP Zone Occupancy Display
ZN	OCC-REQ Zone Occupancy Request
ZN	OFFSET-SP Zone Offset Setpoint
ZN	SUPERVISOR-S Zone Supervisory Control Status
ZN1	C02 FAULT-S-DISP Zone 1 C02 Fault Status Display
ZN1	FAULT-S-DISP Zone1 Fault Status Display

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
ZN1	OCC-C02 Zone 1 Occupied C02
ZN1	OCC-S Zone 1 Occupancy Status
ZN1BYP-O	Zone 1 Bypass Valve Output
ZN1-C02	Zone 1 C02
ZN1D-%	Zone 1 Damper Effective Command
ZN1D-CL	Zone 1 Damper Closed Status
ZN1DEW-S	Zone 1 Condensate Dew Point Status
ZN1D-O	Zone 1 Damper Output
ZN1D-OP	Zone 1 Damper Open Status
ZN1-DP	Zone 1 Differential Pressure
ZN1D-POS	Zone 1 Damper Position
ZN1D-S	Zone 1 Damper Status
ZN1-F	Zone 1 Flow
ZN1-FS	Zone 1 Flow Switch
ZN1-H	Zone 1 Humidity
ZN1HTG-%	Zone 1 Heating Effective Command
ZN1HTG1-C	Zone 1 Heating Stage 1 Command
ZN1HTG1-EC	Zone 1 Heating Effective Stage 1 Command
ZN1HTG-C	Zone 1 Heating Command
ZN1HTG-CL	Zone 1 Heating Closed Status
ZN1HTG-EC	Zone 1 Heating Effective Command
ZN1HTG-O	Zone 1 Heating Output
ZN1HTG-OP	Zone 1 Heating Open Status
ZN1HTG-POS	Zone 1 Heating Position
ZN1HTG-S	Zone 1 Heating Status

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
ZN1-LO-BAT-S	Zone 1 Battery Status
ZN1MIX-O	Zone 1 Mixing Valve Output
ZN1OCC-S	Zone 1 Occupancy Status
ZN1PA-%	Zone 1 Pump A Speed Feedback
ZN1PA-BA	Zone 1 Pump A Belt Alarm Status
ZN1PA-BYPASS	Zone 1 Pump A Bypass Drive
ZN1PA-C	Zone 1 Pump A Command
ZN1PA-D0%	Zone 1 Pump A Drive Output Percent
ZN1PA-FAULT	Zone 1 Pump A Fault Code
ZN1PA-HOA	Zone 1 Pump A Control Mode
ZN1PA-HZ	Zone 1 Pump A Output Frequency
ZN1PA-KWH	Zone 1 Pump A Kilowatt Hours
ZN1PA-LO	Zone 1 Pump A Lockout Status
ZN1PA-O	Zone 1 Pump A Output
ZN1PA-OL	Zone 1 Pump A Overload Status
ZN1PA-RESET	Zone 1 Pump A Reset Drive Fault
ZN1PA-RPM	Zone 1 Pump A Motor Speed
ZN1PA-S	Zone 1 Pump A Status
ZN1PB-%	Zone 1 Pump B Speed Feedback
ZN1PB-BA	Zone 1 Pump B Belt Alarm Status
ZN1PB-BYPASS	Zone 1 Pump B Bypass Drive
ZN1PB-C	Zone 1 Pump B Command
ZN1PB-D0%	Zone 1 Pump B Drive Output Percent
ZN1PB-FAULT	Zone 1 Pump B Fault Code
ZN1PB-HOA	Zone 1 Pump B Control Mode

<i>Attachment 2 - Object Names (Continued)</i>	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
ZN1PB-HZ	Zone 1 Pump B Output Frequency
ZN1PB-KWH	Zone 1 Pump B Kilowatt Hours
ZN1PB-LO	Zone 1 Pump B Lockout Status
ZN1PB-O	Zone 1 Pump B Output
ZN1PB-OL	Zone 1 Pump B Overload Status
ZN1PB-RESET	Zone 1 Pump B Reset Drive Fault
ZN1PB-RPM	Zone 1 Pump B Motor Speed
ZN1PB-S	Zone 1 Pump B Status
ZN1-Q	Zone 1 Quality
ZN1-SP	Zone 1 Setpoint
ZN1-T	Zone 1 Temperature
ZN1-T-DISP	Zone 1 Temperature Display
ZN1-TOCC	Zone 1 Temporary Occupancy
ZN1WR-T	Zone 1 Water Return Temperature
ZN1WS-T	Zone 1 Water Supply Temperature
ZN-CO2	Zone Carbon Dioxide
ZNF-%	Fan Speed Status Display
ZNF-O	Zone Fan Speed
ZN-H	Zone Humidity
ZN-LO-BAT-S	Zone Battery Status
ZN-Q	Zone Quality
ZN-RH	Zone Relative Humidity
ZN-SP	Zone Local Setpoint
ZN-T	Zone Temperature

Attachment 2 - Object Names (Continued)	
<u>POINT NAME</u>	<u>POINT DESCRIPTION</u>
ZN-TOCC	Zone Temporary Occupancy

Attachment 3

**** NOT USED ****

Attachment 4**Niagara BAS Alarms Policy**

January 2020

Alarms for each given supervisory controller shall be managed by the following Alarm Class definitions:

Default Alarm Class: Non-critical alarms that will remain at the local level and not pushed up to the FX Niagara 4 Server.

Critical Monitoring Alarm Class: The Supervisory controller panel door tamper monitoring switch. This type of alarm will be pushed up to the FX Niagara 4 Server.

Critical Temperature Alarm Class: All critical temperature alarm types related to equipment performance failures and/or high priority zones where temperature and/or occupant comfort is a priority that requires escalated response from Base maintenance. These types of alarms will be pushed up to the FX Niagara 4 Server.

Critical HVAC Alarm Class: All critical AHU, VAV, FCU, WSHP, etc., alarm types such as, but not limited to, Fan Failure, Low Temperature Limit, High/Low Duct Pressure Safety, Smoke Detector, ATRP, etc., that requires escalated response from Base maintenance. These types of alarms will be pushed up to the FX Niagara 4 Server.

Critical Boiler Alarm Class: All critical boiler/heating system alarms defined in the specifications and requiring immediate attention from Base maintenance. These types of alarms will be pushed up to the FX Niagara 4 Server.

Critical Chiller Alarm Class: All critical chiller/chilled water system alarms defined in the specifications and requiring immediate attention from Base maintenance. These type of alarms will be pushed up to the FX Niagara 4 Server.

Attachment 5**Trend (History)****Camp Lejeune COV and Trend Configuration Standards**

The following Change of Value (COV) and Trend configurations shall be followed unless required otherwise.

<i>Example using VAV Box points</i>		
Object ID	COV	Display Precision
ZNT-SP	0.1	
ZN-T	0.3	
SA-F	3	
DPR-O	1	1
HTG-O	1	1
DA-T	0.3	
DAT-SP	0.1	

*** COV Settings**

Temperature = 0.3 deg F
 Humidity = 1.0 %
 Static Pressure = 0.1 in wc
 Fan Outputs = 1.0 %
 Valve Outputs = 1.0 %
 Differential Pressure = 0.1 psi
 VAV Air Flow = 3 cfm
 Airflow Station = 10 cfm
 RPM=10
 kwh=25
 HZ=1
 HW-DP=.1
 Flow=3 gpm
 Water DP = .1 psi

**** Decimal Points Set**

Temperature = 10ths (one to right of decimal .9)
 Humidity = 10ths (one to right of decimal .9)
 Static Pressure = 100ths (hundredths two to right of decimal .09)
 Fan Outputs = 1s (no decimal)
 Valve Outputs = 1s (no decimal)
 Dampers Outputs = 1s (no decimal)
 Differential Pressure = 10ths (one to right of decimal .9)
 VAV Air Flow = 1s (no decimal)
 Water DP = 10ths (one to right of decimal .9)

Trend Configurations - Interval and Change of State (COS)

Point Type	Trend Type	Interval	Buffer <i>(total before rollover or archive)</i>
Analog Output (AO)	Interval	15 Minute	480
Analog Input (AI)	Interval	15 minute	480
Binary Output (BO)	COS	COS	100
Binary Input (BI)	COS	COS	100
Setpoint	COS	COS	100

-- End of Section --

SECTION 23 11 20

FACILITY GAS PIPING
05/20

PART 1 GENERAL

1.1 SUMMARY

This specification section applies to gas piping installed within buildings incidental underground piping under building, above ground steel piping and corrugated stainless steel tubing (CSST) both outside (up to 5 feet beyond exterior walls) and within buildings in compliance with NFPA 54 /AGA Z223.1, "National Fuel Gas Code" NFPA 58, "Fuel Gas Piping".

1.2 REFERENCES

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

AMERICAN GAS ASSOCIATION (AGA)

AGA ANSI B109.4	(2016) Self-Operated Diaphragm-Type Natural Gas Service Regulators for Nominal Pipe Size 1¼ inches (32 mm) and Smaller with Outlet Pressures of 2 psig (13.8 kPa) and Less
AGA XR0603	(2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service
AGA Z223.1	(2012) National Fuel Gas Code

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.15/CSA 9.1	(2009; Addenda A 2012, Addenda B 2013; R 2019) Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves
ANSI Z21.18/CSA 6.3	(2007; R 2017) Gas Appliance Pressure Regulators
ANSI Z21.21/CSA 6.5	(2015) Automatic Valves for Gas Appliances
ANSI Z21.24/CSA 6.10	(2015; R 2020) Connectors for Gas Appliances
ANSI Z21.41/CSA 6.9	(2014; R 2019) Quick-Disconnect Devices for Use with Gas Fuel Appliances
ANSI Z21.69/CSA 6.16	(2015; R 2020) Connectors for Movable Gas Appliances
ANSI Z21.78/CSA 6.20	(2010; R 2020) Standard Specification for Combination Gas Controls for Gas Appliances

ANSI Z21.80/CSA 6.22

(2019) Line Pressure Regulators

AMERICAN PETROLEUM INSTITUTE (API)

API RP 2003

(2015; 8th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents

API RP 2009

(2002; R 2007; 7th Ed) Safe Welding, Cutting, and Hot Work Practices in Refineries, Gasoline Plants, and Petrochemical Plants

API Spec 6D

(June 2018, 4th Ed; Errata 1 July 2018; Errata 2 August 2018) Specification for Pipeline and Piping Valves

API Std 598

(2009) Valve Inspecting and Testing

API Std 607

(2016) Fire Test for Quarter-turn Valves and Valves Equipped with Non-metallic Seats

ASME INTERNATIONAL (ASME)

ASME A13.1

(2020) Scheme for the Identification of Piping Systems

ASME B1.1

(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)

ASME B1.20.1

(2013; R 2018) Pipe Threads, General Purpose (Inch)

ASME B16.3

(2016) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.5

(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard

ASME B16.9

(2018) Factory-Made Wrought Buttwelding Fittings

ASME B16.11

(2016) Forged Fittings, Socket-Welding and Threaded

ASME B16.21

(2016) Nonmetallic Flat Gaskets for Pipe Flanges

ASME B16.33

(2012; R 2017) Manually Operated Metallic Gas Valves for Use in Gas Piping Systems Up to 125 psi, (Sizes NPS 1/2 - NPS 2)

ASME B16.39

(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300

ASME B18.2.1

(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)

ASME B18.2.2	(2015) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.9	(2017) Building Services Piping
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS WHB-2.9	(2004) Welding Handbook; Volume 2, Welding Processes, Part 1

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2020a) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both

CSA GROUP (CSA)

ANSI LC 1/CSA 6.26	(2019) Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing (CSST)

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code
NFPA 58	(2020) Liquefied Petroleum Gas Code

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3 (2007) Commercial Blast Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101 (2014; Rev C) Color Code for Pipelines and
for Compressed Gas Cylinders

UNDERWRITERS LABORATORIES (UL)

UL FLAMMABLE & COMBUSTIBLE (2012) Flammable and Combustible Liquids
and Gases Equipment Directory

1.3 SYSTEM DESCRIPTION

The gas piping system includes natural gas piping and appurtenances from point of connection with supply system, as indicated, to gas operated equipment within the facility. Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, in three separate packages. Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS applies to this section, with additions and modifications specified herein. Provide cathodically protected insulating joints connecting aboveground piping from the meter to the building, with lightning arrestors conforming to API RP 2003, installed where indicated.

1.3.1 Gas Facility System and Equipment Operation

Include shop drawings showing piping layout, locations of system valves, gas line markers and cathodic protection system; step-by-step procedures for system start up, operation and shutdown (index system components and equipment to the system drawings); isolation procedures including valve operation to shutdown or isolate each section of the system (index valves to the system maps and provide separate procedures for normal operation and emergency shutdown if required to be different). Submit Data package No. 4.

1.3.2 Gas Facility System Maintenance

Include maintenance procedures and frequency for system and equipment; identification of pipe materials and manufacturer by locations, pipe repair procedures, and jointing procedures at transitions to other piping material or material from a different manufacturer. Submit Data Package No.4.

1.3.3 Gas Facility Equipment Maintenance

Include identification of valves, shut-offs, disconnects, and other equipment by materials, manufacturer, vendor identification and location; maintenance procedures and recommended tool kits for valves and equipment; recommended repair methods (i.e., field repair, factory repair, or replacement) for each valve and piece of equipment; and preventive maintenance procedures, possible failure modes and troubleshooting guide. Submit Data Package No. 3.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 10.05 20 DESIGN SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Gas Piping System; G

SD-03 Product Data

Pipe and Fittings;

Gas Equipment Connectors;

Gas Piping System;

Pressure Regulators; G

Valves;

SD-06 Test Reports

Testing;

Pressure Tests;

Test with Gas;

SD-07 Certificates

Welders Procedures and Qualifications

Assigned Number, Letter, or Symbol

SD-10 Operation and Maintenance Data

Gas Facility System and Equipment Operation;

Gas Facility System Maintenance;

Gas Facility Equipment Maintenance;

1.5 QUALITY ASSURANCE

Submit manufacturer's descriptive data and installation instructions for approval for compression-type mechanical joints used in joining dissimilar materials and for insulating joints. Mark all valves, flanges and fittings in accordance with MSS SP-25.

1.5.1 Welding Qualifications

- a. Weld piping in accordance with qualified procedures using performance qualified welders and welding operators in accordance with API RP 2009, ASME BPVC SEC IX, and ASME B31.9. Welding procedures qualified by

others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.9. Notify the Contracting Officer at least 24 hours in advance of tests, and perform at the work site if practicable.

- b. Submit a certified copy of welders procedures and qualifications metal and PE in conformance with ASME B31.9 for each welder and welding operator. Submit the assigned number, letter, or symbol that will be used in identifying the work of each welder to the Contracting Officer. Weld all structural members in accordance with Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS, and in conformance with AWS A5.8/A5.8M, and AWS WHB-2.9.

1.5.2 Shop Drawings

Submit drawings for complete Gas Piping System, within 30 days of contract award, showing location, size and all branches of pipeline; location of all required shutoff valves; and instructions necessary for the installation of gas equipment connectors and supports.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Asbestos or products containing asbestos are not allowed. Submit catalog data and installation instructions for pipe, valves, all related system components, pipe coating materials and application procedures. Conform to NFPA 54NFPA 58 and with requirements specified herein. Provide supply piping to appliances or equipment at least as large as the inlets thereof.

2.2 GAS PIPING SYSTEM AND FITTINGS

2.2.1 Steel Pipe, Joints, and Fittings

- a. Pipe: Black carbon steel in accordance with ASTM A53/A53M, Schedule 40, threaded ends for sizes 2 inches and smaller; otherwise, plain end beveled for butt welding.
- b. Threaded Fittings: ASME B16.3, black malleable iron.
- c. Socket-Welding Fittings: ASME B16.11, forged steel.
- d. Butt-Welding Fittings: ASME B16.9, with backing rings of compatible material.
- e. Unions: ASME B16.39, black malleable iron.
- f. Flanges and Flanged Fittings: ASME B16.5 steel flanges or convoluted steel flanges conforming to ASME BPVC SEC VIII D1, with flange faces having integral grooves of rectangular cross sections which afford containment for self-energizing gasket material.

2.2.2 Sealants for Steel Pipe Threaded Joints

Provide joint sealing compound as listed in UL FLAMMABLE & COMBUSTIBLE,

Class 20 or less. For taping, use tetrafluoroethylene tape conforming to **UL FLAMMABLE & COMBUSTIBLE**.

2.2.3 Warning and Identification

Provide pipe flow markings, **warning and identification tape**, and metal tags as required.

2.2.4 Flange Gaskets

Provide gaskets of nonasbestos compressed material in accordance with **ASME B16.21**, **1/16 inch** thickness, full face or self-centering flat ring type, containing aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR) suitable for a maximum **600 degree F** service, to be used for hydrocarbon service.

2.2.5 Pipe Threads

Provide pipe threads conforming to **ASME B1.20.1**.

2.2.6 Escutcheons

Provide chromium-plated steel or chromium-plated brass escutcheons, either one piece or split pattern, held in place by internal spring tension or set screw.

2.2.7 Insulating Pipe Joints

2.2.7.1 Insulating Joint Material

Provide insulating joint material between flanged or threaded metallic pipe systems where shown to control galvanic or electrical action.

2.2.7.2 Threaded Pipe Joints

Provide threaded pipe joints of steel body nut type dielectric unions with insulating gaskets.

2.2.7.3 Flanged Pipe Joints

Provide joints for flanged pipe consisting of full face sandwich-type flange insulating gasket of the dielectric type, insulating sleeves for flange bolts, and insulating washers for flange nuts.

2.2.8 Flexible Connectors

- a. Provide flexible connectors for connecting gas utilization equipment to building gas piping conforming to **ANSI Z21.24/CSA 6.10** or **ANSI Z21.41/CSA 6.9** for quick disconnect devices, and flexible connectors for movable food service equipment conforming to **ANSI Z21.69/CSA 6.16**. Provide combination gas controls for gas appliances conforming to **ANSI Z21.78/CSA 6.20**.
- b. Do not install the flexible connector through the appliance cabinet face. Provide rigid metallic **pipe and fittings** to extend the final connection beyond the cabinet, except when appliance is provided with an external connection point.

2.3 VALVES

Provide lockable shutoff or service isolation valves conforming to the following:

2.3.1 Valves 2 Inches and Smaller

Provide valves 2 inches and smaller conforming to ASME B16.33 of materials and manufacture compatible with system materials used.

2.3.2 Valves 2-1/2 Inches and Larger

Provide valves 2-1/2 inches and larger of carbon steel conforming to API Spec 6D, Class 150.

2.4 PIPE HANGERS AND SUPPORTS

Provide pipe hangers and supports conforming to MSS SP-58.

2.5 LINE AND APPLIANCE REGULATORS AND SHUTOFF VALVES

Provide regulators conforming to ANSI Z21.18/CSA 6.3 for appliances ANSI Z21.78/CSA 6.20 for combination gas controls for gas appliances , and ANSI Z21.80/CSA 6.22 for line pressure regulators. Provide shutoff valves conforming to ANSI Z21.15/CSA 9.1 for manually controlled gas shutoff valves and ANSI Z21.21/CSA 6.5 for automatic shutoff valves for gas appliances.

2.6 NATURAL GAS SERVICE

2.6.1 Service Regulators

- a. Provide ferrous bodied pressure regulators for individual service lines, capable of reducing distribution line pressure to pressures required for users. Provide service regulators conforming to AGA ANSI B109.4 CGA-6.18-M95 with full capacity internal relief . Set pressure relief at a lower pressure than would cause unsafe operation of any connected user.
- b. Adjust regulators for liquified petroleum gas to 2.5 to 3 kPa 10 to 12 inches of water column, with pressure relief set at 4 kPa 16 inches of water column.
- c. Provide regulator(s) having a single port with orifice diameter no greater than that recommended by the manufacturer for the maximum gas flow rate at the regulator inlet pressure. Provide regulator valve vent of resilient materials designed to withstand flow conditions when pressed against the valve port, capable of regulating downstream pressure within limits of accuracy and limiting the buildup of pressure under no-flow conditions to 50 percent or less of the discharge pressure maintained under flow conditions. Provide a self-contained service regulator, and pipe not exceeding exceed 2 inch size.

2.6.2 Gas Meter

2.6.2.1 Utility Monitoring and Control System (UMCS) / Energy Monitoring and Control (EMCS) or Automatic Meter Reading Interfaces

Provide gas meters capable of interfacing the output signal, equivalent to volumetric flow rate, with the existing UMCS / EMCS for data gathering in units of cubic meters cubic feet. Provide meters that do not require power to function and deliver data. Output signal must be either a voltage or amperage signal that can be converted to volumetric flow by using an appropriate scaling factor.

2.6.2.2 Measurement Configuration

For buildings that already have a gas meter with a pulse output, ensure that the pulse output is connected to a data gathering device (i.e. electric meter). For buildings where a natural gas meter already exists but does not have a pulse output, add a pulse kit to the existing meter and tie the output to a data gathering device. If the existing gas meter will not accept a pulse kit or if no meter exists a new natural gas meter must be installed, also requiring a pulse output to a data gathering device. Ensure the pulse frequency and electronic characteristics are compatible with the existing data gathering device, if any.

2.7 BOLTING (BOLTS AND NUTS)

Stainless steel bolting; [ASTM A193/A193M](#), Grade B8M or B8MA, Type 316, for bolts; and [ASTM A194/A194M](#), Grade 8M, Type 316, for nuts. Dimensions of bolts, studs, and nuts must conform with [ASME B18.2.1](#) and [ASME B18.2.2](#) with coarse threads conforming to [ASME B1.1](#), with Class 2A fit for bolts and studs and Class 2B fit for nuts. Bolts or bolt-studs must extend through the nuts and may have reduced shanks of a diameter not less than the diameter at root of threads. Bolts must have American Standard regular square or heavy hexagon heads; nuts must be American Standard heavy semifinished hexagonal.

2.8 GASKETS

Fluorinated elastomer, compatible with flange faces.

2.9 IDENTIFICATION FOR ABOVEGROUND PIPING

[MIL-STD-101](#) for legends and type and size of characters. For pipes [3/4 inch](#) od and larger, provide printed legends to identify contents of pipes and arrows to show direction of flow. Color code label backgrounds to signify levels of hazard. Make labels of plastic sheet with pressure-sensitive adhesive suitable for the intended application. For pipes smaller than [3/4 inch](#) od, provide brass identification tags [1 1/2 inches](#) in diameter with legends in depressed black-filled characters.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 EXCAVATION AND BACKFILLING

Provide required excavation, backfilling, and compaction as specified in Section 31 23 00.00 20 EXCAVATION AND FILL.

3.3 GAS PIPING SYSTEM

Provide a gas piping system from the point of delivery, defined as the outlet of the meter set assembly service regulator shutoff valve, as specified under "Gas Service" within this specification, to the connections to each gas utilization device that is in compliance with NFPA 54..

3.3.1 Protection and Cleaning of Materials and Components

Protect equipment, pipe, and tube openings by closing with caps or plugs during installation. At the completion of all work, thoroughly clean the entire system.

3.3.2 Workmanship and Defects

Piping, tubing and fittings must be clear and free of cutting burrs and defects in structure or threading and must be thoroughly brushed and chip-and scale-blown. Repair of defects in piping, tubing or fittings is not allowed; replace defective items when found.

3.4 PROTECTIVE COVERING

3.4.1 Aboveground Metallic Piping Systems

3.4.1.1 Ferrous Surfaces

Touch up shop primed surfaces with ferrous metal primer. Solvent clean surfaces that have not been shop primed. Mechanically clean surfaces that contain loose rust, loose mill scale and other foreign substances by power wire brushing or commercial sand blasted conforming to SSPC SP 6/NACE No.3 and prime with ferrous metal primer or vinyl type wash coat. Finish primed surfaces with two coats of exterior oil paint or vinyl paint.

3.4.1.2 Nonferrous Surfaces

Except for aluminum alloy pipe, do not paint nonferrous surfaces. Paint surfaces of aluminum alloy pipe and fittings to protect against external corrosion where they contact masonry, plaster, insulation, or are subject to repeated wettings by such liquids as water, detergents or sewage. Solvent-clean the surfaces and treat with vinyl type wash coat. Apply a first coat of aluminum paint and a second coat of alkyd gloss enamel or silicone alkyd copolymer enamel.

3.5 INSTALLATION

Install the gas system in conformance with the manufacturer's recommendations and applicable provisions of NFPA 54 and AGA XR0603, and as indicated. Perform all pipe cutting without damage to the pipe, with an approved type of mechanical cutter, unless otherwise authorized. Use wheel cutters where practicable. On steel pipe 6 inches and larger, an approved gas cutting and beveling machine may be used. Cut thermoplastic and fiberglass pipe in accordance with AGA XR0603.

3.5.1 Connections Between Metallic and Plastic Piping

Connections between metallic and plastic piping are only allowed outside, underground, and with approved transition fittings.

3.5.2 Concealed Piping in Buildings

Do not use combinations of fittings (unions, tubing fittings, running threads, right- and left-hand couplings, bushings, and swing joints) to conceal piping within buildings.

3.5.2.1 Piping and Tubing in Partitions

Locate concealed piping and tubing in hollow, rather than solid, partitions. Protect tubing passing through walls or partitions against physical damage both during and after construction, and provide appropriate safety markings and labels. Provide protection of concealed pipe and tubing in accordance with [ANSI LC 1/CSA 6.26](#).

3.5.2.2 Piping in Floors

Lay piping in solid floors in channels suitably covered to permit access to the piping with minimum damage to the building.

3.5.3 Aboveground Piping

Run aboveground piping as straight as practicable along the alignment and elevation indicated, with a minimum of joints, and separately supported from other piping system and equipment. Install exposed horizontal piping no farther than [6 inches](#) from nearest parallel wall and at an elevation which prevents standing, sitting, or placement of objects on the piping.

3.5.4 Final Gas Connections

Unless otherwise specified, make final connections with rigid metallic pipe and fittings. Flexible connectors may be used for final connections to residential dryers. Flexible connectors may be used for final connections to gas utilization equipment. In addition to cautions listed in instructions required by ANSI standards for flexible connectors, insure that flexible connectors do not pass through equipment cabinet. Provide accessible gas shutoff valve and coupling for each gas equipment item.

3.6 PIPE JOINTS

Design and install pipe joints to effectively sustain the longitudinal pull-out forces caused by contraction of the piping or superimposed loads.

3.6.1 Threaded Metallic Joints

Provide threaded joints in metallic pipe with tapered threads evenly cut and made with UL approved graphite joint sealing compound for gas service or tetrafluoroethylene tape applied to the male threads only. Threaded joints up to [1-1/2 inches](#) in diameter may be made with approved tetrafluoroethylene tape. Threaded joints up to [2 inches](#) in diameter may be made with approved joint sealing compound. After cutting and before threading, ream pipe and remove all burrs. Caulking of threaded joints to stop or prevent leaks is not permitted.

3.6.2 Welded Metallic Joints

Conform beveling, alignment, heat treatment, and inspection of welds to NFPA 54. Remove weld defects and make repairs to the weld, or remove the weld joints entirely and reweld. After filler metal has been removed from its original package, protect and store so that its characteristics or welding properties are not affected adversely. Do not use electrodes that have been wetted or have lost any of their coating.

3.6.3 Solder or Brazed Joints

Make all joints in metallic tubing and fittings with materials and procedures recommended by the tubing supplier. Braze joints with material having a melting point above 1000 degrees F, containing no phosphorous.

3.7 PIPE SLEEVES

Provide pipes passing through concrete or masonry walls or concrete floors or roofs with pipe sleeves fitted into place at the time of construction. Do not install sleeves in structural members except where indicated or approved. Make all rectangular and square openings as detailed. Extend each sleeve through its respective wall, floor or roof, and cut flush with each surface, except in mechanical room floors not located on grade where clamping flanges or riser pipe clamps are used. Extend sleeves in mechanical room floors above grade at least 4 inches above finish floor. Unless otherwise indicated, use sleeves large enough to provide a minimum clearance of 1/4 inch all around the pipe. Provide steel pipe for sleeves in bearing walls, waterproofing membrane floors, and wet areas. Provide sleeves in nonbearing walls, floors, or ceilings of steel pipe, galvanized sheet metal with lock-type longitudinal seam, or moisture-resistant fiber or plastic. For penetrations of fire walls, fire partitions and floors which are not on grade, seal the annular space between the pipe and sleeve with fire-stopping material and sealant that meet the requirement of Section 07 84 00 FIRESTOPPING.

3.8 PIPES PENETRATING WATERPROOFING MEMBRANES

Install pipes penetrating waterproofing membranes as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.9 FIRE SEAL

Fire seal all penetrations of fire rated partitions, walls and floors in accordance with Section 07 84 00 FIRESTOPPING.

3.10 ESCUTCHEONS

Provide escutcheons for all finished surfaces where gas piping passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms.

3.11 SPECIAL REQUIREMENTS

Provide drips, grading of the lines, freeze protection, and branch outlet locations as shown and conforming to the requirements of NFPA 54NFPA 58.

3.12 BUILDING STRUCTURE

Do not weaken any building structure by the installation of any gas piping. Do not cut or notch beams, joists or columns. Attach piping supports to metal decking. Do not attach supports to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.13 PIPING SYSTEM SUPPORTS

Support gas piping systems in buildings with pipe hooks, metal pipe straps, bands or hangers suitable for the size of piping or tubing. Do not support any gas piping system by other piping. Conform spacing of supports in gas piping and tubing installations to the requirements of NFPA 54. Conform the selection and application of supports in gas piping and tubing installations to the requirements of MSS SP-58. In the support of multiple pipe runs on a common base member, use a clip or clamp where each pipe crosses the base support member. Spacing of the base support members is not to exceed the hanger and support spacing required for any of the individual pipes in the multiple pipe run. Rigidly connect the clips or clamps to the common base member. Provide a clearance of 1/8 inch between the pipe and clip or clamp for all piping which may be subjected to thermal expansion.

3.14 ELECTRICAL BONDING AND GROUNDING

Provide a gas piping system within the building that is electrically continuous and bonded to a grounding electrode as required by NFPA 54, NFPA 58, and NFPA 70.

3.15 SHUTOFF VALVE

Install the main gas shutoff valve controlling the gas piping system to be easily accessible for operation, as indicated, protected from physical damage, and marked with a metal tag to clearly identify the piping system controlled. Install valves approximately at locations indicated. Orient stems vertically, with operators on top, or horizontally. Provide PE piping manufacturer bracket support assembly securely fastened to structure for valve connections to resist operating torque applied to PE pipes. Provide stop valve on service branch at connection to main and shut-off valve on riser outside of building.

3.16 LINE AND APPLIANCE PRESSURE REGULATORS

Install line pressure regulators and appliance regulators in accordance with the manufacturer's requirements and in accordance with NFPA 54. Install each regulator in an accessible location and install shutoff valves ahead of each line and appliance regulator to allow for maintenance. Where vent limiting devices are not included in the regulators, install a vent pipe to the exterior of the building. Terminate all service regulator vents and relief vents in the outside air in rain and insect resistant fittings. Locate the open end of the vent where gas can escape freely into the atmosphere, away from any openings into the building and above areas subject to flooding.

3.17 TESTING

Submit test procedures and reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating

the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Test entire gas piping system to ensure that it is gastight prior to putting into service. Prior to testing, purge the system, clean, and clear all foreign material. Test each joint with an approved gas detector, soap and water, or an equivalent nonflammable solution. Inspect and test each valve in conformance with API Std 598 and API Std 607. Complete testing before any work is covered, enclosed, or concealed, and perform with due regard for the safety of employees and the public during the test. Install bulkheads, anchorage and bracing suitably designed to resist test pressures if necessary, and as directed and or approved by the Contracting Officer. Do not use oxygen as a testing medium.

3.17.1 Pressure Tests

Submit test procedures and reports in booklet form tabulating test and measurements performed; dated after award of this contract, and stating the Contractor's name and address, the project name and location, and a list of the specific requirements which are being certified. Before appliances are connected, test by filling the piping systems with air or an inert gas to withstand a minimum pressure of 3 pounds gauge for a period of not less than 10 minutes as specified in NFPA 54 as specified in NFPA 58 without showing any drop in pressure. Do not use Oxygen for test. Measure pressure with a mercury manometer, slope gauge, or an equivalent device calibrated to be read in increments of not greater than 0.1 pound. Isolate the source of pressure before the pressure tests are made.

3.17.2 Test With Gas

Before turning on gas under pressure into any piping, close all openings from which gas can escape. Immediately after turning on the gas, check the piping system for leakage by using a laboratory-certified gas meter, an appliance orifice, a manometer, or equivalent device. Conform all testing to the requirements of NFPA 54. If leakage is recorded, shut off the gas supply, repair the leak, and repeat the tests until all leaks have been stopped.

3.17.3 Purging

After testing is completed, and before connecting any appliances, fully purge all gas piping. Do not purge piping into the combustion chamber of an appliance. Do not purge the open end of piping systems into confined spaces or areas where there are ignition sources unless the safety precautions recommended in NFPA 54 are followed.

3.17.4 Labor, Materials and Equipment

Furnish all labor, materials and equipment necessary for conducting the testing and purging.

3.18 PIPE COLOR CODE MARKING

Provide color code marking of piping as specified in Section 09 90 00 PAINTS AND COATINGS, conforming to ASME A13.1.

-- End of Section --

SECTION 23 24 00

HYDRONIC PIPE CLEANING AND FLUSHING PROCEDURES

08/10

PART 1 GENERAL

1.1 PERFORMANCE REQUIREMENTS

Cleaning and flushing shall remove organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances. Removal of tightly adherent mill scale is not required.

1.2 DELIVERY, STORAGE, AND HANDLING

Handle and store detergent to protect equipment, environment and persons. Store detergent according to manufacturer's recommendations.

1.3 ENVIRONMENTAL REQUIREMENTS

All chemicals shall be acceptable for discharge into sanitary sewer.

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

Cleaning Detergent

Water Treatment Chemicals and Chemical Supplier

PART 2 PRODUCTS

2.1 MATERIALS

The cleaning compound/detergent shall be an alkaline phosphate or non-phosphate detergent/surfactant/specific to remove organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances, with or without inhibitor, suitable for system wetted metals without deleterious effects.

Cleaning compound/detergent shall not contain corrosion inhibitors such as sodium nitrite, molybdate, etc. The only corrosion inhibitor that may be used in conjunction with detergent is sodium sulfite (an oxygen scavenger).

Suggested detergent is trisodium phosphate.

Sodium sulfite, sodium lauroly sarcosinate, and dipotassium phosphate are used for water treatment.

PART 3 EXECUTION

3.1 PROTECTION

Do not exceed service factor amperage on pump motor.

3.1.1 Special Techniques

- a. Use existing steam heating system to maintain a water temperature of 120F.
- b. Close terminal unit service valves and open bypass valve. Flushing bypass should connect upstream of the terminal unit supply service valve and downstream of the return service valve. If necessary, provide temporary piping or hose to bypass terminal unit. Remove any component which may be damaged. In lieu of providing a bypass, three-way valves may be driven 100 percent to bypass. If three-way valves are utilized, do not close service valves.
- c. Fill system with water and detergent solution to manufacture's specified water/detergent concentration, heat to 120F. Test both systems to determine system volume using fluorescent dye and fluorometric analysis.
- d. Operate system pump, hot water pump and circulate solution for a minimum of 48 hrs, while maintaining 120 F. From bottom of air/solids separator, bleed water as necessary while filling system thru standard fill station ensuring to maintain the manufacturer's specified water/detergent concentration. Modulate drain to maintain system pressure. Do not exceed service factor amperage on pump motor. Throttle discharge valve as necessary. The pump start up strainer shall remain in place. Periodically clean the pump strainer. Also, periodically check and clean terminal unit strainers during the 48 hours of cleaning.
- e. Open terminal device service valves, three-way valves, and close bypass valves. Flush each terminal device. Ensure to clean all strainers before opening terminal device service valves. Repeat "Step d" for the terminal devices for a minimum of 48 hour.
- f. Drain system and thoroughly flush with fresh water. Demonstrate to Government that system water runs clear. Coordinate with Construction Manager to provide sample water opacity.
- g. Clean all strainers. Remove pump startup strainer.
- h. The water shall be treated to the following chemical parameters:

Sodium sulfite:	30-100 ppm
Sodium lauroyl sarcosinate:	30-100 ppm
pH:	8.5 - 9.5 (use Dipotassium Phosphate as pH buffer)

The water chemical levels shall be retested in one day, one week and four weeks following initial treatment. If the chemical levels are not within the range specified above, additional treatment shall be conducted to bring the levels within range.

Prepare a report documenting the water system volume, pH, and sulfite concentration levels for the initial treatment and the subsequent three retests and necessary treatment. Submit report to government contracting officer and the Camp Lejeune mechanical design branch.

Provide material safety data sheets (MSDS) for treatment chemicals and permanently locate a copy in each mechanical room.

Provide one plastic sign no smaller than 12"x12" square with engraved lettering ½" in height. Sign shall be located in the mechanical room. It shall be hung on the wall in an area with an unobstructed view and near the respective chemical shot feeder.

The sign shall state the respective system volume (determined from testing and verified by hand calculations) and the following:

"This hydronic system is treated to the following chemical parameters:

Sodium sulfite:	30-100 ppm
Sodium lauroyl sarcosinate:	30-100 ppm
pH*:	8.5 - 9.5

System Volume:

*use Dipotassium Phosphate as pH buffer"

-- End of Section --

SECTION 23 30 00

HVAC AIR DISTRIBUTION
05/20

PART 1 GENERAL

1.1 REFERENCES

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

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 201	(2002; R 2011) Fans and Systems
AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans
AMCA 301	(2014) Methods for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA 500-D	(2018) Laboratory Methods of Testing Dampers for Rating

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 260 I-P	(2012) Sound Rating of Ducted Air Moving and Conditioning Equipment
AHRI 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 430	(2009) Central-Station Air-Handling Units
AHRI 880 I-P	(2011) Performance Rating of Air Terminals
AHRI 885	(2008; Addendum 2011) Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets
AHRI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

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

- ASHRAE 52.2 (2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
- ASHRAE 62.1 (2010) Ventilation for Acceptable Indoor Air Quality
- ASHRAE 68 (1997) Laboratory Method of Testing to Determine the Sound Power In a Duct
- ASHRAE 70 (2006; R 2011) Method of Testing for Rating the Performance of Air Outlets and Inlets

ASME INTERNATIONAL (ASME)

- ASME A13.1 (2020) Scheme for the Identification of Piping Systems

ASTM INTERNATIONAL (ASTM)

- ASTM A53/A53M (2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A167 (2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- ASTM A240/A240M (2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
- ASTM A924/A924M (2020) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
- ASTM B117 (2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
- ASTM B152/B152M (2019) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
- ASTM B209 (2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- ASTM B766 (1986; R 2015) Standard Specification for Electrodeposited Coatings of Cadmium

ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D3359	(2017) Standard Test Methods for Rating Adhesion by Tape Test
ASTM E2016	(2020) Standard Specification for Industrial Woven Wire Cloth

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH (CDPH)

CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2018) Motors and Generators
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 701	(2019) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1819	(2002) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th Edition
SMACNA 1884	(2003) Fibrous Glass Duct Construction Standards, 7th Edition
SMACNA 1966	(2005) HVAC Duct Construction Standards

Metal and Flexible, 3rd Edition

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168 (2017) Adhesive and Sealant Applications

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

40 CFR 82 Protection of Stratospheric Ozone

UNDERWRITERS LABORATORIES (UL)

UL 6 (2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel

UL 181 (2013; Reprint Apr 2017) UL Standard for Safety Factory-Made Air Ducts and Air Connectors

UL 555 (2006; Reprint Aug 2016) UL Standard for Safety Fire Dampers

UL 586 (2009; Reprint Dec 2017) UL Standard for Safety High-Efficiency Particulate, Air Filter Units

UL 705 (2017; Reprint Oct 2018) UL Standard for Safety Power Ventilators

UL 900 (2015) Standard for Air Filter Units

UL 1995 (2015) UL Standard for Safety Heating and Cooling Equipment

UL Bld Mat Dir (updated continuously online) Building Materials Directory

UL Fire Resistance (2014) Fire Resistance Directory

1.2 SYSTEM DESCRIPTION

Furnish ductwork, piping offsets, fittings, and accessories as required to provide a complete installation. Coordinate the work of the different trades to avoid interference between piping, equipment, structural, and electrical work. Provide complete, in place, all necessary offsets in piping and ductwork, and all fittings, and other components, required to install the work as indicated and specified.

1.2.1 Mechanical Equipment Identification

The number of charts and diagrams must be equal to or greater than the number of mechanical equipment rooms. Where more than one chart or diagram per space is required, mount these in edge pivoted, swinging leaf, extruded aluminum frame holders which open to 170 degrees.

1.2.1.1 Charts

Provide chart listing of equipment by designation numbers and capacities such as flow rates, pressure and temperature differences, heating and

cooling capacities, horsepower, pipe sizes, and voltage and current characteristics.

1.2.1.2 Diagrams

Submit proposed diagrams, at least 2 weeks prior to start of related testing. provide neat mechanical drawings provided with extruded aluminum frame under 1/8-inch glass or laminated plastic, system diagrams that show the layout of equipment, piping, and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system. After approval, post these items where directed.

1.2.2 Service Labeling

Label equipment, including fans, air handlers, terminal units, etc. with labels made of self-sticking, plastic film designed for permanent installation. Provide labels in accordance with the typical examples below:

SERVICE	LABEL AND TAG DESIGNATION
Air handling unit Number	AHU - 01, 02 ...
Control and instrument air	CONTROL AND INSTR.
Exhaust Fan Number	EF - 01, 02 ...
VAV Box Number	VAV - 1.01, 2.01, etc (first character indicates the AHU served by)

Identify similar services with different temperatures or pressures. Where pressures could exceed 125 pounds per square inch, gage, include the maximum system pressure in the label. Label and arrow piping in accordance with the following:

- Each point of entry and exit of pipe passing through walls.
- Each change in direction, i.e., elbows, tees.
- In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard.
- In long straight runs, locate labels at distances within eyesight of each other not to exceed 75 feet. All labels must be visible and legible from the primary service and operating area.

For Bare or Insulated Pipes	
for Outside Diameters of	Lettering
1/2 thru 1-3/8 inch	1/2 inch
1-1/2 thru 2-3/8 inch	3/4 inch
2-1/2 inch and larger	1-1/4 inch

1.2.3 Color Coding

Color coding of all piping systems must be in accordance with ASME A13.1 .

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G

SD-03 Product Data

Insulated Nonmetallic Flexible Duct Runouts

Duct Connectors

Duct Access Doors

Fire Dampers

Manual Balancing Dampers

Gravity Backdraft And Relief Dampers

Sound Attenuation Equipment

Diffusers

Registers and Grilles

Louvers

Air Vents, Penthouses, and Goosenecks

Centrifugal Fans

In-Line Centrifugal Fans

Centrifugal Type Power Wall Ventilators

Air Handling Units; G

Constant Volume, Single Duct Terminal Units

Variable Volume, Single Duct Terminal Units; G

Reheat Units; G

Energy Recovery Devices; G

Test Procedures

Diagrams

Indoor Air Quality for Duct Sealants; S

SD-06 Test Reports

Performance Tests

Damper Acceptance Test

SD-07 Certificates

Ozone Depleting Substances Technician Certification

SD-08 Manufacturer's Instructions

Manufacturer's Installation Instructions

Operation and Maintenance Training

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

Fire Dampers

Manual Balancing Dampers

Centrifugal Fans

In-Line Centrifugal Fans

Centrifugal Type Power Wall Ventilators

Air Handling Units

Constant Volume, Single Duct Terminal Units

Variable Volume, Single Duct Terminal Units

Reheat Units

Energy Recovery Devices

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.4 QUALITY ASSURANCE

Except as otherwise specified, approval of materials and equipment is based on manufacturer's published data.

- a. Where materials and equipment are specified to conform to the standards of the Underwriters Laboratories, the label of or listing with reexamination in **UL Bld Mat Dir**, and **UL 6** is acceptable as sufficient evidence that the items conform to Underwriters Laboratories requirements. In lieu of such label or listing, submit a written certificate from any nationally recognized testing agency, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified requirements. Outline methods of testing used by the specified agencies.
- b. Where materials or equipment are specified to be constructed or tested, or both, in accordance with the standards of the ASTM International (ASTM), the ASME International (ASME), or other standards, a manufacturer's certificate of compliance of each item is acceptable as proof of compliance.
- c. Conformance to such agency requirements does not relieve the item from compliance with other requirements of these specifications.
- d. Where products are specified to meet or exceed the specified energy efficiency requirement of FEMP-designated or ENERGY STAR covered product categories, equipment selected must have as a minimum the efficiency rating identified under "Energy-Efficient Products" at <http://femp.energy.gov/procurement>.

1.4.1 Prevention of Corrosion

Protect metallic materials against corrosion. Provide rust-inhibiting treatment and standard finish for the equipment enclosures. Do not use aluminum in contact with earth, and where connected to dissimilar metal. Protect aluminum by approved fittings, barrier material, or treatment. Provide hot-dip galvanized ferrous parts such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous parts not of corrosion-resistant steel or nonferrous materials in accordance with **ASTM A123/A123M** for exterior locations and cadmium-plated in conformance with **ASTM B766** for interior locations.

1.4.2 Asbestos Prohibition

Do not use asbestos and asbestos-containing products.

1.4.3 Ozone Depleting Substances Technician Certification

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.4.4 Detail Drawings

Submit detail drawings showing equipment layout, including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications. Include any information required to demonstrate that the system has been coordinated and functions properly as a unit on the drawings and show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Submit drawings showing bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Submit function designation of the equipment and any other requirements specified throughout this Section with the shop drawings.

1.4.5 Test Procedures

Conduct performance tests as required in Section 23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS and Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect stored equipment at the jobsite from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all pipes until installed.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Except for the fabricated duct, plenums and casings specified in paragraphs "Metal Ductwork" and "Plenums and Casings for Field-Fabricated Units", provide components and equipment that are standard products of manufacturers regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. This requirement applies to all equipment, including diffusers, registers, fire dampers, and balancing dampers.

- a. Standard products are defined as components and equipment that have been in satisfactory commercial or industrial use in similar applications of similar size for at least two years before bid opening.
- b. Prior to this two year period, these standard products must have been

sold on the commercial market using advertisements in manufacturers' catalogs or brochures. These manufacturers' catalogs, or brochures must have been copyrighted documents or have been identified with a manufacturer's document number.

- c. Provide equipment items that are supported by a service organization. In product categories covered by ENERGY STAR or the Federal Energy Management Program, provide equipment that is listed on the ENERGY STAR Qualified Products List or that meets or exceeds the FEMP-designated Efficiency Requirements.

2.2 IDENTIFICATION PLATES

In addition to standard manufacturer's identification plates, provide engraved laminated phenolic identification plates for each piece of mechanical equipment. Identification plates are to designate the function of the equipment. Submit designation with the shop drawings. Provide identification plates that are layers, black-white-black, engraved to show white letters on black background. Letters must be upper case. Identification plates that are 1-1/2-inches high and smaller must be 1/16-inch thick, with engraved lettering 1/8-inch high; identification plates larger than 1-1/2-inches high must be 1/8-inch thick, with engraved lettering of suitable height. Identification plates 1-1/2-inches high and larger must have beveled edges. Install identification plates using a compatible adhesive.

2.3 EQUIPMENT GUARDS AND ACCESS

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact according to OSHA requirements. Properly guard or cover with insulation of a type specified, high temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard. The requirements for catwalks, operating platforms, ladders, and guardrails are specified in Section 08 31 00 ACCESS DOORS AND PANELS.

2.4 ELECTRICAL WORK

- a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown. For packaged equipment, include manufacturer provided controllers with the required monitors and timed restart.
- b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11. Provide premium efficiency type integral size motors in accordance with NEMA MG 1.
- c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Select premium efficiency polyphase motors in accordance

with NEMA MG 10.

- d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Provide motors rated for continuous duty with the enclosure specified. Provide motor duty that allows for maximum frequency start-stop operation and minimum encountered interval between start and stop. Provide motor torque capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Fit motor bearings with grease supply fittings and grease relief to outside of the enclosure.
- e. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers are allowed to accomplish the same function. Use solid-state variable-speed controllers for motors rated 10 hp or less and adjustable frequency drives for larger motors. Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.

2.5 ANCHOR BOLTS

Provide anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts to be of the size and number recommended by the equipment manufacturer and located by means of suitable templates. Installation of anchor bolts must not degrade the surrounding concrete.

2.6 PAINTING

Paint equipment units in accordance with approved equipment manufacturer's standards unless specified otherwise. Field retouch only if approved. Otherwise, return equipment to the factory for refinishing. Paint in accordance with Section 09 96 00 HIGH-PERFORMANCE COATINGS.

2.7 INDOOR AIR QUALITY

Provide equipment and components that comply with the requirements of ASHRAE 62.1 unless more stringent requirements are specified herein.

2.8 DUCT SYSTEMS

2.8.1 Metal Ductwork

Provide metal ductwork construction, including all fittings and components, that complies with SMACNA 1966, as supplemented and modified by this specification .

- a. Construct ductwork meeting the requirements for the duct system static pressure specified in APPENDIX D of Section 23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS.
- b. Provide radius type elbows with a centerline radius of 1.5 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes are allowed.
- c. Provide ductwork that meets the requirements of Seal Class A. Provide ductwork in VAV systems upstream of the VAV boxes that meets the

requirements of Seal Class A.

- d. Provide sealants that conform to fire hazard classification specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS and are suitable for the range of air distribution and ambient temperatures to which it is exposed. Do not use pressure sensitive tape as a sealant. Provide duct sealant products that meet either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168 (HVAC duct sealants are classified as "Other" within the SCAQMD Rule 1168 sealants table). Provide validation of indoor air quality for duct sealants.
- e. Make spiral lock seam duct, and flat oval with duct sealant and lock with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA 1966. Apply the sealant to the exposed male part of the fitting collar so that the sealer is on the inside of the joint and fully protected by the metal of the duct fitting. Apply one brush coat of the sealant over the outside of the joint to at least 2 inch band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar are not acceptable.
- f. Fabricate outdoor air intake ducts and plenums with watertight soldered or brazed joints and seams.

2.8.1.1 Insulated Nonmetallic Flexible Duct Runouts

Use flexible duct runouts only where indicated. Runout length is indicated on the drawings, and is not to exceed 5 feet. Provide runouts that are preinsulated, factory fabricated, and that comply with NFPA 90A and UL 181. Provide either field or factory applied vapor barrier. Provide not less than 20 ounce glass fabric duct connectors coated on both sides with neoprene. Where coil induction or high velocity units are supplied with vertical air inlets, use a streamlined, vaned and mitered elbow transition piece for connection to the flexible duct or hose. Provide a die-stamped elbow and not a flexible connector as the last elbow to these units other than the vertical air inlet type. Insulated flexible connectors are allowed as runouts. Provide insulated material and vapor barrier that conform to the requirements of Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Do not expose the insulation material surface to the air stream.

2.8.1.2 General Service Duct Connectors

Provide a flexible duct connector approximately 6 inches in width where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, secure the flexible material by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, install the flexible material locked to metal collars using normal duct construction methods. Provide a composite connector system that complies with NFPA 701 and is classified as "flame-retardent fabrics" in UL Bld Mat Dir.

2.8.1.3 High Temperature Service Duct Connections

Provide material that is approximately 3/32 inch thick, 35 to 40-ounce per square yard weight, plain weave fibrous glass cloth with, nickel/chrome wire reinforcement for service in excess of 1200 degrees F.

2.8.1.4 Aluminum Ducts

ASTM B209, alloy 3003-H14 for aluminum sheet and alloy 6061-T6 or equivalent strength for aluminum connectors and bar stock.

2.8.1.5 Copper Sheets

ASTM B152/B152M, light cold rolled temper.

2.8.1.6 Corrosion Resisting (Stainless) Steel Sheets

ASTM A167

2.8.2 Duct Access Doors

Provide hinged access doors conforming to **SMACNA 1966** in ductwork and plenums where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system. Provide access doors upstream and downstream of air flow measuring primaries and heating and cooling coils. Provide doors that are a minimum **15 by 18 inches**, unless otherwise shown. Where duct size does not accommodate this size door, make the doors as large as practicable. Equip doors **24 by 24 inches** or larger with fasteners operable from inside and outside the duct. Use insulated type doors in insulated ducts.

2.8.3 Fire Dampers

Use 1.5 hour rated fire dampers unless otherwise indicated. Provide fire dampers that conform to the requirements of **NFPA 90A** and **UL 555**. Perform the fire damper test as outlined in **NFPA 90A**. Provide automatic operating fire dampers with a dynamic rating suitable for the maximum air velocity and pressure differential to which it is subjected. Provide fire dampers approved for the specific application, and install according to their listing. Equip fire dampers with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, does not impair the operation of the damper. Equip sleeves or frames with perimeter mounting angles attached on both sides of the wall or floor opening. Construct ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies in conformance with **UL Fire Resistance**. Provide curtain type with damper blades out of the air stream fire dampers. Install dampers that do not reduce the duct or the air transfer opening cross-sectional area. Install dampers so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness. Unless otherwise indicated, comply with the installation details given in **SMACNA 1819** and in manufacturer's instructions for fire dampers. Perform acceptance testing of fire dampers according to paragraph Fire Damper Acceptance Test and **NFPA 90A**.

2.8.4 Manual Balancing Dampers

- a. Furnish factory manufactured and assembled manual balancing dampers with accessible locking-type quadrant operators. Manufacturer must publish damper data sheets and dampers must be sold on the open market. Use chromium plated operators (with all exposed edges rounded) in finished portions of the building where ductwork is exposed.
- b. Furnish stand-off mounting brackets, bases, or adapters, not less than

the thickness of the insulation, to provide clearance between the duct surface and the operator. Stand-off mounting items are to be integral with the operator or standard accessory of the damper manufacturer. For duct widths greater than 30 inches, provide locking regulator at each end of the damper shaft.

- c. Dampers installed in ductwork with an air velocity over 1500 fpm, and/or pressure class greater than 2 inches must be rated for the design velocity and pressure class indicated.

2.8.4.1 Single Blade Round Dampers:

- a. May be furnished up to 20 inches in diameter.
- b. Provide a minimum 3/8 inch square continuous full length galvanized or plated steel axle shaft that supports the entire blade diameter and extends through the standoff bracket and quadrant operator. Firmly affix the axle shaft to the blade. Spring-loaded positioners are not permitted.
- c. Must be factory fabricated in a frame with a minimum length of 6 inches made of galvanized steel with straightening ribs; minimum of 22 gage up to 8 inch diameter, and 20 gage above 8 inch diameter. Damper frames are to be mounted end to end with round duct. Supply the axle shaft on both ends with a pressed in elastomeric bearing/seal, for low infiltration/exfiltration air leakage.
- d. Provide galvanized steel damper blade; minimum of 22 gage up to 8 inch diameter, and 20 gage above 8 inch diameter.

2.8.4.2 Single Blade Rectangular Dampers:

- a. May be furnished up to 12 inches in height for rectangular ducts.
- b. Provide square galvanized or plated steel axle shaft(s) that support the blade at both ends and extends through the standoff bracket and quadrant operator; minimum 3/8 inch up to 19 inch blade length, and 1/2 inch over 19 inch blade length. Firmly affix the axle shaft(s) to the blade. Spring-loaded positioners are not permitted. Provide, at the duct wall shaft penetration, an elastomeric seal for low infiltration/exfiltration air leakage.
- c. Must be factory fabricated in a frame with a minimum length 3 inches made of galvanized steel; minimum of 24 gage up to 19 inch blade length, and 22 gage over 19 inch blade length. Damper frames are to be mounted inside the duct. Support axle shaft on both ends with a bearing in the frame.
- d. Provide damper blades made of galvanized steel with roll formed or broke stiffener(s); minimum of 20 gage up to 19 inch blade length, and 18 gage over 19 inch blade length.

2.8.4.3 Multi-blade Rectangular Dampers:

- a. Furnish for round ducts larger than 20 inches and rectangular duct greater than 12 inches in height, except flanged duct system. Furnish square to round transitions for application in round duct.
- b. Provide 1/2 inch galvanized or plated steel axle shafts that support

each blade at both ends. Operator shaft shall extend thru the standoff bracket and quadrant operator. An elastomeric seal for low infiltration/exfiltration air leakage must be at the duct wall shaft penetration.

- c. Must be factory fabricated in a frame with a minimum length of 5 inches made of minimum 16 gage galvanized steel. Damper frames are to be mounted inside the duct. Support axle shafts on both end with a bearing in the frame. Blade linkage must be galvanized or plated steel and concealed in the frame, out of the air stream.
- d. Provide opposed blades made of galvanized steel with roll formed or broke stiffeners(s); minimum of 16 gage.

2.8.4.4 Rectangular Dampers for Flanged Duct:

- a. Provide for flanged duct systems.
- b. Must be multi-blade rectangular.
- c. Provide 1/2 inch galvanized or plated steel axle shafts that support each blade at both ends. Operator shaft shall extend thru the standoff bracket and quadrant operator.
- d. Must be factory fabricated in a frame with a minimum length of 3 inches made galvanized steel with a thickness to match the duct and at least 16 gage, or 20 gage with additional reinforcing such as a C channel. Mount damper frames end to end with the duct. Support axle shafts on both ends with a pressed in elastomeric bearing/seal for low infiltration/exfiltration air leakage. Provide galvanized or plated steel blade linkage, conealed in a frame, out of the air stream.
- e. Provide opposed blades made of galvanized steel with roll formed or broker stiffeners(s); minimum of 16 gage.

2.8.5 Automatic Balancing Dampers

Provide dampers as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS.

2.8.6 Gravity Backdraft and Relief Dampers

Backdraft dampers shall be furnished and installed where shown on plans and/or as described in schedules. Dampers shall be counterbalanced, backdraft dampers suitable for application in HVAC systems with pressures to 2.5" w.g., velocities of up to 2,000 fpm and temperatures to 180°F. It was

Solidy secure frames and mullions in place and seal with elastomer caulking against air bypass.

Provide damper blades with extruded vinyl edge seals mechanically locked into the blade edge.

Equip with adjustable counterbalancing weights to allow operation of the blades such that "start to open" occurs at 0.02" w.g. and the damper achieves fully open position at 0.05" w.g.

Testing and ratings to be in accordance with AMCA 500-D.

Gravity backdraft dampers may be manufacturer's standard construction when furnished integral with air moving equipment.

2.8.7 Sound Attenuation Equipment

2.8.7.1 Systems with total pressure above 4 Inches Water Gauge

Provide sound attenuators on the discharge duct of each fan operating at a total pressure above 4 inch water gauge, and, when indicated, at the intake of each fan system. Provide sound attenuators elsewhere as indicated. Provide factory fabricated sound attenuators, tested by an independent laboratory for sound and performance characteristics. Provide a net sound reduction as indicated. Maximum permissible pressure drop is not to exceed 0.63 inch water gauge. Construct traps to be airtight when operating under an internal static pressure of 10 inch water gauge. Provide air-side surface capable of withstanding air velocity of 10,000 fpm. Certify that the equipment can obtain the sound reduction values specified after the equipment is installed in the system and coordinated with the sound information of the system fan to be provided. Provide sound absorbing material conforming to ASTM C1071, Type I or II. Provide sound absorbing material that meets the fire hazard rating requirements for insulation specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. For connection to ductwork, provide a duct transition section. Factory fabricated double-walled internally insulated spiral lock seam and round duct and fittings designed for high pressure air system can be provided if complying with requirements specified for factory fabricated sound attenuators, in lieu of factory fabricated sound attenuators. Construct the double-walled duct and fittings from an outer metal pressure shell of zinc-coated steel sheet, 1 inch thick acoustical blanket insulation, and an internal perforated zinc-coated metal liner. Provide a sufficient length of run to obtain the noise reduction coefficient specified. Certify that the sound reduction value specified can be obtained within the length of duct run provided. Provide welded or spiral lock seams on the outer sheet metal of the double-walled duct to prevent water vapor penetration. Provide duct and fittings with an outer sheet that conforms to the metal thickness of high-pressure spiral and round ducts and fittings shown in SMACNA 1966. Provide acoustical insulation with a thermal conductivity "k" of not more than 0.27 Btu/inch/square foot/hour/degree F at 75 degrees F mean temperature. Provide an internal perforated zinc-coated metal liner that is not less than 24 gauge with perforations not larger than 1/4 inch in diameter providing a net open area not less than 10 percent of the surface.

2.8.7.2 System with total pressure of 4 Inch Water Gauge and Lower

Use sound attenuators only where indicated. Provide factory fabricated sound attenuators that are constructed of galvanized steel sheets. Provide attenuator with outer casing that is not less than 22 gauge. Provide fibrous glass acoustical fill. Provide net sound reduction indicated. Obtain values on a test unit not less than 24 by 24 inches outside dimensions made by a certified nationally recognized independent acoustical laboratory. Provide air flow capacity as indicated or required. Provide pressure drop through the attenuator that does not exceed the value indicated, or that is not in excess of 15 percent of the total external static pressure of the air handling system, whichever is less. Acoustically test attenuators with metal duct inlet and outlet sections while under the rated air flow conditions. Include with the noise reduction data the effects of flanking paths and vibration

transmission. Construct sound attenuators to be airtight when operating at the internal static pressure indicated or specified for the duct system, but in no case less than 2 inch water gauge.

2.8.8 Diffusers, Registers, and Grilles

Provide Diffusers, Registers and Grilles as indicated on the Diffuser, Register and Grille Schedule on the drawings. Provide factory-fabricated units of aluminum that distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 50 fpm in occupied zone, or dead spots anywhere in the conditioned area. Provide outlets for diffusion, spread, throw, and noise level as required for specified performance. Certify performance according to ASHRAE 70. Provide sound rated and certified inlets and outlets according to ASHRAE 70. Provide linear slot diffusers with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 7 feet above the floor, protect them by a grille or screen according to NFPA 90A.

2.8.8.1 Diffusers

Provide diffuser types indicated. Furnish ceiling mounted units with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Provide diffusers with air deflectors of the type indicated. Install ceiling mounted units with rims tight against ceiling. Provide sponge rubber gaskets between ceiling and surface mounted diffusers for air leakage control. Provide suitable trim for flush mounted diffusers. For connecting the duct to diffuser, provide duct collar that is airtight and does not interfere with volume controller. Provide return or exhaust units as indicated on the Diffuser, Register and Grille Schedule.

2.8.8.2 Registers and Grilles

Provide units that are four-way directional-control type, except provide return and exhaust registers that are fixed horizontal or vertical louver type similar in appearance to the supply register face. Furnish registers with sponge-rubber gasket between flanges and wall or ceiling. Install wall supply registers at least 6 inches below the ceiling unless otherwise indicated. Achieve four-way directional control by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes as indicated. Provide grilles as specified for registers, without volume control damper.

2.8.9 Louvers

Provide louvers for installation in exterior walls that are associated with the air supply and distribution system as specified in Section 08 91 00 METAL WALL LOUVERS.

2.8.10 Air Vents, Penthouses, and Goosenecks

Fabricate air vents, penthouses, and goosenecks from galvanized steel andodized aluminum alloy or stainless steel. sProvide sheet metal thickness, reinforcement, and fabrication that conform to SMACNA 1966. Accurately fit and secure louver blades to frames. Fold or bead edges of louver blades for rigidity and baffle these edges to exclude driving rain. Provide air vents, penthouses, and goosenecks with bird screen.

2.8.11 Bird Screens and Frames

Provide bird screens that conform to [ASTM E2016](#), No. 2 mesh, aluminum or stainless steel. Provide "medium-light" rated aluminum screens. Provide "light" rated stainless steel screens. Provide removable type frames fabricated from either stainless steel or extruded aluminum.

2.9 AIR SYSTEMS EQUIPMENT

2.9.1 Fans

Test and rate fans according to [AMCA 210](#). Calculate system effect on air moving devices in accordance with [AMCA 201](#) where installed ductwork differs from that indicated on drawings. Install air moving devices to minimize fan system effect. Where system effect is unavoidable, determine the most effective way to accommodate the inefficiencies caused by system effect on the installed air moving device. The sound power level of the fans must not exceed 85 dBA when tested according to [AMCA 300](#) and rated in accordance with [AMCA 301](#). Provide all fans with an AMCA seal. Connect fans to the motors either directly or indirectly with V-belt drive. Use V-belt drives designed for not less than 150 percent of the connected driving capacity. Provide variable pitch motor sheaves for [15 hp](#) and below, and fixed pitch as defined by [AHRI Guideline D](#) (A fixed-pitch sheave is provided on both the fan shaft and the motor shaft. This is a non-adjustable speed drive.). Select variable pitch sheaves to drive the fan at a speed which can produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, provide a replaceable sheave when needed to achieve system air balance. Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Provide sound power level as indicated. Obtain the sound power level values according to [AMCA 300](#). Provide standard AMCA arrangement, rotation, and discharge as indicated. Provide power ventilators that conform to [UL 705](#) and have a UL label.

2.9.1.1 Centrifugal Fans

Provide fully enclosed, single-width single-inlet, or double-width double-inlet centrifugal fans, with AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Provide impeller wheels that are rigidly constructed and accurately balanced both statically and dynamically. Provide forward curved or backward-inclined airfoil design fan blades in wheel sizes up to [30 inches](#). Provide backward-inclined airfoil design fan blades for wheels over [30 inches](#) in diameter. Provide fan wheels over [36 inches](#) in diameter with overhung pulleys and a bearing on each side of the wheel. Provide fan wheels [36 inches](#) or less in diameter that have one or more extra long bearings between the fan wheel and the drive. Provide sleeve type, self-aligning and self-oiling bearings with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Connect grease fittings to tubing for serviceability.

from a single accessible point. Provide L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide steel, accurately finished fan shafts, with key seats and keys for impeller hubs and fan pulleys. Provide fan outlets of ample proportions, designed for the attachment of angles and bolts for attaching flexible connections. Unless otherwise indicated, provide motors that do not exceed 1800 rpm and have totally enclosed or explosion-proof enclosures. Provide magnetic across-the-line type motor starters with general-purpose enclosures or as required for the installation.

2.9.1.2 In-Line Centrifugal Fans

Provide in-line fans with centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Mount fans in a welded tubular casing. Provide a fan that axially flows the air in and out. Streamline inlets with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Enclose and isolate fan bearings and drive shafts from the air stream. Provide precision, self aligning ball or roller type fan bearings that are sealed against dust and dirt and are permanently lubricated. Provide L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide motors with totally enclosed or explosion-proof enclosure as indicated. Provide magnetic motor starters across-the-line with general-purpose enclosures (or as required for the installation).

2.9.1.3 Centrifugal Type Power Wall Ventilators

Provide direct or V-belt driven centrifugal type fans with backward inclined, non-overloading wheel. Provide removable and weatherproof motor housing. Provide unit housing that is designed for sealing to building surface and for discharge and condensate drippage away from building surface. Construct housing of heavy gauge aluminum. Equip unit with an aluminum or plated steel wire discharge bird screen, disconnect switch, motor-operated damper, an airtight and liquid-tight metallic wall sleeve. Provide totally enclosed fan cooled or explosion-proof type motor enclosure as indicated. Use only lubricated bearings.

2.9.1.4 High Volume Low Velocity (HVLS) Fans

High Volume Low Speed (HVLS) or LVF (Low Velocity Fan) fans shall be provided as indicated on the drawings. HVLS fans shall be factory-assembled and tested horizontal, non-ducted fan unit, consisting of large diameter aluminum airfoil blade set, direct-drive electric motor with either a speed-reducing gearbox or variable speed motor controller. Fan shall be designed specifically to circulate large air volumes, vertically at low velocities. HVLS Fans shall be designed for a maximum operating space temperatures up to 122°F. Fan shall be provided with motor size, drive type, electrical characteristics (voltage/phase) as indicated on the drawing schedules. Fans shall be provided with manufacturer's wall mounted controller with integration capability to the building DDC control system. Manufacturer's controller shall provide on/off and variable speed control of the fan(s). Fan mounting system shall be provided by fan manufacturer as applicable to the installation with standard installation kit for attachment to I-beam and/or bar joists and optional available mounting hardware for installation on solid beams and purlins.

2.9.2 Coils

Provide fin-and-tube type coils constructed of seamless copper tubes and aluminum or copper fins mechanically bonded or soldered to the tubes. Provide copper tube wall thickness that is a minimum of 0.016 inches.. Provide copper fins that are 0.0045 inch minimum thickness. Provide casing and tube support sheets that are not lighter than 16 gauge galvanized steel, formed to provide structural strength. When required, provide multiple tube supports to prevent tube sag. Mount coils for counterflow service. Rate and certify coils to meet the requirements of AHRI 410. Provide factory applied phenolic, vinyl or epoxy/electrodeposition coating.

2.9.2.1 Water Coils

Install water coils with a pitch of not less than 1/8 inch/foot of the tube length toward the drain end. Use headers constructed of cast iron, welded steel or copper. Furnish each coil with a plugged vent and drain connection extending through the unit casing. Provide removable water coils with drain pans. Pressure test coils in accordance with UL 1995.

2.9.2.2 Eliminators

Equip each cooling coil having an air velocity of over 400 fpm through the net face area with moisture eliminators, unless the coil manufacturer guarantees, over the signature of a responsible company official, that no moisture can be carried beyond the drip pans under actual conditions of operation. Construct of minimum 24 gage zinc-coated steel or stainless steel, removable through the nearest access door in the casing or ductwork. Provide eliminators that have not less than two bends at 45 degrees and are spaced not more than 2-1/2 inches center-to-center on face. Provide each bend with an integrally formed hook as indicated in the SMACNA 1884.

2.9.2.3 Sprayed Coil Dehumidifiers

Provide assembly with reinforced, braced, and externally insulated galvanized steel casing, vertical in-line spray pump, bronze self-cleaning spray nozzles, galvanized steel pipe spray headers, adjustable float valve with replaceable neoprene seat, manufacturer's standard cooling coil, and welded black steel drain tank. Provide overflow drain, make-up, and bleed connection.

2.9.2.4 Corrosion Protection for Coastal Installations

Provide coils exposed to outdoor airstreams with copper tube/copper fin construction or immersion applied, baked phenolic or other approved coating that passes the 6000 hour salt spray resistance test using the ASTM B117 procedure. Manufacturer's standard "off-the-shelf" anti-corrosion options for "coastal" or "seacoast" installations that meet or exceed the ASTM B117 6000 hour requirements are acceptable. Field applied coatings are not acceptable. Coil capacities indicated on the plans and specifications shall be achieved by the coil with the protective coatings applied.

2.9.3 Air Filters

List air filters according to requirements of UL 900, except list high efficiency particulate air filters of 99.97 percent efficiency by the DOP

Test method under the Label Service to meet the requirements of [UL 586](#).

2.9.3.1 Extended Surface Pleated Panel Filters

Provide [2 inch](#) depth, sectional, disposable type filters of the size indicated with a MERV of 8 when tested according to [ASHRAE 52.2](#). Provide initial resistance at [500 fpm](#) that does not exceed [0.36 inches water gauge](#). Provide UL Class 2 filters, and nonwoven cotton and synthetic fiber mat media. Attach a wire support grid bonded to the media to a moisture resistant fiberboard frame. Bond all four edges of the filter media to the inside of the frame to prevent air bypass and increase rigidity.

2.9.3.2 Cartridge Type Filters

Provide [4 inch](#) depth, sectional, replaceable dry media type filters of the size indicated with a MERV of 13 when tested according to [ASHRAE 52.2](#). Provide initial resistance at [500 fpm](#) that does not exceed [0.65 inches, water gauge](#). Provide UL class 1 filters, and pleated microglass paper media with corrugated aluminum separators, sealed inside the filter cell to form a totally rigid filter assembly. Fluctuations in filter face velocity or turbulent airflow have no effect on filter integrity or performance. Install each filter with a [MERV 8](#) extended surface pleated media panel filter as a prefilter in a factory preassembled side access housing, or a factory-made sectional frame bank, as indicated.

2.9.3.3 Holding Frames

Fabricate frames from not lighter than [16 gauge](#) sheet steel with rust-inhibitor coating. Equip each holding frame with suitable filter holding devices. Provide gasketed holding frame seats. Make all joints airtight.

2.9.3.4 Filter Gauges

Provide dial type filter gauges, diaphragm actuated draft for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Provide gauges that are at least [3-7/8 inches](#) in diameter, with white dials with black figures, and graduated in [0.01 inch of water](#), with a minimum range of [1 inch of water](#) beyond the specified final resistance for the filter bank on which each gauge is applied. Provide each gauge with a screw operated zero adjustment and two static pressure taps with integral compression fittings, two molded plastic vent valves, two [5 foot](#) minimum lengths of [1/4 inch](#) diameter aluminum tubing, and all hardware and accessories for gauge mounting.

2.10 [AIR HANDLING UNITS](#)

2.10.1 Factory-Fabricated Air Handling Units

Provide single-zone draw-through type units as indicated. Units must include fans, coils, airtight insulated casing, prefilters, secondary filter sections, adjustable V-belt drives, belt guards for externally mounted motors, access sections where indicated, combination sectional filter-mixing box, vibration-isolators, and appurtenances required for specified operation. Provide vibration isolators as indicated. Physical dimensions of each air handling unit must be suitable to fit space allotted to the unit with the capacity indicated. Provide air handling unit that is rated in accordance with [AHRI 430](#) and AHRI certified for

cooling.

2.10.1.1 Casings

Provide the following:

- a. Casing sections 2 inch double wall type , constructed of a minimum 18 gauge corrosion-resisting sheet steel conforming to ASTM A167, Type 304 or ASTM A240/A240M, Type 201. Inner casing of double-wall units that are a minimum corrosion-resisting sheet steel conforming to ASTM A167, Type 304 or ASTM A240/A240M, Type 201. Design and construct casing with an integral insulated structural galvanized steel frame such that exterior panels are non-load bearing.
- b. Individually removable exterior panels with standard tools. Removal must not affect the structural integrity of the unit. Furnish casings with access sections, according to paragraph AIR HANDLING UNITS, inspection doors, and access doors, all capable of opening a minimum of 90 degrees, as indicated.
- c. Insulated, fully gasketed, double-wall type inspection and access doors, of a minimum 18 gauge outer and 20 gauge inner panels made of either galvanized steel or corrosion-resisting sheet steel conforming to ASTM A167, Type 304. Provide rigid doors with heavy duty hinges and latches. Inspection doors must be a minimum 12 inches wide by 12 inches high. Access doors must be a minimum 24 inches wide, the full height of the unit casing or a minimum of 6 foot, whichever is less.
- d. Double-wall insulated type drain pan (thickness equal to exterior casing) constructed of 16 gauge corrosion resisting sheet steel conforming to ASTM A167, Type 304 or or ASTM A240/A240M, Type 201, conforming to ASHRAE 62.1. Construct stainless steel drain pans water tight, treated to prevent corrosion, and designed for positive condensate drainage. When 2 or more cooling coils are used, with one stacked above the other, condensate from the upper coils must not flow across the face of lower coils. Provide intermediate drain pans or condensate collection channels and downspouts, as required to carry condensate to the unit drain pan out of the air stream and without moisture carryover. Construct drain pan to allow for easy visual inspection, including underneath the coil without removal of the coil and to allow complete and easy physical cleaning of the pan underneath the coil without removal of the coil. Provide coils that are individually removable from the casing.
- e. Casing insulation that conforms to NFPA 90A. Insulate single-wall casing sections handling conditioned air with not less than 1 inch thick, 1-1/2 pound density coated fibrous glass material having a thermal conductivity not greater than 0.23 Btu/hr-sf-F. Insulate double-wall casing sections handling conditioned air with not less than 2 inches of the same insulation specified for single-wall casings. Foil-faced insulation is not an acceptable substitute for use with double wall casing. Seal double wall insulation completely by inner and outer panels.
- f. Factory applied fibrous glass insulation that conforms to ASTM C1071, except that the minimum thickness and density requirements do not apply, and that meets the requirements of NFPA 90A. Make air handling unit casing insulation uniform over the entire casing. Foil-faced insulation is not an acceptable substitute for use on double-wall

access doors and inspections doors and casing sections.

- g. Duct liner material, coating, and adhesive that conforms to fire-hazard requirements specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Protect exposed insulation edges and joints where insulation panels are butted with a metal nosing strip or coat to meet erosion resistance requirements of ASTM C1071.
- h. A latched and hinged inspection door, in the fan and coil sections. Plus additional inspection doors, access doors and access sections where required for system maintenance and inspection.

2.10.1.2 Heating and Cooling Coils

Provide coils as specified in paragraph AIR SYSTEMS EQUIPMENT.

2.10.1.3 Ultraviolet Disinfection System for Chilled Water AHU Coils

Provide central station air handling units with an ultraviolet c-band (UVC) disinfection system for mold, bacteria and odor control in each air handler that has a chilled water coil. Irradiation-emitters and fixtures are to be installed in sufficient quantity and in such an arrangement so as to provide an equal distribution of UV energy on the coil and the drain pan. To maintain energy efficiency, the UVC energy produced shall be of the lowest possible reflected and shadowed losses. Energy Efficiency - Power supplies shall be of the high efficiency electronic type and matched to the emitter. Intensity - the minimum UV energy striking the leading edge (if installed upstream) or trailing edge (if installed downstream) of all the coil fins shall not be less than 820 $\mu\text{W}/\text{cm}^2$ at the closest point and through placement, not less than 60% of that value at the farthest point. Equal amounts are to strike the drain pan, either directly or indirectly through reflection. The foregoing sets the placement and minimum quantity of fixtures to be installed. Installation - emitters and fixtures shall be installed at right angles to the conforming lines of the coil fins, such that through incident angle reflection, UVC energy bathes all surfaces of the coil and drain pan as well as all of the available line of sight airstream. One complete set of spare bulbs shall be supplied.

2.10.1.4 Air Filters

Provide air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

2.10.1.5 Fans

Provide the following:

- a. Fans that are double-inlet, centrifugal type with each fan in a separate scroll. Dynamically balance fans and shafts prior to installation into air handling unit, then after it has been installed in the air handling unit, statically and dynamically balance the entire fan assembly. Mount fans on steel shafts, accurately ground and finished.
- b. Fan bearings that are sealed against dust and dirt and are precision self-aligning ball or roller type, with L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide bearings that are permanently lubricated or lubricated type with

lubrication fittings readily accessible at the drive side of the unit. Support bearings by structural shapes, or die formed sheet structural members, or support plates securely attached to the unit casing. Do not fasten bearings directly to the unit sheet metal casing. Furnish fans and scrolls with coating indicated.

- c. Fans that are driven by a unit-mounted, or a floor-mounted motor connected to fans by V-belt drive complete with belt guard for externally mounted motors. Furnish belt guards that are the three-sided enclosed type with solid or expanded metal face. Design belt drives for not less than a 1.3 service factor based on motor nameplate rating.
- d. Motor sheaves that are variable pitch for 25 hp and below and fixed pitch above 25 hp as defined by AHRI Guideline D. Where fixed sheaves are required, the use of variable pitch sheaves is allowed during air balance, but replace them with an appropriate fixed sheave after air balance is completed. Select variable pitch sheaves to drive the fan at a speed that produces the specified capacity when set at the approximate midpoint of the sheave adjustment. Furnish motors for V-belt drives with adjustable bases, and with enclosures as appropriate/recommended by the AHU manufacturer.
- e. Motor starters of magnetic type with enclosures as appropriate for the installed location. Select unit fan or fans to produce the required capacity at the fan static pressure with sound power level as indicated. Obtain the sound power level values according to AMCA 300, ASHRAE 68, or AHRI 260 I-P.

2.10.1.6 Access Sections and Filter/Mixing Boxes

Provide access sections where indicated and furnish with access doors as shown. Construct access sections and filter/mixing boxes in a manner identical to the remainder of the unit casing and equip with access doors. Design mixing boxes to minimize air stratification and to promote thorough mixing of the air streams.

2.11 TERMINAL UNITS

2.11.1 Variable Air Volume (VAV) Terminal Units

- a. Provide VAV and dual duct terminal units that are the type, size, and capacity shown, mounted in the ceiling or wall cavity, plus units that are suitable for single or dual duct system applications. Provide actuators and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. For each VAV terminal unit, provide a temperature sensor in the unit discharge ductwork.
- b. Provide unit enclosures that are constructed of galvanized steel not lighter than 22 gauge or aluminum sheet not lighter than 18 gauge. Provide single or multiple discharge outlets as required. Units with flow limiters are not acceptable. Provide unit air volume that is factory preset and readily field adjustable without special tools. Provide reheat coils as indicated.
- c. Attach a flow chart to each unit. Base acoustic performance of the terminal units upon units tested according to AHRI 880 I-P with the calculations prepared in accordance with AHRI 885. Provide sound power level as indicated. Show discharge sound power for minimum and

1-1/2 inches water gauge inlet static pressure. Provide acoustical lining according to NFPA 90A.

2.11.1.1 Constant Volume, Single Duct Terminal Units

Provide constant volume, single duct, terminal units that contain within the casing, a constant volume regulator. Provide volume regulators that control air delivery to within plus or minus 5 percent of specified air flow subjected to inlet pressure from 3/4 to 6 inch water gauge.

2.11.1.2 Variable Volume, Single Duct Terminal Units

Provide variable volume, single duct, terminal units with a calibrated air volume sensing device, air valve or damper, actuator, and accessory relays. Provide units that control air volume to within plus or minus 5 percent of each air set point volume as determined by the thermostat with variations in inlet pressures from 3/4 to 6 inch water gauge. Provide units with an internal resistance not exceeding 0.4 inch water gauge at maximum flow range. Provide external differential pressure taps separate from the control pressure taps for air flow measurement with a 0 to 1 inch water gauge range.

2.11.1.3 Reheat Units

2.11.1.3.1 Hot Water Coils

Provide fin-and-tube type hot-water coils constructed of seamless copper tubes and copper or aluminum fins mechanically bonded or soldered to the tubes. Provide headers that are constructed of cast iron, welded steel or copper. Provide casing and tube support sheets that are 16 gauge, galvanized steel, formed to provide structural strength. Provide tubes that are correctly circuited for proper water velocity without excessive pressure drop and are drainable where required or indicated. At the factory, test each coil at not less than 250 psi air pressure and provide coils suitable for 200 psi working pressure. Install drainable coils in the air handling units with a pitch of not less than 1/8 inch per foot of tube length toward the drain end. Coils must conform to the provisions of AHRI 410.

2.12 ENERGY RECOVERY DEVICES

2.12.1 Plate Heat Exchanger

Provide energy recovery ventilator unit that is factory-fabricated for indoor installation, consisting of a flat plate cross-flow heat exchanger, cooling coil, supply air fan and motor and exhaust air fan and motor. The casing must be 20 gauge G90, galvanized steel, double wall construction with one inch insulation. Provide fibrous desiccant cross-flow type heat exchanger core capable of easy removal from the unit.

2.13 FACTORY PAINTING

Factory paint new equipment, which are not of galvanized construction. Paint with a corrosion resisting paint finish according to ASTM A123/A123M or ASTM A924/A924M. Clean, phosphatize and coat internal and external ferrous metal surfaces with a paint finish which has been tested according to ASTM B117, ASTM D1654, and ASTM D3359. Submit evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors. Provide rating

of failure at the scribe mark that is not less than 6, average creepage not greater than $\frac{1}{8}$ inch. Provide rating of the inscribed area that is not less than 10, no failure. On units constructed of galvanized steel that have been welded, provide a final shop docket of zinc-rich protective paint on exterior surfaces of welds or welds that have burned through from the interior according to ASTM D520 Type I.

Field paint factory painting that has been damaged prior to acceptance by the Contracting Officer in compliance with the requirements of paragraph FIELD PAINTING OF MECHANICAL EQUIPMENT.

2.14 SUPPLEMENTAL COMPONENTS/SERVICES

2.14.1 Chilled, Condenser, or Dual Service Water Piping

The requirements for chilled, condenser, or dual service water piping and accessories are specified in Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS

2.14.2 Water Heating System Accessories

The requirements for water heating accessories such as expansion tanks are specified in Section 23 64 26 HYDRONIC CHILLED AND HOT WATER PIPING SYSTEMS

2.14.3 Condensate Drain Lines

Provide and install condensate drainage for each item of equipment that generates condensate in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE except as modified herein.

2.14.4 Backflow Preventers

The requirements for backflow preventers are specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.14.5 Insulation

The requirements for shop and field applied insulation are specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.14.6 Controls

The requirements for controls are specified in Section 23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS and Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- a. Install materials and equipment in accordance with the requirements of the contract drawings and approved manufacturer's installation

instructions. Accomplish installation by workers skilled in this type of work. Perform installation so that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors.

- b. No installation is permitted to block or otherwise impede access to any existing machine or system. Install all hinged doors to swing open a minimum of 120 degrees. Provide an area in front of all access doors that clears a minimum of **3 feet**. In front of all access doors to electrical circuits, clear the area the minimum distance to energized circuits as specified in OSHA Standards, part 1910.333 (Electrical-Safety Related work practices) and an additional **3 feet**.
- c. Except as otherwise indicated, install emergency switches and alarms in conspicuous locations. Mount all indicators, to include gauges, meters, and alarms in order to be easily visible by people in the area.

3.2.1 Condensate Drain Lines

Provide water seals in the condensate drain from all units . Provide a depth of each seal of **2 inches** plus **the number of inches, measured in water gauge**, of the total static pressure rating of the unit to which the drain is connected. Provide water seals that are constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Provide pipe cap or plug cleanouts where indicated. Connect drains indicated to connect to the sanitary waste system using an indirect waste fitting. Insulate air conditioner drain lines as specified in Section **23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS**.

3.2.2 Equipment and Installation

Provide frames and supports for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Floor mount or ceiling hang air handling units as indicated. Anchor and fasten as detailed. Set floor-mounted equipment on not less than **6 inch** concrete pads or curbs doweled in place unless otherwise indicated. Make concrete foundations heavy enough to minimize the intensity of the vibrations transmitted to the piping, duct work and the surrounding structure, as recommended in writing by the equipment manufacturer. In lieu of a concrete pad foundation, build a concrete pedestal block with isolators placed between the pedestal block and the floor. Make the concrete foundation or concrete pedestal block a mass not less than three times the weight of the components to be supported. Provide the lines connected to the pump mounted on pedestal blocks with flexible connectors. Submit foundation drawings as specified in paragraph **DETAIL DRAWINGS**. Provide concrete for foundations as specified in Section **03 47 13 TILT-UP CONCRETE**.

3.2.3 Access Panels

Install access panels for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance of sufficient size, and locate them so that the concealed items are easily serviced and maintained or completely removed and replaced. Provide access panels as specified in Section **08 31 00 ACCESS DOORS AND PANELS**.

3.2.4 Flexible Duct

Install pre-insulated flexible duct in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Provide

hangers, when required to suspend the duct, of the type recommended by the duct manufacturer and set at the intervals recommended.

3.2.5 Metal Ductwork

Install according to [SMACNA 1966](#) unless otherwise indicated. Install duct supports for sheet metal ductwork according to [SMACNA 1966](#), unless otherwise specified. Do not use friction beam clamps indicated in [SMACNA 1966](#). Anchor risers on high velocity ducts in the center of the vertical run to allow ends of riser to move due to thermal expansion. Erect supports on the risers that allow free vertical movement of the duct. Attach supports only to structural framing members and concrete slabs. Do not anchor supports to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, provide suitable intermediate metal framing. Where C-clamps are used, provide retainer clips.

3.2.6 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, perform temporary dust control protection. Protect the distribution system (supply and return) with temporary seal-offs at all inlets and outlets at the end of each day's work. Keep temporary protection in place until system is ready for startup.

3.2.7 Insulation

Provide thickness and application of insulation materials for ductwork, piping, and equipment according to Section [23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS](#). Externally insulate outdoor air intake ducts and plenums up to the point where the outdoor air reaches the conditioning unit.

3.2.8 Duct Test Holes

Provide holes with closures or threaded holes with plugs in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Plug insulated duct at the duct surface, patched over with insulation and then marked to indicate location of test hole if needed for future use.

3.2.9 Power Roof Ventilator Mounting

Provide foamed [1/2 inch](#) thick, closed-cell, flexible elastomer insulation to cover width of roof curb mounting flange. Where wood nailers are used, predrill holes for fasteners.

3.2.10 Power Transmission Components Adjustment

Test V-belts and sheaves for proper alignment and tension prior to operation and after 72 hours of operation at final speed. Uniformly load belts on drive side to prevent bouncing. Make alignment of direct driven couplings to within 50 percent of manufacturer's maximum allowable range of misalignment.

3.3 EQUIPMENT PADS

Provide equipment pads to the dimensions shown or, if not shown, to conform to the shape of each piece of equipment served with a minimum

3-inch margin around the equipment and supports. Allow equipment bases and foundations, when constructed of concrete or grout, to cure a minimum of 14 calendar days before being loaded.

3.4 CUTTING AND PATCHING

Install work in such a manner and at such time that a minimum of cutting and patching of the building structure is required. Make holes in exposed locations, in or through existing floors, by drilling and smooth by sanding. Use of a jackhammer is permitted only where specifically approved. Make holes through masonry walls to accommodate sleeves with an iron pipe masonry core saw.

3.5 CLEANING

Thoroughly clean surfaces of piping and equipment that have become covered with dirt, plaster, or other material during handling and construction before such surfaces are prepared for final finish painting or are enclosed within the building structure. Before final acceptance, clean mechanical equipment, including piping, ducting, and fixtures, and free from dirt, grease, and finger marks. Incorporate housekeeping for field construction work which leaves all furniture and equipment in the affected area free of construction generated dust and debris; and, all floor surfaces vacuum-swept clean.

3.6 PENETRATIONS

Provide sleeves and prepared openings for duct mains, branches, and other penetrating items, and install during the construction of the surface to be penetrated. Cut sleeves flush with each surface. Place sleeves for round duct 15 inches and smaller. Build framed, prepared openings for round duct larger than 15 inches and square, rectangular or oval ducts. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Provide one inch clearance between penetrating and penetrated surfaces except at grilles, registers, and diffusers. Pack spaces between sleeve or opening and duct or duct insulation with mineral fiber conforming with ASTM C553, Type 1, Class B-2.

3.6.1 Sleeves

Fabricate sleeves, except as otherwise specified or indicated, from 20 gauge thick mill galvanized sheet metal. Where sleeves are installed in bearing walls or partitions, provide black steel pipe conforming with ASTM A53/A53M, Schedule 20.

3.6.2 Framed Prepared Openings

Fabricate framed prepared openings from 20 gauge galvanized steel, unless otherwise indicated.

3.6.3 Insulation

Provide duct insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS continuous through sleeves and prepared openings except firewall penetrations. Terminate duct insulation at fire dampers and flexible connections. For duct handling air at or below 60 degrees F, provide insulation continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air.

3.6.4 Closure Collars

Provide closure collars of a minimum 4 inches wide, unless otherwise indicated, for exposed ducts and items on each side of penetrated surface, except where equipment is installed. Install collar tight against the surface and fit snugly around the duct or insulation. Grind sharp edges smooth to prevent damage to penetrating surface. Fabricate collars for round ducts 15 inches in diameter or less from 20 gauge galvanized steel. Fabricate collars for square and rectangular ducts, or round ducts with minimum dimension over 15 inches from 18 gauge galvanized steel. Fabricate collars for square and rectangular ducts with a maximum side of 15 inches or less from 20 gauge galvanized steel. Install collars with fasteners a maximum of 6 inches on center. Attach to collars a minimum of 4 fasteners where the opening is 12 inches in diameter or less, and a minimum of 8 fasteners where the opening is 20 inches in diameter or less.

3.6.5 Firestopping

Where ducts pass through fire-rated walls, fire partitions, and fire rated chase walls, seal the penetration with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING.

3.7 FIELD PAINTING OF MECHANICAL EQUIPMENT

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except clean to bare metal on metal surfaces subject to temperatures in excess of 120 degrees F. Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Provide aluminum or light gray finish coat.

3.7.1 Temperatures less than 120 degrees F

Immediately after cleaning, apply one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat to metal surfaces subject to temperatures less than 120 degrees F.

3.7.2 Temperatures between 120 and 400 degrees F

Apply two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of two mils to metal surfaces subject to temperatures between 120 and 400 degrees F.

3.7.3 Temperatures greater than 400 degrees F

Apply two coats of 315 degrees C 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of two mils to metal surfaces subject to temperatures greater than 400 degrees F.

3.8 IDENTIFICATION SYSTEMS

Provide identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number on all valves and dampers. Provide tags that are 1-3/8 inch minimum diameter

with stamped or engraved markings. Make indentations black for reading clarity. Attach tags to valves with No. 12 AWG 0.0808-inch diameter corrosion-resistant steel wire, copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.9 DUCTWORK LEAK TESTS

The requirements for ductwork leak tests are specified in Section 23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS.

3.10 DAMPER ACCEPTANCE TEST

Submit the proposed schedule, at least 2 weeks prior to the start of test. Operate all fire dampers and smoke dampers under normal operating conditions, prior to the occupancy of a building to determine that they function properly. Test each fire damper equipped with fusible link by having the fusible link cut in place. Test dynamic fire dampers with the air handling and distribution system running. Reset all fire dampers with the fusible links replaced after acceptance testing. To ensure optimum operation and performance, install the damper so it is square and free from racking.

3.11 TESTING, ADJUSTING, AND BALANCING

The requirements for testing, adjusting, and balancing are specified in Section 23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS. Begin testing, adjusting, and balancing only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.12 PERFORMANCE TESTS

Conduct performance tests as required in Section 23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS and Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

3.13 CLEANING AND ADJUSTING

Provide a temporary bypass for water coils to prevent flushing water from passing through coils. Inside of room fan-coil units and air terminal units thoroughly clean ducts, plenums, and casing of debris and blow free of small particles of rubbish and dust and then vacuum clean before installing outlet faces. Wipe equipment clean, with no traces of oil, dust, dirt, or paint spots. Provide temporary filters prior to startup of all fans that are operated during construction, and provide new filters after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. Perform and document that proper "Indoor Air Quality During Construction" procedures have been followed; provide documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. Maintain system in this clean condition until final acceptance. Properly lubricate bearings with oil or grease as recommended by the manufacturer. Tighten belts to proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions. Maintain all equipment installed under the contract until close out documentation is received, the project is completed and the building has been documented as beneficially occupied.

3.14 RADIANT PANELS

3.14.1 Installation

Install radiant panels level and plumb, maintaining sufficient clearance for normal services and maintenance.

3.14.2 Soldering

When soldering copper fittings at the panel, a heat pad will be used to protect the panel finish.

3.14.3 Connections

Install piping adjacent to radiant panels to allow for service and maintenance.

3.15 OPERATION AND MAINTENANCE

3.15.1 Operation and Maintenance Manuals

Submit six manuals at least 2 weeks prior to field training. Submit data complying with the requirements specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit Data Package 3 for the items/units listed under SD-10 Operation and Maintenance Data

3.15.2 Operation And Maintenance Training

Conduct a training course for the members of the operating staff as designated by the Contracting Officer. Make the training period consist of a total of 8 hours of normal working time and start it after all work specified herein is functionally completed and the Performance Tests have been approved. Conduct field instruction that covers all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations. Submit the proposed On-site Training schedule concurrently with the Operation and Maintenance Manuals and at least 14 days prior to conducting the training course.

-- End of Section --

SECTION 23 52 43.00 20

LOW PRESSURE WATER HEATING BOILERS (UNDER 800,000 BTU/HR OUTPUT)

05/15, CHG 2: 08/18

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.13/CSA 4.9 (2017; Errata 2018) Gas-Fired Low Pressure Steam and Hot Water Boilers

ASME INTERNATIONAL (ASME)

ASME BPVC SEC IV (2017) BPVC Section IV-Rules for Construction of Heating Boilers

ASME CSD-1 (2016) Control and Safety Devices for Automatically Fired Boilers

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M (2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS (NBBI)

NBBI NB-23 PART 1 (2013) National Board Inspection Code - Part 1 Installation

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 31 (2020) Standard for the Installation of Oil-Burning Equipment

NFPA 54 (2021) National Fuel Gas Code

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

NFPA 211 (2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

UNDERWRITERS LABORATORIES (UL)

UL 795 (2016; Reprint Sep 2020) UL Standard for

Safety Commercial-Industrial Gas Heating Equipment

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section, with the additions and modifications specified herein.

1.3 QUALITY ASSURANCE

Boiler shall be suitable for installation in the space shown with ample room for opening doors and cleaning and removal and replacement of tubes. The boiler shall bear the ASME "H" stamp for 160 psi working pressure and shall be National Board listed. The boiler shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.13/CSA 4.9 test standard for the U.S. and Canada. The boiler shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 - IP Standard and the minimum efficiency requirements of the latest edition of the BTS2000 Standard. The boiler shall be certified for indoor installation. The boiler's Thermal Efficiency shall be verified through third party testing by the Hydronics Institute Division of AHRI and listed in the AHRI Certification Directory.

1.4 DESIGN REQUIREMENTS

Boiler must be suitable for installation in the space shown with ample room for opening doors and cleaning and removal and replacement of tubes. Boiler must be designed and tested in accordance with ASME BPVC SEC IV, ASME CSD-1, NFPA 54, NFPA 31, NFPA 70 and ANSI Z21.13/CSA 4.9. Boiler must be installed in accordance with NBBI NB-23 PART 1. Paint boiler in accordance with manufacturer's recommendations. Boiler design working pressure must be 80 psig minimum.

1.4.1 Boiler Installation Requirements

1.4.1.1 Location

Install Boiler(s) and associated hot water pumps in a mechanical room inside the facility in accordance with NBBI NB-23 PART 1. Provide ample clearance around boilers to allow access for inspection, maintenance and repair. Passageways around all sides of boilers must have an unobstructed minimum width of 36 inches or the clearances recommended by the boiler manufacturer whichever is greater.

1.4.1.2 Combustion Air

Provide supply of air for combustion and ventilation. In accordance with NFPA 54, NFPA 211 and manufacturer's installation manual, calculate the amount of combustion air necessary to operate the boiler. Install and locate properly sized combustion air dampers and louvers.

1.4.1.3 Sequence of Operation

Local, manual starting of boilers is required. Remote starting and stopping of the boiler by the HVAC control system is not permitted. This is to ensure that an operator witness the initial firing of the boiler at the beginning of each heating season to verify proper operation of the boiler and to promote proper maintenance.

1.4.2 Detail Drawings

1.4.2.1 Drawings

Show boiler hot water isolation valves, emergency disconnect switch, and complete boiler gas train on the contract drawings.

1.4.2.2 Fuel Train / Wiring Diagram

Submit [fuel train](#) and [wiring diagram](#).

1.4.3 [Water Analysis](#)

Provide test reports of water analysis. UFC 3-240-13FN Industrial Water Treatment must be followed for all boiler installations.

1.5 SAFETY STANDARDS

Hot water boilers, burners and supplementary control devices, safety interlocks, or limit controls required under this specification, must meet requirements of the following standards as applicable:

- a. Gas-Fired Units: [ASME CSD-1](#), [NFPA 54](#), [NFPA 70](#), [ANSI Z21.13/CSA 4.9](#) or [UL 795](#).
- b. All Units: [ASME BPVC SEC IV](#), [NFPA 70](#) and [ASME CSD-1](#).

Controls not covered by the above must have a UL label, UL listing mark, or must be listed in the Factory Mutual Approval Guide.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section [01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES](#):

Submittals for this Section must be delivered to the project Contracting Officer, who will forward two complete sets of copies to the appropriate approving official for review and approval.

[SD-02 Shop Drawings](#)

[Fuel Train](#)

[Wiring Diagram](#)

[SD-03 Product Data](#)

[Boilers](#)

[Boiler Trim and Control Equipment](#)

[Burners and Control Equipment](#)

[SD-06 Test Reports](#)

Operational Tests

Water Analysis

SD-07 Certificates

Boilers

Burners and Control Equipment

Boiler Trim and Control Equipment

Boiler manufacturer's certificate of boiler performance including evidence that the burners provided must be a make, model, and type certified and approved by the manufacturer of the boiler being provided.

SD-08 Manufacturer's Instructions

Boilers

SD-10 Operation and Maintenance Data

Boilers, Data Package 4

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Posted Operating Instructions for Heating Water Boilers

PART 2 PRODUCTS

2.1 BOILERS

Provide hot water heating boiler complete with firing equipment, combustion chamber, insulation with steel jacket, safety and operating controls, integral electrical wiring and other appurtenances, to make the boiler a complete, self-contained, fully-automatic unit, ready for service upon completion of utility connections. Commercial boilers less than 300,000 Btuh must have an Annual Fuel Utilization Efficiency (AFUE) of at least 80 percent. Gas fired boilers greater than 300,000 Btuh input must have a thermal efficiency of at least 80 percent when fired at the maximum and minimum capacities which are provided and allowed by the controls.

2.1.1 General Requirements

Design, construction, installation, testing, and operation of boiler and appurtenances shall comply with NBBI NB-23 PART 1, ASME BPVC SEC IV, ASME CSD-1, NFPA 54, NFPA 31, ANSI Z21.13/CSA 4.9, and the manufacturer's instructions.

The boiler shall bear the ASME "H" stamp for 160 psi working pressure and shall be National Board listed. The boiler shall have a fully welded, stainless steel, water tube heat exchanger. Multiple pressure vessels in a single enclosure are not acceptable. There shall be no banding material, bolts, gaskets or "O" rings in the pressure vessel construction. The heat exchanger shall be designed for a single-pass water flow to limit the water

side pressure drop. Pressure drop shall be no greater than 2.2 psi at 75 GPM. The condensate collection basin shall be constructed of welded stainless steel. The complete heat exchanger assembly shall carry a ten (10) year limited warranty.

The heat exchanger shall have a volume of water no less than 0.88 gallons per 100MBH rated nominal input capacity.

The boiler shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.13 test standard for the U.S. and Canada. The boiler shall comply with the energy efficiency requirements of the latest edition of ASHRAE 90.1 and the minimum efficiency requirements of the latest edition of the AHRI BTS-2000 Standard as defined by the Department of Energy in 10 CFR Part 431. The boiler shall operate at a minimum of 97% Combustion and Thermal Efficiency at full fire as registered with AHRI. The boiler shall be certified for indoor installation.

The boiler shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. A burner/flame observation port shall be provided for observing the burner flame and combustion chamber. The burner shall be a premix design constructed of high temperature stainless steel with a woven Inconel outer covering to provide smooth operation at all modulating firing rates. The boiler shall be supplied with a negative pressure regulation gas valve and be equipped with a pulse width modulation blower system to precisely control the fuel/air mixture to the burner. The boiler shall operate in a safe condition with gas supply pressures as low as 4 inches of water column. The burner flame shall be ignited by direct spark ignition with flame monitoring via a flame sensor.

The boiler shall utilize a 24 VAC control circuit and components. The control system shall have a factory installed display for boiler set-up, boiler status, and boiler diagnostics. All components shall be easily accessed and serviceable from the front and top of the jacket. The boiler shall be equipped with a temperature/pressure gauge; high limit temperature control with manual reset; ASME certified pressure relief valve set for 50 psi (standard); outlet water temperature sensor with a dual thermistor to verify accuracy; system supply water temperature sensor; outdoor air sensor, flue temperature sensor with dual thermistor to verify accuracy; low water cut off with manual reset, blocked drain switch and a condensate trap for the heat exchanger condensate drain.

The boiler shall feature the touchpad control, standard and factory installed with an liquid crystal touch screen display, password security, outdoor air reset, pump delay with freeze protection, pump exercise, ramp delay featuring six steps, domestic hot water prioritization with limiting capabilities and PC port connection. The boiler shall have alarm contacts for any failure, runtime contacts and data logging of runtime at given modulation rates, ignition attempts and ignition failures. The boiler shall have a built-in master boiler cascading algorithm capability to sequence and rotate while maintaining modulation of up to eight boilers of different Btu inputs without utilization of an external controller. The internal cascading function shall be capable of lead-lag, efficiency optimization, front-end loading, and rotation of lead boiler every 24 hours. The control must include cascade redundancy to allow a member boiler to become the temporary leader if the original lead boiler shall lose communication with the members. The boiler shall be capable of controlling an isolation valve

during heating operation and rotation of open valves in standby operation for full flow applications. The control must be equipped with standard BACnet MSTP and Modbus communication protocol with a minimum 55 readable points. The boiler shall have a gateway device which will allow integration with BACnet (IP) protocol.

The manufacturer's controller shall include a communication platform that will allow remote access via a smart phone or Tablet. This shall allow the ability to monitor and manage multiple boilers and send alerts via text or e-mail notifying of changes in system status. A user shall have the ability to check system status or re-program any boiler function remotely.

The controller shall increase fan speed to boost flame signal when a weak flame signal is detected during normal operation. A 0 -10 VDC output signal shall control a variable speed boiler circulation pump to keep a fixed delta t across the boiler regardless of the modulation rate. The boiler shall have the capability to receive a 0 - 10 VDC input signal from a variable speed system pump to anticipate changes in system heat load in order to prevent flow related issues and erratic temperature cycling.

The boiler shall be equipped with two terminal strips for electrical connection. A low voltage connection board with 44 connection points for safety and operating controls, i.e., Alarm Contacts, Runtime Contacts, Louver Proving Switch, Tank Thermostat, Domestic Hot Water Building Recirculation Pump Contacts, Domestic Hot Water Building Recirculation Temperature Sensor Contacts, Remote Enable/Disable, System Supply Temperature Sensor, Outdoor Temperature Sensor, Tank Temperature Sensor, Modbus Building Management System Signal and Cascade Control Circuit. A high voltage terminal strip shall be provided for Supply voltage. Supply voltage shall be 120 volt / 60 hertz / single phase. The high voltage terminal strip plus integral relays are provided for independent pump control of the Boiler pump.

The boiler shall be installed and vented with a direct vent system with sidewall or roof termination as indicated on the plans for both the exhaust vent and combustion air intake. Exhaust vents shall be vertical discharge for environmental reasons (even with sidewall penetrations) - no rain caps. The flue shall be Category IV pre-engineered/pre-manufactured, UL Listed constructed of multi wall insulated Stainless Steel. A separate Combustion Air Intake (CAI) pipe shall supply combustion air directly to the boiler from the outside. CAI shall be of a material approved in the boiler manufacturer's installation and operations manual. The boiler's total combined air intake length and exhaust lengths shall not exceed manufacturer's allowances.

The boiler shall have an independent laboratory rating for Oxides of Nitrogen (NOx) to meet the requirements of South Coast Air Quality Management District in Southern California and the requirements of Texas Commission on Environmental Quality. The manufacturer shall verify proper operation of the burner, all controls and the integrity of the heat exchanger by connection to water and venting for a factory fire test prior to shipping.

2.2 BURNERS AND CONTROL EQUIPMENT

2.2.1 Gas-Fired Power Burner

Gas-fired power burner (over 400,000 BTU/hr input). Interrupted pilot type ignition system, and pilot must be the electrode-ignited natural gas

type. Design burner and combustion control equipment for firing natural gas having a specific gravity of 0.6 and a heating value of approximately 1000 BTU per cubic foot and be an integral part of the boiler. Burner controls and safety equipment must conform to applicable requirements of ASME CSD-1, NFPA 54, ANSI Z21.13/CSA 4.9 and UL 795. Mount controls; including operating switches, indicating lights, gages, alarms, motor starters, fuses, and circuit elements of control systems on a single control panel or cabinet designed for separate mounting not on the burner. The combustion control system must be the positioning or metering type. Locate flame scanner such that testing and cleaning of scanner can be accomplished without disassembly of burner. Provide fuel train as indicated.

2.3 BOILER TRIM AND CONTROL EQUIPMENT

Provide in accordance with ASME CSD-1 and ASME BPVC SEC IV and additional requirements specified below.

2.3.1 Emergency Disconnect Switch

Provide and locate on wall outside boiler room entrance or just inside door, when boiler room door is on building exterior as required by ASME CSD-1 to allow rapid and complete shutdown of the boiler in the event of an emergency. Emergency switch must be a 15 or 20-amp. fuse-type safety switch. Switch must be red and furnished with a label indicating function of switch.

2.3.2 Relief Valves

Provide relieving capacity for the full output of boiler installed. Safety relief-valve piping must conform to ASTM A53/A53M, schedule 40 steel pipe and be piped full-size to a floor drain .

2.3.3 Pressure and Altitude Gage or Combination Pressure/Altitude Gage

Provide one located on supply water piping and one on return water piping.

2.3.4 Thermometer

Provide thermometer with a scale equivalent to 1.5 times outlet water temperature. Provide one located on supply water piping and one on return water piping.

2.3.5 Drain Tapping

Provide drain valve and piping to a floor drain .

2.3.6 Make-up Water Station

2.3.6.1 Pressure Reducing Station

Provide a water pressure-reducing valve and relief valve, or a combination of the two in the makeup water line to the boiler to maintain a water pressure of 12 psig in the hot water system. Provide a 3/4 inch globe valve by-pass around this valve.

2.3.6.2 Backflow Preventers

Section 22 00 00 PLUMBING, GENERAL PURPOSE. Locate upstream of by-pass.

2.3.7 Combustion Regulator

Provide adjustable temperature, thermostatic immersion type that must limit boiler water temperature to a maximum of 250 degrees F. Control must actuate burner through an electric relay system to maintain boiler water temperature within normal prescribed limits at loads within rated capacity of boiler.

2.3.8 Air Vent Valve

Provide with screwed connection, stainless steel disk, and stainless steel seats to vent entrapped air.

2.3.9 High Temperature Limit Switch

Provide adjustable immersible aquastat type with a temperature setting above that of the combustion regulator and below that of the lowest relief valve setting. Aquastat must function to cause a safety shutdown by closing fuel valves, and shutting down burner equipment in the event that boiler water temperature rises to the high temperature limit setting. A safety shutdown due to high temperature must require manual reset before operation can resume and prevent recycling of burner equipment. Pre-set high temperature limit devices that cannot be easily tested are not allowed.

2.3.10 Low Water Level Cutoff Switch

Low water level cutoff must cause a safety shutdown by closing fuel valves, and shutting down burner equipment in the event that water level drops below the lowest safe permissible water level established by the boiler manufacturer and ASME BPVC SEC IV. A safety shutdown due to low water must require manual reset before operation can resume and prevent recycling of burner equipment.

2.3.11 Boiler Safety Control Circuits

Provide boiler safety control circuits, including control circuits for burner and draft fan, must be single-phase, two-wire one-side grounded, and not over 120 volts. Provide safety control switching in ungrounded conductors. Provide overcurrent protection. In addition to circuit grounds, ground metal parts which do not carry current to a grounding conductor.

2.3.12 Post-Combustion Purge

Provide controls and wiring necessary to ensure operation of draft fan for a period of not less than 15 seconds or of sufficient duration to provide four complete air changes in the boiler combustion chamber (whichever is greater) following shutdown of burner upon satisfaction of heat demand and in accordance with ASME CSD-1. Upon completion of post-combustion purge period, draft fan must automatically shutdown until next restart.

2.3.13 Draft

Comply with boiler manufacturer's recommendations.

2.4 ELECTRIC MOTORS

Electric motors must meet requirements of NEMA MG 1. Motors less than 1 hp must meet NEMA High Efficiency requirements. Motors 1 hp and larger must meet NEMA Premium Efficiency requirements. Motors which are an integral part of the packaged boiler system must be the highest efficiency available by the manufacturer of the packaged boiler. Motors must be variable speed.

PART 3 EXECUTION

3.1 EQUIPMENT INSTALLATION

Install equipment in accordance with manufacturer's installation instructions and NBBB NB-23 PART 1. Grout equipment mounted on concrete foundations before installing piping. Install piping in such a manner as not to place a strain on equipment. Do not bolt flanged joints tight unless they match. Grade, anchor, guide, and support piping without low pockets. Feedwater treatment feeders must be mounted so that the top of the feeder is no higher than 48 inches above the finished floor.

3.2 EQUIPMENT FOUNDATIONS

Locate equipment foundations as indicated, designed, and made of sufficient size and weight to preclude shifting of equipment under operating conditions or under abnormal conditions that could be imposed upon the equipment. Foundations must meet requirements of the equipment manufacturer. Concrete and grout must conform to Section 03 47 13 TILT-UP CONCRETE.

3.3 BOILER CLEANING

Before being placed in service, boiler must be boiled out for a period of 24 hours at a pressure not exceeding 12 psig. Solution to be used in the boiler for the boiling out process must consist of two pounds of trisodium phosphate per 100 gallons of water. Upon completion of boiling out, flush out boiler with potable water, drain, and charge with chemically treated water. Protect boiler and appurtenances against internal corrosion until testing is completed and boiler is accepted. Professional services are required for cleaning/treatment process.

3.4 FIELD QUALITY CONTROL

Perform and furnish everything required for inspections and tests as specified herein to demonstrate that boiler and auxiliary equipment, as installed, are in compliance with contract requirements. Start-up and operate the system. During this time, clean strainers until no further accumulation of foreign material occurs. Exercise care to minimize loss of water when strainers are cleaned. Adjust safety and automatic control instruments as necessary to place them in proper operation and sequence. Test instrumentation must be calibrated and have full scale readings from 1.5 to 2 times test values.

3.4.1 Operational Tests

Furnish the services of an engineer or technician approved by the boiler manufacturer of installation, startup, operational and safety testing. This person must remain on the job until each boiler has been successfully operated. Furnish and perform everything required for inspections and

tests of the boiler and auxiliary equipment. Test instrumentation must be calibrated and have full-scale reading from 1.5 to 2 times test values. Demonstrate proper operability of combustion control, flame safeguard control and safety interlocks. Provide a detailed description of all boiler startup and operational tests in the Commissioning Plan.

3.4.1.1 Preliminary Operational Test

Operate the boilers continuously for a period of at least 8 hours to demonstrate proper operability of the combustion control, flame safeguard control, and safety interlocks.

3.4.1.2 Acceptance Operational Test and Inspection

Prior to requesting an acceptance test, conduct a satisfactory operational test for at least 8 hours, and provide a certified statement that the equipment is installed per all requirements of this guide. Contracting Officer, upon receipt of the notice from the Contractor, will request a boiler inspection by a Naval Facilities Engineering and Expeditionary Warfare Center (EXWC) NAVFAC boiler inspector. Fifteen days advance notice is required for scheduling inspector to conduct acceptance operational test and inspection.

-- End of Section --

SECTION 23 64 10

WATER CHILLERS, VAPOR COMPRESSION TYPE
11/16

PART 1 GENERAL

1.1 REFERENCES

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

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 550/590 I-P (2015; ERTA 2016) Performance Rating Of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11 (2014) Load Ratings and Fatigue Life for Roller Bearings

ABMA 9 (2015) Load Ratings and Fatigue Life for Ball Bearings

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

ANSI/ASHRAE 15 & 34 (2016) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1 (2012) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A307 (2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength

ASTM B117 (2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM D520 (2000; R 2011) Zinc Dust Pigment

ASTM E84 (2020) Standard Test Method for Surface Burning Characteristics of Building Materials

ASTM F104 (2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2018) Motors and Generators

NEMA MG 11 (1977; R 2012) Energy Management Guide for
Selection and Use of Single Phase Motors

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

40 CFR 82 Protection of Stratospheric Ozone

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 25 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

Water Chiller; G

Verification of Dimensions

System Performance Tests

Demonstrations

Refrigerant

Water Chiller - Field Acceptance Test Plan

SD-06 Test Reports

Field Acceptance Testing

Water Chiller - Field Acceptance Test Report

System Performance Tests

SD-07 Certificates

Refrigeration System

Ozone Depleting Substances Technician Certification

SD-08 Manufacturer's Instructions

Water Chiller - Installation Instructions

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.3 CERTIFICATIONS

1.3.1 Ozone Depleting Substances Technician Certification

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.4 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.

1.5 DELIVERY, STORAGE, AND HANDLING

Stored items must be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation will be the Contractor's responsibility. Any materials found to be damaged must be replaced at the Contractor's expense. During installation, piping and similar openings must be capped to keep out dirt and other foreign matter.

1.6 PROJECT REQUIREMENTS

1.6.1 Verification of Dimensions

The Contractor must become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment will be standard Commercial cataloged products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. These products must have a two year record of satisfactory field service prior to bid opening. The two year record of service must include applications of equipment and materials under similar circumstances and of similar size. Products having less than a two year record of satisfactory field service will be acceptable if a certified record of satisfactory field service for not less than 6000 hours can be shown. The 6000 hour service record must not include any manufacturer's prototype or factory testing. Satisfactory field service must have been completed by a product that has been, and presently is being sold or offered for sale on the commercial market through the following copyrighted means: advertisements, manufacturer's catalogs, or brochures.

2.2 MANUFACTURER'S STANDARD NAMEPLATES

Nameplates are required on major components if the manufacturer needs to

provide specific engineering and manufacturing information pertaining to the particular component. Should replacement of this component be required, nameplate information will insure correct operation of the unit after replacement of this component. Plates shall be durable and legible throughout equipment life and made of non-corroding metal such as but not limited to nickel-copper, 304 stainless steel, or monel. Aluminum is unacceptable.

2.3 ELECTRICAL WORK

- a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.
- b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.
- c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.
- d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors must be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor enclosure type may be either TEAO or TEFC.
- e. Use adjustable frequency drives for all variable-speed motor applications. Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.
- f. Provide inverter duty premium efficiency motors for use with variable frequency drives.

2.4 SELF-CONTAINED WATER CHILLERS, VAPOR COMPRESSION TYPE

Unless necessary for delivery purposes, units must be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site by a factory representative. Unit components delivered separately must be sealed and charged with a nitrogen holding charge. Parts weighing 50 pounds or more which must be removed for inspection, cleaning, or repair, such as motors,

gear boxes, cylinder heads, casing tops, condenser, and cooler heads, must have lifting eyes or lugs. Chiller must be provided with a single point wiring connection for incoming power supply. Chiller's condenser and water cooler must be provided with standard water boxes with flanged connections.

2.4.1 Scroll or Rotary Screw Type

Chiller must be certified for performance per [AHRI 550/590 I-P](#). If specified performance is outside of the Application Rating Conditions of [AHRI 550/590 I-P](#), Table 2 then the chiller's performance must be rated in accordance with [AHRI 550/590 I-P](#). Chiller must conform to [ANSI/ASHRAE 15 & 34](#). As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

- a. Refrigerant and oil
- b. Structural base
- c. Chiller refrigerant circuit
- d. Controls package
- e. Scroll or rotary screw compressor
- f. Compressor driver, electric motor
- g. Compressor driver connection
- h. Water cooler (evaporator)
- i. Air-cooled condenser coil

2.5 CHILLER COMPONENTS

2.5.1 [Refrigerant](#) and Oil

Refrigerants must be one of the fluorocarbon gases. Refrigerants must have number designations and safety classifications in accordance with [ANSI/ASHRAE 15 & 34](#). CFC-based refrigerants are prohibited. Refrigerants must have an Ozone Depletion Potential (ODP) no greater than 0.0, with the exception of R-123. Provide SDS sheets for all refrigerants.

2.5.2 Structural Base

Chiller and individual chiller components must be provided with a factory-mounted structural steel base (welded or bolted) or support legs. Chiller and individual chiller components must be isolated from the building structure by means of vibration isolators with published load ratings. Vibration isolators must have isolation characteristics as recommended by the manufacturer for the unit supplied and the service intended.

2.5.3 Chiller Refrigerant Circuit

Chiller refrigerant circuit must be completely piped and factory leak tested in accordance with [ANSI/ASHRAE 15 & 34](#). For multicompressor units, not less than 2 independent refrigerant circuits must be provided. Circuit must include as a minimum a combination filter and drier,

combination sight glass and moisture indicator, an electronic or thermostatic expansion valve with external equalizer or float valve, charging ports, compressor service valves for field-serviceable compressors, and superheat adjustment.

2.5.4 Controls Package

Provide chillers with a complete factory-mounted, microprocessor based operating and safety control system. Controls package must contain as a minimum a digital display, an on-auto-off switch, motor starters, variable frequency motor controller, disconnect switches, power wiring, and control wiring. Controls package must provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and BAS interfaces as defined below.

2.5.4.1 Operating Controls

Chiller must be provided with the following adjustable operating controls as a minimum.

- a. Leaving chilled water temperature control
- b. Adjustable timer or automated controls to prevent a compressor from short cycling
- c. Automatic lead/lag controls (adjustable) for multi-compressor units
- d. Load limiting
- e. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls must automatically re-cycle the chiller on power interruption.
- f. Startup and head pressure controls to allow system operation at all ambient temperatures down to 20 degrees F.
- g. Fan sequencing for air-cooled condenser

2.5.4.2 Monitoring Capabilities

During normal operations, the control system must be capable of monitoring and displaying the following operating parameters. Access and operation of display must not require opening or removing any panels or doors.

- a. Entering and leaving chilled water temperatures
- b. Chilled water flow
- c. Self diagnostic
- d. Operation status
- e. Operating hours
- f. Number of starts
- g. Compressor status (on or off)
- h. Compressor load (percent)

- i. Refrigerant discharge and suction pressures
- j. Magnetic bearing levitation status (if applicable)
- k. Magnetic bearing temperatures (if applicable)
- l. Oil pressure

2.5.4.3 Configurable Setpoints

The control system must be capable of being configured directly at the unit's interface panel. No parameters may be capable of being changed without first entering a security access code. The programmable setpoints must include the following as a minimum:

- a. Leaving Chilled Water Temperature
- b. Time Clock/Calendar Date

2.5.4.4 Safety Controls with Manual Reset

Chiller must be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

- a. Low chilled water temperature protection
- b. High condenser refrigerant discharge pressure protection
- c. Low evaporator pressure protection
- d. Chilled water flow detection
- e. High motor winding temperature protection
- f. Low oil flow protection if applicable
- g. Magnetic bearing controller (MBC), Internal fault (if applicable)
- h. MBC, High bearing temperature (if applicable)
- i. MBC, Communication fault (if applicable)
- j. MBC, Power supply fault (if applicable)
- k. Motor current overload and phase loss protection

2.5.4.5 Safety Controls with Automatic Reset

Chiller must be provided with the following safety controls which automatically shutdown the chiller and which provide automatic reset.

- a. Over/under voltage protection
- b. Chilled water flow interlock
- c. MBC, Vibration (if applicable)
- d. MBC, No levitation (if applicable)

e. Phase reversal protection

2.5.4.6 Remote Alarm

During the initiation of a safety shutdown, a chiller's control system must be capable of activating a remote alarm bell. In coordination with the chiller, the Contractor must provide an alarm circuit (including transformer if applicable) and a minimum 4 inch diameter alarm bell. Alarm circuit must activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell must not sound for a chiller that uses low-pressure cutout as an operating control.

2.5.4.7 Utility Monitoring and Control System Interface

Provide a Utility Monitoring and Control System (UMCS) interface meeting the requirements of Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC. The interface must provide all system operating conditions, capacity controls, and safety shutdown conditions as network points. In addition, the following points must be overridable via the network interface:

- a. Unit Start/Stop
- b. Leaving Chilled Water Temperature Setpoint
- c. Leaving Condenser Water Temperature Setpoint

2.5.5 Compressor(s)

2.5.5.1 Scroll Compressor(s)

Compressors must be of the hermetically sealed design. Compressors must be mounted on vibration isolators to minimize vibration and noise. Rotating parts must be statically and dynamically balanced at the factory to minimize vibration. Lubrication system must be centrifugal pump type equipped with a means for determining oil level and an oil charging valve. Crankcase oil heater must be provided.

2.5.5.2 Rotary Screw Compressor(s)

Compressors must operate stably for indefinite time periods to at least 25 percent capacity reduction without gas bypass external to the compressor. Provision must be made to insure proper lubrication of bearings and shaft seals on shutdown with or without electric power supply. Rotary screw compressors must include:

- a. An open or hermetic, positive displacement, oil-injected design directly driven by the compressor driver. Allow access to internal compressor components for repairs, inspection, and replacement of parts.
- b. Rotors must be solid steel, possessing sufficient rigidity for proper operation.
- c. A maximum rotor operating speed no greater than 3600 RPM. Provide cast iron rotor housing.
- d. Casings of cast iron, precision machined for minimal clearance about

periphery of rotors with minimal clearance at rotor tops and rotor ends.

- e. A lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.
- f. Bearing housing must be conservatively loaded and rated for an L (10) life of not less than 200,000 hours. Shaft main bearings of the sleeve type with heavy duty bushings or rolling element type in accordance with ABMA 9 or ABMA 11.
- g. A differential oil pressure or flow cutout to allow the compressor to operate only when the required oil pressure or flow is provided to the bearings.
- h. Use a Variable Frequency Drive (VFD) to modulate capacity modulation from 100 percent to 15 percent.
- i. An oil separator and oil return system to remove oil entrained in the refrigerant gas and automatically return the oil to the compressor.
- j. Crankcase oil heaters must be provided.

2.5.6 Compressor Driver, Electric Motor

Components such as motors, starters, variable speed drives and wiring must be in accordance with paragraph ELECTRICAL WORK. Variable frequency drive must be unit mounted as indicated with variable frequency drive type, wiring, and accessories coordinated with the chiller manufacturer.

2.5.7 Compressor Driver Connections

Each compressor must be driven by a V-belt drive or direct connected through a flexible coupling, except that flexible coupling is not required on hermetic units. V-belt drives must be designed for not less than 150 percent of the driving motor capacity. Flexible couplings must be of the type that does not require lubrication.

2.5.8 Water Cooler (Evaporator)

Cooler must be of the shell-and-coil or shell-and-tube type design. Cooler shell must be constructed of seamless or welded steel. Coil bundles must be totally removable and arranged to drain completely. Tubes must be seamless copper, plain, integrally finned with smooth bore or integrally finned with enhanced bore. Each tube must be individually replaceable. Tubes must be installed into carbon mild steel tube sheets by rolling. Tube baffles must be properly spaced to provide adequate tube support and cross flow. Performance must be based on a water velocity not less than 3 fps nor more than 12 fps and a fouling factor per AHRI 550/590 I-P.

Brazed plate heat exchanger must be constructed of 304 or 316 stainless steel, designed to a refrigerant-side working pressure of 430 psig and a waterside working pressure of 150 psig. Evaporator must be factory tested at 1.1 times maximum allowable refrigerant side working pressure and 1.5 times maximum allowable water side working pressure. Provide cooler with factory-installed flow switches. All water connections must use either flanged or grooved-pipe connections. Factory insulate all cold surfaces.

2.5.9 Air-Cooled Condenser Coil

Condenser coil must be of the extended-surface fin-and-tube type and must be constructed of seamless copper or aluminum tubes with compatible copper or aluminum fins. Fins must be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils must be circuited and sized for a minimum of 5 degrees F subcooling and full pumpdown capacity. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34. The condenser coil must be of the microchannel heat exchanger technology (MCHX) type consisting of a series of flat tubes containing a series of multiple, parallel flow microchannels layered between the refrigerant manifolds in a two-pass arrangement. Provide coils constructed of aluminum alloys for fins, tubes, and manifolds. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34.

Coil must be entirely coated in accordance with the requirements of paragraph COIL CORROSION PROTECTION.

2.6 ACCESSORIES

2.6.1 Gaskets

Gaskets must conform to ASTM F104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 700 degrees F service.

2.6.2 Bolts and Nuts

Bolts and nuts, except as required for piping applications, must be in accordance with ASTM A307. The bolt head must be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A307.

2.7 FABRICATION

2.7.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish, except that items located outside of buildings must have weather resistant finishes that will withstand 6000 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.7.2 Factory Applied Insulation

Chiller must be provided with factory installed insulation on surfaces subject to sweating including the water cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it must be installed to provide easy removal and replacement of heads without damage to the insulation. Where motors are the gas-cooled type, factory installed insulation must be provided on the cold-gas inlet connection to the motor per manufacturer's standard practice. Factory insulated items installed outdoors are not required to

be fire-rated. As a minimum, factory insulated items installed indoors must have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes must be determined by [ASTM E84](#). Insulation must be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket must be tested as a composite material. Jackets, facings, and adhesives must have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with [ASTM E84](#).

2.7.3 Coil Corrosion Protection

Provide coil with a uniformly applied [electrophoretic epoxy](#) type coating to all coil surface areas without material bridging between fins. Submit product data on the type coating selected, the coating thickness, the application process used, the estimated heat transfer loss of the coil, and verification of conformance with the salt spray test requirement. Coating must be applied at either the coil or coating manufacturer's factory. Coating process must ensure complete coil encapsulation. Coating must be capable of withstanding a minimum [6,000](#) hours exposure to the salt spray test specified in [ASTM B117](#) using a 5 percent sodium chloride solution.

2.8 SUPPLEMENTAL COMPONENTS/SERVICES

2.8.1 Chilled and Condenser Water Piping and Accessories

Chilled and condenser water piping and accessories must be provided and installed in accordance with Section [23 64 26](#) CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.8.2 Temperature Controls

Chiller control packages must be fully coordinated with and integrated into the temperature control system indicated in Section [23 30 00](#) HVAC AIR DISTRIBUTION and Section [23 09 23.13 22](#) BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

PART 3 EXECUTION

3.1 INSTALLATION

Installation of [water chiller](#) systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing must be in accordance with the manufacturer's written installation instructions, including the following:

- (1) [Water chiller - installation instructions](#)

3.1.1 Installation Instructions

Provide manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show features such as materials, dimensions, options, performance and efficiency. Data must include manufacturer's recommended installation instructions and procedures. Data must be adequate to demonstrate

compliance with contract requirements.

3.1.2 Vibration Isolation

If vibration isolation is specified for a unit, vibration isolator literature must be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

3.1.3 Verification of Dimensions

Provide a letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

3.1.4 System Performance Test Schedules

Provide a schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules must identify the proposed date, time, and location for each test.

3.1.5 Certificates

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, proof of such compliance must be provided. The label or listing of the specified agency must be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above must be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

3.1.6 Operation and Maintenance Manuals

Provide Six complete copies of an operation manual in bound 8 1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. Six complete copies of maintenance manual in bound 8 1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.1.7 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and

other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.8 Refrigeration System

3.1.8.1 Equipment

Refrigeration equipment and the installation thereof must conform to **ANSI/ASHRAE 15 & 34**. Necessary supports must be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, water coolers, and similar items. Compressors must be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations must be provided. Each foundation must include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment must be set on not less than a **6 inch** concrete pad doweled in place. Concrete foundations for floor mounted pumps must have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block must be of mass not less than three times the combined pump, motor, and base weights. Isolators must be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Lines connected to pumps mounted on pedestal blocks must be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts must be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations must be as specified in Section **03 47 13 TILT-UP CONCRETE**. Equipment must be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.1.8.2 Field Refrigerant Charging

- a. Initial Charge: Upon completion of all the refrigerant pipe tests, the vacuum on the system must be broken by adding the required charge of dry refrigerant for which the system is designed, in accordance with the manufacturer's recommendations. Contractor must provide the complete charge of refrigerant in accordance with manufacturer's recommendations. Upon satisfactory completion of the system performance tests, any refrigerant that has been lost from the system must be replaced. After the system is fully operational, service valve seal caps and blanks over gauge points must be installed and tightened.
- b. Refrigerant Leakage: If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system must immediately be isolated from the remainder of the system and the refrigerant must be pumped into the system receiver or other suitable container. The refrigerant must not be discharged into the atmosphere.
- c. Contractor's Responsibility: The Contractor must, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps must include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time must more than

3 ounces of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year must be repaired in accordance with the specified requirements including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.1.8.3 Oil Charging

Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase must be furnished. One charge must be used during the performance testing period, and upon the satisfactory completion of the tests, the oil must be drained and replaced with the second charge.

3.1.9 Field Applied Insulation

Field installed insulation must be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.10 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.2 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative must be provided for 3 days. The representative shall advise on the following:

a. Hermetic machines:

- (1) Testing hermetic water-chilling unit under pressure for refrigerant leaks; evacuation and dehydration of machine to an absolute pressure of not over 300 micrometers.
- (2) Charging the machine with refrigerant.
- (3) Starting the machine.

b. Open Machines:

- (1) Erection, alignment, testing, and dehydrating.
- (2) Charging the machine with refrigerant.
- (3) Starting the machine.

3.3 CLEANING AND ADJUSTING

Equipment must be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Provide temporary filters for all fans that are operated during construction. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. System must be maintained in this clean condition until final acceptance. Bearings must be properly lubricated with oil or grease as recommended by the

manufacturer. Belts must be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment must be adjusted to setting indicated or directed. Fans must be adjusted to the speed indicated by the manufacturer to meet specified conditions. At least one week before the official equipment warranty start date, all condenser coils on air-cooled water chillers and split-system water chillers must be cleaned in accordance with the chiller manufacturer's instructions. This work covers two coil cleanings. The condenser coils must be cleaned with an approved coil cleaner by a service technician, factory trained by the chiller manufacturer. The condenser coil cleaner must not have any detrimental affect on the materials or protective coatings on the condenser coils. Testing, adjusting, and balancing must be as specified in Section 23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS.

3.4 FIELD ACCEPTANCE TESTING

3.4.1 Test Plans

- a. Manufacturer's Test Plans: Within 120 calendar days after contract award, submit the following plans:

- (1) Water chiller - Field Acceptance Test Plan

Field acceptance test plans must be developed by the chiller manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance tests of the chiller and subsequent test reporting.

- b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls for the equipment provided under Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.
 - c. Prerequisite testing: Chillers for which performance testing is dependent upon the completion of the work covered by Section 23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.
 - d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Each test plan must include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures must be structured to test the controls through all

modes of control to confirm that the controls are performing with the intended sequence of control.

Controller must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

- e. Performance variables: Each test plan must list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Chiller manufacturer must furnish with each test procedure a description of acceptable results that have been verified.

Chiller manufacturer must identify the acceptable limits or tolerance within which each tested performance variable must acceptably operate.

- f. Job specific: Each test plan must be job specific and must address the particular cooling towers and particular conditions which exist in this contract. Generic or general preprinted test procedures are not acceptable.
- g. Specialized components: Each test plan must include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.4.2 Testing

- a. Each water chiller system must be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:

- (1) [Water chiller - Field Acceptance Test Report](#)

- b. Manufacturer's recommended testing: Conduct the manufacturer's recommended field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.
- c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.
- d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.
- e. Report forms: Type data entries and writing on the test report

forms. Completed test report forms for each item of equipment must be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative must review, approve, and sign the report of the manufacturer's recommended test. Signatures must be accompanied by the person's name typed.

- f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

3.5 SYSTEM PERFORMANCE TESTS

Six copies of the report must be provided in bound 8 1/2 by 11 inch booklets.

3.5.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment must be conducted by the manufacturer's approved start-up representative experienced in system start-up and testing, at such times as directed. Tests must cover a period of not less than 48 hours for each system and must demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments must be made as necessary and tests must be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points must be installed and tightened. Any refrigerant lost during the system startup must be replaced. If tests do not demonstrate satisfactory system performance, deficiencies must be corrected and the system must be retested. Tests must be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test must be provided by the Contractor. Field tests must be coordinated with Section 23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS.

3.5.2 Test Report

The report must document compliance with the specified performance criteria upon completion and testing of the system. The report must indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report must also include the following information and must be taken at least three different times at outside dry-bulb temperatures that are at least 5 degrees F apart:

- a. Date and outside weather conditions.
- b. The load on the system based on the following:
 - (1) The refrigerant used in the system.
 - (2) Condensing temperature and pressure.
 - (3) Suction temperature and pressure.
 - (4) Running current, voltage and proper phase sequence for each phase of all motors.
 - (5) The actual on-site setting of all operating and safety controls.
 - (6) Chilled water pressure, flow and temperature in and out of the chiller.
 - (7) The position of the capacity-reduction gear at machine off,

one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

3.6 DEMONSTRATIONS

Contractor must conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total 8 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The training course must cover all of the items contained in the approved [operation and maintenance manuals](#) as well as demonstrations of routine maintenance operations.

Provide a schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

-- End of Section --

SECTION 23 64 26

HYDRONIC CHILLED AND HOT WATER PIPING SYSTEMS

08/09, CHG 5: 11/19

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.22/CSA 4.4 (2015; R 2020) Relief Valves for Hot Water Supply Systems

ASME INTERNATIONAL (ASME)

ASME B1.20.1 (2013; R 2018) Pipe Threads, General Purpose (Inch)

ASME B16.1 (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

ASME B16.3 (2016) Malleable Iron Threaded Fittings, Classes 150 and 300

ASME B16.9 (2018) Factory-Made Wrought Buttwelding Fittings

ASME B16.11 (2016) Forged Fittings, Socket-Welding and Threaded

ASME B16.18 (2018) Cast Copper Alloy Solder Joint Pressure Fittings

ASME B16.21 (2016) Nonmetallic Flat Gaskets for Pipe Flanges

ASME B16.22 (2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

ASME B16.26 (2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes

ASME B16.39 (2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300

ASME B31.9 (2017) Building Services Piping

ASME B40.100 (2013) Pressure Gauges and Gauge Attachments

ASME BPVC SEC IX (2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing

Qualifications

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

- ASSE 1003 (2009) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)
- ASSE 1017 (2009) Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems - (ANSI approved 2010)

AMERICAN WELDING SOCIETY (AWS)

- AWS A5.8/A5.8M (2019) Specification for Filler Metals for Brazing and Braze Welding
- AWS BRH (2007; 5th Ed) Brazing Handbook
- AWS D1.1/D1.1M (2020) Structural Welding Code - Steel
- AWS Z49.1 (2012) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

- ASTM A53/A53M (2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- ASTM A653/A653M (2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- ASTM A733 (2016) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
- ASTM B32 (2020) Standard Specification for Solder Metal
- ASTM B42 (2020) Standard Specification for Seamless Copper Pipe, Standard Sizes
- ASTM B62 (2017) Standard Specification for Composition Bronze or Ounce Metal Castings
- ASTM B75/B75M (2020) Standard Specification for Seamless Copper Tube
- ASTM B88 (2020) Standard Specification for Seamless Copper Water Tube
- ASTM B117 (2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM D2308	(2007; R 2013) Standard Specification for Thermoplastic Polyethylene Jacket for Electrical Wire and Cable
ASTM D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM F1199	(1988; R 2019) Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.2	(2014) Rotodynamic (Centrifugal) Pump for Nomenclature and Definitions

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 515	(2017) Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(2018) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-67	(2017; Errata 1 2017) Butterfly Valves
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check

Valves

MSS SP-85 (2011) Gray Iron Globe & Angle Valves
Flanged and Threaded Ends

MSS SP-110 (2010) Ball Valves Threaded,
Socket-Welding, Solder Joint, Grooved and
Flared Ends

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2018) Enclosures for Electrical Equipment
(1000 Volts Maximum)

NEMA MG 1 (2018) Motors and Generators

NEMA MG 11 (1977; R 2012) Energy Management Guide for
Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A (2021) Standard for the Installation of
Air Conditioning and Ventilating Systems

1.2 SYSTEM DESCRIPTION

Provide the water systems having the minimum service (design) temperature-pressure rating indicated. Provision of the piping systems, including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with the required and advisory provisions of ASME B31.9 except as modified or supplemented by this specification section or design drawings. This specification section covers the water systems piping which is located within, on, and adjacent to building(s) within the building(s) 5 foot line.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

Calibrated Balancing Valves

Water Temperature Mixing Valve

Water Temperature Regulating Valves

Water Pressure Reducing Valve

Pressure Relief Valve

Combination Pressure and Temperature Relief Valves

Expansion Joints

Pumps; G

Combination Strainer and Pump Suction Diffuser

Expansion Tanks

Air Separator Tanks

Electrical Heat Tracing

Water Treatment Systems

Proposed water treatment plan including a layout, control scheme, a list of existing make-up water conditions including the items listed in paragraph WATER ANALYSIS", a list of chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals.

SD-06 Test Reports

Piping Welds NDE Report

Pressure Tests Reports

Report shall be provided in bound 8-1/2 by 11 inch booklets. In the reports, document all phases of the tests performed. Include initial test summaries, all repairs/adjustments made, and the final test results.

SD-07 Certificates

Employer's Record Documents (For Welding)

Welding Procedures and Qualifications

Certificates shall be submitted showing conformance with the referenced standards contained in this section.

SD-08 Manufacturer's Instructions

Lesson plan for the Instruction Course

SD-10 Operation and Maintenance Data

Requirements for data packages are specified Section 01 78 23 OPERATION AND MAINTENANCE DATA, except as supplemented and modified by this specification section.

Submit spare parts data for each different item of equipment specified, with operation and maintenance data packages. Include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Submit a list of qualified permanent service organizations with operation and maintenance data packages. Include service

organization addresses and service area or expertise. The service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

Water Treatment Systems; G

An operation manual in bound 8-1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown. Include testing procedures used in determining water quality.

A maintenance manual in bound 8-1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide.

Calibrated Balancing Valves

Water Temperature Mixing Valve

Water Temperature Regulating Valves

Water Pressure Reducing Valve

Pressure Relief Valve

Combination Pressure and Temperature Relief Valves

Expansion Joints

Pumps

Combination Strainer and Pump Suction Diffuser

Expansion Tanks

Air Separator Tanks

1.4 MODIFICATIONS TO REFERENCES

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.4.1 Definitions

For the International Code Council (ICC) 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" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.5 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired.

1.6 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter. Any porous materials found to be contaminated with mold or mildew will be replaced at the Contractor's expense. Non-porous materials found to be contaminated with mold or mildew will be disinfected and cleaned prior to installation.

1.7 PROJECT/SITE CONDITIONS

1.7.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.7.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.7.3 Accessibility

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening.

The two year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures.

Products having less than a 2 year field service record shall be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. System components shall be environmentally suitable for the indicated locations.

The equipment items shall be supported by service organizations. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

2.2 STEEL PIPING

Water piping shall be steel pipe or copper tubing. Provide steel piping with a ANSI/ASME Class 125 service rating, which for 150 degrees F, the pressure rating is 175 psig.

2.2.1 Pipe

Steel pipe, conform to ASTM A53/A53M, Schedule 40, Type E or S, Grades A or B. Do not use Type F pipe.

2.2.2 Fittings and End Connections (Joints)

Piping and fittings 1 inch and smaller shall have threaded connections. Piping and fittings larger than 1 inch and smaller than 3 inches shall have either threaded, or welded connections. Piping and fittings 3 inches and larger shall have welded, or flanged connections. The manufacturer of each fitting shall be permanently identified on the body of the fitting in accordance with MSS SP-25.

2.2.2.1 Threaded Connections

Use threaded valves and pipe connections conforming to ASME B1.20.1. Used threaded fitting conforming to ASME B16.3. Use threaded unions conforming to ASME B16.39. Use threaded pipe nipples conforming to ASTM A733.

2.2.2.2 Flanged Connections

Flanges shall conform to ASME B16.1, Class 125. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type. These gaskets shall contain aramid fibers bonded with styrene butadiene rubber (SBR) or

nitrile butadiene rubber (NBR). Bolts, nuts, and bolt patterns shall conform to [ASME B16.1](#).

2.2.2.3 Welded Connections

Welded valves and pipe connections (both butt-welds and socket-welds types) shall conform to [ASME B31.9](#). Butt-welded fittings shall conform to [ASME B16.9](#). Socket-welded fittings shall conform to [ASME B16.11](#). Welded fittings shall be identified with the appropriate grade and marking symbol.

2.2.2.4 Dielectric Waterways and Flanges

Provide dielectric waterways with a water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint. When dry, insulation barrier shall be able to withstand a 600-volt breakdown test. Provide dielectric waterways constructed of galvanized steel and have threaded end connections to match connecting piping. Dielectric waterways shall be suitable for the required operating pressures and temperatures. Provide dielectric flanges with the same pressure ratings as standard flanges and provide complete electrical isolation between connecting pipe and/or equipment as described herein for dielectric waterways.

2.3 COPPER TUBING

Provide copper tubing and fittings with a ANSI/ASME Class 125 service rating, which for [150 degrees F.](#), the pressure rating is [175 psig](#).

2.3.1 Tube

Use copper tube conforming to [ASTM B88](#), Type L or M for aboveground tubing, and Type K for buried tubing.

2.3.2 Fittings and End Connections (Solder and Flared Joints)

Wrought copper and bronze solder joint pressure fittings, including unions and flanges, shall conform to [ASME B16.22](#) and [ASTM B75/B75M](#). Provide adapters as required. Cast copper alloy solder-joint pressure fittings, including unions and flanges, shall conform to [ASME B16.18](#). Cast copper alloy fittings for flared copper tube shall conform to [ASME B16.26](#) and [ASTM B62](#). [ASTM B42](#) copper pipe nipples with threaded end connections shall conform to [ASTM B42](#).

Copper tubing of sizes larger than [4 inches](#) shall have brazed joints. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

Extracted brazed tee joints may be used if produced with an acceptable tool and installed in accordance with tool manufacturer's written procedures.

2.3.3 Solder

Provide solder in conformance with [ASTM B32](#), grade Sb5, tin-antimony alloy. Solder flux shall be liquid or paste form, non-corrosive and conform to [ASTM B813](#).

2.3.4 Brazing Filler Metal

Filler metal shall conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type 3 flux, except Type BCuP-5 or BCuP-6 may be used for brazing copper-to-copper joints.

2.4 VALVES

Provide valves with a ANSI/ASME Class 125 service rating, which for 150 degrees F, the pressure rating is 175 psig.

Valves in sizes larger than 1 inch and used on steel pipe systems, may be provided with rigid grooved mechanical joint ends. Such grooved end valves shall be subject to the same requirements as rigid grooved mechanical joints and fittings and, shall be furnished by the same manufacturer as the grooved pipe joint and fitting system.

2.4.1 Gate Valve

Gate valves 2-1/2 inches and smaller shall conform to MSS SP-80 Class 125 and shall be bronze with wedge disc, rising stem and threaded, soldered, or flanged ends. Gate valves 3 inches and larger shall conform to MSS SP-70, Class 125, cast iron with bronze trim, outside screw and yoke, and flanged or threaded ends.

2.4.2 Globe and Angle Valve

Globe and angle valves 2-1/2 inches and smaller shall conform to MSS SP-80, Class 125. Globe and angle valves 3 inches and larger shall conform to MSS SP-85, Class 125.

2.4.3 Check Valve

Check valves 2-1/2 inches and smaller shall conform to MSS SP-80. Check valves 3 inches and larger shall conform to MSS SP-71, Class 125.

2.4.4 Butterfly Valve

Butterfly valves shall conform to MSS SP-67, Type 1 and shall be either the wafer or lug type. Valves smaller than 8 inches shall have throttling handles with a minimum of seven locking positions. Valves 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators.

2.4.5 Ball Valve

Full port design. Ball valves 1/2 inch and larger shall conform to MSS SP-72 or MSS SP-110 and shall be cast iron or bronze with threaded, soldered, or flanged ends. Valves 8 inches or larger shall be provided with manual gear operators with position indicators. Ball valves may be provided in lieu of gate valves.

2.4.6 Square Head Cocks

Provide copper alloy or cast-iron body with copper alloy plugs, suitable for 125 psig water working pressure.

2.4.7 Calibrated Balancing Valves

Copper alloy or cast iron body, copper alloy or stainless internal working parts. Provide valve calibrated so that flow can be determined when the temperature and pressure differential across valve is known. Balancing valves shall be sized based on anticipated flow rates of the equipment / location served for accurate calibration and flow measurement. Valve shall have an integral pointer which registers the degree of valve opening. Valve shall function as a service valve when in fully closed position. Valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation.

Provide valve bodies with tapped openings and pipe extensions with positive shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable differential pressure meter connections to verify the pressure differential. Provide metal tag on each valve showing the gallons per minute flow for each differential pressure reading.

2.4.8 Water Temperature Mixing Valve

Valve, ASSE 1017 for water service.

2.4.9 Water Temperature Regulating Valves

Provide copper alloy body, direct acting, pilot operated, for the intended service.

2.4.10 Water Pressure Reducing Valve

Valve, ASSE 1003 for water service, copper alloy body.

2.4.11 Pressure Relief Valve

Valve shall prevent excessive pressure in the piping system when the piping system reaches its maximum heat buildup. Valve, ANSI Z21.22/CSA 4.4 and shall have cast iron bodies with corrosion resistant internal working parts. The discharge pipe from the relief valve shall be the size of the valve outlet unless otherwise indicated.

2.4.12 Combination Pressure and Temperature Relief Valves

ANSI Z21.22/CSA 4.4, copper alloy body, automatic re-seating, test lever, and discharge capacity based on AGA temperature steam rating.

2.4.13 Drain Valves

Valves, MSS SP-80 gate valves. Valve shall be manually-operated, 3/4 inch pipe size and above with a threaded end connection. Provide valve with a water hose nipple adapter. Freeze-proof type valves shall be provided in installations exposed to freezing temperatures.

2.4.14 Air Venting Valves

Automatic type air venting shall be the ball-float type with brass/bronze or brass bodies, 300 series corrosion-resistant steel float, linkage and removable seat. Air venting valves on water coils shall have not less than 1/8 inch threaded end connections. Air venting valves on water mains shall have not less than 3/4 inch threaded end connections. Air venting

valves on all other applications shall have not less than 1/2 inch threaded end connections.

2.4.15 Vacuum Relief Valves

ANSI Z21.22/CSA 4.4

2.5 PIPING ACCESSORIES

2.5.1 Strainer

Strainer, ASTM F1199, except as modified and supplemented in this specification. Strainer shall be the cleanable, basket or "Y" type, the same size as the pipeline. Strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. Provide blowoff outlet with pipe nipple, gate valve, and discharge pipe nipple. The bodies shall have arrows clearly cast on the sides indicating the direction of flow.

Provide strainer with removable cover and sediment screen. The screen shall be made of minimum 22 gauge brass sheet, with small perforations numbering not less than 400 per square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

2.5.2 Cyclonic Separator

Metal- bodied, with removal capability of removing solids 45 microns/325 mesh in size and heavier than 1.20 specific gravity, maximum pressure drop of 5 psid, with cleanout connection.

2.5.3 Combination Strainer and Pump Suction Diffuser

Angle type body with removable strainer basket and internal straightening vanes, a suction pipe support, and a blowdown outlet and plug. Strainer shall be in accordance with ASTM F1199, except as modified and supplemented by this specification. Unit body shall have arrows clearly cast on the sides indicating the direction of flow.

Strainer screen shall be made of minimum 22 gauge brass sheet, with small perforations numbering not less than 400 per square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. Flow shall be into the screen and out through the perforations. Provide an auxiliary disposable fine mesh strainer which shall be removed 30 days after start-up. Provide warning tag for operator indicating scheduled date for removal.

Casing shall have connection sizes to match pump suction and pipe sizes, and be provided with adjustable support foot or support foot boss to relieve piping strains at pump suction. Provide unit casing with blowdown port and plug. Provide a magnetic insert to remove debris from system.

2.5.4 Flexible Pipe Connectors

Provide flexible bronze or stainless steel piping connectors with single braid. Equip flanged assemblies with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by

the manufacturer. Provide covers to protect the bellows where indicated.

2.5.5 Pressure and Vacuum Gauges

Gauges, ASME B40.100 with throttling type needle valve or a pulsation dampener and shut-off valve. Provide gauges with 4.5 inch dial, brass or aluminum case, bronze tube, and siphon. Gauge shall have a range from 0 psig to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.

2.5.6 Temperature Gauges

Temperature gauges, shall be the industrial duty type and be provided for the required temperature range. Provide gauges with fixed thread connection, dial face gasketed within the case; and an accuracy within 2 percent of scale range. Gauges shall have Fahrenheit scale in 2 degree graduations scale (black numbers) on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 5 feet of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 5 to 7 feet above the finished floor or in locations indicated. Remote element type temperature gauges shall be provided in thermal wells located 7 feet above the finished floor or in locations indicated.

2.5.6.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 9 inches long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.5.6.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 3-1/2 inches, stainless steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment.

2.5.6.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 3-1/2 inches, stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.5.6.4 Thermal Well

Thermal well shall be identical size, 1/2 or 3/4 inch NPT connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 1/2 inch NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Mercury shall not be used in thermometers. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 1 inch.

2.5.7 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, guides, and supports: to MSS SP-58 and MSS SP-69. If ferrous materials are utilized provide hot-dipped galvanized hangers,

inserts and supports.

2.5.8 Escutcheons

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Secure plates in place by internal spring tension or set screws. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

2.5.9 Expansion Joints

2.5.9.1 Flexible Loop Type

Provide flexible expansion loops of the size and type indicated on the drawings. Flexible loops shall consist of two flexible sections of hose and braid, two, 90 degree elbows, and an 180 degree return assembled in such a way that the piping does not change direction, but maintains its course along a single axis. Flexible loops shall have a factory supplied, center support nut located at the bottom of the 180 degree return, and a drain/air release plug. Flexible loops shall impart no thrust loads to system support anchors or building structure. Loops shall be installed in a neutral, pre-extended condition as required for the application. Install and guide in accordance with manufacturer's recommendations. Materials of construction and end fitting type shall be consistent with pipe material and equipment/pipe connections fittings. Braided hose section shall consist of carbon steel, copper or stainless steel ends, connecting braze or weldment, and connection shall be encased in a stress relieving weld collar. Hose shall be stainless steel or bronze flexible metallic hose encased in a stainless steel or bronze braid. Rubber hose materials are prohibited.

2.6 PUMPS

Pumps shall be the electrically driven, non-overloading, centrifugal type which conform to **HI 1.1-1.2**. Pumps shall be selected at or within 5 percent of peak efficiency. Pump curve shall rise continuously from maximum capacity to shutoff. Pump motor shall conform to **NEMA MG 1**, be totally enclosed, and have sufficient **horsepower** for the service required. Pump motor shall have the required capacity to prevent overloading with pump operating at any point on its characteristic curve. Pump speed shall not exceed 3,600 rpm, except where the pump head is less than **60 feet of water**, the pump speed shall not exceed 1,750 rpm. Pump motor shall be equipped with an across-the-line magnetic controller in a **NEMA 250**, Type 1 enclosure with "START-STOP" switch in the cover.

2.6.1 Construction

Each pump casing shall be designed to withstand the discharge head specified plus the static head on system plus 50 percent of the total, but not less than **125 psig**. Pump casing and bearing housing shall be close grained cast iron. High points in the casing shall be provided with manual air vents; low points shall be provided with drain plugs. Provide threaded suction and discharge pressure gage tapping with square-head plugs.

Impeller shall be statically and dynamically balanced. Impeller, impeller wearing rings, glands, casing wear rings, and shaft sleeve shall be bronze. Shaft shall be carbon or alloy steel, turned and ground.

Bearings shall be ball-bearings, roller-bearings, or oil-lubricated bronze-sleeve type bearings, and be efficiently sealed or isolated to prevent loss of oil or entrance of dirt or water.

Pump and motor shall be mounted on a common cast iron base having lipped edges and tapped drainage openings or structural steel base with lipped edges or drain pan and tapped drainage openings. Pump shall be provided with steel shaft coupling guard. Base-mounted pump, coupling guard, and motor shall each be bolted to a fabricated steel base which shall have bolt holes for securing base to supporting surface. Close-coupled pump shall be provided with integrally cast or fabricated steel feet with bolt holes for securing feet to supporting surface. Close-coupled pumps shall be provided with drip pockets and tapped openings. Pump shall be accessible for servicing without disturbing piping connections. Shaft seals shall be mechanical-seals or stuffing-box type.

2.6.2 Mechanical Shaft Seals

Seals shall be single, inside mounted, end-face-elastomer bellows type with stainless steel spring, brass or stainless steel seal head, carbon rotating face, and tungsten carbide or ceramic sealing face. Glands shall be bronze and of the water-flush design to provide lubrication flush across the face of the seal. Bypass line from pump discharge to flush connection in gland shall be provided, with filter or cyclone particle separator in line.

2.7 EXPANSION TANKS

Tank shall be welded steel, constructed for, and tested to pressure-temperature rating of 125 psi at 150 degrees F. Provide tanks precharged to the minimum operating pressure. Tank shall have polypropylene or butyl lined bladder which keeps the air charge separated from the water.

Tanks shall accommodate expanded water of the system generated within the normal operating temperature range, limiting this pressure increase at all components in the system to the maximum allowable pressure at those components. Each tank air chamber shall be fitted with a drain, fill, an air charging valve, and system connections. Tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The only air in the system shall be the permanent sealed-in air cushion contained within the expansion tank.

2.8 AIR SEPARATOR TANKS

External air separation tank shall be steel combination air and sediment separator with internal coalescing medium to remove entrained air and suspended solids. It shall be constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 125 psi. Provide inlet and outlet connections, flanged for sizes 2 1/2 inches and larger. Provide with automatic air release device and galvanized steel strainer. Provide a blow down connection with a gate valve and piped to nearest floor drain.

2.9 ELECTRICAL HEAT TRACING

Heat trace systems for pipes, valves, and fittings shall be in accordance with IEEE 515 and be UL listed. System shall include all necessary components, including heaters and controls to prevent freezing.

Provide self-regulating heaters consisting of two 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature along its length. Heater shall be able to be crossed over itself without overheating. Heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket in accordance with ASTM D2308.

Provide heater with self-regulating factor of at least 90 percent, in order to provide energy conservation and to prevent overheating.

Heater shall operate on line voltages of 120 volts single phase without the use of transformers.

Size Heat Tracing according to the following table:

Pipe Size (Inch, Diameter)	Minus 10 degrees F	Minus 20 degrees F
3 inches or less	5 watts per foot (wpf)	5 wpf
4 inch	5 wpf	8 wpf
6 inch	8 wpf	8 wpf
8 inch	10 wpf	10 wpf

System shall be controlled by an ambient sensing thermostat set at 40 degrees F either directly or through an appropriate contactor.

2.10 WATER TREATMENT SYSTEMS

When water treatment is specified, the use of chemical-treatment products containing equivalent chromium (CPR) is prohibited.

2.10.1 Hydronic Chilled and Heating Water

Water to be used in the chilled and heating water systems shall be treated to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the boiler, chiller and associated heating and cooling coils throughout the system(s). Chemicals shall meet all required federal, state, and local environmental regulations for the treatment of evaporator coils and direct discharge to the sanitary sewer.

2.10.2 Chilled and Heating Water Systems

A shot feeder shall be provided on the chilled water piping and on the hydronic heating piping as indicated. Size and capacity of feeder shall be based on local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.11 ELECTRICAL WORK

Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required

for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers including the required monitors and timed restart.

Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with [NEMA MG 11](#).

Provide polyphase, squirrel-cage medium induction motors, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with [NEMA MG 1](#). Provide motors in accordance with [NEMA MG 1](#) and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Use solid-state variable-speed controllers for motors rated [10 hp](#) or less and adjustable frequency drives for larger motors. Provide variable frequency drives for motors as specified in [Section 26 29 23](#) ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

2.12 PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

2.12.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided. The factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 500 hours in a salt-spray fog test.

Salt-spray fog test shall be in accordance with [ASTM B117](#), and for that test, the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of [0.125 inch](#) on either side of the scratch mark. The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen.

If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above [120 degrees F](#), the factory painting system shall be designed for the temperature service.

2.12.2 Shop Painting Systems for Metal Surfaces

Clean, retreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the

surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F shall be cleaned to bare metal.

Where hot-dip galvanized steel has been cut, resulting surfaces with no galvanizing shall be coated with a zinc-rich coating conforming to ASTM D520, Type I.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

- a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.
- b. Temperatures Between 120 and 400 degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.
- c. Temperatures Greater Than 400 degrees F: Metal surfaces subject to temperatures greater than 400 degrees F shall receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

2.13 FACTORY APPLIED INSULATION

Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 25 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E84.

Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.14 NAMEPLATES

Major equipment including pumps, pump motors, expansion tanks, and air separator tanks shall have the manufacturer's name, type or style, model or serial number on a plate secured to the item of equipment. The nameplate of the distributing agent will not be acceptable. Plates shall be durable and legible throughout equipment life and made of non-corroding metal such as but not limited to nickel-copper, 304 stainless steel, or monel. Aluminum is unacceptable. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.15 RELATED COMPONENTS/SERVICES

2.15.1 Drain and Make-Up Water Piping

Requirements for drain and make-up water piping and backflow preventer is specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.15.2 Field Applied Insulation

Requirements for field applied insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.15.3 Field Applied Insulation

Requirements for field installed insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as supplemented and modified by this specification section.

2.15.4 Field Painting

Requirements for painting of surfaces not otherwise specified, and finish painting of items only primed at the factory, are specified in Section 09 90 00 PAINTS AND COATINGS.

2.15.4.1 Color Coding

Requirements for color coding for piping identification are specified in Section 09 90 00 PAINTS AND COATINGS.

PART 3 EXECUTION

3.1 INSTALLATION

Cut pipe accurately to measurements established at the jobsite, and work into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation is not permitted without written approval. Cut pipe or tubing square, remove burrs by reaming, and fashion to permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.1 Welding

Provide welding work specified this section for piping systems in conformance with ASME B31.9, as modified and supplemented by this specification section and the accompanying drawings. The welding work includes: qualification of welding procedures, welders, welding operators, brazers, brazing operators, and nondestructive examination personnel; maintenance of welding records, and examination methods for welds.

3.1.1.1 Employer's Record Documents (For Welding)

Submit for review and approval the following documentation. This documentation and the subject qualifications shall be in compliance with [ASME B31.9](#).

- a. List of qualified welding procedures that is proposed to be used to provide the work specified in this specification section.
- b. List of qualified welders, brazers, welding operators, and brazing operators that are proposed to be used to provide the work specified in this specification section.
- c. List of qualified weld examination personnel that are proposed to be used to provide the work specified in this specification section.

3.1.1.2 Welding Procedures and Qualifications

- a. Specifications and Test Results: Submit copies of the welding procedures specifications and procedure qualification test results for each type of welding required. Approval of any procedure does not relieve the Contractor of the responsibility for producing acceptable welds. Submit this information on the forms printed in [ASME BPVC SEC IX](#) or their equivalent.
- b. Certification: Before assigning welders or welding operators to the work, submit a list of qualified welders, together with data and certification that each individual is performance qualified as specified. Do not start welding work prior to submitting welder, and welding operator qualifications. The certification shall state the type of welding and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

3.1.1.3 Examination of Piping Welds

Conduct non-destructive examinations (NDE) on piping welds and brazing and verify the work meets the acceptance criteria specified in [ASME B31.9](#). NDE on piping welds covered by [ASME B31.9](#) is visual inspection only. Submit a [piping welds NDE report](#) meeting the requirements specified in [ASME B31.9](#).

3.1.1.4 Welding Safety

Welding and cutting safety requirements shall be in accordance with [AWS Z49.1](#).

3.1.2 Directional Changes

Make changes in direction with fittings, except that bending of pipe [4 inches](#) and smaller is permitted, provided a pipe bender is used and wide weep bends are formed. Mitering or notching pipe or other similar construction to form elbows or tees is not permitted. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations is not acceptable.

3.1.3 Functional Requirements

Pitch horizontal supply mains down in the direction of flow as indicated. The grade shall not be less than **1 inch in 40 feet**. Reducing fittings shall be used for changes in pipe sizes. Cap or plug open ends of pipelines and equipment during installation to keep dirt or other foreign materials out of the system.

Pipe not otherwise specified shall be uncoated. Connections to appliances shall be made with malleable iron unions for steel pipe **2-1/2 inches** or less in diameter, and with flanges for pipe **3 inches** and above in diameter. Connections between ferrous and copper piping shall be electrically isolated from each other with dielectric waterways or flanges.

Piping located in air plenums shall conform to **NFPA 90A** requirements. Pipe and fittings installed in inaccessible conduits or trenches under concrete floor slabs shall be welded. Equipment and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance. Electric isolation fittings shall be provided between dissimilar metals.

3.1.4 Fittings and End Connections

3.1.4.1 Threaded Connections

Threaded connections shall be made with tapered threads and made tight with PTFE tape complying with **ASTM D3308** or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.4.2 Brazed Connections

Brazing, **AWS BRH**, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Do not use brazing flux. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Piping shall be supported prior to brazing and not be sprung or forced.

3.1.4.3 Welded Connections

Branch connections shall be made with welding tees or forged welding branch outlets. Pipe shall be thoroughly cleaned of all scale and foreign matter before the piping is assembled. During welding, the pipe and fittings shall be filled with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld shall conform to **ASME B31.9**. Weld defects shall be removed and rewelded at no additional cost to the Government. Electrodes shall be stored and dried in accordance with **AWS D1.1/D1.1M** or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.1.4.4 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the

flare while tightening the nut.

3.1.4.5 Flanges and Unions

Except where copper tubing is used, union or flanged joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Flanged joints shall be assembled square end tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for the intended application.

3.1.5 Valves

Isolation gate or ball valves shall be installed on each side of each piece of equipment, at the midpoint of all looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purpose. Isolation valves may be omitted where balancing cocks are installed to provide both balancing and isolation functions. Each valve except check valves shall be identified. Valves in horizontal lines shall be installed with stems horizontal or above.

3.1.6 Air Vents

Air vents shall be provided at all high points, on all water coils, and where indicated to ensure adequate venting of the piping system.

3.1.7 Drains

Drains shall be provided at all low points and where indicated to ensure complete drainage of the piping. Drains shall be accessible, and shall consist of nipples and caps or plugged tees unless otherwise indicated.

3.1.8 Flexible Pipe Connectors

Connectors shall be attached to components in strict accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the flexible pipe connector manufacturer and shall be provided at the intervals recommended.

3.1.9 Temperature Gauges

Temperature gauges shall be located on coolant supply and return piping at each heat exchanger, on condenser water piping entering and leaving a condenser, at each automatic temperature control device without an integral thermometer, and where indicated or required for proper operation of equipment. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 1 inch.

3.1.10 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as supplemented and modified in this specification section. Pipe hanger types 5, 12, and 26 shall not be used. Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.1.10.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.1.10.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.1.10.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued per [MSS SP-69](#) and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.1.10.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.1.10.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe [4 inches](#) and larger when the temperature of the medium is [60 degrees F](#) or higher. Type 40 shields shall be used on all piping less than [4 inches](#) and all piping [4 inches](#) and larger carrying medium less than [60 degrees F](#). A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping [2 inches](#) and larger.

3.1.10.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in [MSS SP-69](#) and a support shall be installed not over [1 foot](#) from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over [5 feet](#) apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of [50 pounds](#) shall have the excess hanger loads suspended from panel points.

3.1.10.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than [15 feet](#), not more than [8 feet](#) from end of risers, and at vent terminations.

3.1.10.8 Pipe Guides

Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.1.10.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral

movement, an alternate guide method may be used. On piping 4 inches and larger, a Type 39 saddle shall be used. On piping under 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.1.10.10 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.1.10.11 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material used for support shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.1.11 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 5 feet on each side of each expansion joint, and in lines 4 inches or smaller not more than 2 feet on each side of the joint.

3.1.12 Pipe Anchors

Anchors shall be provided where indicated. Unless indicated otherwise, anchors shall comply with the requirements specified. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required.

Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal.

3.1.13 Building Surface Penetrations

Sleeves shall not be installed in structural members except where indicated or approved. Except as indicated otherwise piping sleeves shall comply with requirements specified. Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A653/A653M, Coating Class G-90, 20 gauge. Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A53/A53M, Standard weight. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 1/2 inch depth. Sleeves shall not be installed in structural

members.

3.1.13.1 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be of such size as to provide a minimum of **1/4 inch** all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section **07 92 00** JOINT SEALANTS.

3.1.13.2 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a **.17 ounce** copper sleeve, or a **0.032 inch** thick aluminum sleeve, each within an integral skirt or flange.

Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than **8 inches** from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of **2 inches** above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

- a. Waterproofing Clamping Flange: Pipes up to and including **10 inches** in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.
- b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut.

After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.1.13.3 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section **07 84 00** FIRESTOPPING.

3.1.13.4 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.1.14 Access Panels

Access panels shall be provided where indicated for all concealed valves, vents, controls, and additionally for items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.2 ELECTRICAL INSTALLATION

Install electrical equipment in accordance with NFPA 70 and manufacturers instructions.

3.3 CLEANING AND ADJUSTING

Pipes shall be cleaned free of scale and thoroughly flushed of all foreign matter. A temporary bypass shall be provided for all water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from all water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed.

3.4 FIELD TESTS

Field tests shall be conducted in the presence of the QC Manager or his designated representative to verify systems compliance with specifications. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor.

3.4.1 Equipment and Component Isolation

Prior to testing, equipment and components that cannot withstand the tests shall be properly isolated.

3.4.2 Pressure Tests

Each piping system, except for polypropylene piping, shall be hydrostatically tested at a pressure not less than 188 psig for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Test pressure shall be monitored by a currently calibrated test pressure gauge. Leaks shall be repaired and piping retested until test requirements are met. No leakage or reduction in gage pressure shall be allowed.

Leaks shall be repaired by rewelding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping

shall be tested in place before concealing.

Submit for approval [pressure tests reports](#) covering the above specified piping pressure tests; describe the systems tested, test results, defects found and repaired, and signature of the pressure tests' director. Obtain approval from the QC Manager before concealing piping or applying insulation to tested and accepted piping.

3.4.3 Related Field Inspections and Testing

3.4.3.1 Piping Welds

Examination of Piping Welds is specified in the paragraph EXAMINATION OF PIPING WELDS (above).

3.4.3.2 HVAC TAB

Requirements for testing, adjusting, and balancing (TAB) of HVAC water piping, and associated equipment is specified in Section [23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS](#). Coordinate with the TAB team, and provide support personnel and equipment as specified in Section [23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING FOR MECHANICAL SYSTEMS](#) to assist TAB team to meet the TAB work requirements.

3.5 INSTRUCTION TO GOVERNMENT PERSONNEL

Furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the chilled water, [and hot water piping systems](#). Instructors shall be thoroughly familiar with all parts of the installation and shall be instructed in operating theory as well as practical operation and maintenance work. Submit a [lesson plan for the instruction course](#) for approval. The lesson plan and instruction course shall be based on the approved operation and maintenance data and maintenance manuals.

Conduct a training course for the operating staff and maintenance staff selected by the Contracting Officer. Give the instruction during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be one man-day.. Use approximately half of the time for classroom instruction and the other time for instruction at the location of equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

-- End of Section --

SECTION 23 81 00

DECENTRALIZED UNITARY HVAC EQUIPMENT
05/18

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section with the additions and modifications specified herein.

1.2 REFERENCES

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

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 340/360 I-P	(2015) Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
AHRI 700	(2016) Specifications for Fluorocarbon Refrigerants
ANSI/AHRI 210/240	(2008; Add 1 2011; Add 2 2012) Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment
ANSI/AHRI 460	(2005) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers

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

ANSI/ASHRAE 15 & 34	(2016) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 15 & 34	(2013) ASHRAE Standard 34-2016 Safety Standard for Refrigeration Systems/ASHRAE Standard 34-2016 Designation and Safety Classification of Refrigerants-ASHRAE Standard 34-2016
ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62.1	(2010) Ventilation for Acceptable Indoor Air Quality

ASHRAE 90.1 - IP	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASME INTERNATIONAL (ASME)	
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
AMERICAN WELDING SOCIETY (AWS)	
AWS Z49.1	(2012) Safety in Welding and Cutting and Allied Processes
ASTM INTERNATIONAL (ASTM)	
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)	
NEMA MG 1	(2018) Motors and Generators
NEMA MG 2	(2014) Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators
U.S. DEPARTMENT OF DEFENSE (DOD)	
MIL-DTL-5541	(2006; Rev F) Chemical Conversion Coatings on Aluminum and Aluminum Alloys
UNDERWRITERS LABORATORIES (UL)	
UL 1995	(2015) UL Standard for Safety Heating and Cooling Equipment

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

Spare Parts

Posted Instructions

Coil Corrosion Protection

System Performance Tests

Training

Inventory

Manufacturer's Standard Catalog Data

Dehumidifier

SD-06 Test Reports

Refrigerant Tests, Charging, and Start-Up

System Performance Tests

SD-07 Certificates

Service Organizations

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Ozone Depleting Substances; S

1.4 QUALITY ASSURANCE

Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions. Submit drawings consisting of:

- a. Equipment layouts which identify assembly and installation details.
- b. Plans and elevations which identify clearances required for maintenance and operation.
- c. Wiring diagrams which identify each component individually and interconnected or interlocked relationships between components.
- d. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for equipment indicated or required to have concrete foundations.
- e. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.
- f. Automatic temperature control diagrams and control sequences.

- g. Installation details which includes the amount of factory set superheat and corresponding refrigerant pressure/temperature.
- h. Equipment schedules

1.5 DELIVERY, STORAGE, AND HANDLING

Protect stored items from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Properly protect and care for all material both before and during installation. Submit an [inventory](#) of all the stored items. Replace any materials found to be damaged, at no additional cost to the Government. During installation, cap piping and similar openings capped to keep out dirt and other foreign matter.

1.6 ENVIRONMENTAL REQUIREMENTS

For proper Indoor Environmental Quality, maintain pressure within the building as indicated. Ventilation must meet or exceed [ASHRAE 62.1](#) and all published addenda. Meet or exceed filter media efficiency as tested in accordance with [ASHRAE 52.2](#).

1.7 WARRANTY

Provide equipment with the Manufacturer's Standard Warranty.

PART 2 PRODUCTS

2.1 MATERIALS

Provide [Manufacturer's standard catalog data](#) prior to the purchase or installation of a particular component, highlighted to show material, size, options, performance charts and curves, etc. in adequate detail to demonstrate compliance with contract requirements. Data includes manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, include vibration isolator literature containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations. Submit data for each specified component. Minimum efficiency requirements must be in accordance with [ASHRAE 90.1 - IP](#).

2.1.1 Standard Products

Provide materials and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products must have been in satisfactory commercial or industrial use for 2 years prior to request for proposal. The 2 year use includes applications of equipment and materials under similar circumstances and of similar size. The 2 years' experience must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products must be supported by a service organization. Ensure system components are environmentally suitable for the indicated geographic locations.

2.1.2 Product Sustainability Criteria

2.1.2.1 Energy Efficient Equipment

Provide equipment meeting the efficiency requirements as stated within this section and provide documentation in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN BUILD paragraph ENERGY EFFICIENT EQUIPMENT.

2.1.2.2 Electrical Equipment / Motors

Provide electrical equipment, motors, motor efficiencies, and wiring which are in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical motor driven equipment specified must be provided complete with motors, motor starters, and controls. Electrical characteristics must be as shown, and unless otherwise indicated, all motors of 1 horsepower and above with open, dripproof, totally enclosed, or explosion proof fan cooled enclosures, must be the premium efficiency type in accordance with NEMA MG 1. Field wiring must be in accordance with manufacturer's instructions. Each motor must conform to NEMA MG 1 and NEMA MG 2 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors must be continuous duty with the enclosure specified. Motor starters must be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors must be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors must be sized for the applicable loads. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings must be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, must be provided.

2.1.2.3 Ozone Depleting Substances

Unitary air conditioning equipment must not use CFC-based refrigerants. Refrigerant may be an approved alternative refrigerant in accordance with EPA's Significant New Alternative Policy (SNAP) listing. Provide documentation in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN BUILD paragraph OZONE DEPLETING SUBSTANCES.

2.1.3 Nameplates

Major equipment including compressors, condensers, receivers, heat exchanges, fans, and motors must have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates must be durable and legible throughout equipment life and made of nickel-copper, 304 stainless steel, or monel. Aluminum is unacceptable. Fix plates in prominent locations with nonferrous screws or bolts.

2.1.4 Safety Devices

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to

operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.

2.2 EQUIPMENT

2.2.1 Split-System Air Conditioners and Heat Pumps

2.2.1.1 Small-Capacity Split-System Air-Conditioners (Not Exceeding 65,000 Btu/hr)

Provide an air-cooled, split system which employs a remote condensing unit, a separate floor mounted, wall mounted, or ceiling mounted indoor unit (as scheduled and indicated on the plans), and interconnecting refrigerant piping. Provide the air conditioning or heat pump type unit (as scheduled) conforming to applicable Underwriters Laboratories (UL) standards including UL 1995. Unit must be rated in accordance with ANSI/AHRI 210/240 or AHRI 340/360 I-P. Provide indoor unit with necessary fans, air filters, and galvanized steel cabinet construction. The remote unit must be as specified in paragraph CONDENSING UNIT. Provide double-width, double inlet, forward curved backward inclined, or airfoil blade, centrifugal scroll type evaporator or supply fans. Provide the manufacturer's standard condenser or outdoor fans for the unit specified and may be either propeller or centrifugal scroll type. Fan and condenser motors must have totally enclosed enclosures. Design unit to operate at outdoor ambient temperatures up to 115 degrees F.

2.2.1.1.1 Energy Efficiency

Combination indoor-outdoor units must meet the minimum required efficiencies of ASHRAE 90.1.

2.2.1.1.2 Air-to-Refrigerant Coil

Provide condensing coils with copper or aluminum tubes of 3/8 inch minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Casing must be galvanized steel or aluminum. Avoid contact of dissimilar metals. Test coils in accordance with ASHRAE 15 & 34 at the factory and ensure suitability for the working pressure of the installed system. Dehydrate and seal each coil testing and prior to evaluation and charging.

Coat outdoor condenser coil with a uniformly applied epoxy electrodeposition, phenolic, or vinyl type coating to all coil surface areas without material bridging between fins. Apply coating at either the coil or coating manufacturer's factory. Coating process must ensure complete coil encapsulation and be capable of withstanding a minimum 6,000 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

2.2.1.1.3 Refrigeration Circuit

Refrigerant-containing components must comply with ASHRAE 15 & 34 and be factory tested, cleaned, dehydrated, charged, and sealed. Provide each unit with a factory operating charge of refrigerant and oil or a holding charge. Field charge unit shipped with a holding charge. Provide refrigerant charging valves. Provide filter-drier in liquid line to prevent freeze-up in event of loss of water flow during heating cycle.

2.2.1.1.4 Unit Controls

Provide unit internally prewired with a 24 volt control circuit powered by an internal transformer. Provide terminal blocks for power wiring and external control wiring. Internally protect unit by fuses or a circuit breaker in accordance with [UL 1995](#). Equip units with three-phase power with phase monitoring protection to protect against problems caused by phase loss, phase imbalance and phase reversal. Provide unit with microprocessor controls to provide all 24V control functions.

Controls must include a control system interface to a BACnet Control system. The control system interface, as well as any network between physically separate units, must meet the requirements of Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

2.2.1.1.5 Condensing Coil

Provide coils with nonferrous copper or aluminum tubes of [3/8 inch](#) minimum diameter with copper or aluminum fins that are mechanically bonded or soldered to the tubes. Protect coil in accordance with paragraph CORROSION PROTECTION. Provide galvanized steel or aluminum casing. Avoid contact of dissimilar metals. Test coils in accordance with [ANSI/ASHRAE 15 & 34](#) at the factory and ensure suitability for the working pressure of the installed system. Dehydrate and seal each coil after testing and prior to evaluation and charging. Provide separate expansion devices for each compressor circuit.

2.2.1.1.6 Remote Condenser or Condensing Unit

Fit each remote condenser coil fitted with a manual isolation valve and an access valve on the coil side. Saturated refrigerant condensing temperature must not exceed [120 degrees F](#) at [104 degrees F](#) ambient. Provide unit with low ambient condenser controls to ensure proper operation in an ambient temperature of [15degrees F](#). Provide fan and cabinet construction as specified in paragraph UNITARY EQUIPMENT ACCESSORIES. Fan and condenser motors must have totally enclosed enclosures. Condensing unit must have controls to initiate a refrigerant pump down cycle at system shut down on each refrigerant circuit.

2.2.1.1.6.1 Air-Cooled Condenser

Provide Unit in accordance with [ANSI/AHRI 460](#) and conform to the requirements of [UL 1995](#). Provide factory fabricated, tested, packaged, and self-contained unit; complete with casing, propeller or centrifugal type fans, heat rejection coils, connecting piping and wiring, and all necessary accessories.

2.2.1.1.7 Air Filters

Provide filters of the sectional or panel cleanable type that are capable of filtering the entire air supply. Mount filter(s) integral within the unit and make accessible.

2.2.1.1.8 Fans

Provide direct driven, statically and dynamically balanced, centrifugal or propeller type fans. Design the outdoor fan so that condensate will evaporate without drip, splash, or spray on building exterior. Provide

indoor fan with a minimum two-speed motor with built-in overload protection. Fan motors must be the inherently protected, permanent split-capacitor type.

2.2.2 Dehumidifier

Dehumidifier shall be as indicated on plans / drawing equipment schedules. Dehumidifier shall be permanently installed (not portable) with piped connection to drain system. Unit shall be provided with adjustable control to maintain humidity levels between 35% to 65% with automatic unit operation when space conditions are within 5% of the unit setpoint. Unit shall have integral defrost cycle to prevent frost formation on the unit - when frost is detected the unit shall cease dehumidifying operations and run the fan until normal operating conditions are restored. Unit shall be provided with replaceable MERV-13 filtration, provide with 2 extra filters at time of building acceptance.

2.3 COMPONENTS

2.3.1 Refrigerant and Oil

Refrigerant must be one of the fluorocarbon gases. Refrigerants must have number designations and safety classifications in accordance with ASHRAE 15 & 34. Refrigerants must meet the requirements of AHRI 700 as a minimum. Provide a complete charge of refrigerant for the installed system as recommended by the manufacturer. Lubricating oil must be of a type and grade recommended by the manufacturer for each compressor. Where color leak indicator dye is incorporated, charge must be in accordance with manufacturer's recommendation.

2.3.2 Condensate Drain Piping

Provide condensate drain piping in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.3.3 Ductwork

Provide ductwork in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.3.4 Temperature Controls

Temperature controls shall be in accordance with Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

2.4 FINISHES

2.4.1 Coil Corrosion Protection

Provide coil with a uniformly applied epoxy electrodeposition, phenolic, or vinyl type coating to all coil surface areas without material bridging between fins. Submit product data on the type coating selected, the coating thickness, the application process used, the estimated heat transfer loss of the coil, and verification of conformance with the salt spray test requirement. Coating must be applied at either the coil or coating manufacturer's factory. Coating process must ensure complete coil encapsulation. Coating must be capable of withstanding a minimum 6,000 hours exposure to the salt spray test specified in ASTM B117 using a 5

percent sodium chloride solution.

2.4.2 Equipment and Components Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish, except that items located outside of buildings must have weather resistant finishes that will withstand 6,000 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to ASTM D520, Type I.

Where stipulated in equipment specifications of this section, coat finned tube coils of the affected equipment as specified below. Apply coating at the premises of a company specializing in such work. Degrease and prepare for coating in accordance with the coating applicator's procedures for the type of metals involved. Completed coating must show no evidence of softening, blistering, cracking, crazing, flaking, loss of adhesion, or "bridging" between the fins.

2.4.2.1 Phenolic Coating

Provide a resin base thermosetting phenolic coating. Apply coating by immersion dipping of the entire coil. Provide a minimum of two coats. Bake or heat dry coils following immersions. After final immersion and prior to final baking, spray entire coil with particular emphasis given to building up coating on sheared edges. Total dry film thickness must be 2.5 to 3.0 mils.

2.4.2.2 Chemical Conversion Coating with Polyelastomer Finish Coat

Dip coils in a chemical conversion solution to molecularly deposit a corrosion resistant coating by electrolysis action. Chemical conversion coatings must conform to MIL-DTL-5541, Class 1A. Cure conversion coating at a temperature of 110 to 140 degrees F for a minimum of 3 hours. Coat coil surfaces with a complex polymer primer with a dry film thickness of 1 mil. Cure primer coat for a minimum of 1 hour. Using dip tank method, provide three coats of a complex polyelastomer finish coat. After each of the first two finish coats, cure the coils for 1 hour. Following the third coat, spray a fog coat of an inert sealer on the coil surfaces. Total dry film thickness must be 2.5 to 3.0 mils. Cure finish coat for a minimum of 3 hours. Coating materials must have 300 percent flexibility, operate in temperatures of minus 50 to plus 220 degrees F, and protect against atmospheres of a pH range of 1 to 14.

2.4.2.3 Vinyl Coating

Apply coating using an airless fog nozzle. For each coat, make at least two passes with the nozzle. Materials to be applied are as follows:

- a. Total dry film thickness, 6.5 mils maximum
- b. Vinyl Primer, 24 percent solids by volume: One coat 2 mils thick
- c. Vinyl Copolymer, 30 percent solids by volume: One coat 4.5 mils thick

2.4.3 Factory Applied Insulation

Refrigeration equipment must be provided with factory installed insulation on surfaces subject to sweating including the suction line piping. Where motors are the gas-cooled type, factory installed insulation must be provided on the cold-gas inlet connection to the motor in accordance with manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors must have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes must be determined by [ASTM E84](#). Insulation must be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket must be tested as a composite material. Jackets, facings, and adhesives must have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with [ASTM E84](#).

2.5 TESTS, INSPECTIONS, AND VERIFICATIONS

All manufactured units must be inspected and tested, and documentation provided to demonstrate that each unit is in compliance with ANSI/AHRI and UL requirements and that the minimum efficiency requirements of [ASHRAE 90.1 - IP](#) have been met.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform Verification of Dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Perform work in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. Where equipment is specified to conform to the requirements of [ASME BPVC SEC VIII D1](#) and [ASME BPVC SEC IX](#), the design, fabrication, and installation of the system must conform to [ASME BPVC SEC VIII D1](#) and [ASME BPVC SEC IX](#).

3.2.1 Equipment

Provide refrigeration equipment conforming to [ASHRAE 15 & 34](#). Provide necessary supports for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, and similar items. Isolate compressors from the building structure. Equipment must be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.2.2 Field Applied Insulation

Apply field applied insulation as specified in Section [23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS](#), except as defined differently herein.

3.2.3 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09 90 00 PAINTS AND COATINGS.

3.3 CLEANING AND ADJUSTING

Equipment must be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters must be provided for all fans that are operated during construction, and new filters must be installed after all construction dirt has been removed from the building. System must be maintained in this clean condition until final acceptance. Bearings must be properly lubricated with oil or grease as recommended by the manufacturer. Belts must be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment must be adjusted to setting indicated or directed. Fans must be adjusted to the speed indicated by the manufacturer to meet specified conditions. Testing, adjusting, and balancing must be as specified in Section 23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.4 TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total 4 hours of normal working time and start after the system is functionally completed but prior to final acceptance tests.

- a. Submit a schedule, at least 2 weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.
- b. Submit the field posted instructions, at least 2 weeks prior to construction completion, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions must include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The posted instructions must be framed under glass or laminated plastic and be posted where indicated by the Contracting Officer.
- c. The posted instructions must cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations. Submit 6 complete copies of an operation manual in bound 8-1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features.
- d. Submit 6 complete copies of maintenance manual in bound 8-1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.5 REFRIGERANT TESTS, CHARGING, AND START-UP

Split-system refrigerant piping systems must be tested and charged in accordance with the manufacturer's requirements. Packaged refrigerant systems which are factory charged must be checked for refrigerant and oil capacity to verify proper refrigerant levels in accordance with manufacturer's recommendations. Following charging, packaged systems must be tested for leaks with a halide torch or an electronic leak detector.

3.5.1 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system must immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. Under no circumstances must the refrigerant be discharged into the atmosphere.

3.5.2 Contractor's Responsibility

Take steps, at all times during the installation and testing of the refrigeration system, to prevent the release of refrigerants into the atmosphere. The steps must include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time must more than 3 ounces of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year must be repaired in accordance with the requirements herein at no cost to the Government including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.6 SYSTEM PERFORMANCE TESTS

Before each refrigeration system is accepted, conduct tests to demonstrate the general operating characteristics of all equipment by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Six copies of the report provided in bound 8-1/2 by 11 inch booklets. The report must document compliance with the specified performance criteria upon completion and testing of the system. The report must indicate the number of days covered by the tests and any conclusions as to the adequacy of the system.

For equipment providing heating and cooling the system performance tests must be performed during the heating and cooling seasons.

- a. Submit a schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules must identify the proposed date, time, and location for each test. Tests must cover a period of not less than 48 hours for each system and must demonstrate that the entire system is functioning in accordance with the drawings and specifications.
- b. Make corrections and adjustments, as necessary, tests must be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, install and tighten service valve seal caps and blanks over gauge points. Replace any refrigerant lost

during the system startup.

- c. If tests do not demonstrate satisfactory system performance, correct deficiencies and retest the system. Conduct tests in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Provide all material, equipment, instruments, and personnel required for the test.
- d. Coordinate field tests with Section 23 05 93.00 22 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Submit 6 copies of the report provided in bound 8-1/2 by 11 inch booklets. The report must document compliance with the specified performance criteria upon completion and testing of the system. The report must indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. Submit the report including the following information (where values are taken at least three different times at outside dry-bulb temperatures that are at least 5 degrees F apart):

- (1) Date and outside weather conditions.
- (2) The load on the system based on the following:
 - (a) The refrigerant used in the system.
 - (b) Condensing temperature and pressure.
 - (c) Suction temperature and pressure.
 - (d) Ambient, condensing and coolant temperatures.
 - (e) Running current, voltage and proper phase sequence for each phase of all motors.
- (3) The actual on-site setting of operating and safety controls.
- (4) Thermostatic expansion valve superheat - value as determined by field test.
- (5) Subcooling.
- (6) High and low refrigerant temperature switch set-points
- (7) Low oil pressure switch set-point.
- (8) Defrost system timer and thermostat set-points.
- (9) Moisture content.
- (10) Capacity control set-points.
- (11) Field data and adjustments which affect unit performance and energy consumption.
- (12) Field adjustments and settings which were not permanently marked as an integral part of a device.

3.7 MAINTENANCE

3.7.1 EXTRA MATERIALS

Submit spare parts data for each different item of equipment specified, after approval of detail drawings and not later than 2 months prior to the date of beneficial occupancy. Include in the data a complete list of

parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

3.7.2 Maintenance Service

Submit a certified list of qualified permanent [service organizations](#), which includes their addresses and qualifications, for support of the equipment. The service organizations must be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

-- End of Section --

SECTION 23 81 23

COMPUTER ROOM AIR CONDITIONING UNITS

11/20

PART 1 GENERAL

1.1 REFERENCES

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

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

- ASHRAE 52.2 (2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
- ASHRAE 90.1 - IP (2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
- ASHRAE 127 (2012) Method of Testing for Rating Computer and Data Processing Room Unitary Air-Conditioners

ASME INTERNATIONAL (ASME)

- ASME B31.1 (2020) Power Piping
- ASME B31.5 (2020) Refrigeration Piping and Heat Transfer Components

ASTM INTERNATIONAL (ASTM)

- ASTM B117 (2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

ETL TESTING LABORATORIES (ETL)

- ETL DLP (updated continuously) ETL Listed Mark Directory

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

- UL Elec Equip Dir (2011) Electrical Appliance and Utilization Equipment Directory

1.2 DEFINITIONS

Computer Room Air Conditioner (CRAC): A single, self-contained unit

or split-system unit designed and manufactured specifically for temperature and humidity control of data processing environments.

Cold Aisle: The aisle between or adjacent to rows of racks from which the computing equipment draws cool air.

Hot Aisle: The aisle between or adjacent to rows of racks to which the computing equipment ejects hot air.

Rack: Telecommunications support frame that can consist of post-and-frame or full cabinet construction. Racks are provided under Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

Computer Room Air Conditioner; G

Space Temperature Control System Drawings

Filters

Refrigerants

Leak Detection; G

SD-06 Test Reports

Field Test Schedule

Manufacturer's Field Test Plans

Field Test Reports

SD-08 Manufacturer's Instructions

Installation Manual for Each Type of CRAC

SD-10 Operation and Maintenance Data

Computer Room Air Conditioner Operation and Maintenance Data

SD-11 Closeout Submittals

Indoor Air Quality During Construction

1.4 REFRIGERANTS

Refrigerants must have an Ozone Depletion Potential (ODP) no greater than 0.0. CFC-based refrigerants are prohibited. HCFCs and Halons are not

permitted. Provide SDS sheets for all refrigerants.

1.5 QUALIFICATIONS

1.6 QUALIFICATIONS

1.6.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design, and workmanship. Standard products must have been in satisfactory commercial or industrial use for two years prior to bid opening. The two-year use must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the two-year period.

1.6.2 Alternative Equipment Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.6.3 Service Support

The equipment items must be supported by service organizations. These service organizations must be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6.4 Manufacturer's Nameplate

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

1.6.5 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.6.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions must be considered mandatory, the word "should" is interpreted as "must." Reference to the "code official" must be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" must be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" must be interpreted to mean the "lessor." References to the "permit holder" must be interpreted to mean the "Contractor."

1.6.5.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, must be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.7 PROJECT REQUIREMENTS

1.7.1 Verification of Dimensions

Become familiar with the details of the work, verify all dimensions in the field, and provide adequate clearance for all connections and service access. Notify the Contracting Officer of any discrepancy before performing any work.

1.7.2 Energy Efficiency

Provide equipment with minimum efficiencies as required by [ASHRAE 90.1 - IP](#).

1.8 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

PART 2 PRODUCTS

2.1 [COMPUTER ROOM AIR CONDITIONER](#) (CRAC)

Provide complete working CRACs, designed, and factory assembled, and factory tested. Equipment must be listed in [UL Elec Equip Dir](#) or [ETL DLP](#) for computer room application. CRACs must have a minimum sensible coefficient of performance ([NSenCOP W/W](#) of [11](#) in accordance with [ASHRAE 127](#). CRACs must include room cabinet and frame, floor stand, fan section, filter section, cooling coil, reheat coil, humidifier, controls, and, interconnecting piping internal to the CRAC.

2.1.1 Unit Airflow Configuration

2.1.1.1 Downflow Units

The CRAC must draw return air in at the top of the cabinet and discharge supply air at the bottom of the cabinet.

2.1.2 Cabinet and Frame

2.1.2.1 Unit Frame

Unit frame must be manufactured of welded steel tubes and must be mill-galvanized or coated with an epoxy finish.

2.1.2.2 Unit Cabinet

Exterior panels must be steel sheet, minimum of 20 gage, mill-galvanized or coated with a corrosion-inhibiting epoxy finish in manufacturer's standard color. Mill galvanized sheet metal must be coated with not less than 1.25 ounces of zinc per square foot of two-sided surface. Mill rolled structural steel must be hot-dip galvanized or primed and painted. Cut edges, burns and scratches in hot-dip galvanized surfaces must be coated with galvanizing repair coating. Manufacturer's standard cabinet materials and finishes will be acceptable if equivalent to the above requirements and approved by the Contracting Officer.

Provide removable panel for access to controls without interrupting airflow. Panels must be gasketed to prevent air leakage under system operating pressure and must be removable for service access without the use of special tools.

2.1.3 Fan Section

Electrically Commutated (EC) Fans shall be plug type, integral direct driven fan with backward curved blades and Electronically Commutated DC motors. Units exceeding 6 tons total capacity shall be provided with two or more fans. The fan speed shall be a variable and automatically regulated by the unit controls through all modes of operation. The impeller shall be made of composite material and dynamically balanced. The fan shall be located to draw air through the coil to ensure even distribution and maximum coil performance.

In downflow applications the fans shall be located below the V-Frame coil in the casing of the unit, or be lowered into the raised floor environment when installed on a floorstand of at least 24" height.

2.1.4 Cooling Coil

Provide coil and slope for drainage. Coil must be manufactured of seamless copper tubes with plate aluminum or copper fins. Each coil, in the production process, must be individually tested at 320 psi with compressed air under water and verified to be air tight. Factory dehydrate and seal each coil after testing and prior to evaluation and charging. Provide hydronic coils complete with drain and vent connections.

Provide double-sloped condensate drain pan of minimum 22 gage Type 304 stainless steel with nonferrous connections, and internal trap,, and a condensate pump system complete with integral pump discharge check valve, integral float switch, reservoir, and pump and motor assembly.

2.1.5 Filters

Provide UL listed 2 inches thick deep pleated fiberglass throwaway type filters. Provide filtration media with a Minimum Efficiency Reporting Value (MERV) of 8 as determined by ASHRAE 52.2. Provide one complete spare filter bank set per unit for installation prior to final acceptance testing covered in Part 3 of this section.

2.1.6 Reheat Coil

Provide reheat coils and slope for drainage. Provide coil manufactured of seamless copper tubes with plate aluminum or copper fins. Each coil, in the production process, must be individually tested at 320 psi with compressed air under water and verified to be air tight.

2.1.7 Humidifier

Humidifier section must include liquid-level control, emergency overflow and automatic water supply system factory pre-piped for final connection..

Arrange system to be cleanable and serviceable. Provide humidifier capable of operation with standard potable tap water without any water treatment requirements.

Provide humidifier of the self-contained steam generating electrode type utilizing a plastic canister with full probes connected to electric power via electrode screw connectors. Provide electrodes manufactured from expanded low carbon steel, zinc plated and dynamically formed for precise current control. The humidifier assembly must include integral fill cup, fill and drain valves and associated piping. Design the canister to collect the mineral deposits in the water and provide clean particle free steam to the air stream.

2.1.8 Floorstand

Provide an adjustable 24 inches high floorstand for each CRAC for freestanding installation on the main building structural floor. Floorstand must elevate the unit to the height of the raised computer floor and must allow for leveling and locking at the desired height. Floorstand must be retractable, or removable, for installing the unit directly on the raised floor. Unit must be fully gasketed (rubber or neoprene) to prevent air leakage at the raised floor penetration.

2.2 INSTRUMENTATION AND CONTROLS

All controls provided under this section must comply with the requirements of Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

2.2.1 Unit Level Controls

Provide factory installed components and wiring to control a unit's basic functions and space ambient conditions including humidification and dehumidification at one factory installed and tested station. Controller modules must provide automatic centralized control of computer room critical equipment, simplifying emergency switching and unit testing. When the module recognizes an alarm condition, it must automatically switch to a stand-by device. User must be able to program a switching delay to allow time to correct emergency conditions. Provide modules with capability to balance the runtime of all connected air units. Provide clear, simplified instructions for programming and configuration of controllers, minimizing the chances of operator error. Provide an electronic temperature and humidity recorder, integral or external to the unit, readable to specified control accuracy, complete with supplies required for one year of operation. Controls must include a control system interface to an HVAC control system. The control system interface must meet DDC Hardware requirements of Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC. Unit controls must comply with the requirements of Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

2.2.1.1 Display Panel

Provide LCD digital display with push button navigation. Display panel must include the following minimum data: power on, power off, unit in alarm, description of alarm, filter status, room temperature, room

relative humidity, event log, service contact information, and unit run hours. Display must have capability to set up password protection.

Provide the following minimum externally accessible controls at the unit: start and stop total system functions, silence audible alarm, main power disconnect.

2.2.1.2 Alarms

Display alarms on unit display panel. Alarm for the following: high and low space temperature, high and low space humidity, dirty filters, loss of airflow, loss of water flow, compressor high head pressure, custom alarms as indicated on the controls drawings, humidifier problems, and leak detection. Provide field accessible local audible alarm with silence pushbutton. Provide push-to-test lamps or all-lamp test pushbutton. CRACs must have local devices which provide signals for remote audible and visual alarming capability for the above specified alarm conditions.

2.2.1.3 Leak Detection

Provide rope moisture detection system for each computer room. Leak detection must be designed for installation on the subfloor below the raised floor of the computer room. Leak detection system must interface with the associated CRAC control panel to alarm upon detection of moisture on the subfloor.

2.2.1.4 Factory Wired Components

Provide factory installed and wired chilled and hot water valves. Valves must meet the requirements of Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

Provide CRAC manufacturer's remote room temperature sensor and room humidity sensor. Sensors must meet the requirements of Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

Provide factory wired discharge air temperature sensor. Sensors must meet the requirements of Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

2.2.2 Supervisory CRAC Controls

In addition to stand alone controls, provide a device to network together all CRACs as indicated. The network device must integrate all data for each CRAC, as required under stand alone controls, and display it on any connected CRAC's display panel. The network device must optimize the operation of all connected CRACs to minimize energy use. The network device must balance runtime across all connected units. The network device must automatically switch to a standby unit upon detection of failure of a duty unit. Provide all control wiring among CRACs and network devices as required to meet this specification.

2.2.3 Integration to HVAC control system

Integrate CRAC control into the HVAC control system defined in Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC. HVAC control system interface point is located in Mechanical Room 402.

Refer to controls drawings for minimum points required to interface with

the HVAC control system.

2.3 FACTORY PAINTING SYSTEMS

Provide manufacturer's standard factory painting. Certify that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with **ASTM B117**, and for that test the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond **0.125 inch** on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. The factory painting system must be designed for the anticipated temperature service.

2.4 ELECTRICAL

The electrical system shall conform to National Electrical Code requirements. The control circuit shall be 24 volts AC, wire in accordance with NEC Class II requirements. The control circuit wire shall not be smaller than 18 AWG. All wiring shall be neatly wrapped and routed in bundles. Each wire shall end with a service loop and be securely fastened by an approved method. Each wire in the unit shall be numbered for ease of service tracing. All electrically actuated components shall be easily accessible from the front of the unit without reaching over exposed high voltage components or rotating parts. Each high voltage circuit shall be individually protected by circuit breakers or manual motor starters on all three phases. The blower motor shall have thermal and short circuit protection. Line voltage and 24 volt control circuit wiring shall be routed in separate bundles. The electric box shall be positioned for service convenience and shall include all the contactors, starters, fuses, circuit breakers, terminal boards and control transformer required for operation of the CRAC unit and shall allow for full service access.

2.4.1 Electrical Motors, Controllers, Contactors, and Disconnects

Provide motors, controllers, disconnects and contactors with their respective pieces of equipment. Motors, controllers, disconnects and contactors must conform to and have electrical connections provided under Section **26 20 00** INTERIOR DISTRIBUTION SYSTEM. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Extended voltage range motors will not be permitted. Controllers and contactors must have a maximum of 120 volt control circuits, and must have auxiliary contacts for use with the controls provided. When motors and equipment provided are larger than sizes indicated, the cost of additional electrical service and related work must be included under the section that specified that motor or equipment. Power wiring and conduit for field installed equipment must be provided under and conform to the requirements of Section **26 20 00** INTERIOR DISTRIBUTION SYSTEM.

2.4.2 Electrical Control Wiring

Provide control wiring under Section **23 09 23.13 22** BACnet DIRECT DIGITAL

CONTROL SYSTEMS FOR HVAC. Provide Space temperature control system drawings which include point-to-point electrical wiring diagrams.

2.5 HVAC WATER PIPING AND METAL DUCTWORK

Requirements for HVAC water piping and metal ductwork are specified in Section 23 64 26 HYDRONIC CHILLED AND HOT WATER PIPING SYSTEMS and Section 23 30 00 HVAC AIR DISTRIBUTION.

2.6 FIRE PROTECTION DEVICES

The requirements for duct smoke detectors are specified in Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

2.7 SOURCE QUALITY CONTROL

Provide factory test plans, factory test schedules, factory tests and factory test report on each of the CRACs; .

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 CRAC System

Installation of each CRAC system including equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing, must be in accordance with ASME B31.1, ASME B31.5, NFPA 70, as modified and supplemented by the requirements of this section and the CRAC manufacturer's written installation instructions.

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

3.1.2 Installation Instructions

Provide a manufacturer's installation manual for each type of CRAC.

3.1.3 Operation and Maintenance Data

Submit Computer Room Air Conditioner Operation and Maintenance Data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

3.1.4 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Provide materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Provide labor and tools for making actual connections to existing systems.

3.2 FIELD QUALITY CONTROL

Upon completion and before final acceptance of work, test each CRAC subsystem in service to demonstrate compliance with the contract requirements, including field testing specified below. Adjust controls

and balance systems prior to final acceptance of completed systems. Test controls through every cycle of operation. Test safety controls to demonstrate performance of required function. Correct defects in work provided and repeat tests. Provide steam, fuel, water, electricity, instruments, connecting devices, and personnel for tests. Flush and clean piping before placing in operation. Clean equipment, piping, strainers, and ducts. Prior to commencement of field testing, remove all filters and provide new filters. Perform and document that proper [Indoor Air Quality During Construction](#) procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new filters were provided.

3.3 FIELD TESTING

Provide field test plans, field test schedules, field tests and field test reports on each of the CRACs. Field test each CRAC for Contracting Officer acceptance in accordance with the CRAC manufacturer's approved field test plan.

3.3.1 [Manufacturer's Field Test Plans](#)

Submit field test plans developed by the manufacturer for each CRAC; submit the field test plans at least 90 calendar days prior to planned date of the field test. Field test plans developed by the installing Contractor, or the equipment sales agency furnishing the CRAC, will not be acceptable.

The Contracting Officer will review and approve the field test plan for each of the listed CRACs prior to commencement of field testing of the equipment. The approved field test plans must be followed for the field tests of the CRAC and test reporting.

3.3.1.1 Coordinated Testing

Indicate in each field test plan when work required by this section requires coordination with test work required by other specification sections. Provide test procedures for the simultaneous or integrated testing of: CRAC controls which interlock and interface with controls factory prewired; and external controls for the CRAC provided under Section [23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC](#).

3.3.1.2 Prerequisite Testing

Each CRAC for which performance testing is dependent upon the completion of the work covered by Section [23 05 93.00 22 TESTING, ADJUSTING AND BALANCING FOR HVAC](#) must have that work completed as a prerequisite to testing work under this section. Indicate in each field test plan when such prerequisite work is required.

3.3.1.3 Test Procedure

Indicate in each field test plan the CRAC manufacturer's published start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

Procedures must be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controllers must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

3.3.1.4 Performance Variables

Each test plan must list performance variables that are required to be measured or tested as part of the field test.

Include, in the listed performance variables, requirements indicated on the CRAC schedules on the design drawings. Manufacturer must provide, with each test procedure, a description of acceptable results that have been verified.

Manufacturer must identify the acceptable limits or tolerances within which each tested performance variable must acceptably operate.

3.3.1.5 Test Configuration

Plans must indicate that tests are to be performed for a minimum of four continuous hours in a wet coil condition. If test period is interrupted, the four hour test period must be started over. Each test plan must be job specific and must address the particular CRACs and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable. Tests must include a pressurized raised floor discharge configuration at the specified or indicated height above the floor, with or without the air discharge elbows;

3.3.1.6 Tested Variables

Plans must provide for air side testing which includes verification of the airflow, total static pressure; fan drive motor KW, amperage and RPM; and fan RPM. Provide entering air temperatures equal to those indicated on the CRAC schedules.

3.3.1.7 Thermal Testing

Plans must provide thermal testing utilizing chilled water and hot water with temperatures equal to those indicated on the CRAC schedules. Thermal testing must verify CRAC heating, sensible cooling, total cooling, and humidifying performance scheduled on the contract drawings.

3.3.1.8 Specialized Components

Include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.3.1.9 Field Test Reporting Forms

Each test plan must include the required test reporting forms to be completed by the Contractor's testing representatives.

3.3.2 Field Test Schedule

Notify the Contracting Officer in writing at least 30 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for the review and approval of the Contracting Officer.

3.3.3 Manufacturer's Test Representative

Provide a factory trained field test representative authorized by the CRAC manufacturer to oversee the complete execution of the field testing. This test representative must also review, approve, and sign the completed field test report. Signatures must be accompanied by the person's name typed.

3.3.4 Field Tests

Conduct the field testing in compliance with the Contracting Officer approved manufacturer's field test plan, and in accordance with additional field testing requirements specified herein. Record the required data using the test reporting forms approved of the approved field test plan. Conduct the test for each CRAC for a continuous 24-hour test period. A CRAC shutdown before the continuous 24-hour test period is completed must result in the 24-hour test period being started again and run for the required duration.

3.3.5 Deficiency Resolution

The test requirements must be acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations. Corrections must be tested again in compliance with the requirements specified in the paragraph FIELD TEST PLANS.

3.3.6 Field Test Reports

Use the test reporting forms approved in the field test plan. Final test report forms must be typed, including data entries and remarks. Completed test report forms for each CRAC must be reviewed, approved, and signed by the Contractor's test director and the QC manager.

3.4 INSTRUCTION TO GOVERNMENT PERSONNEL

Provide the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors must be thoroughly familiar with all parts of the installation and must be trained in operating theory as well as practical operation and maintenance work.

Instruction must be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. Provide 4 hours of training for each type of CRAC specified.

-- End of Section --

SECTION 23 82 00.00 20

TERMINAL HEATING UNITS

02/16, CHG 1: 08/18

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z83.8/CSA 2.6 (2016; Errata 2017) Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters, and Gas-Fired Duct Furnaces

ANSI Z83.19/CSA 2.35 (2017) Gas-Fired High-Intensity Infrared Heaters

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

ASHRAE 33 (2016) Method of Testing Forced Circulation Air Cooling and Air Heating Coils

ASTM INTERNATIONAL (ASTM)

ASTM A109/A109M (2016; R 2018) Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A240/A240M (2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

ASTM A463/A463M (2015; R 2020; E 2020) Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process

ASTM A653/A653M (2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A1011/A1011M (2018a) 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

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 90B	(2021) Standard for the Installation of Warm Air Heating and Air Conditioning Systems
NFPA 91	(2020) Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists and Noncombustible Particulate Solids
NFPA 211	(2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

UNDERWRITERS LABORATORIES (UL)

UL 441	(2016; Reprint Jul 2016) UL Standard for SafetyGas Vents

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section with additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for

Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

Unit Heaters

Infrared Heaters

SD-10 Operation and Maintenance Data

Unit Heaters, Data Package 2

Infrared Heaters, Data Package 2

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

PART 2 PRODUCTS

2.1 UNIT HEATERS

Self-contained and factory assembled, propeller or centrifugal fan with capacities expressed as Btu per hour output and cubic foot-per-minute air delivery, operating conditions, and mounting arrangements as indicated. Average fan bearing life must be minimum 200,000 hours at operating conditions. Provide fan motor with direct or belt drive. Construct fan-guard motor mount of steel wire. Equip each heater with individually adjustable package discharge louver. Louvers may be substituted by discharge cones or diffusers. Provide thermostats as indicated. Furnish circuit breaker disconnect switch.

2.1.1 Gas-Fired Unit Heater

ANSI Z83.8/CSA 2.6 and AGA label.

2.1.1.1 Casing

Minimum 22 gage steel or aluminum. Provide removable access panels.

2.1.1.2 Heat Exchanger

Minimum 20 gage all-welded steel construction with corrosion-resistant aluminum finish.

2.1.1.3 Burners

Die-formed, slot ports, and steel construction with aluminum paint.

2.1.1.4 Draft Diverter

All-welded steel construction and an integral part of each heat exchanger section. Allows backdrafts to bypass burner assembly without affecting normal operation.

2.1.1.5 Controls

Consisting of a combination pressure regulator, main shutoff valve, pilot cock, pilot safety switch for 100 percent shutoff, high temperature limit

switch, and time-delay fan switch. Include power and control connections in an integral junction box.

2.1.1.6 Efficiency

Unit heater must have a minimum combustion efficiency of 80 percent when tested in accordance with ANSI Z83.8/CSA 2.6.

2.1.2 Hot-Water Unit Heater

ASHRAE 33 tested for heating coils; UL listed for motor and controls.

2.1.2.1 Casing

Minimum 20 gage steel or aluminum with removable access panels or means to remove, service, and maintain major components.

2.1.2.2 Coil

Fin-and-tube coil constructed of copper, tubes and copper or aluminum fins.

2.1.2.3 Controls

Automatic controls of combination of modulating and on-off-auto system as indicated .

2.1.3 Electric Unit Heater

UL listed; wattage, voltage, phase, and number of steps as indicated. Provide control-circuit terminals and single source of power supply. Heater 5 Kw and larger must be three-phase, with load balanced on each of the three phases. Limit leaving air temperature below 140 degrees F at 60 degrees F entering air.

2.1.3.1 Casing

Minimum 21 gage steel.

2.1.3.2 Heating Element

Nickel-chromium heating wire element, free from expansion noise and 60 Hz hum. Embed element in magnesium-oxide insulating refractory. Seal element in high-mass steel or corrosion-resisting metallic sheath with fins. Enclose element ends in terminal box. Space fins at maximum six fins per inch. Limit fin surface temperature 550 degrees F at any point during normal operation.

2.1.3.3 Controls

Include limit controls for thermal overheat protection of heaters. For remote thermostatic operation, provide contactor rated for 100,000 duty cycles. Provide room thermostat for pilot duty.

2.1.3.4 Wiring

Completely factory-prewired to terminal strips, ready to receive branch circuit and control connections for 140 degrees F copper or aluminum wiring.

2.2 INFRARED HEATERS

Operating conditions as indicated. Provide pre-wired control boxes, thermostats, and reflector and duct hangers.

2.2.1 Sheet Metal

- a. Aluminum-Clad Steel: **ASTM A463/A463M**, nominal thickness of minimum 16 gage for radiant tubing between burners and vacuum pump or vent.
- b. Aluminum: **ASTM B209**, manufacturer's standard thickness.
- c. Stainless Steel: **ASTM A240/A240M**, nominal thickness of not less than 20 gage.
- d. Ceramic-Coated or Enamel-Coated Steel: **ASTM A1011/A1011M** hot rolled or **ASTM A109/A109M** cold rolled, low-carbon steel. Provide coating able to withstand infrared heater operating temperatures.

2.2.2 Vented Gas Infrared Heater

ANSI Z83.19/CSA 2.35 with AGA label, single-burner power vented .

2.2.2.1 Vent

NFPA 54 and **NFPA 211**, Type 316 stainless steel . Vent flue gas to outdoors by induced draft.

2.2.2.2 Reflector

Polished aluminum, stainless steel or approved high infrared reflector materials. Provide manufacturer's standard reflector supports.

2.2.2.3 Heat Exchanger and Combustion Chamber

Construct heat exchanger and combustion chamber of aluminum-clad steel, ceramic-coated steel, or stainless steel.

2.2.2.4 Controls

Incorporate either an intermittent pilot ignition system or a solid-state direct ignition system. Provide safety air-flow switch for each burner.

2.2.2.5 Fan or Vacuum Pump

Heater manufacturer's standard.

2.3 FAN

Provide steel or aluminum fans with ball or roller bearings for motors over **1/8 horsepower (hp)** and sleeve bearings for motors **1/8 hp** and under. Provide sleeve bearings with oil reservoir, if not permanently lubricated.

2.4 MOTOR AND STARTER

NEMA MG 1, and **NEMA ICS 2**, and **NEMA ICS 6**, respectively. Provide explosion-proof motors and motor starters where indicated. Provide continuous-duty motor with built-in automatic reset thermal overload

protection. For motor 1/2 hp and larger, use three-phase. Provide single-phase motor of permanent split capacitor or capacitor start. Limit motor speed at 1800 r/min. Wire motor to heater power supply source.

2.5 GAS PIPING SYSTEM AND FLUE VENT

Comply with Section 23 11 20 FACILITY GAS PIPING for gas valves and piping. Use UL 441 flue vents , of galvanized steel aluminum or stainless steel.

2.6 HOT WATER PIPING SYSTEM

Section 23 64 26 HYDRONIC CHILLED AND HOT WATER PIPING SYSTEMS.

2.7 SOURCE QUALITY CONTROL

Special protection is not required for equipment that has a zinc coating conforming to ASTM A123/A123M or ASTM A653/A653M. Otherwise, protect affected equipment items by manufacturers' corrosion-inhibiting coating or paint system that has proved capable of withstanding salt-spray test in accordance with ASTM B117. Test indoor and outdoor equipment for 125 hours; test outdoor equipment used in a marine atmosphere for 500 hours. For each specimen, perform a scratch test as defined in ASTM D1654.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment where indicated and as recommended by manufacturer's recommendations, NFPA 54, NFPA 90A, NFPA 90B, NFPA 91 and NFPA 211.

3.1.1 Suspensions of Equipment

Provide equipment supports including beam clamps, turnbuckles and twist links or weld-wire chains, wire ropes with rope clips and rope thimbles, threaded-eye rod hangers with lock nuts and heat-duct hangers, threaded-eye bolts with expansion screws, brackets, platform and mounting frame, and vibration isolators. Locate equipment in such a manner that working space is available for servicing, such as vacuum pump and burner removal, access to automatic controls, and lubrication. Provide electrical isolation of dissimilar metals. Clean interior of casings or cabinets before and after completion of installation.

3.1.2 Vents

NFPA 54 and NFPA 211. Provide vents with weatherproofing flashings in accordance with Section 07 60 00 FLASHING AND SHEET METAL.

3.1.3 Electrical Work

NFPA 70 and Division 26, "ELECTRICAL." When replacing original control wires, provide No. 16 AWG with minimum 105 degrees C insulation.

3.2 FIELD QUALITY CONTROL

Administer, schedule, and conduct specified tests. Furnish personnel, instruments and equipment for such tests. Correct defects and repeat the respective inspections and tests. Conduct inspections and testing in the presence of the Contracting Officer.

3.2.1 Test Instruments and Apparatus

Provide instruments and apparatus currently certified as being accurate to within one percent of their full scale. Use gages with a maximum scale between 1 1/2 and 2 times test pressure.

3.2.2 Field Inspection

Prior to initial operation, inspect equipment installation to ensure that indicated and specified requirements have been met.

3.2.3 Field Tests

3.2.3.1 Fuel Piping Pressure Tests

Hydrostatically test fuel oil piping at 1 1/2 times maximum working pressure.

3.2.3.2 Fire Tests for Nonelectrical Heating Equipment

Test combustion controls and equipment with specified fuel at 100 percent full rated load. During tests, verify proper operation of controls. Adjust burners for maximum efficiency using Orsat or similar apparatus. Maintain firing for at least four hours, and where high-low-off combustion controls are provided, operate the heating equipment for one hour at low fire and 3 hours at high fire. For acceptable combustion efficiency, allow maximum 4.5 percent carbon dioxide in flue gases.

3.2.3.3 Insulation-Resistance Tests for Electrical Equipment

At the completion of wiring, test 600 volt wiring to verify that no short circuits exist before or after the attachment of electrical heating equipment to the power source. Make tests with an instrument which applies a voltage of approximately 500 volts for a direct reading of insulation resistance.

3.2.3.4 Operational Tests

After completing fire tests and insulation-resistance tests, operate equipment continuously under varying load conditions to verify functioning of combustion controls, electrical controls, flame safeguard controls, safety interlocks, and specified operating sequence. Run each test for a minimum period of one hour.

-- End of Section --

SECTION 25 05 11

CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS
11/17

PART 1 GENERAL

This Section refers to Security Requirements Guide (SRGs) and Security Technical Implementation Guide (STIGs). STIGs and SRGs are available online at the Information Assurance Support Environment (IASE) website at <http://iase.disa.mil/stigs/Pages/index.aspx>. Not all control system components have applicable STIGs or SRGs.

1.1 RELATED REQUIREMENTS

All Sections containing facility-related control systems or control system components are related to the requirements of this Section. Review all specification sections to determine related requirements.

1.2 REFERENCES

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

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

ASHRAE 135 (2016) BACnet—A Data Communication
Protocol for Building Automation and
Control Networks

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

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

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

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

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 8551.01 (2014) Ports, Protocols, and Services
Management (PPSM)

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

1.3 DEFINITIONS

1.3.1 Computer

As used in this Section, a computer is one of the following:

- a. a device running a non-embedded desktop or server version of Microsoft Windows
- b. a device running a non-embedded version of MacOS
- c. a device running a non-embedded version of Linux
- d. a device running a version or derivative of the Android OS, where Android is considered separate from Linux
- e. a device running a version of Apple iOS

1.3.2 Network Connected

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

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

1.3.3 User Account Support Levels

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

1.3.3.1 FULLY Supported

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

1.3.3.2 MINIMALLY Supported

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

1.3.3.3 NOT Supported

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

1.3.4 User Interface

Generally, a user interface is hardware on a device allowing user interaction with that device via input (buttons, switches, sliders,

keyboard, touch screen, etc.) and a screen. There are three types of user interfaces defined in this Section: Limited Local User Interface, Full Local User Interface and Remote User Interface. In this Section, when the term "User Interface" is used without specifying which type, it refers only to Full Local User Interface and Remote User Interface (NOT to Limited Local User Interface).

1.3.4.1 Limited Local User Interface

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

Examples of Limited Local User Interface include thermostats ([Space Sensor Modules as defined in Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC](#)).

1.3.4.2 Full Local User Interface

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

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

1.3.4.3 Remote User Interface

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

Examples of Remote User Interfaces include web browsers [and Local Display Panels as defined in Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC](#).

1.4 ADMINISTRATIVE REQUIREMENTS

1.4.1 Coordination

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

- a. If requesting permission for wireless communication, the Wireless Communication Request submittal must be approved prior to control system device selection and integration.
- b. If requesting permission for alternate account lock permissions, the Device Account Lock Exception Request must be approved prior to control system device selection and integration.
- c. If requesting permission for the use of a device with multiple IP connections, the Multiple IP Connection Device Request must be approved prior to control system device selection and integration.
- d. Wireless testing may be required as part of the control system testing. See requirements for the [Wireless Communication Test Report](#) submittal.

- e. If the Device Audit Record Upload Software is to be installed on a computer not being provided as part of the control system, coordination is required to identify the computer on which to install the software.
- f. Cybersecurity Interconnection Schedule must be coordinated with other work that will be interconnected to, and interconnections must be approved by the Government before relying on them for system functionality.
- g. Cybersecurity testing support must be coordinated across control systems and with the Government cybersecurity testing schedule.
- h. Passwords must be coordinated with the indicated contact for the project site.
- i. If applicable, HTTP web server certificates must be obtained from the indicated contact for the project site.
- j. Contractor Computer Cybersecurity Compliance Statements for each contractor using contractor owned computers.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Wireless Communication Request; G

Device Account Lock Exception Request; G

Multiple IP Connection Device Request; G

Contractor Computer Cybersecurity Compliance Statements; G

Contractor Temporary Network Cybersecurity Compliance Statements; G

SD-02 Shop Drawings

User Interface Banner Schedule; G

Network Communication Report; G

Cybersecurity Riser Diagram; G

Control System Inventory Report; G

Cybersecurity Interconnection Schedule; G

SD-03 Product Data

Control System Cybersecurity Documentation; G

SD-06 Test Reports

Wireless Communication Test Report; G

SD-07 Certificates

Software Licenses; G

SD-11 Closeout Submittals

Password Summary Report; G

Software Recovery And Reconstitution Images; G

Device Audit Record Upload Software; G

1.6 CYBERSECURITY DOCUMENTATION

1.6.1 Cybersecurity Interconnection Schedule

{For Reference Only: This subpart (and its subparts) relates to CA-3(b), CCI-00258}

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

In addition to the requirements of Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES, provide the Cybersecurity Interconnection Schedule as an editable Microsoft Excel file (a template Cybersecurity Interconnection Schedule in Excel format is available at <http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic>

1.6.2 Network Communication Report

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

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

In addition to the requirements of Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES, provide the Network Communication Report as an editable Microsoft Excel file.

1.6.3 Control System Inventory Report

{For Reference Only: This subpart (and its subparts) relates to CM-8(a), CP-12, SI-17, IA-3; CCI-000389, CCI-000392, CCI-000398, CCI-002855, CCI-002856, CCI-002857, CCI-002773, CCI-002774, CCI-002775, CCI-000777, CCI-000778, CCI-001958}

Provide a Control System Inventory report using the Inventory Spreadsheet listed under this Section at

<http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic> documenting all devices, including networked devices, network infrastructure devices, non-networked devices, input devices (e.g. sensors) and output devices (e.g. actuators). For each device provide all applicable information for which there is a field on the spreadsheet in accordance with the instructions on the spreadsheet.

In addition to the requirements of Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES, provide the Control System Inventory Report as an editable Microsoft Excel file.

1.6.4 Software Recovery and Reconstitution Images

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

For each computer on which software is installed under this project, provide a recovery image of the final as-built computer. This image must allow for bare-metal restore such that restoration of the image is sufficient to restore system operation to the imaged state without the need for re-installation of software.

1.6.5 Cybersecurity Riser Diagram

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

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

1.6.6 Control System Cybersecurity Documentation

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

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

1.6.6.1 Software Applications

For all software applications running on computers provide:

- a. administrator documentation that describes secure configuration of the software {relates to CCI-003124}

- b. administrator documentation that describes secure installation of the software {relates to CCI-003125}
- c. administrator documentation that describes secure operation of the software {relates to CCI-003124}
- d. administrator documentation that describes effective use and maintenance of security functions or mechanisms for the software {relates to CCI-003127}
- e. administrator documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the software {relates to CCI-003128}
- f. user documentation that describes user-accessible security functions or mechanisms in the software and how to effectively use those security functions or mechanisms {relates to CCI-003129}
- g. user documentation that describes methods for user interaction which enables individuals to use the software in a more secure manner {relates to CCI-003130}
- h. user documentation that describes user responsibilities in maintaining the security of the software {relates to CCI-003131}

1.6.6.2 For HVAC Control System Devices

1.6.6.2.1 HVAC Control System Devices FULLY Supporting User Accounts

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

- a. Documentation that describes secure configuration of the device {for reference only: relates to CCI-003124}
- b. Documentation that describes secure operation of the device {for reference only: relates to CCI-003124}
- c. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {for reference only: relates to CCI-003127}
- d. Documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the device {for reference only: relates to CCI-003128}
- e. Documentation that describes user-accessible security functions or mechanisms in the device and how to effectively use those security functions or mechanisms; or a specific indication that there are no user-accessible security functions or mechanisms in the device {for reference only: relates to CCI-003129}
- f. Documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {for reference only: relates to CCI-003130}

1.6.6.2.2 All Other HVAC Control System Devices

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

- a. Documentation that describes secure configuration of the device; or a specific indication that there are no secure configuration steps that apply {for reference only: relates to CCI-003124}
- b. Documentation that describes effective use and maintenance of security functions or mechanisms for the device; or a specific indication that there are no security functions or mechanisms in the device {for reference only: relates to CCI-003127}
- c. For devices which include a user interface, documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {for reference only: relates to CCI-003130}

1.6.6.3 Default Requirements for Control System Devices

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

- a. Documentation that describes secure configuration of the device {for reference only: relates to CCI-003124}
- b. Documentation that describes secure installation of the device {for reference only: relates to CCI-003125}
- c. Documentation that describes secure operation of the device {for reference only: relates to CCI-003124}
- d. Documentation that describes effective use and maintenance of security functions or mechanisms for the device {for reference only: relates to CCI-003127}
- e. Documentation that describes known vulnerabilities regarding configuration and use of administrative (i.e. privileged) functions for the device {for reference only: relates to CCI-003128}
- f. Documentation that describes user-accessible security functions or mechanisms in the device and how to effectively use those security functions or mechanisms {for reference only: relates to CCI-003129}
- g. Documentation that describes methods for user interaction which enables individuals to use the device in a more secure manner {for reference only: relates to CCI-003130}
- h. Documentation that describes user responsibilities in maintaining the security of the device {for reference only: relates to CCI-003131}

1.7 SOFTWARE UPDATE LICENSING

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

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

- a. Security and bug-fix patches issued by the software manufacturer.
- b. Security patches to address any vulnerability identified in the National Vulnerability Database at <http://nvd.nist.gov> with a Common Vulnerability Scoring System (CVSS) severity rating of MEDIUM or higher.

Provide a single [Software Licenses](#) submittal with documentation of the software licenses for all software provided

1.8 CYBERSECURITY DURING CONSTRUCTION

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

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

1.8.1 Contractor Computer Equipment

Contractor owned computers may be used for construction. When used, contractor computers must meet the following requirements:

1.8.1.1 Operating System

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

1.8.1.2 Anti-Malware Software

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

1.8.1.3 Passwords and Passphrases

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

1.8.1.4 [Contractor Computer Cybersecurity Compliance Statements](#)

Provide a single submittal containing completed Contractor Computer Cybersecurity Compliance Statements for each company using contractor owned computers. Contractor Computer Cybersecurity Compliance Statements must use the template published at

<http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic>
Each Statement must be signed by a cybersecurity representative for the

relevant company.

1.8.2 Temporary IP Networks

Temporary contractor-installed IP networks may be used during construction. When used, temporary contractor-installed IP networks must meet the following requirements:

1.8.2.1 Network Boundaries and Connections

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

1.8.3 Government Access to Network

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

1.8.4 Temporary Wireless IP Networks

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

1.8.5 Passwords and Passphrases

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

1.8.6 Contractor Temporary Network Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Temporary Network Cybersecurity Compliance Statements for each company implementing a temporary IP network. Contractor Temporary Network Cybersecurity Compliance Statements must use the template published at <http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic>. Each Statement must be signed by a cybersecurity representative for the relevant company. If no temporary IP networks will be used, provide a single copy of the Statement indicating this.

1.9 CYBERSECURITY DURING WARRANTY PERIOD

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

PART 2 PRODUCTS

(NOT USED)

PART 3 EXECUTION

3.1 ACCESS CONTROL REQUIREMENTS

3.1.1 User Accounts

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

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

Implement a warning banner on terminal interfaces that conforms to DoD warning banner guidelines. Configure each component of the product to operate using the principle of least privilege. This includes operating system permissions, file access, user accounts, application-to-application communication, and energy delivery system services.

Provide user accounts with configurable access and permissions associated with one or more organizationally defined user role(s), where roles are used. Provide a system administration mechanism for changing user(s') role (e.g., group) associations.

Configure the product such that when a session or inter-process communication is initiated from a less privileged application, access shall be limited and enforced at the more critical side. Provide a method for protecting against unauthorized privilege escalation.

Document options for defining access and security permissions, user accounts, and applications with associated roles. Configure these options, as specified.

Prevent unauthorized changes to the Basic Input/Output System (BIOS) and other firmware and document if not feasible, provide mitigation recommendations.

Verify and provide documentation for the procured product, attesting that unauthorized logging devices are not installed (e.g., keyloggers, cameras, and microphones).

3.1.1.1 Computers

All computers must FULLY support user accounts.

3.1.1.2 For HVAC Control System Devices

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

3.1.1.3 Default Requirements for Control System Devices

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

- a. Devices with web interfaces must either FULLY support user accounts or

have their web interface disabled.

- b. Field devices with full local user interfaces allowing modification of data must FULLY support user accounts.
- c. Field devices with read-only full local user interfaces must at least MINIMALLY support user accounts.

3.1.2 Account Management

Document all accounts (including, but not limited to, generic or default) that need to be active for proper operation of the product. Change default account settings to specific settings (e.g., length, complexity, history, and configurations) provided by government rep. Changed account information will not be published. All new account information will be provided by a protected mechanism. Remove or disable any accounts that are not needed for normal or maintenance operations of any energy delivery system. Accounts for emergency operations shall be placed in a highly secure configuration and documentation on their configuration.

3.1.3 Unsuccessful Logon Attempts

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

Except for high availability user interfaces indicated as exempt, devices must meet the indicated requirements for handling unsuccessful logon attempts.

3.1.3.1 Devices MINIMALLY Supporting Accounts

Devices which MINIMALLY support accounts must lock the user input when **three unsuccessful logon attempts** and must support unlocking of the user input when **unlocked by an administrator**.

3.1.3.2 Devices FULLY Supporting Accounts

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

- a. It must lock the user account when three unsuccessful logon attempts occur within a 15 minute interval.
- b. Once an account is locked, the account must stay locked until unlocked by an administrator.
- c. Once the indicated number of unsuccessful logon attempts occurs, delay further logon prompts by 5 seconds.

3.1.3.3 High Availability Interfaces Exempt from Unsuccessful Logon Attempts Requirements

Contact local ISSM and System Owner/Program Manager for requirements for

high availability interfaces that are exempt from unsuccessful logon attempts. Work with local ISSM and local CIO to complete the following:

High Availability Interfaces Exempt from Unsuccessful Logon Attempts Requirements		
User Interface	Location	Action to take in lieu of locking screen

3.1.4 System Use Notification

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

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

Devices which are connected to a network and have a user interface must display a warning banner meeting the requirements of **DTM 08-060** if capable of doing so. Devices which are connected to a network and have a user interface but are not capable of displaying a banner must have a permanently affixed label displaying an approved banner from **DTM 08-060**. Labels must be machine printed or engraved, plastic or metal, designed for permanent installation, must use a font no smaller than 14 point, and must provide a high contrast between font and background colors.

3.1.4.1 User Interface Banner Schedule

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

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

3.1.5 Permitted Actions Without Identification or Authentication

{For Reference Only: This subpart (and its subparts) relates to AC-14;

CCI-000061, CCI-000232}

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

3.1.6 Wireless Access

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

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

3.1.6.1 Wireless Communication Request

Provide a report documenting the proposed use of wireless communication prior to beginning construction using the Wireless Communication Request Schedule at

<http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic>

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

3.2 CYBERSECURITY AUDITING

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

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

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

3.2.1.1 Computers

For each computer, provide the capability to select audited events and the content of audit logs. Configure computers to audit the indicated events, and to record the indicated information for each auditable event

3.2.1.1.1 Audited Events

Configure each computer to audit the following events:

- a. Successful and unsuccessful attempts to access, modify, or delete privileges, security objects, security levels, or categories of

information (e.g. classification levels)

- a. Successful and unsuccessful logon attempts
- b. Privileged activities or other system level access
- c. Starting and ending time for user access to the system
- d. Concurrent logons from different workstations
- e. Successful and unsuccessful accesses to objects
- f. All program initiations
- g. All direct access to the information system
- h. All account creations, modifications, disabling, and terminations
- i. All kernel module load, unload, and restart

3.2.1.1.2 Audit Event Information To Record

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

- a. What type of event occurred
- b. When the event occurred
- c. Where the event occurred
- d. The source of the event
- e. The outcome of the event
- f. The identity of any individuals or subjects associated with the event

3.2.1.2 For HVAC Control System Devices

3.2.1.2.1 HVAC Control System Devices FULLY Supporting User Accounts

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

- a. Successful and unsuccessful logon attempts to the device
- b. Starting and ending time for user access to the device
- c. All account creations, modifications, disabling, and terminations
- d. All device shutdown and startup

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

3.2.1.2.2 Other HVAC Control System Devices

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

3.2.1.3 Default Requirements for Control System Devices

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

3.2.1.3.1 Devices Which FULLY Support Accounts

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

3.2.1.3.1.1 Audited Events

Configure each device to audit the following events:

- a. Successful and unsuccessful attempts to access, modify, or delete privileges, security objects, security levels, or categories of information (e.g. classification levels)
- a. Successful and unsuccessful logon attempts
- b. Privileged activities or other system level access
- c. Starting and ending time for user access to the system
- d. Concurrent logons from different workstations
- e. All account creations, modifications, disabling, and terminations
- f. All kernel module load, unload, and restart

3.2.1.3.1.2 Audit Event Information To Record

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

- a. what type of event occurred
- b. when the event occurred
- c. where the event occurred
- d. the source of the event
- e. the outcome of the event
- f. the identity of any individuals or subjects associated with the event

3.2.1.3.2 Devices Which Do Not FULLY Support Accounts

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

3.2.2 Audit Storage Capacity and Audit Upload

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

- a. For devices that have STIG/SRGs related to audit storage capacity (CCI-001848 or CCI-001849) comply with the requirements of those STIG/SRGs.
- b. For non-computer control system devices capable of generating audit records, provide 60 days worth of secure local storage, assuming 10 auditable events per day.
- c. For computers, provide storage for **audit records in conformance with applicable STIG/SRGs**.

3.2.2.1 Device Audit Record Upload Software

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

Contact local ISSM and System Owner/Program Manager for device audit record upload software requirements. Submit copies of device audit record upload software. If there are no non-computer devices requiring auditing, provide a document stating this in lieu of this submittal.

3.2.3 Response to Audit Processing Failures

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

Front end computers associated with auditing must, in the case of a failure in the auditing system, notify **Information Security System Manager (ISSM) or Information Security System Officer (ISSO)** via e-mail. In case of an audit failure, if possible, continue to collect audit records by overwriting existing audit records.

3.2.4 Time Stamps

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

3.2.4.1 Computers

Computers generating audit records must have internal clocks capable of providing time with a resolution of 1 second. Clocks must not drift more than 10 seconds per day.

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

3.2.4.2 For HVAC Control System Devices

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

HVAC Control System specifications.

3.2.4.3 Default Requirements for Control System Devices

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

3.3 REQUIREMENTS FOR LEAST FUNCTIONALITY

{For Reference Only: This subpart (and its subparts), along with the network communication report submittal specified elsewhere in this section, relates to CM-6 (a), (c), CM-7, CM-7 (1)(b), SC-41; CCI-000363, CCI-000364, CCI-000365, CCI-001588, CCI-001755, CCI-000381, CCI-000380, CCI-00382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546.}

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

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

For Other Control Systems: Do not use a networked sensor or actuator where a non-networked sensor or actuator would suffice.

3.3.1 Non-IP Control Networks

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

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

3.3.2 IP Control Networks

Do not use nonsecure functions, ports, protocols and services as defined in **DODI 8551.01** unless those ports, protocols and services are specifically required by the control system specifications or otherwise specifically authorized by the Government. Do not use ports, protocols and services that are not specified in the control system specifications or required for operation of the control system.

3.4 SAFE MODE AND FAIL SAFE OPERATION

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

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

3.5 IDENTIFICATION AND AUTHENTICATION

3.5.1 User Identification and Authentication

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

- a. Devices that FULLY support accounts must uniquely identify and authenticate organizational users.
- b. Devices which allow network access to privileged accounts must implement multifactor authentication for network access to privileged accounts.

3.5.1.1 HVAC Control Systems Devices

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

3.5.1.2 Electronic Security System Devices

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

3.5.1.3 Default Requirements for Control System Devices

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

3.5.2 Authenticator Management

{For Reference Only: This subpart (and its subparts) relates to IA-5 (b),(c),(e),(g),(1),(11); CCI-000176, CCI-001544, CCI-001989, CCI-000182, CCI-001610, CCI-000192, CCI-000193, CCI-000194, CCI-000205, CCI-001619, CCI-001611, CCI-001612, CCI-001613, CCI-001614, CCI-000195, CCI-001615, CCI-000196, CCI-000197, CCI-000199, CCI-000198, CCI-001616, CCI-001617, CCI-000200, CCI-001618, CCI-002041, CCI-002002, CCI-002003}

3.5.2.1 Authentication Type

3.5.2.1.1 For HVAC Control System Devices

Unless otherwise indicated:

- a. Software which FULLY supports accounts and which runs on a computer must use hardware token-based authentication.
- b. Other devices which FULLY support accounts must use password-based authentication.

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

3.5.2.1.2 Default Requirements for Control System Devices

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

- a. Software which FULLY supports accounts and which runs on a computer must use hardware token-based authentication.
- b. Other devices which FULLY support accounts must use either password-based authentication or hardware token-based authentication.
- c. Devices MINIMALLY supporting accounts must use either password-based authentication or hardware token-based authentication.

3.5.2.2 Password-Based Authentication Requirements

3.5.2.2.1 Passwords for Computers

All computers supporting password-based authentication must enforce the following requirements:

- a. Minimum password length of 12 characters
- b. Password must contain at least one uppercase character.
- c. Password must contain at least one lowercase character.
- d. Password must contain at least one numeric character.
- e. Password must contain at least one special character.
- f. Password must have a minimum lifetime of 24 hours.
- g. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.
- h. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters.
- i. Passwords must be cryptographically protected during storage and transmission.

3.5.2.2.2 Passwords for Non-Computer Devices FULLY Supporting Accounts

All non-computer devices FULLY supporting accounts and supporting password-based authentication must enforce the following requirements:

- a. Minimum password length of twelve (12) characters
- b. Password must contain at least one uppercase character.
- c. Password must contain at least one lowercase character.
- d. Password must contain at least one numeric character.
- e. Password must contain at least one special character.

- f. Password must have a maximum lifetime of sixty (60) days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.
- g. Password must differ from previous five (5) passwords, where differ is defined as changing at least fifty percent of the characters.
- h. Passwords must be cryptographically protected during storage and transmission.

3.5.2.2.3 Passwords for Web Interfaces

Passwords for connecting to a web interface supporting password-based authentication must enforce the following requirements:

- a. Minimum password length of 12 characters
- b. Password must contain at least one uppercase character.
- c. Password must contain at least one lowercase character.
- d. Password must contain at least one numeric character.
- e. Password must contain at least one special character.
- f. Password must have a maximum lifetime of 60 days. When passwords expire, prompt users to change passwords. Do not lock accounts due to expired passwords.
- g. Password must differ from previous five passwords, where differ is defined as changing at least 50 percent of the characters.
- h. Passwords must be cryptographically protected during storage and transmission.

3.5.2.2.4 Passwords for Devices Minimally Supporting Accounts

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

3.5.2.2.5 Password Configuration and Reporting

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

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

3.5.2.3 Hardware Token-Based Authentication Requirements

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

3.5.3 Authenticator Feedback

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

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

3.5.4 Device Identification and Authentication

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

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

3.5.4.1 For HVAC Control System Devices

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

3.5.4.2 Default Requirements for Control System Devices

Contact local ISSM and System Owner/Program Manager.

For control system devices where Device Identification and Authentication requirements are not otherwise indicated in this Section: Devices using HTTP as a control protocol must use HTTPS. **Contact local ISSM and System Owner/Program Manager for requirements for using web server certificates and who will provide them.**

3.5.5 Cryptographic Module Authentication

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

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

3.6 EMERGENCY POWER

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

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

3.7 DURABILITY TO VULNERABILITY SCANNING

{For Reference Only: This subpart (and its subparts) relates to RA-5 (a),(b),(c),(d); CCI-001054, CCI-001055, CCI-0010156, CCI-001641, CCI-001643, CCI-001057, CCI-001058, CCI-001059}

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

Computers must respond to scans from **Assured Compliance Assessment Solution (ACAS)** by responding with a **a valid credentialed scan**. For control system devices other than computers:

3.7.1 HVAC Control System Devices Other Than Computers

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

3.7.2 Default Requirements for Control System Devices

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

3.8 FIPS 201-2 REQUIREMENT

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

All control system devices which implement PIV must be on the **NIST FIPS 201-2** approved product list.

3.9 DEVICES WITH CONNECTION TO MULTIPLE IP NETWORKS

Except for Ethernet switches, do not use more than one physical connection to IP networks on the same device unless doing so is both required by the project specifications and the specific application is approved. If a device with multiple IP connections is required, provide a **Multiple IP Connection Device Request** using the Multiple IP Connection Device Request Schedule at

<http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-graphic> to request approval for each device.

3.10 SYSTEM AND COMMUNICATION PROTECTION

3.10.1 Denial of Service Protection, Process Isolation and Boundary Protection

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

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

3.11 SYSTEM AND INTEGRATION INTEGRITY

3.11.1 Malicious Code Protection

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

For all computers installed under this project, install and configure malware protection software in accordance with the relevant STIGs.

3.12 FIELD QUALITY CONTROL

3.12.1 Tests

In addition to testing and testing support required by other Sections, provide a minimum of 40 hours of technical support for cybersecurity testing of control systems.

-- End of Section --

SECTION 26 08 00

APPARATUS INSPECTION AND TESTING

08/08, CHG 1: 02/15

PART 1 GENERAL

1.1 REFERENCES

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

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS

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

1.2 RELATED REQUIREMENTS

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

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-06 Test Reports

Acceptance tests and inspections; G

SD-07 Certificates

Qualifications of organization, and lead engineering technician; G

Acceptance test and inspections procedure; G

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Contractor shall engage the services of a qualified testing organization to provide inspection, testing, calibration, and adjustment of the electrical distribution system and generation equipment listed in paragraph entitled "Acceptance Tests and Inspections" herein. Organization shall be independent of the supplier, manufacturer, and installer of the equipment. The organization shall be a first tier subcontractor. No work required by this section of the specification shall be performed by a second tier subcontractor.

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

used shall be calibrated in accordance with NETA ATS.

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

1.4.2 Acceptance Tests and Inspections Reports

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

1.4.3 Acceptance Test and Inspections Procedure

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

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 ACCEPTANCE TESTS AND INSPECTIONS

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

- a. Section 26 32 15.00 ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES. Functional engine shutdown tests, vibration base-line test, and load bank test shall not be performed by the testing organization. These tests shall be performed by the start-up engineer.
- b. Section 26 12 19.10 THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS
- d. Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION

- e. Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Medium voltage cables and grounding systems only.
- i. Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH
- k. Section 26 24 13 SWITCHBOARDS

3.2 SYSTEM ACCEPTANCE

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

3.3 PLACING EQUIPMENT IN SERVICE

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

-- End of Section --

SECTION 26 12 19.10

THREE-PHASE, LIQUID-FILLED PAD-MOUNTED TRANSFORMERS
05/19

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM A240/A240M	(2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2017b) Standard Test Method for Pour Point of Petroleum Products
ASTM D877/D877M	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

FM GLOBAL (FM)

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.47	(2011) Standard for High Voltage Distribution Class Current-Limiting Type Fuses and Fuse Disconnecting Switches
IEEE C57.12.00	(2015) General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.34	(2015) Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 10 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2015; Corr 2017) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 260	(1996; R 2004) Safety Labels for Pad-Mounted Switchgear and Transformers Sited in Public Areas
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"
EPA 821-R-02-012	(2002) Methods for Measuring the Acute

Toxicity of Effluents and Receiving Waters
to Freshwater and Marine Organisms

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

10 CFR 431

Energy Efficiency Program for Certain
Commercial and Industrial Equipment

UNDERWRITERS LABORATORIES (UL)

UL 467

(2013; Reprint Jun 2017) UL Standard for
Safety Grounding and Bonding Equipment

1.2 RELATED REQUIREMENTS

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

1.3 DEFINITIONS

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

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Pad-mounted Transformer Drawings; G

SD-03 Product Data

Pad-mounted Transformers; G

SD-06 Test Reports

Acceptance Checks and Tests; G

SD-07 Certificates

Transformer Efficiencies; G

SD-09 Manufacturer's Field Reports

Transformer Test Schedule; G

Pad-mounted Transformer Design Tests; G

Pad-mounted Transformer Routine and Other Tests; G

SD-10 Operation and Maintenance Data

Transformer(s), Data Package 5; G

1.4.1 Reduced Submittal Requirements

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

- a. A certification, signed by the manufacturer, stating that the manufacturer will meet the technical requirements of this specification.
- b. An outline drawing of the transformer with devices identified (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item a).
- c. ANSI nameplate data of the transformer (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item b).
- d. Manufacturer's published time-current curves in PDF format and in electronic format suitable for import or updating into the EasyPower computer program of the transformer high side fuses (paragraph PAD-MOUNTED TRANSFORMER DRAWINGS, item e).
- e. Provide transformer test schedule and routine and other tests required by submittal item "SD-09 Manufacturer's Field Reports".
- f. Provide acceptance test reports required by submittal item "SD-06 Test Reports".
- g. Provide operation and maintenance manuals required by submittal item "SD-10 Operation and Maintenance Data".

1.5 QUALITY ASSURANCE

1.5.1 Pad-Mounted Transformer Drawings

Include the following as a minimum:

- a. An outline drawing, including front, top, and side views.
- b. IEEE nameplate data.
- c. Elementary diagrams and wiring diagrams.
- d. One-line diagram, including switch(es).
- e. Manufacturer's published time-current curves in PDF format and in electronic format suitable for import or updating into the EasyPower computer program of the transformer high side fuses.

1.5.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, except of NFPA 70 when more stringent requirements are specified or indicated, as though the word "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of

similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with NFPA 70 unless more stringent requirements are specified or indicated.

1.5.3 Standard Products

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

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
- b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.3.1 Alternative Qualifications

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

1.5.3.2 Material and Equipment Manufacturing Date

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

1.6 MAINTENANCE

1.6.1 Additions to Operation and Maintenance Data

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

- a. An instruction manual with pertinent items and information highlighted
- b. An outline drawing, front, top, and side views
- c. Prices for spare parts and supply list
- d. Routine and field acceptance test reports
- e. Fuse curves for primary fuses
- g. Actual nameplate diagram
- h. Date of purchase

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be pad-mounted transformers and related accessories are specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION, Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2 THREE-PHASE PAD-MOUNTED TRANSFORMERS

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

2.2.1 Compartments

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

2.2.1.1 High Voltage, Dead-Front

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

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

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

- c. Bushing well inserts: IEEE 386, 200 amperes, 15 kV Class. Provide a bushing well insert for each bushing well unless indicated otherwise.

- e. Load-break switch

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

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

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

Bayonet fuse assembly: 150 kV BIL.

Oil-immersed current-limiting fuses: **IEEE C37.47**; 50,000 rms amperes symmetrical interrupting rating at the system voltage specified.

- g. Surge arresters: **IEEE C62.11**, rated 10 kV, fully shielded, dead-front, metal-oxide-varistor, elbow type with resistance-graded gap. Provide three arresters for loop feed circuits.
- h. Parking stands: Provide a parking stand near each bushing. Provide insulated standoff bushings for parking of energized high-voltage connectors on parking stands.
- i. Protective caps: **IEEE 386**, 200 amperes, 15 kV Class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushings.

2.2.1.2 Low Voltage

Low-voltage compartment contains: low-voltage bushings with NEMA spade

terminals, accessories, metering, stainless steel or laser-etched anodized aluminum diagrammatic transformer nameplate, and ground pad.

- a. Include the following accessories: drain valve with sampler device, fill plug, pressure relief device, liquid level gage, pressure-vacuum gage, and dial type thermometer with maximum temperature indicator.
- b. Metering: Provide as specified in Section 26 27 14.00 20 ELECTRICITY METERING.

2.2.2 Transformer

- a. Less-flammable liquid-insulated, two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.
- b. Transformer rated (as indicated in design documents) kVA.
- c. Transformer voltage ratings: 12470 V Delta - 480Y/277 V or 208Y/120 V, as indicated on the plans.
- d. Tap changer: externally operated, manual type for changing tap setting when the transformer is de-energized. Provide four 2.5 percent full capacity taps, two above and two below rated primary voltage. Indicate which tap setting is in use, clearly visible when the compartment is opened.
- e. Minimum tested percent impedance at 85 degrees C:
 - 2.50 for units rated 75kVA and below
 - 2.87 for units rated 112.5kVA to 300kVA
 - 4.03 for 500kVA rated units
 - 5.32 for units rated 750kVA and above
- f. Comply with the following audible sound level limits:

KVA	DECIBELS (MAX)
75	51
112.5	55
150	55
225	55
300	55
500	56
750	57
1000	58
1500	60

2000	61
2500	62

g. Include:

- (1) Lifting lugs and provisions for jacking under base, with base construction suitable for using rollers or skidding in any direction.
- (2) An insulated low-voltage neutral bushing with NEMA spade terminal, and with removable ground strap.
- (3) Provide transformer top with an access handhole.
- (4) kVA rating conspicuously displayed using 3 inch high yellow letters on its enclosure.

2.2.2.1 Specified Transformer Efficiencies

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

KVA	EFFICIENCY (percent)
15	98.65
30	98.83
45	98.92
75	99.03
112.5	99.11
150	99.16
225	99.23
300	99.27
500	99.35
750	99.40

1000	99.43
1500	99.48
2000	99.51
2500	99.53
above 2500	99.54

2.2.3 Insulating Liquid

- a. Less-flammable transformer liquids: [NFPA 70](#) and [FM APP GUIDE](#) for less-flammable liquids having a fire point not less than 300 degrees C tested per [ASTM D92](#) and a dielectric strength not less than 33 kV tested per [ASTM D877/D877M](#). Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

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

- (1) Pour point: [ASTM D97](#), less than -15 degree C
- (2) Aquatic biodegradation: [EPA 712-C-98-075](#), ultimately biodegradable as designated by EPA.
- (3) Trout toxicity: [OECD Test 203](#), zero mortality of [EPA 821-R-02-012](#), pass

2.2.3.1 Liquid-Filled Transformer Nameplates

Provide nameplate information in accordance with [IEEE C57.12.00](#) and as modified or supplemented by this section.

2.2.4 Corrosion Protection

Provide entire transformer assembly, including tank and radiator, base, enclosure, and metering enclosure fabricated of stainless steel conforming to [ASTM A240/A240M](#), Type 304 or 304L. Form enclosure of stainless steel sheets. The optional use of aluminum is permitted for the metering enclosure.

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

2.3 WARNING SIGNS AND LABELS

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

- a. When the enclosure integrity of such equipment is specified to be in accordance with [IEEE C57.12.28](#), such as for pad-mounted transformers, provide self-adhesive warning labels on the outside of the high voltage compartment door(s) with nominal dimensions of **7 by 10 inches** with the legend "WARNING HIGH VOLTAGE" printed in two lines of nominal

2 inch high letters. Include the word "WARNING" in white letters on an orange background and the words "HIGH VOLTAGE" in black letters on a white background.

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

2.4 ARC FLASH WARNING LABEL

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

2.5 GROUNDING AND BONDING

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

2.6 PADLOCKS

Provide padlocks for pad-mounted equipment and for each fence gate, keyed as directed by the Contracting Officer. Comply with Section 08 71 00 DOOR HARDWARE.

2.7 CAST-IN-PLACE CONCRETE

Provide concrete associated with electrical work for other than encasement of underground ducts rated for 4000 psi minimum 28-day compressive strength unless specified otherwise. Conform to the requirements of Section 03 47 13 TILT-UP CONCRETE.

Provide concrete associated with electrical work as follows:

- a. Composed of fine aggregate, coarse aggregate, portland cement, and water so proportioned and mixed as to produce a plastic, workable mixture.
- b. Fine aggregate: hard, dense, durable, clean, and uncoated sand.
- c. Coarse aggregate: reasonably well graded from 3/16 inch to 1 inch.
- d. Fine and coarse aggregates: free from injurious amounts of dirt, vegetable matter, soft fragments or other deleterious substances.
- e. Water: fresh, clean, and free from salts, alkali, organic matter, and other impurities.
- f. Concrete associated with electrical work for other than encasement of underground ducts: 4000 psi minimum 28-day compressive strength unless specified otherwise.
- g. Slump: Less than 4 inches. Retempering of concrete will not be permitted.
- h. Exposed, unformed concrete surfaces: smooth, wood float finish.

- i. Concrete must be cured for a period of not less than 7 days, and concrete made with high early strength portland cement must be repaired by patching honeycombed or otherwise defective areas with cement mortar as directed by the Contracting Officer.
- j. Air entrain concrete exposed to weather using an air-entraining admixture conforming to **ASTM C260/C260M**.
- k. Air content: between 4 and 6 percent.

2.8 SOURCE QUALITY CONTROL

2.8.1 Transformer Test Schedule

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

a. Test Instrument Calibration

- (1) Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.
- (2) Accuracy: Traceable to the National Institute of Standards and Technology.
- (3) Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.
- (4) Dated calibration labels: visible on all test equipment.
- (5) Calibrating standard: higher accuracy than that of the instrument tested.
- (6) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:
 - (a) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.
 - (b) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.8.2 Design Tests

IEEE C57.12.00, and **IEEE C57.12.90**. Section 5.1.2 in **IEEE C57.12.80** states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for the specified transformer(s), with design tests performed prior to the award of this contract.

- a. Tests: certified and signed by a registered professional engineer.
- b. Temperature rise: "Basically the same design" for the temperature rise test means a pad-mounted transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA, the same cooling type (KNAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.
- c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a pad-mounted transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests includes the primary windings only of that transformer.
 - (1) IEEE C57.12.90, paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98.
 - (2) State test voltage levels.
 - (3) Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.
- d. Lifting and moving devices: "Basically the same design" requirement for the lifting and moving devices test means a test report confirming that the lifting device being used is capable of handling the weight of the specified transformer in accordance with IEEE C57.12.34.
- e. Pressure: "Basically the same design" for the pressure test means a pad-mounted transformer with a tank volume within 30 percent of the tank volume of the transformer specified.
- f. Short circuit: "Basically the same design" for the short circuit test means a pad-mounted transformer with the same kVA as the transformer specified.

2.8.3 Routine and Other Tests

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

- a. Phase relation
- b. Ratio
- c. No-load losses (NLL) and excitation current
- d. Load losses (LL) and impedance voltage
- e. Dielectric
 - (1) Impulse
 - (2) Applied voltage
 - (3) Induced voltage

f. Leak

PART 3 EXECUTION

3.1 INSTALLATION

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

3.2 GROUNDING

NFPA 70 and **IEEE C2**, except provide grounding systems with a resistance to solid earth ground not exceeding **5** ohms.

3.2.1 Grounding Electrodes

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

3.2.2 Pad-Mounted Transformer Grounding

Provide a ground ring around the transformer with 4/0 AWG bare copper. Provide four ground rods in the ground ring, one per corner. Install the ground rods at least **10 feet** apart from each other. Provide separate copper grounding conductors and connect them to the ground loop as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

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

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

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

3.4 FIELD APPLIED PAINTING

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

3.5 WARNING SIGN MOUNTING

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

3.6 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

Mount transformer on prefabricated concrete support as indicated on the drawings as follows:

- a. Place prefabricated concrete support on a 6 inch thick, well-compacted gravel base.
- b. Install prefabricated concrete support such that top of support is approximately 12 inches above the finished grade with gradual slope for drainage.
- c. Provide support of adequate size to project at least 8 inches beyond the equipment.

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

3.6.1 Cast-In-Place Concrete

Provide cast-in-place concrete work in accordance with the requirements of Section 03 47 13 TILT-UP CONCRETE.

3.6.2 Sealing

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

3.7 FIELD QUALITY CONTROL

3.7.1 Performance of Acceptance Checks and Tests

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

3.7.1.1 Pad-Mounted Transformers

- a. Visual and mechanical inspection
 - (1) Compare equipment nameplate data with specifications and approved shop drawings.
 - (2) Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.
 - (3) Inspect anchorage, alignment, and grounding.
 - (4) Verify the presence of PCB content labeling.

- (5) Verify the bushings and transformer interiors are clean.
- (6) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.
- (7) Verify correct liquid level in tanks and bushings.
- (8) Verify that positive pressure is maintained on gas-blanketed transformers.
- (9) Perform specific inspections and mechanical tests as recommended by manufacturer.
- (10) Verify de-energized tap changer position is left as specified.
- (11) Verify the presence of transformer surge arresters.

b. Electrical tests

- (1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter.
- (2) Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.7.1.2 Grounding System

a. Visual and mechanical inspection

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

b. Electrical tests

- (1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.
- (2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.7.1.3 Surge Arresters, Medium- and High-Voltage

a. Visual and mechanical inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical and mechanical condition.
- (3) Inspect anchorage, alignment, grounding, and clearances.
- (4) Verify the arresters are clean.
- (5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.
- (6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

b. Electrical tests

- (1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.
- (2) Perform an insulation-resistance test on each arrester, phase terminal-to-ground.
- (3) Test grounding connection.

3.7.2 Follow-Up Verification

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

-- End of Section --

SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM

08/19

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

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

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- ANSI C80.1** (2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
- ANSI C80.3** (2015) American National Standard for Electrical Metallic Tubing (EMT)
- ANSI C80.5** (2015) American National Standard for Electrical Rigid Aluminum Conduit
- NEMA 250** (2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
- NEMA FU 1** (2012) Low Voltage Cartridge Fuses

NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA MG 1	(2018) Motors and Generators
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors
NEMA RN 1	(2017; Errata 2017) Standard for Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2016) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2015) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2016) Wiring Devices Dimensions Specifications
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

NFPA 70E (2021) Standard for Electrical Safety in the Workplace

NFPA 780 (2017) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-568-C.1 (2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard

TIA-569 (2015d) Commercial Building Standard for Telecommunications Pathways and Spaces

TIA-607 (2015c; Addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

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

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

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

29 CFR 1910.303 Electrical, General

UNDERWRITERS LABORATORIES (UL)

UL 1 (2005; Reprint Jan 2020) UL Standard for Safety Flexible Metal Conduit

UL 5 (2016; Reprint Aug 2020) UL Standard for Safety Surface Metal Raceways and Fittings

UL 5A (2015; Reprint Aug 2020) Nonmetallic Surface Raceways and Fittings

UL 6 (2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel

UL 6A (2008; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel

UL 20 (2010; Reprint Feb 2012) General-Use Snap Switches

UL 44 (2018) UL Standard for Safety Thermoset-Insulated Wires and Cables

UL 50 (2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations

UL 67 (2018; Reprint Jul 2020) UL Standard for Safety Panelboards

UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 198M	(2018) UL Standard for Mine-Duty Fuses
UL 360	(2013; Reprint Nov 2018) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 486A-486B	(2018) UL Standard for Safety Wire Connectors
UL 486C	(2019) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Aug 2020) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017) UL Standard for Safety Specialty Transformers
UL 508	(2018) UL Standard for Safety Industrial Control Equipment
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint Mar 2020) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Mar 2017) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters

UL 984	(1996; Reprint Sep 2005) Hermetic Refrigerant Motor-Compressors
UL 1063	(2017) UL Standard for Safety Machine-Tool Wires and Cables
UL 1242	(2006; Reprint Aug 2020) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2021) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 1660	(2019) Liquid-Tight Flexible Nonmetallic Conduit
UL 1699	(2017) UL Standard for Safety Arc-Fault Circuit-Interrupters
UL 4248-1	(2017) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2018) UL Standard for Safety Fuseholders - Part 12: Class R

1.2 DEFINITIONS

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

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Panelboards; G

Transformers; G

Cable Trays; G

Modular Power Distribution System; G

Marking Strips Drawings; G

SD-03 Product Data

Receptacles; G

Circuit Breakers; G

Switches; G

Transformers; G

Enclosed Circuit Breakers; G

Motor Controllers; G

Manual Motor Starters; G

Telecommunications Grounding Busbar; G

Surge Protective Devices; G

SD-06 Test Reports

600-volt Wiring Test; G

Grounding System Test; G

Transformer Tests; G

Ground-fault Receptacle Test; G

SD-07 Certificates

Fuses; G

SD-09 Manufacturer's Field Reports

Transformer Factory Tests

1.4 QUALITY ASSURANCE

1.4.1 Fuses

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

1.4.2 Regulatory Requirements

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

1.4.3 Standard Products

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

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
- b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3.1 Alternative Qualifications

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

1.4.3.2 Material and Equipment Manufacturing Date

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

1.5 WARRANTY

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

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

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

2.2 CONDUIT AND FITTINGS

Conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6.

2.2.1.2 Rigid Aluminum Conduit

ANSI C80.5, UL 6A.

2.2.2 Rigid Nonmetallic Conduit

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

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.5 Plastic-Coated Rigid Steel and IMC Conduit

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

2.2.6 Flexible Metal Conduit

UL 1.

2.2.6.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360.

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

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

2.2.7.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.7.2 Fittings for EMT

Steel compression type.

2.2.8 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC, and UL 514B.

2.2.9 Liquid-Tight Flexible Nonmetallic Conduit

UL 1660.

2.3 SURFACE RACEWAY

2.3.1 Surface Metal Raceway

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

2.3.2 Surface Nonmetallic Raceway

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

2.4 CABLE TRAYS

NEMA VE 1. Provide the following:

- a. Cable trays: form a wireway system, with a nominal 4 inch depth as indicated.
- b. Cable trays: constructed of steel that has been zinc-coated after fabrication.
- c. Cable trays: include splice and end plates, dropouts, and miscellaneous hardware.
- d. Edges, fittings, and hardware: finished free from burrs and sharp edges.
- e. Fittings: ensure not less than load-carrying ability of straight tray sections and have manufacturer's minimum standard radius.
- f. Radius of bends: as indicated.

2.4.1 Basket-Type Cable Trays

Provide of nominal 18, inch width and 4 inch depth with maximum wire mesh spacing of 2 by 4 inch.

2.5 OUTLET BOXES AND COVERS

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

2.5.1 Floor Outlet Boxes

Provide the following:

- a. Boxes: nonadjustable and concrete tight.
- b. Each outlet: consisting of cast-metal body with threaded openings, for conduits, brass flange ring, and cover plate with 1 1/4 inch threaded plug.
- c. Telecommunications outlets: consisting of flush, aluminum or stainless steel housing with a receptacle as specified and 3/4 inch top opening.
- d. Receptacle outlets: consisting of flush aluminum or stainless steel housing with duplex-type receptacle as specified herein.
- e. Provide gaskets where necessary to ensure watertight installation.

2.5.2 Outlet Boxes for Telecommunications System

Provide the following:

- a. Standard type 4 11/16 inches square by 2 1/8 inches deep.
- b. Outlet boxes for wall-mounted telecommunications outlets: 4 by 2 1/8 by 2 1/8 inches deep.

- c. Depth of boxes: large enough to allow manufacturers' recommended conductor bend radii.
- d. Outlet boxes for fiber optic telecommunication outlets: include a minimum **3/8 inch** deep single or two gang plaster ring as shown and installed using a minimum **one inch** conduit system.

2.6 CABINETS, JUNCTION BOXES, AND PULL BOXES

UL 50; volume greater than **100 cubic inches**, NEMA Type 1 enclosure; sheet steel, hot-dip, zinc-coated. Where exposed to wet, damp, or corrosive environments, NEMA Type 4X.

2.7 WIRES AND CABLES

Provide wires and cables in accordance applicable requirements of **NFPA 70** and **UL** for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 12 months prior to date of delivery to site.

2.7.1 Conductors

Provide the following:

- a. Conductor sizes and capacities shown are based on copper, unless indicated otherwise.
- b. Conductors No. 8 AWG and larger diameter: stranded.
- c. Conductors No. 10 AWG and smaller diameter: solid.
- d. Conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3: stranded unless specifically indicated otherwise.
- e. All conductors: copper.

2.7.1.1 Minimum Conductor Sizes

Provide minimum conductor size in accordance with the following:

- a. Branch circuits: No. 12 AWG.
- b. Class 1 remote-control and signal circuits: No. 14 AWG.
- c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.
- d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.
- e. Digital low voltage lighting control (DLVLC) system at 24 Volts or less: Category 5 UTP cables in EMT conduit.

2.7.2 Color Coding

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

2.7.2.1 Ground and Neutral Conductors

Provide color coding of ground and neutral conductors as follows:

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

2.7.2.2 Ungrounded Conductors

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

- a. 208/120 volt, three-phase
 - (1) Phase A - black
 - (2) Phase B - red
 - (3) Phase C - blue
- b. 480/277 volt, three-phase
 - (1) Phase A - brown
 - (2) Phase B - orange
 - (3) Phase C - yellow
- c. 120/240 volt, single phase: Black and red

2.7.3 Insulation

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

2.7.4 Bonding Conductors

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

2.7.4.1 Telecommunications Bonding Backbone (TBB)

Provide a copper conductor TBB in accordance with TIA-607 with No. 6 AWG minimum size, and sized at 2 kcmil per linear foot of conductor length up to a maximum size of 3/0 AWG.

2.7.4.2 Bonding Conductor for Telecommunications

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

2.8 SPLICES AND TERMINATION COMPONENTS

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

2.9 DEVICE PLATES

Provide the following:

- a. UL listed, one-piece device plates for outlets to suit the devices installed.
- b. For metal outlet boxes, plates on unfinished walls: zinc-coated sheet steel or cast metal having round or beveled edges.
- c. For nonmetallic boxes and fittings, other suitable plates may be provided.
- d. Plates on finished walls: nylon or lexan, minimum 0.03 inch wall thickness and same color as receptacle or toggle switch with which they are mounted.
- f. Screws: machine-type with countersunk heads in color to match finish of plate.
- g. Sectional type device plates are not be permitted.
- h. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.10 SWITCHES

2.10.1 Toggle Switches

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

- a. Handles: white thermoplastic.
- b. Wiring terminals: screw-type, side-wired.
- c. Contacts: silver-cadmium and contact arm - one-piece copper alloy.
- d. Switches: rated quiet-type ac only, 120/277 volts, with current rating and number of poles indicated.

2.10.2 Switch with Red Pilot Handle

NEMA WD 1. Provide the following:

- a. Pilot lights that are integrally constructed as a part of the switch's handle.
- b. Pilot light color: red and illuminate whenever the switch is closed or "on".
- c. Pilot lighted switch: rated 20 amps and 120 volts or 277 volts as indicated.
- d. The circuit's neutral conductor to each switch with a pilot light.

2.10.3 Breakers Used as Switches

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

2.10.4 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches where indicated, where switches are rated higher than 240 volts, and for double-throw switches. Utilize Class R fuseholders and fuses for fused switches, unless indicated otherwise. Provide horsepower rated for switches serving as the motor-disconnect means. Provide switches in NEMA 1 4X Type 304 stainless steel, enclosure as indicated per **NEMA ICS 6**.

2.11 FUSES

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

2.11.1 Fuseholders

Provide in accordance with **UL 4248-1**.

2.11.2 Cartridge Fuses, Current Limiting Type (Class R)

UL 198M, Class RK-1. Provide only Class R associated fuseholders in accordance with **UL 4248-12**.

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

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

2.11.4 Cartridge Fuses, Current Limiting Type (Class T)

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

2.12 RECEPTACLES

Provide the following:

- a. **UL 498**, general purpose specification grade, grounding-type. Residential grade receptacles are not acceptable.
- b. Ratings and configurations: as indicated.
- c. Bodies: white as per **NEMA WD 1**.
- d. Face and body: thermoplastic supported on a metal mounting strap.
- e. Dimensional requirements: per **NEMA WD 6**.
- f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.
- g. Grounding pole connected to mounting strap.
- h. The receptacle: containing triple-wire power contacts and double or triple-wire ground contacts.

2.12.1 Split Duplex Receptacles

Provide separate terminals for each ungrounded pole. One receptacle must be controlled separately.

2.12.2 Weatherproof Receptacles

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

2.12.3 Ground-Fault Circuit Interrupter Receptacles

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

2.12.4 Special Purpose Receptacles

Receptacles serving **telecommunication areas** are special purpose. Provide in ratings indicated.

2.12.5 Tamper-Resistant Receptacles

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

2.13 PANELBOARDS

Provide panelboards in accordance with the following:

- a. **UL 67** and **UL 50** having a short-circuit current rating as indicated .
- b. Panelboards for use as service disconnecting means: additionally

conform to [UL 869A](#).

- c. Panelboards: circuit breaker-equipped.
- d. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.
- e. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings.
- f. Use of "Subfeed Breakers" is not acceptable.
- g. Main breaker: "separately" mounted "above" or "below" branch breakers.
- h. Where "space only" is indicated, make provisions for future installation of breakers.
- i. Directories: indicate load served by each circuit in panelboard.
- j. Directories: indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).
- l. Type directories and mount in holder behind transparent protective covering.
- m. Panelboards: listed and labeled for their intended use.
- n. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.13.1 Enclosure

Provide panelboard enclosure in accordance with the following:

- a. [UL 50](#).
- b. Cabinets mounted outdoors or flush-mounted: hot-dipped galvanized after fabrication .
- c. Cabinets: painted in accordance with paragraph PAINTING.
- d. Outdoor cabinets: NEMA 4x with a removable steel plate [1/4 inch](#) thick in the bottom for field drilling for conduit connections.
- e. Front edges of cabinets: form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front.
- f. All cabinets: fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than [1/8 inch](#).
- g. Holes: provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a [1/2 inch](#) clear space between the back of the cabinet and the wall surface.
- h. Flush doors: mounted on hinges that expose only the hinge roll to

view when the door is closed.

- i. Each door: fitted with a combined catch and lock latch.
- j. Keys: two provided with each lock, with all locks keyed alike.
- k. Finished-head cap screws: provided for mounting the panelboard fronts on the cabinets.
- l. Front covers: Provide fully hinged front covers with a hinged door for accessing circuit breaker handles (door-in-door arrangement).

2.13.2 Panelboard Buses

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

2.13.2.1 Panelboard Neutrals for Non-Linear Loads

Provide in accordance with the following:.

- a. UL listed, with panelboard type specifically UL heat rise tested for use on non-linear loads.
- b. Panelboard: heat rise tested in accordance with [UL 67](#), except with the neutral assembly installed and carrying 200 percent of the phase bus current during testing.
- c. Verification of the testing procedure: provided upon request.
- d. Two neutral assemblies paralleled together with cable is not acceptable.
- e. Nameplates for panelboard rated for use on non-linear loads: marked "SUITABLE FOR NON-LINEAR LOADS" and in accordance with paragraph FIELD FABRICATED NAMEPLATES.
- f. Provide a neutral label with instructions for wiring the neutral of panelboards rated for use on non-linear loads.

2.13.3 Circuit Breakers

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

2.13.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent

breaker poles are connected to Phases A, B, and C, respectively.

2.13.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

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

2.13.3.3 Arc-Fault Circuit Interrupters

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

2.14 ENCLOSED CIRCUIT BREAKERS

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

2.15 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

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

2.16 TRANSFORMERS

Provide transformers in accordance with the following:

- a. NEMA ST 20, general purpose, dry-type, self-cooled, ventilated type in non-hazardous indoor locations and unventilated sealed type in outdoor or classified areas, as indicated.
- b. Provide transformers in NEMA 1 enclosure for indoor locations or NEMA 4X stainless steel enclosure for outdoor locations, as indicated.
- c. Taps for transformers 15 kVA and larger: Two 2.5 percent taps Full Capacity Above Nominal (FCAN) and two 2.5 percent taps Full Capacity Below Nominal (FCBN) .
- d. Transformer insulation system:
 - (1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 115 degrees C under full-rated load in maximum ambient of 40 degrees C.
 - (2) 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 80 degrees C under full-rated load in maximum ambient of 40 degrees C.
- e. Transformer of 150 degrees C temperature rise is not acceptable.

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

2.16.1 Specified Transformer Efficiency

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

2.16.2 Transformers With Non-Linear Loads

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

- a. Transformer insulation: UL recognized 220 degrees C system. Neither the primary nor the secondary temperature is allowed to exceed 220 degrees C at any point in the coils while carrying their full rating of non-sinusoidal load.
- b. Transformers are to be UL listed and labeled for K-13 in accordance with UL 1561.
- c. Transformers evaluated by the UL K-Factor evaluation: listed for 115 degrees C average temperature rise only.
- d. Transformers with K-Factor ratings with temperature rise of 150 degrees C rise are not acceptable.
- e. K-Factor rated transformers impedance: allowed range of 3 percent to 5 percent, with a minimum reactance of 2 percent to prevent excessive neutral current when supplying loads with large amounts of third harmonic.

2.17 MOTORS

Provide motors in accordance with the following:

- a. NEMA MG 1
- b. Hermetic-type sealed motor compressors: Also comply with UL 984.
- c. Provide the size in terms of HP, or kVA, or full-load current, or a combination of these characteristics, and other characteristics, of each motor as indicated or specified.
- d. Determine specific motor characteristics to ensure provision of correctly sized starters and overload heaters.
- e. Rate motors for operation on 208-volt, 3-phase circuits with a terminal voltage rating of 200 volts, and those for operation on 480-volt, 3-phase circuits with a terminal voltage rating of 460 volts.
- f. Use motors designed to operate at full capacity with voltage variation of plus or minus 10 percent of motor voltage rating.
- g. Unless otherwise indicated, use continuous duty type motors if rated 1

HP and above.

- h. Where fuse protection is specifically recommended by the equipment manufacturer, provide fused switches in lieu of non-fused switches indicated.
- i. Use Inverter-Rated motors designed to operate with adjustable speed drive (ASD).

2.17.1 High Efficiency Single-Phase Motors

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

2.17.2 Premium Efficiency Polyphase and Single-Phase Motors

Select polyphase and continuous-duty single phase motors based on high efficiency characteristics relative to typical characteristics and applications as listed in NEMA MG 10 and NEMA MG 11. In addition, continuous rated, polyphase squirrel-cage medium induction motors must meet the requirements for premium efficiency electric motors in accordance with NEMA MG 1, including the NEMA full load efficiency ratings. In exception, for motor-driven equipment with a minimum seasonal or overall efficiency rating, such as a SEER rating, provide equipment with motor to meet the overall system rating indicated.

2.17.3 Motor Sizes

Provide size for duty to be performed, not exceeding the full-load nameplate current rating when driven equipment is operated at specified capacity under most severe conditions likely to be encountered. When motor size provided differs from size indicated or specified, make adjustments to wiring, disconnect devices, and branch circuit protection to accommodate equipment actually provided. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

2.17.4 Wiring and Conduit

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

2.18 MOTOR CONTROLLERS

Provide motor controllers in accordance with the following:

- a. UL 508, NEMA ICS 1, and NEMA ICS 2.
- b. Provide controllers with thermal overload protection in each phase,

and one spare normally open auxiliary contact, and one spare normally closed auxiliary contact.

- c. Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage.
- d. Provide protection for motors from immediate restart by a time adjustable restart relay.
- e. When used with pressure, float, or similar automatic-type or maintained-contact switch, provide a hand/off/automatic selector switch with the controller.
- f. Connections to selector switch: wired such that only normal automatic regulatory control devices are bypassed when switch is in "hand" position.
- g. Safety control devices, such as low and high pressure cutouts, high temperature cutouts, and motor overload protective devices: connected in motor control circuit in "hand" and "automatic" positions.
- h. Control circuit connections to hand/off/automatic selector switch or to more than one automatic regulatory control device: made in accordance with indicated or manufacturer's approved wiring diagram.
- i. Provide selector switch with the means for locking in any position.
- j. Provide a disconnecting means, capable of being locked in the open position, for the motor that is located in sight from the motor location and the driven machinery location. As an alternative, provide a motor controller disconnect, capable of being locked in the open position, to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location.
- k. Overload protective devices: provide adequate protection to motor windings; be thermal inverse-time-limit type; and include manual reset-type pushbutton on outside of motor controller case.
- l. Cover of combination motor controller and manual switch or circuit breaker: interlocked with operating handle of switch or circuit breaker so that cover cannot be opened unless handle of switch or circuit breaker is in "off" position.
- m. Minimum short circuit withstand rating of combination motor controller: 10,000 rms symmetrical amperes.
- n. Provide controllers in hazardous locations with classifications as indicated.

2.18.1 Control Wiring

Provide control wiring in accordance with the following:

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

- b. Hinge wire: Class K stranding.
- c. Current transformer secondary leads: not smaller than No. 10 AWG.
- d. Control wire minimum size: No. 14 AWG.
- e. Power wiring for 480-volt circuits and below: the same type as control wiring with No. 12 AWG minimum size.
- f. Provide wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.18.2 Control Circuit Terminal Blocks

Provide control circuit terminal blocks in accordance with the following:

- a. NEMA ICS 4.
- b. Control circuit terminal blocks for control wiring: molded or fabricated type with barriers, rated not less than 600 volts.
- c. Provide terminals with removable binding, fillister or washer head screw type, or of the stud type with contact and locking nuts.
- d. Terminals: not less than No. 10 in size with sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal.
- e. Terminal arrangement: subject to the approval of the Contracting Officer with not less than four spare terminals or 10 percent, whichever is greater, provided on each block or group of blocks.
- f. Modular, pull apart, terminal blocks are acceptable provided they are of the channel or rail-mounted type.
- g. Submit data showing that any proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.18.2.1 Types of Terminal Blocks

- a. Short-Circuiting Type: Short-circuiting type terminal blocks: furnished for all current transformer secondary leads with provision for shorting together all leads from each current transformer without first opening any circuit. Terminal blocks: comply with the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.
- b. Load Type: Load terminal blocks rated not less than 600 volts and of adequate capacity: provided for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits, except those for feeder tap units. Provide terminals of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Provide each

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

2.18.3 Control Circuits

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

2.18.4 Enclosures for Motor Controllers

NEMA ICS 6.

2.18.5 Multiple-Speed Motor Controllers and Reversible Motor Controllers

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

2.18.6 Pushbutton Stations

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

2.18.7 Pilot and Indicating Lights

Provide LED cluster lamps.

2.19 **MANUAL MOTOR STARTERS** (MOTOR RATED SWITCHES)

Single **or** Double pole designed for surface mounting with overload protection and pilot lights, **as indicated.**

2.19.1 Pilot Lights

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

2.20 LOCKOUT REQUIREMENTS

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

2.21 TELECOMMUNICATIONS SYSTEM

Provide system of telecommunications wire-supporting structures (pathway), including: outlet boxes, conduits with pull wires, wireways, cable trays, and other accessories for telecommunications outlets and pathway in accordance with **TIA-569** and as specified herein. Additional

telecommunications requirements are specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

2.22 GROUNDING AND BONDING EQUIPMENT

2.22.1 Ground Rods

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

2.22.2 Ground Bus

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

2.22.3 Telecommunications and CATV Grounding Busbar

Provide corrosion-resistant grounding busbar suitable for indoor installation in accordance with TIA-607. Busbars: plated for reduced contact resistance. If not plated, clean the busbar prior to fastening the conductors to the busbar and apply an anti-oxidant to the contact area to control corrosion and reduce contact resistance. Provide a telecommunications main grounding busbar (TMGB) in the telecommunications entrance facility and a (TGB) in all other telecommunications rooms and equipment rooms. The telecommunications main grounding busbar (TMGB) and the telecommunications grounding busbar (TGB): sized in accordance with the immediate application requirements and with consideration of future growth. Provide telecommunications grounding busbars with the following:

- a. Predrilled copper busbar provided with holes for use with standard sized lugs,
- b. Minimum dimensions of 0.25 in thick by 4 in wide for the TMGB and 2 in wide for TGBs with length as indicated;
- c. Listed by a nationally recognized testing laboratory.

2.23 MANUFACTURER'S NAMEPLATE

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

2.24 FIELD FABRICATED NAMEPLATES

Provide field fabricated nameplates in accordance with the following:

- a. ASTM D709.
- b. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings.
- c. Each nameplate inscription: identify the function and, when applicable, the position.
- d. Nameplates: melamine plastic, 0.125 inch thick, white with black

center core.

- e. Provide red laminated plastic label with white center core where indicated.
- f. Surface: matte finish. Corners: square. Accurately align lettering and engrave into the core.
- g. Minimum size of nameplates: one by 2.5 inches.
- h. Lettering size and style: a minimum of 0.25 inch high normal block style.

2.25 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA 2535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.26 FIRESTOPPING MATERIALS

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

2.27 MODULAR POWER DISTRIBUTION SYSTEM

The modular power distribution system shall consist of a modular wiring system, with quick connection of components, to provide a zone distribution of multiple circuits to raised access floor boxes. Component's wiring shall not be de-populated to impede future reconfigurations. System shall fit within a 1.75 inch tall cavity under a raised floor, minimum. The system shall be UL 183 listed and certified to CSA 22.2 No. 203-M. Connectors will be polarity keyed and shaped to prevent interconnection of electrically incompatible components. The modular power distribution system shall be in accordance with NEC Article 604 and all applicable UL standards. All components shall be labeled with both voltage ratings and installation information. The system shall be designed and keyed to prevent mismatching of different voltages. All devices and wiring shall be rated for 20 amperes, minimum. The connector-grounding pin on each modular assembly shall be designed so that the grounding connection is made, prior to the contact made within the current carrying conductors, per NEC Article 604.

Home Run Cable: The cable shall be metal clad cable consisting of multiple #10 AWG, THHN 90 C insulation. The cable type shall be UL listed and recognized as outlined in Article #334 of the latest edition of National Electrical Code.

Main Distribution Box: A Main Distribution Box (MDB) with multiple ports (as noted on the plans) shall provide general-purpose 3-phase, 120/208 volts power. The MDB shall include a home run as specified. Ground conductors shall be added as required by National Electrical Code (NEC). The MDB shall be UL-listed and identified accordingly. The MDB

shall be suitable for use in environmental air-handling spaces (plenums) in accordance with NEC 300.22(c).

Extender Cables: Extender cables shall interface with the MDB and feed to the Secondary Distribution Boxes as indicated on the plans. Extender cables shall consist of 90 degree C insulated, #12 AWG solid copper conductors, with a #12 AWG solid copper ground conductor. The extender cable shall have line side (power out) and load side (power in) connectors. The connectors shall be capable of having 5 pins for the distribution of 3-phase, 4 wire, 120/208 volt general-purpose power.

Floor Box Modules: The Floor Box Modules shall be designed for use in the open office environment. It shall provide power and telecom outlets in a raised floor as shown on the plans. The Floor Box Module shall have a square shape to allow repositioning to any of four orientations without modification of the module or floor panel. The dual compartment enclosure shall be fitted with power receptacles and telecommunications jack arrangements as shown on the plans. The floor box shall be pre-wired with the specified electrical devices at the factory and tested for continuity and highpot prior to installation.

2.28 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with **UL 1449** at the service entrance, load centers, panelboards, and switchboards. Provide surge protectors in a NEMA 1 enclosure for indoor installations and NEMA 4X stainless steel enclosure for outdoor installations per **NEMA ICS 6**. SPD must have the same short-circuit current rating as the protected equipment and shall not be installed at a point of system where the available fault current is in excess of that rating. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker. Submit performance and characteristic curves.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-

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

SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G) and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G).

Provide SPDs per NFPA 780 for the lightning protection system.

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

- 600V for 120V, single phase system

- 600V for 208Y/120V, three phase system
- 1,200V for 480Y/277V, three phase system

Maximum L-G Protection Rating:

- 700V for 120V, single phase system

- 700V for 208Y/120V, three phase system

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

Maximum L-L Voltage Protection Rating:

1,200V for 208Y/120V, three phase system

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

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

2.29 FACTORY APPLIED FINISH

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

- a. **NEMA 250** corrosion-resistance test and the additional requirements as specified herein.
- b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.
- c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.
- d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.
- e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.
- f. Equipment located indoors: ANSI Light Gray, and equipment located outdoors: ANSI Light Gray.
- g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.30 SOURCE QUALITY CONTROL

2.30.1 Transformer Factory Tests

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

2.31 COORDINATED POWER SYSTEM PROTECTION

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

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof and hazardous locations and ducts, plenums and other air-handling spaces: conform to requirements

of NFPA 70 and IEEE C2 and to requirements specified herein.

3.1.1 Underground Service

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

3.1.2 Service Entrance Identification

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

3.1.2.1 Labels

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

3.1.3 Wiring Methods

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

3.1.3.1 Pull Wire

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

3.1.4 Conduit Installation

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

3.1.4.1 Restrictions Applicable to Aluminum Conduit

- a. Do not install underground or encase in concrete or masonry.

- b. Do not use brass or bronze fittings.
- c. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.2 Restrictions Applicable to EMT

- a. Do not install underground.
- b. Do not encase in concrete, mortar, grout, or other cementitious materials.
- c. Do not use in areas subject to physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.
- d. Do not use in hazardous areas.
- e. Do not use outdoors.
- f. Do not use in fire pump rooms.
- g. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.4.3 Restrictions Applicable to Nonmetallic Conduit

- a. PVC Schedule 40.
 - (1) Do not use where subject to physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, fire pump rooms, and where restrictions are applying to both PVC Schedule 40 and PVC Schedule 80.
 - (2) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.
- b. PVC Schedule 40 and Schedule 80.
 - (1) Do not use where subject to physical damage, including but not limited to, hospitals, power plant, missile magazines, and other such areas.
 - (2) Do not use in hazardous (classified) areas.
 - (3) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

3.1.4.4 Restrictions Applicable to Flexible Conduit

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

3.1.4.5 Underground Conduit

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

3.1.4.6 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.1.4.7 Conduit Installed Under Floor Slabs

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

3.1.4.8 Conduit Through Floor Slabs

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

3.1.4.9 Conduit Installed in Concrete Floor Slabs

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

3.1.4.10 Stub-Ups

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

3.1.4.11 Conduit Support

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

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

3.1.4.12 Directional Changes in Conduit Runs

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

3.1.4.13 Locknuts and Bushings

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

3.1.4.14 Flexible Connections

Provide flexible steel conduit between 3 and 6 feet in length for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: 1/2 inch diameter. Provide liquid tight flexible conduit in wet and damp locations and in fire pump rooms for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.1.4.15 Telecommunications and Signal System Pathway

Install telecommunications pathway in accordance with TIA-569.

- a. Horizontal Pathway: Telecommunications pathways from the work area to the telecommunications room: installed and cabling length requirements in accordance with TIA-568-C.1. Size conduits, wireways, and cable trays in accordance with TIA-569 and as indicated.
- b. Backbone Pathway: Telecommunication pathways from the telecommunications entrance facility to telecommunications rooms, and, telecommunications equipment rooms (backbone cabling): installed in accordance with TIA-569. Size conduits, wireways, and cable trays for telecommunications risers in accordance with TIA-569 and as indicated.

3.1.5 Busway Installation

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

3.1.6 Cable Tray Installation

Install cable trays parallel with or at right angles to ceilings, walls, and structural members. Support at maximum **6 foot** intervals. In addition, install and ground telecommunications cable tray in accordance with **TIA-569**, and **TIA-607** Ensure edges, fittings, and hardware are finished free from burrs and sharp edges. Provide No. 2 AWG bare copper wire throughout cable tray system, and bond to each section. Use No. 1/0 aluminum wire if cable tray is aluminum. Install conductors that run through smoke and fire partitions in **4 inch** rigid steel conduits with grounding bushing, extending **12 inches** beyond each side of partitions. Seal conduit on both ends to maintain smoke and fire ratings of partitions. Provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.7 Boxes, Outlets, and Supports

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

metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.7.1 Boxes

Boxes for use with raceway systems: minimum 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets: minimum 4 inches square, except that 4 by 2 inch boxes may be used where only one raceway enters outlet. Telecommunications outlets: a minimum of 5 inches square by 2 7/8 inches deep, except for wall mounted telephones and outlet boxes for handicap telephone stations. Mount outlet boxes flush in finished walls.

3.1.7.2 Pull Boxes

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

3.1.8 Mounting Heights

Mount panelboards, enclosed circuit breakers, motor controller and disconnecting switches so height of operating handle at its highest position is maximum 78 inches above floor. Mount lighting switches 48 inches above finished floor. Mount receptacles and telecommunications outlets 18 inches above finished floor, unless otherwise indicated. Wall-mounted telecommunications outlets: mounted at height indicated. Mount other devices as indicated. Measure mounting heights of wiring devices and outlets in non-hazardous areas to center of device or outlet. Measure mounting heights of receptacle outlet boxes in the hazardous area to the bottom of the outlet box.

3.1.9 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves. Identify control circuit terminations in accordance with Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC. Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.

3.1.9.1 Marking Strips

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

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

- b. Use permanent ink for the wire numbers
- c. Provide reversible marking strips to permit marking both sides, or provide two marking strips with each block.
- d. Size marking strips to accommodate the two sets of wire numbers.
- e. Assign a device designation in accordance with **NEMA ICS 1** to each device to which a connection is made. Mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Contractor's schematic and connection diagrams.
- f. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Government's wire designations.
- g. Prints of the **marking strips** drawings submitted for approval will be so marked and returned to the Contractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.1.10 Splices

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

3.1.10.1 Splices of Aluminum Conductors

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

3.1.11 Covers and Device Plates

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

3.1.12 Electrical Penetrations

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

3.1.13 Grounding and Bonding

Provide in accordance with **NFPA 70** and **NFPA 780**. Ground exposed, non-current-carrying metallic parts of electrical equipment, access flooring support system, metallic raceway systems, grounding conductor in

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

3.1.13.1 Ground Rods

Provide ground rods and measure the resistance to ground using the fall-of-potential method described in [IEEE 81](#). Do not exceed 5 ohms under normally dry conditions for the maximum resistance of a driven ground. If the resultant resistance exceeds 5 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer who will decide on the number of ground rods to add.

3.1.13.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required, by exothermic weld or high compression connector.

- a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.
- b. Make high compression connections using a hydraulic or electric compression tool to provide the correct circumferential pressure. Provide tools and dies as recommended by the manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.13.3 Ground Bus

Provide a copper ground bus in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of electrical equipment: effectively grounded by bonding to the ground bus. Bond the ground bus to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately [4 inches](#) above the floor. Make connections and splices of the brazed, welded, bolted, or pressure-connector type, except use pressure connectors or bolted connections for connections to removable equipment.

3.1.13.4 Resistance

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

3.1.13.5 Telecommunications System

Provide telecommunications grounding in accordance with the following:

- a. **Telecommunications Grounding Busbars:** Provide a telecommunications main grounding busbar (TMGB) in the telecommunications entrance facility. Install the TMGB as close to the electrical service entrance grounding connection as practicable. Provide a telecommunications grounding busbar (TGB) in all other telecommunications rooms and telecommunications equipment rooms. Install the TGB as close to the telecommunications room panelboard as practicable, when equipped. Where a panelboard for telecommunications equipment is not installed in the telecommunications room, locate the TGB near the backbone cabling and associated terminations. In addition, locate the TGB to provide for the shortest and straightest routing of the grounding conductors. Where a panelboard for telecommunications equipment is located within the same room or space as a TGB, bond that panelboard's alternating current equipment ground (ACEG) bus (when equipped) or the panelboard enclosure to the TGB. Install telecommunications grounding busbars to maintain clearances as required by **NFPA 70** and insulated from its support. A minimum of **2 inches** separation from the wall is recommended to allow access to the rear of the busbar and adjust the mounting height to accommodate overhead or underfloor cable routing.
- b. **Telecommunications Bonding Conductors:** Provide main telecommunications service equipment ground consisting of separate bonding conductor for telecommunications, between the TMGB and readily accessible grounding connection of the electrical service. Grounding and bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place grounding and bonding conductors in ferrous metallic conduit that exceeds **3 feet** in length, bond the conductors to each end of the conduit using a grounding bushing or a No. 6 AWG conductor, minimum. Provide a telecommunications bonding backbone (TBB) that originates at the TMGB extends throughout the building using the telecommunications backbone pathways, and connects to the TGBs in all telecommunications rooms and equipment rooms. Install the TBB conductors such that they are protected from physical and mechanical damage. The TBB conductors should be installed without splices and routed in the shortest possible straight-line path. Make the bonding conductor between a TBB and a TGB continuous. Where splices are necessary, the number of splices should be a minimum. Make the splices accessible and located in telecommunications spaces. Connect joined segments of a TBB using exothermic welding, irreversible compression-type connectors, or equivalent. Install all joints to be adequately supported and protected from damage. Whenever two or more TBBs are used within a multistory building, bond the TBBs together with a grounding equalizer (GE) at the top floor and at a minimum of every third floor in between. Do not connect the TBB and GE to the pathway ground, except at the TMGB or the TGB.
- c. **Telecommunications Grounding Connections:** Telecommunications grounding connections to the TMGB or TGB: utilize listed compression two-hole lugs, exothermic welding, suitable and equivalent one hole non-twisting lugs, or other irreversible compression type connections. Bond all metallic pathways, cabinets, and racks for telecommunications cabling and interconnecting hardware located within the same room or space as the TMGB or TGB to the TMGB or TGB respectively. In a metal frame (structural steel) building, where the

steel framework is readily accessible within the room; bond each TMGB and TGB to the vertical steel metal frame using a minimum No. 6 AWG conductor. Where the metal frame is external to the room and readily accessible, bond the metal frame to the TGB or TMGB with a minimum No. 6 AWG conductor. When practicable because of shorter distances and, where horizontal steel members are permanently electrically bonded to vertical column members, the TGB may be bonded to these horizontal members in lieu of the vertical column members. All connectors used for bonding to the metal frame of a building must be listed for the intended purpose.

3.1.14 Equipment Connections

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

3.1.15 Government-Furnished Equipment

Contractor rough-in for Government-furnished equipment to make equipment operate as intended, including providing miscellaneous items such as plugs, receptacles, wire, cable, conduit, flexible conduit, and outlet boxes or fittings.

3.1.16 Repair of Existing Work

Perform repair of existing work, demolition, and modification of existing electrical distribution systems as follows:

3.1.16.1 Workmanship

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

3.1.16.2 Existing Concealed Wiring to be Removed

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

3.1.16.3 Removal of Existing Electrical Distribution System

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

3.1.16.4 Continuation of Service

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

3.1.17 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet avoiding 90 degree bends.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

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

3.3 WARNING SIGN MOUNTING

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

3.4 FIELD APPLIED PAINTING

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

3.5 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer 5 working days notice prior to each test.

3.5.1 Devices Subject to Manual Operation

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

3.5.2 600-Volt Wiring Test

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

3.5.3 Transformer Tests

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

3.5.4 Ground-Fault Receptacle Test

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

3.5.5 Grounding System Test

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

3.5.6 Phase Rotation Test

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

-- End of Section --

SECTION 26 24 13

SWITCHBOARDS

05/15

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 ((2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A153/A153M (2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A240/A240M (2020a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

ASTM A653/A653M (2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A780/A780M (2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

ASTM D149 (2020) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

ASTM D1535 (2014; R 2018) Standard Practice for Specifying Color by the Munsell System

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81 (2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA PB 2.1	(2013) General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 V or Less
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA ST 20	(2014) Dry-Type Transformers for General Applications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 891	(2005; Reprint Oct 2012) Switchboards

1.2 RELATED REQUIREMENTS

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

1.3 DEFINITIONS

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

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor QC approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20, SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Switchboard Drawings; G

SD-03 Product Data

Switchboard; G

SD-06 Test Reports

Switchboard Design Tests; G

Switchboard Production Tests; G

Acceptance Checks and Tests; G

SD-07 Certificates

Cybersecurity Equipment Certification; G

Submit certification indicating conformance with the paragraph CYBERSECURITY EQUIPMENT CERTIFICATION.

Cybersecurity Installation Certification; G

Submit certification indicating conformance with the paragraph CYBERSECURITY INSTALLATION CERTIFICATION.

SD-10 Operation and Maintenance Data

Switchboard Operation and Maintenance, Data Package 5; G

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals; G

Equipment Test Schedule; G

Required Settings; G

Service Entrance Available Fault Current Label; G

1.5 QUALITY ASSURANCE

1.5.1 Product Data

Include manufacturer's information on each submittal for each component, device and accessory provided with the switchboard including:

- a. Circuit breaker type, interrupting rating, and trip devices, including available settings.
- b. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device.

1.5.2 Switchboard Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices. Include the nameplate data, size, and capacity on submittal. Also include applicable federal, military, industry, and technical society publication references on submittals. Include the following:

- a. One-line diagram including breakers, fuses, current transformers, and meters.
- b. Outline drawings including front elevation, section views, footprint, and overall dimensions.
- c. Bus configuration including dimensions and ampere ratings of bus bars.
- d. Markings and NEMA nameplate data, including fuse information (manufacturer's name, catalog number, and ratings).
- e. Circuit breaker type, interrupting rating, and trip devices, including available settings.
- f. Wiring diagrams and elementary diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.
- g. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device. Use this information (designer of record) to provide breaker settings that ensures protection and coordination are achieved. For Navy installations, provide electronic format curves using EasyPower device library format depending on installation modeling software requirements.

1.5.3 Regulatory Requirements

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

1.5.4 Standard Products

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

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
- b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

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

1.5.4.2 Material and Equipment Manufacturing Date

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

1.6 MAINTENANCE

1.6.1 Switchboard Operation and Maintenance Data

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

1.6.2 Assembled Operation and Maintenance Manuals

Assemble and securely bind manuals in durable, hard covered, water resistant binders. Assemble and index the manuals in the following order with a table of contents:

- a. Manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA.
- b. Catalog data required by the paragraph SD-03, PRODUCT DATA.

- c. Drawings required by the paragraph SD-02, SHOP DRAWINGS.
- d. Prices for spare parts and supply list.
- e. Information on metering.
- f. Design test reports.
- g. Production test reports.

1.7 WARRANTY

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

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

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

2.2 SWITCHBOARD

NEMA PB 2 and UL 891.

2.2.1 Ratings

Provide equipment with the following ratings:

- a. Voltage rating: 480Y/277 volts AC, three-phase, 4-wire.
- b. Continuous current rating of the main bus: as indicated.
- c. Short-circuit current rating: as indicated.
- d. UL listed and labeled as service entrance equipment.

2.2.2 Construction

Provide the following:

- a. Switchboard: consisting of one or more vertical sections bolted together to form a rigid assembly and rear aligned as indicated.
- b. All circuit breakers: front accessible.
- c. Rear aligned switchboards: front accessible load connections.
- d. Where indicated, "space for future" or "space" means to include a vertical bus provided behind a blank front cover. Where indicated, "provision for future" means full hardware provided to mount a breaker suitable for the location.
- e. Completely factory engineered and assembled, including protective devices and equipment indicated with necessary interconnections,

instrumentation, and control wiring.

2.2.2.1 Enclosure

Provide the following:

- a. Enclosure: NEMA ICS 6 Type 1 enclosure for indoor installation or NEMA 4X fabricated entirely of 12 gauge ASTM A240/A240M type 304 or 304L stainless steel for outdoor installation, as indicated on plans.
- b. Enclosure: bolted together with removable bolt-on side and rear covers.
- c. Front doors: provided with stainless steel padlockable vault handles with a three point catch.
- d. Bases, frames and channels of enclosure: corrosion resistant and fabricated of ASTM A240/A240M type 304 or 304L stainless steel for outdoor installation or galvanized steel for indoor installation.
- e. Base: includes any part of enclosure that is within 3 inches of concrete pad.
- f. Galvanized steel: ASTM A123/A123M, ASTM A653/A653M G90 coating, and ASTM A153/A153M, as applicable. Galvanize after fabrication where practicable.
- g. Paint color: ASTM D1535 light gray No. 61 or No. 49 over rust inhibitor.
- h. Paint coating system: comply with IEEE C57.12.28 for galvanized steel and IEEE C57.12.29 for stainless steel.

2.2.2.2 Bus Bars

Provide the following:

- a. Bus bars: copper with silver-plated contact surfaces.
 - (1) Phase bus bars: insulated with a tape wrap or insulating sleeve providing a minimum breakdown voltage of 16,000 volts per ASTM D149.
 - (2) Neutral bus: rated 100 percent of the main bus continuous current rating as indicated.
- b. Make bus connections and joints with hardened steel bolts.
- c. Main-bus (through bus): rated at the full ampacity of the main throughout the switchboard.
- d. Minimum one-quarter by 2 inch copper ground bus secured to each vertical section along the entire length of the switchboard.

2.2.2.3 Main Section

Provide the main section consisting of an individually mounted fixed air power circuit breaker or insulated-case circuit breaker, as indicated.

2.2.2.4 Distribution Sections

Provide the distribution sections consisting of individually mounted, insulated-case circuit breakers and/or molded-case circuit breakers as indicated.

2.2.2.5 Auxiliary Sections

Provide auxiliary sections consisting of indicated metering equipment, control equipment, current transformer compartments as indicated.

2.2.2.6 Handles

Provide handles for individually mounted devices of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

2.2.3 Protective Device

Provide main and branch protective devices as indicated.

2.2.3.1 Insulated-Case Breaker

Provide the following:

- a. **UL 489.** UL listed and labeled, 100 percent rated main breaker, manually operated, low voltage, insulated-case circuit breaker, with a short-circuit current rating as indicated at 480Y/277 volts.
- b. Breaker frame size: as indicated.
- c. Series rated circuit breakers are unacceptable.

2.2.3.2 Molded-Case Circuit Breaker

Provide the following:

- a. **UL 489.** UL listed and labeled, standard rated branch breakers, manually operated, low voltage molded-case circuit breaker, with a short-circuit current rating of as indicated at 480Y/277 volts.
- b. Breaker frame size: as indicated.
- c. Series rated circuit breakers are unacceptable.

2.2.4 Electronic Trip Units

Equip main and distribution breakers as indicated with a solid-state tripping system consisting of three current sensors and a microprocessor-based trip unit that provides true rms sensing adjustable time-current circuit protection. Include the following:

- a. Current sensors ampere rating: as indicated.
- b. Trip unit ampere rating: as indicated.
- c. Ground fault protection: as indicated.

d. Electronic trip units: provide additional features as indicated:

- (1) Indicated Breakers: include long delay pick-up and time settings, and LED indication of cause of circuit breaker trip.
- (2) Main breakers: include short delay pick-up and time settings and, instantaneous settings and ground fault settings as indicated.
- (3) Distribution breakers: include short delay pick-up and time settings, instantaneous settings as indicated.
- (8) For electronic trip units that are rated for or can be adjusted to 1,200 amperes or higher, provide arc energy reduction capability with an energy-reducing maintenance switch with local status indicator.

2.2.5 Metering

2.2.5.1 Digital Meters

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

a. Display capability:

- (1) Multi-Function Meter: Display a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, KVA, kVAR, FREQ, kVAh, kWh. Detected alarm conditions include over/under current, over/under voltage, over/under KVA, over/under frequency, over/under selected PF/kVAR, voltage phase reversal, voltage imbalance, reverse power, over percent THD. Include a Form C KYZ pulse output relay on the meter.
- b. Design meters to accept input from standard 5A secondary instrument transformers and direct voltage monitoring range to 600 volts, phase to phase.
 - c. Provide programming via a front panel display and a communication interface accessible by a computer.
 - d. Provide password secured programming stored in non-volatile EEPROM memory.
 - e. Provide digital communications in a Modbus RTU protocol via a RS485 serial port and an independently addressable RS485 serial port.
 - f. Provide meter that calculates and stores average max/min demand values with time and date for all readings based on a user selectable sliding window averaging period.
 - g. Provide meter with programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.
 - h. Provide meter with a display of Total Harmonic Distortion (THD) measurement to a minimum of the thirty-first order.

- i. Include historical trend logging capability with the ability to store up to 100,000 data points with intervals of 1 second to 180 minutes. Provide a unit that can store and time stamp up to 1000 programmable triggered conditions.
- j. Provide event waveform recording triggered by the rms of 2 cycles of voltage or current exceeding programmable set points. Store waveforms for all 6 channels of voltage and current for a minimum of 10 cycles prior to the event and 50 cycles past the event.

2.2.5.2 Electronic Watthour Meter

Provide as specified in Section 26 27 14.00 20 ELECTRICITY METERING.

2.2.6 Heaters

Provide 120-volt heaters in each switchboard section. Provide heaters of sufficient capacity to control moisture condensation in the section, 250 watts minimum, and controlled by a thermostat located in the section. Provide industrial type thermostat, high limit, to maintain sections within the range of 60 to 90 degrees F. Obtain supply voltage for the heaters from a control power transformer within the switchboard. If heater voltage is different than switchboard voltage, provide transformer rated to carry 125 percent of heater full load rating. Provide transformer with a 220 degrees C insulation system with a temperature rise not exceeding 115 degrees C and conforming to NEMA ST 20.

2.2.7 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Provide short-circuiting type terminal boards associated with current transformer. Terminate conductors for current transformers with ring-tongue lugs. Provide terminal board identification that is identical in similar units. Provide color coded external wiring that is color coded consistently for similar terminal boards.

2.2.8 Wire Marking

Mark control and metering conductors at each end. Provide factory installed, white, plastic tubing, heat stamped with black block type letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Provide a single letter or number on each sleeve, elliptically shaped to securely grip the wire, and keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Indicate on each wire marker the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.3 MANUFACTURER'S NAMEPLATE

Provide a nameplate on each item of equipment bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each switchboard, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Identify on each nameplate inscription the function and, when applicable, the position. Provide nameplates of melamine plastic, **0.125 inch** thick, white with black center core. Provide red laminated plastic label with white center core where indicated. Provide matte finish surface. Provide square corners. Accurately align lettering and engrave into the core. Provide nameplates with minimum size of **one by 2.5 inches**. Provide lettering that is a minimum of **0.25 inch** high normal block style.

2.5 SOURCE QUALITY CONTROL

2.5.1 Equipment Test Schedule

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

Provide the following as part of test equipment calibration:

- a. Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.
- b. Accuracy: Traceable to the National Institute of Standards and Technology.
- c. Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.
- d. Dated calibration labels: visible on all test equipment.
- e. Calibrating standard: higher accuracy than that of the instrument tested.
- f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:
 - (1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.
 - (2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Switchboard Design Tests

NEMA PB 2 and **UL 891**.

2.5.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of

the same series and rating as that provided by this specification.

- a. Short-circuit current test.
- b. Enclosure tests.
- c. Dielectric test.

2.5.3 Switchboard Production Tests

NEMA PB 2 and UL 891. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

- a. 60-hertz dielectric tests.
- b. Mechanical operation tests.
- c. Electrical operation and control wiring tests.
- d. Ground fault sensing equipment test.

2.5.4 Cybersecurity Equipment Certification

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

2.6 COORDINATED POWER SYSTEM PROTECTION

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

2.7 ARC FLASH WARNING LABEL

Provide warning label for switchboards. Locate this self-adhesive warning label on the outside of the enclosure warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.8 SERVICE ENTRANCE AVAILABLE FAULT CURRENT LABEL

Provide label on exterior of switchboards used as service equipment listing the maximum available fault current at that location. Include on the label the date that the fault calculation was performed and the contact information for the organization that completed the calculation. Locate this self-adhesive warning label on the outside of the switchboard. Provide label format as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

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

3.2 GROUNDING

NFPA 70 and **IEEE C2**, except that grounds and grounding systems with a resistance to solid earth ground not exceeding **5** ohms.

3.2.1 Grounding Electrodes

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

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than **24 inches** below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

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

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchboard

ANSI/NEMA PB 2.1.

3.3.2 Meters and Instrument Transformers

ANSI C12.1.

3.3.3 Field Applied Painting

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

3.3.4 Galvanizing Repair

Repair damage to galvanized coatings using **ASTM A780/A780M**, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.5 Field Fabricated Nameplate Mounting

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

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Exterior Location

Mount switchboard on concrete slab as follows:

- a. Unless otherwise indicated, provide the slab with dimensions at least **8 inches** thick, reinforced with a **6 by 6 inch** No. 6 mesh placed uniformly **4 inches** from the top of the slab.
- b. Place slab on a **6 inch** thick, well-compacted gravel base.
- c. Install slab such that the top of the concrete slab is approximately **4 inches** above the finished grade.
- d. Provide edges above grade **1/2 inch** chamfer.
- e. Provide slab of adequate size to project at least **8 inches** beyond the equipment.
- f. Provide conduit turnups and cable entrance space required by the equipment to be mounted.
- g. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.
- h. Cut off and bush conduits **3 inches** above slab surface.
- i. Provide concrete work as specified in Section **03 47 13 TILT-UP CONCRETE**.

3.4.2 Interior Location

Mount switchboard on concrete slab as follows:

- a. Unless otherwise indicated, provide the slab with dimensions at least **4 inches** thick.
- b. Install slab such that the top of the concrete slab is approximately **4 inches** above the finished grade.
- c. Provide edges above grade **1/2 inch** chamfer.
- d. Provide slab of adequate size to project at least **8 inches** beyond the equipment.
- e. Provide conduit turnups and cable entrance space required by the equipment to be mounted.
- f. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.
- g. Cut off and bush conduits **3 inches** above slab surface.

- h. Provide concrete work as specified in Section 03 47 13 TILT-UP CONCRETE.

3.5 FIELD QUALITY CONTROL

Submit Required Settings of breakers to the Contracting Officer after approval of switchboard and at least 30 days in advance of their requirement.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.5.1.1 Switchboard Assemblies

a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical, electrical, and mechanical condition.
- (3) Verify appropriate anchorage, required area clearances, and correct alignment.
- (4) Clean switchboard and verify shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
- (5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.
- (6) Verify that circuit breaker sizes and types correspond to approved shop drawings as well as to the circuit breaker's address for microprocessor-communication packages.
- (7) Verify that current transformer ratios correspond to approved shop drawings.
- (8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.
- (9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.
- (10) Confirm correct application of manufacturer's recommended lubricants.
- (11) Inspect insulators for evidence of physical damage or contaminated surfaces.
- (12) Verify correct barrier installation and operation.
- (13) Exercise all active components.

- (14) Inspect all mechanical indicating devices for correct operation.
- (15) Verify that filters are in place and vents are clear.
- (16) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.
- (17) Inspect control power transformers.

b. Electrical Tests

- (1) Perform insulation-resistance tests on each bus section.
- (2) Perform dielectric withstand voltage tests.
- (3) Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.
- (4) Perform control wiring performance test.
- (5) Perform primary current injection tests on the entire current circuit in each section of assembly.
- (7) Verify operation of switchboard heaters.

3.5.1.2 Circuit Breakers

Low Voltage - Insulated-Case and Low Voltage Molded Case with Solid State Trips

a. Visual and Mechanical Inspection

- (1) Compare nameplate data with specifications and approved shop drawings.
- (2) Inspect circuit breaker for correct mounting.
- (3) Operate circuit breaker to ensure smooth operation.
- (4) Inspect case for cracks or other defects.
- (5) Inspect all bolted electrical connections for high resistance using low resistance ohmmeter, verifying tightness of accessible bolted connections and/or cable connections by calibrated torque-wrench method, or performing thermographic survey.
- (6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

- (1) Perform contact-resistance tests.
- (2) Perform insulation-resistance tests.
- (3) Perform Breaker adjustments for final settings in accordance with Government provided settings.
- (4) Perform long-time delay time-current characteristic tests

- (5) Determine short-time pickup and delay by primary current injection.
- (6) Determine ground-fault pickup and time delay by primary current injection.
- (7) Determine instantaneous pickup current by primary injection.
- (8) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

3.5.1.3 Current Transformers

a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical and mechanical condition.
- (3) Verify correct connection.
- (4) Verify that adequate clearances exist between primary and secondary circuit.
- (5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.
- (6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

- (1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.
- (2) Perform insulation-resistance tests.
- (3) Perform polarity tests.
- (4) Perform ratio-verification tests.

3.5.1.4 Metering and Instrumentation

a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical and mechanical condition.
- (3) Verify tightness of electrical connections.

b. Electrical Tests

- (1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

- (2) Calibrate watthour meters according to manufacturer's published data.
- (3) Verify all instrument multipliers.
- (4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.5 Grounding System

a. Visual and Mechanical Inspection

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

b. Electrical Tests

- (1) **IEEE 81**. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.
- (2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.5.1.6 Cybersecurity Installation Certification

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

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contracting Officer 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

SECTION 26 27 14.00 20

ELECTRICITY METERING

02/11

PART 1 GENERAL

1.1 REFERENCES

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.13	(2016) Requirements for Instrument Transformers
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	((2014; Errata 2016) Electric Meters - Code for Electricity Metering
ANSI C12.18	(2006) Protocol Specification for ANSI Type 2 Optical Port
ANSI C12.20	(2015; E 2018) Electricity Meters - 0.1, 0.2, and 0.5 Accuracy Classes
ANSI C12.7	(2014) Requirements for Watthour Meter Sockets
NEMA C12.19	(2008) Utility Industry End Device Data Tables

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in [IEEE Stds Dictionary](#).

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval.

Technical data packages consisting of technical data and computer software (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications shall be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered 'shop drawings' under the Federal Acquisition Regulation Supplement (FARS) and shall contain no proprietary information and be delivered with unrestricted rights.

Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G, S

SD-03 Product Data

Electricity meters; G, S

The most recent meter product data shall be submitted as a Technical Data Package and shall be licensed to the project site. Any software shall be submitted on CD-ROM and 5 hard copies of the software user manual shall be submitted for each piece of software provided.

Current transformer; G

Potential transformer; G

External communications devices; G

Configuration Software; G

The most recent version of the configuration software for each type (manufacturer and model) shall be submitted as a Technical Data Package and shall be licensed to the project site. Software shall be submitted on CD-ROM and 5 hard copies of the software user manual shall be submitted for each piece of software provided.

SD-06 Test Reports

Acceptance checks and tests

System functional verification

Building meter installation sheet, per building

Completed meter installation schedule

Completed meter data schedule

Meter configuration template

Contractor shall fill in the meter configuration template and submit to the Activity for concurrence.

Meter configuration report; G

The meter configuration report shall be submitted as a Technical Data Package.

SD-10 Operation and Maintenance Data

Electricity Meters and Accessories, Data Package 5; G

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

SD-11 Closeout Submittals

System functional verification

1.4 QUALITY ASSURANCE

1.4.1 Installation Drawings

Drawings shall be provided in hard-copy and electronic format, and shall include but not be limited to the following:

- a. Wiring diagrams with terminals identified of advanced meter, current transformers, potential transformers, protocol modules, communications interfaces, Ethernet connections, . For each typical meter installation, provide a diagram.
- b. One-line diagram, including meters, switch(es), current transformers, potential transformers, protocol modules, communications interfaces, Ethernet connections, telephone outlets, and fuses. For each typical meter installation, provide a diagram.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 1 year prior to bid opening. The 1-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product, or an earlier release of the product, shall have been on sale on the commercial market through advertisements, manufacturers catalogs, or brochures during the prior 1-year period. Where two or more items of the same class of

equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3 Material and Equipment Manufacturing Data

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.5 MAINTENANCE

1.5.1 Additions to Operation and Maintenance Data

In addition to requirements of Data Package 5, include the following on the actual [electricity meters and accessories](#) provided:

- a. A condensed description of how the system operates
- b. Block diagram indicating major assemblies
- c. Troubleshooting information
- d. Preventive maintenance
- e. Prices for spare parts and supply list

1.6 WARRANTY

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

1.7 SYSTEM DESCRIPTION

1.7.1 System Requirements

Electricity metering, consisting of meters and associated equipment, will be used to record the electricity consumption and other values as described in the requirements that follow and as shown on the drawings. Communication system requirements are contained in a separate specification section as identified in paragraph entitled "Communications Interfaces".

1.7.2 Selection Criteria

Metering components and software are part of a system that includes the physical meter, data recorder function and communications method. Every building site identified shall include sufficient metering components to measure the electrical parameters identified and to store and communicate the values as required.

Contractor shall verify that the electricity meter installed on any building site is compatible with the base-wide metering system with respect to the types of meters selected and the method used to program the meters for initial use. Software and meter programming tools are necessary to set up the meters described by this specification. New software tools different from the meter programming methods currently used by base

personnel will require separate approval for use.

The Base Wide Metering System is "ITRON_CENTRON" metering.

PART 2 PRODUCTS

2.1 ELECTRICITY METERS AND ACCESSORIES

Provide meter(s) and connect the meter(s) to the existing AMI DAS. The contractor shall use the existing government laptop computers to configure the meter using existing software loaded on the computer. The contractor will not be allowed to modify any software or add any additional software to the computer. Alternatively, the government will configure the meter(s), which must be compatible with the existing system, using existing software. Contract shall insure that the meter(s) will transmit the specified data to the DAS. The current meters being used by Camp Lejeune are: ITRON_CENTRON.

2.1.1 Physical and Common Requirements

- a. Provide metering system components in accordance with the Metering System Schedule shown in this specification. Provide Meter configuration template.
- b. Meter shall have NEMA 3R enclosure for surface mounting with bottom or rear penetrations.
- c. Surge withstand capability shall conform to IEEE C37.90.1.
- d. Use #12 SIS (XHHW, or equivalent) wiring with ring lugs for all meter connections. Color code and mark the conductors as follows:
 - (1) Red - Phase A CT - C1
 - (2) Orange - Phase B CT - C2
 - (3) Brown - Phase C CT - C3
 - (4) Gray with white stripe - neutral current return - C0
 - (5) Black - Phase A voltage - V1
 - (6) Yellow - Phase B voltage - V2
 - (7) Blue - Phase C voltage - V3
 - (8) White - Neutral voltage

2.1.2 Potential Transformer Requirements

- a. Meter shall be capable of connection to the service voltage phases and magnitude being monitored. If the meter is not rated for the service voltage, provide suitable potential transformers to send an acceptable voltage to the meter.
- b. Voltage input shall be optically isolated to 2500 volts DC from signal and communications outputs. Components shall meet or exceed IEEE C37.90.1.
- c. Provide one fuse per phase, Class RK type, to protect the voltage input to the meter. Size fuses as recommended by the meter manufacturer. Fusing shall either be inside the secondary compartment of the transformer or inside the same enclosure as the CT shorting device.

2.1.1.3 Current Transformer Requirements

- a. Current transformer shall be installed with a rating as shown in the schedule.
- b. Current transformers shall have an Accuracy Class of 0.3 (with a maximum error of plus/minus 0.3 percent at 5.0 amperes) when operating within the specified rating factor.
- c. Current transformers shall be solid-core, bracket-mounted for new installations using ring-tongue lugs for electrical connections. Current transformers shall be accessible and the associated wiring shall be installed in an organized and neat workmanship arrangement. Current transformers that are retrofitted onto existing switchgear busbar can be a busbar split-core design.
- d. Current transformers shall have:
 - (1) Insulation Class: All 600 volt and below current transformers shall be rated 10 KV BIL.
 - (2) Frequency: Nominal 60 Hz.
 - (3) Burden: Burden class shall be selected for the load.
 - (4) Phase Angle Range: 0 to 60 degrees.
- e. Meter shall accept current input from standard instrument transformers (5A secondary current transformers).
- f. Current inputs shall have a continuous rating in accordance with IEEE C57.13.
- g. Provide one single-ratio current transformer for each phase per power transformer with characteristics listed in the following table.

Single-Ratio Current Transformer Characteristics

kVA	Sec. Volt	CT Ratio	RF	Meter Acc. Class
1000	480Y/277	1200/5	1.33	0.3 thru B0.5
225	208Y/120	600/5	2.0	0.3 thru B0.2

2.1.1.4 Meter Requirements

Electricity meters shall include the following features:

- a. Meter shall comply with ANSI C12.1, NEMA C12.19, and ANSI C12.20.
- b. Meter sockets shall comply with ANSI C12.7.
- c. Provide socket-mounted meters.
- d. Meter shall be a Class 20, transformer rated design.
- e. Use Class 200 meters for direct current reading without current transformers for applications with an expected load less than 200 amperes, where indicated.

- f. Meter shall be rated for use at temperature from minus 40 degrees Centigrade to plus 85 degrees Centigrade.
- g. The meters shall have an electronic demand recording register and shall be secondary reading as indicated. The register shall be used to indicate maximum kilowatt demand as well as cumulative or continuously cumulative demand. Demand shall be measured on a block-interval basis and shall be capable of a 5 to 60 minute interval and initially set to a 15-minute interval. It shall have provisions to be programmed to calculate demand on a rolling interval basis. Meter readings shall be true RMS.
- h. The meter electronic register shall be of modular design with non-volatile data storage. Downloading meter stored data shall be capable via an optical port. Recording capability of data storage with a minimum capability of 89 days of 15 minute, 2 channel interval data. The meter shall be capable of providing at least 2 KYZ pulse outputs (dry contacts). Default initial configuration (unless identified otherwise by base personnel) shall be:
 - (1) First channel - kWh
 - (2) Second channel - kVARh
 - (3) KYZ output #1 - kWh
 - (4) KYZ output #2 - kVARh
- i. All meters shall have identical features available in accordance with this specification. The meter schedule identifies which features shall be activated at each meter location.
- j. Enable switches for Time of Use (TOU), pulse and load profile measurement module at the factory.
- k. Meter shall have an optical port on front of meter capable of speeds from 9600 to a minimum of 19.2k baud, and shall be initially set at 9600 baud. Optical device shall be compatible with ANSI C12.18.
- l. Meters shall be 120-480 volts auto ranging.
- m. Provide blank tag fixed to the meter faceplate for the addition of the meter multiplier, which will be the product of the current transformer ratio and will be filled in by base personnel on the job site. The meter's nameplate shall include:
 - (1) Meter ID number.
 - (2) Rated voltage.
 - (3) Current class.
 - (4) Metering form.
 - (5) Test amperes.
 - (6) Frequency.
 - (7) Catalog number.
 - (8) Manufacturing date.
- n. Meter covers shall be polycarbonate resins with an optical port and reset. Backup battery shall be easily accessible for change-out after removing the meter cover.
- o. The normal billing data scroll shall be fully programmable. Data scroll display shall include the following.

- (1) Number of demand resets.
 - (2) End-of-interval indication.
 - (3) Maximum demand.
 - (4) New maximum demand indication.
 - (5) Cumulative or continuously cumulative.
 - (6) Time remaining in interval.
 - (7) Kilowatt hours.
- p. The register shall incorporate a built-in test mode that allows it to be tested without the loss of any data or parameters. The following quantities shall be available for display in the test mode:
- (1) Present interval's accumulating demand.
 - (2) Maximum demand.
 - (3) Number of impulses being received by the register.
- q. Pulse module simple I/O board with programmable ratio selection.
- r. Meters shall be programmed after installation via an optical port. Optical display shall show TOU data, peak kwh, semi-peak kwh, off peak kwh, and phase angles.
- s. Self-monitoring to provide for:
- (1) Unprogrammed register.
 - (2) RAM checksum error.
 - (3) ROM checksum error.
 - (4) Hardware failure.
 - (5) Memory failure.
 - (6) EPROM error.
 - (7) Battery status (fault, condition, or time in service).
- t. Liquid crystal alphanumeric displays, 9 digits, blinking squares confirm register operation. 6 Large digits for data and smaller digits for display identifier.
- u. Display operations, programmable sequence with display identifiers. Display identifiers shall be selectable for each item. Continually sequence with time selectable for each item.
- v. The meters shall support three modes of registers: Normal Mode, Alternate Mode, and Test Mode. The meter also shall support a "Toolbox" or "Service Information" (accessible in the field) through an optocom port to a separate computer using the supplied software to allow access to instantaneous service information such as voltage, current, power factor, load demand, and the phase angle for individual phases.
- w. Meter shall have a standard 4-year warranty.

2.1.5 Disconnect Method

- a. Provide a 10-pole safety disconnect complete with isolation devices for the voltage and current transformer inputs, including a shorting means for the current transformers.

2.1.6 Installation Methods

- a. Stand Mounted Adjacent to Transformer ("STAND" in Metering Systems Schedule). Meter base shall be mounted on a structural steel pole approximately 4 feet from the transformer pad. This can be used for multiple meters associated with a single transformers.

2.2 COMMUNICATIONS INTERFACES

Meter shall be fully integrate into an existing Itron fixed network automatic meter reading system leveraging 900 MHz RF technology. Meter shall be equipped with a high powered RF 900 MHz electronic receiver transmitter communication modules. Meter shall provide standard consumption and interval data messages to an Itron fixed network repeater or collection station. Meter RF transmission shall include the unit identification number, unit type, energy usage, tamper status, and CRC check. Meter shall be based on a solid sate metering platform. Meter shall provide an accuracy of 0.3% or better. Meter shall provide a partial load profile including usage, demand, and power factor.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70 (National Electrical Code), and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.1.1 Scheduling of Work and Outages

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

3.1.2 Configuration Software

The standard meter shall include the latest available version of firmware and software. Meter shall either be programmed at the factory or shall be programmed in the field. Meters shall have a password that shall be provided to the contracting officer upon project completion. When field programming is performed, turn field programming device over to the Contracting Officer at completion of project. When interfacing software is used for a meter that is different than the existing meters in use at the Activity, turn the software over to the Contracting Officer at completion of the project.

3.2 FIELD QUALITY CONTROL

Perform the following acceptance checks and tests on all installed meters.

3.2.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

- a. Meter Assembly

- (1) Visual and mechanical inspection.

- (a) Compare equipment nameplate data with specifications and approved shop drawings.
 - (b) Inspect physical and mechanical condition. Confirm the meter is firmly seated in the socket, the socket is not abnormally heated, the display is visible, and the ring and seal on the cover are intact.
 - (c) Inspect all electrical connections to ensure they are tight. For Class 200 services, verify tightness of the service conductor terminations for high resistance using low-resistance ohmmeter, or by verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - (d) Record model number, serial number, firmware revision, software revision, and rated control voltage.
 - (e) Verify operation of display and indicating devices.
 - (f) Record password and user log-in for each meter.
 - (g) Verify grounding of metering enclosure.
 - (h) Set all required parameters including instrument transformer ratios, system type, frequency, power demand methods/intervals, and communications requirements. Verify that the CT ratio and the PT ratio are properly included in the meter multiplier or the programming of the meter. Confirm that the multiplier is provided on the meter face or on the meter.
 - (i) Provide [building meter installation sheet, per building](#) for each facility. See example Graphic E-S1.
 - (j) Provide the [completed meter installation schedule](#) for the installation. See example Graphic E-S2.
 - (k) Provide the [completed meter data schedule](#) for the installation. See example Graphic E-S3.
- (2) Electrical tests.
- (a) Apply voltage or current as appropriate to each analog input and verify correct measurement and indication.
 - (b) Confirm correct operation and setting of each auxiliary input/output feature including mechanical relay, digital, and analog.
 - (c) After initial system energization, confirm measurements and indications are consistent with loads present.
 - (d) Make note of, and report, any "Error-Code" or "Caution-Code" on the meter's display.
- (3) Provide [meter configuration report](#).

b. Current Transformers

(1) Visual and mechanical inspection.

- (a) Compare equipment nameplate data with specification and approved shop drawings.
- (b) Inspect physical and mechanical condition.
- (c) Verify correct connection, including polarity.
- (d) Inspect all electrical connections to ensure they are tight.
- (e) Verify that required grounding and shorting connections provide good contact.

(2) Electrical Tests.

Verify proper operation by reviewing the meter configuration report.

3.2.2 System Functional Verification

Verify that the installed meters are working correctly in accordance with the meter configuration report:

- a. The correct meter form is installed.
- b. All voltage phases are present.
- c. Phase rotation is correct.
- d. Phase angles are correct.
- e. The new meter accurately measures power magnitude and direction, and can communicate as required by paragraph entitled "Communications Interfaces".

-- End of Section --

SECTION 26 28 01.00 10

COORDINATED POWER SYSTEM PROTECTION
10/07

PART 1 GENERAL

1.1 REFERENCES

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

- IEEE 242 (2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
- IEEE 399 (1997) Brown Book IEEE Recommended Practice for Power Systems Analysis
- IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
- IEEE C37.46 (2010) Standard for High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
- IEEE C57.13 (2016) Requirements for Instrument Transformers

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- NEMA FU 1 (2012) Low Voltage Cartridge Fuses
- NEMA ICS 1 (2000; R 2015) Standard for Industrial Control and Systems: General Requirements
- NEMA ICS 2 (2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
- NEMA ICS 3 (2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
- NEMA ICS 6 (1993; R 2016) Industrial Control and Systems: Enclosures
- NEMA/ANSI C12.11 (2006; R 2019) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA

20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 198M	(2018) UL Standard for Mine-Duty Fuses
UL 486E	(2015; Reprint Apr 2019) UL Standard for Safety Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2018) UL Standard for Safety Industrial Control Equipment
UL 845	(2005; Reprint Oct 2018) UL Standard for Safety Motor Control Centers
UL 1203	(2013; Reprint Jan 2020) UL Standard for Safety Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations

1.2 SYSTEM DESCRIPTION

The power system covered by this specification consists of: 480Y/277V and 208Y/120V three-phase 4-wire services and power distribution to the P1338 II MEF Simulation/Training Center..

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

Fault Current Analysis
Protective Device Coordination Study
Equipment
System Coordinator

Installation

SD-06 Test Reports

Field Testing

SD-07 Certificates

Devices and Equipment

1.4 QUALITY ASSURANCE

1.4.1 System Coordinator

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

1.4.2 System Installer

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

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 PROJECT/SITE CONDITIONS

Submit certificates attesting that all devices or equipment meet the requirements of the contract documents. [Devices and equipment](#) furnished under this section shall be suitable for the following site conditions. .

Altitude	26 feet
Ambient Temperature	73.8 degrees F
Frequency	60

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Provide protective devices and [equipment](#) which are the standard product of

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

2.2 NAMEPLATES

Provide nameplates to identify all protective devices and equipment. Nameplate information shall be in accordance with [UL 489](#).

2.3 CORROSION PROTECTION

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

2.4 MOTOR CONTROLS

Motor controls shall be in accordance with [NEMA ICS 1](#), [NEMA ICS 2](#), [NEMA ICS 3](#) and [NEMA ICS 6](#), and [UL 508](#) and [UL 845](#).

2.4.1 Motor Starters

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

2.4.2 Thermal-Overload Protection

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

2.4.3 Low-Voltage Motor Overload Relays

2.4.3.1 General

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

2.4.3.2 Construction

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

2.4.3.3 Ratings

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

2.4.4 Automatic Control Devices

2.4.4.1 Direct Control

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

2.4.4.2 Pilot-Relay Control

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

2.4.4.3 Manual/Automatic Selection

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

2.5 LOW-VOLTAGE FUSES

2.5.1 General

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

characteristics requires for effective power system coordination.

2.5.2 Cartridge Fuses; Noncurrent-Limiting Type

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

2.5.3 Cartridge Fuses; Current-Limiting Type

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

- a. Class G fuses shall conform to [UL 198M](#).
- b. Class K fuses shall conform to [UL 198M](#).
- c. Class R fuses shall conform to [UL 198M](#).
- d. Class T fuses shall conform to [UL 198M](#).

2.5.3.1 Continuous Current Ratings (600 amperes and smaller)

Service entrance and feeder circuit fuses (600 amperes and smaller) shall be Class RK1 RK5 , current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.5.3.2 Continuous Current Ratings (greater than 600 amperes)

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

2.5.3.3 Motor and Transformer Circuit Fuses

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

2.6 MEDIUM-VOLTAGE AND HIGH-VOLTAGE FUSES

2.6.1 General

Medium-voltage and high-voltage fuses shall be distribution fuse cutouts or power fuses, E-rated, C-rated, or R-rated current-limiting fuses as shown.

2.6.2 Construction

Units shall be suitable for outdoor use. Fuses shall have integral blown-fuse indicators. All ratings shall be clearly visible.

2.6.3 Ratings

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

Continuous-current ratings shall be as shown.

2.6.3.1 Fuse Cutouts

Medium-voltage fuses and cutouts shall be of the loadbreak type construction ratings and types indicated. Open-link cutouts are not acceptable. Fuses shall be either indicating or dropout type. Fuse ratings shall be as indicated. Fuses cutouts shall be equipped with mounting brackets suitable for the indicated installations.

2.6.3.2 Power Fuses

Expulsion-type power fuses shall have ratings in accordance with **IEEE C37.46** and as follows:

Nominal voltage	14.4 kV
Rated maximum voltage	15 kV
Maximum symmetrical interrupting capacity	16 kA
Rated continuous current	As indicated on plans
BIL	110 kV

2.6.3.3 E-Rated, Current-Limiting Power Fuses

E-rated, current-limiting, power fuses shall conform to **IEEE C37.46**.

2.6.3.4 C-Rated, Current-Limiting Fuses

C-rated, current-limiting, power fuses shall open in 1000 seconds at currents between 170 and 240 percent of the C rating.

2.6.3.5 R-Rated, Current-Limiting Fuses

R-rated, current-limiting, fuses shall be used with medium-voltage motor controllers only. R-rated fuses shall conform to **IEEE C37.46**.

2.7 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

2.7.1 General

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

2.7.2 Construction

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

2.7.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Letter designations shall be A through Y for motor controller Sizes 0, 1, 2, 3, 4, and 5, with 100,000 amperes interrupting capacity rating. Letter designations shall correspond to controller sizes as follows:

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

2.8 MOLDED-CASE CIRCUIT BREAKERS

2.8.1 General

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

2.8.2 Construction

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

2.8.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to

the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with [UL 489](#). Ratings shall be coordinated with system X/R ratio.

2.8.4 Cascade System Ratings

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

2.8.5 Thermal-Magnetic Trip Elements

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

2.8.6 Solid-State Trip Elements

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

- a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.
- b. Adjustable long-time delay.
- c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.
- d. Adjustable short-time delay.
- e. Short-time I^2 times t switch.
- f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.
- g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of

ground-fault current at the main bonding jumper or ground strap shall not be permitted.

- h. Adjustable ground-fault delay.
- i. Ground-fault $I^2 t$ switch.
- j. Overload and Short-circuit and Ground-fault trip indicators shall be provided.

2.8.7 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through $I^2 t$ to a value less than the $I^2 t$ of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.8.8 SWD Circuit Breakers

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

2.8.9 HACR Circuit Breakers

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

2.8.10 Motor Circuit Protectors (MCP)

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

2.9 INSTRUMENT TRANSFORMERS

2.9.1 General

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

2.9.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be not less than 1.2. Other thermal and mechanical ratings of current transformers and their primary leads shall be coordinated with the design of the circuit breaker

and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accidental open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

2.9.2.1 For kW Hour and Demand Metering (Low Voltage)

Current transformers shall conform to [IEEE C57.13](#). Current transformers with a metering accuracy Class of 0.3 through [B0.9 for 1500 kVA and B-1.8 for 2000 kVA](#), with a minimum RF of [1.33](#) at [86 degrees F](#), with 600-volt insulation, and 10 kV BIL shall be provided. Butyl-molded, window-type current transformers mounted on the transformer low-voltage bushings shall be provided. Route current transformer leads in a location as remote as possible from the power transformer secondary cables to permit current measurements to be taken with hook-on-ammeters.

2.9.2.2 Voltage Transformers

Voltage transformers shall have indicated ratios. Units shall have an accuracy rating of [0.3](#). Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.10 COORDINATED POWER SYSTEM PROTECTION

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

2.10.1 Scope of Analyses

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

2.10.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. Utilize the fault current availability indicated as a basis for fault current

studies.

2.10.3 Single Line Diagram

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

2.10.4 Fault Current Analysis

2.10.4.1 Method

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

2.10.4.2 Data

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

2.10.4.3 Fault Current Availability

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

2.10.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided describing: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.10.6 Study report

- a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.
- b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include

manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

- c. The report shall document existing power system data including time-current characteristic curves and protective device ratings and settings.
- d. The report shall contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.
- e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

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

3.3 FIELD TESTING

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

3.3.1 General

Perform field testing in the presence of the Contracting Officer. Notify the Contracting Officer 30 days prior to conducting tests. Furnish all materials, labor, and equipment necessary to conduct field tests. Perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. Maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results.

3.3.2 Safety

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

procedures or handling.

3.3.3 Molded-Case Circuit Breakers

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

3.3.4 Power Circuit Breakers

3.3.4.1 General

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

-- End of Section --

SECTION 26 29 23

ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS
02/20

PART 1 GENERAL

1.1 REFERENCES

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

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519 (2014) Recommended Practices and
Requirements for Harmonic Control in
Electrical Power Systems

IEEE C62.41.1 (2002; R 2008) Guide on the Surges
Environment in Low-Voltage (1000 V and
Less) AC Power Circuits

IEEE C62.41.2 (2002) Recommended Practice on
Characterization of Surges in Low-Voltage
(1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2018) Enclosures for Electrical Equipment
(1000 Volts Maximum)

NEMA ICS 1 (2000; R 2015) Standard for Industrial
Control and Systems: General Requirements

NEMA ICS 3.1 (2019) Guide for the Application,
Handling, Storage, Installation and
Maintenance of Medium-Voltage AC
Contactors, Controllers and Control Centers

NEMA ICS 6 (1993; R 2016) Industrial Control and
Systems: Enclosures

NEMA ICS 7 (2014) Adjustable-Speed Drives

NEMA ICS 7.2 (2015) Application Guide for AC Adjustable
Speed Drive Systems

NEMA MG 1 (2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70

(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

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

47 CFR 15

Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 489

(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

UL 508C

(2002; Reprint Nov 2010) Power Conversion Equipment

1.2 RELATED REQUIREMENTS

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

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements

1.3.1.1 Electromagnetic Interference Suppression

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

1.3.1.2 Electromechanical and Electrical Components

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

1.3.2 Electrical Requirements

1.3.2.1 Power Line Surge Protection

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

1.3.2.2 Sensor and Control Wiring Surge Protection

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

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

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

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

- Schematic Diagrams; G

- Interconnecting Diagrams; G

- Installation Drawings; G

- As-Built Drawings; G

SD-03 Product Data

- Adjustable Speed Drives; G

- Wires and Cables

- Equipment Schedule

SD-06 Test Reports

- ASD Test

- Performance Verification Tests

- Endurance Test

SD-08 Manufacturer's Instructions

- Installation instructions

SD-09 Manufacturer's Field Reports

- ASD Test Plan; G

- Standard Products

SD-10 Operation and Maintenance Data

- Adjustable Speed Drives, Data Package 4

1.5 QUALITY ASSURANCE

1.5.1 Schematic Diagrams

Submit diagrams showing circuits and device elements for each replaceable module. Schematic diagrams of printed circuit boards are permitted to

group functional assemblies as devices, provided that sufficient information is provided for government maintenance personnel to verify proper operation of the functional assemblies.

1.5.2 Interconnecting Diagrams

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

1.5.3 Installation Drawings

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

1.5.4 Equipment Schedule

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

1.5.5 Installation Instructions

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

1.5.6 Standard Products

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

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
- b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6 DELIVERY AND STORAGE

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

1.7 WARRANTY

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

1.8 MAINTENANCE

1.8.1 Operation and Maintenance Data

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

1.8.2 Maintenance Support

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

1.8.3 Technical Support

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

PART 2 PRODUCTS

2.1 ADJUSTABLE SPEED DRIVES (ASD)

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

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

- b. A converter stage per [UL 508C](#) must change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter must utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter must be insensitive to three phase rotation of the ac line and must not cause displacement power factor of less than .95 lagging under any speed and load condition.
- c. An inverter stage must change fixed dc voltage to variable frequency, variable ac voltage for application to a standard [NEMA MG 1](#) Part 30 motor designed for use with adjustable frequency power supplies. Switch the inverter to produce a sine coded pulse width modulated (PWM) output waveform.
- d. The ASD shall be capable of supplying 120 percent of rated full load current for one minute at maximum ambient temperature.
- e. The ASD must be designed to operate from a [480](#) volt, plus or minus 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.
- f. Acceleration and deceleration time must be independently adjustable from one second to 60 seconds.

Required deceleration time may be achieved using not only dynamic braking resistor but with other methods described in [NEMA ICS 7.2-2015](#) paragraph 5.2.5.

- g. Adjustable full-time current limiting must limit the current to a preset value which must not exceed 110 percent of the controller rated current. The current limiting action must maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override must allow starting current to reach 175 percent of controller rated current to maximum starting torque.
- h. The controllers must be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection must be included such that a failure in the controller electronic circuitry must not cause frequency to exceed 110 percent of the maximum controller output frequency selected.
- i. Minimum and maximum output frequency must be adjustable over the following ranges: 1) Minimum frequency 3 Hz to 50 percent of maximum selected frequency; 2) Maximum frequency 40 Hz to 60 Hz.
- j. The controller efficiency at any speed must not be less than 96 percent.
- k. The controllers must be capable of being restarted into a motor coasting in the forward direction without tripping.
- l. Protection of power semiconductor components must be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions must not result in component failure or the need for fuse replacement:

(1) Short circuit at controller output

- (2) Ground fault at controller output
 - (3) Open circuit at controller output
 - (4) Input undervoltage
 - (5) Input overvoltage
 - (6) Loss of input phase
 - (7) AC line switching transients
 - (8) Instantaneous overload
 - (9) Sustained overload exceeding 115 percent of controller rated current
 - (10) Over temperature
 - (11) Phase reversal
- m. Solid state motor overload protection must have sensor in each phase, Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing, Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting, NC isolated overload alarm contact, external overload, reset push button.
 - n. Include slip compensation circuit that will sense changing motor load conditions and adjust output frequency to provide speed regulation of **NEMA MG 1** Part 30 designed for use with adjustable frequency power supplies motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.
 - o. The ASD must be factory set for manual restart after the first protective circuit trip for malfunction (overcurrent, undervoltage, overvoltage or overtemperature) or an interruption of power. The ASD must be capable of being set for automatic restart after a selected time delay. If the drive faults again within a specified time period (adjustable 0-60 seconds), a manual restart will be required. Provide Bidirectional Autospeed Search capable of starting the ASD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
 - p. The ASD must include external fault reset capability. All the necessary logic to accept an external fault reset contact must be included.
 - q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations. The ASD must have a minimum of three user selectable bandwidths.
 - r. Provide properly sized NEMA rated by-pass and isolation contactors to enable operation of motor in the event of ASD failure and for safety transfers motor between power converter output and bypass circuit using a field-selectable automatic and manual bypass mode. Install mechanical and electrical interlocks between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer.

Motor overload and short circuit protective features must remain in use during the bypass mode.

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

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

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

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

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

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

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

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

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

2.1.1.1 ASD for HVAC Application

ASDs must have the following features:

- a. A local operator control providing the following functions:

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

- (2) Run/Stop and manual speed commands.

- (3) All programming functions.

- (4) Scrolling through all display functions.

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

- (1) ASD status.

- (2) Frequency.

- (3) Motor RPM.

- (4) Phase current.

- (5) Scrolling through all display functions.
- (6) Fault diagnostics in descriptive text.
- (7) All programmed parameters.
- c. Standard PI loop controller with input terminal for controlled variable and parameter settings.
- d. User interface terminals for remote control of ASD speed, speed feedback, and an isolated form C SPDT relay, which energizes on a drive fault condition.
- e. An isolated form C SPDT auxiliary relay which energizes on a run command.
- f. An adjustable carrier frequency with 16 KHz minimum upper limit.
- g. A built-in or external line reactor with 3 percent minimum impedance to protect the DC bus capacitors and rectifier section diodes, reduce power line transient voltage, line notching, DC bus over-voltage tripping and improve the inverter over-current and over-voltage conditions.
- h. Historical logging information and displays:
 - (1) Real-time clock with current time and date.
 - (2) Running log of total power versus time.
 - (3) Total run time.
 - (4) Fault log, maintaining last four faults with time and data stamp for each.
- i. The ASD must be capable of automatic control by a remote 0 to 10 VDC signal, by BACnet network command, or manually by the ASD control panel.
- j. ASDs must include the following operator programmable parameters:
 - (1) Upper and lower limit frequency.
 - (2) Acceleration and deceleration rate.
 - (3) Variable torque volts per Hertz curve.
 - (4) Starting voltage level.
 - (5) Starting frequency level.
 - (6) Display speed scaling.
 - (7) Enable/disable soft stall feature.
 - (8) Motor overload level.

- (9) Motor stall level.
- (10) Jump frequency and hysteresis band.
- (11) PWM carrier frequency.

k. ASD must have the following protective features:

- (1) An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.
- (2) An electronic adjustable soft stall feature, allowing the ASD to lower the frequency to a point where the motor will not exceed the full-load amperage when an overload ASD will automatically return to the requested frequency when load conditions permit.
- (3) A separate electronic stall at 110 percent ASD rated current, and a separate hardware trip at 190 percent current.
- (4) The ability to shut down if inadvertently started into a rotating load without damaging the ASD or the motor.
- (5) The ability to keep a log of a minimum of four previous fault conditions, indicating the fault type and time of occurrence in descriptive text.
- (6) The ability to sustain 110 percent rated current for 60 seconds.
- (7) The ability to shutdown safely or protect against and record the following fault conditions:
 - (a) Over current (and an indication if the over current was during acceleration, deceleration, or running).
 - (b) Over current internal to the drive.
 - (c) Motor overload at start-up.
 - (d) Over voltage from utility power.
 - (e) Motor running overload.
 - (f) Over voltage during deceleration.
 - (g) ASD over heat.
 - (h) Load and ground fault.
 - (h) Abnormal parameters or data in ASD EEPROM.

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, and NEMA ICS 6, with a heater if located outdoors, as indicated.

2.3 WIRES AND CABLES

All wires and cables must conform to NEMA 250, NEMA ICS 7, NFPA 70.

2.4 NAMEPLATES

Nameplates external to NEMA enclosures must conform with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manufacturer's standard, permanent nameplates for internal areas of enclosures.

2.5 SOURCE QUALITY CONTROL

2.5.1 ASD Test Plan

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans.

2.5.2 ASD Test Report

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test reports.

PART 3 EXECUTION

3.1 INSTALLATION

Per NEMA ICS 3.1, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer must supervise the installation of all equipment, and wiring.

3.2 GROUNDING

Per NEMA ICS 7.2, ASD must be solidly grounded to the main distribution.

3.3 FIELD QUALITY CONTROL

Specified products must be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Conduct performance verification tests in the presence of Government representative, observing and documenting complete compliance of the system to the specifications. Submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.3.1 ASD Test

A proposed test plan must be submitted to the contracting officer at least 28 calendar days prior to proposed testing for approval. The tests must conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Government reserves the right to witness all tests and review any documentation. Inform the Government at least 14 working days prior to the dates of testing. Perform the ASD test with the assistance of a factory-authorized service representative.

3.3.2 Performance Verification Tests

"Performance Verification Test" plan must provide the step by step procedure required to establish formal verification of the performance of the ASD. Compliance with the specification requirements must be verified

by inspections, review of critical data, demonstrations, and tests. The Government reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. Inform the Government 14 calendar days prior to the date the test is to be conducted.

3.3.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test must commence. The system must be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of 0.9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. The contractor is not allowed in the building during the endurance test. The system must respond as designed.

3.4 DEMONSTRATION

3.4.1 Training

Coordinate training requirements with the Contracting Officer. Provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. Provide all training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the contracting officer.

3.4.1.1 Instructions to Government Personnel

Provide the services of competent instructors with minimum two-year field experience with the operation and maintenance of similar ASDs who will give full instruction to designated personnel in operation, maintenance, calibration, configuration, and programming of the complete control system. Orient the training specifically to the system installed. Instructors must be thoroughly familiar with the subject matter they are to teach. The number of training days of instruction furnished must be as specified. A training day is defined as eight hours of instruction, including two 15-minute breaks and excluding lunch time; Monday through Friday. Provide a training manual for each student at each training phase which describes in detail the material included in each training program. Provide one additional copy for archiving. Provide equipment and materials required for classroom training. Provide a list of additional related courses, and offers, noting any courses recommended. List each training course individually by name, including duration, approximate cost per person, and location of course. Unused copies of training manuals must be turned over to the Government at the end of last training session.

3.4.1.2 Operating Personnel Training Program

Provide one 2-hour training session at the site at a time and place mutually agreeable between the Contractor and the Government. Provide session to train 4 operation personnel in the functional operations of the system and the procedures that personnel will follow in system operation. This training shall include:

- a. System overview
- b. General theory of operation

- c. System operation
- d. Alarm formats
- e. Failure recovery procedures
- f. Troubleshooting

3.4.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training must be conducted on site at a location designated by the Government. Provide a one-day training session to train four engineering personnel in the functional operations of the system. This training must include:

- a. System overview
- b. General theory of operation
- c. System operation
- d. System configuration
- e. Alarm formats
- f. Failure recovery procedures
- g. Troubleshooting and repair
- h. Maintenance and calibration
- i. System programming and configuration

-- End of Section --

SECTION 26 32 15.00

ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES
05/20

PART 1 GENERAL

1.1 REFERENCES

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

ASME INTERNATIONAL (ASME)

ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2016) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B31.3	(2016) Process Piping

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A181/A181M	(2014; R 2020) Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2020a) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

ASTM D975 (2020) Standard Specification for Diesel Fuel Oils

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P (1995) Performance Standard for Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1 (2000; R 2011) General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation

IEEE 43 (2013) Recommended Practice for Testing Insulation Resistance of Rotating Machinery

IEEE 81 (2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

IEEE 115 (2019) Guide for Test Procedures for Synchronous Machines: Part I Acceptance and Performance Testing; Part II Test Procedures and Parameter Determination for Dynamic Analysis

IEEE 120 (1989; R 2007) Master Test Guide for Electrical Measurements in Power Circuits

IEEE 519 (2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

IEEE C50.12 (2005; R 2010) Standard for Salient Pole 50 Hz and 60 Hz Synchronous Generators and Generation/Motors for Hydraulic Turbine Applications Rated 5 MVA and above

IEEE C57.13 (2016) Requirements for Instrument Transformers

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC (2021) International Building Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

- ISO 3046 (2002, 2006, 2009, 2001) Reciprocating Internal Combustion Engines - Performance--Part 1, 3, 4, 5, 6
- ISO 8528 (1993; R 2018) Reciprocating Internal Combustion Engine Driven Alternating Current Generator Sets--Part 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

- MSS SP-58 (2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
- MSS SP-80 (2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- NEMA ICS 2 (2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
- NEMA ICS 6 (1993; R 2016) Industrial Control and Systems: Enclosures
- NEMA MG 1 (2018) Motors and Generators
- NEMA PB 1 (2011) Panelboards
- NEMA PB 2 (2011) Deadfront Distribution Switchboards
- NEMA/ANSI C12.11 (2006; R 2019) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 30 (2018) Flammable and Combustible Liquids Code
- NFPA 37 (2018) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
- NFPA 54 (2021) National Fuel Gas Code
- NFPA 58 (2020) Liquefied Petroleum Gas Code
- NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
- NFPA 99 (2021) Health Care Facilities Code

NFPA 110	(2016) Standard for Emergency and Standby Power Systems
SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)	
SAE ARP892	(1965; R 1994) DC Starter-Generator, Engine
SAE J537	(2016) Storage Batteries
U.S. DEPARTMENT OF DEFENSE (DOD)	
MIL-DTL-16884	(2017; Rev P) Fuel, Naval Distillate
MIL-STD-461	(2015; Rev G) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)	
40 CFR 60	Standards of Performance for New Stationary Sources
UNDERWRITERS LABORATORIES (UL)	
UL 142	(2006; Reprint Jul 2013) Steel Aboveground Tanks for Flammable and Combustible Liquids
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 1236	(2015; Reprint Mar 2016) UL Standard for Safety Battery Chargers for Charging Engine-Starter Batteries
UL 1437	(2006) Electrical Analog Instruments - Panel Board Types

1.2 RELATED MATERIALS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 26 08 00 APPARATUS INSPECTION AND TESTING apply to this section, except as modified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Engine-Generator Set and Auxiliary Equipment; G
Auxiliary Systems; G
Detailed Drawings; G
Acceptance; G

SD-03 Product Data

Harmonic Requirements; G
Engine-Generator Set Efficiencies; G
Emissions; G
filters; G
special tools; G

Engine-Generator Parameter Schedule
Heat Exchanger
Generator
Manufacturer's Catalog

Spare Parts
Onsite Training
Vibration-Isolation
Posted Data and Instructions; G

Experience
Field Engineer
General Installation
Exciter

SD-05 Design Data

Performance Criteria
Sound Limitations; G
Integral Main Fuel Storage Tank

Power Factor

Heat Exchanger

Time-Delay on Alarms

Cooling System

Vibration Isolation

Battery Charger

Capacity Calculations for Engine-Generator Set; G

Brake Mean Effective Pressure (BMEP) Calculations; G

Torsional Vibration Stress Analysis Computations; G

Capacity Calculations for Batteries; G

Turbocharger Load Calculations; G

SD-06 Test Reports

Performance Tests

Factory Inspection and Tests

Factory Tests

Onsite Inspection and Tests; G

Acceptance Checks and Tests; G

Functional Acceptance Tests; G

Maintenance Procedures; G

Operation and Maintenance Manuals; G

Inspections; G

Functional Acceptance Test Procedure; G

SD-07 Certificates

Cooling System

Vibration Isolation

Prototype Test

Reliability and Durability

Fuel System Certification; G

Start-Up Engineer; G

Instructor's Qualification Resume; G

Engine Emission Limits; G

Sound Limitations

Site Visit

Current Balance

Materials and Equipment

Factory Inspection and Tests

SD-09 Manufacturer's Field Reports

Engine Tests; G

Generator Tests; G

Assembled Engine-Generator Set Tests; G

SD-10 Operation and Maintenance Data

Preliminary Assembled Operation and Maintenance Manuals; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and the paragraph ASSEMBLED OPERATION AND MAINTENANCE MANUALS.

SD-11 Closeout Submittals

Posted Data and Instructions; G

Training Plan; G

1.4 QUALITY ASSURANCE

1.4.1 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, NEMA, etc., the design, fabrication and installation must also conform to the code.

1.4.2 Vibration Limitation

Limit the maximum engine-generator set vibration in the horizontal, vertical, and axial directions to 6 mils (peak-peak RMS), with an overall velocity limit of 0.95 inches/second RMS, at rated speed for all loads through 110 percent of rated speed. The engine-generator set must be provided with vibration isolation in accordance with the manufacturer's standard recommendation. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

1.4.3 Torsional Analysis

Submit torsional analysis including prototype testing or calculations which certify and demonstrate that no damaging or dangerous torsional

vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus/minus 10 percent.

1.4.4 Performance Data

Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor. Also submit a description of seismic qualification of the engine-generator mounting, base, and vibration isolation.

1.4.5 Experience

Each component manufacturer must have a minimum of 3 years' experience in the manufacture, assembly and sale of components used with stationary engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler must have a minimum of 3 years' experience in the manufacture, assembly and sale of stationary engine-generator sets for commercial and industrial use. Submit a statement showing and verifying these requirements.

1.4.6 Field Engineer

The engine-generator set manufacturer or assembler must furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. The field engineer must have attended the engine generator manufacturer's training courses on installation and operation and maintenance of engine generator sets. Submit a letter listing the qualifications, schools, formal training, and experience of the field engineer.

1.4.7 Detailed Drawings

Submit detailed drawings showing the following:

- a. Base-mounted equipment, complete with base and attachments, including anchor bolt template and recommended clearances for maintenance and operation.
- b. Starting system.
- c. Fuel system.
- d. Cooling system.
- e. Exhaust system.
- f. Electric wiring of relays, breakers, programmable controllers, and switches including single line and wiring diagrams.
- g. Lubrication system, including piping, pumps, strainers, filters, electric heater, controls and wiring.
- h. Location, type, and description of vibration isolation devices for all applications.
- i. The safety system, including wiring schematics.

- j. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and instrumentation.
- k. Panel layouts.
- l. Mounting and support for each panel and major piece of electrical equipment.
- m. Engine-generator set rigging points and lifting instructions.

1.4.8 [Auxiliary Systems](#) Engine-Generator Set and Auxiliary Equipment Drawing Requirements

Submit drawings pertaining to the engine-generator set and auxiliary equipment, including but not limited to the following:

- a. Certified outline, general arrangement (setting plan), and anchor bolt details. Show total weight and center of gravity of assembled equipment on the steel sub-base.
- b. Detailed elementary, schematic wiring, and interconnection diagrams of the engine starting system, jacket coolant heating system, engine protective devices, engine alarm devices, engine speed governor system, generator and excitation system, and other integral devices.
- c. Detailed elementary, schematic wiring; and interconnection diagrams of the fuel system, starting battery system, engine-generator control panel, generator circuit breaker.
- d. Dimensional drawings or catalog cuts of exhaust silencers, radiator, fuel day tanks, fuel oil cooler, valves and pumps, intake filters, vibration isolators, and other auxiliary equipment not integral with the engine-generator set.

1.4.9 Vibration Isolation System Certification

Submit certification from the manufacturer that the vibration isolation system will reduce the vibration to the limits specified in the paragraph VIBRATION ISOLATION.

1.4.10 [Fuel System Certification](#)

When the fuel system requires a fuel oil cooler as described in the paragraph FUEL OIL COOLER, submit certification from the engine manufacturer that the fuel system design is satisfactory.

1.5 DELIVERY, STORAGE, AND HANDLING

Properly protect materials and equipment, in accordance with the manufacturers recommended storage procedures, before, during, and after installation. Protect stored items from the weather and contamination. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

Deliver equipment on pallets or blocking wrapped in heavy-duty plastic, sealed to protect parts and assemblies from moisture and dirt. Protect and prepare batteries for shipment as recommended by the battery manufacturer. Store auxiliary equipment at the site in covered

enclosures, protected from atmospheric moisture, dirt, and ground water.

1.6 EXTRA MATERIALS

Provide two sets of special tools and two sets of filters required for maintenance. Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. One handset must be provided for each electronic governor when required to indicate and/or change governor response settings. Furnish 4 liters one gallon of identical paint used on engine-generator set in manufacturer's sealed container with each engine-generator set.

Wrenches and tools specifically designed and required to work on the new equipment, which are not commercially available as standard mechanic's tools, must be furnished to the Contracting Officer.

Provide proposed operating instructions for the engine-generator set and auxiliary equipment laminated between matte-surface thermoplastic sheets and suitable for placement adjacent to corresponding equipment. After approval, install operating instructions where directed.

1.7 MAINTENANCE SERVICES

Submit the operation and maintenance manuals and have them approved prior to commencing onsite tests.

1.7.1 Operation Manual

Provide three copies of the manufacturers standard operation manual . Sections must be separated by heavy plastic dividers with tabs which identify the material in the section. Fold drawings with the title block visible, and placed in 8-1/2 by 11 inch plastic pockets with reinforced holes. The manual must include:

- a. Step-by-step procedures for system startup, operation, and shutdown;
- b. Drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems with their controls, alarms, and safety systems;
- c. Procedures for interface and interaction with related systems to include automatic transfer switches fire alarm/suppression systems .

1.7.2 Maintenance Manual

Provide three copies of the manufacturers standard maintenance manual . Separate each section by a heavy plastic divider with tabs. Fold drawings with the title block visible, and placed in plastic pockets with reinforced holes. The manual must include:

- a. Procedures for each routine maintenance item. Procedures for troubleshooting. Factory-service, take-down overhaul, and repair service manuals, with parts lists.
- b. The manufacturer's recommended maintenance schedule.
- c. A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components.

- d. A list of spare parts for each piece of equipment and a complete list of materials and supplies needed for operation.

1.7.3 Assembled Operation and Maintenance Manuals

The contents of the assembled operation and maintenance manuals must include the manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA and the manufacturer's O&M information specified in Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH.

- a. Manuals must be in separate books or volumes, assembled and bound securely in durable, hard covered, water resistant binder, and indexed by major assembly and components in sequential order.
- b. A table of contents (index) must be made part of the assembled O&M. The manual must be assembled in the order noted in table of contents.
- c. The cover sheet or binder on each volume of the manuals must be identified and marked with the words, "Operation and Maintenance Manual."

1.8 SITE CONDITIONS

Protect the components of the engine-generator set, including cooling system components, pumps, fans, and similar auxiliaries when not operating and provide components capable of the specified outputs in the following environment:

- a. Site Location: MCB Camp Lejeune, North Carolina
- b. Site Elevation: 33 feet above mean sea level.
- c. Ambient Temperatures:
 - (1) Maximum 93.2 degrees F dry bulb, 78.1 degrees F wet bulb.
 - (2) Minimum 22.9 degrees F dry bulb.
- d. Design Wind Velocity: 150 mph.
- e. Prevailing Wind Direction: East
- f. Seismic Zone: Zone 0 as defined by ICC IBC.

PART 2 PRODUCTS

2.1 SYSTEM REQUIREMENTS

- a. Provide and install each engine-generator set complete and totally functional, with all necessary ancillary equipment to include: air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; and engine exhaust system. Each engine-generator set must satisfy the requirements specified in the Engine-Generator Parameter Schedule. Submit certification that the engine-generator set and cooling system function properly in the ambient temperatures specified.

- b. Provide each engine-generator set consisting of one engine, one generator, and one exciter mounted, assembled, and aligned on one base; and all other necessary ancillary equipment which may be mounted separately. Assemble sets having a capacity of 750 kW or smaller and attach to the base prior to shipping. Sets over 750 kW capacity may be shipped in sections. Provide set components that are environmentally suitable for the locations shown and that are the manufacturer's standard product offered in catalogs for commercial or industrial use. Provide a generator strip heater for moisture control when the generator is not operating. Identify any nonstandard products or components and the reason for their use.

2.1.1 Engine-Generator Parameter Schedule

Engine-Generator Set and Auxiliary Equipment Capacity Calculations for Engine-Generator Set

ENGINE-GENERATOR PARAMETER SCHEDULE	
Identification	Make/Model
Electrical Characteristics	
Power Rating	Emergency Standby Gross bhp rating / Net brake power rating As shown on plans kW at 0.8 power factor
Governor Type	Type Make / Model Isochronous
Overload Capacity (Prime applications only)	110 percent of Service Load for 1 hour in 12 consecutive hours
Service Load	1738.9 kVA (maximum) 1136.1 kVA (continuous)
Motor Starting kVA (Max.)	1878.8 kVA
Power Factor	0.8 lagging
Engine-Generator Applications	stand-alone
Voltage Regulation (No Load to Full Load)(Stand-alone applications)	plus or minus 2 percent (maximum)
Voltage Bandwidth (steady state)	plus or minus 1 percent
Frequency	60 Hz
Voltage	480Y/277 volts

ENGINE-GENERATOR PARAMETER SCHEDULE	
Phases	3 Phase, Wye
Minimum Generator Sub-transient Reactance	10 percent Sub-transient
Nonlinear Loads	698.8 kVA
Max Step Load Increase	50 percent of Service Load at 0.8 PF
Transient Recovery Time with Step Load Increase (Voltage)	5 seconds
Transient Recovery	5 seconds
Time with Step Load Increase (Frequency)	
Maximum Voltage Deviation with Step Load Increase	30 percent of rated voltage
Maximum Frequency Deviation with Step Load Increase	5 percent of rated frequency
Max Step Load Decrease (without shutdown)	100 percent of Service Load at 0.8 PF
Frequency Bandwidth (steady state)	plus or minus 0.4 percent
Frequency Regulation (droop) (No Load to Full Load)	3 percent (maximum)
Frequency Bandwidth (steady state)	plus or minus 0.4 percent
Reactances	Synchronous reactance, X_d Transient reactance, X'_d Sub-transient reactance, X''_d Negative sequence reactance, X_2 Zero sequence reactance, X_0
Capacity Calculations	
Calculations must verify that the engine-generator set power rating is adequate for the following load conditions:	
Lighting	kW
Computer	kW
Uninterruptible Power Supplies (UPS)	kVA, pulse

ENGINE-GENERATOR PARAMETER SCHEDULE					
Variable Frequency Drives (VFD)	95.6 kVA, 12 pulse				
Motor Starting Sequence	Starting Order	Size (hp)	Locked Rotor NEMA Code	Starting Method	Maximum Voltage Dip
					Percent
					Percent
					Percent
Other Load	kW at 0.8 power factor				
Capacity Calculations for Batteries					
Calculation must verify that the engine starting battery capacity exceeds dc power requirements.					
Mechanical Characteristics					
Engine Description	Strokes/cycle Number of cylinders Bore and Stroke, inches				
Engine Speed	1800 rpm				
Piston Speed	2250 fpm				
Heat Exchanger Type	fin-tube (radiator)				
Engine Cooling Type	water/ethylene glycol				
Intercooler Type	Air-to-Air / Jacket Water				
Induction Method	Naturally Aspirated / Turbocharged				
Turbocharger	Make / Model				
Max Time to Start and be Ready to Assume Load	10 seconds				
Max Summer Indoor Temp (Prior to Engine-generator Operation)	N/A degrees F				
Min Winter Indoor Temp (Prior to Engine-generator Operation)	N/A degrees F				

ENGINE-GENERATOR PARAMETER SCHEDULE	
Max Allowable Heat Transferred To Engine Generator Space at Rated Output Capacity	N/A MBTU/hr
Max Summer Outdoor Temp (Ambient)	93 degrees F
Min Winter Outdoor Temp (Ambient)	23 degrees F
Installation Elevation	26 above sea level
Engine-Generator Set Efficiencies	
Fuel Consumption	At 0.8 power factor, Gallons / hour for: 1 / 2 load 3 / 4 load Full Load
Generator Efficiency	At 0.8 power factor, (per cent) for: 1 / 2 load 3 / 4 load Full Load
Radiator Capacity	Coolant Type gpm coolant cfm air through radiator Btu per hr of heat exchange based on optimum coolant temperature to and from engine
Engine-Generator Set Emissions Data	
Exhaust Temperature	Degrees F at full load
Weight of Exhaust Gas	lb per hr at full load
Weight of Intake Air	lb per hr at full load
Total Heat Rejected	Btu per hr, at full load to: Jacket Coolant System Fuel Oil Cooling System
Emissions	lb per hr, at full load Total Suspended Particulate Particulate Matter with an average aerodynamic diameter of 10 microns Sulfur Dioxides Nitrogen Oxides (as NO2) Carbon Monoxide Volatile Organic Compounds
Visible Emissions	Percent opacity at full load
Brake Mean Effective Pressure (BMEP) Calculations	

ENGINE-GENERATOR PARAMETER SCHEDULE
Calculation must verify that the engine meets the specified maximum BMEP, as follows: $\text{BMEP psi} = \frac{(120,000 \times \text{bkw}) \times (792,000 \times \text{bhp})}{(\text{rpm} \times \text{cu. in.})}$ Where: bkw bhp = bkw' + bkw" bhp' + bhp" bkw" bhp" is the Brake kW horsepower required by engine driven fan for cooling radiator or motor driven fan for cooling radiator. bkw' bhp' = kW/GEN.EFF. kW/(GEN.EFF. times 0.746) GEN.EFF. = Generator efficiency cu. in. = Total engine piston displacement in cubic inches rpm = Engine revolutions per minute kW = Minimum power rating
Torsional Vibration Stress Analysis Computations
Torsional vibrational stresses in the crankshaft and generator shaft of assembled engine and driven generator must not exceed 5000 psi when engine is driving generator at rated speed while assembled unit is loaded to rated engine-generator set power. Computations must be based on a mathematical model of the assembled generator set provided or based on calculations using measured values from tests on a unit identical to the one provided. Calculations based on models of, or measured data from, the unassembled engine and generator will not be acceptable. Calculations must include: - A description of the system relating information pertinent to analysis such as operating speed range and identification plate data. - A mass elastic assembly drawing, showing the arrangement of the units in the generator set and dimensions of shafting, including minimum diameters (or section moduli) of shafting in the system. - A labeled line diagram of the mass elastic system indicating values of masses, stiffness, equivalent lengths, and equivalent diameters including basic assumptions and definition of terms. - Sample computations showing procedures used to obtain resulting stress values. - Computations indicating assembled engine-generator speed of 1800 rpm with assembly loaded to rated generator power and the resulting computed critical torsional stress values in the assembled engine crankshaft and generator shaft.
Turbocharger Load Calculations

ENGINE-GENERATOR PARAMETER SCHEDULE	
NOTE: When the engine-generator set installation includes field installed exhaust system (i.e., the engine-generator set is installed internal to a building in lieu of in a self-contained outdoor enclosure), include the following paragraph. When the proposed exhaust system layout is different from that shown on the contract drawings, submit calculations showing that the external loads from the exhaust system such as weight and thermal expansion do not exceed the engine manufacturer's maximum allowed forces and moments on the turbocharger.	

2.1.2 Rated Output Capacity

Provide each engine-generator-set with power equal to the sum of service load plus the machine's efficiency loss and associated ancillary equipment loads. Rated output capacity must also consider engine and/or generator oversizing required to meet requirements in paragraph Engine-Generator Parameter Schedule.

The engine must meet the specified maximum BMEP requirements at rated speed as calculated in accordance with the calculations in the engine-generator parameter schedule. The engine capacity must be based on the following:

- a. Engine burning diesel fuel conforming to MIL-DTL-16884 or ASTM D975, Grade 2-Dat an ambient temperature of 85 degrees F. For stationary engines operated in the United States, diesel fuel requirements are found in 40 CFR 60 Subpart IIII.
- b. Engine cooled by a radiator fan mechanically driven by the engine or remote with a motor driven fan.
- c. Engine cooled by coolant mixture of water and ethylene glycol, 50 percent by volume of each.

Maximum BMEP, psi			
	Naturally Aspirated	Turbocharged	Turbocharged and Intercooled
Four-cycle engines		340	
Engine speed, rpm:		1800	

2.1.2.1 Engine Emission Limits

Engine must be certified by the manufacturer to meet applicable EPA emission standards found in 40 CFR 60 Subpart IIII. In addition, engine must meet any applicable state or local emission requirements (ex:

California SCAQMD).

2.1.2.2 Performance Class

The voltage and frequency behavior of the generator set must be in accordance with **ISO 8528** operating limit values for performance Class G2.

2.1.3 Power Ratings

Power ratings must be in accordance with **EGSA 101P**.

2.1.4 Transient Response

The engine-generator set governor and voltage regulator must cause the engine-generator set to respond to the maximum step load changes such that output voltage and frequency recover to and stabilize within the operational bandwidth within the transient recovery time. The engine-generator set must respond to maximum step load changes such that the maximum voltage and frequency deviations from bandwidth are not exceeded.

2.1.5 Reliability and Durability

Each standby engine-generator set must have both an engine and a generator capable of delivering the specified power on a standby basis with an anticipated mean time between overhauls of no less than 5,000 hours operating with a load factor of 70 percent. Cite two like engines and two like generators that have performed satisfactorily in a stationary power plant, independent and separate from the physical location of the manufacturer's and assembler's facilities, for standby without any failure to start, including all periodic exercise. Provide like engines and generators that have had no failures resulting in downtime for repairs in excess of 72 hours during two consecutive years of service. Provide engines that are the same model, speed, bore, stroke, number and configuration of cylinders, and rated output capacity. Provide generators that are the same model, speed, pitch, cooling, exciter, voltage regulator and rated output capacity.

Submit a reliability and durability certification letter from the manufacturer and assembler to prove that existing facilities are and have been successfully utilizing the same components proposed to meet this specification, in similar service. Certification may be based on components, i.e. engines used with different models of generators and generators used with different engines, and does not exclude annual technological improvements made by a manufacturer in the basic standard-model component on which experience was obtained, provided parts interchangeability has not been substantially affected and the current standard model meets the performance requirements specified. Provide a list with the name of the installations, completion dates, and name and telephone number of a point of contact.

2.1.6 Engine-Generator Set Enclosure

Provide engine-generator set enclosures that are corrosion resistant and fully weather resistant. **Provide vandal-resistant coastal high humidity rated aluminum weatherproof enclosure with stainless steel hardware and 175 MPH wind rating, with a Level 3 sound attenuating rating.** The enclosure must contain all set components and provide ventilation to permit operation at Service Load under secured conditions. Provide access

doors to controls and equipment requiring periodic maintenance or adjustment. Provide removable panels for access to components requiring periodic replacement. The enclosure must be capable of being removed without disassembly of the engine-generator set or removal of components other than the exhaust system. The enclosure must reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS.

2.1.7 Vibration Isolation

Provide an engine-generator set with a vibration isolation system in accordance with the manufacturer's standard recommendation. Submit vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor plus description of seismic qualification of the engine-generator mounting, base, and vibration isolation. Submit torsional analysis including prototype testing or and calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, plus 10 percent. Design and qualify vibration isolation systems as an integral part of the base and mounting system in accordance with the seismic parameters specified. Where the vibration isolation system does not secure the base to the structure floor or unit foundation, provide seismic restraints in accordance with the seismic parameters specified.

2.1.8 Harmonic Requirements

Non-linear loads to be served by each engine-generator set are as indicated. The maximum linear load demand (kVA at PF) when non-linear loads will also be in use is as indicated.

2.1.9 Starting Time Requirements

Upon receipt of a signal to start, each engine generator set will start, reach rated frequency and voltage and be ready to assume load within the time specified. For standby sets used in emergency power applications, each engine generator set will start, reach rated frequency and voltage, and power will be supplied to the load terminals of the automatic transfer switch within the starting time specified.

2.2 NAMEPLATES

Provide the manufacturer's name, type or style, model or serial number and rating on a plate secured to the equipment for each major component of this specification. Provide plates and tags sized so that inscription is readily legible to operating or maintenance personnel and securely mounted to or attached in proximity of their identified controls or equipment. Lettering must be normal block lettering, a minimum of 0.25 inch high. As a minimum, provide nameplates for:

Engines	Relays
Generators	Transformers (CT & PT)
Regulators	Day tanks

Pumps and pump motors	Governors
Generator Breaker	Air Starting System
Economizers	Heat exchangers (other than base mounted)

Where the following equipment is not provided as a standard component by the engine generator set manufacturer, the nameplate information may be provided in the maintenance manual in lieu of nameplates.

Battery charger	Heaters
Switchboards	Exhaust mufflers
Switchgear	Silencers
Battery	Exciters

2.2.1 Materials

Construct ID plates and tags of 16 gage minimum thickness bronze or stainless steel sheet metal engraved or stamped with inscription. Construct plates and tags not exposed to the weather or high operational temperature of the engine of laminated plastic, 0.125 inch thick, matte white finish with black center core, with lettering accurately aligned and engraved into the core.

2.2.2 Control Devices and Operation Indicators

Provide ID plates or tags for control devices and operation indicators, including valves, off-on switches, visual alarm annunciators, gages and thermometers, that are required for operation and maintenance of provided mechanical systems. Plates or tags must be minimum of 0.5 inch high and 2 inches long and must indicate component system and component function.

2.2.3 Equipment

Provide ID plates of a minimum size of high and 5 inches long on provided equipment indicating the following information:

- Manufacturer's name, address, type and model number, serial number, and certificate of compliance with applicable EPA mission standards;
- Contract number and accepted date;
- Capacity or size;
- System in which installed; and
- System which it controls.

2.3 SAFETY DEVICES

Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices such

that proper operation of the equipment is not impaired.

2.4 MATERIALS AND EQUIPMENT

Submit certification stating that where materials or equipment are specified to comply with requirements of UL, written proof of such compliance has been obtained. The label or listing of the specified agency, or a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency are acceptable as proof.

2.4.1 Circuit Breakers, Low Voltage

UL 489.

2.4.2 Filter Elements

Provide the manufacturer's standard fuel-oil, lubricating-oil, and combustion-air filter elements.

2.4.3 Instrument Transformers

NEMA/ANSI C12.11.

2.4.4 Revenue Metering

IEEE C57.13.

2.4.5 Pipe (Fuel/Lube-Oil, Compressed Air, Coolant, and Exhaust)

ASTM A53/A53M, or ASTM A106/A106M steel pipe. Pipe smaller than 2 inches must be Schedule 80. Pipe 2 inches and larger must be Schedule 40.

2.4.5.1 Flanges and Flanged Fittings

ASTM A181/A181M, Class 60, or ASME B16.5, Grade 1, Class 150.

2.4.5.2 Pipe Welding Fittings

ASTM A234/A234M, Grade WPB or WPC, Class 150 or ASME B16.11, 3000 lb.

2.4.5.3 Threaded Fittings

ASME B16.3, Class 150.

2.4.5.4 Valves

MSS SP-80, Class 150.

2.4.5.5 Gaskets

Manufacturer's standard.

2.4.6 Pipe Hangers

MSS SP-58.

2.4.7 Electrical Enclosures

NEMA ICS 6.

2.4.7.1 Switchboards

NEMA PB 2.

2.4.7.2 Panelboards

NEMA PB 1.

2.4.8 Electric Motors

Provide electric motors that conform to the requirements of NEMA MG 1. Motors must have sealed ball bearings and a maximum speed of 1800 rpm. Motors used indoors must have drip-proof frames; enclose those that are used outside. Alternating current motors larger than 1/2 Hp must be of the squirrel-cage induction type for operation on 208 volts or higher, 60 Hz, and three-phase power. Alternating current motors 1/2 Hp or smaller, must be suitable for operation on 120 volts, 60 Hz, and single-phase power. Direct current motors must be suitable for operation on 125 volts.

2.4.9 Motor Controllers

Provide motor controllers and starters that conform to the requirements of NFPA 70 and NEMA ICS 2.

2.5 ENGINE

Each engine must operate on No. 2-D diesel fuel conforming to ASTM D975, must be designed for stationary applications and must be complete with ancillaries. The engine must be a standard production model shown in the manufacturer's catalog describing and depicting each engine-generator set and all ancillary equipment in sufficient detail to demonstrate complete specification compliance. The engine must be naturally aspirated, supercharged, or turbocharged. The engine must be 2- or 4-stroke-cycle and compression-ignition type. The engine must be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. The engine must have a minimum of two cylinders. Opposed-piston type engines must have more than four cylinders. Each block must have a coolant drain port. Equip each engine with an over-speed sensor.

ISO 3046. Diesel engines must be four-cycle naturally aspirated, or turbocharged, or turbocharged and intercooled; vertical in-line or vertical Vee type; designed for stationary service. Engines must be capable of immediate acceleration from rest to normal speed without intermediate idle/warm up period or pre-lubrication to provide essential electrical power. Two-cycle engines are not acceptable.

2.5.1 Sub-base Mounting

Mount each engine-generator set on a structural steel sub-base sized to support the engine, generator, and necessary accessories, auxiliaries and control equipment to produce a complete self-contained unit as standard with the manufacturer. Design the structural sub-base to properly support the equipment and maintain proper alignment of the engine-generator set in the specified seismic zone. In addition, provide sub-base with both

lifting rings and jacking pads properly located to facilitate shipping and installation of the unit. Factory align engine and generator on the sub-base and securely bolt into place in accordance with the manufacturer's standard practice. Crankshaft must have rigid coupling for connection to the generator.

2.5.2 Assembly

Completely shop assemble each engine-generator set on its structural steel sub-base. Paint entire unit with manufacturer's standard paints and colors. After factory tests and before shipping, thoroughly clean and retouch painting as necessary to provide complete protection.

2.5.3 Turbocharger

If required by the manufacturer to meet the engine-generator set rating, provide turbine type driven by exhaust gas from engine cylinders, and direct connected to the blower supplying air to the engine intake manifold.

2.5.4 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.5.5 Crankcase Protection

2.5.6 Miscellaneous Engine Accessories

Provide the following engine accessories where the manufacturer's standard design permits:

- a. Piping on engine to inlet and outlet connections, including nonstandard companion flanges.
- b. Structural steel sub-base and vibration isolators, foundation bolts, nuts, and pipe sleeves.
- c. Level jack screws or shims, as required.
- d. Rails, chocks, and shims for installation of sub-base on the foundation.
- e. Removable guard, around fan. Support guard, on engine sub-base, to suit manufacturer's standard.

2.5.7 Intercooler

Provide manufacturer's standard intercooler for engine size specified.

2.6 FUEL SYSTEM

Provide fuel system conforming to the requirements of **NFPA 30** and **NFPA 37** and containing the following elements.

2.6.1 Pumps

Fuel transfer pumps may be mounted on the day tank. Pumps must be horizontal, positive displacement. Direct-connect pump to motor through a flexible coupling. Equip each pump with a bypass relief valve, if not provided with an internal relief valve. Provide motor and controller in

accordance with the paragraphs ELECTRIC MOTORS and MOTOR CONTROLLERS, respectively.

2.6.1.1 Main Pump

Provide engines with an engine driven pump. The pump must supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet the performance indicated within the parameter schedule. Base the fuel flow rate on meeting the load requirements and all necessary recirculation.

2.6.1.2 Auxiliary Fuel Pump

Provide auxiliary fuel pumps to maintain the required engine fuel pressure, if either required by the installation or indicated on the drawings. The auxiliary pump must be driven by a dc electric motor powered by the starting/station batteries. Automatically actuate the auxiliary pump by a pressure-detecting device.

2.6.2 Fuel Filter

Provide a minimum of one full-flow fuel filter for each engine. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark the inlet and outlet connections of the filter.

Provide intake filter assemblies for each engine of the oil bath or dry type, as standard with the manufacturer. Filters must be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.6.3 Relief/Bypass Valve

Provide a relief/bypass valve to regulate pressure in the fuel supply line, return excess fuel to a return line and prevent the build-up of excessive pressure in the fuel system.

2.6.4 Integral Main Fuel Storage Tank

Provide each engine with an integral main fuel tank. Each tank must be factory installed and provided as an integral part of the generator manufacturer's product. Provide each tank with connections for fuel supply line, fuel return line, local fuel fill port, gauge, vent line, and float switch assembly. Provide a fuel return line cooler as recommended by the manufacturer and assembler. The temperature of the fuel returning to the tank must be below the flash point of the fuel. Mount the tank within the enclosure for each engine-generator set provided with weatherproof enclosures. The fuel fill line must be accessible without opening the enclosure.

- a. All Tanks: **UL 142**. Provide integral in skid double wall (110 percent containment) fuel tanks with a capacity as indicated. Epoxy coat day tanks inside and prime and paint outside. Construct tanks of not less than **3/16 inch** steel plate with welded joints and necessary stiffeners on exterior of tank. Provide a braced structural steel framework support. Weld tank top tight. Provide **4 1/2 inch** square inspection port with a 2 inch NPT fill connection and spill box. Provide proper normal and emergency venting for the primary tank and emergency venting only for the secondary tank / containment basin in

accordance with [UL 142](#) requirements.

- b. Float Switches for Day Tanks: Provide tank-top mounted or external float cage, single-pole, single-throw type designed for use on fuel oil tanks. Arrange high level float switches to close on rise of liquid level, and low level float switches to close on fall of liquid level. Mount float cage units with isolating and drain valves. Contacts must be suitable for the station battery voltage.
 - (1) Critical low level float switch which must activate at 5 percent of normal liquid level must shut engine off.
 - (2) Low-low level float switch which must activate alarm at 30 percent of normal liquid level.
 - (3) Low level float switch which must open the fuel oil solenoid valve and start the fuel transfer pump at 75 percent of normal liquid level.
 - (4) High level float switch which must close the fuel oil solenoid valve and stop the fuel transfer pump at 90 percent of normal liquid level.
 - (5) Critical high level float switch which must activate alarm at 95 percent of normal liquid level.
- c. Leak Detector Switch for All Tanks: Actuates when fuel is detected in containment basin, stops fuel transfer pump, and closes the fuel oil solenoid valve.
- d. Control Panel for All Tanks: Provide [NEMA ICS 6](#), Type [4X stainless steel](#), enclosed control panel for each day tank. Control panel must include the following accessories.
 - (1) Power available LED (green).
 - (2) Critical low fuel alarm contacts for shut down of engine.
 - (3) Low-low level fuel alarm LED.
 - (4) Low-low level fuel alarm contracts for remote annunciator.
 - (5) Critical high level fuel alarm LED.
 - (6) Leak detecting alarm LED.
 - (7) Alarm horn.
- e. Tank Gages for All Tanks: Provide buoyant force type gages for fuel tanks with dial indicator not less than [4 inches](#) in size and arranged for top mounting. Calibrate each reading dial or scale for its specific tank to read from empty to full, with intermediate points of 1/4, 1/2, and 3/4.
- f. Integral Base Tanks Used as Primary Tank: Provide a 2 inch opening at the tank fill port, fitted an overfill prevention valve (OPV). Additionally, the fill opening must be perpendicular to the tank in order to allow operation of the OPV. Integral base tank must be sized and configured such that the filling and venting nozzles are outside

the generator cabinet for ease of accessibility, inspection, and maintenance. Level gage must be in the line of sight from the fill port.

- g. Integral Base Tanks Located Inside Buildings. The tank vents must discharge outside the building in accordance with NFPA 30 and NFPA 37. The fill pipe must terminate outside the building. The fill pipe connection point must be housed in a sealed spill box. High level alarms or level gauges used as overfill protection mechanisms must annunciate at the fill connection point. Provide an overfill prevention valve (OPV) at the tank with a check valve mounted on the fill line in the spill box. The fill connection point must be labeled with tank contents and capacity.

2.6.4.1 Capacity

Each tank must have capacity as shown at 100 percent rated load without being refilled.

2.6.4.2 Local Fuel Fill

Each local fuel fill port on the day tank must have a screw-on cap.

2.6.4.3 Fuel Level Controls

Provide tanks with a float-switch assembly to perform the following functions:

- a. Activate the "Low Fuel Level" alarm at 70 percent of the rated tank capacity.
- b. Activate the "Overfill Fuel Level" alarm at 95 percent of the rated tank capacity.

2.6.4.4 Arrangement

Integral tanks may allow gravity flow into the engine. Gravity flow tanks and any tank that allows a fuel level above the fuel injectors must have an internal or external factory installed valve located as near as possible to the shell of the tank. The valve must close when the engine is not operating. Provide integral day tanks with any necessary pumps to supply fuel to the engine as recommended by the generator set manufacturer. The fuel supply line from the tank to the manufacturer's standard engine connection must be welded pipe.

2.6.5 Fuel Oil Cooler

Provide an air cooled fuel oil cooler if the temperature of the fuel returned to the tank from the engine will cause overheating of the tank fuel above the maximum fuel temperature allowed by the engine manufacturer when operating at maximum rated generator power output and low fuel level in the tank. The fuel oil cooler must be furnished by the engine manufacturer for the application and the installation must be complete including piping and power requirements.

2.7 LUBRICATION

Provide engine with a separate lube-oil system conforming to NFPA 30 and NFPA 37. Pressurize each system by engine-driven pumps. Regulate system pressure as recommended by the engine manufacturer. Provide a pressure relief valve on the crankcase for closed systems. Vent the crankcase in accordance with the manufacturer's recommendation. Do not vent the crankcase to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, must be piped to vent to the outside. The system must be readily accessible for service such as draining, refilling, etc. Each system must permit addition of oil and have oil-level indication with the set operating. The system must utilize an oil cooler as recommended by the engine manufacturer.

2.7.1 Lube-Oil Filter

Provide one full-flow filter for each pump. The filter must be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. Mark inlet and outlet connections.

2.7.2 Lube-Oil Sensors

Equip each engine with lube-oil pressure sensors located downstream of the filters and provide signals for required indication and alarms. Submit two complete sets of filters, required for maintenance, supplied in a suitable storage box. Provide these filters in addition to filters replaced after testing.

2.7.3 Precirculation Pump

Provide a motor-driven precirculation pump powered by the station battery, complete with motor starter, if recommended by the engine manufacturer.

2.8 COOLING SYSTEM

Provide each engine with its own cooling system to operate automatically while its engine is running. The cooling system coolant must use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across each engine must not exceed that recommended below. Submit a letter which certifies that the engine-generator set and cooling system function properly in the ambient temperature specified, stating the following values:

- a. The maximum allowable inlet temperature of the coolant fluid.
- b. The minimum allowable inlet temperature of the coolant fluid through the engine.
- c. The maximum allowable temperature rise in the coolant fluid through the engine.
- d. The minimum allowable inlet fuel temperature.

2.8.1 Coolant Pumps

Provide centrifugal coolant pumps. Each engine must have an engine-driven primary pump. Provide secondary pumps that are electric motor driven and have automatic controllers. Control raw-water circulating pump by

manual-off-automatic controllers and must be engine driven.

2.8.2 Heat Exchanger

Provide heat exchanger with the size and capacity to limit the maximum allowable temperature rise in the coolant across the engine to that recommended and submitted for the maximum summer outdoor design temperature and site elevation. Submit manufacturer's data to quantify heat rejected to the space with the engine generator set at rated capacity. Provide heat exchangers that are corrosion resistant, suitable for service in ambient conditions of application.

2.8.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosion resistant film, provided that corrective measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via oversizing, or other compensating methods. Provide internal surfaces that are compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Provide heat exchangers that are pressure type incorporating a pressure valve, vacuum valve and a cap. Design caps for pressure relief prior to removal. Provide heat exchanger and cooling system that is capable of withstanding a minimum pressure of 7 psi and protect with a strong grille or screen guard. Provide heat exchanger with at least two tapped holes; equip one tapped hole with a drain cock, and plug the rest.

Provide for each engine-generator set, as standard with the manufacturer.

- a. Design Conditions: Each radiator unit must have ample capacity to remove not less than the total Btu per hour of heat rejected by its respective engine at 100 percent full-rated load to the jacket water, fuel oil, and lubricating oil system, and intercooler. Radiator capacity must be rated at optimum temperature of coolant leaving the engine and intercooler as recommended by the engine manufacturer with an ambient dry bulb air temperature outside the enclosure of 93 degrees F maximum, and 23 degrees F minimum at the site elevation specified in the paragraph SITE CONDITIONS, and with the coolant mixture specified in the paragraph ENGINE CAPACITY. Pressure drop through the radiator must not exceed 6 psi when circulating the maximum required coolant flow. Radiator air velocity must be a maximum of 1500 feet per minute.
- b. Engine Mounted Radiator Construction: Radiator fan must direct airflow from the engine outward through the radiator. Fan must be V-belt driven directly from the engine crankshaft. Radiator fan must have sufficient capacity to meet design conditions against a static restriction of 1 inch of water. Fan static capacity must be adjusted to suit the ductwork furnished. Cooling section must have a tube and fin-type core consisting of copper or copper base alloy tubes with nonferrous fins. Select engine-driven fans for quiet vibration-free operation. Make provision for coolant expansion either by self-contained expansion tanks or separately mounted expansion tanks, as standard with the manufacturer. Provide suitable guards for each fan and drive.
- c. Coolant solution must be a mixture of clean water and ethylene glycol,

50 percent by volume each. Provide an anti-freeze solution tester suitable for the mixture.

2.8.3 Thermostatic Control Valve

Provide a modulating type, thermostatic control valve in the coolant system to maintain the coolant temperature range submitted in paragraph SUBMITTALS.

2.8.4 Temperature Sensors

Equip each engine with coolant temperature sensors. Provide temperature sensors with signals for pre-high and high indication and alarms.

2.9 SOUND LIMITATIONS

Submit sound power level data for the packaged unit operating at 100 percent load in a free field environment. The data should demonstrate compliance with the sound limitation requirements of this specification. Submit certification from the manufacturer stating that the sound emissions meet the specification. Do not exceed the following sound pressure levels in any of the indicated frequencies when measured in a free field at a radial distance of 22.9 feet 7 meters at 45 degrees apart in all directions when operating at 100 percent load.

Frequency Band (Hz)	Maximum Acceptable Sound Level (Decibels)
31	72
63	72
125	72
250	72
500	72
1,000	72
2,000	72
4,000	72
8,000	72

2.10 AIR INTAKE EQUIPMENT

Locate filters and silencers in locations that are convenient for servicing. Provide high-frequency filter type silencers and locate in the air intake system as recommended by the engine manufacturer. Provide silencer to reduce the noise level at the air intake so that the indicated pressure levels specified in paragraph SOUND LIMITATIONS will not be exceeded. A combined filter-silencer unit meeting requirements for the separate filter and silencer items may be provided. Provide copper expansion elements in air-intake lines.

Provide intake filter assemblies for each engine of the oil bath or dry

type, as standard with the manufacturer. Filters must be capable of removing a minimum of 92 percent of dirt and abrasive 3 microns and larger from intake air. Size filters to suit engine requirements at 100 percent of rated full load. Design unit for field access for maintenance purposes.

2.11 EXHAUST SYSTEM

Provide a separate and complete system for each engine. Support piping to minimize vibration. Where a V-type engine is provided, use a V-type connector, with necessary flexible sections and hardware, to connect the engine exhaust outlets.

2.11.1 Flexible Sections and Expansion Joints

Provide a flexible section at each engine and an expansion joint at each muffler. Provide flexible sections and expansion joints that have flanged connections. Provide flexible sections made of convoluted seamless tube without joints or packing. Provide bellows type expansion joints. Provide stainless steel expansion and flexible elements suitable for engine exhaust gas at the maximum exhaust temperature that is specified by the engine manufacturer. Provide expansion and flexible elements that are capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.11.2 Exhaust Muffler

Provide a chamber type exhaust muffler. Provide welded steel muffler designed for outside horizontal mounting. Provide eyebolts, lugs, flanges, or other items as necessary for support in the location and position indicated. Do not exceed the engine manufacturer's recommended pressure drop. Outside mufflers must be zinc coated or painted with high temperature 400 degrees F resisting paint. The muffler and exhaust piping together must reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. Provide muffler with a drain valve, nipple, and cap at the low-point of the muffler.

A residential class silencer must be provided for each engine which will reduce the exhaust sound spectrum by the following listed values at a 75 foot radius from the outlet, with generator set loaded to rated capacity and clear weather. Inlet and outlet connections must be flanged.

Octave Band Center Frequency (Hertz)								
Minimum Silencer Attenuation Decibels	63	125	250	500	1000	2000	4000	8000
Residential Class	10	25	32	30	25	25	24	23

2.11.3 Exhaust Piping

Slope horizontal sections of exhaust piping downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction must be long radius. Insulate exhaust piping, mufflers and silencers installed inside any building in accordance with paragraph THERMAL INSULATION and covered to protect personnel. Provide horizontal exhaust discharge piping with a 45-degree slash cut and

mechanically fastened screen cover.

Field installed exhaust piping must conform to the following:

- a. Exhaust Piping: Provide flanges for connections to engines, exhaust mufflers, and flexible connections. Provide steel pipe conforming to **ASTM A53/A53M** for each engine complete with necessary fittings, flanges, gaskets, bolts, and nuts. Exhaust piping must be Schedule 40 pipe for **12 inches** and smaller, standard weight for sizes **14 inches** through **24 inches**, and **0.25 inch** wall thickness for sizes larger than **24 inches**. Flanges must be Class 150 slip-on forged steel welding flanges in accordance with **ASME B16.5**, with material in accordance with **ASTM A181/A181M**, Grade I. Fittings must be butt welding conforming to **ASTM A234/A234M**, with wall thickness same as adjoining piping. Fittings must be of same material and wall thickness as pipe. Built-up miter welded fittings may be used. Miter angles of each individual section must not exceed 22.5 degrees total and not more than 11.25 degrees relative to the axis of the pipe at any one cut. Gaskets for exhaust piping must be of high temperature asbestos-free material suitable for the service and must be **ASME B16.21**, composition ring, **0.0625 inch** thick. Bolting material for exhaust flanges must be alloy-steel bolt-studs conforming to **ASTM A193/A193M**, Grade B7 bolts and alloy-steel nuts conforming to **ASTM A194/A194M**, Grade 7. Bolts must be of sufficient length to obtain full bearing on the nuts and must project not more than two full threads beyond the nut. Provide stainless steel counterbalance type rain caps at termination of each exhaust pipe.
- b. Expansion (Flexible) Joints: Provide sections of multiple corrugated stainless steel expansion joints in the engine exhaust piping for each engine to absorb expansion strains and vibration transmitted to the piping. Flexible joints must be suitable for operation at **200 degrees F** above normal exhaust gas temperature at 100 percent load, 10,000 cycles, minimum. Joints must be flanged and located between engine exhaust manifold and exhaust piping, must be the same size as exhaust piping size, and must be designed and constructed for engine exhaust service.
- c. Hangers and Supports: **MSS SP-58**.
- d. Piping Sleeves: Provide where piping passes through masonry or concrete walls, floors, roofs, and partitions. Sleeves must be placed during construction. Unless indicated otherwise, pipe sleeves must comply with following requirements: sleeves in outside walls below and above grade, in floor, or in roof slabs, must be standard weight zinc coated steel pipe. Sleeves in partitions must be zinc coated sheet steel having a nominal weight of not less than **0.90 pound per square foot**. Space between piping insulation and the sleeve must not be less than **0.25 inch**. Sleeves must be held securely in proper position and location during construction. Sleeves must be sufficient length to pass through entire thickness of walls, partitions, or slabs. Sleeves in floor slabs must extend **2 inches** above the finished floor. Space between the pipe and the sleeve must be firmly packed with insulation and caulked at both ends of the sleeve with plastic waterproof cement.
- e. Piping Insulation: Provide exhaust piping insulation in accordance with Section **23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS**.

2.12 PYROMETER

Provide a pyrometer, multi-point selector switch, and individual thermocouples with calibrated leads to show the temperature of the combined exhaust. For a supercharged engine, provide additional points, thermocouples and leads to show the temperature in the turbocharger exhaust gas outlet and combustion air discharge passages. Graduated scale length less than 6 inches is not acceptable. Provide double pole selector switch with an "off" position, one set of points for each thermocouple, and suitable indicating dial. Calibrate the pyrometer, thermocouples, leads and compensating devices to show true exhaust temperature within plus or minus 1 percent above the highest temperature encountered at 110 percent load conditions.

2.13 EMISSIONS

The finished installation must comply with Federal, state, and local regulations and restrictions regarding the limits of emissions, as listed here: as required by MCB Camp Lejeune Environmental standards. Submit certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions specified. At a minimum this certification must include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and for hazardous air pollutants (HAPs).

2.14 STARTING SYSTEM

Provide starting system for standby engine generator sets used in emergency applications in accordance with NFPA 99 and NFPA 110 and as follows.

2.14.1 Controls

Provide an engine control switch with functions including: run/start (manual), off/reset, and, automatic mode. Provide start-stop logic for adjustable cycle cranking and cool-down operation. Arrange the logic for fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION. Provide electrical starting systems with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.14.2 Capacity

Provide starting system with sufficient capacity, at the maximum outdoor summer temperature specified to crank the engine without damage or overheating. The system must provide a minimum of three cranking periods with 15 second intervals between cranks. Each cranking period must have a maximum duration of 15 seconds. Starting must be accomplished using an adequately sized dc starter system with a positive shift solenoid to engage the starter motor and to crank the engine continuously for 60 seconds without overheating.

2.14.3 Electrical Starting

Manufacturers recommended dc system, utilizing a negative circuit ground. Starting motors must be in accordance with SAE ARP892.

2.14.3.1 Battery

Provide a starting battery system including the battery, battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. Provide battery in accordance with SAE J537. Size critical system components (rack, protection, etc.) to withstand the seismic acceleration forces specified. Provide lead-acid battery with sufficient capacity, at the minimum outdoor and maximum outdoor temperature specified, to provide the specified cranking periods. Valve-regulated lead-acid batteries are not acceptable.

Provide maintenance free, sealed, lead-acid, SAE Type D engine starting batteries. Batteries must have sufficient capacity to provide 60 seconds of continuous cranking of the engine in an ambient temperature of 23 degrees F.

2.14.3.2 Battery Charger

Provide a current-limiting battery charger, conforming to UL 1236, that automatically recharges the batteries. Submit battery charger sizing calculations. The charger must be capable of an equalize charging rate for recharging fully depleted batteries within 24 hours and a floating charge rate for maintaining the batteries at fully charged condition. Provide an ammeter to indicate charging rate. Provide a voltmeter to indicate charging voltage. Provide a timer for the equalize charging-rate setting. A battery is considered to be fully depleted when the output voltage falls to a value which will not operate the engine generator set and its components.

Provide 120 volt ac, enclosed, automatic equalizing, dual-rate, solid-state, constant voltage type battery charger with automatic ac line compensation. DC output must be voltage regulated and current limited. Charger must have two ranges, float and equalize, and must provide continuous taper charging. The charger must have a continuous output rating of not less than 10 amperes and must be sized to recharge the engine starting batteries in a minimum of 8 hours while providing the control power needs of the engine-generator set. Enclosure must be NEMA ICS 6, Type 4X stainless steel. The following accessories must be included:

- a. DC ammeter
- b. DC voltmeter
- c. Equalize light
- d. AC on light
- e. Low voltage light
- f. High voltage light
- g. Equalize test button/switch
- h. AC circuit breaker
- i. Low dc voltage alarm relay
- j. High dc voltage alarm relay

k. Current failure relay

l. AC power failure relay

2.14.4 Starting Aids

Provide one or more of other following methods to assist engine starting.

2.14.4.1 Glow Plugs

Design glow plugs to provide sufficient heat for combustion of fuel within the cylinders to guarantee starting at an ambient temperature of **-25 degrees F**.

2.14.4.2 Jacket-Coolant Heaters

Mount a thermostatically controlled electric heater in the engine coolant jacketing to automatically maintain the coolant within plus or minus **3 degrees F** of the control temperature. The heater must operate independently of engine operation so that starting times are minimized. Power for the heaters must be **208** volts ac. Include necessary equipment, piping, controls, wiring, and accessories.

2.14.4.2.1 Standby Rated Sets

The control temperature must be the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.14.4.3 Lubricating-Oil Heaters

Mount a thermostatically controlled electric heater in the engine lubricating-oil system to automatically maintain the oil temperature within plus or minus **3 degrees F** of the control temperature. The heater must operate independently of engine operation so that starting times are minimized. Power for the heaters must be **208** volts ac.

2.14.5 Exerciser

Provide exerciser in accordance with Section **26 36 23** AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.15 GOVERNOR

Provide a forward acting type engine speed governor system. Steady-state frequency band and frequency regulation (droop) must be in accordance with the operating limit values of the performance class specified in the paragraph PERFORMANCE CLASS.

Provide engine with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100 percent of rated output capacity. Configure the governor for safe manual adjustment of the speed/frequency during operation of the engine-generator set, without **special tools**, from 90 to 110 percent of the rated speed/frequency, over a steady state load range of 0 to 100 percent or rated capacity. Submit two complete sets of special tools required for maintenance (except for electronic governor handset). Special tools are those that only the manufacturer provides, for special purposes, or to

reach otherwise inaccessible parts. Provide a suitable tool box for tools. Provide one handset for each electronic governor when required to indicate and/or change governor response settings. Maintain the midpoint of the frequency bandwidth at the same value for steady-state loads over the range of zero to 100 percent of rated output capacity for isochronous governors.

2.16 GENERATOR

Provide synchronous type, one or two bearing, generator conforming to the performance criteria in NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Submit calculations of the engine and generator output power capability, including efficiency and parasitic load data. Provide Class F insulation.

- a. Select NEMA MG 1, Part 16, standby duty, and temperature rise of 130 degrees C for engine-generator sets which are expected to operate for less than 300 hours per year. Select NEMA MG 1, Part 22, continuous duty, and temperature rise of 105 degrees C for engine-generator sets expected to operate 300 hours or greater per year or rated 300 kW and above.
- b. Select 2/3 pitch design option for engine-generator sets rated 300 kW and above.
- c. Select 10-12 lead re-connectable for engine-generator sets rated 300 kW to 800 kW.
- d. For applications requiring high SCR loading or in harsh environments laden with salts and chemicals, select vacuum pressure impregnation (VPI) insulated coils. When engine-generator sets are rated 800 kW and larger, also select form wound coils.
- e. Provide salient-pole type, ac, brushless-excited, revolving field, air-cooled, self-ventilated, coupled type, synchronous generator conforming to NEMA MG 1, Part 16, and IEEE C50.12. Generator must be rated for standby duty at 100 percent of the power rating of the engine-generator set as specified in paragraph ENGINE-GENERATOR SET RATINGS AND PERFORMANCE. Temperature rise of each of the various parts of the generator must not exceed 105 degrees C as measured by resistance, based on a maximum ambient temperature of 40 degrees C. Winding insulation must be Class H.
- f. Stator: Stator windings must be 2/3 pitch design 10-12 lead re-connectable .
- g. Rotor: The rotor must have connected amortisseur windings.
- h. Generator Space Heater: Provide 208 volt ac heaters. Heater capacity must be as recommended by the generator manufacturer to aid in keeping the generator insulation dry.
- i. Grounding: Provide non-corrosive steel grounding pads located at two opposite mounting legs.
- j. Filters: Provide manufacturer's standard generator cooling air filter assembly.

- k. Design generator to protect against mechanical, electrical and thermal damage due to vibration, 25 percent overspeeds, or voltages and temperatures at a rated output capacity of 110 percent for prime applications and 100 percent for standby applications.
- l. Provide generator ancillary equipment meeting the short circuit requirements of **NEMA MG 1**. Select drip-proof guarded option for generators without weatherproof enclosures.
- m. Submit manufacturer's standard data for each generator (prototype data at the specified rating or above is acceptable), listing the following information:
 - (1) Direct-Axis sub-transient reactance (per unit).
 - (2) The generator kW rating and short circuit current capacity (both symmetric and asymmetric).

2.16.1 Current Balance

At 100 percent rated output capacity, and load impedance equal for each of the 3 phases, the permissible current difference between any 2 phases must not exceed 2 percent of the largest current on either of the 2 phases. Submit certification stating that the flywheel has been statically and dynamically balanced and is capable of being rotated at 125 percent of rated speed without vibration or damage.

2.16.2 Voltage Balance

At any balanced load between 75 and 100 percent of rated output capacity, the difference in line-to-neutral voltage among the 3 phases must not exceed 1 percent of the average line-to-neutral voltage. For a single phase load condition, consisting of 25 percent load at unity power factor placed between any phase and neutral with no load on the other 2 phases, the maximum simultaneous difference in line-to-neutral voltage between the phases must not exceed 3 percent of rated line to neutral voltage. The single-phase load requirement must be valid utilizing normal exciter and regulator control. The interpretation of the 25 percent load for single phase load conditions means 25 percent of rated current at rated phase voltage and unity power factor.

2.16.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced rated output capacity must not exceed 10 percent. The RMS of all harmonics must be less than 5.0 percent and that of any one harmonic less than 3.0 percent of the fundamental at rated output capacity. Design and configure engine-generator to meet the total harmonic distortion limits of **IEEE 519**.

2.17 EXCITER

Provide brushless generator exciter. Provide semiconductor rectifiers that have a minimum safety factor of 300 percent for peak inverse voltage and forward current ratings for all operating conditions, including 110 percent generator output at **104 degrees F** ambient. The exciter and regulator in combination must maintain generator-output voltage within the limits specified.

Provide a brushless excitation system consisting of an exciter and rotating rectifier assembly, and permanent magnet generator integral with the generator and a voltage regulator. Insulation class for parts integral with the generator must be as specified in paragraph GENERATOR. System must provide a minimum short circuit of 300 percent rated engine-generator set current for at least 10 seconds. Steady state voltage regulation must be in accordance with the operating limit values of the performance class specified in the paragraph PERFORMANCE CLASS.

- a. Exciter and Rotating Rectifier Assembly: Rectifiers must be provided with surge voltage protection.
- b. Permanent Magnet Generator: Provide a voltage spike suppression device for permanent magnet generator (PMG) excitation systems.
- c. Voltage Regulator: Voltage regulator must be solid state or digital, automatic, three-phase sensing, volts per hertz type regulator. Regulator must receive its input power from a PMG. Voltage variation for any 40 degree C change over the operating temperature range must be less than plus or minus 1.0 percent. Operating temperature must be minus 40 degree C to plus 70 degree C. Voltage adjust range must be plus to minus 5.0 percent of nominal. Inherent regulator features must include over excitation shutdown.

2.17.1 Electromagnetic Interference (EMI) Suppression

Provide as an integral part of the generator and excitation system, EMI suppression complying with MIL-STD-461.

2.18 VOLTAGE REGULATOR

Provide a solid-state voltage regulator, separate from the exciter, for each generator. Maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100 percent of rated output capacity. Configure regulator for safe manual adjustment of the engine-generator voltage output without special tools, during operation, from 90 to 110 percent of the rated voltage over the steady state load range of 0 to 100 percent of rated output capacity. Regulation drift exceeding plus or minus 0.5 percent for an ambient temperature change of 68 degrees F is not acceptable. Reactive droop compensation or reactive differential compensation must load share the reactive load proportionally between sets during parallel operation. Provide voltage regulator with a maximum droop of 2 percent of rated voltage over a load range from 0 to 100 percent of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.19 GENERATOR ISOLATION AND PROTECTION

Provide necessary devices for electrical protection and isolation of each engine-generator set and its ancillary equipment. The generator circuit breaker (IEEE Device 52) ratings must be consistent with the generator rated voltage and frequency, with continuous, short circuit withstand, and interrupting current ratings to match the generator capacity. Provide operated as indicated generator circuit breaker. Mount a set of surge capacitors at the generator terminals. Provide monitoring and control devices as specified in paragraph GENERATOR PANEL.

The generator circuit breaker must comply with UL 489 requirements for molded case, adjustable thermal magnetic trip type circuit breaker. The

circuit breaker continuous current rating must be adequate for the power rating of the engine-generator set and the circuit breaker must be rated to withstand the short circuit current provided by the generator set. Provide circuit breaker in a NEMA ICS 6, Type 4X stainless steel enclosure mounted on the engine-generator set. Provide an equivalent generator load bank circuit breaker, complete with #4/0 AWG pigtails and female CAM-LOK connectors for connection to load bank, as shown on the plans.

2.19.1 Devices

Provide switches, circuit breakers, switchgear, fuses, relays, and other protective devices as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects must conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical connections under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide controllers and contactors with maximum of 120-volt control circuits, and auxiliary contacts for use with controls furnished. When motors and equipment furnished are larger than size indicated, the cost of providing additional electrical service and related work must be included under this section.

2.20 SAFETY SYSTEM

Provide and install devices, wiring, remote panels, and local panels, etc., as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. Provide a safety system with a self-test method to verify its operability. Provide alarm signals that have manual acknowledgment and reset devices. The alarm signal systems must reactivate for new signals after acknowledgment is given to any signal. Configure the systems so that loss of any monitoring device will be dealt with as an alarm on that system element.

2.20.1 Audible Signal

Provide audible alarm signal sound at a frequency of 70 Hz at a volume of 75 dB at 10 feet. The sound must be continuously activated upon alarm and silenced upon acknowledgment. Locate signal devices as shown.

2.20.2 Visual Signal

The visual alarm signal must be a panel light. The light must be normally off, activated to be blinking upon alarm. The light must change to continuously lit upon acknowledgement. If automatic shutdown occurs, the display must maintain activated status to indicate the cause of failure and must not be reset until cause of alarm has been cleared and/or restored to normal condition. Shutdown alarms must be red; all other alarms must be amber.

2.20.3 Alarms and Action Logic

2.20.3.1 Shutdown

Accomplish simultaneous activation of the audible signal, activation of the visual signal, stopping the engine, and opening the generator main circuit breakers.

2.20.3.2 Problem

Accomplish activation of the visual signal.

2.20.4 Safety Indications and Shutdowns

Provide a local alarm panel with the following shutdown and alarm functions in accordance with NFPA 110 level 2 mounted either on or adjacent to the engine generator set.

A remote alarm panel is is not required for audible alarms, e.g., in the control room.

Indicator Function (at battery voltage)			NFPA 110 Level 2 CV S RA
Overcrank			X X 0
Low water temperature			X NA 0
High engine temperature pre-alarm			0 NA NA
High engine temperature			X X 0
Low lube oil pressure pre-alarm			NA NA NA
Low lube oil pressure			X X 0
Overspeed			X X 0
Low fuel main tank			0 NA 0
Low coolant level			X 0 X
EPS supplying load			0 NA NA
Control switch not in automatic position			X NA X
High battery voltage			0 NA NA
Low cranking voltage			0 NA NA
Low voltage in battery			0 NA NA
Battery charger ac failure			0 NA NA
Lamp test			X NA NA
Contacts for local and remote common alarm			X NA X

Indicator Function (at battery voltage)			NFPA 110 Level 2 CV S RA
Audible alarm silencing switch			NA NA O
Low starting air pressure			O NA NA
Low starting hydraulic pressure			O NA NA
Air shutdown damper when used			X X O
Remote emergency stop			NA X NA
Symbology: CV: Control panel-mounted visual. S: Shutdown of EPS indication. RA: Remote audible. Symbology: CV: Control panel-mounted visual. S: Shutdown of EPS indication. RA: Remote audible. X: Required. O: Optional. NA: Not applicable.			

2.20.5 Time-Delay on Alarms

For startup of the engine-generator set, install time-delay devices bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. Submit the magnitude of monitored values which define alarm or action set points, and the tolerance (plus and/or minus) at which the devices activate the alarm or action for items contained within the alarm panels. The lube-oil time-delay device must return its alarm to normal status after the engine starts. The coolant time-delay device must return its alarm to normal status 5 minutes after the engine starts.

2.21 SYNCHRONIZING PANEL

Provide panel as specified in paragraph PANELS and provide controls, gauges, meters, and displays to include:

- a. Frequency meters, dial type, with a range of 90 to 110 percent of rated frequency. Do not use vibrating-reed type meters. One must monitor generator output frequency ("Generator Frequency Meter") and the other must monitor the frequency of the parallel source ("Bus Frequency Meter").

- b. Voltmeters, ac, dial type, 3-phase, with 4-position selector switch for the generator output ("Generator Volt Meter") and for the parallel power source ("Bus volt meter").
- c. Automatic synchronizer.
- d. Manual synchronizing controls.
- e. Indicating lights for supplementary indication of synchronization.
- f. Synchroscope.
- g. Wattmeter, indicating.

2.22 PANELS

Each panel must be of the type and kind necessary to provide specified functions. Mount panels as shown. Mount instruments flush or semiflush. Provide convenient access to the back of panels to facilitate maintenance. Calibrate instruments using recognized industry calibration standards. Provide a panel identification plate identifying the panel function. Provide a plate identifying the device and its function for each instrument and device on the panel. Provide switch plates identifying the switch-position function.

2.22.1 Enclosures

Design enclosures for the application and environment, conforming to [NEMA ICS 6](#). Locking mechanisms must be keyed alike.

Provide for each engine-generator set and fabricate from [stainless steel](#) in accordance with the manufacturer's standard design. Provide a complete, weatherproof enclosure for the engine, generator, and auxiliary systems and equipment. Support exhaust piping and silencer so that the turbocharger is not subjected to exhaust system weight or lateral forces generated in connecting piping that exceed the engine manufacturer's maximum allowed forces and moments. The housing must have sufficient louvered openings to allow entrance of outside air for engine and generator cooling at full load. Design louvered openings to exclude driving rain and snow. Provide properly arranged and sized, hinged panels in the enclosure to allow convenient access to the engine, generator, and control equipment for maintenance and operational procedures. Provide hinged panels with spring type latches which must hold the panels closed securely and will not allow them to vibrate. Brace the housing internally to prevent excessive vibration when the set is in operation

2.22.2 Analog

Provide analog electrical indicating instruments in accordance with [UL 1437](#) with semi-flush mounting. Switchboard, switchgear, and control-room panel-mounted instruments must have 250 degree scales with an accuracy of not less than 99 percent. Unit-mounted instruments must be the manufacturer's standard with an accuracy of not less than 98 percent. The instrument's operating temperature range must be [minus 4 to plus 158 degrees F](#). Distorted generator output voltage waveform of a crest factor less than 5 must not affect metering accuracy for phase voltages, hertz and amps.

2.22.3 Electronic

Electronic indicating instruments must be true RMS indicating instruments, 100 percent solid state, state-of-the-art, microprocessor controlled to provide specified functions. Provide control, logic, and function devices that are compatible as a system, sealed, dust and water tight, and that utilize modular components with metal housings and digital instrumentation. Provide an interface module to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy less than 98 percent for unit mounted devices and 99 percent for control room, panel mounted devices, throughout a temperature range of **minus 4 to 158 degrees F** is not acceptable. Provide LED or back lit LCD data display. Additionally, the display must provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height must be **0.5 inch**.

2.22.4 Parameter Display

Provide indication or readouts of the tachometer, lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and safety system parameters. Specify a momentary switch for other panels.

2.23 SURGE PROTECTION

Electrical and electronic components must be protected from, or designed to withstand the effects of surges from switching and lightning.

2.24 AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION

Provide fully automatic operation for the following operations: engine-generator set starting and load transfer upon loss of normal source; retransfer upon restoration of the normal source; sequential starting; paralleling, and load-sharing for multiple engine-generator sets; and stopping of each engine-generator set after cool-down. Devices must automatically reset after termination of their function.

2.24.1 Automatic Transfer Switch

Provide automatic transfer switches in accordance with Section **26 36 23** AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.24.2 Monitoring and Transfer

Provide devices to monitor voltage and frequency for the normal power source and each engine-generator set, and control transfer from the normal source and retransfer upon restoration of the normal source. Describe functions, actuation, and time delays as described in Section **26 36 23** AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH.

2.25 MANUAL ENGINE-GENERATOR-SET SYSTEM OPERATION

Provide complete facilities for manual starting and testing of each set without load, loading and unloading of each set.

2.26 BASE

Provide a steel base. Design the base to rigidly support the engine-generator set, ensure permanent alignment of rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure

that alignment is maintained during shipping and normal operation. The base must permit skidding in any direction during installation and must withstand and mitigate the affects of synchronous vibration of the engine and generator. Provide base with suitable holes for anchor bolts and jacking screws for leveling.

2.27 THERMAL INSULATION

Provide thermal insulation as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.28 PAINTING AND FINISHING

Clean, prime and paint the engine-generator set in accordance with the manufacturer's standard color and practice.

2.29 FACTORY INSPECTION AND TESTS

Submit six complete reproducible copies of the factory inspection result on the checklist format specified below. Perform the factory tests on each engine-generator set. The component manufacturer's production line test is acceptable as noted. Run each engine-generator set for at least 1 hour at rated output capacity prior to inspections. Complete inspections and make all necessary repairs prior to testing. Use engine generator controls and protective devices that are provided by the generator set manufacturer as part of the standard package for factory tests. When controls and switchgear are not provided as part of the generator set manufacturer's standard package, the actual controls and protective devices provided for the project are not required to be used during the factory test. The Contracting Officer may provide one or more representatives to witness inspections and tests.

2.29.1 Factory Inspection

Perform inspections prior to beginning and after completion of testing of the assembled engine-generator set. Look for leaks, looseness, defects in components, proper assembly, etc. and note any item found to be in need of correction as a necessary repair. Use the following checklist for the inspection:

INSPECTION ITEM	GOOD	BAD	NOTES
Drive belts			
Governor and adjustments			
Engine timing mark			
Starting motor			
Starting aids			
Coolant type and concentration			
Radiator drains			

INSPECTION ITEM	GOOD	BAD	NOTES
Block coolant drains			
Coolant fill level			
All coolant line connections			
All coolant hoses			
Combustion air filter			
Combustion air silencer			
Lube oil type			
Lube oil sump drain			
Lube-oil filter			
Lube-oil-level indicator			
Lube-oil-fill level			
All lube-oil line connections			
All lube-oil lines			
Fuel type and amount			
All fuel-line connections			
All fuel lines			
Fuel filter			
Coupling and shaft alignment			
Voltage regulators			
Battery-charger connections			
All wiring connections			
Instrumentation			
Hazards to personnel			
Base			
Nameplates			
Paint			

INSPECTION ITEM	GOOD	BAD	NOTES
Exhaust-heat recovery unit			
Switchboard			
Switchgear			

2.29.2 Factory Tests

Submit a letter giving notice of the proposed dates of factory inspections and tests at least 14 days prior to beginning tests, including:

- a. A detailed description of the manufacturer's procedures for factory tests at least 14 days prior to beginning tests.
- b. Six copies of the Factory Test data described below in 8-1/2 by 11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Separate sections by heavy plastic dividers with tabs. Provide full size (8-1/2 by 11 inch minimum) data plots showing grid lines, with full resolution.
 - (1) A detailed description of the procedures for factory tests.
 - (2) A list of equipment used, with calibration certifications.
 - (3) A copy of measurements taken, with required plots and graphs.
 - (4) The date of testing.
 - (5) A list of the parameters verified.
 - (6) The condition specified for the parameter.
 - (7) The test results, signed and dated.
 - (8) A description of adjustments made.

On engine-generator set tests where the engine and generator are required to be connected and operated together, the load power factor must be the power factor specified in the engine generator set parameter schedule . For engine-generator set with dual-fuel operating capability, perform the following tests using the primary fuel type . Perform electrical measurements in accordance with IEEE 120. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulation must be in accordance with IEEE 1. In the following tests where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Tests specifically for the generator may be performed utilizing any prime mover.

- a. Insulation Resistance for Stator and Exciter Test, IEEE 115 and IEEE 43, to the performance criteria in NEMA MG 1, Part 22. Generator

manufacturer's production line test is acceptable.

- b. High Potential Test, in accordance with IEEE 115 and NEMA MG 1, test voltage in accordance with NEMA MG 1. Generator manufacturer's production line test is acceptable.
- c. Winding Resistance Test, Stator and Exciter, in accordance with IEEE 115. Generator manufacturer's production line test is acceptable.
- d. Phase Balance Voltage Test, to the performance criteria specified in paragraph GENERATOR. This test can be performed with any prime mover. Generator manufacturer's production line test results are acceptable.
 - (1) Start and operate the generator at no load.
 - (2) Adjust a regulated phase voltage (line-to-neutral) to rated voltage.
 - (3) Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.
 - (4) Apply 75 percent rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.
 - (5) Apply rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.
 - (6) Calculate average line-neutral voltage and percent deviation of individual line-neutral voltages from average for each load condition.
- e. Current Balance on Stator Winding Test, by measuring the current on each phase of the winding with the generator operating at 100 percent of Rated Output Capacity, with the load impedance equal for each of the three phases: to the performance criteria specified in paragraph GENERATOR.
- f. Voltage Waveform Deviation and Distortion Test in accordance with IEEE 115 to the performance criteria specified in paragraph GENERATOR. Use high-speed recording instruments capable of recording voltage waveform deviation and all distortion, including harmonic distortion. Include appropriate scales to provide a means to measure and interpret results.
- g. Voltage and Frequency Droop Test. Verify that the output voltage and frequency are within the specified parameters as follows:
 - (1) With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency. Record the generator output frequency and line-line and line-neutral voltages.
 - (2) Increase load to Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.
 - (3) Calculate the percent droop for voltage and frequency with the following equations:

$$\text{Voltage droop percent} = \frac{(\text{No-Load Volts}) - (\text{Rated Capacity Volts})}{(\text{Service-Load Volts})} \times 100$$

$$\text{Frequency droop percent} = \frac{(\text{No-Load Hertz}) - (\text{Rated Capacity Hertz})}{(\text{Service-Load Hertz})} \times 100$$

(4) Repeat steps 1 through 3 two additional times without making any adjustments.

h. Frequency and Voltage Stability and Transient Response. Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Include the following tabular data:

- (1) Ambient temperature (at 15 minute intervals).
- (2) Generator output current (before and after load changes).
- (3) Generator output voltage (before and after load changes).
- (4) Frequency (before and after load changes).
- (5) Generator output power (before and after load changes).
- (6) Graphic representations must include the actual instrument trace of voltage and frequency showing: charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.
 - (a) Perform and record engine manufacturer's recommended pre-starting checks and inspections.
 - (b) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.
 - (c) With the unit at no load, apply the Maximum Step Load Increase.
 - (d) Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.
 - (e) Decrease load to the unit such that addition of the Maximum

Step Load Increase will load the unit to 100 percent of Service Load.

(f) Apply the Maximum Step Load Increase.

(g) Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

(h) Repeat steps (c) through (g).

- j. Test Voltage Unbalance with Unbalanced Load (Line-to-Neutral) to the performance criteria specified in paragraph GENERATOR. [Prototype test](#) data is acceptable in lieu of the actual test. Submit manufacturer's standard certification that prototype tests were performed for the generator model proposed. This test may be performed using any prime mover.

- (1) Start and operate the generator set at rated voltage, no load, rated frequency, and under control of the voltage regulator. Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.
- (2) Apply the specified load between terminals L_1-L_2 , L_2-L_0 , and L_3-L_0 in turn. Record all instrument readings at each line-neutral condition.
- (3) Express the greatest difference between any two of the line-to-line voltages and any two of the line-to-neutral voltages as a percent of rated voltage.
- (4) Compare the largest differences expressed in percent with the maximum allowable difference specified.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the job, perform a [Site Visit](#) to verify the information shown on the drawings, before performing any work. Submit a letter stating the date the site was visited and listing discrepancies found. Notify the Contracting Officer in writing of any discrepancies.

3.2 GENERAL INSTALLATION

Provide clear space for operation and maintenance in accordance with [NFPA 70](#) and [IEEE C2](#). Submit a copy of the manufacturer's installation procedures and a detailed description of the manufacturer's recommended break-in procedure. Install pipe, duct, conduit, and ancillary equipment to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.3 PIPING INSTALLATION

Weld piping. Provide flanged valve connections. Provide flanged connections at equipment. Provide threaded connections to the engine if the manufacturer's standard connection is threaded. Except where otherwise specified, use welded flanged fittings to allow for complete dismantling and removal of each piping system from the facility without disconnecting

or removing any portion of any other system's equipment or piping. Make connections to equipment with vibration isolation-type flexible connectors. Support and align piping and tubing to prevent stressing of flexible hoses and connectors. Flash pipes extending through the roof. Install piping clear of windows, doors and openings, to permit thermal expansion and contraction without damage to joints or hangers, and install a 1/2 inch drain valve with cap at each low point.

The installation of gas engines must conform to the requirements of NFPA 37 and its references therein, including NFPA 54, NFPA 58, and ASME B31.3.

3.3.1 Support

Provide hangers, inserts, and supports to accommodate any insulation and conforming to MSS SP-58. Space supports no more than 7 feet on center for pipes 2 inches in diameter or less, no more than 12 feet on center for pipes larger than 2 inches but smaller than 4 inches in diameter, and not more than 17 feet on center for pipes larger than 4 inches in diameter. Provide supports at pipe bends or change of direction.

3.3.1.1 Ceiling and Roof

Support exhaust piping with appropriately sized Type 41 single pipe roll and threaded rods; support all other piping with appropriately sized Type 1 clevis and threaded rods.

3.3.1.2 Wall

Make wall supports for pipe by suspending the pipe from appropriately sized Type 33 brackets with the appropriate ceiling and roof pipe supports.

3.3.2 Flanged Joints

Provide flanges that are Class 125 type, drilled, and of the proper size and configuration to match the equipment and engine connections. Provide gasketed flanged joints that are square and tight.

3.3.3 Cleaning

After fabrication and before assembly, piping interiors must be manually wiped clean of debris.

3.3.4 Pipe Sleeves

Fit pipes passing through construction such as ceilings, floors, or walls with sleeves. Extend each sleeve through and fasten in its respective structure and cut flush with each surface. Build the structure tightly to the sleeve. The inside diameter of each sleeve must be minimum 1/2 inch, and where pipes pass through combustible materials 1 inch larger than the outside diameter of the passing pipe or pipe insulation/covering.

3.4 ELECTRICAL INSTALLATION

Perform electrical installation in compliance with NFPA 70, IEEE C2, and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. For vibration isolation, provide flexible fittings for conduit, cable trays, and raceways attached to engine-generator sets; provide flexible stranded conductor for metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set; and

provide crimp-type terminals or lugs for terminations of conductors on the engine generator set.

3.5 FIELD PAINTING

Perform field painting as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 ONSITE INSPECTION AND TESTS

Perform and report on factory tests and inspections prior to shipment. Provide certified copies of manufacturer's test data and results. Test procedures must conform to ASME, IEEE, and ANSI standards, and to ISO requirements on testing, as appropriate and applicable. The manufacturer performing the tests must provide equipment, labor, and consumables necessary for tests and measuring and indicating devices must be certified to be within calibration. Tests must indicate satisfactory operation and attainment of specified performance. If satisfactory, equipment tested will be given a tentative approval. Equipment must not be shipped before approval of the factory test reports for the following tests.

Submit a letter giving notice of the proposed dates of onsite inspections and tests at least 14 days prior to beginning tests.

- a. Submit a detailed description of the Contractor's procedures for onsite tests including the test plan and a listing of equipment necessary to perform the tests at least 30 days prior to beginning tests.
- b. Submit six copies of the onsite test data described below in 8-1/2 by 11 inch binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Separate sections by heavy plastic dividers with tabs. Provide full size (8-1/2 by 11 inch minimum) data plots showing grid lines, with full resolution.

- (1) A detailed description of the procedures for onsite tests.
- (2) A list of equipment used, with calibration certifications.
- (3) A copy of measurements taken, with required plots and graphs.
- (4) The date of testing.
- (5) A list of the parameters verified.
- (6) The condition specified for the parameter.
- (7) The test results, signed and dated.
- (8) A description of adjustments made.

3.6.1 Test Conditions

3.6.1.1 Data

Make and record measurements of all parameters necessary to verify that each set meets specified parameters. If the results of any test step are not satisfactory, make adjustments, replacements, or repairs and repeat

the step until satisfactory results are obtained. Unless otherwise indicated, record data in 15 minute intervals during engine-generator set operation and include: readings of all engine-generator set meters and gauges for electrical and power parameters; oil pressure; ambient temperature; and engine temperatures available from meters and gauges supplied as permanent equipment on the engine-generator set. Perform electrical measurements in accordance with IEEE 120. Definitions of terms are in accordance with IEEE 100. Provide temperature limits in the rating of electrical equipment and for the evaluation of electrical insulations in accordance with IEEE 1.

3.6.1.2 Power Factor

Submit the generator capability curve showing generator kVA output capability (kW vs. kvar) for both leading and lagging power factors ranging from 0 to 1.0. For all engine-generator set operating tests the load power factor must be the power factor specified in the engine-generator set parameter schedule .

3.6.1.3 Contractor Supplied Items

Provide equipment and supplies required for inspections and tests including fuel, test instruments, and loadbanks at the specified power factors.

3.6.1.4 Instruments

Verify readings of panel gauges, meters, displays, and instruments provided as permanent equipment during test runs, using test instruments of greater precision and accuracy. Test instrument accuracy must be within the following: current plus or minus 1.5 percent, voltage plus or minus 1.5 percent, real power plus or minus 1.5 percent, reactive power plus or minus 1.5 percent, power factor plus or minus 3 percent, frequency plus or minus 0.5 percent. Calibrate test instruments by a recognized standards laboratory within 30 days prior to testing.

3.6.1.5 Sequence

Provide the sequence of testing as specified in the approved testing plan unless variance is authorized by the Contracting Officer. Perform field testing in the presence of the Contracting Officer. Schedule and sequence tests in order to optimize run-time periods; however, follow the general order of testing: Construction Tests; Inspections; Pre-operational Tests; Safety Run Tests; Performance Tests; and Final Inspection.

3.6.2 Construction Tests

Perform individual component and equipment functional tests for fuel piping, coolant piping, and lubricating-oil piping, electrical circuit continuity, insulation resistance, circuit protective devices, and equipment not provided by the engine-generator set manufacturer prior to connection to the engine-generator set.

3.6.2.1 Piping Test

- a. Flush lube-oil and fuel-oil piping with the same type of fluid intended to flow through the piping, until the outflowing fluid has no obvious sediment or emulsion.

- b. Test fuel piping which is external to the engine-generator set in accordance with **NFPA 30**. Pressure all remaining piping which is external to the engine-generator set with air pressure at 150 percent of the maximum anticipated working pressure, but not less than **150 psi**, for a period of 2 hours to prove the piping has no leaks. If piping is to be insulated, perform the test before the insulation is applied.

3.6.2.2 Electrical Equipment Tests

- a. Perform low-voltage cable insulation integrity tests for cables connecting the generator breaker to the automatic transfer switch . Test low-voltage cable, complete with splices, for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. Apply a test voltage of 500 volts dc for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. Provide the minimum value of insulation as follows:

- (1) $R \text{ in meg-ohms} = (\text{rated voltage in kV plus } 1) \times 304.8 / (\text{length of cable in meters})$
- (2) $R \text{ in meg-ohms} = (\text{rated voltage in kV plus } 1) \times 1000 / (\text{length of cable in feet})$
- (3) Each cable failing this test must be repaired or replaced. The repair cable must be retested until failures have been eliminated.

- c. Ground-Resistance Tests. Measure the resistance of the ground ring using the fall-of-potential method defined in **IEEE 81**. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. Take measurements in normally dry weather, not less than 48 hours after rainfall. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance. The combined resistance of separate systems may be used to meet the requirements resistance, but the specified number of electrodes must still be provided as follows:

- (2) Multiple rod electrodes - **5** ohms.

- d. Examine and test circuit breakers and switchgear in accordance with the manufacturer's published instructions for functional testing.

3.6.3 Inspections

Perform the following inspections jointly by the Contracting Officer and the Contractor, after complete installation of each engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Submit a letter certifying that all facilities are complete and functional; that each system is fully functional; and that each item of equipment is complete, free from damage, adjusted, and ready for beneficial use. Perform checks applicable to the installation. Document

and submit the results of those which are physical inspections (I) in accordance with paragraph SUBMITTALS. Present manufacturer's data for the inspections designated (D) at the time of inspection. Verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Provide manufacturer's statements to certify provision of features which cannot be verified visually.

Drive belts	I
Governor type and features	I
Engine timing mark	I
Starting motor	I
Starting aids	I
Coolant type and concentration	D
Radiator drains	I
Block coolant drains	I
Coolant fill level	I
Coolant line connections	I
Coolant hoses	I
Combustion air filter	I
Intake air silencer	I
Lube oil type	D
Lube oil sump drain	I
Lube-oil filter	I
Lube-oil level indicator	I
Lube-oil fill level	I
Lube-oil line connections	I
Lube-oil lines	I
Fuel type	D
Fuel level	I
Fuel-line connections	I

Fuel lines	I
Fuel filter	I
Access for maintenance	I
Voltage regulator	I
Battery-charger connections	I
Wiring and terminations	I
Instrumentation	I
Hazards to personnel	I
Base	I
Nameplates	I
Paint	I
Exhaust-heat system	I
Exhaust muffler	I
Switchboard	I
Switchgear	I
Access provided to controls	I
Enclosure is weather resistant	I
Engine and generator mounting bolts (application)	I

3.6.4 Engine Tests

Perform customary commercial factory tests in accordance with [ISO 3046](#) on each engine and associated engine protective device, including, but not limited to the following:

- a. Perform dynamometer test at rated power. Record horsepower at rated speed and nominal characteristics such as lubricating oil pressure, jacket water temperature, and ambient temperature.
- b. Test and record the values that the low oil pressure alarm and protective shutdown devices actuate prior to assembly on the engine.
- c. Test and record values that the high jacket water temperature alarm and protective shutdown devices actuate prior to assembly on the engine.

3.6.5 Generator Tests

Tests must be performed on the complete factory assembled generator prior to shipment. Conduct tests in accordance with IEEE 115, and NEMA MG 1.

3.6.5.1 Routine Tests

Perform the following routine tests on the generators and their exciters:

- a. Resistance of armature and field windings.
- b. Mechanical balance.
- c. Phases sequence.
- d. Open circuit saturation curve and phase (voltage) balance test.
- e. Insulation resistance of armature and field windings.
- f. High potential test

3.6.5.2 Design Tests

Submit the following design tests made on prototype machines that are physically and electrically identical to the generators specified.

- a. Temperature rise test
- b. Short circuit saturation curve and current balance test

3.6.6 Assembled Engine-Generator Set Tests

Perform the following tests on the assembled engine-generator set.

3.6.6.1 Initial Stabilization Readings

Operate the engine-generator set and allow the set to stabilize at rated kW at rated power factor, rated voltage, and rated frequency. During this period record instrument readings for output power (kW), terminal voltage, line current, power factor, frequency (rpm) generator (exciter) field voltage and current, lubricating oil pressure, jacket water temperature, and ambient temperature at minimum intervals of 15 minutes. Adjust the load, voltage, and frequency to maintain rated load at rated voltage and frequency. Adjustments to load, voltage, or frequency controls must be recorded on the data sheet at the time of adjustment. Stabilization must be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made.

3.6.6.2 Regulator Range Test

Remove load and record instrument readings (after transients have subsided). Adjust voltage to the maximum attainable value or to a value just prior to actuation of the overvoltage protection device. Apply rated load and adjust voltage to the minimum attainable value or a value just prior to activation of the under-voltage protection device. The data sheets must indicate the voltage regulation as a percent of rated voltage

and the maximum and minimum voltages attainable. Voltage regulation must be defined as follows:

$$\text{Percent Regulation} = \frac{((\text{No-Load Voltage}) - (\text{Rated-Load Voltage})) \times 100}{(\text{Rated-Load Voltage})}$$

3.6.6.3 Frequency Range Test

Adjust the engine-generator set frequency for the maximum attainable frequency at rated load. Record instrument readings. Adjust the engine-generator set frequency for the specified minimum attainable frequency at rated load. Record instrument readings. Reduce the load to zero and adjust the engine-generator set frequency for the maximum attainable frequency. Record instrument readings. Adjust the engine-generator set frequency for the minimum attainable frequency. Record instrument readings. The data sheet must show the maximum and minimum frequencies attained at rated load, and at no load.

3.6.6.4 Transient Response Test

Drop the load to no load and re-apply rated load three times to ensure that the no load and rated load voltage and frequency values are repeatable and that the frequency and voltage regulation is within the limits specified. Record generator terminal voltage and frequency using a high speed strip chart recorder. The data sheet must show the following results:

a. Frequency

- (1) Stability bandwidth or deviation in percent of rated frequency.
- (2) Recovery time.
- (3) Overshoot and undershoot.

b. Voltage

- (1) Stability bandwidth or deviation in percent of rated voltage.
- (2) Recovery time.
- (3) Overshoot and undershoot.

3.6.7 Pre-operational Tests

3.6.7.1 Insulation Test

Test generator and exciter circuits insulation resistance in accordance with [IEEE 43](#). Take stator readings including generator leads to switchboard at the circuit breaker. Record results of insulation resistance tests. Readings must be within limits specified by the manufacturer. Verify mechanical operation, insulation resistance, protective relay calibration and operation, and wiring continuity of switchboard assembly. Do not damage generator components during test.

3.6.7.2 Engine-Generator Connection Coupling Test

When the generator provided is a two-bearing machine, inspect and check

the engine-generator connection coupling by dial indicator to prove that no misalignment has occurred. Use the dial indicator to measure variation in radial positioning and axial clearance between the coupling halves. Take readings at four points, spaced 90 degrees apart. Align solid couplings and pin-type flexible couplings within a total indicator reading of 0.0005 to 0.001 inch for both parallel and angular misalignment. For gear-type or grid-type couplings, 0.002 inch will be acceptable.

3.6.8 Safety Run Test

For the following tests, repeat the associated safety tests if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries.

- a. Perform and record engine manufacturer's recommended prestarting checks and inspections.
- b. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.
- c. Activate the manual emergency stop switch and verify that the engine stops.
- d. Remove the high and pre-high lubricating oil temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.
- e. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine-generator set at no load until the output voltage and frequency stabilize. Monitor the temporarily installed temperature gauges. If either temperature reading exceeds the value required for an alarm condition, activate the manual emergency stop switch.
- f. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.
- g. Remove the high and pre-high coolant temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.
- h. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine generator-set at no load until the output voltage and frequency stabilize.
- i. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on

the engine.

- j. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.
- k. Operate the engine generator-set for at least 2 hours at 75 percent of Service Load.
- l. Verify proper operation and set-points of gauges and instruments.
- m. Verify proper operation of ancillary equipment.
- n. Manually adjust the governor to increase engine speed past the over-speed limit. Record the RPM at which the engine shuts down.
- o. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.
- p. Manually adjust the governor to increase engine speed to within 2 percent of the over-speed trip speed previously determined and operate at that point for 5 minutes. Manually adjust the governor to the rated frequency.
- q. Manually fill the day tank to a level above the overfill limit. Record the level at which the overfill alarm sounds. Verify shutdown of the fuel transfer pump. Drain the day tank down below the overfill limit.
- r. Shut down the engine. Remove the time-delay low lube oil pressure alarm bypass and try to start the engine.
- s. Attach a manifold to the engine oil system (at the oil pressure sensor port) that contains a shutoff valve in series with a connection for the engine's oil pressure sensor followed by an oil pressure gauge ending with a bleed valve. Move the engine's oil pressure sensor from the engine to the manifold. Open the manifold shutoff valve and close the bleed valve.
- t. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75 percent of Service Load.
- u. Close the manifold shutoff valve. Slowly allow the pressure in the manifold to bleed off through the bleed valve while watching the pressure gauge. Record the pressure at which the engine shuts down. Catch oil spillage from the bleed valve in a container. Add the oil from the container back to the engine, remove the manifold, and reinstall the engine's oil pressure sensor on the engine.
- v. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 100 percent of Service Load. Record the maximum sound level in each frequency band at a distance of 75 feet from the end of the exhaust and air intake piping directly along the path of intake and discharge for horizontal piping; or at a radius of 75 feet from the engine at 45 degrees apart in all

directions for vertical piping. If a sound limiting enclosure is provided, modify or replace the enclosure, the muffler, and intake silencer must be modified or replaced as required to meet the sound requirements contained within this specification

- w. Manually drain off fuel slowly from the day tank to empty it to below the low fuel level limit and record the level at which the audible alarm sounds. Add fuel back to the day tank to fill it above low level alarm limits.

3.6.9 Performance Tests

In the following tests, where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. For the following tests, repeat the associated tests if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries.

3.6.9.1 Continuous Engine Load Run Test

Test the engine-generator set and ancillary systems at service load to demonstrate durability; verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, repeat the entire test. Accomplish the engine load run test during daylight hours, with an average ambient temperature of 90 degrees F, during the month of July. After each change in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Take data taken at 15 minute intervals and include the following:

Electrical: Output amperes, voltage, real and reactive power, power factor, frequency.

Pressure: Lube-oil.

Temperature: Coolant, Lube-oil, Exhaust, Ambient.

- a. Perform and record engine manufacturer's recommended prestarting checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.
- b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warmup period.
- c. Operate the engine generator-set for 2 hours at 75 percent of Service Load.
- d. Increase load to 100 percent of Service Load and operate the engine generator-set for 4 hours.
- e. For prime rated units, increase load to 110 percent of Service Load and operate the engine generator-set for 2 hours.
- f. Decrease load to 100 percent of Service Load and operate the engine generator-set for 2 hours or until all temperatures have stabilized.

- g. Remove load from the engine-generator set.

3.6.9.2 Voltage and Frequency Droop Test

For the following steps, verify that the output voltage and frequency return to and stabilize within the specified bandwidth values following each load change. Record the generator output frequency and line-line and line-neutral voltages following each load change.

- a. With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency.
- b. Increase load to 100 percent of Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.
- c. Calculate the percent droop for voltage and frequency with the following equations.

$$\text{Voltage droop percent} = \frac{\text{No-load volts} - \text{rated output capacity volts}}{\text{Rated output capacity volts}} \times 100$$

$$\text{Frequency droop percent} = \frac{\text{No load hertz} - \text{rated output capacity hertz}}{\text{Rated output capacity volts}} \times 100$$

- d. Repeat steps a. through c. two additional times without making any adjustments.

3.6.9.3 Voltage Regulator Range Test

- a. While operating at no load, verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.
- b. Increase load to 100 percent of Rated Output Capacity. Verify that the voltage regulator adjusts from 90 to 110 percent of rated voltage.

3.6.9.4 Governor Adjustment Range Test

- a. While operating at no load, verify that the governor adjusts from 90 to 110 percent of rated frequency.
- b. Increase load to 100 percent of Rated Output Capacity. Verify that the governor adjusts from 90 to 110 percent of rated frequency.

3.6.9.5 Frequency and Voltage Stability and Transient Response

Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Include the following tabular data:

- (1) Ambient temperature (at 15 minute intervals).

- (2) Generator output current (before and after load changes).
- (3) Generator output voltage (before and after load changes).
- (4) Frequency (before and after load changes).
- (5) Generator output power (before and after load changes).
- (6) Include the actual instrument trace of voltage and frequency in graphic representations showing:

Charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

- a. Perform and record engine manufacturer's recommended prestarting checks and inspections.
- b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.
- c. With the unit at no load, apply the Maximum Step Load Increase.
- d. Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.
- e. Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100 percent of Service Load.
- f. Apply the Maximum Step Load Increase.
- g. Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.
- h. Repeat steps c. through g.

3.6.10 Automatic Operation Tests for Stand-Alone Operation

Test the automatic loading system to demonstrate automatic starting, and loading and unloading of each engine-generator set. Utilize the actual loads to be served for this test, and the loading sequence is the indicated sequence. Perform this test for a minimum of two successive, successful tests. Include the following data:

- (1) Ambient temperature (at 15 minute intervals).
- (2) Generator output current (before and after load changes).
- (3) Generator output voltage (before and after load changes).
- (4) Generator output frequency (before and after load changes).

- a. Initiate loss of the primary power source and verify automatic sequence of operation.
- b. Restore the primary power source and verify sequence of operation.
- c. Verify resetting of controls to normal.

3.7 GROUNDING

NFPA 70 and IEEE C2, except that grounding systems must have a resistance to solid earth ground not exceeding 5 ohms.

3.7.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.7.2 Engine-Generator Set Grounding

Provide separate copper grounding conductors and connect them to the ground system as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" must apply.

3.7.3 Connections

Make joints in grounding conductors by exothermic weld or compression connector. Exothermic welds and compression connectors must be installed as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION paragraph regarding GROUNDING.

3.7.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.8 START-UP ENGINEER

Provide the services of a qualified factory trained start-up engineer, regularly employed by the engine-generator set manufacturer. The start-up services must include conducting preliminary operations and functional acceptance tests. The start-up engineer must be present at the engine generator set installation-site, full-time, while preliminary operations and functional acceptance tests are being conducted.

3.9 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the engine-generator set and auxiliary equipment.

3.9.1 Performance of Acceptance Checks and Tests

The acceptance checks and tests must be accomplished by the testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.9.2 Generator Sets

Complete as specified in the paragraph ACCEPTANCE CHECKS AND TESTS.

3.9.2.1 Automatic Transfer Switches

Complete acceptance checks and tests as specified in Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH.

3.9.3 Preliminary Operations

The start-up engineer must conduct manufacturer recommended start-up procedures and tests to verify that the engine-generator set and auxiliary equipment are ready for functional acceptance tests. Give the Contracting Officer 15 days' advance notice that preliminary operations will be conducted. After preliminary operation has been successfully conducted, the start-up engineer will notify the Contracting Officer in writing stating the engine-generator set and auxiliary equipment are ready for functional acceptance tests.

3.9.4 Preliminary Assembled Operation and Maintenance Manuals

Preliminary assembled operation and maintenance manuals must have been submitted to and approved by the Contracting Officer. Manuals must be prepared as specified in the paragraph ASSEMBLED OPERATION AND MAINTENANCE MANUALS.

3.9.5 Functional Acceptance Test Procedure

Test procedure must be prepared by the start-up engineer specifically for the engine-generator set and auxiliary equipment. The test agenda must cover the requirements specified in the paragraph FUNCTIONAL ACCEPTANCE TESTS. The test procedure must indicate in detail how tests are to be conducted. A statement of the tests that are to be performed without indicating how the tests are to be performed is not acceptable. Indicate what work is planned on each workday and identify the calendar dates of the planned workdays. Specify what additional technical support personnel is needed such as factory representatives for major equipment. Specify on which testing workday each technical support personnel is needed. Data recording forms to be used to document test results are to be submitted with the proposed test procedure. A list of test equipment and instruments must also be included in the test procedure.

3.9.6 Test Equipment

Test equipment and instruments must be on hand prior to scheduling field tests or, subject to Contracting Officer approval, evidence must be provided to show that arrangements have been made to have the necessary equipment and instruments on-site prior to field testing.

3.10 FIELD QUALITY CONTROL

Give Contracting Officer 30 days' notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The Contractor must be responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary

power conditions. The Contractor must provide labor, equipment, fuel, test load, and consumables required for the specified tests. The test load must be a cataloged product. Calibration of measuring devices and indicating devices must be certified. Refer to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, for requirements for a cataloged product. Perform the following field tests.

3.10.1 Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.10.1.1 Circuit Breakers - Low Voltage Insulated Case/Molded Case

a. Visual and Mechanical Inspection

- (1) Compare nameplate data with specifications and approved shop drawings.
- (2) Inspect circuit breaker for correct mounting.
- (3) Operate circuit breaker to ensure smooth operation.
- (4) Inspect case for cracks or other defects.
- (5) Verify tightness of accessible bolted connections and cable connections by calibrated torque-wrench method. Thermo-graphic survey is not required.
- (6) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests

- (1) Perform contact-resistance tests.
- (2) Perform insulation-resistance tests.
- (3) Adjust breaker(s) for final settings in accordance with engine-generator set manufacturer's requirements.

3.10.1.2 Current Transformers

a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical and mechanical condition.
- (3) Verify correct connection.
- (4) Verify that adequate clearances exist between primary and secondary circuit.
- (5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.

- (6) Verify that all required grounding and shorting connections provide good contact.

- b. Electrical Tests

- (1) Perform insulation-resistance tests.
- (2) Perform polarity tests.
- (3) Perform ratio-verification tests.

3.10.1.3 Metering and Instrumentation

- a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical and mechanical condition.
- (3) Verify tightness of electrical connections.

- b. Electrical Tests

- (1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.
- (2) Calibrate watt-hour meters according to manufacturer's published data.
- (3) Verify all instrument multipliers.
- (4) Electrically confirm that current transformer secondary circuits are intact.

3.10.1.4 Battery Systems

- a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical and mechanical condition.
- (3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermo-graphic survey is not required.
- (4) Measure electrolyte specific gravity and temperature and visually check fill level.
- (5) Verify adequacy of battery support racks, mounting, anchorage, and clearances.

- b. Electrical Tests

- (1) Set charger float and equalizing voltage levels.
- (2) Verify all charger functions and alarms.

(3) Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.

(4) Perform a capacity load test.

3.10.1.5 Engine-Generator Set

a. Visual and Mechanical Inspection

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

(2) Inspect physical and mechanical condition.

(3) Inspect for correct anchorage and grounding.

b. Electrical and Mechanical Tests

(1) Perform an insulation-resistance test on generator winding with respect to ground. Calculate polarization index.

(2) Perform phase rotation test to determine compatibility with load requirements.

3.10.1.6 Grounding System

a. Visual and Mechanical Inspection

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

b. Electrical Tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method defined in [IEEE 81](#). On systems consisting of interconnected ground rods, perform tests after interconnections are complete. Take measurements in normally dry weather, not less than 48 hours after rainfall. Provide site diagram indicating location of test probes with associated distances, and provide a plot of resistance vs. distance.

3.10.2 Functional Acceptance Tests

The tests must be performed by the start-up engineer. Upon successful test completion, the start-up engineer must provide the Contracting Officer with a written test report within 15 calendar days showing the tests performed and the results of each test. The report must include the completed approved test data forms and certification from the start-up engineer that the test results fall within the manufacturer's recommended limits and meet the specified requirements performance. The report must be dated and signed by the start-up engineer, and submitted for approval by the Contracting Officer. The Contracting Officer will witness final acceptance tests. Testing must include, but not be limited to, the following:

- a. Verify proper functioning of each engine protective shutdown device and pre-shutdown alarm device. Testing of the devices must be accomplished by simulating device actuation and observing proper alarm

and engine shutdown operation.

- b. Verify proper functioning of the engine over-speed trip device. Testing of the over-speed trip device must be accomplished by raising the speed of the engine-generator set until an over-speed trip is experienced.
- c. Verify proper functioning of the crank cycle/terminate relay. Testing of the relay must be accomplished by engaging the starter motor with the engine being prevented from running. Observe the complete crank/rest cycle as described in the paragraph STARTING SYSTEM.
- d. Verify proper functioning of the following automatic and manual operations. Testing must include, but not be limited to, the following:
 - (1) Loss of Utility: Initiate a normal power failure with connected test load of rated kW at 1.0 power factor. Record time delay on start, cranking time until engine starts and runs, time to come up to operating speed, voltage and frequency overshoot, and time to achieve steady state conditions with all switches transferred to emergency position.
 - (2) Return of Utility: Return normal power and record time delay on retransfer for each automatic transfer switch, and time delay on engine cool-down and shutdown.
 - (3) Manual starting.
 - (4) Emergency stop.
- e. Operate the engine-generator set at rated current (amperes) until the jacket water temperature stabilizes. Stabilization will be considered to have occurred when three consecutive temperature readings remain unchanged. Continue to operate the generator set for an additional 2 hours. Record instrument readings for terminal voltage, line current, frequency (Hz), engine speed rpm, lubricating oil pressure, jacket water temperature, and ambient temperature at 5 minute intervals for first 15 minutes and at 15 minute intervals thereafter.

3.11 DEMONSTRATION

Upon completion of the work and at a time approved by the Contracting Officer, the Contractor must provide instructions by a qualified instructor to the Government personnel in the proper operation and maintenance of the equipment. **four** Government personnel must receive training comparable to the equipment manufacturer's factory training. The duration of instruction must be for not less than one 8 hour working day for instruction of operating personnel and not less than one 8 hour working day for instruction of maintenance personnel.

3.11.1 Instructor's Qualification Resume

Instructors must be regular employees of the engine-generator set manufacturer. The instruction personnel provided to satisfy the requirements above must be factory certified by the related equipment manufacturer to provide instruction services. Submit the name and qualification resume of instructor to the Contracting Officer for approval.

3.11.2 Training Plan

Submit training plan 30 calendar days prior to training sessions. Training plan must include scheduling, content, outline, and training material (handouts). Content must include, but not be limited to, the following:

3.11.2.1 Operating Personnel Training

This instruction includes operating the engine-generator set, auxiliary equipment including automatic transfer switches in all modes, and the use of all functions and features specified.

3.11.2.2 Maintenance Personnel Training

Training must include mechanical, hydraulic, electrical, and electronic instructions for the engine-generator set and auxiliary equipment including automatic transfer switches.

a. Mechanical Training: Must include at least the following:

- (1) A review of mechanical diagrams and drawings.
- (2) Component location and functions.
- (3) Troubleshooting procedures and techniques.
- (4) Repair procedures.
- (5) Assembly/disassembly procedures.
- (6) Adjustments (how, when, and where).
- (7) Preventive maintenance procedures.
- (8) Review of flow diagram.
- (9) Valve locations and function.
- (10) Valve and hydraulic equipment adjustment and maintenance procedures.
- (11) Hydraulic system maintenance and servicing.
- (12) Lubrication points, type, and recommended procedures and frequency.

b. Electrical and Electronic Maintenance Training: Must include at least the following:

- (1) A review of electrical and electronic systems including wiring diagrams and drawings.
- (2) Troubleshooting procedures for the machine and control systems.
- (3) Electrical and electronic equipment servicing and care.
- (4) Use of diagnostics to locate the causes of malfunction.

- (5) Procedures for adjustments (locating components, adjustments to be made, values to be measured, and equipment required for making adjustments).
- (6) Maintenance and troubleshooting procedures for microprocessor or minicomputer where applicable.
- (7) Circuit board repair procedures where applicable (with schematics provided).
- (8) Use of diagnostic tapes.
- (9) Recommended maintenance servicing and repair for motors, switches, relays, solenoids, and other auxiliary equipment and devices.

3.12 ONSITE TRAINING

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total 4 hours of normal working time and must start after the system is functionally completed but prior to final acceptance.

- a. Submit a letter giving the date proposed for conducting the onsite training course, the agenda of instruction, a description of the digital video recording to be provided. The course instructions must cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as major elements of the operation and maintenance manuals. Additionally, the course instructions must demonstrate routine maintenance procedures as described in the operation and maintenance manuals.
- b. Submit a digital video recording of the entire training session .
- c. One full size reproducible Mylar ach drawing must accompany the booklets. Mylars must be rolled and placed in a heavy cardboard tube with threaded caps on each end. The manual must include step-by-step procedures for system startup, operation, and shutdown; drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems together with their controls, alarms, and safety systems; the manufacturer's name, model number, and a description of equipment in the system. The instructions must include procedures for interface and interaction with related systems to include automatic transfer switches fire alarm/suppression systems . Each booklet must include a CD containing an ASCII file of the procedures.
- d. Provide approved operation and maintenance manuals for the training course. Post approved instructions prior to the beginning date of the training course. Coordinate the training course schedule with the using service's work schedule, and submit for approval 14 days prior to beginning date of proposed beginning date of training.

3.13 INSTALLATION

Installation must conform to the applicable requirements of IEEE C2, NFPA 30, NFPA 37, and NFPA 70.

3.14 FINAL TESTING AND INSPECTION

- a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.
- b. Increase the load in steps no greater than the Maximum Step Load Increase to 100 percent of Service Load, and operate the engine-generator set for at least 30 minutes. Measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.
- c. Remove load and shut down the engine-generator set after the recommended cool down period.
- d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Verify any corrective action for effectiveness by running the engine for 8 hours at Service Load, then re-examine the oil and filter.
- e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.
- f. Visually inspect and check engine and generator mounting bolts for tightness and visible damage.
- g. Replace air, oil, and fuel filters with new filters.

3.15 MANUFACTURER'S FIELD SERVICE

The engine generator-set manufacturer must furnish a qualified representative to supervise the installation of the engine generator-set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment.

3.16 POSTED DATA AND INSTRUCTIONS

Post Data and Instructions prior to field acceptance testing of the engine generator set.

- a. Provide two sets of typed instructions/data in 8-1/2 x 11 inch format, laminated in weatherproof plastic, and placed in three-ring vinyl binders. Place the binders as directed by the Contracting Officer. Provide the instructions prior to acceptance of the engine generator set installation.
- b. Include a one-line diagram, wiring and control diagrams and a complete layout of the system in the first set. Include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions in the second set. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches).
- c. Submit instructions including: the manufacturers pre-start checklist

and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches). Provide weatherproof instructions, laminated in plastic, and post where directed.

3.17 ACCEPTANCE

Submit drawings which accurately depict the as-built configuration of the installation, upon acceptance of the engine-generator set installation. Revise layout drawings to reflect the as-built conditions and submit them with the as-built drawings. Final acceptance of the engine-generator set will not be given until the Contractor has successfully completed all tests and all defects in installation material or operation have been corrected.

-- End of Section --

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH
05/20

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM B117 (2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2018) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA ICS 2 (2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V

NEMA ICS 4 (2015) Application Guideline for Terminal Blocks

NEMA ICS 6 (1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

NFPA 110 (2016) Standard for Emergency and Standby Power Systems

UNDERWRITERS LABORATORIES (UL)

UL 508 (2018) UL Standard for Safety Industrial Control Equipment

UL 1008 (2014) Transfer Switch Equipment

UL 1066

(2012; Reprint Mar 2017) UL Standard for
Safety Low-Voltage AC and DC Power Circuit
Breakers Used in Enclosures

1.2 RELATED REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 26 08 00 APPARATUS INSPECTION AND TESTING, applies to this section, with the additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Automatic Transfer Switch Drawings; G

SD-03 Product Data

Automatic Transfer Switches; G

BY-PASS/ISOLATION SWITCH (BP/IS); G

SD-06 Test Reports

Acceptance Checks and Tests; G

Functional Acceptance Tests; G

Factory Testing; G

Factory Test Reports; G

SD-07 Certificates

Proof of Listing; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manual, Submit in accordance with
Section 01 78 23 OPERATION AND MAINTENANCE DATA, Data Package 5; G

1.4 OPERATION AND MAINTENANCE MANUAL

Assemble and bind manuals in durable, hard-covered, water resistant binders. Assemble and index the manuals per the following table of contents:

- a. Manufacturer's O&M per "SD-10 Operation and Maintenance Data".

- b. Catalog data required by "SD-03 Product Data"
- c. Drawings required by "SD-02 Shop Drawings".

1.4.1 Additions to Operation and Maintenance Manuals

In addition to requirements of SD-10 Data Package 5, include the followings on the actual equipment provided:

- a. An outline drawing, front, top, and side views.
- b. Prices for spare parts and supply list.
- c. Date of Purchase.
- d. Corrective maintenance procedures.
- e. Operating manual outlining step-by-step procedures for system startup, operation, and shutdown.
- f. Include simplified wiring and control diagrams in the manual for system as installed.
- g. Provide typical contact voltage drop readings under specified conditions for use during periodic maintenance. Provide instructions for determination of contact integrity.

1.5 QUALITY ASSURANCE

1.5.1 Proof of Listing

Submit proof of listing by **UL 1008**.

1.5.2 Automatic Transfer Switch Drawings

Include the following as a minimum:

- a. An outline drawing, including front, top, and side views.
- b. Provide a nameplate of corrosion-resistant material with not less than **1/8 inch** tall characters showing manufacturer's name and equipment ratings. Mount nameplate to front of enclosure and meet the nameplate requirements of **NEMA ICS 2**.
- c. Provide detail drawings that include manufacturer's name and catalog number, electrical ratings, total system transfer statement, reduced normal supply voltage at which transfer to the alternate supply is initiated, transfer delay times, short-circuit current rating, wiring diagram, description of interconnections, testing instructions, acceptable conductor type for terminals, tightening torque for each wire connector, and other required **UL 1008** markings.
- d. Submit interface equipment connection diagram showing conduit and wiring between ATS and related equipment. Provide diagrams showing interlocking provisions and cautionary notes, if any.
- e. Drawings are to indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.5.3 Regulatory Requirements

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

1.5.4 Standard Product

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

- a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
- b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
- c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record are acceptable if the manufacturer has been regularly engaged in the design and production of automatic transfer switches and if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

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

1.6 DELIVERY AND STORAGE

Protect equipment placed in storage from humidity and temperature variations, moisture, water intrusion, dirt, dust, or other contaminants. In harsh environments where temperatures exceed non-operational parameters established within this specification, provide an environmentally controlled equipment storage facility to ensure temperature parameters are within equipment specification. Provide documentation of same to the Government when storage is implemented.

1.7 ENVIRONMENTAL CONDITIONS

Provide an ATS that is suitable for prolonged performance under following service conditions:

- a. Operating altitude: Sea level to 3,300 ft. (Systems applied at higher altitudes are to be derated in accordance with the manufacturer's instructions).

- b. Operating ambient temperature range: 40 to 104 degrees F.
- c. Operating relative humidity: 0 to 90 percent, without condensation.

PART 2 PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCHES

Each automatic transfer switch must be rated and marked for total system transfer and have the current and voltage ratings as indicated. Provide a switch operating mechanism that is electrically operated, have quick-make, quick-break, load break contacts, and be mechanically held in both positions. Switches utilizing circuit breakers are not acceptable. Provide an ATS that is UL listed. ATS must be manufactured and tested in accordance with applicable requirements of NEMA ICS 2, UL 1008 and UL 1066. ATS must conform to NFPA 110. Provide the ATS with the following characteristics:

- a. Voltage: 480Y/277 volts ac.
- b. Amperage: As indicated on plans amps ac. Provide an ATS with a continuous load current rating of the switch rating.
- c. Number of Phases: Three.
- d. Number of Wires: Four.
- e. Frequency: 60 Hz.
- f. Poles: Four switched. One of the poles is the neutral.
- g. ATS Withstand Current Rating: Rated to withstand closing current short-circuit current of As indicated on plans amperes, RMS symmetrical.
- h. Nonwelding Contacts: Provide contacts that are nonwelding at the available fault current rating.
- i. Phase and Neutral Contacts: Provide contacts with silver alloy composition. Provide neutral contacts with the same continuous current rating as main or phase contacts.
- j. Configuration. Provide an ATS for use in emergency systems described in NFPA 70. Provide an ATS that is listed for emergency use.
- k. ATS Configuration. Provide an open transition ATS. Neutral is to break and make with the phase contacts.
- l. Service Entrance Rated. Provide an integrated circuit breaker and automatic transfer switch. Provide a separate deadfront compartment for the circuit breaker on switches 600 amp and larger. Provide label indicating that the ATS is the service disconnect. Provide a circuit breaker that is rated for 100% of the switch contact current rating. All components, except as noted herein, are to have a continuous load rating.

2.1.1 Undervoltage Sensing - Normal/Preferred Source

Undervoltage Sensing - Normal Source. Provide undervoltage sensing for each phase in the normal/preferred source. Sense low phase-to-ground voltage on each phase. Provide sensing circuit with adjustable dropout, 75-98 percent of nominal value and adjustable pickup, 85-100 percent of nominal value. Factory set dropout value to 85percent. Factory set pickup value to 90percent.

2.1.2 Adjustable Time Delay - Override Transfer

Adjustable Time Delay - Override Transfer. For override of normal-source voltage sensing to delay transfer and engine starting signals. Engine starting control contacts with adjustable commit-to-start delay circuit, 0.0-6.0 seconds. Factory set at 1second.

2.1.3 Voltage/Frequency Lockout Relay - Alternate/Emergency Source

Voltage/Frequency Lockout Relay. Prevent premature transfer to alternate/emergency source. Provide pickup voltage that is adjustable from 85-100 percent of nominal. Factory set for pickup at 90 percent. Provide pickup frequency that is adjustable from 90-97 percent of nominal. Factor set frequency pickup for 95 percent.

2.1.4 Adjustable Time Delay - Transfer to Alternate/Emergency Power Source

Adjustable Time Delay - Transfer to Alternate Power Source. Transfer to alternate power source time delay for transfer switches as indicated, adjustable 0-5 minutes. Factory set to 0 seconds. ATS is to monitor the frequency and voltage of alternate power source and transfer when frequency and voltage are stabilized.

2.1.5 Adjustable Time Delay- Re-transfer to Normal/Preferred Source

Adjustable Time Delay- Transfer to Source. Re-transfer to normal source time delay, adjustable 0-30 minutes. Factory set at 10 minutes. Time delay is automatically defeated upon loss or sustained undervoltage of alternate power source, provided that normal source has been restored.

2.1.6 Engine-Generator Exerciser

Exerciser. Solid-state, programmable-time switch exerciser to allow automatic starting of the generator set, subsequent load transfer, retransfer of load and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from on a daily, weekly, bi-weekly or monthly basis.. Running periods are adjustable from 10-30 minutes. Factory settings are for 7-day exercise cycle, 20 minute running period and 5-minute cool-down period. Exerciser features include the following:

- a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer or dual independent exercisers that allow for unloaded and loaded schedule testing.
- b. Push-button programming control with digital display of settings.
- c. Integral battery operation of time switch when normal control power is not available.

2.1.7 Engine Shutdown Time Delay

Engine Shutdown. Provide time delay that is adjustable from 0 to 5 minutes and is factory set at 5 minutes.

2.1.8 Engine Starting Contacts

Provide 2 isolated normally closed and 2 isolated normally open contact that is rated 5 A at 250 VAC/30 VDC minimum.

2.1.9 Controls for Fire Pump Service Automatic Transfer Switch

Provide the following additional controls features:

Phase reversal of the normal source is to initiate transfer to the emergency/alternate source.

2.1.10 Auxiliary Contact for Uninterruptible Power Supply

Provide a contact that closes when transferred to the alternate power source.

2.1.11 Unassigned Auxiliary Contacts

Provide two normally open and two normally closed, single-pole, double-throw auxiliary contacts for each switch position rated at 10 amperes at 240 volts.

2.1.12 Front Panel Devices

Provide devices mounted on cabinet front consisting of:

- a. Mode selector switch with the following positions and associated functions. Selector switch can be part of the microprocessor controller consisting of an LCD screen with a graphical interface or as a stand-alone test switch.
 - (1) TEST - Simulates loss of normal/preferred source system operation.
 - (2) NORMAL - Transfers system to normal/preferred source bypassing re-transfer time delay.
- b. Switch position indicating lights or graphical LCD display. Indicate source to which load is connected.
- c. Source-Available Monitor. Provide source-available indicating lights or graphical LCD display monitor that is labeled to show when one or both sources of power are available. If indicating lights are used, then the preference is to have Green be normal/preferred power and Red be for alternate/emergency power; however, other color schemes are allowed if clearly marked..
- d. Lamp test button.

2.2 BY-PASS/ISOLATION SWITCH (BP/IS)

Include load-break by-pass/isolation switches for the indicated automatic transfer switches that are arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined by-pass/isolation switch and automatic transfer switch:

- a. Bypass/isolation switch (BP/IS) and associated ATS are to be made by the same manufacturer and must be completely interconnected and tested at factory and at project site as specified.

- b. ATS is to be manufactured, listed and tested in accordance with paragraph AUTOMATIC TRANSFER SWITCH. BP/IS switch current, voltage, closing, and short-circuit withstand closing ratings are to be equal or exceed comparable ratings specified for ATS and have the same phase arrangement and number of poles.
- c. Provide externally operated and arranged selector switch or handle so designed and constructed not to stop in an intermediate or neutral position during operation and that one person can safely bypass the ATS. Accomplish isolation of the ATS externally by one person without opening a door. Provide interlocks that ensure ATS is disconnected from source and load during isolation. Interlocks prevent ATS operation, except for testing and maintenance, while isolated. BP/IS operation is to be accomplished without disconnecting switch load terminal conductors.
- d. Provide drawout transfer switch that provides physical separation from bypass switch and live parts and accessibility for testing and maintenance operation.
- e. Provide contacts that have the same contact temperature that do not exceed those of the ATS contacts when carrying rated load. Provide contacts as specified for associated ATS, including provisions for inspection of contacts without disassembly of BP/IS or removal of entire contact enclosure. Provide manufacturer instructions for determining contact integrity in order To facilitate maintenance.
- f. The ATS controls remain functional with the ATS isolated or in bypass mode to permit monitoring of the normal power source and automatic starting of the generator in the event of a loss of the normal power source. In the isolated mode, the bypass section is capable of functioning as a manual transfer or automatic switch to transfer the load to either power source. The ATS can be completely removed from the enclosure, if required for maintenance or repair, while the bypass section continues to power the load.
- h. Construct Bypass/isolation switch for convenient removal of parts from front of switch enclosure without removal of other parts or disconnection of external power conductors.
- i. Achieve load by-pass to the source with no load interruption or a load interruption of not more than 0.16 seconds unless the time delay (neutral time delay) option is used.
- j. Provide drawout bypass switch that provides physical separation from ATS and live parts and accessibility for testing and maintenance operation. Provide automatic shutters that closed to isolate the bus.

2.2.1 Markings

Mark isolation handle positions with engraved plates or other approved means to indicate position or operating condition of associated ATS, as follows:

- a. Provide an indication that shows that BP/IS section is providing power to the load.
- b. Provide indication of ATS isolation/test position.

- c. Provide suitable control labels and instruction signs describing operating instructions.
- d. Indicating lamps or LCD screen for indicating that shows the source availability, bypass switch position, transfer switch position, and isolation handle position. If indicating lights are used, provide a lamp test button that turns the indicating lights on, but does not cause any function to take place.

2.2.2 Interconnection

Interconnect BP/IS and associated ATS with suitably sized copper bus bars silver-plated at each connection point, and braced to withstand magnetic and thermal forces created at withstand current rating specified for associated ATS.

2.3 ENCLOSURE

Provide an enclosure that meets the following:

- a. Provide ATS and accessories in a free-standing, floor-mounted, ventilated NEMA 250, Type 1 or 4X as indicated on the plans, smooth sheet metal enclosure constructed in accordance with applicable requirements of NEMA ICS 6, UL 508, UL 1066, and UL 1008. Provide door with suitable hinges, locking handle latch, and gasketed jamb. Provide at least No. 14 metal gauge.
- b. Factory wiring within enclosure and field wiring terminating within enclosure must comply with NFPA 70. Provide wire that is permanently tagged or marked near terminal at each end with wire number shown on approved detail drawing, when wiring is not color coded. Conform terminal block to NEMA ICS 4. Arrange terminals for entrance of external conductors from top and bottom of enclosure as shown. Main switch terminals, including neutral terminal if used, must be pressure type suitable for termination of external copper conductors shown.
- c. Provide thermostatically controlled heater within enclosure to prevent condensation over temperature range stipulated in paragraph SERVICE CONDITIONS.

2.3.1 Construction

Construct enclosure for ease of removal and replacement of ATS components and control devices from front without disconnection of external power conductors or removal or disassembly of major components.

2.3.2 Cleaning and Painting

Protect both the inside and outside surfaces of an enclosure, including means for fastening against corrosion by enameling, galvanizing, plating, powder coating, or other equivalent means. Protection is not required for metal parts that are inherently resistant to corrosion, bearings, sliding surfaces of hinges, or other parts where such protection is impractical. Provide manufacturer's standard finish material, process, and color that is free from runs, sags, peeling, or other defects. An enclosure marked Type 1, 3R, 4 or 12 is acceptable if there is no visible rust at the conclusion of a salt spray (fog) test using the test method in ASTM B117, employing a 5 percent by weight, salt solution for 24 hours. Type 4X enclosures are acceptable following performance of the above test with an

exposure time of 200 hours.

2.3.3 Field Fabricated Nameplates

Nameplate is to comply with **ASTM D709**. Provide laminated plastic nameplates for each equipment enclosure as specified or as indicated on the drawings. Provide an inscription on each nameplate that identifies the name of the equipment, sources of power, calculated short circuit with date and the location e.g. 'SWB-1 Electrical Room 103'. Provide nameplates that are made of melamine plastic, **0.125 inch** thick, white with black center core. Provide the nameplate with a surface that is matte finished and that has square corners.. Accurately align lettering and engrave into the core. Provide nameplates that are at least **1.0 by 2.5 inches** with a minimum lettering size of **0.25 inch** high normal block style.

2.4 FACTORY TESTING

Submit a description of proposed field test procedures, including proposed date and steps describing each test, its duration and expected results, not less than **4** weeks prior to test date. Submit certified factory and field test reports, within 14 days following completion of tests. Provide reports that are certified and dated and that demonstrate that tests were successfully completed prior to shipment of equipment.

2.4.1 Prototype Factory Testing

A prototype of specified ATS is to be factory tested in accordance with **UL 1008**. In addition, perform factory tests on each ATS as follows:

- a. Insulation resistance test to ensure integrity and continuity of entire system
- b. Main switch contact resistance test.
- c. Visual inspection to verify that each ATS is as specified.
- d. Mechanical test to verify that ATS sections are free of mechanical hindrances.
- e. Electrical tests to verify complete system electrical operation and to set up time delays and voltage sensing settings.

2.4.2 Factory Test Reports

Provide three certified copies of factory test reports from the manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

Installation must conform to the requirements of **NFPA 70** and manufacturer's recommendation.

3.2 PREREQUISITES FOR FUNCTIONAL ACCEPTANCE TESTING

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the automatic transfer switch.

3.2.1 Performance of Acceptance Checks and tests

Complete as specified in paragraph entitled "Acceptance Checks and Tests". The Acceptance Checks and Tests are to be accomplished by the Testing organization as described in Section 26 08 00 APPARATUS INSPECTION AND TESTING.

3.2.2 Manufacturers O&M Information

The manufacturers O&M information required by the paragraph entitled "SD-10 Operation and Maintenance Data", is to be submitted to and approved by the Contracting Officer.

3.2.3 Test Equipment

Ensure all test equipment and instruments is on hand prior to scheduling field tests, or subject to Contracting Officer's approval, evidence must be provided to show that arrangements have been made to have the necessary equipment and instruments on site prior to field testing.

3.3 FIELD QUALITY CONTROL

Give Contracting Officer 15 days notice of dates and times scheduled for tests which require the presence of the Contracting Officer. The Contracting Officer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The contractor is responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary power conditions. The contractor provides labor, equipment, apparatus, including test load, and consumables required for the specified tests. Calibration of all measuring devices and indicating devices must be certified. Provide the services of a qualified factory-trained manufacturer's representative to assist the contractor in installation and start-up of the equipment specified under this section. The manufacturer's representative is to provide technical direction and assistance to the contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly components contained herein. Provide a test load that is a cataloged product in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Perform the following field tests in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.3.1 Automatic Transfer Switch [Acceptance Checks and Tests](#)

a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical and mechanical condition.
- (3) Confirm correct application of manufacturer's recommended lubricants.
- (4) Verify that manual transfer warnings are attached and visible.
- (5) Verify tightness of all control connections.

- (6) Verify tightness of accessible bolted connections by calibrated torque-wrench method. Thermographic survey is not required.
- (7) Perform manual transfer operation.
- (8) Verify positive mechanical interlocking between normal and alternate sources.

b. Electrical Tests

- (1) Measure contact-resistance. Correct values that exceed 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
- (2) Perform insulation-resistance on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole for one minute. Perform tests in both source positions.
- (3) Verify settings and operations of control devices.
- (4) Calibrate and set all relays and timers.
- (5) Test ground-fault protective device.

3.3.2 Functional Acceptance Tests

Functional Acceptance Tests must be coordinated with Section 26 32 15.00 ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES. Include simulating power failure and demonstrating the following operations for each automatic transfer switch. Demonstrate in service that the automatic transfer switches are in good operating condition, and function not less than five times.

a. Perform automatic transfer tests:

- (1) Simulate loss of normal/preferred power.
- (2) Return to normal/preferred power.
- (3) Simulate loss of emergency/alternate power.
- (4) Simulate all forms of single-phase conditions.

b. Verify correct operation and timing of the following functions:

- (1) Normal source voltage-sensing relays.
- (2) Engine start sequence.
- (3) Time delay upon transfer.

- (4) Alternate source voltage-sensing relays.
- (5) Automatic transfer operation.
- (6) Interlocks and limit switch function.
- (7) Time delay and retransfer upon normal power restoration.
- (8) By-pass/isolation functional modes and related automatic transfer switch operations.

3.3.3 Infrared Scanning

After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

- a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after acceptance.
- b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- c. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 TRAINING

Provide 4 hours of training to maintenance personnel on the proper operation, maintenance and adjustment of the automatic transfer switch. Coordinate this training with that of the generator equipment.

-- End of Section --

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM

11/13

PART 1 GENERAL

1.1 REFERENCES

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81 (2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

NFPA 780 (2017) Standard for the Installation of Lightning Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 96 (2016) UL Standard for Safety Lightning Protection Components

UL 467 (2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment

UL Electrical Construction (2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

1.2.1 Verification of Dimensions

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before making any departures from the design.

1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest UL Listed products of a manufacturer regularly engaged in production of lightning protection system components. Comply with **NFPA 70**, **NFPA 780**, and **UL 96**.

1.2.3 Lightning Protection System Installers Documentation

Provide documentation showing that the installer is certified with a

commercial third-party inspection company whose sole work is lightning protection, or is a UL Listed Lightning Protection Installer. In either case, the documentation must show that they have completed and passed the requirements for certification or listing, and have a minimum of 2 years documented experience installing lightning protection systems for DoD projects of similar scope and complexity.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval.. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overall lightning protection system; G

Each major component; G

SD-06 Test Reports

Lightning Protection and Grounding System Test Plan; G

Lightning Protection and Grounding System Test; G

SD-07 Certificates

Lightning Protection System Installers Documentation; G

Component UL Listed and Labeled; G

Lightning protection system inspection certificate; G

Roof manufacturer's warranty; G

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" has been substituted for "should" wherever it appears. Interpret references in these standards to "authority having jurisdiction," or words of similar meaning, to mean Contracting Officer.

1.4.1 Installation Drawings

1.4.1.1 Overall System Drawing

Submit installation shop drawing for the overall lightning protection system. Include on the drawings the physical layout of the equipment (plan view and elevations), mounting details, relationship to other parts of the work, and wiring diagrams.

1.4.1.2 Major Components

Submit detail drawings for each major component including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

1.4.2 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled. Listing alone in UL Electrical Construction, which is the UL Electrical Construction Directory, is not acceptable evidence. In lieu of Listed and Labeled, submit written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories.

1.4.3 Lightning Protection and Grounding System Test Plan

Provide a lightning protection and grounding system test plan. Detail both the visual inspection and electrical testing of the system and components in the test plan. Identify (number) the system test points/locations along with a listing or description of the item to be tested and the type of test to be conducted. As a minimum, include a sketch of the facility and surrounding lightning protection system as part of the specific test plan for each structure. Include the requirements specified in paragraph, "Testing of Integral Lightning Protection System" in the test plan.

1.4.4 Lightning Protection System Inspection Certificate

Provide certification from a commercial third-party inspection company whose sole work is lightning protection, stating that the lightning protection system complies with NFPA 780. Third party inspection company cannot be the system installer or the system designer. Alternatively, provide a UL Lightning Protection Inspection Master Label Certificate for each facility indicating compliance to NFPA 780.

Inspection must cover every connection, air terminal, conductor, fastener, accessible grounding point and other components of the lightning protection system to ensure 100% system compliance. This includes witnessing the tests for the resistance measurements for ground rods with test wells, and for continuity measurements for bonds. It also includes verification of proper surge protective devices for power, data and telecommunication systems. Random sampling or partial inspection of a facility is not acceptable.

1.5 SITE CONDITIONS

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before changing the design.

PART 2 PRODUCTS

2.1 MATERIALS

Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals.

Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings, such as tin or lead, or oversize conductors. Where a mechanical hazard is involved, increase conductor size to compensate for the hazard or protect conductors. When metallic conduit or tubing is provided, electrically bond conductor to conduit or tubing at the upper and lower ends by clamp type connectors or welds (including exothermic). All lightning protection components, such as bonding plates, air terminals, air terminal supports and braces, chimney bands, clips, connector fittings, and fasteners are to comply with the requirements of **UL 96** classes as applicable.

2.1.1 Main and Bonding Conductors

NFPA 780 and **UL 96** Class I, Class II, or Class II modified materials as applicable.

2.2 COMPONENTS

2.2.1 Air Terminals

Provide solid air terminals with a blunt tip. Tubular air terminals are not permitted. Support air terminals more than **24 inches** in length by suitable brace, supported at not less than one-half the height of the terminal.

2.2.2 Ground Rods

Provide ground rods made of copper-clad steel conforming to conform to **UL 467**. Provide ground rods that are not less than **3/4 inch** in diameter and **10 feet** in length. Do not mix ground rods of copper-clad steel or solid copper on the job.

2.2.3 Connections and Terminations

Provide connectors for splicing conductors that conform to **UL 96**, class as applicable. Conductor connections can be made by clamps or welds (including exothermic). Provide style and size connectors required for the installation.

2.2.4 Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to **NFPA 780** and **UL 96**.

PART 3 EXECUTION

3.1 INTEGRAL SYSTEM

Provide a lightning protection system that meets the requirements of **NFPA 780**. Lightning protection system consists of air terminals, roof conductors, down conductors, ground connections, grounding electrodes and ground ring electrode conductor. Expose conductors on the structures except where conductors are required to be in protective sleeves. Bond secondary conductors with grounded metallic parts within the building. Make interconnections within side-flash distances at or below the level of the grounded metallic parts.

3.1.1 Roof-Mounted Components

Coordinate with the roofing manufacturer and provide certification that the [roof manufacturer's warranty](#) is not violated by the installation methods for air terminals and roof conductors.

3.1.1.1 Air Terminals

Use a standing seam base for installation of air terminals on a standing seam metal roof that does not produce any roof penetrations.

3.1.1.2 Roof Conductors

Use a standing seam base for installation of roof conductors on a standing seam metal roof that does not produce any roof penetrations.

3.1.2 Down Conductors

Protect exposed down conductors from physical damage as required by [NFPA 780](#). Use Schedule 80 PVC to protect down conductors. Paint the Schedule 80 PVC to match the surrounding surface with paint that is approved for use on PVC. Down conductors are to be concealed within the wall cavities.

3.1.3 Ground Connections

Attach each down conductor and ground ring electrode to ground rods by welding (including exothermic), brazing, or compression. All connections to ground rods below ground level must be by exothermic weld connection or with a high compression connection using a hydraulic or electric compression tool to provide the correct circumferential pressure. Accessible connections above ground level and in test wells can be accomplished by mechanical clamping.

3.1.4 Grounding Electrodes

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not less [10 feet](#). Set ground rods not less than [3 feet](#) nor more than [8 feet](#), from the structure foundation, and at least beyond the drip line for the facility. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in [IEEE 81](#). Maximum allowed resistance of a driven ground rod is [5 ohms](#), under normally dry conditions when a ground ring electrode is not used. Contact the Contracting Officer for direction on how to proceed when two of any three ground rods, driven not less than [10 feet](#) into the ground, a minimum of [10 feet](#) apart, and equally spaced around the perimeter, give a combined value exceeding 50 ohms immediately after having driven. For ground ring electrode, provide continuous No. [4/0](#) bare stranded copper cable. Lay ground ring electrode around the perimeter of the structure in a trench not less than [3 feet](#) nor more than [8 feet](#) from the nearest point of the structure foundation, and at least beyond the drip line for the facility. Install ground ring electrode to a minimum depth of [30 inches](#). Install a ground ring electrode in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the cable.

3.2 APPLICATIONS

3.2.1 Nonmetallic Exterior Walls with Metallic Roof

Bond metal roof sections together which are insulated from each other so that they are electrically continuous, having a surface contact of at least 3 square inches.

3.3 INTERFACE WITH OTHER STRUCTURES

3.3.1 Fences

Bond metal fence and gate systems to the lightning protection system whenever the fence or gate is within 6 feet of any part of the lightning protection system in accordance with ANSI C2.

3.4 RESTORATION

Where sod has been removed, place sod as soon as possible after completing the backfilling. Restore, to original condition, the areas disturbed by trenching, storing of dirt, cable laying, and other work. Overfill to accommodate for settling. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration. Maintain disturbed surfaces and replacements until final acceptance.

3.5 FIELD QUALITY CONTROL

3.5.1 Lightning Protection and Grounding System Test

Test the lightning protection and grounding system to ensure continuity is not in excess of 1 ohm and that resistance to ground is not in excess of 5 ohms. Provide documentation for the measured values at each test point. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Include in the written report: locations of test points, measured values for continuity and ground resistances, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

-- End of Section --

SECTION 26 51 00

INTERIOR LIGHTING
05/20

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M	(2018) Standard Specification for Stainless Steel Wire
ASTM A641/A641M	(2019) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A1008/A1008M	(2020) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM B164	(2003; R 2014) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B633	(2019) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM D4674 REV A	(2002; R 2010) Standard Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments

EUROPEAN UNION (EU)

Directive 2011/65/EU	(2011) Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10	(2011; Errata 2015) IES Lighting Handbook
IES LM-79	(2008) Electrical and Photometric Measurements of Solid-State Lighting Products

IES LM-80	(2019) Measuring Lumen Maintenance of LED Light Sources
IES RP-16	(2017) Nomenclature and Definitions for Illuminating Engineering
IES TM-15	(2011) Luminaire Classification System for Outdoor Luminaires
IES TM-21	(2019) Projecting Long Term Lumen Maintenance of LED Light Sources
IES TM-30	(2018) IES Method for Evaluating Light Source Color Rendition

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 77	(2017) Temporal Light Artifacts: Test Methods and Guidance for Acceptance Criteria
NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2017) Electric Lamps— Specifications for the Chromaticity of Solid State Lighting Products
NEMA C82.77-10	(2020) Harmonic Emission Limits - Related Power Quality Requirements
NEMA SSL 1	(2016) Electronic Drivers for LED Devices, Arrays, or Systems
NEMA SSL 3	(2011) High-Power White LED Binning for General Illumination
NEMA SSL 7A	(2015) Phase-Cut Dimming for Solid State Lighting: Basic Compatibility
NEMA WD 1	(1999; R 2015) Standard for General Color Requirements for Wiring Devices
NEMA WD 7	(2011; R 2016) Occupancy Motion Sensors Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

NFPA 101 (2021) Life Safety Code

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

47 CFR 15 Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 20 (2010; Reprint Feb 2012) General-Use Snap Switches

UL 94 (2013; Reprint Jun 2020) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 508 (2018) UL Standard for Safety Industrial Control Equipment

UL 844 (2012; Reprint Jul 2020) UL Standard for Safety Luminaires for Use in Hazardous (Classified) Locations

UL 916 (2015) Standard for Energy Management Equipment

UL 924 (2016; Reprint May 2020) UL Standard for Safety Emergency Lighting and Power Equipment

UL 1472 (2015) UL Standard for Safety Solid-State Dimming Controls

UL 1598 (2008; Reprint Oct 2012) Luminaires

UL 1598C (2014) Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits

UL 2043 (2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces

UL 8750 (2015; Reprint Sep 2020) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires, luminaire accessories, or lighting equipment are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires and accessories that are mounted in exterior environments and not attached to the exterior of the building are

specified in Section 26 56 00 EXTERIOR LIGHTING. Cybersecurity requirements are specified in Section 25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS. Commissioning requirements for Army and Air Force projects are specified in Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING. Commissioning requirements for Navy projects are specified in Section 01 91 00.15 TOTAL BUILDING COMMISSIONING.

1.3 DEFINITIONS

- a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications and on the drawings, must be as defined in IEEE 100 and IES RP-16.
- b. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in IES LM-80.
- c. For LED luminaires, "Luminaire Efficacy" (LE) is the appropriate measure of energy efficiency, measured in lumens/watt. This is gathered from LM-79 data for the luminaire, in which absolute photometry is used to measure the lumen output of the luminaire as one entity, not the source separately and then the source and housing together.
- d. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire Drawings; G

Occupancy/Vacancy Sensor Coverage Layout; G; S

Lighting Control System One-Line Diagram; G

Sequence of Operation for Lighting Control System; G

SD-03 Product Data

Luminaires; G

Light Sources; G

LED Drivers; G

Luminaire Warranty; G

Lighting Controls Warranty; G

Local Area Controller; G

Switches; G

Wall Box Dimmers; G

Occupancy/Vacancy Sensors; G

Photosensors; G

Power Packs; G

Exit Signs; G

Emergency Drivers; G

SD-05 Design Data

Luminaire Design Data; G

SD-06 Test Reports

IES LM-79 Test Report; G

IES LM-80 Test Report; G

IES TM-21 Test Report; G

IES TM-30 Test Report; G

Occupancy/Vacancy Sensor Verification Test; G

Photosensor Verification Test; G

SD-07 Certificates

LED Driver and Dimming Switch Compatibility Certificate; G

SD-10 Operation and Maintenance Data

Lighting System, Data Package 5; G

Lighting Control System, Data Package 5; G

Maintenance Staff Training Plan; G

End-User Training Plan; G

1.5 QUALITY ASSURANCE

Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the **IES HB-10** as applicable, for the lighting system specified.

1.5.1 Luminaire Drawings

Include dimensions, accessories installation details, and construction details. Photometric data, including CRI, CCT, LED driver type, zonal lumen data, and candlepower distribution data must accompany shop drawings.

1.5.2 Luminaire Design Data

- a. Provide safety certification and file number for the luminaire family that must be listed, labeled, or identified in accordance with the **NFPA 70**. Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).
- b. Provide long term lumen maintenance projections for each LED luminaire in accordance with **IES TM-21**. Data used for projections must be obtained from testing in accordance with **IES LM-80**.

1.5.3 **IES LM-79** Test Report

Submit test report on manufacturer's standard production model of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data in IES format as outlined under "14.0 Test Report" in **IES LM-79**.

1.5.4 **IES LM-80** Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "8.0 Test Report" in **IES LM-80**.

1.5.5 **IES TM-21** Test Report

Submit test report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in **IES TM-21**.

1.5.6 IES TM-30 Test Report

Submit color vector graphic in accordance with IES TM-30 on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Include spectral distribution of test LED light source.

1.5.7 LED Driver and Dimming Switch Compatibility Certificate

Submit certification from the luminaire, driver, or dimmer switch manufacturer that ensures compatibility and operability between devices without flickering and to specified dimming levels.

1.5.8 Occupancy/Vacancy Sensor Coverage Layout

Provide floor plans showing coverage layouts of all devices using manufacturer's product information.

1.5.9 Test Laboratories

Test laboratories for the IES LM-79 and IES LM-80 test reports must be one of the following:

- a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program for both LM-79 and LM-80 testing.
- b. One of the qualified labs listed on the Department of Energy - LED Lighting Facts Approved Testing Laboratories List for LM-79 testing.
- c. One of the EPA-Recognized Laboratories listed for LM-80 testing.

1.5.10 Regulatory Requirements

Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70, unless more stringent requirements are specified or indicated. Provide luminaires and assembled components that are approved by and bear the label of UL for the applicable location and conditions unless otherwise specified.

1.5.11 Standard Products

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

1.5.11.1 Alternative Qualifications

Products having less than a six-month field service record will be

acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.11.2 Material and Equipment Manufacturing Date

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

1.6 WARRANTY

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

1.6.1 Luminaire Warranty

Provide and transfer to the government the original LED luminaire manufacturers standard commercial warranty for each different luminaire manufacturer used in the project.

- a. Provide a written five year minimum replacement warranty for material, luminaire finish, and workmanship. Provide written warranty document that contains all warranty processing information needed, including customer service point of contact, whether or not a return authorization number is required, return shipping information, and closest return location to the luminaire location.

- (1) Finish warranty must include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

- (2) Material warranty must include:

- (a) All LED drivers and integral control equipment.

- (b) Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective, non-starting, or operating below 70 percent of specified lumen output.

- b. Warranty period must begin in accordance with the manufacturer's standard warranty starting date.

- c. Provide replacements that are promptly shipped, without charge, to the using Government facility point of contact and that are identical to or an improvement upon the original equipment. All replacements must include testing of new components and assembly.

1.6.2 Lighting Controls Warranty

Provide and transfer to the government the original lighting controls manufacturers standard commercial warranty for each different lighting controls manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Warranty service must be performed by a factory-trained engineer or technician.

- a. Unless otherwise noted, provide a written five year minimum warranty on the complete system for all systems with factory commissioning.

Provide warranty that covers 100 percent of the cost of any replacement parts and services required over the five years which are directly attributable to the product failure. Failures include, but are not limited to, the following:

- (1) Software: Failure of input/output to execute switching or dimming commands.
 - (2) Damage of electronic components due to transient voltage surges.
 - (3) Failure of control devices, including but not limited to occupancy sensors, photosensors, and manual wall station control devices.
- b. Provide a written five year minimum warranty on all input devices against defect in workmanship or materials provided by device manufacturer.
 - c. Provide a written five year minimum warranty on all control components attached to luminaires against defect in workmanship or materials.

1.7 OPERATION AND MAINTENANCE MANUALS

1.7.1 Lighting System

Provide operation and maintenance manuals for the lighting system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting system for the building. Additional requirements for the Navy are provided in Section 01 78 24.00 20 FACILITY ELECTRONIC OPERATION AND MAINTENANCE SUPPORT INFORMATION (eOMSI). Include the following:

- a. Manufacturers' operating and maintenance manuals.
- b. Luminaire shop drawings for modified and custom luminaires.
- c. Luminaire Manufacturers' standard commercial warranty information as specified in paragraph LUMINAIRE WARRANTY.

1.7.2 Lighting Control System

Provide operation and maintenance manuals for the lighting control system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting control system for the building. Include the following:

- a. Lighting control system layout and wiring plan.
- b. Lighting control system one-line diagram.
- c. Product data for all devices, including installation and programming instructions.
- d. Occupancy/vacancy sensor coverage layout.
- e. Training materials, such as videos or in-depth manuals, that cover basic operation of the lighting control system and instructions on modifying the lighting control system. Training materials must include calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

- f. Sequence of operation descriptions for each typical room type, including final programming, schedules, and calibration settings.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

2.2 LUMINAIRES

UL 1598, NEMA C82.77-10. Provide luminaires as indicated in the luminaire schedule and NL plates or details on project plans, complete with light source, wattage, and lumen output indicated. All luminaires of the same type must be provided by the same manufacturer. Luminaires must be specifically designed for use with the driver and light source provided.

2.2.1 Luminaires

UL 8750, IES LM-79, IES LM-80. For all luminaires, provide:

- a. Complete system with LED drivers and light sources.
- b. Housings constructed of non-corrosive materials. All new aluminum housings must be anodized or powder-coated. All new steel housings must be treated to be corrosion resistant.
- c. IES TM-21, IES LM-80. Minimum L70 lumen maintenance value of 50,000 hours unless otherwise indicated in the luminaire schedule. Luminaire drive current value must be identical to that provided by test data for luminaire in question.
- d. Minimum efficacy as specified in the luminaire schedule. Theoretical models of initial lamp lumens per watt are not acceptable. If efficacy values are not listed in the luminaire schedule, provide luminaires that meet the following minimum values:

Luminaire Style	Minimum Luminaire Efficacy
Recessed 1 by 4 Recessed 2 by 4 Recessed 2 by 2	120 LPW 126 LPW 120 LPW
Recessed Downlight (fixed, adjustable, wallwash)	80 LPW
Linear, Accent (undercabinet, cove)	45 LPW
Linear, Ambient (indirect wall mount, linear pendent)	128 LPW
High Bay, Low Bay, and Industrial Locations	149 LPW - High Bay 125 LPW - Low Bay
Food Service and Hazardous Locations	128 LPW
Other (track, residential diffusers)	50 LPW
Exterior Wall Sconce	108 LPW

Luminaire Style	Minimum Luminaire Efficacy
Steplight	30 LPW
Parking Garage Luminaire	113 LPW

- e. UL listed for dry or damp location typical of interior installations. Any luminaire mounted on the exterior of the building must be UL listed for wet location typical of exterior installations.
- f. LED driver and light source package, array, or module are accessible for service or replacement without removal or destruction of luminaire.
- g. Lenses constructed of heat tempered borosilicate glass, UV-resistant acrylic, or silicone. Provide polycarbonate vandal-resistant lenses as indicated. Sandblasting, etching and polishing must be performed as indicated in the luminaire description.
- h. **IES TM-15**. Provide exterior building-mounted luminaires that do not exceed the BUG ratings as listed in the luminaire schedule. If BUG ratings are not listed in the luminaire schedule, provide luminaires that meet the following minimum values for each application and mounting conditions:

Lighting Application	Mounting Conditions	BUG Rating
Exterior Wall Sconce	Above 4 feet AFF	B1-U0-G2
Exterior Wall Sconce	Below or at 4 feet AFF	B4-U0-G4
Steplight	Above 4 feet AFF	B1-U1-G2
Steplight	Below or at 4 feet AFF	B4-U1-G4
Parking Garage Luminaire	Ceiling mounted	B4-U4-G3

2.2.1.1 Luminaire Conversion Kits

Provide luminaire conversion kits that meet **UL 1598C** Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits.

2.2.2 Luminaires for Hazardous Locations

In addition to requirements stated herein, provide LED luminaires for hazardous locations which conform to **UL 844** or which have Factory Mutual certification for the class and division indicated.

2.3 LIGHT SOURCES

NEMA ANSLG C78.377, **NEMA SSL 3**. Provide type, delivered lumen output, and wattage as indicated in the luminaire schedule on project plans.

2.3.1 LED Light Sources

Provide LED light sources that meet the following requirements:

- a. **NEMA ANSLG C78.377**. Emit white light and have a nominal CCT of 3500 Kelvin.
- b. Minimum Color Rendering Index (CRI) of 80.
- c. **Directive 2011/65/EU**. Restriction of Hazardous Substances (RoHS) compliant.
- d. Light source color consistency by utilizing a binning tolerance within a 3-step McAdam ellipse.

2.4 LED DRIVERS

NEMA SSL 1, UL 8750. Provide LED drivers that are electronic, UL Class 1 or Class 2, constant-current type and that comply with the following requirements:

- a. The combined driver and LED light source system does not exceed the minimum luminaire efficacy values as listed in the luminaire schedule provided.
- b. Operates at a voltage of 120-277 volts at 50/60 hertz, with input voltage fluctuations of plus/minus 10 percent.
- c. Power Factor (PF) greater than or equal to 0.90 at full input power and across specified dimming range.
- d. Maximum Total Harmonic Distortion (THD) less than 20 percent at full input power and across specified dimming range.
- e. Operates for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.
- f. Withstands Category A surges of 4 kV without impairment of performance. Provide surge protection that is integral to the driver.
- g. Integral thermal protection that reduces the output power to protect the driver and light source from damage if the case temperature approaches or exceeds the driver's maximum operating temperature.
- h. **47 CFR 15**. Complies with the requirements of the Federal Communications Commission (FCC) rules and regulations, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).
- i. Class A sound rating.
- j. **Directive 2011/65/EU**. Restriction of Hazardous Substances (RoHS) compliant.
- k. Provide dimming capability as indicated in the luminaire schedule on project plans. Dimmable drivers must dim down to 1 percent. Dimmable drivers must be controlled by a Class 2 low voltage 0-10VDC controller dimming signal protocol unless otherwise specified. LED drivers of the same family/series must track evenly across multiple luminaires at all light levels.

2.5 LIGHTING CONTROLS

Provide network certification for all networked lighting control systems and devices in accordance with the requirements of Section 25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS. Provide lighting control systems that do not switch off battery-operated or emergency backup luminaires or exit signs in path of egress. Provide system with override of lighting control devices controlling luminaires in path of egress with activation of fire alarm system.

2.5.1 System

Provide lighting control system that operates the lighting system as described in the lighting control strategies in the project plans. Submit [Sequence of Operation for Lighting Control System](#) describing the operation of the proposed lighting control system and devices. Sequence of Operation must provide the strategies identified in the lighting control strategies.

2.5.1.1 Localized Control Systems

Provide room or area-wide lighting control system capable of manual control, time-based control, and receiving input from photosensors and occupancy/vacancy sensors.

2.5.1.1.1 [Local Area Controller](#)

Provide controller designed for single area or room with the following requirements:

- a. Operates at a voltage of 120-277 volts at 50/60 hertz.
- b. 2 zone, with 1 relay rated 20 amps with one manual switchdimmer per zone.
- c. Provide inputs for occupancy/vacancy sensors, photosensors, and low-voltage wall switches.
- d. Provide daylight harvesting capability with full-range dimming control with input from photosensor.
- e. Provide capability for receptacle load control from occupancy sensors.
- f. Capable of 0-10V dimming.
- g. Provide override 'ON' function with input from Fire Alarm Control Panel for all emergency lighting. Controller must not turn off power to emergency batteries or exit signs.

2.5.2 Devices

2.5.2.1 [Switches](#)

Provide line-voltage toggle switches as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. When used for non-digital loads, devices must be rated at 20 Amps inductive load, and be compatible with the lighting control systems.

2.5.2.2 Wall Box Dimmers

UL 1472, UL 20, IEEE C62.41, NEMA 77, NEMA SSL 7A. Dimmers must provide flicker-free, continuously variable light output throughout the dimming range of 1 percent to 100 percent. Devices must be capable of operating at their full rated capacity regardless of being single or ganged-mounted, and be compatible with three-way and four-way switching scenarios.

Provide wall-box dimmers that meet the following requirements:

- a. Device operates as an independent control device.
- b. Device operates with the use of a vertical slider, paddle, rotary, button, or toggle with adjacent vertical slider.
- c. Finish of device matches switches and outlets in the same area.
- d. Back box in wall has sufficient depth to accommodate body of switch and wiring.
- e. Dimmer is capable of controlling 0-10 volt LED drivers. Dimmers and the drivers they control must be provided from the same manufacturer or tested and certified as compatible for use together.
- f. Radio frequency interference suppression is integral to device.

2.5.2.3 Occupancy/Vacancy Sensors

IEEE C62.41, NEMA WD 1, UL 94, UL 916, UL 508, ASTM D4674 REV A, NEMA WD 7. Provide occupancy/vacancy sensors with coverage patterns as indicated on project plans. Provide no less quantity of sensors as shown on plans, but add additional sensors when required to fulfill coverage requirement for the specific model of sensor provided. Provide occupancy sensor operation that requires movement to activate luminaires controlled and turns luminaires off after a set time of inactivity. Provide ceiling or wall-mounted occupancy/vacancy sensors that meet the following requirements:

- a. Operating voltage of 12-24 volts.
- b. Time delay of 30 seconds to 30 minutes with at least four intermediate time delay settings.
- c. Sensors are ceiling mounted.
- d. Does not exceed a maximum load requirement of 20mA at 24VDC.
- e. Shielded or controlled by internal logic to adjust sensitivity to avoid false triggering due to ambient temperature, air temperature variations or HVAC air movement.
- f. Sensor is equipped to automatically energize the connected load upon loss of normal power when located in a means of egress.
- g. Occupancy and vacancy operation is field-adjustable and programmable with push-button or dip switch on the sensor device.
- h. No leakage current to load when in the off mode.

- i. Utilize zero-crossing circuitry to prevent damage from high inrush current and to promote long life operation.
- j. Allow the adding or deleting of specific luminaires or zones to the assigned sensor without the use of ladders.
- k. Provide an isolated relay for integrating control of HVAC or other automated systems.

2.5.2.3.1 Passive Infrared Sensors

Provide Passive Infrared Sensors (PIR) sensors that detect occupancy by sensing heat and movement in the area of coverage. Provide sensors are constructed of a housing of high-impact, injection-molded thermoplastic. Provide PIR sensors that are temperature compensated, with a dual element sensor and a multi-element fresnel lens of POLY IR4 material.

2.5.2.3.2 Ultrasonic Sensors

Provide ultrasonic sensors that detect occupancy by sensing a change in pattern of reflected ultrasonic waves in the area of coverage. Provide sensors that are constructed of a housing of high-impact, injection-molded thermoplastic. Provide ultrasonic sensors that operate at 40 kHz.

2.5.2.3.3 Dual Technology Sensors

Provide dual technology sensors that meet the requirements for PIR sensors and ultrasonic sensors indicated above. If either the PIR or ultrasonic sensing registers occupancy, the luminaires must remain on.

2.5.2.3.4 High Bay Sensors

Provide occupancy/vacancy sensors specifically designed for high-bay mounting applications for all ceiling-mounted sensors mounted above 35 feet using PIR technology. Provide high-bay sensors with interchangeable lenses for 360 degree open area coverage or narrow rectangular warehouse aisle coverage.

2.5.2.3.5 Power Packs

UL 2043. Provide power packs to provide power to lighting control sensors as required in accordance with the manufacturer's specifications. Provide power packs that meet the following requirements:

- a. Operate at an input voltage of 120-277 VAC, with an output voltage 12-24 VDC at 225 mA.
- b. Constructed of plenum-rated, high-impact thermoplastic enclosure.
- c. Utilizes zero-crossing circuitry to prevent damage from inrush current.
- d. Maximum load rating of 16 amps for electronic lighting loads.
- e. **Directive 2011/65/EU.** Restriction of Hazardous Substances (RoHS) compliant.

2.5.2.4 Photosensors

Provide photosensors that meet the following requirements:

- a. Detect changes in ambient lighting level and enable dimming as required by sequence of operation by operating in an open-loop system.
- b. Contain a detection cone, where the base of the cone may be circular or an elongated shape, and where the smallest angle between the edge and the axis of the cone is between 20 and 50 degrees. The cone axis may be tilted to the vertical when installed to give the sensor preferred directionality.
- c. Sensors are ceiling-mounted with sensitivity, filtering, range and viewing angle to meet requirements of sequence of operation, scope of work and construction documents.
- d. Time delay that is adjustable from 1 to 30 seconds ON delay, and 1 to 30 minutes OFF delay to prevent cycling, with deadband adjustment of 25 percent to 100 percent above lower setpoint.
- e. Output dimming signal is linear to light level with less than 1 percent variation. Cadmium sulfide photo-resistors are not acceptable.
- f. Sensor is not combined in the same housing or location with occupancy or vacancy sensors if the proper location for one function compromises the successful operation of the other function, or in any way reduces the system's ability to meet the design intent.

2.6 EXIT AND EMERGENCY LIGHTING EQUIPMENT

2.6.1 Exit Signs

UL 924, NFPA 101. Provide wattage as indicated in the luminaire schedule on project plans. Provide LED Exit Signs that meet the following criteria:

- a. Housing constructed of clear polycarbonate housing.
- b. UL listed for damp location.
- c. Configured for universal mounting.
- d. 6 inch high, 3/4 inch stroke red lettering on face of sign with chevrons on either side of lettering to indicate direction.
- e. Single or double face as indicated in project plans and luminaire schedule.

2.6.1.1 Exit Signs with Battery Backup

Equip with automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 1-1/2 hours. LEDs must have a minimum rated life of 10 years. Provide self-diagnostic circuitry integral to emergency LED driver.

2.6.2 Emergency Lighting Unit (ELU)

UL 924, NFPA 101. Provide emergency lighting units (ELUs) completely assembled with wiring and mounting devices, ready for installation at the

locations indicated. Provide in UV-stable, thermo-plastic housing with UL damp label as indicated. Emergency lighting units must be rated for 12 volts, except units having no remote-mounted light sources and having no more than two unit-mounted light sources may be rated six volts. Equip units with brown-out sensitive circuit to activate battery when input voltage falls to 75 percent of normal. Equip with two LED light sources, automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free lead-calcium type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 90 minutes. LEDs must have a minimum rated life of 10 years. Provide self-diagnostic circuitry integral to emergency LED driver.

2.6.3 LED Emergency Drivers

UL 924, NFPA 101. Provide LED emergency driver with automatic power failure detection, test switch and LED indicator (or combination switch/indicator) located on luminaire exterior, and fully-automatic solid-state charger, battery and inverter integral to a self-contained housing. Provide self-diagnostic function integral to emergency driver. Integral nickel-cadmium-lead-calcium battery is required to supply a minimum of 90 minutes of emergency power at 10 watts, 10-50 VDC compatible with LED forward voltage requirements, constant output. Driver must be RoHS compliant, rated for installation in plenum-rated spaces and damp locations, and be warranted for a minimum of five years.

2.6.4 Self-Diagnostic Circuitry for LED Drivers

UL 924, NFPA 101. Provide emergency lighting unit with fully-automatic, integral self-testing/diagnostic electronic circuitry. Circuitry must provide for a one minute diagnostic test every 28 days, and a 30 minute diagnostic test every six months, minimum. Any malfunction of the unit must be indicated by LED(s) visible from the exterior of the luminaire. A manual test switch must also be provided to perform a diagnostic test at any given time.

2.7 LUMINAIRE MOUNTING ACCESSORIES

2.7.1 Suspended Luminaires

- a. Provide hangers capable of supporting twice the combined weight of luminaires supported by hangers.
- b. Hangers must allow luminaires to swing within an angle of 45 degrees. Brace pendants 4 feet or longer to limit swinging. Provide with swivel hangers to ensure a plumb installation for rigid stem pendants. Provide cadmium-plated steel with a swivel-ball tapped for the conduit size indicated.
- c. Single-unit suspended luminaires must have cable hangers. Multiple-unit or continuous row luminaires with a separate power supply cord must have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end.
- d. Provide all linear pendant and surface mounted luminaires with two supports per four-foot section or three per eight-foot section unless otherwise recommended by manufacturer.

- e. Provide rods in minimum 0.18 inch diameter.

2.7.2 Recess and Surface Mounted Luminaires

Provide access to light source and LED driver from bottom of luminaire. Provide trim and lenses for the exposed surface of flush-mounted luminaires as indicated on project drawings and specifications. Luminaires recessed in ceilings which have a fire resistive rating of one hour or more must be enclosed in a box which has a fire resistive rating equal to that of the ceiling. For surface mounted luminaires with brackets, provide flanged metal stem attached to outlet box, with threaded end suitable for supporting the luminaire rigidly in design position. Flanged part of luminaire stud must be of broad base type, secured to outlet box at not fewer than three points.

2.7.3 Luminaire Support Hardware

2.7.3.1 Wire

ASTM A641/A641M. Galvanized, soft tempered steel, minimum 0.11 inches in diameter, or galvanized, braided steel, minimum 0.08 inches in diameter.

2.7.3.2 Wire for Humid Spaces

ASTM A580/A580M. Composition 302 or 304, annealed stainless steel, minimum 0.11 inches in diameter.

ASTM B164. UNS N04400, annealed nickel-copper alloy, minimum 0.11 inches in diameter.

2.7.3.3 Threaded Rods

Threaded steel rods, 3/16 inch diameter, zinc or cadmium coated.

2.7.3.4 Straps

Galvanized steel, one by 3/16 inch, conforming to **ASTM A653/A653M**, with a light commercial zinc coating or **ASTM A1008/A1008M** with an electrodeposited zinc coating conforming to **ASTM B633**, Type RS.

2.8 EQUIPMENT IDENTIFICATION

2.8.1 Manufacturer's Nameplate

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

2.8.2 Labels

UL 1598. All luminaires must be clearly marked for operation of specific light sources and LED drivers. The labels must be easy to read when standing next to the equipment, and durable to match the life of the equipment to which they are attached. Note the following light source characteristics in the format "Use Only ____":

- a. Correlated Color Temperature (CCT) and Color Rendering Index (CRI) for

all luminaires.

b. Driver and dimming protocol.

All markings related to light source type must be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when light sources are in place. LED drivers must have clear markings indicating dimming type and indicate proper terminals for the various outputs.

2.9 FACTORY APPLIED FINISH

NEMA 250. Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum, meets requirements of corrosion-resistance testing.

PART 3 EXECUTION

3.1 INSTALLATION

IEEE C2, NFPA 70.

3.1.1 Light Sources

When light sources are not provided as an integral part of the luminaire, deliver light sources of the type, wattage, lumen output, color temperature (CCT), color rendering index (CRI), and voltage rating indicated to the project site and install just prior to project completion, if not already installed in the luminaires from the factory.

3.1.2 Luminaires

Set luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent luminaires and secure in accordance with manufacturers' directions and approved drawings. Provide accessories as required for ceiling construction type indicated on Finish Schedule. Luminaire catalog numbers do not necessarily denote specific mounting accessories for type of ceiling in which a luminaire may be installed. Provide wires, straps, or rods for luminaire support in this section. Install luminaires with vent holes free of air blocking obstacles.

3.1.2.1 Suspended Luminaires

Measure mounting heights from the bottom of the luminaire for ceiling-mounted luminaires and to center of luminaire for wall-mounted luminaires. Obtain architect approval of the exact mounting height on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Support suspended luminaires from structural framework of ceiling or from inserts cast into slab.

- a. Provide suspended luminaires with 45 degree swivel hangers so that they hang plumb and level.
- b. Locate so that there are no obstructions within the 45 degree range in all directions.
- c. The stem, canopy and luminaire must be capable of 45 degree swing.

- d. Rigid pendent stem, aircraft cable, rods, or chains 4 feet or longer excluding luminaire must be braced to prevent swaying using three cables at 120 degree separation.
- e. Suspended luminaires in continuous rows must have internal wireway systems for end to end wiring and must be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces.
- f. Utilize aligning splines on extruded aluminum luminaires to assure minimal hairline joints.
- g. Support steel luminaires to prevent "oil-canning" effects.
- h. Match supporting pendants with supported luminaire. Aircraft cable must be stainless steel.
- i. Match finish of canopies to match the ceiling, and provide low profile canopies unless otherwise shown.
- j. Maximum distance between suspension points must be 10 feet or as recommended by the manufacturer, whichever is less.

3.1.2.2 Recessed and Semi-Recessed Luminaires

- a. Support recessed and semi-recessed luminaires independently from the building structure by a minimum of two wires, straps or rods per luminaire and located near opposite corners of the luminaire. Secure horizontal movement with clips provided by manufacturer. Ceiling grid clips are not allowed as an alternative to independently supported luminaires.
- b. Support round luminaires or luminaires smaller in size than the ceiling grid independently from the building structure by a minimum of four wires, straps or rods per luminaire, spaced approximately equidistant around.
- c. Do not support luminaires by acoustical tile ceiling panels.
- d. Where luminaires of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support each independently and provide at least two 3/4 inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the luminaire.
- e. Luminaires installed in suspended ceilings must also comply with the requirements of Section 09 51 00 ACOUSTICAL CEILINGS.
- f. Adjust aperture rings on all applicable ceiling recessed luminaires to accommodate various ceiling material thickness. Coordinate cut-out size in ceiling to ensure aperture covers cut-out entirely. Install aperture rings such that the bottom of the ring is flush with finished ceiling or not more than 1/16 inch above. Do not install luminaires such that the aperture ring extends below the finished ceiling surface.

3.1.3 LED Drivers

Provide LED drivers integral to luminaire as constructed by the manufacturer.

3.1.4 Exit Signs

NFPA 101. Wire exit signs and emergency lighting units ahead of the local switch, to the normal lighting circuit located in the same room or area.

3.1.5 Lighting Controls

Refer to Section **25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS** for additional lighting control installation requirements.

3.1.5.1 Occupancy/Vacancy Sensors

- a. Provide quantity of sensor units indicated as a minimum. Provide additional units to give full coverage over controlled area. Full coverage must provide hand and arm motion detection for office and administration type areas and walking motion for industrial areas, warehouses, storage rooms and hallways.
- b. Locate ceiling-mounted sensors no closer than **6 feet** from the nearest HVAC supply or return diffuser.
- c. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations.

3.1.5.2 Photosensors

Locate and aim sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor set-point in accordance with the manufacturer's recommendations and for the indicated light level of the area of coverage, measured at the work plane.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

3.2.1.1 Lighting Control Verification Tests

Verify lighting control system and devices operate according to approved sequence of operations. Verification tests are to be completed after commissioning.

- a. Verify occupancy/vacancy sensors operate as described in sequence of operations. Provide testing of sensor coverage, sensitivity, and time-out settings in all spaces where sensors are placed. This is to be completed only after all furnishings have been installed. Submit **occupancy/vacancy sensor verification test**.
- b. Verify photosensors operate as described in sequence of operations. Provide testing of sensor coverage, aiming, and calibration in all spaces where sensors are placed. This is to be completed only after all furnishings have been installed. Submit **photosensor verification test**.
- c. Verify wall box dimmers and scene wallstations operate as described in sequence of operations.

3.2.1.2 Emergency Lighting Test

Interrupt power supply to demonstrate proper operation of emergency

lighting. If adjustments are made to the lighting system, re-test system to show compliance with standards.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Commissioning

NFPA 101. Commission all components of the lighting system and lighting control system in accordance with Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING. Commission all components of the lighting system and lighting control system in accordance with Section 01 91 00.15 TOTAL BUILDING COMMISSIONING. Factory Trained Field Service Technician is responsible for calibration and programming sequences for input devices and systems in accordance with the requirements described in the sequence of operation.

3.3.2 Training

3.3.2.1 Maintenance Staff Training

Submit a **Maintenance Staff Training Plan** at least 30 calendar days prior to training session that describes training procedures for Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide on-site training which demonstrates full system functionality, assigning schedules, calibration adjustments for light levels and sensor sensitivity, integration procedures for connecting to third-party devices, and manual override including information on appropriate use. Provide protocols for troubleshooting, maintenance, repair, and replacement, and literature on available system updates and process for implementing updates.

3.3.2.2 End-User Training

Submit an **End-User Training Plan** at least 30 calendar days prior to training session that describes training procedures for end-users on the lighting control system. Provide users with a list of control devices located within user-occupied spaces, such as photosensors and occupancy and vacancy sensors, including information on the proper operation and schedule for each device. Provide demonstration for each type of interface. Provide users with the building schedule as currently commissioned, including conditional programming based on astronomic time clock functionality. Provide users with the correct contact information for maintenance personnel who will be available to address any lighting control issues.

Provide laminated instructions to the user at each scene wallstation. Provide only instructions relevant to the functionality of the specific scene wallstation. Provide a description of each labeled scene control button. If the room utilizes occupancy/vacancy sensors or photosensors, include a description of this functionality on the instruction sheet.

-- End of Section --

SECTION 26 56 00

EXTERIOR LIGHTING
05/20

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO LTS (2013; Errata 2013) Standard
Specifications for Structural Supports for
Highway Signs, Luminaires and Traffic
Signals

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

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

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M (2016a) Standard Specification for Zinc
Coating (Hot-Dip) on Iron and Steel
Hardware

ASTM B108/B108M (2019) Standard Specification for
Aluminum-Alloy Permanent Mold Castings

ASTM B117 (2019) Standard Practice for Operating
Salt Spray (Fog) Apparatus

EUROPEAN UNION (EU)

Directive 2011/65/EU (2011) Restriction of the Use of Certain
Hazardous Substances in Electrical and
Electronic Equipment

ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10 (2011; Errata 2015) IES Lighting Handbook

IES LM-79 (2008) Electrical and Photometric
Measurements of Solid-State Lighting
Products

IES LM-80 (2019) Measuring Lumen Maintenance of LED
Light Sources

IES RP-8 (2018; Addenda 1 2020) Recommended Practice
for Lighting Roadway and Parking Facilities

IES RP-16	(2017) Nomenclature and Definitions for Illuminating Engineering
IES TM-15	(2011) Luminaire Classification System for Outdoor Luminaires
IES TM-21	(2019) Projecting Long Term Lumen Maintenance of LED Light Sources

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C136.3	(2020) Roadway and Area Lighting Equipment - Luminaire Attachments
ANSI C136.13	(2014) Roadway and Area Lighting Equipment - Metal Brackets for Wood Poles
ANSI C136.21	(2014) American National Standard for Roadway and Area Lighting Equipment - Vertical Tenons Used with Post-Top-Mounted Luminaires
NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2017) Electric Lamps- Specifications for the Chromaticity of Solid State Lighting Products
NEMA C82.77-10	(2020) Harmonic Emission Limits - Related Power Quality Requirements
NEMA C136.31	(2018) Roadway and Area Lighting Equipment - Luminaire Vibration
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA SSL 1	(2016) Electronic Drivers for LED Devices, Arrays, or Systems
NEMA SSL 3	(2011) High-Power White LED Binning for General Illumination
NEMA WD 7	(2011; R 2016) Occupancy Motion Sensors

Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 773 (2016; Reprint Jul 2020) UL Standard for Safety Plug-In, Locking Type Photocontrols for Use with Area Lighting

UL 773A (2016; Reprint Jun 2020) UL Standard for Safety Nonindustrial Photoelectric Switches for Lighting Control

UL 924 (2016; Reprint May 2020) UL Standard for Safety Emergency Lighting and Power Equipment

UL 1310 (2018) UL Standard for Safety Class 2 Power Units

UL 1598 (2008; Reprint Oct 2012) Luminaires

UL 8750 (2015; Reprint Sep 2020) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.2 RELATED REQUIREMENTS

Materials not considered to be luminaires, luminaire accessories, or lighting equipment are specified in Section(s) **33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION**. Luminaires and accessories installed in interior of buildings or attached to the exterior of a building are specified in Section **26 51 00 INTERIOR LIGHTING**. Cybersecurity requirements are specified in Section **25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS**. **Commissioning requirements for Navy projects are specified in Section 01 91 00.15 TOTAL BUILDING COMMISSIONING.**

1.3 DEFINITIONS

- a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications and on the drawings must be as defined in **IEEE 100** and **IES RP-16**.
- b. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in **IES LM-80**.
- c. For LED luminaires, "Luminaire Efficacy" (LE) is the appropriate measure of energy efficiency, measured in lumens/watt. This is gathered from LM-79 data for the luminaire, in which absolute photometry is used to measure the lumen output of the luminaire as one

entity, not the source separately and then the source and housing together.

- d. Total Harmonic Distortion (THD) is the Root Mean Square (RMS) of all the harmonic components divided by the total fundamental current.
- e. The "Groundline Section" of wood poles is that portion of the pole between one foot above, and 2 feet below the groundline.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire Drawings; G

Pole Drawings; G

Control System One-Line Diagram; G

Sequence of Operation for Exterior Lighting Control System; G

SD-03 Product Data

Luminaires; G

Light Sources; G

LED Drivers; G

Luminaire Warranty; G

Lighting Controls Warranty; G

Pole Warranty; G

Motion Sensors; G

Photosensors; G

Lighting Contactor; G

Poles; G

Brackets

SD-05 Design Data

Luminaire Design Data; G

SD-06 Test Reports

IES LM-79 Test Report; G

IES LM-80 Test Report; G

IES TM-21 Test Report; G

SD-08 Manufacturer's Instructions

Poles

SD-10 Operation and Maintenance Data

Lighting System, Data Package 5; G

Exterior Lighting Control System, Data Package 5; G

Maintenance Staff Training Plan; G

End-User Training Plan; G

1.5 QUALITY ASSURANCE

Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES HB-10 as applicable, for the lighting system specified.

1.5.1 Drawing Requirements

1.5.1.1 Luminaire Drawings

Include dimensions, effective projected area (EPA), weight, accessories, and installation and construction details. Photometric data, including CRI, CCT, TM-15-11 BUG rating, LED driver type, aiming diagram, zonal lumen data, and candlepower distribution data per LM-79 must accompany shop drawings.

1.5.1.2 Pole Drawings

Include dimensions, wind load determined in accordance with ASCE 7-16, pole deflection, pole class, and other applicable information. For concrete poles, include: section and details to indicate quantities and position of prestressing steel, spiral steel, inserts, and through holes; initial prestressing steel tension; and concrete strengths at release and at 28 days.

1.5.2 Luminaire Design Data

- a. Provide distribution data according to IES classification type as defined in IES HB-10 and IES RP-8.

- b. B.U.G. rating for the installed position as defined by IES TM-15 and shielding as defined by IES RP-8.
- c. Provide safety certification and file number for the luminaire family. Include listing, labeling and identification in accordance with NFPA 70 (NEC). Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).
- d. Provide long term lumen maintenance projections for each LED luminaire in accordance with IES TM-21. Data used for projections must be obtained from testing in accordance with IES LM-80.
- e. Provide wind loading calculations for luminaires mounted on poles. Weight and effective projected area (EPA) of luminaires and mounting brackets must not exceed maximum rating of pole as installed in particular wind zone area.

1.5.3 IES LM-79 Test Report

Submit test report on manufacturer's standard production model of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "14.0 Test Report" in IES LM-79.

1.5.4 IES LM-80 Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "8.0 Test Report" in IES LM-80.

1.5.5 IES TM-21 Test Report

Submit test report on manufacturer's standard production LED light source (package, array or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in IES TM-21.

1.5.6 Test Laboratories

Test laboratories for the IES LM-79 and IES LM-80 test reports must be one of the following:

- a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program.
- b. One of the qualified labs listed on the Department of Energy - Energy Efficiency & Renewable Energy, Solid-State Lighting web site.
- c. One of the EPA-Recognized Laboratories listed at for LM-80 testing.

1.5.7 Regulatory Requirements

Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated. Provide luminaires and assembled components that are approved by and bear the label of UL for the applicable location and conditions unless otherwise specified.

1.5.8 Standard Products

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

1.5.8.1 Alternative Qualifications

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

1.5.8.2 Material and Equipment Manufacturing Date

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

1.6 DELIVERY, STORAGE, AND HANDLING OF POLES

1.6.1 Aluminum Poles

Do not store poles on ground. Support poles so they are at least one foot above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

1.7 WARRANTY

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

1.7.1 Luminaire Warranty

Provide and transfer to the government the original LED luminaire manufacturers standard commercial warranty for each different luminaire manufacturer used in the project.

- a. Provide a written five year minimum replacement warranty for material, luminaire finish, and workmanship. Provide written warranty document that contains all warranty processing information needed, including

customer service point of contact, whether or not a return authorization number is required, return shipping information, and closest return location to the luminaire location.

- (1) Finish warranty must include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.
- (2) Material warranty must include:
 - (a) All LED drivers and integral control equipment.
 - (b) Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective, non-starting, or operating below 70 percent of specified lumen output.
- b. Warranty period must begin in accordance with the manufacturer's standard warranty starting date.
- c. Provide replacements that are promptly shipped, without charge, to the using Government facility point of contact and that are identical to or an improvement upon the original equipment. All replacements must include testing of new components and installation.

1.7.2 Lighting Controls Warranty

Provide and transfer to the government the original lighting controls manufacturers standard commercial warranty for each different lighting controls manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Warranty service must be performed by a factory-trained engineer or technician.

- a. Unless otherwise noted, provide a written five year minimum warranty on the complete system for all systems with factory commissioning. Provide warranty that covers 100 percent of the cost of any replacement parts and services required over the five years which are directly attributable to the product failure. Failures include, but are not limited to, the following:
 - (1) Software: Failure of input/output to execute switching or dimming commands.
 - (2) Damage of electronic components due to transient voltage surges.
 - (3) Failure of control devices, including but not limited to photosensors and motion sensors.
- b. Provide a written five year minimum warranty on all input devices against defect in workmanship or materials provided by device manufacturer.
- c. Provide a written five year minimum warranty on all control components attached to luminaires against defect in workmanship or materials.

1.7.3 Pole Warranty

Provide and transfer to the government the original pole manufacturers standard commercial warranty for each different pole manufacturer used in the project. Warranty coverage must begin from date of final system

commissioning or three months from date of delivery, whichever is the earliest. Provide a written one year minimum replacement warranty for material, luminaire finish, and workmanship. Warranty service must be performed by a factory-trained engineer or technician.

1.8 OPERATION AND MAINTENANCE MANUALS

1.8.1 Lighting System

Provide operation and maintenance manuals for the lighting system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting system. Additional O&M Manual requirements for the Army are provided in Section 01 78 24.00 10 FACILITY DATA REQUIREMENTS. Additional requirements for the Navy are provided in Section 01 78 24.00 20 FACILITY ELECTRONIC OPERATION AND MAINTENANCE SUPPORT INFORMATION (eOMSI). Include the following:

- a. Manufacturers' operating and maintenance manuals.
- b. Luminaire shop drawings for modified and custom luminaires.
- c. Luminaire Manufacturers' standard commercial warranty information as specified in paragraph LUMINAIRE WARRANTY.

1.8.2 Exterior Lighting Control System

Provide operation and maintenance manuals for the exterior lighting control system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the exterior lighting control system. Include the following:

- a. Control System One-Line Diagram
- b. Product data for all devices, including installation and programming instructions.
- c. Training materials, such as videos or in-depth manuals, that cover basic operation of the lighting control system and instructions on modifying the control system. Training materials must include calibration, adjustment, troubleshooting, maintenance, repair, and replacement.
- d. Motion sensor coverage layout.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

2.2 LUMINAIRES

UL 1598, NEMA C82.77-10. Provide luminaires as indicated in the luminaire schedule and XL plates or details on project plans, complete with light source, wattage, and lumen output indicated. All luminaires of the same type must be provided by the same manufacturer. Luminaires must be specifically designed for use with the LED driver and light source provided.

2.2.1 Luminaires

UL 8750, IES LM-79, IES LM-80. For all luminaires, provide:

- a. Complete system with LED drivers and light sources.
- b. Housing constructed of non-corrosive materials. All new aluminum housings must be anodized or powder-coated. All new steel housings must be treated to be corrosion resistant.
- c. IES TM-21, IES LM-80. Minimum L70 lumen maintenance value of 50,000 hours unless otherwise indicated in the luminaire schedule. Luminaire drive current value must be identical to that provided by test data for luminaire in question.
- d. Minimum efficacy as specified in the luminaire schedule. Theoretical models of initial lamp lumens per watt are not acceptable. If efficacy values are not listed in the luminaire schedule, provide luminaires that meet the following minimum values:

Luminaire Style	Minimum Luminaire Efficacy
Area and Roadway (pole mounted, arm mounted)	95 LPW
Pedestrian Post-Top (pole mounted, arm mounted)	90 LPW
Bollard	35 LPW
Accent (adjustable landscape, sign lighting)	35 LPW
Linear Accent (facade, wallwash)	80 LPW
Exterior Wall Sconce	50 LPW
Steplight	30 LPW
Parking Garage Luminaire	100 LPW

- e. Product rated for operation within an ambient temperature range of minus 22 degrees F to 104 degrees F.
- f. UL listed for wet locations.
- g. IES HB-10. Light distribution and NEMA field angle classifications as indicated in luminaire schedule on project plans.
- h. Housing finish that is baked-on enamel, anodized, or baked-on powder coat paint. Finish must be capable of surviving ASTM B117 salt fog environment testing for 2500 hours minimum without blistering or peeling.
- i. LED driver and light source package, array, or module are accessible for service or replacement without removal or destruction of luminaire.
- j. IES TM-15. Does not exceed the BUG ratings as listed in the luminaire schedule.. If BUG ratings are not listed in the luminaire schedule, provide luminaires that meet the following minimum values for each

application and mounting conditions:

Lighting Application	Mounting Conditions	BUG Rating
Area and Roadway	All	B3-U0-G3
Pedestrian Post-Top	All	B2-U1-G1
Exterior Wall Sconce	Above 4 feet AFF	B1-U0-G2
Exterior Wall Sconce	Below or at 4 feet AFF	B4-U0-G4
Steplight	Above 4 feet AFF	B1-U1-G2
Steplight	Below or at 4 feet AFF	B4-U1-G4
Parking Garage Luminaire	Ceiling mounted	B4-U4-G3

- k. Fully assembled and electrically tested prior to shipment from factory.
- l. Finish color is as indicated in the luminaire schedule or detail on the project plans.
- m. Lenses constructed of clear tempered glass or UV-resistant acrylic. Provide polycarbonate vandal-resistant lenses.
- n. All factory electrical connections are made using crimp, locking, or latching style connectors. Twist-style wire nuts are not acceptable.
- o. **NEMA C136.31**. Comply with 3G vibration testing.
- p. Luminaire arm bolts constructed from 304 stainless steel or zinc-plated steel.
- r. Incorporate modular electrical connections, and construct luminaires to allow replacement of all or any part of the optics, heat sinks, LED drivers, surge suppressors and other electrical components using only a simple tool, such as a manual or cordless electric screwdriver.
- s. **ANSI C136.3**. For all roadway and area luminaires, provide products with an integral tilt adjustment of plus or minus 5 degrees to allow the unit to be leveled.

2.3 LIGHT SOURCES

NEMA ANSLG C78.377, NEMA SSL 3. Provide type, lumen rating, and wattage as indicated in luminaire schedule on project plans.

2.3.1 LED Light Sources

Provide LED light sources that meet the following requirements:

- a. **NEMA ANSLG C78.377**. Emit white light and have a nominal Correlated Color Temperature (CCT) of 4000 Kelvin.
- b. Minimum Color Rendering Index (CRI) of 80.

- c. [Directive 2011/65/EU](#). Restriction of Hazardous Substances (RoHS) compliant.
- d. Light source color consistency by utilizing a binning tolerance within a 4-step McAdam ellipse.

2.4 LED DRIVERS

[NEMA SSL 1](#), [UL 1310](#). Provide LED Drivers that are electronic, UL Class 1 or Class 2, constant-current type and meet the following requirements:

- a. The combined LED driver and LED light source system is greater than or equal to the minimum luminaire efficacy values as listed in the luminaire schedule provided.
- b. Operate at a voltage of 120-277 volts at 50/60 hertz, with input voltage fluctuations of plus or minus 10 percent.
- c. Power Factor (PF) greater than or equal to 0.90 at full input power and across specified dimming range.
- d. Maximum Total Harmonic Distortion (THD) less than or equal to 20 percent at full input power and across specified dimming range.
- e. Operates for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.
- f. Meets the "Elevated" (10kV/10kA) requirements per [IEEE C62.41.2 -2002](#). Manufacturer must indicate whether failure of the electrical immunity system can possibly result in disconnect of power to luminaire. Provide surge protection that is integral to the LED driver.
- g. Contains integral thermal protection that reduces the output power to protect the driver and light source from damage if the case temperature approaches or exceeds the driver's maximum operating temperature.
- h. Complies with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR part 15, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).
- i. Class A sound rating for all drivers mounted under a covered structure, such as a canopy, or where otherwise appropriate.
- j. [Directive 2011/65/EU](#). Restriction of Hazardous Substances (RoHS) compliant.
- k. UL listed for wet locations typical of exterior installations.
- l. Dimmable, and compatible with a standard dimming control circuit of 0 - 10V.
- m. Rated to operate between ambient temperatures of [minus 22 degrees F](#) and [104 degrees F](#).

2.5 LIGHTING CONTROLS

Provide a control system interface within each luminaire that is

compatible with the energy management or control system used by the utility department in charge of the project area for control of site lighting. Provide network certification for all networked lighting control systems and devices in accordance with the requirements of Section 25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

2.5.1 System

Provide exterior lighting control system that operates the exterior lighting system as described in the exterior lighting control strategies in the project plans. Submit [Sequence of Operation for Exterior Lighting Control System](#) describing the operation of the proposed exterior lighting control system and devices. Sequence of Operation must provide the strategies identified in the exterior lighting control strategies.

2.5.1.1 Relay Panel

Enclose panel hardware in a surface-mounted, NEMA 1, painted, steel enclosure with lockable access door and ventilation openings. Internal low-voltage compartment must be separated from line-voltage compartment of enclosure with only low-voltage compartment accessible upon opening of door. Provide additional remote cabinets that communicate back to main control panel as required. Provide relay panel that meets the following criteria:

- a. Input voltage of 120-277 at 50/60 Hz, with internal low voltage power supply as required.
- b. [UL 924](#). 16 single-pole latching relays rated at 20 amps, 120-277 volts. Provide provision for relays to close upon power failure. Provide relays designed for 10 years of use at full rated load.
- c. Relay control module operates at 24 VDC and is rated to control a minimum of 16 relays.

2.5.2 Devices

2.5.2.1 Photosensors

[UL 773](#), [UL 773A](#). Provide Photosensors that meet the following requirements:

- a. Hermetically sealed, silicon diode light sensor type, rated at [1800](#) watts, [277](#) volts, 50/60 Hz with single-pole, double-throw contacts.
- b. Turns ON at [1 to 3 footcandles](#) and turns OFF at [3 to 15 footcandles](#).
- c. Designed to fail to the ON position.
- d. Housing is constructed of UV stabilized polypropylene, rated to operate within a temperature range of [minus 40 to 158 degrees F](#).
- e. Time delay that prevents accidental switching from transient light sources.
- f. Directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.
- g. Designed for 20-year service to match life expectancy of long-life LED

fixtures and exceed 15,000 operations at full load. Provide photosensors with zero-cross technology to withstand severe in-rush current and extend relay life.

- h. Swivel base type housing with 1/2 in threaded base for mounting to a junction box or conduit.
- j. Provide photosensors with metal oxide varistor (MOV) type surge protection.

2.5.2.2 Motion Sensors

NEMA WD 7, UL 773A. Provide sensors that meet the following requirements:

- a. Operating voltage of 120-277 volts.
- b. Passive infrared type sensors with 270 degree coverage.
- c. Time delay that can be adjusted from 15 seconds to 15 minutes.
- d. Default state is "Fail to ON position."
- e. Sensors installed integral to the luminaire must be provided by the luminaire manufacturer.
- f. Sensor contains an integral light level sensor that does not allow luminaires to operate during daylight hours
- g. Mounted directly to luminaire.
- h. Operates in conjunction with bi-level controllers that reduce the connected lighting power by 50 percent.

2.5.2.3 Lighting Contactor

NEMA ICS 2. Provide a electrically-held lighting contactor housed in a NEMA 1 or 4X enclosure conforming to NEMA ICS 6, as indicated on the plans. Contactor must have 6 poles, configured as normally open (NO). Contacts must be rated 600 volts, 30 amperes for a resistive load. Coil operating voltage must be 277 volts. Contactor must have silver cadmium oxide double-break contacts and must require no arcing contacts. Provide contactor with hand-off-automatic on-off selector switch.

2.6 POLES

ASCE 7-16. Provide round tapered poles designed for wind loading of 150 miles per hour while supporting luminaires and all other appurtenances indicated. The effective projected areas (EPA) of luminaires and appurtenances used in calculations must be specific for the actual products provided on each pole. Provide poles that are anchor-base type designed for use with underground supply conductors. Poles must have oval-shaped hand hole having a minimum clear opening of 3 by 5 inches. Secure hand hole covers by stainless steel captive screws. Provide metal poles with an internal grounding connection accessible from the hand hole near the bottom of each pole. Install a means of wire disconnection accessible from the hand hole. Do not install square poles. Provide poles from a Manufacturer with a standard provision for protecting the finish during shipment and installation. Do not install scratched,

stained, chipped, or dented poles.

2.6.1 Aluminum Poles

Provide aluminum poles with uniform satin finish unless otherwise noted in luminaire schedule on project plans. Do not paint aluminum poles. Provide poles that meet the following requirements:

- a. **AASHTO LTS**. Manufactured of corrosion resistant aluminum alloys for Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys and Alloy 356-T4 (3,5) for cast alloys.
- b. Seamless extruded or spun seamless-type with minimum 0.188 inch wall thickness.
- c. Top of shaft is fitted with a round or tapered cover.
- d. **ASTM B108/B108M**. Pole base is mounted by anchor bolts, made of cast 356-T6 aluminum alloy. Base must be machined to receive the lower end of shaft.
- e. Joint between shaft and base is welded.
- f. **ASTM B108/B108M**. Base cover is cast 356-T6 aluminum alloy.
- g. All hardware other than anchor bolts are either 2024-T4 anodized aluminum alloy or stainless steel.
- h. Grounding connection is designed to prevent electrolysis when used with copper ground wire.

2.6.2 Brackets and Supports

ANSI C136.3, **ANSI C136.13**, and **ANSI C136.21**. Provide pole brackets that are not less than 1 1/4 inch aluminum secured to pole. Slip-fitter or pipe-threaded brackets may be used, but brackets must be coordinated to luminaires provided, and brackets for use with one type of luminaire must be identical. Brackets for pole-mounted street lights must correctly position luminaire no lower than mounting height indicated. Mount brackets not less than 24 feet above street. Provide special mountings or brackets as indicated and of metal which will not promote galvanic reaction with luminaire head.

2.6.3 Pole Foundations

Provide anchor bolts consisting of a steel rod with a minimum yield strength of 50,000 psi; the top 12 inches of the rod must be galvanized in accordance with **ASTM A153/A153M**. Concrete must be as specified in Section 03 47 13 TILT-UP CONCRETE and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.7 EQUIPMENT IDENTIFICATION

2.7.1 Manufacturer's Nameplate

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

2.7.2 Labels

UL 1598. Luminaires must be clearly marked for operation of specific light sources and drivers according to proper light source type. Note the following luminaire characteristics in the format "Use Only _____":

- a. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.
- b. Driver and dimming protocol.

Markings related to light source type must be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when light sources are in place. LED drivers must have clear markings indicating dimming type and indicate proper terminals for the various outputs.

2.8 FACTORY APPLIED FINISH

NEMA 250. Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum meets requirements of corrosion-resistance testing.

PART 3 EXECUTION

3.1 INSTALLATION

IEEE C2, NFPA 70.

3.1.1 Luminaires

Install all luminaires in accordance with the luminaire manufacturer's written instructions. Install all luminaires at locations and heights as indicated on the project plans. Level all luminaires in accordance to manufacturer's written instructions. Aim all luminaires in accordance with aiming diagram.

3.1.2 LED Drivers

Provide LED drivers integral to luminaire as constructed by the manufacturer.

3.1.3 Aluminum Poles

Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end. Provide ornamental covers to match pole and galvanized nuts and washers for anchor bolts. Concrete for anchor bases, polyvinyl chloride (PVC) conduit bells, and ground rods must be as specified in Section 03 47 13 TILT-UP CONCRETE and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.

3.1.4 Lighting Controls

Refer to Section 25 05 11. CYBERSECURITY FOR FACILITY-RELATED CONTROL

SYSTEMS for additional lighting control installation requirements.

3.1.4.1 Photosensors

Aim photosensor according to manufacturer's recommendations.

3.1.4.2 Motion Sensors

Locate sensors in accordance with the manufacturer's recommendation. Locate sensors to achieve coverage of areas as indicated on project plans. Coverage patterns must be derated as recommended by manufacturer based on mounting height of sensor and any obstructions such as trees. Do not use gross rated coverage in manufacturer's product literature.

3.1.5 Grounding

Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Perform initial operational test, consisting of the entire system energized for 72 consecutive hours without any failures of any kind occurring in the system. All circuits must test clear of faults, grounds, and open circuits.

3.2.1.1 Lighting Control Verification Test

Verify lighting control system and devices operate according to approved sequence of operations. Verification tests are to be completed after commissioning.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Training

Provide on-site training to the Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide training that includes calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

3.3.1.1 Maintenance Staff Training

Submit a [Maintenance Staff Training Plan](#) at least 30 calendar days prior to training session that describes training procedures for Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide on-site training which demonstrate full system functionality, assigning schedules, calibration adjustments for light levels and sensor sensitivity, integration procedures for connecting to third-party devices, and manual override including information on appropriate use. Provide protocols for troubleshooting, maintenance, repair, and replacement, and literature on available system updates and process for implementing updates.

3.3.1.2 End-User Training

Submit a [End-User Training Plan](#) at least 30 calendar days prior to training session that describes training procedures for end-users on the lighting control system. Provide demonstration for each type of user interface. Provide users with the curfew schedule as currently commissioned, including conditional programming based on astronomic time clock functionality. Provide users with the correct contact information for maintenance personnel who will be available to address any lighting control issues.

-- End of Section --

SECTION 27 05 29.00 10

PROTECTIVE DISTRIBUTION SYSTEM (PDS) FOR SIPRNET COMMUNICATION SYSTEMS
08/11

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

1.2 REFERENCES

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.3 (2015) American National Standard for
Electrical Metallic Tubing (EMT)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA
20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

NATIONAL SECURITY TELECOMMUNICATIONS AND INFORMATION SYSTEMS
SECURITY (NSTISS)

NSTISSAM TEMPEST/2-95 (1995; Am A 2000) RED/BLACK Installation
Guidance

NSTISSI-7003 (1996) Protective Distribution Systems
(PDS)

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-569 (2015d) Commercial Building Standard for
Telecommunications Pathways and Spaces

1.3 ADMINISTRATIVE REQUIREMENTS

1.3.1 Conditions

Notify the Contracting Officer if it is impossible to install SIPRNET PDS that complies with this section and references.

1.3.2 Construction Methods

Methods of construction that are not specifically described or indicated in the Contract will be subject to the control and approval of the Contracting Officer.

1.3.3 PDS Design

Include separate plans, elevations, sections, details, and attachments to other work. Indicate PDS carrier route, PDS carrier mounting height above

finished floor, user drop box mounting height, and user drop box locations. Submit the PDS design to the cognizant Central TEMPEST Technical Authority (CTTA), for a technical review prior to the acquisition of material, through the installation Network Enterprise Center (NEC) or Directorate of Information Management (DOIM).

1.3.4 PDS Design Technical Review

Coordinate with the installation NEC/DOIM and submit PDS design for technical review to CTTA. Provide PDS carrier shop drawings, List of Material (LOM), and any other documentation required 90-days prior to PDS carrier installation (see [NSTISSI-7003](#), Appendix C).

1.3.5 PDS Design Approval Request

PDS design approving authority is the installation NEC/DOIM Designated Approving Authority (DAA). Submit PDS design and CTTA technical review to the installation NEC/DOIM to obtain PDS design approval from the DAA prior to installation.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with [01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES](#):

SD-02 Shop Drawings

- PDS Design; G
- PDS Design Technical Review; G
- PDS Design Approval; G

SD-03 Product Data

- PDS Hardened Carrier

SD-04 Samples

- PDS Carrier Surface Mounted Pull Boxes
- Fittings

SD-11 Closeout Submittals

- User Drop Box
- Other Enclosures

1.5 QUALITY ASSURANCE

1.5.1 Manufacturer's Qualifications

Use firms regularly engaged in manufacture of secure raceway systems, boxes, and fittings of the types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

1.5.2 Installer's Qualifications

Installer is required to obtain certification from the manufacturer of

secure raceway system and install secure raceway system in accordance with manufacturer's instructions.

1.5.3 Equipment

PDS Hardened Carrier shall meet or exceed guidelines as defined by NSTISSI-7003 and shall be approved for use by DHS, U.S. Army, U.S. Marine Corps, U.S. Navy, and U.S. Air Force. Submit manufacturer's descriptive data.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver secure raceways, conduit, fittings and components in factory labeled packages. Store and handle in strict compliance with manufacturer's written instructions and recommendations. Protect from damage due to weather, excessive temperature, and construction operations.

PART 2 PRODUCTS

2.1 PDS CARRIER CONFIGURATION

Use secure raceway carrier system in office environments, Use conduit carrier in Non-office environments, such as hangars, maintenance facilities, warehouse, training areas, industrial areas.

2.1.1 Secure Raceway Carrier

Provide secure raceway, fittings and components manufactured from ferrous material. Submit three 6-inch lengths of exposed type PDS carrier surface mounted conduit material, including component and fitting samples from the manufacturer, along with a LOM to the NEC/DOIM. Show finishes available (if applicable). PDS carrier that is comprised of Secure Raceway systems shall be:

- a. Square or rectangular design with removable top covers or solid construction
- b. 2 by 4 inch raceway for horizontal backbone and vertical riser runs
- c. 1 by 1 inch raceway for vertical user drops from horizontal backbone
- d. Utilize elbows, couplings, fittings and connectors constructed from the same type of ferrous material as the secure raceway
- e. Do not exceed 70 percent cable fill capacity of secure raceway with removable top cover in horizontal runs. TIA-569 cable fill standards do not apply.
- f. Do not exceed 60 percent fill capacity of secure raceway of solid construction. TIA-569 cable fill standards do not apply.

2.1.1.1 Fittings and Components

Fittings and components include flat internal and external elbows, tees, couplings for joining raceway sections, nipples, wire clips, blank end fittings, and device mounting brackets and plates as applicable. Provide full capacity corner elbows and fittings to maintain a controlled 2-inch cable bend radius that meet the TIA-569 specification for Fiber Optic and UTP cabling and exceeding the requirements for communications pathways.

2.1.1.2 Mounting Accessories

Mount secure raceways to the wall partition using 1-inch stand-off mounting brackets or spacers. Do not mount the secure raceways flush with the wall partition.

2.1.1.3 Through Wall Penetrating

- a. Use trim plates threaded rigid pipe and locking rings on both the inside and outside of the raceway to secure the thru-wall penetration.
- b. Provide dielectric breaks when penetrating secure room wall partitions.
- c. Seal space between wall partition and through wall penetration using fire-stop material.
- d. Fire-stop vertical risers and through wall penetrations of fire rated wall partitions after pulling cabling. Annotate firewall penetrations on PDS design.

2.1.1.4 Pull Points

- a. Provide a pull point for secure raceway with removable top cover every 270 degree change in direction. Provide additional pull points in accordance with the manufacturer's instructions.
- b. Provide a pull point for secure raceway of solid construction every 180 degree change in direction. Provide additional pull points in accordance with the manufacturer's instructions.

2.1.2 Conduit Carrier

Provide electrical metallic tubing (EMT) manufactured from ferrous material that meets ANSI C80.3. Use fittings, couplers, and connectors manufactured from ferrous material. Use of EMT, fittings, couplers, and connectors construction from non-ferrous material is not acceptable. TIA-569 cable fill standards do not apply. Do not exceed 60 percent cable fills capacity in horizontal or vertical runs.

2.1.2.1 Conduit

Use 4-inch EMT conduit for horizontal backbone or vertical riser runs; 1-inch EMT conduit for vertical runs from horizontal runs to secure user drop box. Use components (e.g. couplers, connectors, conduit, fittings, pull boxes, enclosures) constructed from ferrous metallic material. Use of components constructed from non-ferrous metallic material is not acceptable.

2.1.2.2 Mounting Brackets

Surface mount PDS conduit carrier on interior walls using 1/2 -inch stand-off mounting brackets. Use of non-metallic pipe hangers is acceptable to mount PDS conduit carrier to wall partitions.

2.1.2.3 Fittings

PDS conduit carrier fittings include; flat internal and external elbows; tees; conduit; pulling elbows; couplings for joining conduit sections;

wire clips; blank end fittings; device mounting brackets; trim plates as applicable.

- a. Provide full capacity corner elbows and fittings to maintain a controlled 2-inch cable bend radius that meets the TIA-569 specification for Fiber Optic and UTP/STP cabling for communications pathways.
- b. Use EMT conduit compression fittings and couplers to connect EMT conduit carrier sections, fittings and components together. Use of set screw connectors or set screw couplers to connect EMT conduit sections together is prohibited.

2.1.2.4 Through Wall Penetrating

- a. Provide dielectric breaks when penetrating secure room wall partitions.
- b. Seal space between wall partition and PDS conduit using appropriate fill material or fire-stop material.
- c. Fire-stop vertical risers and through wall penetrations of fire rated wall partitions after pulling cabling. Annotate firewall penetrations on PDS design.

2.1.2.5 Pull Points

Provide a pull point with a pull string between every pair of adjacent access/pull locations; for every 180 degree bends in EMT conduit carrier; and every 100 feet of continuous conduit run.

- a. Size pull boxes according to the size of the conduit, not the number of cables or conduits that enter/exit the pull box. NFPA 70 conduit fill standards do not apply.
- b. Leave pull string in place throughout the conduit carrier, even after cable is pulled, in each horizontal and vertical run.

2.2 USER DROP BOX

Provide User Drop Box (UDB) (aka Secure User Workstation Enclosure, Drop Box, or Lockbox) that is at least 7-inch high by 6-inch wide by 4-inch deep, tamper-resistant design constructed from 16 gauge steel with welded internal hinges, without pre-punched knockouts; and has a single door that has a built-in steel hasp that accepts a GSA approved changeable combination padlock. UDB shall accommodate a complete line of open connectivity outlets; modular inserts for Category 6 UTP or STP cable; fiber optic cabling with matching faceplates. STP cabling shall use shielded connectors, jacks, and patch panels. UDB with exterior hinges, pre-punched knockouts, and built-in locks are not acceptable.

2.3 ENCLOSURES

Provide equipment and pull-box enclosures constructed from 16 gauge steel; have a single door with a built-in steel hasp or multi-point security hasp that accepts a GSA approved changeable combination padlock; without pre-punched knockouts; and a tamper-resistant design with welded internal hinges.

PART 3 EXECUTION

3.1 EXAMINATION

Examine the route and mounting locations of the raceways, boxes, distribution systems, supporting structure and accessories, to determine if conditions exist that will inhibit or prevent proper PDS installation. Notify the Contracting Officer in writing of conditions detrimental to proper completion of the work (i.e. that would render the distribution system non-compliant with governing security regulations). Do not proceed with work until unsatisfactory conditions are corrected.

3.2 PDS CARRIER ROUTING

3.2.1 General

Route the PDS carrier in a tree type fashion.

- a. Start the PDS horizontal backbone at the TR (SIPRNET TR or at IPS container location) with a single raceway or conduit sized accordingly (70 percent cable fill for secure raceway with removable top cover, 60 percent cable fill for EMT conduit and solid construction secure raceway) to contain CAT6 UTP, CAT6 STP, or fiber optic cable runs.
- b. Extend the PDS carrier from the PDS horizontal backbone throughout the facility to areas where SIPRNET access is required. Branch off the PDS horizontal backbone with a horizontal run to an area where the UDB is located.
- c. Use vertical carrier runs from the horizontal run to the UDB. TIA-569 change in direction standard does not apply.
- d. Use standard under-floor cable distribution methods to distribute SIPRNET cabling within Secure Room and SCIF spaces with raised flooring.
- e. Maintain RED/BLACK cable separation in accordance with NSTISSAM TEMPEST/2-95.
- f. Remove all burrs from carrier segments prior to installation.

3.2.2 Distribution Topology

Use a distributed topology when designing the PDS carrier. Locating a small secondary network switch in an equipment enclosure mounted in an Uncontrolled Access Area (UAA) space or in a relay or equipment rack within a Controlled Access Area (CAA) space (i.e. SCIF, NOC/BOC, etc.) that has a high concentration of users is acceptable. Interconnect network switches using single-mode fiber optic cable. Increase the capacity of the network switch to provide service to adjacent spaces as required.

3.2.3 Mounting Location Considerations

- a. Route the PDS carrier so that it does not cross windows or doorway openings; does not cross ceiling or wall mounted lighting fixtures; does not obscure EXIT signs or fire alarms; and maintains a minimum 3-foot separation from fire sprinkler heads.

- b. Bend (saddle or offset) conduit to follow wall contours and avoid wall obstacles (columns, pipes, etc.).
- c. Use offset raceway to route secure raceway systems around columns and other wall partition obstacles.
- d. Route PDS carrier so that it is surface mounted on interior walls wherever possible. Obtain exceptions from NEC/DOIM prior to installation to mount PDS carrier on exterior wall partitions.
- e. Route PDS carrier to maximized cable fills in horizontal runs and reduce the number of horizontal runs within the same space.
- f. Use all-thread rod to mount the PDS carrier to true ceiling structure when routing across open areas (e.g. large hallways, open office areas, large rooms) that exceed 8 feet. Mounting the PDS carrier directly from suspended ceiling framework is not acceptable.

3.2.4 Adjacent Infrastructure Considerations

Keep conduit a minimum of 6 inches from parallel runs of flues and steam or hot water pipes. A minimum separation of 6-inches is required between the PDS carrier and water pipes, electrical wires, electrical pipes, plumbing, air conditioning, etc.

3.3 INSTALLATION

Strictly comply with manufacturer's installation instructions and recommendations and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and compliance with project site manager and NEC/DOIM.

3.3.1 Mounting PDS Carrier

Surface mount PDS Conduit on the wall using conduit clamps, brackets, or mounts with 0.5 to 1-inch offset spacer from the wall surface. Mount PDS carrier to a wall partition every 5 feet and/or within 18 inches of a section or component connection. Do not mount the PDS Carrier directly to the wall surface.

- a. Where wall mounting is unavailable, use appropriately sized all thread rods to mount PDS carrier to ceiling structure.
- b. Do not mount PDS carrier to acoustical tile ceiling (ATC) framework.
- c. Fasten PDS carrier and component items to building wall partitions using appropriate anchor and fastener for wall partition type.
- d. Mount PDS carrier so that it is level and plumb along its route. The top edge of the carrier is horizontally level. Whenever possible maintain a minimum of 2-inches below the suspended ceiling line or the true ceiling line, whichever is lower.
- e. Use appropriate hanger type to mount PDS Conduit carrier from ceiling structure.
- f. Struts are not allowed to be used to mount secure raceway or conduit to wall partitions.

- g. No more than $1/4$ inch play is allowed on TOP CAP (top cover) and span cut per segment span.
- h. Install the PDS carrier to permit visual inspections of its entire run.
- i. Do not block doorways or access to emergency exits and do not inhibit the operation of windows.
- j. Do not paint or cover the PDS carrier with wallpaper or other covering unless the paint is applied by the carrier manufacturer.
- k. Bond PDS carrier to TGB or TMGB at point of origin.

3.3.2 Enclosures

Use of enclosures with pre-punched knockouts or external hinges is not acceptable. Fasten UDB, pull boxes, and enclosures to the wall partition using fasteners appropriate for the wall partition type.

3.3.2.1 User Drop Box (UDB)

- a. Indicate UDB locations in the PDS Plan and on as-built drawings.
- b. Size the UDB to terminate up to 6 cables.
- c. Coordinate drop box location with furniture, fixtures and equipment that will be used in the vicinity. Surface mount drop boxes on the wall partition approximately 4 to 5 feet above final floor line depending on room furniture height and layout.

3.3.2.2 Other Enclosures

Indicate enclosure type (user drop box, equipment, or pull-box) on shop and as-built drawings.

3.3.3 Mechanical Security

Comply with site specific epoxy standards obtained from the installation NEC/DOIM. Apply a continuous bead of epoxy at all component, coupling, and fitting connection joints of an EMT conduit PDS carrier system. Seal pull box covers to the pull boxes around the mating surfaces after installation if they cannot be secured with GSA approved changeable combination padlock.

3.3.4 Carrier Support

Support carrier with mounting brackets at intervals not to exceed 5 feet .

3.4 FIELD QUALITY ASSURANCE

3.4.1 Physical Inspection

Physically inspect all interfaces to ensure that they are tight and cannot turn. Also, physically inspect lock covers to ensure that the lock cap is properly sealed inside the locking mechanism.

3.4.2 Magnetic Test

Perform magnet test on all components (e.g. carrier conduit, carrier

raceway, pull boxes, enclosures, conduit bodies, cover plates, etc) and fittings used to construct the carrier. Place a magnet on the carrier component or fitting to verify that construction is from ferrous material. Some alloys will fail the magnet test (e.g. 309 stainless steel) but meet the ferrous material requirements. Provide alloy material property list for components that fail magnet test to the Contracting Officer for approval. Use of components and fittings that fail the magnet test and are not made from ferrous material is not acceptable.

3.5 CLEANING AND PROTECTION

Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer. Protect raceways and boxes until acceptance.

-- End of Section --

SECTION 27 10 00

BUILDING TELECOMMUNICATIONS CABLING SYSTEM

06/17

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E (2005) Cabinets, Racks, Panels, and Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-83-596 (2016) Indoor Optical Fiber Cables

ICEA S-90-661 (2012) Category 3, 5, & 5e Individually Unshielded Twisted Pair Indoor Cables for Use in General Purpose and LAN Communications Wiring Systems Technical Requirements

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA/BICSI 568 (2006) Standard for Installing Building Telecommunications Cabling

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 66 (2013) Performance Standard for Category 6 and Category 7 100 Ohm Shielded and Unshielded Twisted Pairs

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-1152 (2009) Requirements for Field Test

	Instruments and Measurements for Balanced Twisted-Pair Cabling
ANSI/TIA-568-C.2	(2009; Errata 2010) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-455-21	(1988a; R 2012) FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices
TIA-492AAAD	(2009) Detail Specification for 850-nm Laser- Optimized, 50-µm Core Diameter/ 125-µm Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers Suitable for Manufacturing OM4 Cabled Optical Fiber
TIA-526-14	(2015c) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-526-7	(2015a) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
TIA-568-C.0	(2009; Add 1 2010; Add 2 2012) Generic Telecommunications Cabling for Customer Premises
TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-568-C.2	(2009; Errata 2010; Add 2 2014; Add 1 2016) Balanced Twisted-Pair Telecommunications Cabling and Components Standards
TIA-568-C.3	(2008; Add 1 2011) Optical Fiber Cabling Components Standard
TIA-569	(2015d) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-570	(2012c) Residential Telecommunications Infrastructure Standard
TIA-606	(2012b; Add 1 2015) Administration Standard for the Telecommunications Infrastructure
TIA-607	(2015c; Addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA/EIA-598	(2014d) Optical Fiber Cable Color Coding
TIA/EIA-604-3	(2004b; R 2014) Fiber Optic Connector

Intermateability Standard (FOCIS), Type SC
and SC-APC, FOCIS-3

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 68

Connection of Terminal Equipment to the
Telephone Network (47 CFR 68)

UNDERWRITERS LABORATORIES (UL)

UL 1286	(2008; Reprint Feb 2015) Office Furnishings
UL 1666	(2007; Reprint Jun 2012) Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
UL 444	(2008; Reprint Apr 2015) Communications Cables
UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 969	(1995; Reprint Sep 2014) Standard for Marking and Labeling Systems
UL 2043	(2013) Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces

1.2 RELATED REQUIREMENTS

Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES, Section 26 20 00
INTERIOR DISTRIBUTION SYSTEM and Section 33 82 00.00 22
TELECOMMUNICATIONS, OUTSIDE PLANT (OSP) apply to this section with
additions and modifications specified herein.

Contact Camp Lejeune Base Telephone (aka Telecommunications Support
Division or TSD) for special requirements on classified service cabling and
color, unofficial service, under slab cabling, using water block, and any
item not covered in this document.

Buildings with Special Network Requirements such as Classified networks,
other government agencies (Navy NMCfI, Navy Medical, DLA, VA. Etc.),
Marine Corps Community Services, Commercial ISP's, and CATV may require
additional guidance outside this specification. Controlled or Restricted
Access Areas may contain Classified networks may require Protected
Distribution System which shall be installed in accordance with the
current CNSSI No. 7003, UFGS27 05 29.00 10, and other restricted release
publications. Classified networks may require shielded twisted pair,

specific separation, distinct colored components, and shall be in accordance with current CNSSAM TEMPEST 1-13, RED/BLACK Separation documentation. In these cases contact Telecommunications Support Division G-6 MCIEAST-MCB CAMLEJ for additional guidance at (910) 451-9439 or (910) 451-3100.

Contact AHJ for special requirements on classified service, unofficial service, under slab cabling, using water block, and any item not covered in this document.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-569, TIA-606 and IEEE 100 and herein.

1.3.1 Main Distribution Frame (MDF)

A physical structure at a central location for terminating permanent backbone cables to interconnect with service provider (SP) equipment at the activity minimum point of presence. The MDF generally includes vendor specific components to support voice and data circuits, building surge protector assemblies, main cross connect blocks, equipment support frames, and fire rated plywood backboard. Depending upon local site conditions, the MDF, BDF and EF may be the same space.

1.3.2 Building Distribution Frame (BDF)

A structure with terminations for connecting backbone, campus, and horizontal cabling. The BDF generally includes a cross connect, equipment support frame or lockable terminal cabinet, cable supports, and fire rated plywood backboard. The BDF shall include building protector assemblies when used for campus backbone or SP cabling. Also known as a (BD).

1.3.3 Intermediate Distribution Frame (IDF)

An intermediate termination point for horizontal wiring and cross connections within telecommunications rooms. Shall be connected to MDF with both fiber and copper. Secure Internet Protocol (SIPR) vault or cabinet is considered an IDF. Also known as a (FD).

1.3.4 Communications Room (CR)

An enclosed space for telecommunications equipment, terminations, and cross connect wiring for horizontal cabling. Also known as (TR), (CR), and IT Room. Terms are used interchangeably in this section and are considered to have the same meaning.

1.3.5 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect (MC). Also known as Central Office (CO) or Area Distribution Node (ADN)).

1.3.6 Building Distributor (BD)

A distributor in which the building backbone (customer owned outside plant) cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect

(IC).)

1.3.7 Floor Distributor (FD)

A distributor used to connect horizontal cable and cabling subsystems or equipment. (International expression for horizontal cross-connect (HC)).

1.3.8 Telecommunications Room (TR)

An enclosed space for housing telecommunications equipment, cable, terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and the horizontal cabling. Also known as a (CR), and IT Room.

1.3.9 Entrance Facility (EF) (Telecommunications) (can be same as the MDF)

An entrance to the building for both private and public network service cables (including wireless) including the entrance point at the building wall and continuing to the equipment room.

1.3.10 Equipment Room (ER) (Telecommunications) (can be same as communications room)

An environmentally controlled centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity.

1.3.11 Open Cable

Cabling that is not run enclosed in a raceway as defined by NFPA 70. This refers to cabling that is "open" to the space in which the cable has been installed and is therefore exposed to the environmental conditions associated with that space, such as wire basket tray, cable tray, J-hooks, D-rings, or bridal rings. D rings should only be used in the communications room for cable management and J-hooks/bridal rings shall not be used.

1.3.12 Open Office

A floor space division provided by furniture, moveable partitions, or other means instead of by building walls, normally over 100 square feet.

1.3.13 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable. Also known as raceway.

1.4 SYSTEM DESCRIPTION

The building telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport telephone data, and other communications systems (including LAN A/V, intercom, PA, CATV, CCTV, and WiFi) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor/IDF or building

distributor/MDF or campus distributor or communications room at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding and interbuilding interconnecting cabling, pathway, and terminal hardware. The intrabuilding backbone provides connectivity from the floor distributors to the building distributors or to the campus distributor and from the building distributors to the campus distributor as required. The backbone system shall be wired in a star topology with the campus distributor (Area Distribution Node) at the center or hub of the star. The interbuilding backbone system provides connectivity between the campus distributors and is specified in Section 33 82 00.00 22 TELECOMMUNICATIONS OUTSIDE PLANT (OSP). Provide telecommunications pathway systems referenced herein as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. The telecommunications contractor must coordinate with MCB CL Base Telephone (TSD) concerning access to and configuration of telecommunications spaces. The telecommunications contractor may be required to coordinate work effort within the telecommunications spaces with the electrical sub and general contractor, ROICC and MCI East G-6 Telecommunications Support Division (TSD).

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Telecommunications drawings; G

Telecommunications Space Drawings; G

In addition to Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES, provide shop drawings in accordance with paragraph SHOP DRAWINGS.

SD-03 Product Data

Telecommunications cabling (backbone and horizontal); G

Patch panels; G

Telecommunications outlet/connector assemblies; G

Equipment support frame; G

Connector blocks; G

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Include performance and characteristic curves. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required in 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES.

SD-06 Test Reports

Telecommunications cabling testing; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G

Key Personnel Qualifications; G

Manufacturer Qualifications; G

Test plan; G

SD-09 Manufacturer's Field Reports

Factory reel tests; G

SD-10 Operation and Maintenance Data

Telecommunications cabling and pathway system Data Package 5; G

SD-11 Closeout Submittals

Record Documentation; G

1.5.1 Additional Submittal Requirements

All submittals of material, equipment and design must be approved by the Telecommunications Support Division (TSD) prior to installing any telecommunications wiring, equipment, or power to support communications.

1.6 QUALITY ASSURANCE

1.6.1 Shop Drawings

In exception to Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES, submitted plan drawings shall be a minimum of 11 by 17 inches in size using a minimum scale of 1/8 inch per foot. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Drawings

Provide Registered Communications Distribution Designer (RCDD) approved, drawings in accordance with TIA-606. The identifier for each termination and cable shall appear on the drawings. Drawings shall depict final telecommunications installed wiring system infrastructure in accordance with TIA-606. The drawings should provide details required to prove that the distribution system shall properly support connectivity from the EF telecommunications and ER telecommunications, CD's, BD's, and FD's to the telecommunications work area outlets. Provide a plastic laminated

schematic of the as-installed telecommunications cable system showing cabling, CD's, BD's, FD's, and the EF and ER for telecommunications keyed to floor plans by room number. Mount the laminated schematic in the EF telecommunications space as directed by the Contracting Officer. The following drawings shall be provided as a minimum:

- a. T1 - Layout of complete building per floor - Building Area/Serving Zone Boundaries, Backbone Systems, and Horizontal Pathways. Layout of complete building per floor. The drawing indicates location of building areas, serving zones, vertical backbone diagrams, telecommunications rooms, access points, pathways, grounding system, and other systems that need to be viewed from the complete building perspective.
- b. T2 - Serving Zones/Building Area Drawings - Drop Locations and Cable Identification (ID'S). Shows a building area or serving zone. These drawings show drop locations, telecommunications rooms, **dedicated electrical**, access points and detail call outs for common equipment rooms and other congested areas.
- c. T4 - Typical Detail Drawings - Faceplate Labeling, Firestopping, Americans with Disabilities Act (ADA), Safety, Department of Transportation (DOT). Detailed drawings of symbols and typicals such as faceplate labeling, faceplate types, faceplate population installation procedures, detail racking, and raceways.

1.6.1.2 Telecommunications Space Drawings

Provide T3 drawings in accordance with **TIA-606** that include telecommunications rooms plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and cabinet, rack, backboard and wall elevations. Drawings shall show layout of applicable equipment including incoming cable stub or connector blocks, building protector assembly, outgoing cable connector blocks, **mechanical/electrical**, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings.

1.6.2 Telecommunications Contractor Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems within the past 3 years of similar scope and size. Submit documentation for a minimum of three and a

maximum of five successful telecommunication system installations for the telecommunications contractor. Also IAW Section on QC Specialists; a Telecommunications Systems QC Specialist may be required on site, full time with 10 years minimum experience in telecom installation and experience. Specialist shall be very familiar with UFGS Divisions 27, 28, 33 concerning communications systems work and installation.

1.6.2.2 Key Personnel

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Supervisors and installers assigned to the installation of this system or any of its components shall be Building Industry Consulting Services International (BICSI) Registered Cabling Installers, Technician Level. Submit documentation of current BICSI certification for each of the key personnel.

In lieu of BICSI certification, supervisors and installers assigned to the installation of this system or any of its components shall have a minimum of 3 years experience in the installation of the specified copper and fiber optic cable and components. They shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications systems and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful

experience. Any substitutions for the telecommunications contractor's key personnel requires approval from The Contracting Officer.

1.6.2.3 Minimum Manufacturer Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with TIA-568-C.1, TIA-568-C.2 and TIA-568-C.3.

1.6.3 Test Plan

Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the components and accessories for each cable type specified, 60 days prior to the proposed test date. Include procedures for certification, validation, sample report, and testing.

1.6.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70, manufacturer recommendations/installation manual, best known industry practices, and industry standards, unless more stringent requirements are specified or indicated.

1.6.5 Standard Products

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

1.6.5.1 Alternative Qualifications

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

1.6.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 DELIVERY AND STORAGE

Provide protection from weather, moisture, extreme heat and cold, dirt, dust, and other contaminants for telecommunications cabling and equipment placed in storage.

1.8 ENVIRONMENTAL REQUIREMENTS

Connecting hardware shall be rated for operation under ambient conditions of 0 to 60 degrees C 32 to 140 degrees F and in the range of 0 to 95 percent relative humidity, noncondensing. All telecommunications spaces shall follow TIA-569 design.

1.9 WARRANTY

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

1.10 MAINTENANCE

1.10.1 Operation and Maintenance Manuals

Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications cabling and pathway system, Data Package 5. Submit operations and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data Package 5, include the requirements of paragraphs TELECOMMUNICATIONS DRAWINGS, TELECOMMUNICATIONS SPACE DRAWINGS, and RECORD DOCUMENTATION. Ensure that these drawings and documents depict the as-built configuration. Also provide copies of all telecommunications manuals to TSD.

1.10.2 Record Documentation

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts and cover plate assignments, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided in hard copy format and on electronic media (PDF and AutoCAD 2016 format). Provide the following T5 drawing documentation as a minimum:

- a. Cables - A record of installed cable shall be provided in accordance with TIA-606. The cable records shall include only the required data fields in accordance with TIA-606. Include manufacture date of cable with submittal.
- b. Termination Hardware - A record of installed patch panels, cross-connect points, distribution frames, terminating block arrangements and type, and outlets shall be provided in accordance with TIA-606. Documentation shall include the required data fields as a minimum in accordance with TIA-606.

PART 2 PRODUCTS

2.1 COMPONENTS

Components shall be UL or third party certified. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard. Provide a complete system of telecommunications cabling and pathway components using star topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets/racks. Cabling and interconnecting hardware and components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70 and conform to the requirements specified herein.

2.2 TELECOMMUNICATIONS PATHWAY

Provide telecommunications pathways in accordance with TIA-569 and as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide system furniture pathways in accordance with UL 1286.

2.2.1 Pathways Aboard Camp Lejeune Greater Area, Including MCAS New River

Pathway shall be conduit, cable tray, or modular access flooring that provides protection for cabling. Under floor duct, free laying and wireway shall not be used. Cantilever-type center hung tray or Poke-Thru devices shall not be used. J-hooks/D-rings/bridal rings and other open face type cable pathways are not authorized except in minor renovations or to continue like existing system. Provide grounding and bonding as required by TIA-607. Cable tray wiring shall comply with NFPA 70. All conduits entering the communications room shall be grouped and consolidated. Conduits can be "Home Run" or stubbed to cable tray using approved pull boxes after every 180 degrees of bends or every 100 feet. All homerun conduits shall have insulated bonding bushings in the TR, and shall extend down from the ceiling to within 3 to 4 inches of the ladder rack, or 3 to 6 inches onto the backboard, and shall be bonded to the TMGB or TGB by a minimum 6 AWG green sheathed, copper stranded bonding conductor. All penetrations will be sealed in accordance with code (fire-stopping). A minimum of two 3 inch conduits overhead will be installed between the main communications room and other communication rooms (IDFs); if installed below slab they are considered OSP and will have a minimum of three 4-inch pathways; refer to Section 33 82 00.00 22 TELECOMMUNICATIONS, OUTSIDE PLANT (OSP). Distribution Enclosures shall not be used as a pull box and will only be approved for their intended use.

2.2.2 Work area Pathways

Comply with TIA-569, except minimum 1 1/4 inch diameter conduit shall be used. System furniture pathways shall comply with UL 1286. In system furniture that blocks access to or is distant from the communications wall outlets, each system furniture desk/cubical shall be equipped with listed manufacturer telecommunication raceway and outlets. All system furniture

outlets shall be extended from a consolidation point (CP) to the system furniture outlet locations, and shall comply with TIA-568-C.1 through TIA-568-C.3. When office reconfiguration will be frequent, a multi-user terminal outlet assembly (MUTOA) may be used in lieu of a CP.

2.2.3 Pull Boxes

Pull boxes shall be constructed of galvanized sheet steel with screw-fastened covers. Size pull boxes per TIA-569, except a 5 inches wide by 5 inches in length by 2 7/8 inches deep telecommunications box may be used for individual 1 1/4 inch diameter conduit runs. Provide pull boxes where length of conduit exceeds 100 feet or where more than 180 degree of cumulative bends occur. Align conduit ends on opposite sides of pull boxes as a straight pull through. Provide pull boxes in straight lengths of conduit only; direction changes in pull boxes are authorized. Electrical pull points, LC, LB, condulets, distribution enclosures, and splice boxes, are not pull boxes and are not authorized.

2.2.4 Consolidation Points

Consolidation Points (CP) shall be used when system furniture will be installed. CP's shall not support more than 12 work areas. CP's shall be centrally located permanent area, near the work area served, fully accessible, and should be located at least 50 feet from the FD when used for balanced twisted pair cabling. CP's shall be installed per TIA-569, except a S210 interface is required.

2.3 TELECOMMUNICATIONS OUTLET BOXES

Communications outlet boxes shall be placed in all work areas and any areas that can be converted to work areas. Work areas shall have an outlet connection within 6 feet' . Recommended practice is 6" to the left or right of (the outside edge of) each electrical outlet box in workable office areas or any area that could be converted into workable office area such as a large storage closet. Conference rooms should have one floor box and one box just above the ceiling. All administrative areas shall have a minimum of one ceiling mounted outlet box every 5,000 square feet of open administrative space for wireless LAN deployment. Additional boxes may be required where building composition prohibits wireless LAN coverage.Boxes shall be standard type 5 inches square by 2-7/8 inches deep with 1-1/4 inch diameter knock-outs, with a double gang to single gang reducer ring. Mount flush on finished walls/ceilings or just above ceiling tile for grid ceilings, height indicated by drawings. Outlet boxes for wall-mounted telephones shall be mounted at ADA required height. Outlet boxes for work counter area shall be mounted at a height 48 inches above finished floor, or other appropriate height as required. Install outlet boxes for security cameras, televisions, wall monitors, etc. at height indicated in drawings. Outlet boxes installed in floor shall be communications floor boxes large enough to support a surge of users with proper cable protection and ports that are in multiples of 4 and not parallel to the floor. For raised access flooring, boxes shall be below the floor with an access cover flush with the floor. Tombstones or boxes below floor that require removal of the floor panels to access are not allowed. Floor boxes and under slab cabling should not be used on the first floor or in wet areas; tele electric poles or furniture managed pathways fed from above the wet area should be used. Multi-user Telecommunications Outlet Assembly i.e. Multi-User Terminal Outlet Assemblies (MUTOA) should be placed where best suited for open office spaces may be frequently reconfigured.

2.4 TELECOMMUNICATIONS CABLING

Cabling shall be UL listed for the application and shall comply with TIA-568-C.0, TIA-568-C.1, TIA-568-C.2, TIA-568-C.3 and NFPA 70. Provide a labeling system in accordance with the manufacturer and local AHJ guidance for cabling as required by TIA-606 and UL 969. Confirm labeling is compatible with Camp Lejeune requirements. Ship cable on reels or in boxes bearing manufacture date for unshielded/shielded twisted pair (UTP/STP) in accordance with ICEA S-90-661 and optical fiber cables in accordance with ICEA S-83-596 for all cable used on this project. Cabling manufactured more than 12 months prior to date of installation shall not be used.

2.4.1 Backbone Cabling

2.4.1.1 Backbone Copper

Copper backbone and riser cable shall be solid conductor, 24 AWG, 100 ohm, 25 to 100 -pair, Category 3, UTP, in accordance with ICEA S-90-661, TIA-568-C.1, TIA-568-C.2 and UL 444, formed into 25 pair binder groups covered with a gray thermoplastic jacket and overall metallic shield if required for additional protection. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) at regular length marking intervals in accordance with ICEA S-90-661. Sufficient pair count of CAT 3 or 5, as required shall be installed between the MDF and each of the IDF's. Provide plenum (CMP), riser (CMR), or non-jell filled indoor/outdoor communications rated cabling in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. If under slab it is considered Outside Plant shall be installed per Section 33 82 00.00 22 TELECOMMUNICATIONS, OUTSIDE PLANT (OSP) with proper surge protection at both ends.

2.4.1.2 Backbone Optical Fiber

Provide in accordance with ICEA S-83-596, TIA-568-C.3, UL 1666 and NFPA 70. Cable shall be imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 40 inches.

Provide the number of strands indicated, (but not less than 24 strands between the main telecommunication room and each of the other telecommunication rooms or secure racks), of single-mode(OS2), tight buffered fiber optic cable.

Provide tight buffered fiber optic multimode, 50/125-um diameter(OM3) cable, conforming to TIA-492AAAD as indicated (but not less than 24 strands of multimode between the main communication room and each of the other communications rooms and secure racks).

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70. Substitution of a higher rated cable shall be permitted in accordance with

NFPA 70. The cable cordage jacket, fiber, unit, and group color shall be in accordance with **TIA/EIA-598**.

2.4.2 Horizontal Cabling

Provide horizontal cable in compliance with **NFPA 70** and performance characteristics in accordance with **TIA-568-C.1**.

2.4.2.1 Horizontal Copper

Provide a minimum of four horizontal copper cables to each work area outlet (faceplate), minimum size 23 AWG conductors, 100 ohm, Category 6A, with green thermoplastic jacket for all unclassified outlets (color and cable type for classified services shall be in accordance with current CNSSAM TEMPEST RED/BLACK Installation documentation including Table 1 below) in accordance with **TIA-568-C.2**, **UL 444**, **ANSI/NEMA WC 66**, **ICEA S-90-661**. Cable shall be imprinted with manufacturers name or identifier, flammability rating, gauge of conductor, transmission performance rating (category designation) and length marking at regular intervals in accordance with **ICEA S-90-661**. Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG) communications rated cabling in accordance with **NFPA 70**. Substitution of a higher rated cable shall be permitted in accordance with **NFPA 70**. Cables installed in conduit within and under slabs are not recommended but can be used if approved by local AHJ and shall be UL listed and labeled for wet locations in accordance with **NFPA 70**. Contact AHJ for special requirements on classified service, unofficial service, under slab cabling, using water block, and any item not covered in this document.

Communications CAT 6A twisted pair shall have a minimum of 12 inches of available slack at the communications outlet boxes. Minimum manufacturer's bend radius for each type of cable shall be maintained. All communications work area outlet boxes should have 4 cables to a double gang box (no rough in or empty conduit for future use allowed).

Table 1 - (U/FOUO) Cable Color Scheme

<u>Classification Level</u>	<u>Cable Color</u>
Unclassified	Green
Collateral Confidential	Blue
Collateral Secret	Red
Collateral Top Secret	Orange
Special Category	Yellow

2.4.3 Work Area Cabling (Equipment Cables)

2.4.3.1 Work Area Copper

Provide work area copper cable in accordance with **TIA-568-C.2**, with a green thermoplastic jacket for unclassified services (classified color code shall be in accordance with current CNSSAM TEMPEST RED/BLACK Installation documentation and Section 2.4.2.1 of this specification).

2.4.3.2 Work Area Optical Fiber

Provide optical work area cable in accordance with TIA-568-C.3.

2.5 TELECOMMUNICATIONS SPACES

Provide connecting hardware and termination equipment in the telecommunications entrance facility and telecommunication equipment rooms to facilitate installation as shown on design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with TIA-606.

Space shall be a minimum 8' x 10' unless a local waiver is provided by the AHJ (authority having jurisdiction) which is the Telecommunications Support Division (TSD) aboard Camp Lejeune. Communications room could be much larger depending on building size, usable square footage served, and customer requirements. Communications rooms shall be centrally located unless there are multiple Communication rooms, and then each room should be centrally located within the area served. Communications Rooms shall not share or be on a wet wall. Generally, the space should be sized to approximately 1.1 percent of the area it serves. For example, a 10,000 sq feet (929 sq m) area should be served by a minimum of one 10 ft x 11 feet (3 m x 3.4 m) Communications room. Access to Rooms shall be from a common area such as a hallway and door shall swing out. Additional/Multiple communications rooms are required if the usable floor space to be served exceeds 10,000 square feet, or the cable length between the horizontal cross-connect and the communications outlet, including slack and vertical distance, exceeds 295 feet. Multiple communications rooms and IDFs shall be stacked and connected by a minimum of two way 3-inch conduits overhead. If under slab it is considered Outside Plant and 3 way 4" shall be used per Section 33 82 00.00 22 TELECOMMUNICATIONS, OUTSIDE PLANT (OSP) with proper surge protection at both ends. The minimum clear height in the room shall be 2.4 m (8 ft) without obstructions. The height between the finished floor and the lowest point of the ceiling should be a minimum of 3 m (10 ft) to accommodate overhead pathways. The flooring shall be sealed concrete to reduce dust and static electricity; no carpet or VCT tile. Two separate dedicated 20 amp electrical outlet will be installed above or behind but not attached to each communications equipment rack. Dedicated outlets and conduits shall be installed on the longest farthest wall from the door, same wall as the communications backboard. OSP conduits shall be to the far left of the communications backboard while facing it. There should not be an electrical panel within the communications room unless it serves only the room, and it should be located as close to the door as possible. The room requires a lockable door keyed or key padded to restrict access to MCIEAST-MCB G-6 personnel only. Room shall not have any windows or skylights. At least one wall, where the point of presence is located, and two adjacent walls should be covered with fire rated plywood backboard for mounting equipment; additional boards may be needed for mounting additional equipment. Light, as measured within the communications room, should be a minimum of 500 lx (50 foot-candles). Lighting design should seek to minimize shadows within the telecommunications room (minimum two light fixtures). Equipment not related to the support of the communications room (e.g., piping, ductwork, pneumatic tubing) shall not be installed in, pass through, or enter the telecommunications room. Equipment related to the support of the communications room (e.g., piping, ductwork, HVAC drains, dedicated power)

shall be installed in support of the communications equipment and not pose a drip/moisture/trip hazard and be usable as intended.

2.5.1 Backboards

Provide void-free, interior grade A-C plywood 3/4 inch thick 4 by 8 feet as indicated. Backboards shall be fire rated by manufacturing process. Fire stamp shall be clearly visible. Backboards shall be provided on a minimum of one telecom wall, two adjacent walls, and anywhere mounting is needed in the telecommunication spaces.

2.5.2 Equipment Support Frame

Provide in accordance with ECIA EIA/ECA 310-E and UL 50. Steel construction shall be treated to resist corrosion.

- a. Bracket, wall mounted (for buildings with very low jack/pair count and no secured electronic equipment requirement), 8 gauge aluminum minimum. Provide hinged bracket compatible with 19 inches panel mounting and must be in a secured communications room.
- b. Racks, wall or floor mounted modular type, 16 gauge steel construction minimum, treated to resist corrosion. Provide rack with vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug and a surge protected power strip with 6 duplex 20 amp receptacles. Racks shall be large enough to support all telephone/data equipment required plus 25 percent spare and shall have a maximum of 7' height. Rack shall be compatible with 19 inches panel mounting and must be in a secured communications room.
- c. Cabinets, freestanding modular type, 16 gauge steel or 11 gauge aluminum construction minimum, treated to resist corrosion. Cabinet shall have removable and lockable side panels, front and rear doors, and have adjustable feet for leveling. All cabinets shall be keyed to current TSD key and large enough to support all telephone/data equipment required in the building plus 25% for future expansion. Dedicated electrical outlets should be installed within the cabinet. A backboard for mounting equipment is still needed when a cabinet is installed. Cabinet shall be mounted to the far right of the board to allow space for OSP cable, lightning protection, and bus bar to be installed on the board's far left. Dedicated power shall be within the cabinet on the backboard. Cabinet shall be vented in the roof and rear door. Cabinet shall have cable access in the roof and base and be compatible with 19 inches panel mounting. Provide cabinet with grounding bar, 550 CFM fan with filter and a surge protected power strip with 6 duplex 20 amp receptacles. All cabinets shall be keyed alike.
- d. Cabinets, wall-mounted modular type, 16 gauge steel or 11 gauge aluminum construction minimum, treated to resist corrosion. Cabinet shall have lockable front and rear doors, louvered side panels, 250 CFM fan, ground lug, and top and bottom cable access. Cabinets shall be no smaller than 24"W X 48"H X 30"D, shall be keyed to current TSD key, and large enough to support all telephone/data equipment required in the building plus 25% for future expansion. Dedicated electrical outlets should be installed within the cabinet. A backboard for mounting equipment is still needed when a cabinet is installed. Cabinet shall be mounted to the far right of the board to allow space for OSP cable, lightning protection, and bus bar to be installed on

the board's far left. Cabinet shall be compatible with 19 inches panel mounting. All cabinets shall be keyed alike. A surge protected power strip with 6 duplex 20 amp receptacles shall be provided within the cabinet.

2.5.3 Connector Blocks

Voice riser shall be terminated on angled insulation displacement connector (IDC), Type 110, 50 pair, 89D style mounted blocks, compatible with industry standard 110 blade punch down tool, designed for Category 3 and higher systems. Provide 50 pair blocks for the number of riser and backbone cables terminated plus 25 percent spare. Also provide sufficient blocks for cross connects for all IDF's. Blocks shall be mounted on an 89D style bracket on a frame, in rack or in cabinet.

2.5.4 Building Protector Assemblies

Building protector assembly is required on all OSP cables and shall have 710 type connector blocks for connection to the exterior cable at full capacity. M150-66 type IDC for connection to the voice cross connect blocks. 110 type IDC is not approved on building protector assembly. For Central office Area Distribution Nodes a R399 type central office protector shall be used.

2.5.5 Cable Guides

Provide cable guides specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 19 inches equipment racks, cabinets, and telecommunications backboards. Cable guides of ring or bracket type devices mounted on rack, cabinet, panels, and backboard for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, or nuts and lockwashers. Cable guides are not to be used outside of the communications room.

2.5.6 Patch Panels

Provide capacity for the number of horizontal and backbone cables terminated on the panel plus 25 percent spare. Provide factory terminated SC type SM optical fiber patch cables and factory terminated CAT 6A stranded copper patch cables for patch panels. Provide patch cords as complete assemblies of various appropriate lengths and with matching connectors and sheath color matched to network in Section 2.4.2.1. Provide fiber optic patch cables with crossover orientation in accordance with TIA-568-C.3. Patch cords shall meet minimum performance requirements specified in TIA-568-C.1, TIA-568-C.2 and TIA-568-C.3 for cables, cable length and hardware specified. Classified service may require shielded jack sets and panels as approved by AHJ.

2.5.6.1 Modular to 110 Block Patch Panel

Provide in accordance with TIA-568-C.1 and TIA-568-C.2. Panels shall be third party verified and shall comply with ANSI/TIA Category 6/6A requirements. Panel shall be constructed of 0.09 inches minimum aluminum and shall be cabinet/rack mounted and compatible with an ECIA EIA/ECA 310-E 19 inches equipment rack. Panel shall support connectors that comply with ANSI/TIA-568-C.2, Category 6 UTP requirements Connectors/Outlets shall be UL2043 listed, non-keyed, compatible with RJ-45 and RJ-11 plugs, glass-reinforced nylon housing, pass through mounting from the front or

rear of the patch panel, with enclosed IDC termination and color-coded for both T568A and T568B wiring. Connectors shall be color matched to network type in Section 2.4.2.1 unless specified otherwise and approved by AHJ. Each outlet/connector shall be terminated T568A. The rear of each panel shall have incoming cable strain-relief and routing guides. **DO NOT USE ZIP TIES ON STRAIN-RELIEF GUIDES.** Panels shall have each port factory numbered and be equipped with laminated plastic nameplates above each port. Labeling shall comply with Section 3.2 of this specification.

2.5.6.2 Fiber Optic Patch Panel

Provide panel for maintenance and cross-connecting of optical fiber cables. Panel **must** be constructed of 16 **or** 18 gauge steel or 11 gauge aluminum minimum and shall be cabinet/rack mounted and compatible with a **ECIA EIA/ECA 310-E 19 inches** equipment rack. Each panel **must** provide multimode/single-mode adapters as **required in** duplex SC in accordance with **TIA/EIA-604-3** with zirconia ceramic alignment sleeves. Provide dust cover for unused adapters. The rear of each panel **must** have a cable management tray a minimum of **8 inches** deep with removable cover, incoming cable strain-relief and routing guides. Panels **must** have each adapter factory numbered and be equipped with laminated plastic nameplates above each adapter. **When populating the panel working left to right start with OSP feed, SM ISO to IDF, MM ISO to IDF, lastly row to row within same comm room.**

2.5.7 Optical Fiber Distribution Panel

Cabinet/**rack** mounted optical fiber distribution panel (OFDP) shall be constructed in accordance with **ECIA EIA/ECA 310-E** utilizing 16 **or** 18 gauge steel or 11 gauge aluminum minimum. Panel shall be divided into two sections, distribution and user. Distribution section shall have strain relief, routing guides, splice tray and shall be lockable. **User** section shall have a cover for patch cord protection. Each panel shall provide multimode and single-mode pigtails and adapters **as required**. Provide adapters as duplex SC with zirconia ceramic alignment sleeves. Provide dust covers for adapters. Provide patch cords as specified in the paragraph PATCH PANELS. **When populating the panel working left to right start with OSP feed, SM ISO to IDF, MM ISO to IDF, lastly row to row within same communications room.**

2.6 TELECOMMUNICATIONS OUTLET/CONNECTOR ASSEMBLIES

2.6.1 Outlet/Connector Copper

Outlet/connectors shall comply with **FCC Part 68**, **TIA-568-C.1**, and **ANSI/TIA-568-C.2**, Category 6A UTP requirements. Outlet/connectors shall be **UL 2043** listed, non-keyed, compatible with RJ-45 and RJ-11 plugs, rated for 2500 plug mating cycles, glass-reinforced nylon housing, pass through mounting from the front or rear of the faceplate, with enclosed IDC termination and color-coded for both T568A and T568B wiring. Connectors shall be color matched to network type in Section 2.4.2.1 unless specified otherwise and approved by AHJ. Each outlet/connector shall be terminated 568A. **UTP outlet/connectors installed in outdoor or marine environments shall be rated for the environmental conditions.**

2.6.2 Optical Fiber Adapters(Couplers)

Provide optical fiber adapters suitable for **duplex SC in Accordance with TIA/EIA-604-3 with zirconia ceramic alignment sleeves**, as indicated.

Provide dust cover for adapters. Optical fiber adapters shall comply with TIA-455-21 for 500 mating cycles.

2.6.3 Optical Fiber Connectors

Provide in accordance with TIA-455-21. Optical fiber connectors shall be duplex SC in accordance with TIA/EIA-604-3 with zirconia ceramic ferrule, epoxyless crimp style compatible with 50/125 multimode and 8/125 single-mode fiber. The connectors shall provide a maximum attenuation of 0.3 dB at 850/1300 and 1310/1550 nm with less than a 0.2 dB change after 500 mating cycles.

2.6.4 Cover Plates

Telecommunications cover plates shall comply with UL 514C, and TIA-568-C.1, TIA-568-C.2, ; flush or oversized design constructed of high impact thermoplastic material, color to match the network color designation in Section 2.4.2.1, or as otherwise specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and authorized by the AHJ.. Provide labeling in accordance with the paragraph LABELING in this section. Additionally, outlet cover plate coloring shall be specified in design, and may be required to match the network color designation in Section 2.4.2.1 of this specification.

2.7 MULTI-USER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)

Provide MUTOA(s) in accordance with TIA-568-C.1. Ensure proper separation from other networks and power.

For Modular Furniture, provide horizontal cabling from the MUTOA to an adaptor plate in the Modular Furniture. The MUTOA should be limited to serving a maximum of six work areas with 2 cables each for a total of 12 cables.

2.8 TERMINAL CABINETS

Construct of zinc-coated sheet steel, 36 by 24 by 6 inches deep, as indicated. Trim shall be fitted with hinged door and locking latch. Doors shall be maximum size openings to box interiors. Boxes shall be provided with 5/8 inch backboard with two-coat varnish finish. Match trim, hardware, doors, and finishes with panelboards. Provide label and identification systems for telecommunications wiring and components consistent with TIA-606.

2.9 GROUNDING AND BONDING PRODUCTS

Provide in accordance with UL 467, TIA-607, and NFPA 70. Components shall be identified as required by TIA-606. Provide ground rods, bonding conductors, and grounding busbars as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. The preferred ground for the Telephone Main Grounding Bus (TMGB) bar will be to the Main electrical Distribution Panel (MDP) bus bar and building steel. In most cases, but not all; a #6 AWG bonding conductor is recommended for telecommunications. All grounding and bonding conductors within the Telecommunications room will be green sheathed copper conductor, stranded, and labeled as suitable for use as such and tagged "DO NOT REMOVE". All grounding and bonding conductors running out of the Telecommunications room should be protected in conduit or attached to the outside of the cable tray and sized according to references. The minimum size of the TMGB shall be no smaller than 4" by

10" by 1/4 inch thick; bus bar should be factory made and factory drilled, not fabricated or drilled onsite. All bonding and grounding terminations shall be irreversible and secured with a double hole crimp termination. Do not exceed minimum bend radius on bonding and grounding conductors. Mount Bus Bar to far left of telecomm backboard at approximately 70" AFF.

2.10 FIRESTOPPING MATERIAL

Provide as specified in Section 07 84 00 FIRESTOPPING.

2.11 MANUFACTURER'S NAMEPLATE

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

2.12 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inches thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inches high normal block style.

2.13 TESTS, INSPECTIONS, AND VERIFICATIONS

2.13.1 Factory Reel Tests

Provide documentation of the testing and verification actions taken by manufacturer to confirm compliance with TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-526-7 for single mode optical fiber, and TIA-526-14 for multimode optical fiber cables.

PART 3 EXECUTION

3.1 INSTALLATION

Install telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware in accordance with NECA/BICSI 568, TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-569, NFPA 70, manufacturer instructions, current industry best practices, and UL standards as applicable. Provide cabling in a star topology network. Provide residential cabling in a star wiring architecture from the distribution device as required by TIA-570. Pathways and outlet boxes shall be installed as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Standard type 5" x 5" x 2 7/8" square boxes with a single gang plaster ring shall be used except in concrete or concrete masonry units where a standard 4 11/16" square or a floor box will be used. Mount flush in finished walls at height indicated by drawings and with proper clearances from other networks and power systems. Depth of boxes shall be large enough to allow manufacturer's recommended conductor bend radii, normally 2 7/8" depth. Install telecommunications cabling with copper media in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications

equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling (normal minimum clearance distances of 4 feet from motors, generators, frequency converters, transformers, x-ray equipment or uninterrupted power system, 300 mm (12 in) from power conduits and cable systems, 125 mm (5 inches) from fluorescent or high frequency lighting system fixtures). Cabling shall be run with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

3.1.1 Cabling

Install UTP/STP, and optical fiber telecommunications cabling system as detailed in TIA-568-C.1, TIA-568-C.2, TIA-568-C.3 and TIA-570 for residential cabling. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not untwist Category 6 UTP cables more than ½" (12 mm) from the point of termination to maintain cable geometry. Provide service loop on each end of the cable, minimum 10' (3 meters) in the telecommunications room, 6" (150mm) in or close to the work area outlet for UTP. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables. Provide a device to monitor cable pull tensions. Do not exceed 25 pounds pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. Only hook and loop fasteners are allowed on Category 6/6A cable and optical fiber cable. DO NOT USE ZIP TIES. For UTP cable, bend radii shall not be less than four times the cable diameter. Cables shall be terminated; no cable shall contain unterminated elements (See NFPA 70 abandoned cabling). Cables shall not be spliced. Label cabling in accordance with paragraph LABELING in this section.

3.1.1.1 Open Cable

Use only where specifically indicated on plans or use in cable trays, or below raised floors in approved pathway (cable free laid on floor is not authorized). Install in accordance with TIA-568-C.1, TIA-568-C.2 and TIA-568-C.3. Do not exceed cable pull tensions recommended by the manufacturer. Copper cable not in a wireway or pathway shall be suspended a minimum of 8 inches above ceilings by cable supports no greater than 60 inches apart. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Placement of cable parallel to power conductors shall be avoided, if possible; a minimum separation of 12 inches shall be maintained when such placement cannot be avoided.

Plenum cable shall be used where open cables are routed through plenum areas. Cable routed exposed under raised floors shall be plenum rated. Plenum cables shall comply with flammability plenum requirements of NFPA 70. Install cabling after the flooring system has been installed in raised floor areas. Cable 6 feet long shall be neatly coiled not less than 12 inches in diameter below each feed point in raised floor areas.

3.1.1.2 Backbone Cable

- a. Copper Backbone Cable. Install intrabuilding backbone copper cable, in minimum 2-way 3 inch overhead conduit or larger in indicated pathways, between the campus distributor, located in the

telecommunications entrance facility or room, the building distributors and the floor distributors located in telecommunications rooms and telecommunications equipment rooms as indicated on drawings.

- b. Optical fiber Backbone Cable. Install intrabuilding backbone optical fiber in indicated pathways (normally in one of multiple inner ducts installed in conduit so as to maximize pathways). Do not exceed manufacturer's recommended bending radii and pull tension. Prepare cable for pulling by cutting outer jacket 10 inches leaving strength members exposed for approximately 10 inches. Twist strength members together and attach to pulling eye. Vertical cable support intervals shall be in accordance with manufacturer's recommendations.

3.1.1.3 Horizontal Cabling

Install horizontal cabling as indicated in the specification and on drawings. Do not untwist Category 6 UTP cables more than one half inch from the point of termination to maintain cable geometry. Provide slack cable in the form of a figure eight or large service loop on each end of the cable (prevent inductance caused by small coils), 10 feet in the telecommunications room, and 12 inches in the work area outlet.

3.1.2 Pathway Installations

Provide in accordance with TIA-569 and NFPA 70, except that 1 1/4 inch diameter conduit from cable tray or telecommunication room backboard to each work area outlet is required. Provide building pathway as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

Conceal conduit within finished walls, ceilings, and floors (not in wet areas). Keep conduit minimum 12 inches away from parallel runs of electrical power equipment, flues, steam, light ballast, and hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit is visible after completion of project. Run conduits in crawl spaces as if exposed. Install no more than two 90 degree bends for a single horizontal cable run. All bends/turns in conduits will be in straight runs of conduit; a pull box shall be installed after every 180 degrees of bends or 100'; in no case will a turn be made within a pull box. The minimum size for a pull box for a single 1 1/4" conduit will be 5" long by 5" wide by 2 7/8" deep, and for a 3" conduit 30"W x 54"L x 9"D. All conduits shall contain an insulated bushing at each end to protect the cable from damage and required bonding. Pull points, LC, LB, and condulets are not authorized.

Under floor cabling, under floor duct, and conduit under floor slabs should be avoided in the Camp Lejeune Greater area due to wet area close to coastal waters.

3.1.3 Service Entrance Conduit, Overhead

Provide service entrance overhead as specified in this section and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEMS.

Ensure entrance fitting or weather head is sized to ensure min bend radius for largest cable is maintained.

3.1.4 Service Entrance Conduit, Underground

Provide service entrance underground as specified in this section and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

Underground portion shall be encased in minimum of 3 inches of concrete extending from the building entrance to OSP demarcation point and shall be a minimum of 18 inches below slab or grade. Location of entrance conduit in communications room shall be to the left of the longest furthest wall from the door.

3.1.5 Cable Tray Installation

Install cable tray as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Only CMP and OFNP type cable shall be installed in a plenum.

A continuous stranded bonding conductor shall be run on the outside along the tray tapped to each section of tray with a listed connector to ensure bonding. Remove all sharps from cable tray and pathways. Ensure bonding is on the pathway so as not to obstruct horizontal cabling. Maintain proper clearance and work space per TIA-569 and TEMPEST.

3.1.6 Work Area Outlets

3.1.6.1 Terminations

Terminate UTP cable in accordance with TIA-568-C.1, TIA-568-C.2 and wiring configuration as specified. Terminate fiber optic cables in accordance with TIA-568-C.3.

All work areas will contain a minimum of two work area outlets. Any work area larger than 80 sq feet will require additional work area outlets to service any work location in the room within 6 feet of an electrical outlet. This also applies to any area that could be converted to work space in the future. Recommend one work area outlet box be placed 6" to the left or right of every electrical outlet in a usable space. All work area face plates shall contain four category 6 jacks as specified herein, terminated T568A configuration unless otherwise approved by AHJ. MUTOAs contain 12 cables and may require additional clearance and power. All other outlets shall contain a minimum of 2 Category six jacks, with the exception of single jack wall phone studded faceplates.

3.1.6.2 Cover Plates

As a minimum, each outlet/connector shall be labeled as to its function and a unique number to identify cable link in accordance with the paragraph LABELING in this section. (For secured networks contact AHJ as shielded twisted pair and color coded face plates may be necessary.)

3.1.6.3 Cables

Unshielded/shielded twisted pair and fiber optic cables shall have a minimum of 12 inches of available service slack loosely coiled into the telecommunications outlet boxes or in cable tray as close as possible to outlet box. Minimum manufacturer's bend radius for each type of cable shall not be exceeded.

3.1.6.4 Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed (this is not normal as all outlets should be cabled).

3.1.6.5 Multi-User Telecommunications Outlet Assembly (MUTOA)

Run horizontal cable per specifications and terminate cables in a MUTOA in each system furniture zone. MUTOAs shall not be located in ceiling spaces, or any obstructed area. MUTOAs shall not be installed in furniture unless that unit of furniture is permanently secured to the building structure. MUTOAs shall be located in an open work area so that each furniture cluster is served by at least one MUTOA. The MUTOA shall be limited to serving a maximum of six work areas with 2 cables each for a total of 12 cables/12 ports. Maximum work area cable length requirements shall also be taken into account. MUTOAs must be labeled to include the maximum length of work area cables. MUTOA labeling is in addition to the labeling described in TIA-606, or other applicable cabling administration standards. Work area cables extending from the MUTOA to the work area device must also be uniquely identified and labeled.

3.1.7 Telecommunications Space Termination

Install termination hardware required for Category 6 and optical fiber system. A single punch manufacture approved insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

3.1.7.1 Connector Blocks

Connector blocks shall be cabinet/rack mounted, as approved by the AHJ, in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Install in accordance with industry standard wire routing guides in accordance with TIA-569.

3.1.7.2 Patch Panels

Patch panels shall be mounted in equipment cabinets/racks with sufficient ports to accommodate the installed cable plant plus 25 percent spares.

- a. Copper Patch Panel. Copper cable entering a patch panel shall be secured to a rear cable manager with hook and loop ties as recommended by the manufacturer to prevent movement of the cable.
- b. Fiber Optic Patch Panel. Fiber optic cable loop shall be 3 feet in length provided as recommended by the manufacturer. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

3.1.7.3 Equipment Support Frames

Install in accordance with TIA-569:

- a. Bracket, wall mounted. Mount bracket to right on plywood backboard in accordance with manufacturer's recommendations. Mount rack so height of highest panel does not exceed 78 inches above floor. Mount so there is sufficient space remaining on backboard to mount lightning

protection, bonding, and cable managers or install additional backboards.

- b. Racks, floor mounted modular type. Permanently anchor rack to the floor in accordance with manufacturer's recommendations. Install sections of ladder rack anchored to telephone rack/cabinet and at least two walls.
- c. Cabinets, freestanding modular type. Permanently anchor to the floor in accordance with manufacturer's recommendations. When cabinets are connected together, remove adjoining side panels for cable routing between cabinets. Mount rack mounted fan and 19" power/surge strip in cabinet. Install sections of ladder rack anchored to telephone rack/cabinet and at least two walls.
- d. Cabinets, wall-mounted modular type. Mount cabinet to right on plywood backboard in accordance with manufacturer's recommendations. Mount cabinet so height of highest panel does not exceed 78 inches above floor. Mount so there is sufficient space remaining on backboard to mount lightning protection, bonding, and cable managers or install additional backboards.

3.1.8 Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings as specified in Section 07 84 00 FIRESTOPPING.

3.1.9 Grounding and Bonding

Provide in accordance with TIA-607, NFPA 70 and as specified in this section and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM except only two hole irreversible compression lugs will be accepted.

3.2 LABELING

3.2.1 Labels

Provide labeling in accordance with TIA-606 except jacks will be numbered in a logical, sequential, clockwise numbering system from 1 to X with a closet designator. Example would be 145 C 146, would be the 145th & 146th jacks from the C telecom room. All labels shall be numbered with manufacturer's labeling system (not fabricated) and be equipped with laminated plastic cover. All terminations that are not to work area outlets should be in the last patch panel locations and labeled accordingly i.e. DDC, FACP, Elevator, Wall phones, or Wireless access points.

3.2.2 Cable

Cables shall be labeled using color labels on both ends with identifiers in accordance with TIA-606.

3.2.3 Termination Hardware

Workstation outlets and patch panel connections shall be labeled using manufacturing labeling system, color coded labels with identifiers in accordance with this section and TIA-606. Coordinate with Base Telephone.

3.3 FIELD APPLIED PAINTING

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

3.3.1 Painting Backboards

Camp Lejeune no longer paints backboards as fire rated plywood is available. Manufactured fire retardant backboard shall be used, so as not to increase flame spread and smoke density and must be appropriately labeled.

3.4 FIELD FABRICATED NAMEPLATE MOUNTING

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

3.5 TESTING

3.5.1 Telecommunications Cabling Testing

Perform telecommunications cabling inspection, verification, and performance tests on both Backbone and Horizontal cabling in accordance with TIA-568-C.1, TIA-568-C.2, TIA-568-C.3 and AHJ local guidance. Test equipment shall conform to TIA-1152. Perform optical fiber field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure.

3.5.1.1 Inspection

Visually inspect all telecommunications cabling jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for T568A pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, and TIA-570 for residential cabling. Visually confirm Category 6 marking of outlets, cover plates, outlet/connectors, cable physical damage, and patch panels.

3.5.1.2 Verification Tests

Backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after all terminations are complete but prior to being cross-connected.

For multimode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with TIA-568-C.3 and TIA-526-14 using Tier 1 Option with power meter and light source for optical fiber. Validate/troubleshoot failures with Tier 2 Option. For single-mode optical fiber of sufficient distance (normally OSP), perform optical fiber end-to-end attenuation tests in accordance with TIA-568-C.3 and TIA-526-7 using Tier 2 Option, OTDR for single-mode optical fiber. Perform verification acceptance tests.

3.5.1.3 Performance Tests

Provide summary in .pdf (hard and soft copy) detailed tester results in test format .flw (soft copy only), and fiber power meter/OTDR reports (summary hard copy and detailed soft copy). All Test reports should have a building or project number on it. The final QC and certification of installation will be performed by TSD after the contractor has provided passing and acceptable test results matching work area outlet labels, as-built drawings showing all telecommunications outlets and their labeled designator to include any empty conduit or ports coiled in overhead for future use and all building automated system ports such as DDC, Elevator, FACP, or WAPs. Test results that are marginal may not be accepted. Also fiber tests that pass the link budget but exceed tolerance on any connector or splice are considered a failure. All discrepancies must be repaired and retested.

Perform testing for each outlet and MUTOA as follows:

- a. Perform Category 6 link tests in accordance with TIA-568-C.1 and TIA-568-C.2. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.
- b. Optical fiber Links. Perform optical fiber end-to-end link tests in accordance with TIA-568-C.3.

3.5.1.4 Final Verification Tests

Perform verification tests for all copper and optical fiber systems after the complete telecommunications cabling and workstation outlet/connectors are installed.

- a. Voice Tests. These tests assume that dial tone service has been installed (normally only done for FACP, Elevator, or emergency phones). Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and DSN telephone call.
- b. Data Tests. These tests assume the Information Technology Staff has a network installed and are available to assist with testing (normally this is only done for VTC, CCTV). Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

-- End of Section --

SECTION 27 51 16

PUBLIC ADDRESS SYSTEMS
05/20

PART 1 GENERAL

1.1 RELATED SECTIONS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, applies to this section, with the additions and modifications specified herein. In addition, refer to the following sections for related work and coordination:

Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.
Section 07 84 00 FIRESTOPPING for additional work related to firestopping.

1.2 SUMMARY

1.2.1 Scope

- a. This work includes design and providing a new, complete, public address system as described herein for the II Marine Expeditionary Force (MEF) Battle Simulation Center and II MEF Combined Arms and Staff Trainer (CAST). Provide a turnkey system capable of receiving, processing, and transmitting indicated input signals including the system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, amplifiers, microphones, speakers, mounting hardware and other accessories and miscellaneous items required for a complete operating system even though each item is not specifically mentioned or described. Provide system complete and ready for operation. See paragraph titled SYSTEM DESCRIPTION for additional requirements.
- b. The system layout on the drawings show the intent of coverage and are shown in suggested locations. Submit plan view drawing showing all component locations, cable routing, junction boxes, other related equipment, conduit routing, and wire counts for all floors.

1.3 REFERENCES

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

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S3.2

(2009; R 2014) Method for Measuring the
Intelligibility of Speech Over
Communication Systems (ASA 85)

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E

(2005) Cabinets, Racks, Panels, and
Associated Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1 (2002; R 2008) Guide on the Surges
Environment in Low-Voltage (1000 V and
Less) AC Power Circuits

IEEE C62.41.2 (2002) Recommended Practice on
Characterization of Surges in Low-Voltage
(1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA
20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15 Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 1449 (2021) UL Standard for Safety Surge
Protective Devices

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualifications; G

SD-02 Shop Drawings

Detail Drawings; G

System Layout; G

System Design; G

SD-03 Product Data

Spare Parts

SD-05 Design Data

Design Analysis and Calculations; G

SD-06 Test Reports

Approved Test Procedures; G

Acceptance Tests

Accreditation; G

SD-07 Certificates

Components

SD-10 Operation and Maintenance Data

Public Address System; G

Submit Data Package 5 for each component in accordance with the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.5 SYSTEM DESCRIPTION

1.5.1 Design Requirements

Provide a Public Address System, capable of distributing the indicated audio signals from equipment including LAN controllers, communication links, cabling, battery backup, power line surge protection and all other necessary components to make a complete and operational system. Complete coverage will be provided for all interior public spaces and other spaces as indicated on the drawings.

Provide a zoned system capable of evenly distributing live and pre-recorded paging and music program sources. Provide balanced and highly intelligible distributed sound free of noise and distortion. Provide capability of both individual and simultaneous paging all separate paging zones. Intelligibility must meet the requirements of Modified Rhyme Test (MRT) of ASA S3.2

Provide all headend interface, amplification components, conditioners and any other equipment necessary. Provide system capable of interfacing with the GFGI telephone system for zone paging.

Provide all materials and labor needed for a complete and operational system for the services in this specification plus the additional system capabilities as indicated. This includes but not limited to all necessary equipment, interfaces, jumpers, terminations, cabling, amplifiers, conditioners, power supplies, battery backup, software and all components required for system operation.

1.5.2 System Application Design

Provide the system application design required to provide a public address system that complies with and satisfies all of the requirements specified in this Section and indicated on the Telecommunications Drawings for this application and project.

1.5.3 Standard Products

Provide an application design that utilizes standard system components that are the product of a Manufacturer regularly engaged in the manufacture of networked public address system, and that have been in satisfactory use for at least six months. Provide all major components from the same manufacturer. The System must be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the facility. Do not deliver material to the project site more than six months prior to the scheduled date of installation.

Provide hardware, software, and installation of a complete and engineered system. Provide a submitted design that is properly engineered for the operational requirements. Include all components required to meet this specification section in the design, other than a change in, or in addition to the operational frequencies identified herein.

1.5.4 Local Products

Incorporate local materials to the greatest extent possible. All proposed local products must meet all applicable hardware and software requirements set forth in these specifications.

1.5.5 Minimum Requirements

Specifications are minimum requirements. If the provided system requires enhanced specifications that exceed those specified herein in order to satisfy the specified design, configuration, capability, and performance requirements, then a provide a system with the enhanced specifications.

1.5.6 Current State-of-the-Art Technology

Provide application design and products that utilize current state-of-the-art products that provide the enhanced capability and performance specified herein. Provide design and products representing the latest manufacturer make and model.

1.5.7 Design Analysis and Calculations

Include in the design analysis and calculations, at a minimum, the following:

- a. Power supply requirements for each component and each separate speaker zone of the system in accordance with the manufacturer's instructions. Provide power consumption and dissipation data under normal and maximum operating conditions.
- b. Cable types and sizes.
- c. Interfaces with all other systems such as the fire alarm and mass notification system for muting of public address system upon fire alarm or mass notification announcement.

1.5.8 Environmental Requirements

Provide equipment to be used indoors rated for continuous duty operation under ambient environmental conditions of 35 to 120 degrees F dry bulb and 10 to 95 percent reflective humidity, noncondensing. Provide all other equipment rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

1.5.9 Electrical Requirements

105 VAC to 130 VAC at 60 Hz operating voltage range, plus or minus 2 percent.

1.5.10 Power supplies

Provide power supplies that provide sufficient power for worst-case conditions of system operation that could occur without signal loss or perceptible degradation.

1.5.11 Power Line Surge Protection

Provide power line surge protection for all equipment connected to AC power. Provide surge protection integral to the equipment or installed as an accessory item in accordance to manufacturer's recommendations. Do not use fuses for surge protection.

1.5.12 Shielding and Grounding

Provide shielding and grounded as required by the system design, Manufacturer's instructions, FCC Part 15 listing, and regulatory requirements.

1.5.13 System Capability and Configuration

1.5.13.1 System Capability

Provide a public address system with capabilities to support zone paging, all-call, priority paging, messaging processors, software, input modules, controllers, interface modules, and other capabilities as defined by the tenant..

1.5.14 Performance Requirements

1.5.14.1 System Initiation and Operation

No user controlled features are permitted on this system. System is to be active on power up and perform as specified without any form of manual control.

1.5.14.2 Priority

Provide paging priorities as indicated.

1.6 QUALIFICATIONS

1.6.1 General Qualification Requirements

- a. The System Contractor, Installer and Manufacturer must each have the minimum qualifications specified, related to the type of system specified for this project.
- b. The Government reserves the right to accept or reject the System Contractor, Installer or Manufacturer based upon qualifications and ability to conform to specified technical or licensing requirements of this Section. System Contractors, Installers and Manufacturers that do not have the specified qualifications will not be acceptable and will not be allowed to perform the work of this section.
- c. The Government will determine the acceptability of any proposed System Contractor, Installer and Manufacturer based on submitted and verified documentation that substantiates that the proposed System Contractor, Installer and Manufacturer have the qualifications specified in this Section.

- d. Submit documented verification of the specified qualifications as part of the Data Qualifications submittal. The Government maintains the right to request, inspect and verify references and resumes of all technical and managerial personnel assigned to the project.
- e. Include qualification documentation, but not limited to the information outlined below:
 - (1) A list of projects performed by the System Contractor and Installer during the last five years explicitly involving the type of system specified in this section, including:
 - (a) Name of facility where work was completed.
 - (b) Name, title, address and telephone number of a point of contact for the listed facility.
 - (c) The make and model of the system provided and total scope of work for the facility.
 - (d) Restrict list to the facilities where the same type of system was installed for the same purpose provided.

1.6.2 System Contractor Qualifications

- a. Contractor qualifications must include the following:
 - (1) The Contractor is regularly engaged in the system application design, documentation, installation, testing, training, and maintenance of the type of system specified in this section.
 - (2) The Contractor has a minimum of five years experience providing these services for systems having the same level of features and functions as the system being provided.
 - (3) The Contractor has a minimum of five years as the manufacturer or an authorized distributor and service organization for the manufacturer of the system provided.
- b. Contactor personnel qualifications must:
 - (1) Be factory trained or certified for the make and model of the system provided.
 - (2) Have a minimum of five years experience performing the services specified in this specification section.
 - (3) Maintain a full compliment of spare parts for the provided system with the ability to furnish on-call maintenance 24 hours per day, 365 days per year.

1.6.3 Installer Qualifications

- a. The installer personnel must be regularly engaged in the installation of the type of system in this specification section.
- b. The installation supervisor must be factory trained or certified for the make and model of the system provided.

- c. The installation supervisor must have a minimum of five years experience providing services having the same level of features and functions for the system included in this specification section.
- d. The installation personnel must have a minimum of three years experience providing services having the same level of features and functions for the system included in this specification section.

1.6.4 Manufacturer Qualifications

The system manufacturer must:

- a. Have a minimum of five years experience in producing the products and type of system included in this specification section.
- b. Produce a system that satisfies all specified features, functions and product requirements.
- c. Guarantee the availability of the replacement parts for the designed system for a minimum of seven years from the date of final acceptance of the system by the Contracting Officer.

1.7 DELIVERY, STORAGE, AND HANDLING

Equipment placed in storage until installation shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

1.8 EXTRA MATERIALS

Submit [spare parts](#) data for each different item of material and equipment specified, after approval of the detail drawings and not later than 2 months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The [public address system](#) shall consist of an audio distribution network to include amplifiers, mixers, microphones, speakers, cabling, and ancillary components required to meet the required system configuration and operation. Submit Data Package 3 in accordance with Section [01 78 23](#) OPERATION AND MAINTENANCE DATA.

2.1.1 Multi-Channel System with Paging

The system shall include microphones, microphone outlet receptacles, microphone inputs with preamplifiers, inputs for telephone, program sources, single channel paging, control for each input, power amplifying equipment, and accessories required to output the public address and paging audio signals through selected portions of the audio distribution network as indicated. The paging signal shall be replaced by zones of the system output, when the paging function is activated.

2.1.2 System Performance

The system shall provide even sound distribution throughout the designated area, plus or minus 3 dB for the 1/1 octave band centered at 4000 Hz. The system shall provide uniform frequency response throughout the designated area, plus or minus 3 dB as measured with 1/3-octave bands of pink noise at locations across the designated area selected by the Contracting Officer. The system shall be capable of delivering 75 dB average program level with additional 10 dB peaking margin sound pressure level (SPL) in the area at an acoustic distortion level below 5 percent total harmonic distortion (THD). Unless otherwise specified the sound pressure reference level is 20 micro Pascal (0.00002 Newtons per square meter).

2.1.3 Detail Drawings

Submit detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Note that the contract drawings show layouts based on typical speakers. Check the layout based on the actual speakers to be installed and make necessary revisions in the detail drawings. Detail drawings shall also contain complete point to point wiring, schematic diagrams and other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

2.2 STANDARD PRODUCTS

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products, and that essentially duplicate material and equipment that have been in satisfactory use at least 2 years. All components used in the system shall be commercial designs that comply with the requirements specified. Submit copies of current approvals or listings issued by UL, or other nationally recognized testing laboratory for all components. Equipment shall be supported by a service organization that is within 50 miles of the site.

2.2.1 Identical Items

Items of the same classification shall be identical. This requirement includes equipment, modules, assemblies, parts, and components.

2.2.2 Nameplates

Each major component of equipment shall have the manufacturer's name, address, model and catalog number, and serial number on a plate secured to the equipment.

2.3 ANALOG AUDIO SYSTEM

2.3.1 MIXER-PREAMPLIFIER

Mixer-preamplifier shall as a minimum conform to the following specifications:

Rated Output	18 dB
Frequency Response	Plus or Minus 1 dB, 20 - 20,000 Hz
Distortion	Less than 0.5 percent, 20 - 20,000 Hz
Signal to noise	Microphone - 60 dB
	Aux - 70 dB
Inputs	5 independent balanced low-impedance transformer-isolated
Input Sensitivity	Microphone - 0.003 volts
	Aux - 0.125 volts
	Magnetic Cartridge - 0.0005 volts
Input Channel Isolation	80 dB minimum
Tone Controls	Plus or Minus 10 dB range at 50 and 15,000 Hz
Power Requirement	110-125 Vac 60 Hz

2.3.2 POWER AMPLIFIERS

Power amplifiers as a minimum conform to the following specifications:

Rated power output	250 watts RMS
Frequency Response	Plus or Minus 3 dB, 20-20,000 Hz
Distortion	Less than 2 percent at RPO, 600-13,000 Hz
Input Impedance	50 k ohm unbalanced
Output Impedance	Balanced 4 and 8 ohms
Output voltage	25 and 70.7 volts
Power Requirement	110-125 Vac 60 Hz

2.3.3 MIXER AMPLIFIER

Mixer amplifier shall as a minimum conform to the following specifications:

Rated Power Output (RPO)	125 watts RMS
Frequency Response	Plus or Minus 3 dB, 20-20,000 Hz

Distortion	Less than 1 percent at RPO, 60 - 13,000 Hz
Inputs	2 microphones (high impedance or low-impedance unbalanced 2 Aux. (high-impedance)
Output Impedance	Balanced 4 and 8 ohms
Output Voltage	25 and 70.7 volts
Power Requirement	110-125 Vac 60 Hz

2.3.4 MICROPHONE INPUT MODULES

Microphone input modules shall as a minimum conform to the following specifications:

Rated Outputs	0.25 volts into 10,000 ohms
	1.0 volts into 10,000 ohms
Frequency Response	Plus or Minus 2 dB, 20 - 20,000 Hz
Distortion	Less than 0.5 percent 20 - 20,000 Hz
Inputs	4 transformer - coupled balanced 150 ohm
Input Sensitivity	0.003 volts
Input Channel Isolation	70 dB minimum

2.3.5 MICROPHONES

2.3.5.1 Desk Microphone

Microphones shall as a minimum conform to the following specifications:

Element	Dynamic
Pattern	Cardioid
Frequency Response	50 - 12,000 Hz
Impedance	Low impedance mic (150-400 ohms)
Front-to-back Ratio	20 dB
Selector switches	Selector switches for zone shall be be integral microphone or

2.3.5.2 Gooseneck Microphone

Gooseneck microphone shall meet the minimum requirements of the desk microphone. Microphone shall have push to talk button. Gooseneck tube length shall be 12 inch.

2.3.5.3 Microphone Jack

Each outlet for microphones shall consist of a standard outlet box, flush-mounted, and fitted with a three-pole, polarized, locking-type, female microphone jack and a corrosion resistant-steel device plate.

2.4 LOUDSPEAKERS

2.4.1 Cone Speaker

The cone speaker shall as a minimum conform to the following specifications:

Application	Ceiling
Frequency range	60 to 12,000 Hz
Power Rating	Normal - 7 watts
	Peak - 10 watts
Voice Coil Impedance	8 ohms
Line Matching Transformer Type	25/ 70.7 volt line
Capacity	4 watts
Magnet	10 ounces or greater
Primary Taps	0.5, 1, 2 and 4 watts
Primary Impedance	25 volts - 1250, 625, and 312 ohms
	70.7 volts - 10k, 5k, and 2.5k ohms
Frequency Response	30 - 20,000 Hz
Insertion Loss	Less than 1 dB

2.4.2 Horn Speaker

The horn speaker shall as a minimum conform to the following specifications:

Application	Indoor

Frequency Response	400 - 14,000 Hz
Power Taps	70 volt line - .9, 1.8, 3.8, 7.5, and 15 watts
Impedance	5000, 2500, 1300, 670, 330, 90, and 45 ohms
	Normal - 7 watts
	Peak - 15 watts
Dispersion	110 degrees

2.4.3 Dual Horn Speaker

The dual horn speaker shall meet the minimum requirements of horn speaker except the dispersion shall be 100 degrees.

2.4.4 High Output Speaker Enclosures

High Output speaker enclosures shall be of the tuned-port design for precise balancing and tuning of the speaker. The enclosures shall be constructed throughout of 3/4 inch high density board, with screwed and glued joints, durably braced, and padded with fiberglass where acoustically required. Speaker enclosures shall have a 45 degree vertical dispersion and 90 degrees horizontal dispersion. The effective length of throw shall be a minimum of 50 feet.

2.4.5 Wall Baffle Speaker Enclosures

The wall baffle speaker shall be of full steel construction painted off-white and complete with cloth grille. Baffle shall feature 9.5 degree slope to provide directional sound dispersion offset in the direction of radiation. Wall baffle enclosure shall come equipped with a wall mounting bracket designed to assure a rigid mounting to any flat surfaces.

2.4.6 Ceiling Speaker Enclosures

Ceiling speaker enclosure shall be constructed of heavy gauge cold steel with interior undercoating and 1-1/2 inch thick high density fiberglass 1-1/2 lbs/cu. ft. The unit shall be round and designed for recessed installations which will be accomplished via standard screw or flange mount mounting. Recessed models shall have a rust-preventive, textured black coating and the surface mount unit finished in textured white. Enclosure shall include four triple compound conduit knockouts.

2.5 SPEAKER SWITCHING PANEL

2.5.1 Selector Switches

Zone control shall be provided for the paging function. The speaker switching panel shall contain at least 6 double-pole, push button selector switches and shall be selector switches built in microphoneto activate priority relays. Selector switches labeling shall be provided to identify the zones.

2.5.2 System Power supply

Power supply shall be provided for priority relays and controls, rack-mounted and sized for a capacity equal to 200 percent of the as-built control system, and shall operate at 24 Vdc. Input and output shall be protected to permit Class 2 wiring in accordance with NFPA 70.

2.6 PRIORITY RELAYS AND CONTROLS

Provide priority relays and controls required to accomplish operations specified. Relays shall be completely enclosed with a plastic dust cover for maximum protection against foreign matter, and shall be plug-in type. Relays shall be provided with a diode wired across the relay coil for transient suppression and shall be installed utilizing factory-prewired, rack-mounted receptacle strips. Coil shall be maximum 24 volts dc.

2.7 SWITCHES AND CONTROLS

2.7.1 Remote Loudspeaker ON/OFF Switches

Remote switches shall be toggle switch 2-pole, wall-mounted, single gang type with engraved switch plates finished to match the approved finish of electrical wall switches. Low-voltage priority override relays shall be provided as part of the switches with all wiring to the racks to allow override of the ON/OFF switches for priority announcements.

2.7.2 Remote Loudspeaker Volume Controls

Remote volume controls shall be an auto transformer type with detented 3 dB steps and an OFF position. The controls shall be wall-mounted in single-gang outlet boxes and furnished with engraved switching plates finished to match approved finish of electrical wall switches. Insertion loss of the controls shall not exceed 0.6 dB and the power-handling capacities of the control shall be 10 watts. Low-voltage priority override relays shall be furnished as part of these controls with all wiring to the racks to allow override of the volume controls for priority announcements.

2.8 EQUIPMENT RACKS AND CABINETS

Equipment shall be mounted on 19 inch racks as indicated on the drawings UL listed and in accordance with ECIA EIA/ECA 310-E and located as shown on drawings. Ventilated rear panels, solid side panels, and solid top panels shall be provided for cabinets. Equipment cabinets shall be provided with lockable front panels that limit access to equipment. The lockable front shall not cover items that require operator access. Cabinet cooling shall be through perforations or louvers in front panels to ensure adequate ventilation of equipment. The racks and cabinets shall be factory finished with a uniform baked enamel over rust inhibiting primer.

2.9 CABLES

2.9.1 Speaker Cable

Cables shall be of the gauge required depending upon the cable run length. In no case shall cable be used which is smaller than 18 AWG. Insulation on the conductors shall be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 0.009 inch. Cables shall be jacketed with a PVC compound. The jacket thickness shall be 0.02 inch

minimum.

2.9.2 Microphone Cable

Cable conductor shall be stranded copper 20 AWG. Insulation on the conductors shall be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 0.009 inch. Cable shall be shielded 100 percent of aluminum polyester foil with a bare 22 gauge stranded soft copper drain conductor. Cables shall be jacketed with a PVC compound. The jacket thickness shall be 0.02 inch minimum.

2.10 TERMINALS

Terminals shall be solderless, tool-crimped pressure type.

2.11 SURGE PROTECTION

2.11.1 Power Line Surge Protection

Major components of the system such as power amplifiers, mixer-preamplifiers, and tuners, shall have a device, whether internal or external, which provides protection against voltage spikes and current surges originating from commercial power sources in accordance with IEEE C62.41.1/IEEE C62.41.2 B3 combination waveform and NFPA 70. Fuses shall not be used for surge protection. The surge protector shall be rated for a maximum let thru voltage of 350 Volts ac (line-to-neutral) and 350 Volt ac (neutral-to-ground). Surge protection device shall be UL listed and labeled as having been tested in accordance with UL 1449.

2.11.2 SIGNAL SURGE PROTECTION

Major components of the system shall have internal protection circuits which protects the component from mismatched loads, direct current, and shorted output lines. Communication cables/conductors shall have surge protection installed at each point where it exits or enters a building.

2.12 TELEPHONE INTERFACE MODULE

2.12.1 Analog Interface Module

Telephone Interface module shall provide one way all call paging access from telephone to PA system. Paging shall be accomplished by the building telephone system instruments interconnected to the PA system via an interface module to allow telephone dial up access to the paging amplifier. Telephone interface module shall as a minimum conform to the following specifications:

Impedance	600 ohms
Frequency response	100Hz to 10Khz
70V Input Impedance	200K ohms
Output level	400mV rms
Input Power Requirement	12-24Vdc (from power supply)

Access requirement	Electronic (analog) or IA2 line key (line card required) PABX loop or ground-start trunk port, or dedicated single-line phone

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

Install equipment as indicated and specified, and in accordance with the manufacturer's recommendations except where otherwise indicated. Equipment mounted out-of-doors or subject to inclement conditions shall be weatherproofed.

3.2.1 Equipment Racks

Mount racks side-by-side and bolt together. Group items of the same function together, either vertically or side-by-side. Arrange controls symmetrically at a height as indicated. Make audio input and interconnections with approved shielded cable and plug connectors; output connections may be screw terminal type. All connections to power supplies shall utilize standard male plug and female receptacle connectors with the female receptacle being the source side of the connection. Inputs, outputs, interconnections, test points, and relays shall be accessible at the rear of the equipment rack for maintenance and testing. Each item shall be removable from the rack without disturbing other items or connections. Empty space in equipment racks shall be covered by blank panels so that the entire front of the rack is occupied by panels.

3.2.2 Wiring

Install wiring in rigid steel conduit, intermediate metal conduit, cable trays, or electric metallic tubing as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Wiring for microphone, grounding, line level, speaker and power cables shall be isolated from each other by physical isolation and metallic shielding. Shielding shall be terminated at only one end.

3.3 GROUNDING

All grounding practices shall comply with NFPA 70. Equipment shall be grounded to the serving panelboard ground bus through a green grounding conductor. Metallic conduits serving the equipment shall be isolated on the equipment end with an insulating bushing to prevent noise from being transferred to the circuit. Equipment racks shall be grounded to the panelboard ground bus utilizing a 8 AWG conductor. Grounding conductor shall be terminated to the rack using connector suitable for that purpose.

3.4 TRAINING

Conduct a training course for 5 members of the operating and maintenance staff as designated by the Contracting Officer. The training course will

be given at the installation during normal working hours for a total of 4 hours and shall start after the system is functionally complete but prior to final acceptance tests. The field instructions shall cover all of the items contained in the approved operating and maintenance manuals, as well as demonstrations of routine maintenance operations. Notify the Contracting Officer at least 14 days prior to the start of the training course.

3.5 ACCEPTANCE TESTS

Submit test reports in booklet form showing all field tests performed to adjust each component and to prove compliance with the specified performance criteria, upon completion and testing of the installed system. The reports shall include the manufacturer, model number, and serial number of test equipment used in each test. Each report shall indicate the final position of controls and operating mode of the system. After installation has been completed, conduct acceptance tests, utilizing the approved test procedures, to demonstrate that equipment operates in accordance with specification requirements. Submit test plan and test procedures for the acceptance tests. The test plan and test procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements specified. The procedure shall also explain methods for simulating the necessary conditions of operation to demonstrate system performance. Notify the Contracting Officer 14 days prior to the performance of tests. In no case shall notice be given until after the Contractor has received written Contracting Officer approval of the test plans as specified.

3.5.1 Testing Requirements

Include the following minimum testing:

- a. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
- b. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
 - (1) Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
 - (2) Repeat test for each separately controlled zone of loudspeakers.
 - (3) Minimum acceptance ratio is 50 dB
- c. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
- d. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band

filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.

- e. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
- f. Power Outage Test: Turn off AC power at the circuit breaker for AC powered components connected to a UPS unit to ensure components continue to operate for a minimum of 15 minutes.
- g. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

Public address system will be considered defective if it does not pass any of the required individual tests and inspections listed above.

-- End of Section --

SECTION 28 31 76

INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM, ADDRESSABLE
08/20

PART 1 GENERAL

1.1 RELATED SECTIONS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS, applies to this section, with the additions and modifications specified herein. In addition, refer to the following sections for related work and coordination:

Section 21 13 13 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION

1.2 SUMMARY

1.2.1 Scope

- a. This work includes designing and providing a new, complete, fire alarm and mass notification (MNS) system as described herein and on the contract drawings. Include system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, initiating devices, notification appliances, supervising station fire alarm system, and other accessories and miscellaneous items required for a complete operational system even though each item is not specifically mentioned or described. Provide systems complete and ready for operation.
- b. Provide equipment, materials, installation, workmanship, inspection, and testing in strict accordance with NFPA 72, except as modified herein. The system layout on the drawings show the intent of coverage and suggested locations. Final quantity, system layout, and coordination are the responsibility of the Contractor.
- c. Where an emergency generator provides standby power supply for life safety system circuits, the generator must be monitored by the FMCP and transmit emergency generator signals in accordance with NFPA 72.
- d. The fire alarm and mass notification system must be independent of the building security, building management, and energy/utility monitoring systems other than for control functions.

1.2.2 Qualified Fire Protection Engineer (QFPE)

The scope includes the services of a QFPE. The QFPE must be a registered professional engineer who has passed the Fire Protection Engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and have relevant experience. The QFPE's services must include:

- a. Reviewing SD-02, SD-03, and SD-05 submittal packages for completeness and compliance with the provisions of this specification.
- b. Providing a letter of confirmation documenting that the SD-02, SD-03, and SD-05 submittal package has been reviewed and noting any

outstanding comments.

- c. Performing in-progress construction surveillance prior to installation of ceilings (rough-in inspection).
- d. Witnessing pre-Government and final Government functional performance testing and performing a final installation review.
- e. Signing applicable certificates under SD-07.

1.2.3 Fire Protection Quality Control Specialist (FPQC)

The scope includes the services of a FPQC as detailed in Specification Section 01 45 00.05 20 DESIGN AND CONSTRUCTION QUALITY CONTROL. The FPQC must be a registered professional engineer who has passed the Fire Protection Engineering written examination administered by the National Council of Examiners for Engineering and Surveying (NCEES) and have relevant experience. The FPQC may be the same person as the QFPE.

1.3 REFERENCES

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

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S3.2 (2009; R 2014) Method for Measuring the Intelligibility of Speech Over Communication Systems (ASA 85)

FM GLOBAL (FM)

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1 (2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.41.2 (2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 4 (2018) Standard for Integrated Fire Protection and Life Safety System Testing

NFPA 13 (2019; Errata 19-1; Errata 19-2; TIA 19-1; TIA 19-2; TIA 19-3; TIA 19-4; Errata 19-3; Errata 20-4; TIA 19-5; TIA 19-6) Standard for the Installation of Sprinkler Systems

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

- NFPA 72 (2019; TIA 19-1; ERTA 1 2019) National Fire Alarm and Signaling Code
- NFPA 90A (2021) Standard for the Installation of Air Conditioning and Ventilating Systems
- NFPA 170 (2018) Standard for Fire Safety and Emergency Symbols

U.S. DEPARTMENT OF DEFENSE (DOD)

- UFC 3-601-02 (2010) Operations and Maintenance: Inspection, Testing, and Maintenance of Fire Protection Systems

UNDERWRITERS LABORATORIES (UL)

- UL 268 (2016; Reprint Oct 2019) UL Standard for Safety Smoke Detectors for Fire Alarm Systems
- UL 268A (2008; Reprint Oct 2014) Smoke Detectors for Duct Application
- UL 464 (2016; Reprint Sep 2017) UL Standard for Safety Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories
- UL 497A (2001; Bul. 2019) UL Standard for Safety Secondary Protectors for Communications Circuits
- UL 497B (2004; Reprint Dec 2012) Protectors for Data Communication Circuits
- UL 864 (2014; Reprint May 2020) UL Standard for Safety Control Units and Accessories for Fire Alarm Systems
- UL 1283 (2017) UL Standard for Safety Electromagnetic Interference Filters
- UL 1449 (2021) UL Standard for Safety Surge Protective Devices
- UL 1480 (2016; Reprint Sep 2017) UL Standard for Safety Speakers for Fire Alarm and Signaling Systems, Including Accessories
- UL 1971 (2002; Reprint Oct 2008) Signaling Devices for the Hearing Impaired
- UL 2017 (2008; Reprint Dec 2018) UL Standard for Safety General-Purpose Signaling Devices and Systems
- UL 2034 (2017; Reprint Sep 2018) UL Standard for

Safety Single and Multiple Station Carbon Monoxide Alarms

UL 2075 (2013; Bul. 2019) UL Standard for Safety Gas and Vapor Detectors and Sensors

UL 2572 (2016; Bul. 2018) UL Standard for Safety Mass Notification Systems

UL Fire Prot Dir (2012) Fire Protection Equipment Directory

1.4 DEFINITIONS

Wherever mentioned in this specification or on the drawings, the equipment, devices, and functions must be defined as follows:

1.4.1 Interface Device

An addressable device that interconnects hard wired systems or devices to an analog/addressable system.

1.4.2 Fire Alarm and Mass Notification Control Unit (FMCP)

A master control unit having the features of a fire alarm control unit (FACU) and an autonomous control unit (ACU) where these units are interconnected to function as a combined fire alarm/mass notification system. The FACU and ACU functions may be contained in a single cabinet or in independent, interconnected, and co-located cabinets.

1.4.3 Local Operating Console (LOC)

A unit designed to allow emergency responders and/or building occupants to operate the MNS including delivery of recorded messages and/or live voice announcements, initiate visual, textual visual, and audible appliance operation and other relayed functions.

1.4.4 Terminal Cabinet

A steel cabinet with locking, hinge-mounted door where terminal strips are securely mounted inside the cabinet.

1.4.5 Control Module and Relay Module

Terms utilized to describe emergency control function interface devices as defined by NFPA 72.

1.4.6 Designated Fire Protection Engineer (DFPE)

The NAVFAC MIDATLANTIC fire protection engineer that oversees that Area of Responsibility for that project. This is sometimes referred to as the "cognizant" fire protection engineer. Interpret reference to "authority having jurisdiction" and/or AHJ in referenced standards to mean the Designated Fire Protection Engineer (DFPE). The DFPE is responsible for review of the contractor submittals having a "G" designation, and for witnessing final inspection and testing.

1.4.7 Qualified Fire Protection Engineer (QFPE)

See Part 1.2 Scope for qualifications and services required by the QFPE.

1.4.8 Fire Protection Quality Control Specialist (FPQC)

See Part 1.2 Scope for qualifications and services required by the FPQC.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation.

Shop drawings (SD-02), product data (SD-03) and calculations (SD-05) must be prepared by the fire alarm designer and combined and submitted as one complete package. The QFPE must review the SD-02/SD-03/SD-05 submittal package for completeness and compliance with the Contract provisions prior to submission to the Government. The QFPE must provide a Letter of Confirmation that they have reviewed the submittal package for compliance with the contract provisions. This letter must include their registered professional engineer stamp and signature. Partial submittals and submittals not reviewed by the QFPE will be returned by the Government disapproved without review.

Submit the following in accordance with Section 01 33 00.05 20
CONSTRUCTION SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

The Contractor must submit the following for review and approval. SD-02, SD-03 and SD-05 submittals received prior to the review and approval of the qualifications of the fire alarm subcontractor and QFPE will be returned disapproved without review. All resultant delays will be the sole responsibility of the Contractor.

Qualified Fire Protection Engineer (QFPE); G

Fire Protection Quality Control Specialist (FPQC); G

Designer; G

Supervisor; G

Installers/Technicians; G

Test Personnel; G

Fire Alarm System Site-Specific Software Acknowledgement; G

SD-02 Shop Drawings

Shop drawings must not be smaller than 1/8" = 1' scale. Drawings must comply with the requirements of NFPA 72 and NFPA 170.

Nameplates; G

Nameplate illustrations and data to obtain approval by the Contracting Officer before installation.

Instructions; G

Wiring Diagrams; G

Point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams must show connections from field devices to the FMCP and remote fire alarm control units, initiating circuits, switches, relays and terminals, including pathway diagrams between the control unit and shared communications equipment within the protected premises. Point-to-point wiring diagrams must be job specific and must not indicate connections or circuits not being utilized. Provide complete riser diagrams indicating the wiring sequence of all devices and their connections to the control equipment. Include a color-code schedule for the wiring.

System Layout; G

Plan view drawing showing device locations, terminal cabinet locations, junction boxes, other related equipment, conduit routing, conduit sizes, wire counts, conduit fill calculations, wire color-coding, circuit identification in each conduit, and circuit layouts for all floors. Indicate candela rating of each visual notification appliance. Indicate the wattage of each speaker. Identify the locations of isolation modules. Indicate the addresses of all devices, modules, relays, etc. Show/identify all acoustically similar spaces.

Provide a complete description of the system operation in matrix format similar to the "Typical Input/Output Matrix" included in the Annex of NFPA 72.

System Operation; G

A complete list of device addresses and corresponding messages.

Notification Appliances; G

Data on each circuit to indicate that there is at least 25 percent spare capacity for notification appliances. Annotate data for each circuit on the drawings.

Initiating devices; G

Data on each circuit to indicate that there is at least 25 percent spare capacity for initiating devices. Annotate data for each circuit on the drawings.

Amplifiers; G

Data to indicate that amplifiers have sufficient capacity to simultaneously drive all notification speakers plus 25 percent spare capacity. Annotate data for each circuit on the drawings.

Battery Power; G

Provide battery calculations as required in paragraph Battery Power Calculations for alarm, alert, and supervisory power requirements. Calculations including ampere-hour requirements for each system component and each panel component, and the battery recharging period, must be included on the drawings.

Voltage Drop Calculations; G

Voltage drop calculations indicating that sufficient voltage is available for proper operation of the system and all components, at a minimum rated voltage of the system operating on batteries. Include the calculations on the system layout drawings.

SD-03 Product Data

Include annotated catalog data as required in the paragraph SUBMITTAL, in table format on the drawings, showing manufacturer's name, model, voltage, and catalog numbers for equipment and components. Product data for all equipment must be combined into a single submittal.

Fire Alarm and Mass Notification Control Unit (FMCP); G

Local Operating Console (LOC); G

Amplifiers; G

Tone Generators; G

Digitalized voice generators; G

Remote Annunciator Panel; G

Manual Stations; G

Smoke Detectors; G

Duct Smoke Detectors; G

Carbon monoxide detectors; G

Addressable Interface Devices; G

Addressable Control Modules; G

Isolation Modules; G

Notification Appliances; G

Batteries; G

Battery Chargers; G

Supplemental Notification Appliance Circuit Panels; G

Auxiliary Power Supply Panels; G

Surge Protective Devices; G

Alarm Wiring; G

Back Boxes and Conduit; G

Ceiling Bridges for Ceiling-Mounted Appliances; G

Terminal Cabinets; G

Digital Alarm Communicator Transmitter (DACT); G

Automatic Fire Alarm Transmitters (including housing); G

Electromagnetic Door Holders; G

Environmental Enclosures or Guards; G

Document Storage Cabinet; G

Spare Parts Cabinet; G

Equipment for Interface to the Base-wide Mass Notification Network; G

SD-05 Design Data

Preliminary Equipment List; G

Provide a preliminary Equipment List identifying the type, quantity, make, and model number of each piece of equipment to be provided under this submittal. The Equipment List must include the type, quantity, make and model of spare equipment. Types and quantities of equipment submitted must coincide with the types and quantities of equipment used in the battery calculations and those shown on the shop drawings.

SD-06 Test Reports

Test Procedures; G

Verification of Compliant Installation; G

Request for Government Final Test; G

SD-09 Manufacturer's Field Reports

System Operation; G

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G

Four copies of the Operation and Maintenance Instructions. The O&M Instructions must be prepared in a single volume or in multiple volumes, with each volume indexed, and may be submitted as a Technical Data Package. Manuals must be approved prior to training. The Interior Fire Alarm And Mass Notification System Operation and Maintenance Instructions must include the following:

a. "Manufacturer Data Package five" as specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA.

b. Operating manual outlining step-by-step procedures required for system startup, operation, and shutdown. The manual must include the manufacturer's name, model number, service manual,

parts list, and preliminary equipment list complete with description of equipment and their basic operating features.

c. Maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals must include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed.

d. Complete procedures for system revision and expansion, detailing both equipment and software requirements.

e. Software delivered for this project on each type of CD/DVD media utilized.

f. Printouts of configuration settings for all devices.

g. Routine maintenance checklist. The routine maintenance checklist must be arranged in a columnar format. The first column must list all installed devices, the second column must state the maintenance activity or state no maintenance required, the third column must state the frequency of the maintenance activity, and the fourth column provided for additional comments or reference.

All data (devices, testing frequencies, etc.) must comply with UFC 3-601-02.

h. A final Equipment List must be submitted with the Operating and Maintenance (O&M) manual.

Instruction of Government Employees; G

SD-11 Closeout Submittals

As-Built Drawings; G

Spare Parts; G

1.6 SYSTEM OPERATION

The addressable interior fire alarm and mass notification system must be a complete, supervised, noncoded, analog/addressable fire alarm and mass notification system conforming to NFPA 72, UL 864, and UL 2572. Systems meeting UL 2017 only are not acceptable. Fire alarm system/mass notification system components requiring power, except for the control panel(s) power supply, must operate on 24 Volts dc.

1.6.1 Alarm Initiating Devices and Notification Appliances (Visual, Voice)

- a. Connect alarm initiating devices Class "B" signaling line circuits.
- b. Connect notification appliances to Class "B" notification appliance circuits (NAC).
- c. The system must be activated into the alarm mode by actuation of any alarm initiating device. The system must remain in the alarm mode until the initiating device is reset and the control panel is reset and restored to normal. The system may be placed in the alarm mode by local microphones, LOC, FMCP, or remotely from authorized locations/users.

1.6.2 Functions and Operating Features

The system must provide the following functions and operating features:

- a. Power, annunciation, supervision, and control for the system. Addressable systems must be microcomputer (microprocessor or microcontroller) based with a minimum word size of eight bits with sufficient memory to perform as specified.
- b. Visual alarm notification appliances must be synchronized as required by NFPA 72.
- c. Electrical supervision of the primary power (AC) supply, presence of the battery, battery voltage, and placement of system modules within the control unit.
- d. An audible and visual trouble signal to activate upon a single break or open condition, or ground fault. The trouble signal must also operate upon loss of primary power (AC) supply, absence of a battery supply, low battery voltage, or removal of alarm or supervisory control unit modules. After the system returns to normal operating conditions, the trouble signal must again sound until the trouble is acknowledged. A smoke detector in the process of being verified for the actual presence of smoke must not initiate a trouble condition.
- e. A trouble signal silence feature that must silence the audible trouble signal, without affecting the visual indicator.
- f. Program capability via switches in a locked portion of the FMCP to bypass the automatic notification appliance circuits and the following when applicable: fire reporting system, air handler shutdown, elevator recall, door release, door unlocking features. Operation of this programmed action must indicate on the FMCP display as a supervisory or trouble condition.
- g. Alarm functions must override trouble or supervisory functions. Supervisory functions must override trouble functions.
- h. The system must be capable of being programmed from the control unit keyboard. Programmed information must be stored in non-volatile memory.
- i. The system must be capable of operating, supervising, and/or monitoring non-addressable alarm and supervisory devices.
- j. There must be no limit, other than maximum system capacity, as to the number of addressable devices that may be in alarm simultaneously.
- k. Where the fire alarm/mass notification system is responsible for initiating an action in another emergency control device or system, such as HVAC, elevator recall, releasing service, the addressable fire alarm relay must be located in the vicinity of the emergency control device.
- l. An alarm signal must automatically initiate the following functions:
 - (1) Transmission of an alarm signal to the dispatch center.
Transmission must be point specific via contact ID format with the

- address, location, and description of the condition as it appears on the FMCP.
- (2) Visual indication of the device operated on the FMCP, and on the remote annunciator.
 - (3) Continuous actuation of alarm notification appliances.
 - (4) Recording of the event electronically in the history log of the FMCP.
- m. A supervisory signal must automatically initiate the following functions:
- (1) Visual indication of the device operated on the FMCP, and on the remote annunciator.
 - (2) Transmission of a supervisory signal to the dispatch center. Transmission must be point specific via contact ID format with the address, location, and description of the condition as it appears on the FMCP.
 - (3) Operation of a duct smoke detector must shut down the appropriate air handler in accordance with NFPA 90A in addition to other requirements of this paragraph and as allowed by NFPA 72.
 - (4) Recording of the event electronically in the history log of the FMCP.
- n. A trouble condition must automatically initiate the following functions:
- (1) Visual indication of the device operated on the FMCP, and on the remote annunciator.
 - (2) Transmission of a trouble signal to the dispatch center. Transmission must be point specific via contact ID format with the address, location, and description of the condition as it appears on the FMCP.
 - (3) Recording of the event electronically in the history log of the FMCP.
- o. A carbon monoxide alarm initiating device must automatically initiate the following functions:
- (1) Visual indication of the device operated on the FMCP, and on the remote annunciator.
 - (2) Transmission of a carbon monoxide alarm signal to the dispatch center. Transmission must be point specific via contact ID format with the address, location, and description of the condition as it appears on the FMCP.
 - (3) Continuous actuation of all strobes and the audible carbon monoxide message throughout the building.
 - (4) Recording of the event electronically in the history log of the FMCP.

- p. System control equipment must be programmed to provide a 60-minute to 180-minute delay in transmission of trouble signals resulting from primary power failure.
- q. Activation of a LOC pushbutton must activate the audible and visual alarms in the facility. The audible message must be the one associated with the pushbutton activated.
- r. A lockout code must not be installed in the hardware, firmware, or software of the fire alarm system. Installer and operator codes shall remain as the factory default setting.

1.7 TECHNICAL DATA AND SITE-SPECIFIC SOFTWARE

Technical data and site-specific software (meaning technical data that relates to computer software) that are specifically identified in this project, and may be required in other specifications, must be delivered, strictly in accordance with the CONTRACT CLAUSES. The fire alarm system manufacturer must submit written confirmation of this contract provision as "[Fire Alarm System Site-Specific Software Acknowledgement](#)". Identify data delivered by reference to the specification paragraph against which it is furnished. Data to be submitted must include complete system, equipment, and software descriptions. Descriptions must show how the equipment will operate as a system to meet the performance requirements of this contract. A lockout code must not be installed in the hardware, firmware, or software of the fire alarm system. Installer and operator codes must remain as the factory default setting. The site-specific software data package must also include the following:

- a. Items identified in [NFPA 72](#), titled "Site-Specific Software".
- b. Identification of programmable portions of the system equipment and capabilities.
- c. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.
- d. Provision of operational software data on all modes of programmable portions for fire alarm and mass notification.
- e. Description of Fire Alarm and Mass Notification Control Unit equipment operation.
- f. Description of auxiliary and remote equipment operations.
- g. Library of application software.
- h. Operation and maintenance manuals.

1.8 QUALITY ASSURANCE

1.8.1 Qualifications

1.8.1.1 Fire Protection Quality Control Specialist (FPQC)

See Part 1.2 Scope for qualifications and services required by the QFPE.

1.8.1.2 Fire Protection Quality Control Specialist (FPQC)

See Part 1.2 Scope for qualifications and services required by the FPQC.

1.8.1.3 Designer

The designer must be certified as a Level IV (minimum) Technician by National Institute for Certification in Engineering Technologies (NICET) in the Fire Alarm Systems subfield of Fire Protection Engineering Technology.

1.8.1.4 Supervisor

The supervisor must be certified as a NICET Level III or IV fire alarm technician with a minimum of eight years experience. The fire alarm technicians supervising the installation of equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.1.5 Installers/Technicians

Electricians may be allowed to install wire, cable, conduit and backboxes for the fire alarm system/mass notification system. Fire alarm technicians must be utilized to assist with the installation of fire alarm/mass notification devices, cabinets and panels. Fire alarm technicians must have a minimum of four years of experience must and must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.1.6 Test Personnel

Test Personnel must include a NICET Level IV fire alarm technician with a minimum of eight years experience in testing and certifying the installation of the fire alarm/mass notification devices, cabinets and panels. Test Personnel must be factory trained in the installation, adjustment, testing, and operation of the equipment installed as part of this project.

1.8.1.7 Manufacturer

Components must be of current design and must be in regular and recurrent production at the time of installation. Provide design, materials, and devices for a protected premises fire alarm system, complete, conforming to NFPA 72, except as specified herein.

1.8.2 Regulatory Requirements

Equipment and material must be listed or approved. Listed or approved, as used in this section, means listed, labeled or approved by a Nationally Recognized Testing Laboratory (NRTL) such as UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of any item of equipment described must not be construed as waiving this requirement. All listings or approvals by testing laboratories must be from an existing ANSI or UL published standard. The recommended practices stated in the manufacturer's literature or documentation must be considered as mandatory requirements.

1.9 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity, and temperature variation, dirt and dust, and other contaminants.

1.10 MAINTENANCE

1.10.1 Spare Parts

Furnish the following spare parts in the Spare Parts Cabinet detailed in Part 2:

- a. Five complete sets of system keys.
- b. Four spare fuses for each fused circuit.
- c. Two manual stations.
- d. Two of each type of detector installed.
- e. Two of each type of detector base and head installed.
- h. Two of each type of audible and visual alarm device installed.
- i. Two low voltage, telephone, and one 120 VAC surge protective device.

1.10.2 Special Tools

Software, connecting cables and proprietary equipment, necessary for the maintenance, testing, and reprogramming of the equipment must be furnished to the Contracting Officer, prior to the instruction of Government employees.

PART 2 PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENT

All fire alarm and mass notification equipment must be listed for use under the applicable reference standards. Interfacing of UL 864 or similar approved industry listing with Mass Notification equipment listed to UL 2572 must be done in a laboratory listed configuration, if the software programming features cannot provide a listed interface control.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Standard Products

Provide materials, equipment, and devices that have been tested by a nationally recognized testing laboratory and listed for fire protection service when so required by NFPA 72 or this specification. Select material from one manufacturer, where possible, and not a combination of manufacturers, for any particular classification of materials. Material and equipment must be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 2 years prior to bid opening.

2.2.2 Nameplates

Major components of equipment must have the manufacturer's name, address,

type or style, model or serial number, catalog number, date of installation, installing Contractor's name and address, and the contract number provided on a new name plate permanently affixed to the item or equipment. Major components include, but are not limited to, the following:

a. FMCP

Lettering on the nameplate must say "Fire Alarm and Mass Notification Control Panel" and must not be less than 1-inch high.

b. Terminal Cabinet

c. Automatic Transmitters

2.2.3 Keys

Keys and locks for equipment, control units and devices must be identical.

2.3 FIRE ALARM AND MASS NOTIFICATION CONTROL UNIT

Provide a complete fire alarm and mass notification control unit (FMCP) fully enclosed in a lockable steel cabinet as specified herein. System must be Simplex, Notifier, or Firelite. Operations required for testing or for normal care, maintenance, and use of the system must be performed from the front of the enclosure.

- a. Each control unit must provide power, supervision, control, and logic for the entire system, utilizing solid state, modular components, internally mounted and arranged for easy access. Each control unit must be suitable for operation on a 120 volt, 60 hertz, normal building power supply. Provide each control unit with supervisory functions for power failure, internal component placement, and operation.
- b. Visual indication of alarm, supervisory, or trouble initiation on the FMCP must be by liquid crystal display or similar means with a minimum of 80 characters. The mass notification control unit must have the capability of temporarily deactivate the fire alarm audible notification appliances while delivering voice messages.
- c. Provide secure operator console for initiating recorded messages, strobes and displays; and for delivering live voice messages. Provide capacity for at least eight prerecorded messages. Provide the ability to automatically repeat prerecorded messages. Provide a secure microphone for delivering live messages. Provide adequate discrete outputs to temporarily deactivate fire alarm audible notification, initiate/synchronize strobes and initiate textual visual notification appliances. Provide a complete set of self-diagnostics for controller and appliance network. Provide local diagnostic information display and local diagnostic information and system event log file.

2.3.1 FMCP Cabinet

Install control panel components in cabinets large enough to accommodate all components and also to allow ample gutter space for interconnection of panels as well as field wiring. The enclosure must be identified by an engraved phenolic resin nameplate. Lettering on the nameplate must say "Fire Alarm and Mass Notification Control Panel" and must not be less than

1-inch high. Provide prominent rigid plastic or metal identification plates for lamps, circuits, meters, fuses, and switches. The cabinet must be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and semi-recessed mounting provisions.

2.3.2 Silencing Switches

2.3.2.1 Alarm Silencing Switch

Provide an alarm silencing switch at the FMCP that must silence the audible and visual notification appliances. This switch must be overridden upon activation of a subsequent alarm.

2.3.2.2 Supervisory/Trouble Silencing Switch

Provide supervisory and trouble silencing switch(es) that must silence the audible trouble and supervisory signal(s), but not extinguish the visual indicator. This switch must be overridden upon activation of a subsequent supervisory or trouble condition. Audible trouble indication must resound automatically every 24 hours after the silencing feature has been operated if the supervisory or trouble condition still exists.

2.3.3 Non-Interfering

Power and supervise each circuit such that a signal from one device does not prevent the receipt of signals from any other device. Initiating devices must be manually reset by switch from the FMCP after the initiating device or devices have been restored to normal.

2.3.4 Audible Notification System

The Audible Notification System must comply with the requirements of NFPA 72 for Emergency Voice/Alarm Communications System requirements, except as specified herein. The system must be a one-way, multi-channel voice notification system incorporating user selectability of a minimum eight distinct sounds for tone signaling, and the incorporation of a voice module for delivery of recorded messages. Audible appliances must produce a three-pulse temporal pattern for three cycles followed by a voice message that is repeated until the control unit is reset or silenced. For carbon monoxide detector activation, audible appliances must produce a four-pulse temporal pattern for three cycles followed by a voice message that is repeated until the control unit is reset or silenced. Automatic messages must be broadcast through speakers throughout the building/facility but not in stairs or elevator cabs. A live voice message must override the automatic audible output through use of a microphone input at the control unit or the LOC.

- a. When using the microphone, live messages must be broadcast through all speakers at the same time.
- b. The microprocessor must actively interrogate circuitry, field wiring, and digital coding necessary for the immediate and accurate rebroadcasting of the stored voice data into the appropriate amplifier input. Loss of operating power, supervisory power, or any other malfunction that could render the digitalized voice module inoperative must automatically cause the three-pulse temporal pattern to take over all functions assigned to the failed unit in the event an alarm is activated.

2.3.4.1 Outputs and Operational Modules

All outputs and operational modules must be fully supervised with on-board diagnostics and trouble reporting circuits. Provide form "C" contacts for system alarm and trouble conditions. Provide circuits for operation of auxiliary appliance during trouble conditions. During a Mass Notification event, the control unit must not generate nor cause any trouble alarms to be generated with the Fire Alarm system.

2.3.4.2 Mass Notification

- a. The system must have the capability of utilizing an LOC with redundant controls of the FMCP. Notification Appliance Circuits (NAC) must be provided for the activation of strobe appliances. Audio output must be selectable for line level. A hand-held microphone must be provided and, upon activation, must take priority over any tone signal, recorded message or PA microphone operation in progress, while maintaining the strobe NAC circuit activation.
- b. The Mass Notification functions must override the manual or automatic fire alarm notification, and public address (PA) functions. Other fire alarm functions including transmission of a signal(s) to the fire department must remain operational. When a mass notification announcement is disengaged and a fire alarm condition still exists, the audible and visual notification appliances must resume activation for alarm conditions.
- c. Messages must be recorded professionally utilizing standard industry methods, in a professional female voice. Message and tone volumes must both be at the same decibel level. Messages recorded from the system microphone must not be accepted. A 1000 Hz tone (as required by NFPA 72) must precede messages and be similar to the following:
 - (1) Fire: "May I have your attention please. May I have your attention please. A fire emergency has been reported in the building. Please leave the building by the nearest exit." Provide a 2 second pause. Repeat the tones and message on a continuous loop.
 - (2) Carbon Monoxide: "May I have your attention please. May I have your attention please. Carbon monoxide has been detected in the building. Please walk to the nearest exit and leave the building." Provide a 2 second pause. Repeat the tones and message on a continuous loop.
 - (3) Test: "May I have your attention please. May I have your attention please. This is a test of the building mass notification system. Please continue your normal duties. This is only a test."
 - (5) All Clear: "May I have your attention please. May I have your attention please. An all clear has been issued, resume normal activities."
- d. Auxiliary Input Module must be designed to be an outboard expansion module to either expand the number of optional LOC's, or allow a telephone interface.

2.3.4.3 Installation-Wide Control

If an installation-wide control system for mass notification exists on the Base, the autonomous control unit must communicate with the central control unit of the Installation-wide system. The autonomous control unit must receive commands/messages from the central control unit and provide status information.

2.3.5 Memory

Provide each control unit with non-volatile memory and logic for all functions. The use of long life batteries, capacitors, or other age-dependent devices must not be considered as equal to non-volatile processors, PROMS, or EPROMS.

2.3.6 Field Programmability

Provide control units and control units that are fully field programmable for both input and output of control, initiation, notification, supervisory, and trouble functions. The system program configuration must be menu driven. System changes must be password protected. Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system must be provided as part of this contract.

2.3.7 Input/Output Modifications

The FMCP must contain features that allow the bypassing of input devices from the system or the modification of system outputs. These control features must consist of a control unit mounted keypad. Any bypass or modification to the system must indicate a trouble condition on the FMCP.

2.3.8 Resetting

Provide the necessary controls to prevent the resetting of any alarm, supervisory, or trouble signal while the alarm, supervisory or trouble condition on the system still exists.

2.3.9 Instructions

Provide a typeset printed or typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. Install the instructions on the interior of the FMCP. The card must show those steps to be taken by an operator when a signal is received as well as the functional operation of the system under all conditions, normal, alarm, supervisory, and trouble. The instructions must also include procedures for operating live voice microphones. The instructions and their mounting location must be approved by the Contracting Officer before being posted.

2.3.10 Walk Test

The FMCP must have a walk test feature. When using this feature, operation of initiating devices must result in limited system outputs, so that the notification appliances operate for only a few seconds and the event is indicated in the history log, but no other outputs occur.

2.3.11 History Logging

The control unit must have the ability to store a minimum of 500 events in

a log. These events must be stored in a battery-protected memory and must remain in the memory until the memory is downloaded or cleared manually. Resetting of the control unit must not clear the memory.

2.4 LOCAL OPERATING CONSOLES (LOC)

2.4.1 General

The LOC must consist of a remote microphone station incorporating a push-to-talk (PTT) hand-held microphone and system status indicators. The LOC must have the capability of being utilized to activate prerecorded messages. The unit must incorporate microphone override of any tone generation or recorded messages. The unit must be fully supervised from the FMCP. The housing for the LOC must not be lockable.

2.4.2 Multiple LOCs

When an installation has more than one LOC, the LOCs must be programmed to allow only one LOC to be available for paging or messaging at a time. Once one LOC becomes active, all other LOC's will have an indication that the system is busy (Amber Busy Light) and cannot be used at that time. This is to avoid two messages being given at the same time. It must be possible to override or lockout the LOC's from the FMCP.

2.5 AMPLIFIERS, PREAMPLIFIERS, TONE GENERATORS

Any amplifiers, preamplifiers, tone generators, digitalized voice generators, and other hardware necessary for a complete, operational, textual audible circuit conforming to NFPA 72 must be housed in a remote FMCP, terminal cabinet, or in the FMCP. Individual amplifiers must be 100 watts maximum.

2.5.1 Operation

The system must automatically operate and control all building speakers.

2.5.2 Construction

Amplifiers must utilize computer grade solid state components and must be provided with output protection devices sufficient to protect the amplifier against any transient up to 10 times the highest rated voltage in the system.

2.5.3 Inputs

Equip each system with separate inputs for the tone generator, digitalized voice driver and control unit mounted microphone. Microphone inputs must be of the low impedance, balanced line type. Both microphone and tone generator input must be operational on any amplifier.

2.5.4 Tone Generator

The tone generator must produce a three-pulse temporal pattern and must be constantly repeated until interrupted by either the digitalized voice message, the microphone input, or the alarm silence mode as specified. The tone generator must be single channel with an automatic backup generator per channel such that failure of the primary tone generator causes the backup generator to automatically take over the functions of the failed unit and also causes transfer of the common trouble relay. The

tone generator must be provided with securely attached labels to identify the component as a tone generator and to identify the specific tone it produces.

2.5.5 Protection Circuits

Each amplifier must be constantly supervised for any condition that could render the amplifier inoperable at its maximum output. Failure of any component must cause illumination of a visual "amplifier trouble" indicator on the control unit, appropriate logging of the condition in the history log, and other actions for trouble conditions as specified.

2.6 REMOTE ANNUNCIATOR

2.6.1 LCD Annunciator

Provide a flush mounted annunciator that includes an LCD display. The display must indicate the device in trouble/alarm or any supervisory device. Display the device name, address, and actual building location. The remote annunciator must duplicate functions of the FMCP for message display, fire alarm, supervisory alarm, and trouble conditions, visual and audible notification, and system reset functions. Remote annunciator must require the use of a key for accessing the reset, control and other functions.

Provide a laminated building floor plan (22" by 34") mounted at the main entrance of the building, adjacent to the annunciator. The drawing must indicate the FMCP, LOC, remote power supply panels, and all initiating devices. The drawing must include room numbers.

2.7 MANUAL STATIONS

Provide metal or plastic, semi-flush mounted, double-action, addressable manual stations, that are not subject to operation by jarring or vibration. Stations must be equipped with screw terminals for each conductor. Stations that require the replacement of any portion of the device after activation are not permitted. Stations must be finished in red with molded raised lettering operating instructions of contrasting color. The use of a key must be required to reset the station.

2.8 SMOKE DETECTORS

2.8.1 Photoelectric Detectors

Provide addressable photoelectric smoke detectors as follows:

- a. Provide analog/addressable photoelectric smoke detectors utilizing the photoelectric light scattering principle for operation in accordance with UL 268. Smoke detectors must be listed for use with the FMCP.
- b. Provide self-restoring type detectors that do not require any readjustment after actuation at the FMCP to restore them to normal operation. Detectors must be listed as smoke-automatic fire detectors.
- c. Components must be rust and corrosion resistant. Vibration must have no effect on the detector's operation. Protect the detection chamber with a fine mesh metallic screen that prevents the entrance of insects or airborne materials. The screen must not inhibit the movement of smoke particles into the chamber.

- d. Provide twist lock bases with screw terminals for each conductor. The detectors must maintain contact with their bases without the use of springs. Provide companion mounting base with screw terminals for each conductor. Terminate field wiring on the screw terminals. The detector must have a visual indicator to show actuation.
- e. The detector address must identify the particular unit, its location within the system, and its sensitivity setting. Detectors must be of the low voltage type rated for use on a 24 VDC system.
- f. An operator at the control panel, having a proper access level, must have the capability to manually access the following information for each initiating device.
 - (1) Primary status
 - (2) Device type
 - (3) Present average value
 - (4) Present sensitivity selected
 - (5) Detector range (normal, dirty, etc.)

2.8.2 Duct Smoke Detectors

Provided duct-mounted addressable photoelectric smoke detectors must be furnished and installed where indicated and in accordance with NFPA 90A. Units must consist of a smoke detector, as specified in paragraph Photoelectric Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry must be mounted in a metallic or plastic enclosure exterior to the duct. It is not permitted to cut the duct insulation to install the duct detector directly on the duct. Detectors must have a manual reset. Detectors must be rated for air velocities that include air flows between 500 and 4000 fpm. Detectors must be powered from the FMCP.

- a. Sampling tubes must run the full width of the duct. The duct detector package must conform to the requirements of NFPA 90A, UL 268A, and must be listed for use in air-handling systems. The control functions, operation, reset, and bypass must be controlled from the FMCP.
- b. Lights to indicate the operation and alarm condition; and the test and reset buttons must be visible and accessible with the unit installed and the cover in place. Remote indicators must be provided where required by NFPA 72 and these must be provided with test and reset switches.
- c. Remote lamps and switches as well as the affected fan units must be properly identified in etched plastic placards. Detectors must provide for control of auxiliary contacts that provide control, interlock, and shutdown functions specified in Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC. Auxiliary contacts provide for this function must be located within 3 feet of the controlled circuit or appliance. The detectors must be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

2.9 CARBON MONOXIDE DETECTORS

Carbon monoxide (CO) detectors must be listed to UL 2075 and set to respond to the sensitivity limits of UL 2034. Carbon monoxide detectors must be listed for use with fire alarm control units. Do not provide CO detectors with local alarms. Detector must be provided with an LED status indicator.

- a. Provide analog/addressable carbon monoxide detectors listed for use with the FMCP. For FMCP with no listed compatible addressable CO detectors, provide listed 4-wire carbon monoxide detectors.
- b. Where 4-wire CO detectors are necessary, each 4-wire CO detector must be individually monitored via addressable interface modules for alarm and off normal/trouble conditions (including loss of power to the individual detector).
- c. Wiring connections must be made by means of screw terminals and detectors must be equipped with trouble relays. Detectors must be able to mount a single-gang electrical box.
- d. A trouble condition at an individual CO detector must not affect any other CO detectors. CO detectors must be powered by the FMCP.
- e. Battery powered and 120 VAC powered detectors are prohibited. Power circuits for 4-wire CO detectors must be dedicated to powering the CO detectors only.
- f. Detectors must be provided with a means to test CO gas entry into the CO sensing cell.

2.10 ADDRESSABLE INTERFACE DEVICES

The initiating device being monitored must be configured as a Class "B" initiating device circuits. The system must be capable of defining any module as an alarm module and report alarm trouble, loss of polling, or as a supervisory module, and reporting supervisory short, supervisory open or loss of polling such as waterflow switches, valve supervisory switches, fire pump monitoring, independent smoke detection systems, relays for output function actuation, etc. The module must be listed as compatible with the control panel. The monitor module must provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. Monitor module must contain an integral LED that flashes each time the monitor module is polled and is visible through the device cover plate. Pull stations with a monitor module in a common backbox are not required to have an LED.

2.11 ADDRESSABLE CONTROL MODULES

The control module must be capable of operating as a relay (dry contact form C) for interfacing the control unit with other systems, and to control door holders or initiate elevator fire service. The module must be listed as compatible with the control unit. The indicating device or the external load being controlled must be configured as Class B notification appliance circuits. The system must be capable of supervising, audible, visual and dry contact circuits. The control module must have both an input and output address. The supervision must detect a short on the supervised circuit and must prevent power from being applied to the circuit. The control model must provide address setting means

compatible with the control panel's SLC supervision and store an internal identifying code. The control module must contain an integral LED that flashes each time the control module is polled and is visible through the device cover plate. Control Modules must be located in environmental areas that reflect the conditions to which they were listed.

2.12 ISOLATION MODULES

- a. Provide isolation modules to as required by NFPA 72 or as indicated on the contract drawings.
- b. Isolation modules must provide short circuit isolation for signaling line circuit wiring.
- c. Power and communications must be supplied by the SLC and must report faults to the FMCP.
- d. After the wiring fault is repaired, the fault isolation modules must test the lines and automatically restore the connection.

2.13 NOTIFICATION APPLIANCES

2.13.1 Speakers

Audible appliances must conform to the applicable requirements of UL 464. Appliances must be connected into notification appliance circuits. Surface mounted audible appliances must be painted red or white. Recessed audible appliances must be installed with a grill that is painted red or white.

- a. Speakers must conform to the applicable requirements of UL 1480. Speakers must have six different sound output levels and operate with audio line input levels of 70.7 VRMs and 25 VRMs, by means of selectable tap settings. Interior speaker tap settings must include taps of 1/4, 1/2, 1, and 2 watt, at a minimum. Exterior speakers must also be multi-tapped with no more than 15 watt maximum setting. Speakers must incorporate a high efficiency speaker for maximum output at minimum power across a frequency range of 400 Hz to 4,000 Hz, and must have a sealed back construction. Speakers must be capable of installation on standard 4-inch square electrical boxes. Where speakers and strobes are provided in the same location, they may be combined into a single unit. All inputs must be polarized for compatibility with standard reverse polarity supervision of circuit wiring via the FMCP.
- b. Provide speaker mounting plates constructed of cold rolled steel having a minimum thickness of 16 gage or molded high impact plastic and equipped with mounting holes and other openings as needed for a complete installation. Fabrication marks and holes must be ground and finished to provide a smooth and neat appearance for each plate. Each plate must be primed and painted.
- c. Speakers must utilize screw terminals for termination of all field wiring.
- d. Exterior weatherproof notification speakers must be "bull horn" style. All conduit penetrations for exterior equipment must enter the junction box or equipment from the bottom to minimize water intrusion. Provide duct seal inside all conduits that penetrate exterior walls per NFPA

70, Section 300.7.

2.13.2 Visual Notification Appliances

Visual notification appliances must conform to the applicable requirements of UL 1971 and conform to the Architectural Barriers Act (ABA). Visual notification appliances are required in all public use areas, common use areas, and employee work areas to include office suites and areas intended to have more than four desks/occupants. Offices that are designed for a single office worker (even though it may be able to hold a meeting with 3 or 4 people) do not require a strobe unless that employee is someone who has a hearing impairment. Visual Notification Appliances must have clear high intensity optic lens, xenon flash tubes, and be marked "Alert" in red letters. The light pattern must be disbursed so that it is visible above and below the strobe and from a 90 degree angle on both sides of the strobe. Strobe flash rate must be 1 flash per second and a minimum of 15 candela (actual output after derating for tinted lens) based on the UL 1971 test. Where more than two appliances are located in the same room or corridor or field of view, provide synchronized operation. Devices must use screw terminals for all field wiring.

2.14 ELECTRIC POWER

2.14.1 Primary Power

Power must be 120 VAC service for the FMCP from the AC service to the building in accordance with NFPA 72.

2.15 SECONDARY POWER SUPPLY

Provide for system operation in the event of primary power source failure. Transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power must be automatic and must not cause transmission of a false alarm.

2.15.1 Batteries

Provide sealed, maintenance-free, sealed lead acid batteries as the source for emergency power to the FMCP. Batteries must contain suspended electrolyte. The battery system must be maintained in a fully charged condition by means of a solid state battery charger. Provide an automatic transfer switch to transfer the load to the batteries in the event of the failure of primary power.

2.15.1.1 Capacity

Battery size must be the greater of the following two capacities. This capacity applies to every control unit associated with this system, including supplemental notification appliance circuit panels, auxiliary power supply panels, fire alarm transmitters, and Base-wide mass notification transceivers. When determining the required capacity under alarm condition, visual notification appliances must include both textual and non-textual type appliances.

- a. Sufficient capacity to operate the fire alarm system under supervisory and trouble conditions, including audible trouble signal devices for 48 hours and audible and visual signal devices under alarm conditions for an additional 15 minutes.

- b. Sufficient capacity to operate the mass notification for 60 minutes after loss of AC power.

2.15.1.2 Battery Power Calculations

- a. Verify that battery capacity exceeds supervisory and alarm power requirements.
 - (1) Substantiate the battery calculations for alarm and supervisory power requirements. Include ampere-hour requirements for each system component and each control unit component, and compliance with [UL 864](#).
 - (2) Provide complete battery calculations for both the alarm and supervisory power requirements. Submit ampere-hour requirements for each system component with the calculations.
 - (3) Provide [voltage drop calculations](#) to indicate that sufficient voltage is available for proper operation of the system and all components. Calculations must be performed using the minimum rated voltage of each component.
- b. For battery calculations assume a starting voltage of 24 VDC for starting the calculations to size the batteries. Calculate the required Amp-Hours for the specified standby time, and then calculate the required Amp-Hours for the specified alarm time. Using 20.4 VDC as starting voltage, perform a voltage drop calculation for circuits containing device and/or appliances remote from the power sources.

2.15.2 Battery Chargers

Provide a solid state, fully automatic, variable charging rate battery charger. The charger must be capable of providing 120 percent of the connected system load and must maintain the batteries at full charge. In the event the batteries are fully discharged (20.4 Volts dc), the charger must recharge the batteries back to 95 percent of full charge within 48 hours after a single discharge cycle as described in paragraph CAPACITY above. Provide pilot light to indicate when batteries are manually placed on a high rate of charge as part of the unit assembly if a high rate switch is provided.

2.16 SURGE PROTECTIVE DEVICES

[Surge protective devices](#) must be provided to suppress all voltage transients which might damage fire alarm control unit components. Systems having circuits located outdoors, communications equipment must be protected against surges induced on any signaling line circuit. Cables and conductors, that serve as communications links, must have surge protection circuits installed at each end. The surge protective device must wire in series to the power supply of the protected equipment with screw terminations. Line voltage surge arrestor must be installed directly adjacent to the power panel where the [FMCP](#) breaker is located.

- a. Surge protective devices for nominal 120 VAC must be [UL 1449](#) listed with a maximum 500 volt suppression level and have a maximum response time of 5 nanoseconds. The surge protective device must also meet [IEEE C62.41.1](#) and [IEEE C62.41.2](#) category B tests for surge capacity. The surge protective device must feature multi-stage construction and be provided with a long-life indicator lamp (either light emitting

diode or neon) which extinguishes upon failure of protected components. Any unit fusing must be externally accessible.

- b. Surge protective devices for nominal 24 VAC, fire alarm telephone dialer, or ethernet connection must be [UL 497B](#) listed and have a maximum response time of 1-nanosecond. The surge protective device must feature multi-stage construction and be self-resetting. The surge protective device must be a base and plug style. The base assembly must have screw terminals for fire [alarm wiring](#). The base assembly must accept "plug-in" surge protective module.
- c. All surge protective devices (SPD) must be the standard product of a single manufacturer and be equal or better than the following:
 - (1) For 120 VAC nominal line voltage: [UL 1449](#) and [UL 1283](#) listed, series connected 120 VAC, 20A rated, surge protective device in a NEMA 4x enclosure. Minimum 50,000 amp surge current rating with EMI/RFI filtering and a dry contact circuit for remote monitoring of surge protection status.
 - (2) For 24-volt nominal line voltage: [UL 497B](#) listed, series connected low voltage, 24-volt, 5A rated, loop circuit protector, base and replaceable module.
 - (3) For alarm telephone dialers: [UL 497A](#) listed, series connected, 130-volt, 150 mA rated with self-resetting fuse, dialer circuit protector with modular plug and play.
 - (4) For IP-DACTS: [UL 497B](#) listed, series connected, 6.4-volt, 1.5A rated with 20 kA/pair surge current, data network protector with modular plug and play.

2.17 WIRING

Provide wiring materials under this section as specified in Section [26 20 00](#) INTERIOR DISTRIBUTION SYSTEM with the additions and modifications specified herein.

2.17.1 Alarm Wiring

IDC and SLC wiring must be solid copper cable or stranded as permitted by NFPA 70. Copper SLCs and Initiating Device Circuit (IDC) field wiring must be No. 18 AWG size conductors at a minimum. Visual notification appliance circuit conductors, that contain audible alarm appliances, must be No. 16 AWG size conductors at a minimum. Speaker circuits must be copper No. 16 AWG size twisted and shielded conductors at a minimum. Wire size must be sufficient to prevent voltage drop problems. Circuits operating at 24 VDC must not operate at less than the listed voltages for the detectors and/or appliances. Power wiring, operating at 120 VAC minimum, must be a minimum No. 12 AWG solid copper having similar insulation. Acceptable power-limited cables are FPL, FPLR or FPLP as appropriate with red colored covering. Nonpower-limited cables must comply with NFPA 70. THHN wiring is not permitted.

2.18 INTERFACE TO THE BASE-WIDE MASS NOTIFICATION NETWORK

- a. The Government will furnish and install the Cooper Industries TRX-401 mass notification system transceiver.

b. Provide space and all other components required for the connection to the basewide mass notification system. See contract drawings for detailed equipment, including but not limited to, NEMA 4X enclosure, mounting board, antenna, cables, and conduit.

c. Provide the following equipment to the PMO-Base Physical Security Office: three uninterruptible power supplies (Eaton Model UPS-8001), two dual UPS Charging Cables (Eaton Model M50-0459), and one Universal Waves Interface (Eaton Model UWI-1302).

2.19 AUTOMATIC FIRE ALARM TRANSMITTERS

2.19.1 Digital Alarm Communicator Transmitter (DACT)

Provide DACT that is compatible with the existing supervising station fire alarm system. Transmitter must have a means to transmit alarm, supervisory, and trouble conditions via a single transmitter. Transmitter must have a source of power for operation that conforms to NFPA 72. Transmitter must be capable of initiating a test signal daily at any selected time. Transmitter must be arranged to seize telephone circuits in accordance with NFPA 72.

For Cherry Point, use the following: Basewide Fire Alarm Reporting System (FARS) is a network that utilizes fiber as the primary connection and digital telephone lines as the secondary connection. Provide the Bosch B465 Conettix Universal Dual Path Communicator (UPDC) & a 10/100/1000BaseT/TX to 1000BaseLX Media Converter, SC/SM. Provide the UPDC in a dedicated panel (not within the FMCP), and key the panel the same as the FMCP. Power the UPDC from the building FMCP, and monitor its power by the FMCP. The Bosch equipment must communicate with the existing Bosch 6600 receiver (with Microkey automation software) at the MCAS Cherry Point Fire Dispatch station. Facility Systems Service Office (FSSO) government personnel will program all individual points at the head end equipment. Coordinate connection to the FARS and programming with the FARS Administrator. Contact FSSO at email CHPT.FACSS.OMB@USMC.MIL.

2.19.2 Signals to Be Transmitted to the Base Receiving Station

All fire alarms, supervisory alarms and trouble conditions indicated at the FMCP shall be transmitted to the fire alarm receiving station. Transmission shall be point specific via contact ID format with the address, location, and description of the condition as it appears on the FMCP.

2.20 SYSTEM MONITORING

2.20.1 Valves

Each valve affecting the proper operation of a fire protection system, including automatic sprinkler control valves, sprinkler service entrance valve, isolating valves for pressure type waterflow or supervision switches, and valves at backflow preventers, whether supplied under this contract or existing, must be electrically monitored to ensure its proper position. Provide each tamper switch with a separate address.

2.20.2 Room Low Temperature Supervisory Switch

Provide monitoring of the listed supervisory air temperature switch for the sprinkler riser room. Switch must cause a supervisory signal to be transmitted to the FMCP whenever the temperature in the room drops to

below 40 degrees F. Device must reset when temperature rises above 40 degrees F.

2.21 DOCUMENT CABINET

Provide a steel cabinet with a hinge-mounted door and lock with lock cylinder keyed the same as the FMCP. Mount the Document Cabinet on the wall adjacent to the FMCP. Prominently label the exterior of the cabinet "SYSTEM RECORD DOCUMENTS". Cabinet must include paper copies and a CD of Fire Alarm As-Built drawings, List of Contact ID descriptions for the fire alarm addressable devices, Sprinkler As-Built drawings, NFPA 72 & NFPA 13 Records of Completion. CD must also include site-specific software and O&M manuals stored in a CD jewel case.

2.22 SPARE PARTS CABINET

Provide a steel cabinet with a hinge-mounted door and lock with lock cylinder keyed the same as the FMCP. Mount the cabinet on the wall adjacent to the FMCP. Prominently label the exterior of the cabinet "SPARE PARTS".

2.23 ENVIRONMENTAL ENCLOSURES OR GUARDS

Environmental enclosures must be provided to permit fire alarm/mass notification components to be used in areas that exceed the environmental limits of the listing. The enclosure must be listed for the device or appliance as either a manufactured part number or as a listed compatible accessory for the component is currently listed. Guards required to deter mechanical damage must be either a listed manufactured part or a listed accessory for the category of the initiating device or notification appliance.

PART 3 EXECUTION

3.1 INSTALLATION OF FIRE ALARM INITIATING DEVICES AND NOTIFICATION APPLIANCES

3.1.1 Fire Alarm and Mass Notification Control Unit (FMCP)

Locate the FMCP where indicated on the drawings. Surface mount the enclosure with the top of the cabinet 6 feet above the finished floor or center the cabinet at 5 feet, whichever is lower. Conductor terminations must be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection must be permanently mounted in the FMCP. Locate the document storage cabinet adjacent to the FMCP unless the Contracting Officer directs otherwise.

3.1.2 Battery Cabinets

When batteries will not fit in the FMCP, locate battery cabinets below or adjacent to the FMCP. Battery cabinets must be installed at an accessible location when standing at floor level. Battery cabinets must not be installed lower than 12 inches above finished floor, measured to the bottom of the cabinet, nor higher than 36 inches above the floor, measured to the top of the cabinet. Installing batteries above drop ceilings or in inaccessible locations is prohibited. Battery cabinets must be large enough to accommodate batteries and also to allow ample gutter space for interconnection of control units as well as field wiring. The cabinet must be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and surface mounting provisions. The cabinet

must be identified by an engraved phenolic resin nameplate. Lettering on the nameplate must indicate the control unit(s) the batteries power and must not be less than 1-inch high.

3.1.3 Manual Stations

Locate manual stations as required by NFPA 72 and as indicated on the drawings. Mount stations so they are located no farther than 5 feet from the exit door they serve, measured horizontally. Manual stations must be mounted at 44 inches measured to the operating handle.

3.1.4 Notification Appliances

Locate notification appliance devices as required by NFPA 72 and as indicated on the drawings. Provide additional appliances as needed to satisfy intelligibility requirements. Audible and visual notification appliances mounted on the exterior of the building, within unconditioned spaces, or in the vicinity of showers must be listed weatherproof appliances installed on weatherproof backboxes.

3.1.5 Smoke Detectors

Locate detectors as required by NFPA 72 and as indicated on the drawings. Mount detectors on a 4-inch mounting box. Install heat detectors not less than 4 inches from a side wall to the near edge. Smoke detectors are permitted to be on the wall no lower than 12 inches from the ceiling with no minimum distance from the ceiling. Install smoke detectors no closer than 3 feet from air handling supply diffusers.

3.1.6 Carbon Monoxide Detectors

Locate detectors as required by NFPA 72 and as indicated on the drawings on a 4-inch mounting box.

3.1.7 LCD REMOTE Annunciator

Locate the LCD annunciator as shown on the drawings. Mount the annunciator, with the top 6 feet above the finished floor or center the annunciator at 5 feet, whichever is lower.

3.1.8 Local Operating Console (LOC)

Locate the LOC(s) as required by NFPA 72 and as indicated. Mount the console so that the top message button and microphone is no higher than 4 feet above the floor.

3.1.9 Ceiling Bridges

Provide ceiling bridges for ceiling-mounted appliances. Ceiling bridges must be as recommended/required by the manufacturer of the ceiling-mounted notification appliance.

3.2 SYSTEM FIELD WIRING

3.2.1 Wiring within Cabinets, Enclosures, and Boxes

Provide wiring installed in a neat and workmanlike manner and installed parallel with or at right angles to the sides and back of any box, enclosure, or cabinet. Conductors that are terminated, spliced, or

otherwise interrupted in any enclosure, cabinet, mounting, or junction box must be connected to screw-type terminal blocks. Mark each terminal in accordance with the [wiring diagrams](#) of the system. The use of wire nuts or similar devices is prohibited. Wiring to conform with [NFPA 70](#).

Indicate the following in the wiring diagrams:

- a. Point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams must show connections from field devices to the [FMCP](#) and remote fire alarm/mass notification control units, initiating circuits, switches, relays and terminals.
- b. Complete riser diagrams indicating the wiring sequence of devices and their connections to the control equipment. Include a color code schedule for the wiring. Include floor plans showing the locations of devices and equipment.

3.2.2 Terminal Cabinets

Provide a terminal cabinet at the base of any circuit riser, on each floor at each riser, and where indicated on the drawings. Terminal size must be appropriate for the size of the wiring to be connected. Conductor terminations must be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection must be permanently mounted in the terminal cabinet. Minimum size is [8 inches by 8 inches](#). Only screw-type terminals are permitted. Provide an identification label, that displays "FIRE ALARM TERMINAL CABINET" with [2-inch](#) lettering, on the front of the terminal cabinet.

3.2.3 Alarm Wiring

- a. Voltages must not be mixed in any junction box, housing or device, except those containing power supplies and control relays.
- b. Utilize shielded wiring where recommended by the manufacturer. For shielded wiring, ground the shield at only one point, in or adjacent to the [FMCP](#).
- c. [All devices must have screw terminals. Where devices are only provided with pigtails from the manufacturer, pigtails must be landed on terminal strips mounted within the junction box. All terminations must be at a terminal strip or the device screw terminals. Terminal strips are only permitted where direct connection to a device is not possible.](#)
- d. Color coding is required for circuits and must be maintained throughout the circuit. Conductors used for the same functions must be similarly color coded. Conform wiring to [NFPA 70](#).
- e. Pull all conductors splice free. The use of wire nuts, crimped connectors, or twisting of conductors is prohibited.
- f. [Provide labels for all addressable devices, panels, and controls. For any device located above a ceiling, provide legible, typed label on the ceiling to identify its purpose and location. Provide clearance for access, inspection, maintenance, repair, and removal.](#)

3.2.4 Back Boxes and Conduit

In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide all wiring in rigid metal conduit or intermediate metal conduit unless specifically indicated otherwise. Minimum conduit size must be 3/4-inch in diameter except for 1/2-inch drops to individual devices. Do not use electrical non-metallic tubing (ENT) or flexible non-metallic tubing and associated fittings.

- a. Galvanized rigid steel (GRS) conduit must be utilized where exposed to weather, where subject to physical damage, and where exposed on exterior of buildings. Intermediate metal conduit (IMC) may be used in lieu of GRS as allowed by NFPA 70.
- b. Electrical metallic tubing (EMT) is permitted above suspended ceilings or exposed where not subject to physical damage. Do not use EMT underground, encased in concrete, mortar, or grout, in hazardous locations, where exposed to physical damage, outdoors or in fire pump rooms. Use die-cast compression connectors.
- c. For rigid metallic conduit (RMC), only threaded type fitting are permitted for wet or damp locations.
- d. Flexible metal conduit is permitted for initiating device circuits 6 feet in length or less. Flexible metal conduit is prohibited for notification appliance circuits and signaling line circuits. Use liquid tight flexible metal conduit in damp and wet locations.
- e. Schedule 40 (minimum) polyvinyl chloride (PVC) is permitted where conduit is routed underground or underground below floor slabs. Convert non-metallic conduit, other than PVC Schedule 40 or 80, to plastic-coated rigid, or IMC, steel conduit before turning up through floor slab.
- f. Exterior wall penetrations must be weathertight. Conduit must be sealed to prevent the infiltration of moisture.

3.2.5 Conductor Terminations

Labeling of conductors at terminal blocks in terminal cabinets, FMCP and the LOC must be provided at each conductor connection. Each conductor or cable must have a shrink-wrap label to provide a unique and specific designation. Each terminal cabinet, FMCP, and remote FMCP must contain a laminated drawing that indicates each conductor, its label, circuit, and terminal. The laminated drawing must be neat, using 12 point lettering minimum size, and mounted within each cabinet, control unit, or unit so that it does not interfere with the wiring or terminals. Maintain existing color code scheme where connecting to existing equipment.

3.3 CONNECTION OF NEW SYSTEM

The following new system connections must be made during the last phase of construction, at the beginning of the pre-Government tests. New system connections must include:

- a. Connection of new relays to existing magnetic door hold-open devices.
- b. Connection of new elevator recall relays to existing wiring and conduit.

- c. Connection of new system transmitter to existing installation fire reporting system.
- d. Connection of the new transceiver to the existing Installation mass notification system (to be performed by the Government).

Once these connections are made, system must be left energized. Report immediately to the Contracting Officer, coordination and field problems resulting from the connection of the above components.

3.4 FIRESTOPPING

Provide firestopping for holes at conduit penetrations through floor slabs, fire-rated walls, partitions with fire-rated doors, corridor walls, and vertical service shafts in accordance with Section 07 84 00 FIRESTOPPING.

3.5 PAINTING

- a. In unfinished areas (including areas above drop ceilings), paint all exposed electrical conduit (serving fire alarm equipment), fire alarm conduit, surface metal raceway, junction boxes and covers red. In lieu of painting conduit, the contractor may utilize red conduit with a factory applied finish.
- b. In finished areas, paint exposed electrical conduit (serving fire alarm equipment), fire alarm conduit, surface metal raceways, junction boxes, and electrical boxes to match adjacent finishes. The inside cover of the junction box must be identified as "Fire Alarm" and the conduit must have painted red bands 3/4-inch wide at 10-foot centers and at each side of a floor, wall, or ceiling penetration.
- c. Painting must comply with Section 09 90 00 PAINTS AND COATINGS.

3.6 FIELD QUALITY CONTROL

3.6.1 Test Procedures

Submit detailed test procedures, prepared and signed by the NICET Level IV Fire Alarm Technician, and the representative of the installing company, and reviewed by the QFPE 30 days prior to performing system tests. Detailed test procedures must list all components of the installed system such as initiating devices and circuits, notification appliances and circuits, signaling line devices and circuits, control devices/equipment, batteries, transmitting and receiving equipment, power sources/supply, annunciators, special hazard equipment, emergency communication equipment, interface equipment, and surge protective devices. Test procedures must include sequence of testing, time estimate for each test, and sample test data forms. The test data forms must be in a check-off format (pass/fail with space to add applicable test data; similar to the forms in NFPA 72 and NFPA 4.) The test procedures and accompanying test data forms must be used for the pre-Government testing and the Government testing. The test data forms must record the test results and must:

- a. Identify the NFPA Class of all Initiating Device Circuits (IDC), and Notification Appliance Circuits (NAC), Voice Notification System Circuits (NAC Audio), and Signaling Line Circuits (SLC).

- b. Identify each test required by NFPA 72 Test Methods and required test herein to be performed on each component, and describe how these tests must be performed.
- c. Identify each component and circuit as to type, location within the facility, and unique identity within the installed system. Provide necessary floor plan sheets showing each component location, test location, and alphanumeric identity.
- d. Identify all test equipment and personnel required to perform each test (including equipment necessary for smoke detector testing. The use of magnets is not permitted.
- e. Provide space to identify the date and time of each test. Provide space to identify the names and signatures of the individuals conducting and witnessing each test.

3.6.2 Pre-Government Testing

3.6.2.1 Verification of Compliant Installation

Conduct inspections and tests to ensure that devices and circuits are functioning properly. Tests must meet the requirements of paragraph entitled "Minimum System Tests" and "Verification of Compliant Installation" as required by NFPA 72. The contractor and an authorized representative from each supplier of equipment must be in attendance at the pre-Government testing to make necessary adjustments. After inspection and testing is complete, provide a signed Verification of Compliant Installation letter by the QFPE that the installation is complete, compliant with the specification and fully operable. The letter must include the names and titles of the witnesses to the pre-Government tests. Provide all completion documentation as required by NFPA 72 including all referenced annex sections and the test reports noted below.

- a. NFPA 72 Record of Completion.
- b. NFPA 72 Record of Inspection and Testing.
- c. Fire Alarm and Emergency Communication System Inspection and Testing Form.
- d. Audibility test results with marked-up test floor plans.
- e. Intelligibility test results with marked-up floor plans.
- f. Documentation that all tests identified in the paragraph "Minimum System Tests" are complete.

3.6.2.2 Request for Government Final Test

When the verification of compliant installation has been completed, submit a formal request for Government final test to the NAVFAC MIDLANT Designated Fire Protection Engineer (DFPE) or Contracting Offices Designated Representative (COR). Government final testing will not be scheduled until the DFPE has received copies of the request for Government final testing and Verification of Compliant Installation letter with all required reports. Government final testing will not be performed until after the connections to the installation-wide fire reporting system and the installation-wide mass notification system have been completed and

tested to confirm communications are fully functional. Submit request for test at least 15 calendar days prior to the requested test date.

3.6.3 Government Final Tests

The tests must be performed in accordance with the approved test procedures in the presence of the NAVFAC MIDLANT DFPE. Furnish instruments and personnel required for the tests. The following must be provided at the job site for Government Final Testing:

- a. The manufacturer's technical representative.
- b. Marked-up red line drawings of the system as actually installed.
- c. Loop resistance test results.
- d. Complete program printout including input/output addresses.
- e. Copy of pre-Government Test Certificate, test procedures and completed test data forms.
- f. Audibility test results with marked-up floor plans.
- g. Intelligibility test results with marked-up floor plans.

Government Final Tests will be witnessed by the NAVFAC MIDLANT Qualified Fire Protection Engineer (QFPE). At this time, any and all required tests noted in the paragraph "Minimum System Tests" must be repeated at their discretion.

3.6.4 Minimum System Tests

Test the system in accordance with the procedures outlined in NFPA 72. The required tests are as follows:

- a. Loop Resistance Tests: Measure and record the resistance of each circuit with each pair of conductors in the circuit short-circuited at the farthest point from the circuit origin. The tests must be witnessed by the Contracting Officer and test results recorded for use at the final Government test.
- b. Verify the absence of unwanted voltages between circuit conductors and ground. The tests must be accomplished at the pre-Government test with results available at the final system test.
- c. Verify that the control unit is in the normal condition as detailed in the manufacturer's O&M manual.
- d. Test each initiating device and notification appliance and circuit for proper operation and response at the control unit. Smoke detectors must be tested in accordance with manufacturer's recommended calibrated test method. Use of magnets is prohibited. Testing of duct smoke detectors must comply with the requirements of NFPA 72 except disconnect at least 20 percent of devices. If there is a failure at these devices, then supervision must be tested at each device.
- e. Carbon Monoxide Detector Tests: Carbon monoxide detectors must be tested in accordance with NFPA 72 and the manufacturer's recommended calibrated test method.

- f. Test the system for specified functions in accordance with the contract drawings and specifications and the manufacturer's O&M manual.
- g. Test both primary power and secondary power. Verify, by test, the secondary power system is capable of operating the system for the time period and in the manner specified.
- h. Determine that the system is operable under trouble conditions as specified.
- i. Visually inspect wiring.
- j. Test the battery charger and batteries.
- k. Verify that software control and data files have been entered or programmed into the FMCP. Hard copy records of the software must be provided to the Contracting Officer.
- l. Verify that red-line drawings are accurate.
- m. Measure the current in circuits to ensure there is the calculated spare capacity for the circuits.
- n. Measure voltage readings for circuits to ensure that voltage drop is not excessive.
- o. Disconnect the verification feature for smoke detectors during tests to minimize the amount of smoke needed to activate the sensor. Testing of smoke detectors must be conducted using real smoke or the use of canned smoke which is permitted.
- p. Measure the voltage drop at the most remote appliance (based on wire length) on each notification appliance circuit.
- q. Verify the documentation cabinet is installed and contains all as-built shop drawings, product data sheets, design calculations, site-specific software data package, and all documentation required by paragraph titled "Test Reports".

3.6.4.1 Audibility Tests

Sound pressure levels from audible notification appliances must not exceed 110 dBa in any occupiable area. The provisions for audible notification (audibility and intelligibility) must be met with doors, fire shuttes, movable partitions, and similar devices closed.

3.6.4.2 Intelligibility Tests

Intelligibility testing of the System must be accomplished in accordance with NFPA 72 for Voice Evacuation Systems, and ASA S3.2. Following are the specific requirements for intelligibility tests:

- a. Intelligibility Requirements: Verify intelligibility by measurement after installation.
- b. Ensure that a CIS value greater than the required minimum value is provided in each area where building occupants typically could be found. The minimum required value for CIS is .7. Rounding of values

is permitted.

- c. Areas of the building provided with hard wall and ceiling surfaces (such as metal or concrete) that are found to cause excessive sound reflections may be permitted to have a CIS score less than the minimum required value if approved by the DFPE, and if building occupants in these areas can determine that a voice signal is being broadcast and they must walk no more than 33 feet to find a location with at least the minimum required CIS value within the same area.
- d. Areas of the building where occupants are not expected to be normally present are permitted to have a CIS score less than the minimum required value if personnel can determine that a voice signal is being broadcast and they must walk no more than 50 feet to a location with at least the minimum required CIS value within the same area.
- e. Take measurements near the head level applicable for most personnel in the space under normal conditions (e.g., standing, sitting, sleeping, as appropriate).
- f. The distance the occupant must walk to the location meeting the minimum required CIS value must be measured on the floor or other walking surface as follows:
 - (1) Along the centerline of the natural path of travel, starting from any point subject to occupancy with less than the minimum required CIS value.
 - (2) Curving around any corners or obstructions, with a 12 inches clearance there from.
 - (3) Terminating directly below the location where the minimum required CIS value has been obtained.

Use commercially available test instrumentation to measure intelligibility as specified by NFPA 72 as applicable. Use the mean value of at least three readings to compute the intelligibility score at each test location.

3.7 SYSTEM ACCEPTANCE

Following acceptance of the system, [as-built drawings](#) and O&M manuals must be delivered to the Contracting Officer for review and acceptance. The drawings must show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final Government test of the system. At least one set of as-built (marked-up) drawings must be provided at the time of, or prior to the Final Government Test.

- a. Furnish one set of CDs or DVDs containing software back-up and CAD based drawings in latest version of AutoCAD, DXF and portable document formats of as-built drawings and schematics.
- b. Include complete wiring diagrams showing connections between devices and equipment, both factory and field wired.
- c. Include a riser diagram and drawings showing the as-built location of devices and equipment.
- d. Provide [Operation and Maintenance \(O&M\) Instructions](#).

3.8 INSTRUCTION OF GOVERNMENT EMPLOYEES

3.8.1 Instructor

Provide the services of an instructor, who has received specific training from the manufacturer for the training of other persons regarding the operation, inspection, testing, and maintenance of the system provided. The instructor must train the Government employees designated by the Contracting Officer, in the care, adjustment, maintenance, and operation of the fire alarm system. The instructor must be thoroughly familiar with all parts of this installation. The instructor must be trained in operating theory as well as in practical O&M work. Submit the instructors information and qualifications including the training history.

3.8.2 Required Instruction Time

Provide training for the active systems consisting of a minimum of two (2) eight (8)-hour sessions to accommodate all shifts of the base fire department and allow for rescheduling for unforeseen fire department responses. The instruction must be given during regular working hours on such dates and times selected by the Contracting Officer.

3.8.2.1 Technical Training

Provide a factory-trained instructor to teach a five-day technical training classroom instruction for at least five Government personnel at Cherry Point. The technical training shall include classroom instruction as well as hands-on programming, troubleshooting and diagnostics exercises. Provide three laptops for the government's retention. Laptops shall be Windows 10 based and include system software, special connecting cable(s), proprietary equipment necessary for the maintenance, testing and reprogramming of the fire alarm equipment and system. Factory training shall occur within six months of system acceptance.

3.8.3 Technical Training Manual

Provide, in manual format, lesson plans, operating instructions, maintenance procedures, and training data for the training courses. The operations training must familiarize designated government personnel with proper operation of the installed system. The maintenance training course must provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system.

3.9 EXTRA MATERIALS

3.9.1 Repair Service/Replacement Parts

Repair services and replacement parts for the system must be available for a period of 10 years after the date of final acceptance of this work by the Contracting Officer. During the warranty period, the service technician must be on-site within 24 hours after notification. All repairs must be completed within 24 hours of arrival on-site.

During the warranty period, the installing fire alarm contractor is responsible for conducting all required testing and maintenance in accordance with the requirements and recommended practices of NFPA 72 and

the system manufacturers. Installing fire alarm contractor is NOT responsible for any damage resulting from abuse, misuse, or neglect of equipment by the end user.

-- End of Section --

SECTION 31 05 19

GEOTEXTILE
08/08

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION
OFFICIALS (AASHTO)

AASHTO M 288

Class 1 Woven Geotextile

ASTM INTERNATIONAL (ASTM)

ASTM D4354	(2012) Sampling of Geosynthetics for Testing
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491/D4491M	(2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533/D4533M	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2016) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4759	(2011; R 2018) Standard Practice for Determining the Specification Conformance of Geosynthetics
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D6241	(2014) Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control

approval. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

Thread
Manufacturing Quality Control Sampling and Testing

SD-04 Samples

Quality Assurance Samples and Tests

SD-07 Certificates

Geotextile

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver, store, and handle geotextile in accordance with ASTM D4873/D4873M.

1.3.1 Delivery

Notify the Contracting Officer a minimum of 24 hours prior to delivery and unloading of geotextile rolls packaged in an opaque, waterproof, protective plastic wrapping. The plastic wrapping shall not be removed until deployment. If quality assurance samples are collected, immediately rewrap rolls with the plastic wrapping. Geotextile or plastic wrapping damaged during storage or handling shall be repaired or replaced, as directed. Label each roll with the manufacturer's name, geotextile type, roll number, roll dimensions (length, width, gross weight), and date manufactured.

1.3.2 Storage

Protect rolls of geotextile from construction equipment, chemicals, sparks and flames, temperatures in excess of 160 degrees F, or any other environmental condition that may damage the physical properties of the geotextile. To protect geotextile from becoming saturated, either elevate rolls off the ground or place them on a sacrificial sheet of plastic in an area where water will not accumulate.

1.3.3 Handling

Handle and unload geotextile rolls with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Rolls shall not be dragged along the ground, lifted by one end, or dropped to the ground.

PART 2 PRODUCTS

2.1 RAW MATERIALS

A minimum of 7 days prior to scheduled use, submit manufacturer's certificate of compliance stating that the geotextile meets the requirements of this section. The certificate of compliance shall be attested to by a person having legal authority to bind the geotextile manufacturer.

2.1.1 Geotextile

Provide geotextile that is a woven pervious sheet in accordance with AASHTO M 288 of polymeric material consisting of long-chain synthetic polymers composed of at least 95 percent by weight polyolefins, polyesters, or polyamides. The use of woven slit film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character) will not be allowed. Add stabilizers and/or inhibitors to the base polymer, as needed, to make the filaments resistant to deterioration by ultraviolet light, oxidation, and heat exposure. Regrind material, which consists of edge trimmings and other scraps that have never reached the consumer, may be used to produce the geotextile. Post-consumer recycled material shall not be used. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Geotextiles shall meet the requirements specified in Table 1. Where applicable, Table 1 property values represent minimum average roll values (MARV) in the weakest principal direction. Values for AOS represent maximum average roll values.

PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
GRAB TENSILE ELONGATION	%	<50	ASTM D4632/D4632M
GRAB TENSILE STRENGTH	LBS	160	ASTM D4632/D4632M
CBR PUNCTURE	LBS	410	ASTM D6241
TRAPEZOID TEAR	LBS	60	ASTM D4533/D4533M
APPARENT OPENING SIZE	U.S. SIEVE	80	ASTM D4751
PERMITTIVITY	SEC -1	1.5	ASTM D4491/D4491M
ULTRAVIOLET DEGRADATION	PERCENT	70 AT 500 HRS	ASTM D4355/D4355M

2.1.2 Thread

A minimum of 7 days prior to scheduled use, submit proposed thread type for sewn seams along with data sheets showing the physical properties of the thread. Construct sewn seams with high-strength polyester, nylon, or other approved thread type. Thread shall have ultraviolet light stability equivalent to the geotextile and the color shall contrast with the geotextile.

2.2 MANUFACTURING QUALITY CONTROL SAMPLING AND TESTING

The Manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification. A minimum of 7 days prior to scheduled use, submit

manufacturer's quality control manual. Documentation describing the quality control program shall be made available upon request. Perform manufacturing quality control sampling and testing in accordance with the manufacturer's approved quality control manual. As a minimum, geotextiles shall be randomly sampled for testing in accordance with [ASTM D4354](#), Procedure A. Acceptance of geotextile shall be in accordance with [ASTM D4759](#). Tests not meeting the specified requirements will result in the rejection of applicable rolls.

PART 3 EXECUTION

3.1 QUALITY ASSURANCE SAMPLES AND TESTS

3.1.1 Quality Assurance Samples

Provide assistance to the Contracting Officer in the collection of quality assurance samples for quality assurance testing; assign 7 days in the schedule to allow for testing. Collect samples upon delivery to the site at the request of the Contracting Officer. Lot size for quality assurance sampling shall be considered to be the shipment quantity of the product or a truckload of the product, whichever is smaller. The unit size shall be considered one roll of geotextile. Identify samples with a waterproof marker by manufacturer's name, product identification, lot number, roll number, and machine direction. The date and a unique sample number shall also be noted on the sample. Discard the outer layer of the geotextile roll prior to sampling a roll. Samples shall then be collected by cutting the full-width of the geotextile sheet a minimum of [3 feet](#) long in the machine direction. Rolls which are sampled shall be immediately resealed in their protective covering.

3.1.2 Quality Assurance Tests

Provide quality assurance samples to an Independent Laboratory. Samples will be tested to verify that geotextile meets the requirements specified in Table 1. Test method [ASTM D4355/D4355M](#) shall not be performed on the collected samples. Geotextile product acceptance shall be based on [ASTM D4759](#). Tests not meeting the specified requirements will result in the rejection of applicable rolls.

3.2 INSTALLATION

3.2.1 Subgrade Preparation

The surface underlying the geotextile shall be smooth and free of ruts or protrusions which could damage the geotextile. Subgrade materials and compaction requirements shall be in accordance with Section [31 23 00.00 20 EXCAVATION AND FILL](#).

3.2.2 Placement

Notify the Contracting Officer a minimum of 24 hours prior to installation of geotextile. Geotextile rolls which are damaged or contain imperfections shall be repaired or replaced as directed. The geotextile shall be laid flat and smooth so that it is in direct contact with the subgrade. The geotextile shall also be free of tensile stresses, folds, and wrinkles.

3.3 SEAMS

3.3.1 Overlap Seams

Continuously overlap geotextile panels a minimum of 24 inches at all longitudinal and transverse joints. Where seams must be oriented across the slope, lap the upper panel over the lower panel.

3.4 PROTECTION

Protect the geotextile during installation from clogging, tears, and other damage. Damaged geotextile shall be repaired or replaced as directed. Use adequate ballast (e.g. sand bags) to prevent uplift by wind. The geotextile shall not be left uncovered for more than 7 days after installation.

3.5 REPAIRS

Repair torn or damaged geotextile. Clogged areas of geotextile shall be removed. Perform repairs by placing a patch of the same type of geotextile over the damaged area. The patch shall extend a minimum of 24 inches beyond the edge of the damaged area. Patches shall be continuously fastened using approved methods. The machine direction of the patch shall be aligned with the machine direction of the geotextile being repaired. Remove and replace geotextile rolls which cannot be repaired. Repairs shall be performed at no additional cost to the Government

3.6 PENETRATIONS

Construct engineered penetrations of the geotextile by methods recommended by the geotextile manufacturer.

3.7 COVERING

Do not cover geotextile prior to inspection and approval by the Contracting Officer. Place aggregate base course in a manner that prevents material from entering the geotextile overlap zone, prevents tensile stress from being mobilized in the geotextile, and prevents wrinkles from folding over onto themselves. Aggregate base course shall not be dropped onto the geotextile from a height greater than 3 feet. No equipment shall be operated directly on top of the geotextile without approval of the Contracting Officer. Aggregate base course material, compaction, and testing requirements are described in Section 32 11 20 AGGREGATE BASE COURSE. Equipment placing aggregate base course shall not stop abruptly, make sharp turns, spin their wheels, or travel at speeds exceeding 5 mph.

-- End of Section --

SECTION 31 11 00
CLEARING AND GRUBBING
11/18

PART 1 GENERAL

1.1 REFERENCES

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

U.S. DEPARTMENT OF DEFENSE (DOD)

DODI 4150.07 (2019) DOD Pest Management Program

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section **01 33 29.05 20** SUSTAINABILITY REPORTING. Submit the following in accordance with Section **01 33 00.05 20** SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Herbicide Application Plan

SD-03 Product Data

Tree Wound Paint

Herbicides

SD-07 Certificates

Qualifications

SD-11 Closeout Submittals

Pest Management Report

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

Comply with **DODI 4150.07** for requirements on Contractor's licensing, certification, and record keeping. Maintain daily records using the Pest Management Maintenance Record, DD Form 1532-1, or a computer generated equivalent. These forms may be obtained from the main web site:
<http://www.dtic.mil/whs/directives/forms/eforms/dd1532-1.pdf>

1.3.2 Qualifications

For the application of herbicides, use the services of an applicator who

is commercially certified in the state where the work is to be performed as required by DODI 4150.07. Submit a copy of the pesticide applicator certificates.

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site, and handle in a manner which will maintain the materials in their original manufactured or fabricated condition until ready for use.

1.4.1 Storage

Storage of herbicides on the installation will not be permitted unless it is written into the contract.

1.4.2 Handling

Handle herbicides in accordance with the manufacturer's label and Safety Data Sheet (SDS), preventing contamination by dirt, water, and organic material. Protect herbicides from weather elements as recommended by the manufacturer's label and SDS. Spill kits must be maintained on herbicide control vehicles. Mixing of herbicides on the installation will not be permitted unless it is written into the contract.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Tree Wound Paint

Use bituminous based paint from standard manufacture specially formulated for tree wounds.

2.1.2 Herbicide

Provide herbicides currently registered by the EPA or approved for such use by the appropriate agency of the host county and approved by the Contracting Officer. Select a herbicide that is suitable for the climatic conditions at the project site. Submit manufacturer's label and SDS for herbicides proposed for use.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Herbicide Application Plan

Prior to commencing application of herbicide, submit a herbicide application plan with proposed sequence of treatment work including dates and times of application. Include the herbicide trade name, EPA registration number, chemical composition, formulation, application rate of active ingredients, method of application, area or volume treated, and amount applied. Include a copy of the pesticide applicator certificates.

3.1.2 Protection

3.1.2.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

3.1.2.2 Trees, Shrubs, and Existing Facilities

Protect trees and vegetation to be left standing from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

3.1.2.3 Utility Lines

Protect existing utility lines that are indicated to remain from damage. Notify the Contracting Officer immediately of damage to or an encounter with an unknown existing utility line. The Contractor is responsible for the repair of damage to existing utility lines that are indicated or made known to the Contractor prior to start of clearing and grubbing operations. When utility lines which are to be removed are encountered within the area of operations, notify the Contracting Officer in ample time to minimize interruption of the service. Refer to Section 01 30 00.05 20 ADMINISTRATIVE REQUIREMENTS and Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS for additional utility protection.

3.2 Application

3.2.1 Herbicide Application

Adhere to safety precautions as recommended by the manufacturer concerning handling and application of the herbicide.

3.2.1.1 Clean Up, Disposal, And Protection

Once application has been completed, proceed with clean up and protection of the site without delay. Clean the site of all material associated with the treatment measures, according to label instructions, and as indicated. Remove and dispose of excess and waste material off Government property.

3.2.1.1.1 Disposal of Herbicide

Dispose of residual herbicides and containers off Government property, and in accordance with the approved disposal plan, label instructions and EPA requirements.

3.3 CLEARING

Clearing consists of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Clearing also includes the removal and disposal of structures that obtrude, encroach upon, or otherwise obstruct the work. Cut off flush with or below the original ground surface trees, stumps, roots, brush, and other vegetation in areas to be cleared, except such trees and vegetation as may be indicated or directed to be left standing. Trim dead branches 1-1/2 inches or more in diameter on trees designated to be left standing within the cleared areas and trim all branches to the heights indicated or directed. Neatly cut close to the bole of the tree or main branches, limbs and branches to be trimmed. Paint, with an approved tree-wound paint, cuts more than 1-1/2 inches in diameter. Apply herbicide in accordance with the manufacturer's label to the top surface of stumps designated not to be removed.

3.3.1 Tree Removal

Where indicated or directed, trees and stumps that are designated as trees shall be removed from areas outside those areas designated for clearing and grubbing. This work includes the felling of such trees and the removal of their stumps and roots as specified in paragraph GRUBBING. Dispose of trees as specified in paragraph DISPOSAL OF MATERIALS.

3.3.2 Grubbing

Grubbing consists of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Remove material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, to a depth of not less than 24 inches below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Fill depressions made by grubbing with suitable material and compact to make the surface conform with the original adjacent surface of the ground.

3.4 DISPOSAL OF MATERIALS

Dispose of excess materials in accordance with the approved solid waste management permit and include those materials in the solid waste management report.

All wood or wood like materials, except for salable timber, remaining from clearing, pruning or grubbing such as limbs, tree tops, roots, stumps, logs, rotten wood, and other similiar materials shall become the property of the Contractor and disposed of as specified. All non-saleable timber and wood or wood like materials remaining from timber harvesting such as limbs, tree tops, roots, stumps, logs, rotten wood, and other similiar materials shall become the property of the Contractor and disposed as specified.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Herbicides

Upon completion of this work, submit the Pest Management Report DD Form 1532, or an equivalent computer product, to the Integrated Pest Management Coordinator. This form identifies the type of operation, brand name and manufacturer of herbicide, formulation, concentration or rate of application used.

-- End of Section --

SECTION 31 23 00.00 20

EXCAVATION AND FILL
02/11

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600 (2017) Installation of Ductile-Iron Mains and Their Appurtenances

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M (2018) Standard Specification for Concrete Aggregates

ASTM C136/C136M (2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM D698 (2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

ASTM D1140 (2017) Standard Test Methods for Determining the Amount of Material Finer than 75- μ m (No. 200) Sieve in Soils by Washing

ASTM D1556/D1556M (2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

ASTM D1557 (2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³) (2700 kN-m/m³)

ASTM D1883 (2016) Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D2216 (2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

ASTM D2321 (2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

ASTM D2487 (2017; E 2020) Standard Practice for

	Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D3786/D3786M	(2018) Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491/D4491M	(2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533/D4533M	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2016) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4759	(2011; R 2018) Standard Practice for Determining the Specification Conformance of Geosynthetics
ASTM D4833/D4833M	(2007; E 2013; R 2013) Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM D5084	(2016a) Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
U.S. ARMY CORPS OF ENGINEERS (USACE)	
EM 385-1-1	(2014) Safety and Health Requirements Manual
U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)	
EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

1.2 DEFINITIONS

1.2.1 Capillary Water Barrier

A layer of clean, poorly graded crushed rock, stone, or natural sand or gravel having a high porosity which is placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below a slab.

1.2.2 Degree of Compaction

Degree of compaction is expressed as a percentage of the maximum density obtained by the test procedure presented in [ASTM D698](#), for general soil types, abbreviated as percent laboratory maximum density.

1.2.3 Hard Materials

Weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" but which usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.4 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding [1 cubic yard](#) in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section [01 33 29.05 20](#) SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section [01 33 00.05 20](#) CONSTRUCTION SUBMITTAL PROCEDURES:

[SD-01 Preconstruction Submittals](#)

[Shoring and Sheeting Plan](#)

[Dewatering work plan](#)

Submit 15 days prior to starting work.

[SD-06 Test Reports](#)

[Borrow Site Testing](#)

[Fill and backfill test](#)

[Select material test](#)

Porous fill test for capillary water barrier

Density tests

Moisture Content Tests

Copies of all laboratory and field test reports within 24 hours of the completion of the test.

1.4 DELIVERY, STORAGE, AND HANDLING

Perform in a manner to prevent contamination or segregation of materials.

1.5 CRITERIA FOR BIDDING

Base bids on the following criteria:

- a. Surface elevations are as indicated.
- b. Pipes or other artificial obstructions, except those indicated, will not be encountered.
- c. Ground water elevations indicated by the boring log were those existing at the time subsurface investigations were made and do not necessarily represent ground water elevation at the time of construction.
- d. Ground water elevation is between 30-40 inches below existing surface elevation.
- e. Material character is indicated by the boring logs.
- f. Hard materials and rock will not be encountered in excavations.
- g. Borrow material, suitable backfill, and bedding material in the quantities required is not available at the project site

1.6 REQUIREMENTS FOR OFF SITE SOIL

Soils brought in from off site for use as backfill shall be tested for petroleum hydrocarbons, BTEX, PCBs and HW characteristics (including toxicity, ignitability, corrosivity, and reactivity). Backfill shall not contain concentrations of these analytes above the appropriate State and/or EPA criteria, and shall pass the tests for HW characteristics. Determine petroleum hydrocarbon concentrations by using appropriate State protocols. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5035/8260B. Perform complete TCLP in accordance with EPA SW-846.3-3 Method 1311. Perform HW characteristic tests for ignitability, corrosivity, and reactivity in accordance with accepted standard methods. Perform PCB testing in accordance with accepted standard methods for sampling and analysis of bulk solid samples. Provide borrow site testing for petroleum hydrocarbons and BTEX from a grab sample of material from the area most likely to be contaminated at the borrow site (as indicated by visual or olfactory evidence), with at least one test from each borrow site. For each borrow site, provide borrow site testing for HW characteristics from a composite sample of material, collected in accordance with standard soil sampling techniques. Do not bring material onsite until tests results have been received and approved by the Contracting Officer.

1.7 QUALITY ASSURANCE

1.7.1 Shoring and Sheet piling Plan

Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheet piling of excavations. Drawings shall include material sizes and types, arrangement of members, and the sequence and method of installation and removal. Calculations shall include data and references used.

1.7.2 Dewatering Work Plan

Submit procedures for accomplishing dewatering work.

1.7.3 Utilities

Movement of construction machinery and equipment over pipes and utilities during construction shall be at the Contractor's risk. Perform work adjacent to non-Government utilities as indicated in accordance with procedures outlined by utility company. Report damage to utility lines or subsurface construction immediately to the Contracting Officer.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Satisfactory Materials

Any materials classified by [ASTM D2487](#) as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SC, CL-ML free of debris, roots, wood, scrap material, vegetation, refuse, soft unsound particles, and frozen, deleterious, or objectionable materials. Unless specified otherwise, the maximum particle diameter shall be one-half the lift thickness at the intended location.

2.1.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials. Unsatisfactory materials also include man-made fills, trash, refuse, or backfills from previous construction. Unsatisfactory material also includes material classified as satisfactory which contains root and other organic matter, frozen material, and stones larger than [4 inches](#). The Contracting Officer shall be notified of any contaminated materials.

2.1.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in [ASTM D2487](#) as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM, GP-GM, GW-GM, SW-SM, SP-SM, and SM shall be identified as cohesionless only when the fines are nonplastic (plasticity index equals zero). Materials classified as GM and SM will be identified as cohesive only when the fines have a plasticity index greater than zero.

2.1.4 Expansive Soils

Soils that have a plasticity index equal to or greater than [15](#) when tested in accordance with [ASTM D4318](#).

2.1.5 Nonfrost Susceptible (NFS) Material

A uniformly graded washed sand with a maximum particle size of **3/8 inch** and less than 5 percent passing the **No. 200** size sieve, and with not more than 3 percent by weight finer than 0.02 mm grain size.

2.1.6 Common Fill

Approved, unclassified soil material with the characteristics required to compact to the soil density specified for the intended location.

2.1.7 Backfill and Fill Material

ASTM D2487, classification GW, GP, GM, SW, SP, SM, SC with a maximum **ASTM D4318** liquid limit of 35, maximum **ASTM D4318** plasticity index of 12, and a maximum of 25 percent by weight passing **ASTM D1140**, **No. 200** sieve.

2.1.8 Select Material

Provide materials classified as **GW, GP, GM, GP-GM, GW-GM, SW, SP, SM, SW-SM, AND SP-SM** or by **ASTM D2487** where indicated. The liquid limit of such material shall not exceed **20** percent when tested in accordance with **ASTM D4318**. The plasticity index shall not be greater than **6** percent when tested in accordance with **ASTM D4318**, and not more than **25** percent by weight shall be finer than **No. 200** sieve when tested in accordance with **ASTM D1140**. Coefficient of permeability shall be a minimum of **0.002 feet per minute** when tested in accordance with **ASTM D5084**.

Bearing Ratio: At **0.1 inch** penetration, the bearing ratio shall be **18** percent at 95 percent **ASTM D698** maximum density as determined in accordance with **ASTM D1883** for a laboratory soaking period of not less than 4 days. Maximum expansion shall be **2** percent. The combined material shall conform to the following sieve analysis:

Sieve Size	Percent Passing by Weight
2 1/2 inches	100
No. 4	40 - 85
No. 10	20 - 80
No. 40	10 - 60
No. 200	5-25

2.1.9 Topsoil

Provide as specified in Section **32 92 19 SEEDING**.

2.2 POROUS FILL FOR CAPILLARY WATER BARRIER

ASTM C33/C33M fine aggregate grading with a maximum of 3 percent by weight passing ASTM D1140, No. 200 sieve, or coarse aggregate Size 57, 67, or 77 and conforming to the general soil material requirements specified in paragraph entitled "Satisfactory Materials."

2.3 UTILITY BEDDING MATERIAL

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 ASTM D2321 materials as follows:

- a. Class I: Angular, 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.
- b. Class II: Coarse sands and gravels with maximum particle size of 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.

2.3.1 Sand

Clean, coarse-grained sand classified as A-1, A-1-a, A-1-b, A-2-4, or A-2-5 in accordance with NCDOT borrow pit standards for bedding and backfill as indicated.

2.3.2 Gravel

Clean, coarsely graded natural gravel, crushed stone or a combination thereof having a classification of GW or GP in accordance with ASTM D2487 for as indicated. Maximum particle size shall not exceed 3 inches.

2.4 BORROW

Obtain borrow materials required in excess of those furnished from excavations from sources outside of Government property.

2.5 BACKFILL FOR UNDERDRAINAGE SYSTEMS & SPECIAL GRANULAR FILTER MATERIAL

Clean sand, crushed rock, or gravel conforming to ASTM C33/C33M coarse aggregate grading size 57, 67, or 78.

2.6 FILTER FABRIC

Provide a pervious sheet of polyester, nylon, glass or polypropylene filaments non-woven, spun bonded, fused, or otherwise manufactured into a nonraveling fabric with uniform thickness and strength where specified on drawings. Fabric shall have the following manufacturer certified minimum average roll properties as determined by ASTM D4759:

	<u>Class A</u>
a. Grab tensile strength (ASTM D4632/D4632M) machine and transversed direction	min. 180
b. Grab elongation (ASTM D4632/D4632M) machine and transverse direction	min. 15
c. Puncture resistance (ASTM D4833/D4833M)	min. 80
d. Mullen burst strength (ASTM D3786/D3786M)	min. 290
e. Trapezoidal Tear (ASTM D4533/D4533M)	min. 50
f. Apparent Opening Size (ASTM D4751)	.6 mm
g. Permeability (ASTM D4491/D4491M)	k fabric greater than k Soil
h. Ultraviolet Degradation (ASTM D4355/D4355M)	70 percent Strength retained at 150 hours

2.7 MATERIAL FOR RIP-RAP

Bedding material, filter fabric and rock conforming to NC DOT standard specification Section 1042 for size and class of material indicated on drawings.

2.7.1 Bedding Material

Consisting of sand, gravel, or crushed rock, well graded, with a maximum particle size of 2 inches. Material shall be composed of tough, durable particles. Fines passing the No. 200 standard sieve shall have a plasticity index less than six.

2.7.2 Grout

Composed of cement, water, an air-entraining admixture, and sand mixed in proportions of one part portland cement to two parts of sand, sufficient water to produce a workable mixture, and an amount of admixture which will entrain sufficient air to produce durable grout, as determined by the Contracting Officer. Mix grout in a concrete mixer. Mixing time shall be sufficient to produce a mixture having a consistency permitting gravity flow into the interstices of the rip-rap with limited spading and brooming. Carefully place rip-rap into grout bed whereas grout disperses into stone by displacement, do not apply grout to top of stone surface to avoid smearing grout on exposed surface of stone.

2.7.3 Rock

Rock fragments sufficiently durable to ensure permanence in the structure and the environment in which it is to be used. Rock fragments shall be free from cracks, seams, and other defects that would increase the risk of

deterioration from natural causes. The size of the fragments shall be such that no individual fragment exceeds a weight of **150 pounds** and that no more than 10 percent of the mixture, by weight, consists of fragments weighing **5 pounds** or less each. Specific gravity of the rock shall be a minimum of **2.40**. The inclusion of more than trace **2** percent quantities of dirt, sand, clay, and rock fines will not be permitted.

2.8 BURIED WARNING AND IDENTIFICATION TAPE

Polyethylene plastic and metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, **3 inch** minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. 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:	Potable Water Systems
Green:	Sewer Systems
White:	Steam Systems
Gray:	Compressed Air
Purple:	Non Potable, Reclaimed Water, Irrigation and Slurry lines

2.8.1 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 **0.003 inch**. Tape shall have a minimum strength of **1500 psi** lengthwise, and **1250 psi** crosswise, with a maximum 350 percent elongation.

2.8.2 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 **0.004 inch**. Tape shall have a minimum strength of **1500 psi** lengthwise and **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 **3 feet** deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.9 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 PROTECTION

3.1.1 Shoring and Sheeting

Provide shoring bracing and sheeting where indicated. In addition to Section 25 A and B of EM 385-1-1, include provisions in the shoring and sheeting plan that will accomplish the following:

- a. Prevent undermining of pavements, foundations and slabs.
- b. Prevent slippage or movement in banks or slopes adjacent to the excavation.

3.1.2 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.2.1 Drainage

So that construction operations progress successfully, completely drain construction site during periods of construction to keep soil materials sufficiently dry. The Contractor shall establish/construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and/or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils, prevent erosion and undermining of foundations. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed. Excavated slopes and backfill surfaces shall be protected to prevent erosion and sloughing. Excavation shall be performed so that the site, the area immediately surrounding the site, and the area affecting operations at the site shall be continually and effectively drained.

3.1.2.2 Dewatering

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 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 1 feet below the working level.

Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly.

3.1.3 Underground Utilities

Location of the existing utilities indicated is approximate. The Contractor shall physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Contractor shall contact the DPW for assistance in locating existing utilities.

3.1.4 Machinery and Equipment

Movement of construction machinery and equipment over pipes during construction shall be at the Contractor's risk. Repair, or remove and provide new pipe for existing or newly installed pipe that has been displaced or damaged.

3.2 SURFACE PREPARATION

3.2.1 Clearing and Grubbing

Unless indicated otherwise, remove trees, stumps, logs, shrubs, brush and vegetation and other items that would interfere with construction operations within the clearing limits. Remove stumps entirely. Grub out matted roots and roots over 2 inches in diameter to at least 24 inches below existing surface.

3.2.2 Stripping

Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Material unsuitable for use as topsoil shall be stockpiled and used for backfilling. Locate topsoil so that the material can be used readily for the finished grading. Where sufficient existing topsoil conforming to the material requirements is not available on site, provide borrow materials suitable for use as topsoil. Protect topsoil and keep in segregated piles until needed.

3.2.3 Unsuitable Material

Remove vegetation, debris, decayed vegetable matter, sod, mulch, and rubbish underneath paved areas or concrete slabs.

3.3 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Reuse excavated materials that meet the specified requirements for the material type required at the intended location. Keep excavations free from water. Excavate soil disturbed or weakened by Contractor's operations, soils softened or made unsuitable for subsequent construction due to exposure to weather. Excavations below indicated depths will not be permitted except to remove unsatisfactory material. Unsatisfactory material encountered below the grades shown shall be removed as directed. Refill with satisfactory material and compact to 95 percent of ASTM D698 maximum density. Unless specified otherwise, refill excavations cut below indicated depth with satisfactory material and compact to 95 percent of ASTM D698 maximum density. Satisfactory material removed below the depths

indicated, without specific direction of the Contracting Officer, shall be replaced with satisfactory materials to the indicated excavation grade; except as specified for spread footings. Determination of elevations and measurements of approved overdepth excavation of unsatisfactory material below grades indicated shall be done under the direction of the Contracting Officer.

3.3.1 Structures With Spread Footings

Ensure that footing subgrades have been inspected and approved by the Contracting Officer prior to concrete placement. Fill over excavations with concrete during foundation placement.

3.3.2 Pile Cap Excavation and Backfilling

Excavate to bottom of pile cap prior to placing or driving piles, unless authorized otherwise by the Contracting Officer. Backfill and compact overexcavations and changes in grade due to pile driving operations to 95 percent of [ASTM D698](#) maximum density.

3.3.3 Pipe Trenches

Excavate to the dimension indicated. Grade bottom of trenches to provide uniform support for each section of pipe after pipe bedding placement. Tamp if necessary to provide a firm pipe bed. Recesses shall be excavated to accommodate bells and joints so that pipe will be uniformly supported for the entire length. Rock, where encountered, shall be excavated to a depth of at least [6 inches](#) below the bottom of the pipe.

3.3.4 Hard Material Excavation

Remove hard material to elevations indicated in a manner that will leave foundation material in an unshattered and solid condition. Roughen level surfaces and cut sloped surfaces into benches for bond with concrete. Protect shale from conditions causing decomposition along joints or cleavage planes and other types of erosion. Removal of hard material beyond lines and grades indicated will not be grounds for a claim for additional payment unless previously authorized by the Contracting Officer. Excavation of the material claimed as rock shall not be performed until the material has been cross sectioned by the Contractor and approved by the Contracting Officer. Common excavation shall consist of all excavation not classified as rock excavation.

3.3.5 Excavated Materials

Satisfactory excavated material required for fill or backfill shall be placed in the proper section of the permanent work required or shall be separately stockpiled if it cannot be readily placed. Satisfactory material in excess of that required for the permanent work and all unsatisfactory material shall be disposed of as specified in Paragraph "DISPOSITION OF SURPLUS MATERIAL."

3.3.6 Final Grade of Surfaces to Support Concrete

Excavation to final grade shall not be made until just before concrete is to be placed. Only excavation methods that will leave the foundation rock in a solid and unshattered condition shall be used. Approximately level surfaces shall be roughened, and sloped surfaces shall be cut as indicated into rough steps or benches to provide a satisfactory bond. Shales shall

be protected from slaking and all surfaces shall be protected from erosion resulting from ponding or flow of water.

3.4 SUBGRADE PREPARATION

Unsatisfactory material in surfaces to receive fill or in excavated areas shall be removed and replaced with satisfactory materials as directed by the Contracting Officer. The surface shall be scarified to a depth of 6 inches before the fill is started. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When subgrades are less than the specified density, the ground surface shall be broken up to a minimum depth of 6 inches, pulverized, and compacted to the specified density. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 12 inches and compacted as specified for the adjacent fill. Material shall not be placed on surfaces that are muddy, frozen, or contain frost. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Material shall be moistened or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Minimum subgrade density shall be as specified herein.

3.4.1 Proof Rolling

Proof rolling shall be done on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade of the building and pavement areas with six passes of a 15 ton, pneumatic-tired roller. Operate the roller in a systematic manner to ensure the number of passes over all areas, and at speeds between 2 1/2 to 3 1/2 miles per hour. When proof rolling under buildings, the building subgrade shall be considered to extend 5 feet beyond the building lines, and one-half of the passes made with the roller shall be in a direction perpendicular to the other passes. Notify the Contracting Officer a minimum of 3 days prior to proof rolling. Proof rolling shall be performed in the presence of the Contracting Officer. Rutting or pumping of material shall be undercut as directed by the Contracting Officer to a depth of 18 inches and replaced with select material.

3.5 SUBGRADE FILTER FABRIC

Place synthetic fiber filter fabric as indicated directly on prepared subgrade free of vegetation, stumps, rocks larger than 2 inches diameter and other debris which may puncture or otherwise damage the fabric. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 2 feet overlap in all directions. Overlap fabric at joints a minimum of 2 feet. Obtain approval of filter fabric installation before placing fill or backfill. Place fill or backfill on fabric in the direction of overlaps and compact as specified herein. Follow manufacturer's recommended installation procedures.

3.6 FILLING AND BACKFILLING

Fill and backfill to contours, elevations, and dimensions indicated. Compact each lift before placing overlaying lift.

3.6.1 Common Fill Placement

Provide for general site .Use satisfactory materials. Place in 6 inch compacted lifts. Compact areas not accessible to rollers or compactors with mechanical hand tampers. Aerate material excessively moistened by rain to a satisfactory moisture content. Finish to a smooth surface by blading, rolling with a smooth roller, or both.

3.6.2 Backfill and Fill Material Placement

Provide for paved areas and under concrete slabs, except where select material is provided. Place in 6 inch compacted lifts. Do not place over wet or frozen areas. Place backfill material adjacent to structures as the structural elements are completed and accepted. Backfill against concrete only when approved. Place and compact material to avoid loading upon or against the structure.

3.6.3 Select Material Placement

Provide under porous fill of structures not pile supported. Place in 6 inch compacted lifts. Do not place over wet or frozen areas. Backfill adjacent to structures shall be placed as structural elements are completed and accepted. Backfill against concrete only when approved. Place and compact material to avoid loading upon or against structure.

3.6.4 Backfill and Fill Material Placement Over Pipes and at Walls

Backfilling shall not begin until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Backfill shall be brought to indicated finish grade . Where pipe is coated or wrapped for protection against corrosion, the backfill material up to an elevation 2 feet above sewer lines and 1 foot above other utility lines shall be free from stones larger than 1 inch in any dimension. Heavy equipment for spreading and compacting backfill shall not be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; the area remaining shall be compacted in layers not more than 6 inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Backfill shall be placed carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Backfill shall not be placed against foundation walls prior to 7 days after completion of the walls. As far as practicable, backfill shall be brought up evenly on each side of the wall and sloped to drain away from the wall.

3.6.5 Porous Fill Placement

Provide under floor and area-way slabs on a compacted subgrade. Place in 4 inch lifts with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.6.6 Trench Backfilling

Backfill as rapidly as construction, testing, and acceptance of work permits. Place and compact backfill under structures and paved areas in 6 inch lifts to top of trench and in 6 inch lifts to one foot over pipe outside structures and paved areas.

3.7 BORROW

Where satisfactory materials are not available in sufficient quantity from required excavations, approved borrow materials shall be obtained as specified herein.

3.8 BURIED WARNING AND IDENTIFICATION TAPE

Provide buried utility lines with utility identification tape. Bury tape **12 inches** below finished grade; under pavements and slabs, bury tape **6 inches** below top of subgrade.

3.9 BURIED DETECTION WIRE

Bury detection wire directly above non-metallic piping at a distance not to exceed **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 **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.

3.10 COMPACTION

Determine in-place density of existing subgrade; if required density exists, no compaction of existing subgrade will be required.

3.10.1 General Site

Compact underneath areas designated for vegetation and areas outside the **5 foot** line of the paved area or structure to 85 percent of **ASTM D698**.

3.10.2 Structures, Spread Footings, and Concrete Slabs

Compact top **12 inches** of subgrades to 95 percent of **ASTM D698**. Compact fill and backfill material select material to 95 percent of **ASTM D698**.

3.10.3 Adjacent Area

Compact areas within **5 feet** of structures to 90 percent of **ASTM D698**.

3.10.4 Paved Areas

Compact top **12 inches** of subgrades to 95 percent of **ASTM D698**. Compact fill and backfill materials to 95 percent of **ASTM D698**.

3.11 SPECIAL EARTHWORK REQUIREMENTS FOR SUBSURFACE DRAINS

Excavate to dimensions indicated. Provide a bedding surface of no more than **one inch** of sand or **coarse** gravel and place on compacted native soil as indicated. Backfill around and over the pipes **only** after pipe installation has been approved. Place special granular filter material in **6 inch** lifts and compact with mechanical, vibrating plate tampers or rammers until no further consolidation can be achieved. Compact backfill overlying the special granular filter material as specified for adjacent or overlying work.

3.11.1 Granular Backfill Using Filter Fabric

3.11.1.1 Perforated or Slotted Wall Pipes

Wrap one layer of filter fabric around pipe in such a manner that longitudinal overlaps are in unperforated or unslotted quadrants of the pipe. Overlap fabric a minimum of 6 inches. Secure fabric to pipe so that backfill material does not infiltrate through overlaps. Place granular material and extend it for one pipe diameter, minimum of 6 inches on each side of and 18 inches above top of pipe. Place a layer of filter fabric on top of granular filter before continuing with backfill.

3.11.1.2 Blind or French Drains

Install filter cloth in trenches with smoothly graded sides and bottom, free of cavities or projecting rocks. Lay the cloth flat but not stretched and secure with anchor pins. Place filter cloth so that drain water must pass through the cloth into the specified granular filter material. Overlap ends at least of 12 inches. Place backfill on filter cloth in the direction of overlaps. Where fabric is damaged, place a new piece of filter cloth over damaged area and overlap at least of 12 inches in every direction.

3.12 RIP-RAP CONSTRUCTION

Construct rip-rap on bedding material placed on filter fabric with grout as noted on drawings.

3.12.1 Preparation

Trim and dress indicated areas to conform to cross sections, lines and grades shown within a tolerance of 0.1 foot.

3.12.2 Bedding Placement

Spread filter fabric and bedding material uniformly to a thickness of at least 4 inches on prepared subgrade as indicated. Bedding stone shall be equally distributed across filter fabric to protect it from direct impingement of rip-rap stone.

3.12.3 Stone Placement

Place rock for rip-rap on prepared bedding material to produce a well graded mass with the minimum practicable percentage of voids in conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above.

3.12.4 Grouting

3.13 FINISH OPERATIONS

3.13.1 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to

drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Contractor's operations, grade as directed.

3.13.2 Topsoil, Sod and Seeding

Provide as specified in Section 32 92 19 SEEDING and/or Section 32 92 23 SODDING.

3.13.3 Protection of Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.14 DISPOSITION OF SURPLUS MATERIAL

Waste in Government disposal area Remove from Government property surplus or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber.

3.15 FIELD QUALITY CONTROL

3.15.1 Sampling

Take the number and size of samples required to perform the following tests.

3.15.2 Testing

Perform one of each of the following tests for each material used. Provide additional tests for each source change.

3.15.2.1 Fill and Backfill Material Testing

Test fill and backfill material in accordance with ASTM C136/C136M for conformance to ASTM D2487 gradation limits; ASTM D1140 for material finer than the No. 200 sieve; ASTM D4318 for liquid limit and for plastic limit; ASTM D698 or ASTM D1557 for moisture density relations, as applicable.

3.15.2.2 Select Material Testing

Test select material in accordance with ASTM C136/C136M for conformance to ASTM D2487 gradation limits; ASTM D1140 for material finer than the No. 200 sieve; ASTM D698 or ASTM D1557 for moisture density relations, as applicable.

3.15.2.3 Porous Fill Testing

Test porous fill in accordance with ASTM C136/C136M for conformance to gradation specified in ASTM C33/C33M.

3.15.2.4 Density Tests

Test density in accordance with ASTM D1556/D1556M, or ASTM D6938. When ASTM D6938 density tests are used, verify density test results by performing an ASTM D1556/D1556M density test at a location already ASTM D6938 tested as specified herein. Perform an ASTM D1556/D1556M density test at the start of the job, and for every 10 ASTM D6938 density

tests thereafter. Test each lift at randomly selected locations every 2000 square feet of existing grade in fills for structures and concrete slabs, and every 2500 square feet for other fill areas and every 2000 square feet of subgrade in cut. Include density test results in daily report.

3.15.2.5 Moisture Content Tests

In the stockpile, excavation or borrow areas, a minimum of two tests per day per type of material or source of materials being placed is required during stable weather conditions. During unstable weather, tests shall be made as dictated by local conditions and approved moisture content shall be tested in accordance with ASTM D2216. Include moisture content test results in daily report.

-- End of Section --

SECTION 31 62 19

TIMBER PILES

11/20

PART 1 GENERAL

1.1 DESCRIPTION

Design, furnish, install and test timber piles at the locations indicated on the drawings and specified herein. Assume test piles will be directed to be placed in a locations that can be incorporated into the work.

1.2 REFERENCES

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

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA C3	(2003) Piles - Preservatitive Treatment by pressure processes.
AWPA M1	(2020) Standard for the Purchase of Treated Wood Products
AWPA M2	(2019) Standard for the Inspection of Preservative Treated Wood Products for Industrial Use
AWPA M3	(2016) Standard for the Quality Control of Preservative Treated Products for Industrial Use
AWPA M4	(2015) Standard for the Care of Preservative-Treated Wood Products
AWPA M6	(2013) Brands Used on Preservative Treated Materials
AWPA T1	(2020) Use Category System: Processing and Treatment Standard
AWPA U1	(2020) Use Category System: User Specification for Treated Wood

ASTM INTERNATIONAL (ASTM)

ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM D25	(2012; R 2017) Standard Specification for Round Timber Piles
ASTM D4945	(2017) Standard Test Method for

High-Strain Dynamic Testing of Deep Foundations

ASTM E329

(2020) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

1.3 SUBSURFACE DATA

Subsurface soil data logs are provided on the project drawings.

1.4 BASIS OF BID

1.4.1 Production Pile Acceptance Criteria

Base bids on the number, circumference of piles at the butt and tip, and length of piles from tip to cutoff as indicated. Safe design capacity for piles is **kips**. Drive piles to a minimum depth indicated on the contract documents, and to such additional depth as required to obtain a bearing capacity of not less than **kips**. The Contractor's Geotechnical Consultant will determine the terminal driving criteria based on results of dynamic pile driving tests at end of drive or restrrike. Test piles that meet performance requirements may be included into the permanent work.

1.4.2 Lump Sum Payment

Base bids upon providing the number, size, capacity, and length of piles as indicated on the drawings.

1.4.3 Unit Price

For unit price bid, see SF 1442, "Solicitation, Offer and Award" and "Schedule of Bid Items." Section **00 22 13.00 20** SUPPLEMENTARY INSTRUCTIONS TO OFFERORS.

Requirements of FAR 52.211-18 Variation in Estimated Quantity do not apply to payment for piling. Each pile and test pile acceptably provided will be paid for at the bid unit price per unit length, which will include items incidental to furnishing and driving the piles including mobilization and demobilization, redriving uplifted piles, an additional **5 feet** in furnished length for any test pile not driven beyond estimated pile length, and cutting off piles at the cut-off elevation. Include the cost for additional length for the test piles in the total unit price cost for the job. Payment will be made for production and test piles at the bid unit price for the length of pile, from tip to final cut-off, actually provided, excluding buildups and splices directed by the Contracting Officer to be made. If the actual cumulative pile length driven (tip to cut-off) vary more than 25 percent from the total pile length specified as a basis for bidding, at the direction of the Contracting Officer, the unit price per unit length will be adjusted in accordance with provisions of FAR 52.236-2 Differing Site Conditions. Payments will be made per each at the respective bid unit price for pile cut-offs, pile build-ups, pile loads tests and pile splices.

1.5 PAYMENT

1.5.1 Furnishing and Delivering Timber Piles

1.5.1.1 Payment

Payment will be made for costs associated with furnishing and delivering the required lengths of permanent timber piles, which includes costs of furnishing and delivering piles to the work site. No payment will be made for the driving head or lengths of piles exceeding required lengths. No payment will be made for piles damaged during delivery, storage, or handling to the extent that they are rendered unsuitable for the work, in the opinion of the Contracting Officer.

1.5.1.2 Measurement

Furnishing and delivering permanent timber piles will be measured for payment by the linear **foot** of piles required below the cut-off elevation as indicated.

1.5.1.3 Unit of Measure

Linear **foot**.

1.5.2 Driving Timber Piles

1.5.2.1 Payment

Payment will be made for costs associated with driving permanent timber piles, which includes costs of handling, driving, performing dynamic testing, interpreting data and submitting reports, measuring heave, redriving heaved piles, removal of driving heads or cutting off piles at the cut-off elevation and removing from the work site, compiling and submitting pile driving records, backfilling voids around piles, and any other items incidental to driving piles to the required elevation.

1.5.2.2 Measurement

Permanent timber piles will be measured for payment for driving on the basis of lengths, to the nearest hundredth (tenth) of a linear **foot**, along the axis of each pile acceptably in place below the cut-off elevation shown.

1.5.2.3 Unit of Measure

Linear **foot**.

1.5.3 Timber Pile Driving Tests

1.5.3.1 Payment

Payment will be made for costs associated with furnishing, delivering, driving, pulling, and disposing of driven test piles, including pile driving points; conducting pile driving tests; backfilling voids around piles; compiling pile driving test records; performing dynamic testing; interpreting data; and submitting reports.

1.5.3.2 Measurement

Timber pile driving tests will be measured for payment on the basis of the applicable contract unit price per pile driving test.

1.5.3.3 Unit of Measure

Each.

1.5.4 Timber Piles for Load Tests

1.5.4.1 Payment

Payment will be made for costs associated with furnishing, delivering, driving, pulling, and disposing of load test piles. No additional payment will be made for load test piles incorporated in the permanent work other than as provided.

1.5.4.2 Measurement

Timber piles for load tests will be measured for payment on the basis of the applicable contract unit price per load test pile.

1.5.4.3 Unit of Measure

Each.

1.5.5 Pile Driving Shoes

1.5.5.1 Payment

Payment will be made for costs associated with pile driving shoes, including furnishing, delivering, and installing.

1.5.5.2 Measurement

Pile driving shoes will be measured for payment on the basis of the number of pile driving shoes required.

1.5.5.3 Unit of Measure

Each.

1.5.6 Preconstruction Condition Survey

1.5.6.1 Payment

Payment will be made for costs associated with preconstruction condition surveys.

1.5.6.2 Measurement

Preconstruction condition survey will be measured for payment on the basis of the applicable contract unit price per structure to be surveyed.

1.5.6.3 Unit of Measure

Each.

1.6 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.

Submit the following in accordance with Section 01 33 00.05 20

CONSTRUCTION SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Testing Agency Qualifications; G

SD-02 Shop Drawings

Installation Drawings; G

SD-03 Product Data

Driving Equipment; G

Helmets and Cushion Blocks; G

Pile Shoes; G

SD-04 Samples

Test Piles; G

SD-06 Test Reports

Pile Driving Test Data; G

Pile Driving Analyzer; G

Dynamic Testing Of Piles

Test Piles; G

SD-07 Certificates

Timber Piles; G

SD-11 Closeout Submittals

Pile Driving Records; G

1.7 DELIVERY, STORAGE, AND HANDLING

Stack piles during delivery and storage so that each pile is maintained in a straight position and is supported every 10 feet or less along its length (ends inclusive). Do not stack piles more than 5 feet high. Use methods for handling and storage of piles such that the piles are not subjected to excessive bending stress.

Load, unload or transfer treated wood products using procedures specified in AWP4 M4. Use slings, padding, or any method to prevent or minimize damage to treated wood products. Treat any damage sustained during handling as specified above.

Untreated piles to be stored for an extended period of time must be inspected periodically, as well as shortly before driving, to detect damage due to fungus and insect attack. If treated piles are to be stored in a horizontal position for an extended period of time, they must be inspected periodically to ensure that the treatment does not seep to the lower half of the pile to the extent that the upper half does not contain a sufficient amount of treatment. Inspect piles for excessive curvature and for damage before transporting them from the storage area to the driving area and immediately prior to placement in the driving leads. Curvature in the pile must be measured with the pile laying on a flat surface and is the distance between the pile at the mid-length of the pile and the flat surface. Maximum permissible curvature is 2 inches over the length of the pile. Piles having excessive curvature will be rejected.

1.7.1 Damaged Piles

Inspect each pile for soundness, splits, knots and holes before transporting them to the project site and immediately prior to placement in the driving leads. Bring any unusual pile conditions to the attention of the Contracting Officer. Piles which are damaged during delivery, storage, or handling to the extent they are rendered unsuitable for the work, in the opinion of the Contracting Officer, will be rejected and removed from the project site, or may be repaired, if approved, at no cost to the Government.

Any pile damaged by reason of internal defects or by improper driving must be corrected by one of the following methods approved by the Engineer for the pile in question:

- a. The pile is withdrawn, if practicable, and replaced by a new and, if necessary, longer pile.
- b. One or more replacement piles are driven adjacent to the defective pile.
- c. A Pile Dynamic Analysis and integrity testing must be performed by the Contractor's Geotechnical Consultant to assess the structural integrity of the driven pile(s).

A pile driven below the specified butt elevation must be corrected by one of the following methods approved by the Engineer:

- a. The pile is spliced (if approved).
- b. A sufficient portion of the footing is extended down to properly embed the pile.

A pile driven out of its proper location or out of plumb as approved by the Engineer, must be corrected by one of the following methods approved by the engineer:

- a. One or more replacement piles are driven next to the pile in question.
- b. As directed by the structural engineer.

1.7.2 Pile Sweep

Limit sweep to 1/8 inch per 10 feet over the length of the pile. Piles

having excessive sweep will be rejected.

1.8 QUALITY ASSURANCE

The producer must brand each treated pile, in accordance with [AWPA M1](#), [AWPA M2](#), [AWPA M6](#), [AWPA T1](#) and [AWPA U1](#). Submit the inspection report of an independent inspection agency, approved by the Contracting Officer, stating that offered products comply with applicable AWPAs Standards, and that the plant conforms to [AWPA M3](#).

1.9 PLANT INSPECTION

The Government, at its discretion, reserves the right to inspect the treating process. Notify the Contracting Officer at least 3 weeks prior to beginning the treatment, stating where preservative treatment will be done. Allow Government inspector access to all parts of the plant. Allow inspection of all facets of the treating process.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 [Piles](#)

Provide pressure treated Douglas fir or southern pine clean-peeled piles conforming to [ASTM D25](#). Minimum tip circumference must be 8". Piles must be in one piece. Splicing is not permitted. Submit the inspection report of an independent inspection agency, approved by the Contracting Officer, stating that offered products comply with applicable AWPAs Standards. Identify treatment on each piece by the quality mark of an agency accredited by the Board of Review of the America Lumber Standard Committee.

2.1.2 Preservative Treatment

Provide round piles conforming to [ASTM D25](#) and [AWPA C3](#). Piles must be treated with ACA (ammoniated copper arsenate) and CCA (copper chrome arsenate) due to the location of the proposed structure in a temperate zone environment

2.2 [PILE DRIVING EQUIPMENT](#)

Provide Pile Driving Equipment as mentioned in this section.

2.2.1 Pile Hammers

Provide a hammer capable of developing the indicated ultimate pile capacity at blow count less than 100 per [foot](#) considering hammer impact velocity; ram weight; stiffness of hammer and pile cushions; cross section, length, and total weight of pile; and character of subsurface material to be encountered. Use the same pile hammer, operating at the same rate and in the same manner, as that used for driving test piles. Use wave equation analysis to verify that the hammer will develop stresses within acceptable limits in the piles. At final driving, operate pile hammer in accordance with manufacturer's recommendation. Provide the plant and equipment for air hammers that have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer. The hose connecting the compressor with the hammer must be at least the minimum size recommended by the Manufacturer. Evaluate hammer performance at the end of driving by measuring blows per

minute and comparing with the manufacturer's recommendations. Measure impact velocity of open-end (single acting) diesel hammers at all times during pile driving operations with a device for this purpose. If such a device is not available, obtain the stroke by measuring the speed of operation either manually or with a device that makes the measurement automatically. Equip closed-end (double acting) diesel hammers with a bounce chamber pressure gauge in good working order, mounted near ground level so as to be easily read by the Contracting Officer. Provide a correlation chart of bounce chamber pressure and potential energy. Equip hydraulic hammers with a system for measurement of ram energy. The system must be in good working order and the results must be easily and immediately available to the Engineer.

2.2.2 Driving Helmets and Cushion Blocks

2.2.2.1 Driving Helmets or Pile Cushions

Use a steel driving helmet or pile cushion between top of pile and driving helmet or cap to prevent impact damage to pile. Use a driving helmet or pile cushion combination capable of protecting pile head, minimizing energy absorption and dissipation, and transmitting hammer energy uniformly over top of pile. Provide driving helmet that fits sufficiently loose around top of pile so that pile may be free to rotate without binding within driving helmet. Use pile cushion of solid wood or of laminated construction using plywood, softwood or hardwood boards with grain parallel to end of pile. Select the pile cushion thickness placed on the pile head prior to driving by wave equation analysis so that the limiting driving stresses are not exceeded. Replace pile cushion at the start of driving of each pile and when it becomes highly compressed, charred or burned, or has become spongy or deteriorated in any manner. Show details of driving helmets, and pile cushions. Submit 2 weeks prior to test pile installation.

2.2.2.2 Hammer Cushion

Use a hammer cushion between driving helmet or cap and hammer ram consisting of a solid hardwood block with grain parallel to the pile axis and enclosed in a close-fitting steel housing. Use steel plates at top and bottom of hammer cushion. Replace hammer cushion when it becomes highly compressed, charred or burned or becomes spongy or deteriorated in any manner. Do not replace hammer cushion during final driving of any pile. Do not use small wood blocks, wood chips, rope or other materials that permit excessive loss of hammer energy.

If the cushion is other than that specified above, submit to the Contracting Officer at least two weeks prior to the commencement of test pile driving, detailed drawings and records of previous successful use. Generally, follow the pile hammer manufacturer's recommendations with respect to hammer cushions.

PART 3 EXECUTION

3.1 PRELIMINARY WORK

3.1.1 Installation Drawings

Submit pile installation drawings at least 28 calendar days prior to installation. Drawings must indicate individual pile numbers, sequencing, and any phasing or special installation considerations.

3.1.2 Wave Equation Analysis of Pile Drivability

- a. Prior to driving any pile, submit a pile Wave Equation Analysis, performed by Contractor's Geotechnical Consultant, for each size pile and distinct subsurface profile condition. These analyses must take into account the proposed hammer assembly, pile capblock and cushion characteristics, the pile properties and estimated lengths and the soil properties anticipated to be encountered throughout the installed pile length based on static capacity analysis with consideration of driving gain/loss factors. Only one specific model of pile hammer may be used for each pile type and capacity.
- b. Demonstrate using the Wave Equation Analysis that the piles will not be damaged during driving, indicate that the driving stresses will be maintained within the limits below and indicate the blow count necessary to achieve the required ultimate static pile capacities.

Allowable Driving Stresses

Wood

Compression - 3 ksi
Tension - 3 ksi

Qa Allowable static timber stress

- c. Perform a refined Wave Equation Analysis upon completion of the dynamic and static testing programs outlined in this specification section, taking into consideration the evaluated capacities, gain/loss factors and recommended production pile lengths. Develop production pile driving criteria based on the results of the refined Wave Equation Evaluations.
- d. All pile driving equipment provided by the Contractor will be subject to the approval of the Contractor's Geotechnical Consultant. Complete the attached pile and driving equipment data form, including hammer information, in full as part of the submittal of the results of the Wave Equation Analyses.
- e. Pay for the cost of performing the Wave Equation Analyses and include in the base bid.

3.1.3 Pile Length Markings

Mark each pile prior to driving with horizontal lines at one foot intervals. Mark the interval number on pile every 5 feet from pile tip.

3.2 PILE DRIVING

3.2.1 Driving Piles

Notify Engineer of Record and Contracting Officer 10 days prior to driving of test piles and load test. Submit pile driving test data and reports of the dynamic testing of piles within one day after each test is completed.

The Contractor's Geotechnical Consultant will determine the terminal driving criteria based on results of dynamic pile driving tests at the end of drive or restrike. Drive piles to reach a driving resistance established by the dynamic pile driving tests at the end of drive or restrike in accordance with the schedule which the Contractor's

Geotechnical Consultant will prepare from the test-pile driving data. During initial driving and until pile tip has penetrated beyond layers of very soft soil, use a reduced driving energy of the hammer as required to prevent pile damage. Refusal criteria will be established by the Contracting Officer. If a pile fails to reach "calculated" tip elevation, or if a pile reaches "calculated" tip elevation without reaching required driving resistance, notify Engineer of Record and perform corrective measures as directed. Provide hearing protection when noise levels exceed 140 dB. Do not handle or move piles or pile sections in any manner that would result in cracking or permanent damage to the concrete or to the grout surrounding the prestressing cables. Piles may be driven without pile guides or leads providing a hammer guide frame is used to keep the pile and hammer in alignment.

3.2.2 Protection of Piles

Take care to avoid damage to piles during handling, placing pile in leads, and during pile driving operations. Support piles laterally during driving, but allow rotation in leads. Square top of pile to longitudinal axis of pile. Maintain axial alignment of pile hammer with that of the pile.

3.2.3 Pile Placement and Tolerances in Driving

Piling must be installed to a maximum tolerance in any direction of 4 inches per pile. Where an individual pile is installed out of position more than 4 inches in any direction and/or where the center of gravity of a pile group is out of position more than 2 inches, the Contractor may be required to install an additional pile or piles to compensate for the eccentricity of the pile and / or pile group. Maintain and check axial alignment of pile and leads at all times. If subsurface conditions cause pile drifting beyond allowable axial alignment tolerance, notify Engineer of Record and perform corrective measures as directed. Place butts within 4 inches of location indicated. Manipulation of piles within specified tolerances will not be permitted. Piles must be monitored for heave immediately after installation and after adjacent piles are installed. If piles heave more than 1/2 inch notify the Engineer of Record. Redrive heaved piles to required point elevation. Piles damaged or driven outside the above tolerances must be replaced, or additional piles driven at locations specified by the Engineer of Record at no expense to the Government.

3.2.4 Rejected Piles

Withdraw piles damaged or impaired for use during handling or driving, mislocated, or driven out of alignment beyond the maximum tolerance. Replace with new piles or cut-off and abandon damaged or impaired piles and drive new piles as directed. Remove excess cut-off from piles and unacceptable piles from the work site. Perform all work in connection with withdrawing and removing rejected piles from the site at no additional cost to the Government.

3.2.5 Pile Cut-Off

Cut-off piles with a smooth level cut using pneumatic tools, sawing, or other suitable methods approved by Contracting Officer. Use of explosives for cutting is not permitted. Remove cut-off sections of piles from the site and off government property upon completion of the work.

3.2.6 As-Driven Survey

After the driving of each pile group is complete and before concrete is placed, provide the Contracting Officer with an as-driven survey showing actual location and top elevation of each pile. Do not proceed with placing concrete until the Contracting Officer has reviewed the survey and verified the safe load for the pile group driven. Present a survey in such form that it gives deviation from plan location in two perpendicular directions and elevations of each pile to nearest **half inch**. Survey must be prepared and certified by a licensed land surveyor.

3.2.7 Protection of Existing Structures

Mitigate impact on existing facilities due to pile driving activities in accordance with the project specific document.

3.2.8 **Pile Shoes**

Where indicated or directed, securely attach pile shoes of an approved design to the piles in a manner described in the detail drawings.

3.3 FIELD QUALITY CONTROL

3.3.1 **Test Piles**

Order test piles **feet** longer in length than production piles. Drive the additional test pile length only at the direction of the Engineer of Record. The Contractor's Geotechnical Consultant will use test pile data to determine "calculated" pile tip elevation or necessary driving criteria. Submit pile driving analyzer data and resport within one day after each test is completed.

Drive test piles at the locations indicated. Drive test piles to indicated tip elevation indicated on drawings. Use test piles, if located properly and offering adequate driving resistance in finished work. Provide and operate a pile driving analyzer as specified in paragraph DYNAMIC PILE ANALYSIS during the driving of each test pile. Modify driving as required based upon recommendation of Contractor's Geotechnical Consultant and approval of the Engineer of Record.

3.3.1.1 Dynamic Pile Analysis

Dynamic testing provides supplemental information for evaluating pile integrity, hammer and drive system performance, assess pile installation driving stresses, and pile capacities. Perform dynamic testing on 100 percent of the test piles during the full length of the pile driving and during restrike a minimum of 7 days after initial driving. Provide equipment to obtain dynamic measurements, record, reduce and display its data that meet the requirements of **ASTM D4945**. The equipment must have been calibrated within 6 months prior to the start of the testing operations and thereafter throughout the contract duration. Drive test piles at the locations indicated on drawings. Employ an independent inspection firm, hereinafter referred to as the "Contractor's Geotechnical Consultant", experienced in the pile driving process, monitoring of test pile installation, and in the use of the Pile Driving Analyzer and its related equipment. Perform dynamic pile analysis as follows:

3.3.1.2 Pile Analyzing

7 working days prior to driving the test piles, submit the pile and complete driving equipment data to the Contracting Officer. The Contractor's Geotechnical Consultant must use the submitted information to perform wave equation analyses and must prepare a summary report of the wave equation results. The wave equation analysis using GRLWEAP software by Pile Dynamics, Inc. or equivalent must be used to assess the ability of the proposed driving system to install the pile to the required capacity and desired penetration depth within the allowable driving stresses.

3.3.1.3 Pile Drivability

Perform each dynamic pile analysis in two steps. The first step is to check the hammer, pile and soil performance, and to determine the suitability of the proposed hammer for the size, length and type of pile being installed for the soil types encountered as the piles are driven. This initial monitoring must determine whether pre-augering or jetting is appropriate, efficiency of the hammer relative to specified efficiency, effectiveness of cushion, level of compressive and tensile stress in pile and extent/location of any pile damage caused by the initial driving. With each blow of the pile, record the information listed below electronically and analyze the information using the [Pile Driving Analyzer](#):

- a. Blow number
- b. Blow rate per minute and stroke.
- c. Input and reflected values of force and velocity.
- d. Value of upward and downward traveling force wave with time.
- e. Maximum and final transferred energy to pile, hammer system efficiency.
- f. Maximum compressive stress, velocity, acceleration and displacement.
- g. Maximum tensile stress in pile.
- h. Pile structural integrity, damage detection, extent and location.
- i. Bearing capacity of pile by Case method.

If the pile, hammer and soil performance evaluation recommends changes to the hammer stroke, pile cushioning, augering or any other aspect for the pile driving operation, incorporate these changes into production pile driving in an effort to control excessive stresses and pile damage. Replace test piles damaged or broken during installation, incorporating driving modifications as determined by the Contractor's Geotechnical Consultant and reviewed and approved by the Contracting Officer. Repeat this procedure until allowable tensile and compressive stresses are achieved in the pile and pile damage is minimized. Subject selected initial driving records to rigorous computer analysis by the Case Pile Wave Analysis Program (CAPWAP) for determination of resistance distribution, soil resistance and properties, and estimation of anticipated gain/loss factors.

3.3.1.4 CAPWAP

Signal matching analysis by CAPWAP software of the dynamic pile testing

data must be performed on data obtained from the end of initial driving and the beginning of restrrike of all control piles. CAPWAP analyses must be performed by an engineer who has achieved Advanced Level or better on the PDI / PDCA Dynamic Measurement and Analysis Proficiency Test for Providers of PDA Testing Services.

Upon completion of test pile driving, allow the piles to set-up for at least 7 days. After evaluation of pile, hammer and soil performance by the Contractor's Geotechnical Consultant, the second step of the dynamic pile analysis may proceed. This portion of the evaluation requires striking the set-up piles a minimum of 20-50 times, or as directed by the Contractor's Geotechnical Consultant using the same hammer which was used for the test pile driving and which will be used for production pile driving. "Warm up" the hammer and make it optimally ready prior to restriking, in order to avoid capacity losses during evaluation of restrrike data. Apply maximum hammer energy during restrrike in order to fully mobilize the soil resistance. However, exercise care so as to not overstress the pile. In addition to those items listed above, selected restrrike driving records (as directed by the Contractor's Geotechnical Consultant) are to be subjected to rigorous computer analysis by the Case Pile Wave Analysis Program (CAPWAP) for determination of resistance distribution, soil resistance and properties, and plot of applied load vs. average pile displacement based on the calculated soil properties.

3.3.1.5 Dynamic Load Test Reporting

- a. Upon satisfactory completion of each dynamic load test, submit a minimum of three copies of a Pile Performance Report for the Contractor by the Contractor's Geotechnical Consultant. The submittal must be prepared and sealed by a Professional Engineer registered in State of North Carolina.
- b. The report for the Dynamic Pile Analysis must contain the following information:
 - (1) Capacity of pile from Case Pile Wave Analysis Program (CAPWAP). Information resulting from analysis of a selected restrrike blow.
 - (2) Maximum and final transferred energy, hammer system efficiency during pile installation.
 - (3) Maximum compressive stress, velocity, acceleration and displacement.
 - (4) Maximum tensile stress in pile.
 - (5) Pile structural integrity, damage detection, extent and location.
 - (6) Blows per minute and blow number.
 - (7) Input and reflection values of force and velocity, upward and downward traveling force wave with time.
 - (8) Pile skin friction and toe resistance distribution.
 - (9) Maximum energy transferred to pile.
- c. The maximum allowable pile design load must be proposed by the Contractor's Geotechnical Consultant based upon the results of a

satisfactory pile load test conducted on a pile driven as specified herein and must include the effects of load transfer to the soil above the foundation stratum.

Use either a model Model 8G or PAX Pile Driving Analyzer as manufactured by Pile Dynamics, Inc., of Cleveland Ohio or approved equivalent, for dynamic testing of the pile hammer and for dynamic load testing of the test pile. All equipment necessary for the dynamic monitoring such as sensors, cables or wireless transmitters, must be furnished by the Contractor's Geotechnical Consultant. The equipment must conform to the requirements of [ASTM D4945](#).

Pay for all services of the Contractor's Geotechnical Consultant. The Contractor's Geotechnical Consultant must be available throughout the pile driving operation to consult with the Contracting Officer when required by the Contracting Officer. The cost of changes in the Contractor's procedure, as required by evaluation of the results of the Pile Driving Analysis, will be at the Contractor's expense.

3.3.2 Pile Driving Records

Keep a complete and accurate record of each pile driven. Indicate the pile location, deviations from pile location, cross section shape and dimensions, original length, ground elevation, tip elevation, cut-off elevations, number of blows required for each [foot](#) of penetration and number of blows for the last [6 inches](#) penetration or fraction thereof as required for the "calculated" driving resistance. Include in the record the beginning and ending times of each operation during driving of pile, type and size of hammer used, rate of operation, stroke or equivalent stroke for diesel hammer, type of driving helmet, and type and dimension of hammer cushion and pile cushion used. Record retap data and unusual occurrences during pile driving such as re-driving, heaving, weaving, splicing, obstructions, and any driving interruptions. A preprinted pile driving log for recording pile driving data and pile driving equipment data form, which can be downloaded at: <http://www.wbdg.org/ffcc/dod/unified-facilities-guide-specifications-ufgs/forms-graphics-tables>

Submit complete and accurate pile driving records of installed piles to Engineer of Record within 15 calendar days after completion of pile driving. Make pile driving records available to the Engineer of Record at the job site, within 24 hours after each day of pile driving. Preparation of the record must be by, or under the direct supervision of a registered professional engineer.

3.3.3 Testing Agency Qualifications

Engage an independent testing agency qualified according to [ASTM C1077](#) and [ASTM E329](#) for testing indicated and approved by the Contracting Officer.

3.4 SPECIAL INSPECTION AND TESTING FOR SEISMIC-RESISTING SYSTEMS

Perform special inspections and testing for seismic-resisting systems and components in accordance with Section [01 45 35.05 20](#) SPECIAL INSPECTIONS FOR DESIGN-BUILD.

3.5 PRECONSTRUCTION CONDITION SURVEY

Perform preconstruction condition survey of structures and utilities within [200 feet](#) of the pile driving activity. Perform outreach to the owner of

the structures 28 days before performing the preconstruction condition survey. The Contractor must obtain written permission from the owner of the structure prior to accessing the structure. The preconstruction condition survey must include video and photographic documentation of the exterior and interior of above ground structures and of the interior of underground structures. Video documentation must be in high definition, and show existing conditions and highlight, where possible, existing cracks, deteriorated concrete, exposed and corroded reinforcement, cracked or broken brick or mortar, and other signs of distress. For utilities, perform the survey when the greatest extent of the interior is exposed. Provide supplementary artificial lighting as needed. The video must include annotation with location and structure nomenclature which describes any areas of distress over the video and time code superimposed on the video. Photographs must be accompanied by sketches or descriptions that indicate the location and direction of each photograph. For each structure surveyed, provide a Pre-Construction Condition Survey Report following completion of the survey. The report must contain all documentation associated with the survey including DVD copies. In the report, include notes, sketches, photographs, and videos. Provide general information, such as location details and structure type, as well as particular information on materials, condition, existing damage, aperture and persistence of cracks, and disrepair observed during visual survey. Provide a graphical depiction of locations of damage or other features of concern. Submit the Preconstruction Condition Survey Reports no later than 28 days before the commencement of pile driving activity. Accept responsibility for damages to existing adjacent or adjoining structures created by pile driving work, and repair any damages to these structures without cost to the Government.

-- End of Section --

SECTION 32 05 33

LANDSCAPE ESTABLISHMENT

08/17

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM D5851

(1995; R 2015) Planning and Implementing a Water Monitoring Program

TREE CARE INDUSTRY ASSOCIATION (TCIA)

TCIA Z133

(2017) American National Standard for Arboricultural Operations - Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush - Safety Requirements

1.2 DEFINITIONS

1.2.1 Pesticide

Any substance or mixture of substances, including biological control agents, that may prevent, destroy, repel, or mitigate pests and are specifically labeled for use by the U.S. Environmental Protection Agency (EPA). Also, any substance used as a plant regulator, defoliant, disinfectant, or biocide. Examples of pesticides include fumigants, herbicides, insecticides, fungicides, nematocides, molluscicides and rodenticides.

1.2.2 Stand of Turf

95 percent ground cover of the established species.

1.2.3 Planter Beds

A planter bed is defined as an area containing one or a combination of the following plant types: shrubs, ground cover, and a mulch topdressing excluding turf. Trees may also be found in planter beds.

1.3 RELATED REQUIREMENTS

Section 32 92 19 SEEDING and Section 32 92 23 SODDING applies to this section for installation of seed and sod requirements, with additions and modifications herein.

Section 32 93 00 EXTERIOR PLANTS applies to this section for installation of trees, shrubs, and ground cover, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 10.05 20 DESIGN SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Integrated Pest Management Plan; G

SD-03 Product Data

Fertilizer; G

Mulches Topdressing

Organic Mulch Materials

SD-07 Certificates

Maintenance Inspection Report

Plant Quantities; G

SD-10 Operation and Maintenance Data

Maintenance

SD-11 Closeout Submittals

Tree Staking and Guying Removal

1.5 DELIVERY, STORAGE AND HANDLING

1.5.1 Delivery

Deliver fertilizer, gypsum, and iron to the site in original containers bearing manufacturer's chemical analysis, name, trade name, or trademark, and indication of conformance to state and federal laws.

1.5.2 Storage

1.5.2.1 Fertilizer, Lime, Iron, and Mulch Storage

Store material in designated areas. Store lime and fertilizer in cool, dry locations away from contaminants.

1.5.2.2 Antidesiccant's Storage

Do not store with fertilizers or other landscape maintenance materials.

1.5.3 Handling

Do not drop or dump materials from vehicles.

1.6 MAINTENANCE

Submit Operation and Maintenance (O&M) Manuals for planting materials. Include instructions indicating procedures during one typical year including variations of maintenance for climatic conditions throughout the year. Provide instructions and procedures for watering; promotion of growth, including fertilizing, pruning, and mowing; and integrated pest management. O&M Manuals must include pictures of planting materials cross referenced to botanical and common names, with a description of the normal appearance in each season.

Develop a water monitoring program for surface and ground water on the project site in accordance with [ASTM D5851](#) and consistent with the water management program utilized during construction operations.

PART 2 PRODUCTS

2.1 POST-PLANT FERTILIZER

Fertilizer for groundcover, wildflowers, and grasses is not permitted. Provide fertilizer for trees, plants, and shrubs as recommended by plant supplier, except synthetic chemical fertilizers are not permitted. Fertilizers containing petrochemical additives or that have been treated with pesticides or herbicides are not permitted.

2.1.1 Granular Fertilizer

Organic, granular controlled release fertilizer with proportions as indicated in recommendations from soil testing report.

2.2 WATER

Source of water must be approved by the Contracting Officer, and be of suitable quality for irrigation. Use collected storm water or graywater when available.

2.3 MULCHES TOPDRESSING

Free from noxious weeds, mold, pesticides, or other deleterious materials.

2.3.1 Organic Mulch Materials

Provide double shredded hardwood bark mulch. Mulch shall not be dyed or stained.

2.4 PESTICIDES

Pesticides and herbicides are not permitted. Submit an [Integrated Pest Management Plan](#), including weed and pest management strategies, proposed alternatives to herbicides and pesticides. Use biological pest controls as approved in the Plan.

PART 3 EXECUTION

3.1 EXTENT OF WORK

Provide landscape construction maintenance to include mowing, edging, overseeding, aeration, fertilizing, watering, weeding, pruning, stake and

guy adjusting, and for all newly installed landscape areas, unless indicated otherwise, and at all areas inside or outside the limits of the construction that are disturbed by the Contractor's operations.

3.1.1 Policing

Police all landscaped areas. Policing includes removal of leaves, branches and limbs regardless of length or diameter, dead vegetation, paper, trash, cigarette butts, garbage, rocks or other debris. Policing must extend to both sides of fencing or walls. Collected debris must be promptly removed and disposed of at an approved disposal site.

3.1.2 Drainage System Maintenance

Remove all obstructions from surface and subsurface drain lines to allow water to flow unrestricted in swales, gutters, catch basins, storm drain curb inlets, and yard drains. Remove grates and clear debris in catch basins. Open drainage channels are to be maintained free of all debris and vegetation at all times. Edges of these channels must be clear of any encroachment by vegetation.

3.2 ESTABLISHMENT PERIOD

3.2.1 Water Restrictions

Abide by state, local or other water conservation regulations in force during the establishment period. Automatic controller must be adjusted to comply with the water conservation regulations schedule.

3.2.2 Fire Hydrants

To use a fire hydrant for irrigation, obtain prior clearance from the Contracting Officer and provide the tools and connections approved for use on fire hydrants. If a fire hydrant is used, Provide a reduced pressure backflow preventer for each connection between hose and fire hydrant. Backflow preventer used must be tested once per month by a certified backflow preventer tester.

3.3 GROUNDCOVER ESTABLISHMENT PERIOD

Groundcover establishment period will commence on the date that inspection by the Contracting Officer shows that the new turf furnished under this contract has been satisfactorily installed to a 95 percent stand of coverage. The establishment period must continue for a period of 365 days.

3.3.1 Frequency of Maintenance

Begin maintenance immediately after turf has been installed. Inspect areas once a week during the installation and establishment period and perform needed maintenance promptly.

3.3.2 Promotion of Growth

Maintain groundcover in a manner that promotes proper health, growth, natural color. Turf must have a neat uniform manicured appearance, free of bare areas, ruts, holes, weeds, pests, dead vegetation, debris, and unwanted vegetation that present an unsightly appearance. Mow, remove excess clippings, eradicate weeds, water, fertilize, overseed, aerate, topdress and perform other operations necessary to promote growth, as

approved by Contracting Officer and consistent with approved Integrated Pest Management Plan. Remove noxious weeds common to the area from planting areas by mechanical means.

3.3.3 Mowing

3.3.3.1 Turf

Mow turf at a uniform finished height. Mow turfed areas to a minimum average height of 1 to 1.5 inches for spring/summer maintenance and to a minimum average height of 1.5 inches for fall maintenance. The height of turf is measured from the soil. Perform mowing of turf in a manner that prevents scalping, rutting, bruising, uneven and rough cutting. Prior to mowing, all rubbish, debris, trash, leaves, rocks, paper, and limbs or branches on a turf area must be picked up and disposed. Adjacent paved areas must be swept/vacuumed clean.

3.3.4 Turf Edging and Trimming

Perimeter of planter bed edges, sidewalks, driveways, curbs, and other paved surfaces must be edged. Uniformly edge these areas to prevent encroachment of vegetation onto paved surfaces and to provide a clear cut division line between planter beds, turf, and ground cover. Edging is to be accomplished in a manner that prevents scalping, rutting, bruising, uneven and rough cutting. Perform edging on the same day that turf is mowed. Use of string line trimmers is permitted in "soft" areas such as an edge between turfgrass and a planter bed. Exercise care to avoid damage to any plant materials, structures, and other landscape features.

Trimming around trees, fences, poles, walls, and other similar objects is to be accomplished to match the height and appearance of surrounding mowed turf growth. Trimming must be performed on the same day the turf's mowed. Care must be exercised to avoid "Girdling" trees located in turf areas. The use of protective tree collars on trees in turf areas may be utilized as a temporary means to avoid injury to tree trunks. At the end of the plant establishment period Contractor will be responsible for removing all protective tree collars.

3.3.5 Post-Fertilizer Application

Do not fertilize wildflowers, groundcover, and grasses. Apply turf fertilizer in a manner that promotes health, growth, vigor, color and appearance of cultivated turf areas. The method of application, fertilizer type and frequencies must be determined by the laboratory soil analysis results the requirements of the particular turf species. Organic fertilizer must be used. In the event that organic fertilizer is not producing the desired effect, the Contractor must contract the Contracting Officer for approval prior to the use of a synthetic type of fertilizer. Apply fertilizer by approved methods in accordance with the manufacturer's recommendations.

3.3.6 Turf Watering

Perform irrigation in a manner that promotes the health, growth, color and appearance of cultivated vegetation and that complies with all Federal, State, and local water agencies and authorities directives. The Contractor must be responsible to prevent over watering, water run-off, erosion, and ponding due to excessive quantities or rate of application. Abide by state, local or other water conservation regulations or

restrictions in force during the establishment period.

3.3.7 Replanting

Replant in accordance with Section 32 92 19 SEEDING, Section 32 92 23 SODDING and within specified planting dates areas which do not have a satisfactory stand of turf. Replant areas which do not have a satisfactory stand of other groundcover and grasses.

3.3.8 Final Inspection and Acceptance

Final inspection will be made upon written request from the Contractor at least 10 days prior to the last day of the turf establishment period. Final turf acceptance will be based upon a satisfactory stand of turf. Final acceptance of wildflower and grass areas will be based upon a stand of 95 percent groundcover of established species.

3.3.9 Unsatisfactory Work

When work is found to not meet design intent and specifications, maintenance period will be extended at no additional cost to the Government until work has been completed, inspected and accepted by Contracting Officer.

3.4 EXTERIOR PLANT ESTABLISHMENT PERIOD

The exterior plant establishment period will commence on the date that inspection by the Contracting Officer shows that the new plants furnished under this contract have been satisfactorily installed and must continue for a period of 365 days.

3.4.1 Frequency of Maintenance

Begin maintenance immediately after plants have been installed. Inspect exterior plants at least once a week during the installation and establishment period and perform needed maintenance promptly.

3.4.2 Promotion of Plant Growth and Vigor

Water, prune, fertilize, mulch, adjust stakes, guys and turnbuckles, eradicate weeds and perform other operations necessary to promote plant growth, and vigor.

3.4.3 Planter Bed Maintenance

Planter beds must be weeded, fertilized, irrigated, kept pest free, turf free, pruned, and mulch levels maintained. Planter beds will not be allowed to encroach into turf areas. A definite break must be maintained between turf areas and planter beds. Fertilize exterior planting materials to promote healthy plant growth without encouraging excessive top foliar growth. Remove noxious weeds common to the area from planting areas by mechanical means.

3.4.3.1 Tree Maintenance

Tree maintenance must include adjustment of stakes, ties, guy supports, watering, fertilizing, pest control, mulching, pruning for health and safety and fall leaf cleanup. Fertilize exterior trees to promote healthy plant growth without encouraging excessive top foliar growth. Inspect and

adjust stakes, ties, guy supports to avoid girdling and promote natural development. All trees within the project boundaries, regardless of caliper, must be selectively pruned for safety and health reasons. These include but are not limited to removal of dead and broken branches and correction of structural defects. Prune trees according to their natural growth characteristics leaving trees well shaped and balanced. Pruning of all trees including palm trees must be accomplished by or in the presence of a certified member of the International Society of Arboriculture and in accordance with **TCIA Z133**. All pruning debris generated must be disposed of in a proper manner.

3.4.4 Slope Erosion Control Maintenance

Provide slope erosion control maintenance to prevent undermining of all slopes in newly landscaped. Maintenance tasks include immediate repairs to weak spots in sloped areas, and maintaining clean, clear culverts, and graded berms, and terraces to intercept and direct water flow to prevent development of large gullies and slope erosion. Eroded areas must be filled with amended topsoil and replanted with the same plant species. Erosion control blankets damaged due to slope erosion must be reinstalled.

3.4.5 Removal of Dying or Dead Plants

Remove dead and dying plants and provide new plants immediately upon commencement of the specified planting season, and replace stakes, guys, mulch and eroded earth mound water basins. Provide an additional 90 day establishment period for replacement plants beyond the original warranty period. A tree must be considered dying or dead when the main leader has died back, or a minimum of 20 percent of the crown has died. A shrub or ground cover must be considered dying or dead when a minimum of 20 percent of the plant has died. This condition must be determined by scraping on a branch an area **1/16 inch** square, maximum, to determine the cause for dying plant material and must provide recommendations for replacement. The Contractor must determine the cause for dying plant material and provide recommendations for replacement.

3.4.6 Tracking of Unhealthy Plants

Note plants not in healthy growing condition, as determined by the Contracting Officer, and as soon as seasonal conditions permit, remove and replace with plants of the same species and sizes as originally specified. Install replacement plantings in accordance with Section **32 93 00 EXTERIOR PLANTS**.

3.4.7 Final Inspection

Final inspection will be made upon written request from the Contractor at least 10 days prior to the last day of the establishment period. Final inspection will be based upon satisfactory health and growth of plants and on the following:

3.4.7.1 Total Plants on Site

Plants have been accepted and required number of replacements have been installed.

3.4.7.2 Mulching and Weeding

Planter beds and earth mound water basins are properly mulched and free of

weeds.

3.4.7.3 Tree Supports

Stakes and guys are in good condition.

3.4.7.4 Remedial Work

Remedial measures directed by the Contracting Officer to ensure plant material survival and promote healthy growth have been completed.

3.4.8 Unsatisfactory Work

When work is found to not meet design intent and specifications, maintenance period will be extended at no additional cost to the Government until work has been completed, inspected and accepted by Contracting Officer.

3.5 FIELD QUALITY CONTROL

3.5.1 Maintenance Inspection Report

Provide maintenance inspection report to assure that landscape maintenance is being performed in accordance with the specifications and in the best interest of plant growth and survivability. Site observations must be documented at the start of the establishment period, then quarterly following the start, and at the end of establishment period. Submit results of site observation visits to the Contracting Officer within 7 calendar days of each site observation visit.

3.5.2 Plant Quantities

Provide Contracting Officer with the number of plant quantities. In addition, provide total exterior area of hardscape and landscaping such as turf and total number of shrubs.

3.5.3 Tree Staking and Guying Removal

Provide a certified letter that all stakes and guys are removed from all project trees at the end of the establishment period.

-- End of Section --

SECTION 32 11 20

SUBBASES FOR FLEXIBLE PAVING
08/17

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

- AASHTO T 88 (2013) Standard Method of Test for Particle Size Analysis of Soils
- AASHTO T 180 (2017) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
- AASHTO T 224 (2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

ASTM INTERNATIONAL (ASTM)

- ASTM C29/C29M (2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
- ASTM C117 (2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
- ASTM C131/C131M (2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- ASTM C136/C136M (2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
- ASTM D75/D75M (2019) Standard Practice for Sampling Aggregates
- ASTM D1556/D1556M (2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
- ASTM D1557 (2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³) (2700 kN-m/m³)

ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM E11	(2020) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.2 DEGREE OF COMPACTION

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum dry density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve will be expressed as a percentage of the laboratory maximum dry density in accordance with AASHTO T 180 Method D and corrected with AASHTO T 224.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00.05 20 SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools

SD-06 Test Reports

Initial Tests

In-Place Tests

1.4 EQUIPMENT, TOOLS, AND MACHINES

All plant, equipment, and tools used in the performance of the work will be subject to approval by the Contracting Officer before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Use equipment capable of minimizing segregation,

producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

1.5 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor. Perform sampling and testing using a laboratory approved in accordance with Section 01 45 00.05 20 QUALITY CONTROL. Work requiring testing will not be permitted until the testing laboratory has been inspected and approved. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. The Contracting Officer may specify the time and location of the tests. Furnish copies of test results to the Contracting Officer within 24 hours of completion of the tests.

1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.5.2 Tests

1.5.2.1 Sieve Analysis

Perform sieve analysis in conformance with ASTM C117 and ASTM C136/C136M using sieves conforming to ASTM E11.

1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with ASTM D4318.

1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture in accordance with paragraph DEGREE OF COMPACTION.

1.5.2.4 Field Density Tests

Measure field density in accordance with ASTM D1556/D1556M, ASTM D2167, or ASTM D6938. For the method presented in ASTM D1556/D1556M, use the base plate, as shown in the drawing. For the method presented in ASTM D6938, check the calibration curves and adjust them, if necessary, using only the sand cone method as described in paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D6938 result in a wet unit weight of soil and ASTM D6938 will be used to determine the moisture content of the soil. Also check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938. Make the calibration checks of both the density and moisture gauges using the prepared containers of material method, as described in paragraph Calibration, in ASTM D6938, on each different type of material to be tested at the beginning of a job and at intervals as directed. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

1.5.2.5 Wear Test

Perform wear tests on subbase course and or rigid pavement base course material in conformance with ASTM C131/C131M.

1.5.2.6 Weight of Slag

Determine weight per cubic foot of slag in accordance with ASTM C29/C29M.

1.6 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 35 degrees F. When the temperature falls below 35 degrees F, protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Subbase Course

Provide select fill consisting of crushed stone or slag, gravel, sand, or other sound, durable, materials processed and blended or naturally combined that meet NC DOT Specification Section 1018 for road subgrade materials Sp. Provide aggregates which are free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. The percentage of loss of material retained on the No. 4 sieve must not exceed 50 percent after 500 revolutions when tested in accordance with ASTM C131/C131M. Provide aggregate that is reasonably uniform in density and quality. Provide slag that is an air-cooled, blast-furnace product having a dry weight of not less than 65 pcf. Provide aggregates with a maximum size of 1-1/2 inch and within the limits specified as follows:

Maximum Allowable Percentage by Weight
Passing Square-Mesh Sieve

Sieve Designation	No. 1	No.2	No. 3
No. 10	50	80	100
No. 200	8	8	8

Particles having diameters less than 0.02 mm must not be in excess of 3 percent by weight of the total sample tested as determined in accordance with AASHTO T 88. The portion of any blended component and of the completed course passing the No. 40 sieve must be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5.

2.1.2 Select-Material Subbase Course

Provide materials consisting of selected soil or other materials from field excavation, stockpiles, or other sources and free from lumps and balls of clay and from organic and other objectionable matter. Provide materials with not more than 25 percent by weight passing the No. 200 sieve. The portion of material passing the No. 40 sieve must have a liquid limit less than 35 and a plasticity index less than 12. Provide materials having a maximum particle size not exceeding 3 inches. Particles having diameters less than 0.02 mm must not be in excess of 3 percent by weight of the total sample tested as determined in accordance

with AASHTO T 88.

2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

2.2.1 Initial Tests

Perform one of each of the following tests on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements prior to installation. Complete this testing for each source if materials from more than one source are proposed.

- a. Sieve Analysis including 0.02 mm size material.
- b. Liquid limit and plasticity index.
- c. Moisture-density relationship.
- d. Wear.
- e. Weight per cubic foot of Slag.

Submit certified copies of test results for approval not less than 30 days before material is required for the work.

2.2.2 Approval of Material

Tentative approval of material will be based on initial test results.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

Provide adequate drainage during the entire period of construction to prevent water from collecting or standing on the working area.

3.2 OPERATION OF AGGREGATE SOURCES

Clearing, stripping and excavating are the responsibility of the Contractor. Condition aggregate sources on Government property to readily drain and leave in a satisfactory condition upon completion of the work.

3.3 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Stockpile aggregates on the cleared and leveled areas designated by the Contracting Officer to prevent segregation. Stockpile materials obtained from different sources separately.

3.4 PREPARATION OF UNDERLYING COURSE OR SUBGRADE

Clean the underlying course or subgrade of all foreign substances prior to constructing the subbase or select-material subbase course. Do not construct subbase or select-material subbase course on underlying course or subgrade that is frozen. Construct the surface of the underlying course or subgrade to meet specified compaction and surface tolerances. Correct ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the

specified requirements set forth herein by loosening and removing soft or unsatisfactory material and adding approved material, reshaping to line and grade, and recompact to specified density requirements. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in [ASTM D2487](#), stabilize the surface prior to placement of the overlying course. Stabilize by mixing the overlying course material into the underlying course and compacting by approved methods. Consider the stabilized material as part of the underlying course and meet all requirements of the underlying course. Do not allow traffic or other operations to disturb the finished underlying course and maintain in a satisfactory condition until the overlying course is placed.

3.5 GRADE CONTROL

Provide a finished and completed subbase select-material subbase courses conforming to the lines, grades, and cross sections shown. Place line and grade stakes as necessary for control.

3.6 MIXING AND PLACING MATERIALS

Mix and place the materials to obtain uniformity of the material at the water content specified. Make such adjustments in mixing or placing procedures or in equipment as may be directed to obtain the true grades, to minimize segregation and degradation, to reduce or accelerate loss or increase of water, and to insure a satisfactory subbase course.

3.7 LAYER THICKNESS

Compact the completed course to the thickness indicated. No individual layer may be thicker than [6 inches](#) nor be thinner than [3 inches](#) in compacted thickness. Compact the course(s) to a total thickness that is within [1/2 inch](#) of the thickness indicated. Where the measured thickness is more than [1/2 inch](#) deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompact as directed. Where the measured thickness is more than [1/2 inch](#) thicker than indicated, the course will be considered as conforming to the specified thickness requirements. The average job thickness will be the average of all thickness measurements taken for the job and must be within [1/4 inch](#) of the thickness indicated. Measure the total thickness of the course(s) at intervals of one measurement for each 500 square [yards](#) of completed course. Measure total thickness using [3 inch](#) diameter test holes penetrating the completed course.

3.8 COMPACTION

Compact each layer of the material, as specified, with approved compaction equipment. Maintain water content during the compaction procedure to within plus or minus 2 percent of optimum water content determined from laboratory tests as specified in this Section. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Slightly vary the length of alternate trips of the roller. Adjust speed of the roller as needed so that displacement of the aggregate does not occur. Compact mixture with hand-operated power tampers in all places not accessible to the rollers. Continue compaction of the rigid base course until each layer is compacted through the full depth to at least 95 percent of laboratory maximum density. Make such adjustments in compacting or finishing procedures as may be directed by the Contracting Officer to obtain true grades, to minimize segregation and degradation, to reduce or

increase water content, and to ensure a satisfactory subbase and select-material subbase course. Remove any materials that are found to be unsatisfactory and replace with satisfactory material or rework, as directed, to meet the requirements of this specification.

3.9 PROOF ROLLING

In addition to the compaction specified, proof roll subbase course in areas designated on the drawings by application of coverages of a heavy pneumatic-tired roller having four or more tires abreast, each tire loaded to a minimum of 30,000 pounds and inflated to a minimum of 125 psi. A coverage is defined as the application of one tire print over the designated area. In the areas designated, apply proof rolling to the top layer of the completed subbase course. Maintain water content of the top layer of the subbase course as specified in paragraph COMPACTION from start of compaction to completion of proof rolling. Remove any subbase course materials that produce unsatisfactory results by proof rolling and replace with satisfactory materials. Then recompact and proof roll to meet specifications.

3.10 EDGES OF SUBBASE AND SELECT-MATERIAL SUBBASE

Place approved material along the outer edges of the subbase and select-material subbase course in sufficient quantity to compact to the thickness of the course being constructed. When the course is being constructed in two or more layers, simultaneously roll and compact at least a 2 foot width of this shoulder material with the rolling and compacting of each layer of the subbase and select-material subbase course, as directed.

3.11 FINISHING

Finish the surface of the top layer of rigid pavement base course after final compaction and proof rolling by cutting any overbuild to grade and rolling with a steel-wheeled roller. Do not add thin layers of material to the top layer of rigid pavement base course to meet grade. If the elevation of the top layer of rigid pavement base course is 1/2 inch or more below grade, scarify the top layer to a depth of at least 3 inches and blend new material in and compact and proof roll to bring to grade. Make adjustments to rolling and finishing procedures as directed by the Contracting Officer to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable rigid pavement base course. Should the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, scarify the unsatisfactory portion and rework and recompact it or replace as directed.

3.12 SMOOTHNESS TEST

Construct the top layer so that the surface shows no deviations in excess of 3/8 inch when tested with a 12 foot straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Also take measurements perpendicular to the centerline at 50 foot intervals. Correct deviations exceeding this amount by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.13 FIELD QUALITY CONTROL

3.13.1 In-Place Tests

Perform one of each of the following tests on samples taken from the placed and compacted subbase and select-material subbase course. Take samples and test at the rates indicated.

- a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 500 square yards, or portion thereof, of completed area.
- b. Perform sieve analysis including 0.02 mm size material on every lift of material placed and at a frequency of one sieve analysis for every 1,000 square yards, or portion thereof, of material placed.
- c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.
- d. Measure the thickness of each course at intervals providing at least one measurement for each 500 square yards or part thereof. Measure the thickness using test holes, at least 3 inches in diameter through the course.

3.13.2 Approval of Material

Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and fully compacted courses.

3.14 TRAFFIC

Completed portions of the rigid pavement base course may be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Do not allow heavy equipment on the completed rigid pavement base course except when necessary for construction. When it is necessary for heavy equipment to travel on the completed rigid pavement base course, protect the area against marring or damage to the completed work.

3.15 MAINTENANCE

Maintain the completed course in a satisfactory condition until the full pavement section is completed and accepted. Immediately repair any defects and repeat repairs as often as necessary to keep the area intact. Retest any course that was not paved over prior to the onset of winter to verify that it still complies with the requirements of this specification. Rework or replace any area that is damaged as necessary to comply with this specification.

3.16 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of any unsuitable materials that have been removed outside the limits of Government-controlled land. No additional payments will be made for materials that have to be replaced.

-- End of Section --

SECTION 32 11 23

AGGREGATE BASE COURSES
08/17

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

- AASHTO T 88 (2013) Standard Method of Test for Particle Size Analysis of Soils
- AASHTO T 180 (2017) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
- AASHTO T 224 (2010) Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test

ASTM INTERNATIONAL (ASTM)

- ASTM C29/C29M (2017a) Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
- ASTM C88 (2018) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
- ASTM C117 (2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
- ASTM C127 (2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
- ASTM C128 (2015) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
- ASTM C131/C131M (2020) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- ASTM C136/C136M (2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³) (2700 kN-m/m ³)
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D5821	(2013; R 2017) Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM E11	(2020) Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

1.2 DEFINITIONS

For the purposes of this specification, the following definitions apply.

1.2.1 Aggregate Base Course

Aggregate base course (ABC) is well graded, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.2 Graded-Crushed Aggregate Base Course

Graded-crushed aggregate (GCA) base course is well graded, crushed, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.3 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum laboratory dry density obtained by the test procedure presented in ASTM D1557 abbreviated as a percent of laboratory maximum dry density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the

3/4 inch sieve, the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve will be expressed as a percentage of the laboratory maximum dry density in accordance with AASHTO T 180 Method D and corrected with AASHTO T 224.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

Plant, Equipment, and Tools

SD-06 Test Reports

Initial Tests

In-Place Tests

1.4 EQUIPMENT, TOOLS, AND MACHINES

All plant, equipment, and tools used in the performance of the work will be subject to approval by the Contracting Officer before the work is started. Maintain all plant, equipment, and tools in satisfactory working condition at all times. Submit a list of proposed equipment, including descriptive data. Use equipment capable of minimizing segregation, producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

1.5 QUALITY ASSURANCE

Sampling and testing are the responsibility of the Contractor. Perform sampling and testing using a laboratory approved in accordance with Section 01 45 00.05 20 QUALITY CONTROL. Work requiring testing will not be permitted until the testing laboratory has been inspected and approved. Test the materials to establish compliance with the specified requirements and perform testing at the specified frequency. The Contracting Officer may specify the time and location of the tests. Furnish copies of test results to the Contracting Officer within 24 hours of completion of the tests.

1.5.1 Sampling

Take samples for laboratory testing in conformance with ASTM D75/D75M. When deemed necessary, the sampling will be observed by the Contracting Officer.

1.5.2 Tests

1.5.2.1 Sieve Analysis

Perform sieve analysis in conformance with ASTM C117 and ASTM C136/C136M using sieves conforming to ASTM E11. .

1.5.2.2 Liquid Limit and Plasticity Index

Determine liquid limit and plasticity index in accordance with [ASTM D4318](#).

1.5.2.3 Moisture-Density Determinations

Determine the laboratory maximum dry density and optimum moisture content in accordance with paragraph DEGREE OF COMPACTION.

1.5.2.4 Field Density Tests

Measure field density in accordance with [ASTM D1556/D1556M](#), [ASTM D2167](#) or [ASTM D6938](#). For the method presented in [ASTM D1556/D1556M](#) use the base plate as shown in the drawing. For the method presented in [ASTM D6938](#) check the calibration curves and adjust them, if necessary, using only the sand cone method as described in paragraph Calibration, of the ASTM publication. Tests performed in accordance with [ASTM D6938](#) result in a wet unit weight of soil and [ASTM D6938](#) will be used to determine the moisture content of the soil. Also check the calibration curves furnished with the moisture gauges along with density calibration checks as described in [ASTM D6938](#). Make the calibration checks of both the density and moisture gauges using the prepared containers of material method, as described in paragraph Calibration of [ASTM D6938](#), on each different type of material being tested at the beginning of a job and at intervals as directed. Submit calibration curves and related test results prior to using the device or equipment being calibrated.

1.5.2.5 Wear Test

Perform wear tests on ABC and GCA course material in conformance with [ASTM C131/C131M](#).

1.5.2.6 Soundness

Perform soundness tests on GCA in accordance with [ASTM C88](#).

1.5.2.7 Weight of Slag

Determine weight per cubic foot of slag in accordance with [ASTM C29/C29M](#) on the ABC and GCA course material.

1.6 ENVIRONMENTAL REQUIREMENTS

Perform construction when the atmospheric temperature is above 35 degrees F. When the temperature falls below 35 degrees F, protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements.

PART 2 PRODUCTS

2.1 AGGREGATES

Provide ABC in accordance with NCDOT Standard Specifications, Section 1010, January 2018. Provide ABC and GCA consisting of clean, sound, durable particles of crushed stone, crushed slag, crushed gravel, crushed recycled concrete, angular sand, or other approved material. Provide ABC that is free of lumps of clay, organic matter, and other objectionable materials or coatings. Provide GCA that is free of silt and clay as

defined by [ASTM D2487](#), organic matter, and other objectionable materials or coatings. The portion retained on the [No. 4](#) sieve is known as coarse aggregate; that portion passing the [No. 4](#) sieve is known as fine aggregate. When the coarse and fine aggregate is supplied from more than one source, provide aggregate from each source that meets the specified requirements.

2.1.1.1 Coarse Aggregate

Provide in accordance with [NCDOT Standard Specifications, Section 1012 \(B\), January 2018](#). Provide coarse aggregates with angular particles of uniform density. Separately stockpile coarse aggregate supplied from more than one source.

- a. Crushed Gravel: Provide crushed gravel that has been manufactured by crushing gravels and that meets all the requirements specified below.
- b. Crushed Stone: Provide crushed stone consisting of freshly mined quarry rock, meeting all the requirements specified below.
- c. Crushed Recycled Concrete: Provide crushed recycled concrete consisting of previously hardened portland cement concrete or other concrete containing pozzolanic binder material. Provide recycled concrete that is free of all reinforcing steel, bituminous concrete surfacing, and any other foreign material and that has been crushed and processed to meet the required gradations for coarse aggregate. Reject recycled concrete aggregate exceeding this value. Provide crushed recycled concrete that meets all other applicable requirements specified below.
- d. Crushed Slag: Provide crushed slag that is an air-cooled blast-furnace product having an air dry unit weight of not less than [70 pcf](#) as determined by [ASTM C29/C29M](#), and meets all the requirements specified below.

2.1.1.1.1 Aggregate Base Course

The percentage of loss of ABC coarse aggregate must not exceed 50 percent when tested in accordance with [ASTM C131/C131M](#). Provide aggregate that contains no more than 30 percent flat and elongated particles. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, the crushed aggregates must contain at least 50 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with [ASTM D5821](#). When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Manufacture crushed gravel from gravel particles 50 percent of which, by weight, are retained on the maximum size sieve listed in TABLE 1.

2.1.1.1.2 Graded-Crushed Aggregate Base Course

The percentage of loss of GCA coarse aggregate must not exceed 40 percent loss when tested in accordance with [ASTM C131/C131M](#). Provide GCA coarse aggregate that does not exhibit a loss greater than 18 percent weighted average, at five cycles, when tested for soundness in magnesium sulfate, or 12 percent weighted average, at five cycles, when tested in sodium sulfate in accordance with [ASTM C88](#). Provide aggregate that contains no

more than 20 percent flat and elongated particles for the fraction retained on the 1/2 inch sieve nor 20 percent for the fraction passing the 1/2 inch sieve. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, the crushed aggregate must contain at least 90 percent by weight of crushed pieces having two or more freshly fractured faces determined in accordance with ASTM D5821. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Manufacture crushed gravel from gravel particles 90 percent of which by weight are retained on the maximum size sieve listed in TABLE 1.

2.1.2 Fine Aggregate

Provide fine aggregates consisting of angular particles of uniform density. Provide in accordance with NCDOT Standard Specifications, Section 1012(C), January 2018.

2.1.2.1 Aggregate Base Course

Provide ABC fine aggregate that consists of screenings, angular sand, crushed recycled concrete fines, or other finely divided mineral matter processed or naturally combined with the coarse aggregate.

2.1.2.2 Graded-Crushed Aggregate Base Course

Provide GCA fine aggregate consisting of angular particles produced by crushing stone, slag, recycled concrete, or gravel that meets the requirements for wear and soundness specified for GCA coarse aggregate. Manufacture fine aggregate from gravel particles 95 percent of which by weight are retained on the 1/2 inch sieve.

2.1.3 Gradation Requirements

Apply the specified gradation requirements to the completed base course. Provide aggregates that are continuously well graded within the limits specified in TABLE 1. Use sieves that conform to ASTM E11.

TABLE 1. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	No. 1	No. 2	No. 3
2 inch	100	----	----
1-1/2 inch	70-100	100	----
1 inch	45-80	60-100	100
1/2 inch	30-60	30-65	40-70
No. 4	20-50	20-50	20-50
No. 10	15-40	15-40	15-40
No. 40	5-25	5-25	5-25
No. 200	0-8	0-8	0-8

NOTE 1: Particles having diameters less than 0.02 mm must not be in excess of 3 percent by weight of the total sample tested as determined in

accordance with [AASHTO T 88](#).

NOTE 2: The values are based on aggregates of uniform specific gravity. If materials from different sources are used for the coarse and fine aggregates, test the materials in accordance with [ASTM C127](#) and [ASTM C128](#) to determine their specific gravities. Correct the percentages passing the various sieves as directed by the Contracting Officer if the specific gravities vary by more than 10 percent.

2.2 LIQUID LIMIT AND PLASTICITY INDEX

Apply liquid limit and plasticity index requirements to the completed course and to any component that is blended to meet the required gradation. The portion of any component or of the completed course passing the [No. 40](#) sieve must be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

2.3.1 Initial Tests

Perform one of each of the following tests, on the proposed material prior to commencing construction, to demonstrate that the proposed material meets all specified requirements when furnished. Complete this testing for each source if materials from more than one source are proposed.

- a. Sieve Analysis including 0.02 mm material.
- b. Liquid limit and plasticity index.
- c. Moisture-density relationship.
- d. Wear.
- e. Soundness.
- f. Weight per cubic [foot](#).

Submit certified copies of test results for approval not less than 30 days before material is required for the work.

2.3.2 Approval of Material

Tentative approval of material will be based on initial test results.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

When the ABC or GCA is constructed in more than one layer, clean the previously constructed layer of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used in areas where power cleaning is not practicable. Provide adequate drainage during the entire period of construction to prevent water from collecting or standing on the working area.

3.2 OPERATION OF AGGREGATE SOURCES

Clearing, stripping, and excavating are the responsibility of the

Contractor. Condition aggregate sources on Government property to readily drain and leave in a satisfactory condition upon completion of the work.

3.3 STOCKPILING MATERIAL

Clear and level storage sites prior to stockpiling of material. Stockpile all materials, including approved material available from excavation and grading, in the manner and at the locations designated. Stockpile aggregates on the cleared and leveled areas designated by the Contracting Officer to prevent segregation. Stockpile materials obtained from different sources separately.

3.4 PREPARATION OF UNDERLYING COURSE OR SUBGRADE

Clean the underlying course or subgrade of all foreign substances prior to constructing the base course(s). Do not construct base course(s) on underlying course or subgrade that is frozen. Construct the surface of the underlying course or subgrade to meet specified compaction and surface tolerances. Correct ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the specified requirements set forth herein by loosening and removing soft or unsatisfactory material and adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in [ASTM D2487](#), stabilize the surface prior to placement of the base course(s). Stabilize by mixing ABC or GCA into the underlying course and compacting by approved methods. Consider the stabilized material as part of the underlying course and meet all requirements of the underlying course. Do not allow traffic or other operations to disturb the finished underlying course and maintain in a satisfactory condition until the base course is placed.

3.5 GRADE CONTROL

Provide a finished and completed base course conforming to the lines, grades, and cross sections shown. Place line and grade stakes as necessary for control.

3.6 MIXING AND PLACING MATERIALS

Mix the coarse and fine aggregates in a stationary plant, or in a traveling plant or bucket loader on an approved paved working area. Make adjustments in mixing procedures or in equipment, as directed, to obtain true grades, to minimize segregation or degradation, to obtain the required water content, and to insure a satisfactory base course meeting all requirements of this specification. Place the mixed material on the prepared subgrade or subbase in layers of uniform thickness with an approved spreader. Place the layers so that when compacted they will be true to the grades or levels required with the least possible surface disturbance. Where the base course is placed in more than one layer, clean the previously constructed layers of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms, as directed. Make adjustments in placing procedures or equipment as may be directed by the Contracting Officer to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to insure an acceptable base course.

3.7 LAYER THICKNESS

Compact the completed base course to the thickness indicated. No individual layer may be thicker than 6 inches nor be thinner than 3 inches in compacted thickness. Compact the base course(s) to a total thickness that is within 1/2 inch of the thickness indicated. Where the measured thickness is more than 1/2 inch deficient, correct such areas by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 1/2 inch thicker than indicated, the course will be considered as conforming to the specified thickness requirements. The average job thickness will be the average of all thickness measurements taken for the job and must be within 1/4 inch of the thickness indicated. Measure the total thickness of the base course at intervals of one measurement for each 500 square yards of base course. Measure total thickness using 3 inch diameter test holes penetrating the base course.

3.8 COMPACTION

Compact each layer of the base course, as specified, with approved compaction equipment. Maintain water content during the compaction procedure to within plus or minus 2 percent of the optimum water content determined from laboratory tests as specified in this Section. Begin rolling at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Slightly vary the length of alternate trips of the roller. Adjust speed of the roller as needed so that displacement of the aggregate does not occur. Compact mixture with hand-operated power tampers in all places not accessible to the rollers. Continue compaction until each layer is compacted through the full depth to at least 100 percent of laboratory maximum density. Make such adjustments in compacting or finishing procedures as may be directed by the Contracting Officer to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory base course. Remove any materials found to be unsatisfactory and replace with satisfactory material or rework, as directed, to meet the requirements of this specification.

3.9 PROOF ROLLING

In addition to the compaction specified, proof roll areas designated on the drawings by application of coverages of a heavy pneumatic-tired roller having four or more tires abreast, each tire loaded to a minimum of 30,000 pounds and inflated to a minimum of 125 psi. A coverage is defined as the application of one tire print over the designated area. In the areas designated, apply proof rolling to the top of the underlying material on which the base course is laid and to the top of each layer of base course. Maintain water content of the underlying material and each layer of the base course as specified in Paragraph COMPACTION from start of compaction to completion of proof rolling of that layer. Remove any base course materials or any underlying materials that produce unsatisfactory results by proof rolling and replace with satisfactory materials. Then recompact and proof roll to meet these specifications.

3.10 EDGES OF BASE COURSE

Place the base course(s) so that the completed section will be a minimum of 2 feet wider, on all sides, than the next layer that will be placed above it. Place approved material along the outer edges of the base course in

sufficient quantity to compact to the thickness of the course being constructed. When the course is being constructed in two or more layers, simultaneously roll and compact at least a 2 foot width of this shoulder material with the rolling and compacting of each layer of the base course, as directed.

3.11 FINISHING

Finish the surface of the top layer of base course after final compaction and proof rolling by cutting any overbuild to grade and rolling with a steel-wheeled roller. Do not add thin layers of material to the top layer of base course to meet grade. If the elevation of the top layer of base course is 1/2 inch or more below grade, scarify the top layer to a depth of at least 3 inches and blend new material in and compact and proof roll to bring to grade. Make adjustments to rolling and finishing procedures as directed by the Contracting Officer to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable base course. Should the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, scarify the unsatisfactory portion and rework and recompact it or replace as directed.

3.12 SMOOTHNESS TEST

Construct the top layer so that the surface shows no deviations in excess of 3/8 inch when tested with a 12 foot straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Also take measurements perpendicular to the centerline at 50 foot intervals. Correct deviations exceeding this amount by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.13 FIELD QUALITY CONTROL

3.13.1 In-Place Tests

Perform each of the following tests on samples taken from the placed and compacted ABC and GCA. Take samples and test at the rates indicated.

- a. Perform density tests on every lift of material placed and at a frequency of one set of tests for every 250 square yards, or portion thereof, of completed area.
- b. Perform sieve analysis including 0.02 mm size material on every lift of material placed and at a frequency of one sieve analysis for every 500 square yards, or portion thereof, of material placed.
- c. Perform liquid limit and plasticity index tests at the same frequency as the sieve analysis.
- d. Measure the thickness of the base course at intervals providing at least one measurement for each 500 square yards of base course or part thereof. Measure the thickness using test holes, at least 3 inch in diameter through the base course.

3.13.2 Approval of Material

Final approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and fully compacted course(s).

3.14 TRAFFIC

Completed portions of the base course may be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Do not allow heavy equipment on the completed base course except when necessary for construction. When it is necessary for heavy equipment to travel on the completed base course, protect the area against marring or damage to the completed work.

3.15 MAINTENANCE

Maintain the base course in a satisfactory condition until the full pavement section is completed and accepted. Immediately repair any defects and repeat repairs as often as necessary to keep the area intact. Retest any base course that was not paved over prior to the onset of winter to verify that it still complies with the requirements of this specification. Rework or replace any area of base course that is damaged as necessary to comply with this specification.

3.16 DISPOSAL OF UNSATISFACTORY MATERIALS

Dispose of any unsuitable materials that have been removed outside the limits of Government-controlled land . No additional payments will be made for materials that have to be replaced.

-- End of Section --

SECTION 32 12 13

BITUMINOUS TACK AND PRIME COATS
05/17

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM D140/D140M (2016) Standard Practice for Sampling Asphalt Materials

ASTM D2995 (1999; R 2009) Determining Application Rate of Bituminous Distributors

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00.05 20 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Sampling and Testing

1.3 QUALITY ASSURANCE

Certificates of compliance for asphalt materials delivered will be obtained and checked to ensure that specification requirements are met. Quantities of applied material will be determined. Payment will be for amount of residual asphalt applied. Tack coat materials will not be diluted. Prime coat materials when emulsions are used can be diluted on site with potable water up to 1 part emulsion to 1 part water.

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect the materials delivered to the site for contamination and damage. Unload and store the materials with a minimum of handling.

1.5 EQUIPMENT, TOOLS AND MACHINES

1.5.1 General Requirements

Equipment, tools and machines used in the work are subject to approval. Maintain in a satisfactory working condition at all times. Calibrate equipment such as asphalt distributors, scales, batching equipment, spreaders and similar equipment within 12 months of their use. If the calibration expires during project, recalibrate the equipment before work can continue.

1.5.2 Bituminous Distributor

Provide a self propelled distributor with pneumatic tires of such size and number to prevent rutting, shoving or otherwise damaging the surface being sprayed. Calibrate the distributor in accordance with [ASTM D2995](#). Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled total liquid rates from [0.03 to 1.0 gallons per square yard](#), with a pressure range of [25 to 75 psi](#) and with an allowable variation from the specified rate of not more than plus or minus 5 percent, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. The distributor will be capable of circulating and agitating the bituminous material during the heating process.

1.5.3 Heating Equipment for Storage Tanks

Use steam, electric, or hot oil heaters for heating the bituminous material. Provide steam heaters consisting of steam coils and equipment for producing steam, so designed that the steam cannot come in contact with the bituminous material. Fix an armored thermometer to the tank with a temperature range from [40 to 400 degrees F](#) so that the temperature of the bituminous material may be determined at all times.

1.5.4 Power Brooms and Power Blowers

Use power brooms and power blowers suitable for cleaning the surfaces to which the bituminous coat is to be applied.

1.6 ENVIRONMENTAL REQUIREMENTS

Apply bituminous coat only when the surface to receive the bituminous coat is dry. A limited amount of moisture (approximately [0.03 gallon/square yard](#)) can be sprayed on the surface of unbound material when prime coat is used to improve coverage and penetration of asphalt material. Apply bituminous coat only when the atmospheric temperature in the shade is [50 degrees F](#) or above and when the temperature has not been below [35 degrees F](#) for the 12 hours prior to application, unless otherwise directed.

PART 2 PRODUCTS

2.1 PRIME COAT

Provide [in accordance with NCDOT Standard Specifications, Section 600, January 2018](#).

2.2 TACK COAT

2.2.1 Cutback Asphalt

Provide [in accordance with NCDOT Standard Specifications, Section 605-2, January 2018](#).

2.2.2 Emulsified Asphalt

Provide in accordance with NCDOT Standard Specifications, Section 605-2, January 2018.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Immediately before applying the bituminous coat, remove all loose material, dirt, clay, or other objectionable material from the surface to be treated by means of a power broom or blower supplemented with hand brooms. Apply treatment only when the surface is dry and clean.

3.2 APPLICATION RATE

The exact quantities within the range specified, which may be varied to suit field conditions, will be determined by the Contracting Officer.

3.2.1 Tack Coat

Apply bituminous material in accordance with NCDOT Standard Specifications, Section 605, January 2018.

3.2.2 Prime Coat

Apply bituminous material for the prime coat in quantities of not less than 0.05 gallons nor more than 0.12 gallons per square yard of residual asphalt for asphalt emulsion up to a 1 to 1 dilution rate or for residual asphalt for cutback asphalt.

3.3 APPLICATION TEMPERATURE

3.3.1 Viscosity Relationship

Apply asphalt at a temperature that will provide a viscosity between 10 and 60 seconds, Saybolt Furol, or between 20 and 120 centistokes, kinematic. Furnish the temperature viscosity relation to the Contracting Officer.

3.3.2 Temperature Ranges

The viscosity requirements determine the application temperature to be used. The following is a normal range of application temperatures:

Cutback Asphalts	
MC-30	85-190 degrees F
SC-70, MC-70, RC-70	120-225 degrees F
SC-250, MC-250, RC-250	165-270 degrees F
Asphalt Emulsion	
All Grades	70-160 degrees F

Cutback Asphalts	
Asphalt Cement	
All Grades	275-350 degrees F

Some of these temperatures for rapid cure cutbacks are above the flash point of the material and care should be taken in their heating.

3.4 APPLICATION

3.4.1 General

Following preparation and subsequent inspection of the surface, apply the bituminous prime or tack coat with the bituminous distributor at the specified rate with uniform distribution over the surface to be treated. Properly treat all areas and spots, not capable of being sprayed with the distributor, with the hand spray. Until the succeeding layer of pavement is placed, maintain the surface by protecting the surface against damage and by repairing deficient areas at no additional cost to the Government. If required, spread clean dry sand to effectively blot up any excess bituminous material. No smoking, fires, or flames other than those from the heaters that are a part of the equipment are permitted within 25 feet of heating, distributing, and transferring operations of cutback materials. Prevent all traffic, except for paving equipment used in constructing the surfacing, from using the underlying material, whether primed or not, until the surfacing is completed. The bituminous coat requirements are described herein.

3.4.2 Prime Coat

Apply a prime coat as shown on the drawings and between existing grade and new asphalt layers. Apply the bituminous material uniformly over the surface to be treated at a pressure range of 25 to 75 psi; the rate will be as specified above in paragraph APPLICATION RATE. To obtain uniform application of the prime coat on the surface treated at the junction of previous and subsequent applications, spread building paper on the surface for a sufficient distance back from the ends of each application to start and stop the prime coat on the paper and to ensure that all sprayers will operate at full force on the surface to be treated. Immediately after application remove and destroy the building paper.

3.4.3 Tack Coat

Apply tack coat at the locations shown on the drawings and between existing asphalt, milled surfaces and new asphalt application areas. A tack coat shall be applied to every bound surface (asphalt or concrete pavement) that is being overlaid with asphalt mixture and at transverse and longitudinal joints. Apply the tack coat when the surface to be treated is clean and dry. Immediately following the preparation of the surface for treatment, apply the bituminous material by means of the bituminous distributor, within the limits of temperature specified herein and at a rate as specified above in paragraph APPLICATION RATE. Apply the bituminous material so that uniform distribution is obtained over the entire surface to be treated. Treat lightly coated areas and spots missed by the distributor by spraying with a hand wand or using other approved method. Following the application of bituminous material, allow the surface to cure without being disturbed for period of time necessary to

permit setting of the tack coat. Apply the bituminous tack coat only as far in advance of the placing of the overlying layer as required for that day's operation. Maintain and protect the treated surface from damage until the succeeding course of pavement is placed.

3.5 CURING PERIOD

Following application of the bituminous material and prior to application of the succeeding layer of asphalt mixture allow the bituminous coat to cure and water or volatiles to evaporate prior to overlaying. Maintain the tacked surface in good condition until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and recoating deficient areas. Allow the prime coat to cure without being disturbed for a period of at least 48 hours or longer, as may be necessary to attain penetration into the treated course. Furnish and spread enough sand to effectively blot up excess bituminous material.

3.6 FIELD QUALITY CONTROL

Obtain certificates of compliance for all asphalt material delivered to the project. Obtain samples of the bituminous material under the supervision of the Contracting Officer. The sample may be retained and tested by the Government at no cost to the Contractor.

3.7 SAMPLING AND TESTING

Furnish certified copies of the manufacturer's test reports indicating temperature viscosity relationship for cutback asphalt or asphalt cement, compliance with applicable specified requirements, not less than 5 days before the material is required in the work.

3.7.1 Sampling

Unless otherwise specified, sample bituminous material in accordance with [ASTM D140/D140M](#).

3.7.2 Calibration Test

Furnish all equipment, materials, and labor necessary to calibrate the bituminous distributor. Calibrate using the approved job material and prior to applying the bituminous coat material to the prepared surface. Calibrate the bituminous distributor in accordance with [ASTM D2995](#).

3.7.3 Trial Applications

Before applying the spray application of tack or prime coat, apply three lengths of at least [100 feet](#) for the full width of the distributor bar to evaluate the amount of bituminous material that can be satisfactorily applied.

3.7.3.1 Tack Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous tack coat materials in the amount of [0.05 gallons per square yard](#). Make other trial applications using various amounts of material as may be deemed necessary.

3.7.3.2 Prime Coat Trial Application Rate

Unless otherwise authorized, apply the trial application rate of bituminous materials in the amount of 0.15 gallon per square yard. Make other trial applications using various amounts of material as may be deemed necessary.

3.7.4 Sampling and Testing During Construction

Perform quality control sampling and testing as required in paragraph FIELD QUALITY CONTROL.

3.8 TRAFFIC CONTROLS

Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces.

-- End of Section --

SECTION 32 12 16

HOT-MIX ASPHALT (HMA) FOR ROADS
08/09

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 156 (2013; R 2017) Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures

AASHTO M 320 (2017) Standard Specification for Performance-Graded Asphalt Binder

ASTM INTERNATIONAL (ASTM)

ASTM C136/C136M (2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM C566 (2013) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying

ASTM D140/D140M (2016) Standard Practice for Sampling Asphalt Materials

ASTM D242/D242M (2009; R 2014) Mineral Filler for Bituminous Paving Mixtures

ASTM D1461 (2017) Standard Test Method for Moisture or Volatile Distillates in Asphalt Mixtures

ASTM D2172/D2172M (2017; E 2018) Standard Test Methods for Quantitative Extraction of Asphalt Binder from Asphalt Mixtures

ASTM D2489/D2489M (2016) Standard Test Method for Estimating Degree of Particle Coating of Asphalt Mixtures

ASTM D2950/D2950M (2014) Density of Bituminous Concrete in Place by Nuclear Methods

ASTM D3665 (2012; R 2017) Standard Practice for Random Sampling of Construction Materials

ASTM D3666 (2016) Standard Specification for Minimum

Requirements for Agencies Testing and
Inspecting Road and Paving Materials

ASTM D4125/D4125M

(2010) Asphalt Content of Bituminous
Mixtures by the Nuclear Method

ASTM D5444

(2015) Mechanical Size Analysis of
Extracted Aggregate

ASTM D6307

(2019) Standard Test Method for Asphalt
Content of Asphalt Mixture by Ignition
Method

ASTM D6925

(2014) Standard Test Method for
Preparation and Determination of the
Relative Density of Hot Mix Asphalt (HMA)
Specimens by Means of the Superpave
Gyratory Compactor

ASTM D6926

(2020) Standard Practice for Preparation
of Asphalt Mixture Specimens Using
Marshall Apparatus

ASTM D6927

(2015) Standard Test Method for Marshall
Stability and Flow of Bituminous Mixtures

STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS)

CTM 526

(2012) Method of Test for Operation of
California Profilograph and Evaluation of
Profiles

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00.05 20 SUBMITTAL PROCEDURES:

SD-03 Product Data

Mix Design

Quality Control

Material Acceptance

SD-04 Samples

Asphalt Cement Binder

Aggregates

SD-06 Test Reports

Aggregates

QC Monitoring

SD-07 Certificates

Asphalt Cement Binder

Testing Laboratory

1.3 ENVIRONMENTAL REQUIREMENTS

Do not place the hot-mix asphalt upon a wet surface, in standing water or when the surface temperature of the underlying course is less than specified in Table 3. The temperature requirements may be waived by the Contracting Officer, if requested; however, meet all other requirements, including compaction.

Table 3. Surface Temperature Limitations of Underlying Course	
Mat Thickness, inches	Degrees F
3 or greater	40
Less than 3	45

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Perform the work consisting of pavement courses composed of mineral aggregate and asphalt material heated and mixed in a central mixing plant and placed on a prepared course. HMA designed and constructed in accordance with this section shall conform to the lines, grades, thicknesses, and typical cross sections indicated. Construct each course to the depth, section, or elevation required by the drawings and roll, finish, and approve it before the placement of the next course.

2.1.1 Asphalt Mixing Plant

Plants used for the preparation of hot-mix asphalt shall conform to the requirements of AASHTO M 156 with the following changes:

2.1.1.1 Truck Scales

Weigh the asphalt mixture on approved, certified scales at the Contractor's expense. Inspect and seal scales at least annually by an approved calibration laboratory.

2.1.1.2 Testing Facilities

Provide laboratory facilities at the plant for the use of the Government's acceptance testing and the Contractor's quality control testing.

2.1.1.3 Inspection of Plant

Provide the Contracting Officer with access at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and material properties; checking the temperatures maintained in the preparation of the mixtures and for

taking samples. Provide assistance as requested, for the Government to procure any desired samples.

2.1.1.4 Storage bins

Use of storage bins for temporary storage of hot-mix asphalt will be permitted as follows:

- a. The asphalt mixture may be stored in non-insulated storage bins for a period of time not exceeding 3 hours.
- b. The asphalt mixture may be stored in insulated storage bins for a period of time not exceeding 8 hours. The mix drawn from bins shall meet the same requirements as mix loaded directly into trucks.

2.1.2 Hauling Equipment

Provide trucks for hauling hot-mix asphalt having tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Petroleum based products shall not be used as a release agent. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers (tarps) shall be securely fastened.

2.1.3 Asphalt Pavers

Provide asphalt pavers which are self-propelled, with an activated screed, heated as necessary, and capable of spreading and finishing courses of hot-mix asphalt which will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

2.1.3.1 Receiving Hopper

Provide paver with a receiving hopper of sufficient capacity to permit a uniform spreading operation and equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

2.1.3.2 Automatic Grade Controls

Equip the paver with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent. A transverse slope controller shall not be used to control grade. Provide controls capable of working in conjunction with any of the following attachments:

- a. Ski-type device of not less than 30 feet in length.
- b. Taut stringline set to grade.

- c. Short ski or shoe for joint matching.
- d. Laser control.

2.1.4 Rollers

Rollers shall be in good condition and shall be operated at slow speeds to avoid displacement of the asphalt mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Do not use equipment which causes excessive crushing of the aggregate.

2.2 AGGREGATES

Provide aggregates consisting of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. Submit sufficient materials to produce 200 lb of blended mixture for mix design verification. The portion of material retained on the No. 4 sieve is coarse aggregate. The portion of material passing the No. 4 sieve and retained on the No. 200 sieve is fine aggregate. The portion passing the No. 200 sieve is defined as mineral filler. Submit all aggregate test results and samples to the Contracting Officer at least 14 days prior to start of construction.

2.2.1 Coarse Aggregate

Provide coarse aggregate consisting of sound, tough, durable particles, free from films of material that would prevent thorough coating and bonding with the asphalt material and free from organic matter and other deleterious substances. Coarse aggregate shall be provided in accordance with NCDOT Standard Specifications, Section 1012-1(B), January 2108.

2.2.2 Fine Aggregate

Fine aggregate shall consist of clean, sound, tough, durable particles free from coatings of clay, silt, or any objectionable material and containing no clay balls. Fine aggregate shall be provided in accordance with NCDOT Standard Specifications, Section 1012-1(C), January 2018.

2.2.3 Mineral Filler

Mineral filler shall be nonplastic material meeting the requirements of ASTM D242/D242M and in accordance with NCDOT Standard Specifications, Section 1012-1(D), January 2018.

2.2.4 Aggregate Gradation

The combined aggregate gradation shall conform to Table 610-2 of the NCDOT Standard Specifications, January 2018.

2.3 ASPHALT CEMENT BINDER

Submit a 5 gallon sample for mix design verification. Asphalt cement binder shall conform to AASHTO M 320 Performance Grade (PG) 64-22. Test data indicating grade certification shall be provided by the supplier at the time of delivery of each load to the mix plant. Submit copies of these certifications to the Contracting Officer. The supplier is defined as the last source of any modification to the binder. The Contracting

Officer may sample and test the binder at the mix plant at any time before or during mix production. Obtain samples for this verification testing in accordance with [ASTM D140/D140M](#) and in the presence of the Contracting Officer. Furnish these samples to the Contracting Officer for the verification testing, which shall be at no cost to the Contractor. Submit samples of the asphalt cement specified for approval not less than 14 days before start of the test section. Submit copies of certified test data, amount, type and description of any modifiers blended into the asphalt cement binder. [Binder shall be in accordance with NCDOT Standard Specifications, Section 1020-2, January 2018.](#)

2.4 MIX DESIGN

- a. [Provide Asphalt Concrete Surface Course, Type S9.5B, in accordance with NCDOT Standard Specifications, Section 610-2 and 610-3, January 2019.](#)
- b. [Provide Asphalt Concrete Intermediate Course, Type I19.0B or B25.0B, in accordance with NCDOT Standard Specifications, Sections 610-2 and 610-3, January 2018.](#)

2.4.1 JMF Requirements

[JMF shall be in accordance with NCDOT Standard Specifications, Section 610-3\(C\), January 2018.](#)

2.4.2 Adjustments to Field JMF

Keep the Laboratory JMF for each mixture in effect until a new formula is approved in writing by the Contracting Officer. Should a change in sources of any materials be made, perform a new laboratory jmf design and a new JMF approved before the new material is used. The Contractor will be allowed to adjust the Laboratory JMF within the limits specified below to optimize mix volumetric properties with the approval of the Contracting Officer. Adjustments to the Laboratory JMF shall be applied to the field (plant) established JMF and limited to those values as shown. Adjustments shall be targeted to produce or nearly produce 4 percent voids total mix (VTM).

TABLE 6. Field (Plant) Established JMF Tolerances	
Sieves	Adjustments (plus or minus), percent
1/2 inch	3
No. 4	3
No. 8	3
No. 200	1
Binder Content	0.4

If adjustments are needed that exceed these limits, develop a new mix design. Tolerances given above may permit the aggregate grading to be outside the limits shown in Table 4; while not desirable, this is acceptable, except for the [No. 200](#) sieve, which shall remain within the

aggregate grading of Table 4.

2.5 GEOTEXTILE

Provide a stabilization geotextile under all new pavement section base courses in accordance with AASHTO M288 Class 1 Woven Geotextile with Elongation < 50%. Seams shall overlap at a minimum of 24 inches. Reference Section 31 05 19 GEOTEXTILES.

PART 3 EXECUTION

3.1 PREPARATION OF ASPHALT BINDER MATERIAL

Heat the asphalt cement material avoiding local overheating and providing a continuous supply of the asphalt material to the mixer at a uniform temperature. The temperature of unmodified asphalts shall be no more than 325 degrees F when added to the aggregates. Performance-Graded (PG) asphalts shall be within the temperature range of 250 - 290 degrees F when added to the aggregate.

3.2 PREPARATION OF MINERAL AGGREGATE

Heat and dry the aggregate for the mixture prior to mixing. No damage shall occur to the aggregates due to the maximum temperature and rate of heating used. The temperature of the aggregate and mineral filler shall not exceed 350 degrees F when the asphalt cement is added. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

3.3 PREPARATION OF HOT-MIX ASPHALT MIXTURE

The aggregates and the asphalt cement shall be weighed or metered and introduced into the mixer in the amount specified by the JMF. Mix the combined materials until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but no less than 25 seconds for batch plants. Establish the wet mixing time for all plants based on the procedure for determining the percentage of coated particles described in ASTM D2489/D2489M, for each individual plant and for each type of aggregate used. The wet mixing time will be set to at least achieve 95 percent of coated particles. The moisture content of all hot-mix asphalt upon discharge from the plant shall not exceed 0.5 percent by total weight of mixture as measured by ASTM D1461.

3.4 PREPARATION OF THE UNDERLYING SURFACE

Immediately before placing the hot mix asphalt, clean the underlying course of dust and debris. Apply a prime coat and/or tack coat in accordance with the contract specifications.

3.5 TEST SECTION

Prior to full production, place a test section for each JMF used. Construct a test section 250 - 500 feet long and two paver passes wide placed for two lanes, with a longitudinal cold joint. The test section shall be of the same thickness as the course which it represents. The underlying grade or pavement structure upon which the test section is to

be constructed shall be the same as the remainder of the course represented by the test section. The equipment and personnel used in construction of the test section shall be the same equipment to be used on the remainder of the course represented by the test section. Place the test section as part of the project pavement, as approved by the Contracting Officer.

3.5.1 Sampling and Testing for Test Section

Take one random sample at the plant, triplicate specimens compacted, and tested for stability, flow, and laboratory air voids. Test a portion of the same sample for theoretical maximum density (TMD), aggregate gradation and asphalt content. Take four randomly selected cores from the finished pavement mat, and four from the longitudinal joint, and tested for density. Random sampling shall be in accordance with procedures contained in [ASTM D3665](#). The test results shall be within the tolerances shown in Table 7 for work to continue. If all test results meet the specified requirements, the test section shall remain as part of the project pavement. If test results exceed the tolerances shown, the test section shall be removed and replaced at no cost to the Government and another test section shall be constructed. The test section shall be paid for with the first lot of paving

Table 7. Test Section Requirements for Material and Mixture Properties	
Property	Specification Limit
Aggregate Gradation-Percent Passing (Individual Test Result)	
No. 4 and larger	JMF plus or minus 8
No. 8, No. 16, No. 30, and No. 50	JMF plus or minus 6
No. 100 and No. 200	JMF plus or minus 2.0
Asphalt Content, Percent (Individual Test Result)	JMF plus or minus 0.5
Laboratory Air Voids, Percent (Average of 3 specimens)	JMF plus or minus 1.0
VMA, Percent (Average of 3 specimens)	15 minimum
Stability, pounds (Average of 3 specimens) (NA for Superpave)	1000 minimum for 50 blows
Flow, 0.01 inch (Average of 3 specimens) (NA for Superpave)	8 - 18 for 50 blows
Mat Density, Percent of TMD (Average of 4 Random Cores)	92.0 - 96.0

Table 7. Test Section Requirements for Material and Mixture Properties	
Property	Specification Limit
Joint Density, Percent of TMD (Average of 4 Random Cores)	90.5 - 92.5

3.5.2 Additional Test Sections

If the initial test section should prove to be unacceptable, make the necessary adjustments to the JMF, plant operation, placing procedures, and/or rolling procedures and place a second test section. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until an acceptable section has been constructed and accepted.

3.6 TESTING LABORATORY

Submit certification of compliance and Plant Scale Calibration Certification. Use a laboratory to develop the JMF that meets the requirements of [ASTM D3666](#). The Government will inspect the laboratory equipment and test procedures prior to the start of hot mix operations for conformance to [ASTM D3666](#). The laboratory shall maintain the Corps certification for the duration of the project. A statement signed by the manager of the laboratory stating that it meets these requirements or clearly listing all deficiencies shall be submitted to the Contracting Officer prior to the start of construction. The statement shall contain as a minimum:

- a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.
- b. A listing of equipment to be used in developing the job mix.
- c. A copy of the laboratory's quality control system.
- d. Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program.

3.7 TRANSPORTING AND PLACING

3.7.1 Transporting

Transport the hot-mix asphalt from the mixing plant to the site in clean, tight vehicles. Schedule deliveries so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Provide adequate artificial lighting for night placements. Hauling over freshly placed material will not be permitted until the material has been compacted as specified, and allowed to cool to [140 degrees F](#). To deliver mix to the paver, use a material transfer vehicle operated to produce continuous forward motion of the paver. [Asphalt temperature delivered to the jobsite shall be above minimum temperature for asphalt grade as listed in Section 609 of the NCDOT standard specifications including relevant asphalt quality management standards \(QMS\).](#)

3.7.2 Placing

Place and compact the mix at a temperature suitable for obtaining density, surface smoothness, and other specified requirements. Upon arrival, place the mixture to the full width by an asphalt paver; it shall be struck off in a uniform layer of such depth that, when the work is completed, it will have the required thickness and conform to the grade and contour indicated. Regulate the speed of the paver to eliminate pulling and tearing of the asphalt mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. Place the mixture in consecutive adjacent strips having a minimum width of 10 feet. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1 foot; however, the joint in the surface course shall be at the centerline of the pavement. Transverse joints in one course shall be offset by at least 10 feet from transverse joints in the previous course. Transverse joints in adjacent lanes shall be offset a minimum of 10 feet. On isolated areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools.

3.8 COMPACTION OF MIXTURE

After placing, the mixture shall be thoroughly and uniformly compacted by rolling. Compact the surface as soon as possible without causing displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once. Furnish sufficient rollers to handle the output of the plant. Continue rolling until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. To prevent adhesion of the mixture to the roller, keep the wheels properly moistened but excessive water will not be permitted. In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers. Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or is in any way defective shall be removed full depth, replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching will not be allowed.

3.9 JOINTS

The formation of joints shall be performed ensuring a continuous bond between the courses and to obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

3.9.1 Transverse Joints

Do not pass the roller over the unprotected end of the freshly laid mixture, except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing material at the joint. Remove the cutback material from the project. In both methods, all contact surfaces shall be given a light

tack coat of asphalt material before placing any fresh mixture against the joint.

3.9.2 Longitudinal Joints

Longitudinal joints which are irregular, damaged, uncompacted, cold (less than 175 degrees F at the time of placing adjacent lanes), or otherwise defective, shall be cut back a maximum of 3 inches from the top of the course with a cutting wheel to expose a clean, sound vertical surface for the full depth of the course. All cutback material shall be removed from the project. All contact surfaces shall be given a light tack coat of asphalt material prior to placing any fresh mixture against the joint. The Contractor will be allowed to use an alternate method if it can be demonstrated that density, smoothness, and texture can be met.

3.10 QUALITY CONTROL

3.10.1 General Quality Control Requirements

Develop and submit an approved Quality Control Plan. Submit aggregate and QC test results. Do not produce hot-mix asphalt for payment until the quality control plan has been approved addressing all elements which affect the quality of the pavement including, but not limited to:

- a. Mix Design
- b. Aggregate Grading
- c. Quality of Materials
- d. Stockpile Management
- e. Proportioning
- f. Mixing and Transportation
- g. Mixture Volumetrics
- h. Moisture Content of Mixtures
- i. Placing and Finishing
- j. Joints
- k. Compaction
- l. Surface Smoothness

3.10.2 Testing Laboratory

Provide a fully equipped asphalt laboratory located at the plant or job site and meeting the pertinent requirements in ASTM D3666. Laboratory facilities shall be kept clean and all equipment maintained in proper working condition. The Contracting Officer shall be permitted unrestricted access to inspect the Contractor's laboratory facility, to witness quality control activities, and to perform any check testing desired. The Contracting Officer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are

serious enough to adversely affect test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are corrected.

3.10.3 Quality Control Testing

Perform all quality control tests applicable to these specifications and as set forth in the Quality Control Program. The testing program shall include, but shall not be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, moisture in the asphalt mixture, laboratory air voids, stability (NA for Superpave), flow (NA for Superpave), in-place density, grade and smoothness. Develop a Quality Control Testing Plan as part of the Quality Control Program.

3.10.3.1 Asphalt Content

A minimum of two tests to determine asphalt content will be performed per lot (a lot is defined in paragraph MATERIAL ACCEPTANCE and PERCENT PAYMENT) by one of the following methods: the extraction method in accordance with [ASTM D2172/D2172M](#), Method A or B, the ignition method in accordance with [ASTM D6307](#), or the nuclear method in accordance with [ASTM D4125/D4125M](#). Calibrate the ignition oven or the nuclear gauge for the specific mix being used. For the extraction method, determine the weight of ash, as described in [ASTM D2172/D2172M](#), as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture.

3.10.3.2 Gradation

Determine aggregate gradations a minimum of twice per lot from mechanical analysis of recovered aggregate in accordance with [ASTM D5444](#). When asphalt content is determined by the ignition oven or nuclear method, aggregate gradation shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix plants. For batch plants, test aggregates in accordance with [ASTM C136/C136M](#) using actual batch weights to determine the combined aggregate gradation of the mixture.

3.10.3.3 Temperatures

Check temperatures at least four times per lot, at necessary locations, to determine the temperature at the dryer, the asphalt cement in the storage tank, the asphalt mixture at the plant, and the asphalt mixture at the job site.

3.10.3.4 Aggregate Moisture

Determine the moisture content of aggregate used for production a minimum of once per lot in accordance with [ASTM C566](#).

3.10.3.5 Moisture Content of Mixture

Determine the moisture content of the mixture at least once per lot in accordance with [ASTM D1461](#) or an approved alternate procedure.

3.10.3.6 Laboratory Air Voids, Marshall Stability and Flow

Take mixture samples at least four times per lot compacted into specimens, using 50 blows per side with the hand-held Marshall hammer as described in [ASTM D6926](#). When the Superpave gyratory compactor is used, mixes will be compacted to 50 gyrations in accordance with [ASTM D6925](#). Hot-mix provided under the DOT Superpave option shall be compacted in accordance with the DOT requirements. After compaction, determine the laboratory air voids of each specimen. Stability and flow shall be determined for the Marshall-compacted specimens, in accordance with [ASTM D6927](#).

3.10.3.7 In-Place Density

Conduct any necessary testing to ensure the specified density is achieved. A nuclear gauge may be used to monitor pavement density in accordance with [ASTM D2950/D2950M](#).

3.10.3.8 Grade and Smoothness

Conduct the necessary checks to ensure the grade and smoothness requirements are met in accordance with paragraphs MATERIAL ACCEPTANCE and PERCENT PAYMENT.

3.10.3.9 Additional Testing

Any additional testing, which the Contractor deems necessary to control the process, may be performed at the Contractor's option.

3.10.3.10 QC Monitoring

Contractor shall have a NCDOT certified asphalt technician on site to observe paving operations during all times of material placement. Submit all QC test results to the Contracting Officer on a daily basis as the tests are performed. The Contracting Officer reserves the right to monitor any of the Contractor's quality control testing and to perform duplicate testing as a check to the Contractor's quality control testing.

3.10.4 Sampling

When directed by the Contracting Officer, sample and test any material which appears inconsistent with similar material being produced, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

3.10.5 Control Charts

For process control, establish and maintain linear control charts on both individual samples and the running average of last four samples for the parameters listed in Table 8, as a minimum. These control charts shall be posted as directed by the Contracting Officer and kept current at all times. The control charts shall identify the project number, the test parameter being plotted, the individual sample numbers, the Action and Suspension Limits listed in Table 8 applicable to the test parameter being plotted, and the Contractor's test results. Target values from the JMF shall also be shown on the control charts as indicators of central tendency for the cumulative percent passing, asphalt content, and laboratory air voids parameters. When the test results exceed either applicable Action Limit, take immediate steps to bring the process back in

control. When the test results exceed either applicable Suspension Limit, halt production until the problem is solved. Use the control charts as part of the process control system for identifying trends so that potential problems can be corrected before they occur. Make decisions concerning mix modifications based on analysis of the results provided in the control charts. The Quality Control Plan shall indicate the appropriate action to be taken to bring the process into control when certain parameters exceed their Action Limits.

Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts				
	Individual Samples		Running Average of Last Four Samples	
Parameter to be Plotted	Action Limit	Suspension Limit	Action Limit	Suspension Limit
No. 4 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	6	8	4	5
No. 30 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	4	6	3	4
No. 200 sieve, Cumulative percent passing, deviation for JMF target; plus or minus values	1.4	2.0	1.1	1.5
Stability, pounds (minimum) (NA for Superpave)				
75 Blow JMF	1800	1700	1900	1800
50 Blow JMF	1000	900	1100	1000
Flow, 0.01 inch (NA for Superpave)				
75 Blow JMF	8 min.	7 min.	9 min.	8 min.
	16 max.	17 max.	15 max.	16 max.
50 Blow JMF	8 min.	7 min.	9 min.	8 min.
	18 max.	19 max.	17 max.	18 max.
Asphalt content, percent deviation from JMF target; plus or minus value	0.4	0.5	0.2	0.3
Laboratory Air Voids, percent deviation from JMF target value	No specific action and suspension limits set since this parameter is used to determine percent payment			
In-place Mat Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			

Table 8. Action and Suspension Limits for the Parameters to be Plotted on Individual and Running Average Control Charts				
Parameter to be Plotted	Individual Samples		Running Average of Last Four Samples	
	Action Limit	Suspension Limit	Action Limit	Suspension Limit
In-place Joint Density, percent of TMD	No specific action and suspension limits set since this parameter is used to determine percent payment			

3.11 MATERIAL ACCEPTANCE

Testing for acceptability of work will be performed by an independent laboratory hired by the Contractor. Forward test results and payment calculations daily to the Contracting Officer. Acceptance of the plant produced mix and in-place requirements will be on a lot to lot basis. A standard lot for all requirements will be equal to 8 hours of production. Where appropriate, adjustment in payment for individual lots of hot-mix asphalt will be made based on in-place density, laboratory air voids, grade and smoothness in accordance with the following paragraphs. Grade and surface smoothness determinations will be made on the lot as a whole. Exceptions or adjustments to this will be made in situations where the mix within one lot is placed as part of both the intermediate and surface courses, thus grade and smoothness measurements for the entire lot cannot be made. In order to evaluate laboratory air voids and in-place (field) density, each lot will be divided into four equal sublots.

3.11.1 Sublot Sampling

One random mixture sample for determining laboratory air voids, theoretical maximum density, and for any additional testing the Contracting Officer desires, will be taken from a loaded truck delivering mixture to each sublot, or other appropriate location for each sublot. All samples will be selected randomly, using commonly recognized methods of assuring randomness conforming to [ASTM D3665](#) and employing tables of random numbers or computer programs. Laboratory air voids will be determined from three laboratory compacted specimens of each sublot sample in accordance with [ASTM D6926](#). The specimens will be compacted within 2 hours of the time the mixture was loaded into trucks at the asphalt plant. Samples will not be reheated prior to compaction and insulated containers will be used as necessary to maintain the temperature.

3.11.2 Additional Sampling and Testing

The Contracting Officer reserves the right to direct additional samples and tests for any area which appears to deviate from the specification requirements. The cost of any additional testing will be paid for by the Government. Testing in these areas will be in addition to the lot testing, and the requirements for these areas will be the same as those for a lot.

3.11.3 Grade

The final wearing surface of pavement shall conform to the elevations and cross sections shown and shall vary not more than [0.05 foot](#) from the plan grade established and approved at site of work. Finished surfaces at

juncture with other pavements shall coincide with finished surfaces of abutting pavements. Deviation from the plan elevation will not be permitted in areas of pavements where closer conformance with planned elevation is required for the proper functioning of drainage and other appurtenant structures involved. The grade will be determined by running lines of levels at intervals of 25 feet, or less, longitudinally and transversely, to determine the elevation of the completed pavement surface. Within 5 working days, after the completion of a particular lot incorporating the final wearing surface, test the final wearing surface of the pavement for conformance with the specified plan grade. Diamond grinding may be used to remove high spots to meet grade requirements. Skin patching for correcting low areas or planing or milling for correcting high areas will not be permitted.

3.11.4 Surface Smoothness

Use one of the following methods to test and evaluate surface smoothness of the pavement. Perform all testing in the presence of the Contracting Officer. Keep detailed notes of the results of the testing and furnish a copy to the Government immediately after each day's testing. Use the profilograph method for all longitudinal testing, except where the runs would be less than 200 feet in length and the ends where the straightedge will be used. Where drawings show required deviations from a plane surface (crowns, drainage inlets, etc.), the surface shall be finished to meet the approval of the Contracting Officer.

3.11.4.1 Smoothness Requirements

3.11.4.1.1 Straightedge Testing

The finished surfaces of the pavements shall have no abrupt change of 1/4 inch or more, and all pavements shall be within the tolerances of 1/4 inch in both the longitudinal and transverse directions, when tested with an approved 12 feet straightedge.

3.11.4.1.2 Profilograph Testing

The finished surfaces of the pavements shall have no abrupt change of 1/8 inch or more, and each 0.1 mile segment of each pavement lot shall have a Profile Index not greater than 9 inches/mile when tested with an approved California-type profilograph. If the extent of the pavement in either direction is less than 200 feet, that direction shall be tested by the straightedge method and shall meet requirements specified above.

3.11.4.2 Testing Method

After the final rolling, but not later than 24 hours after placement, test the surface of the pavement in each entire lot in such a manner as to reveal all surface irregularities exceeding the tolerances specified above. Separate testing of individual sublots is not required. If any pavement areas are ground, these areas shall be retested immediately after grinding. Test each lot of the pavement in both a longitudinal and a transverse direction on parallel lines. Set the transverse lines 15 feet or less apart, as directed. The longitudinal lines shall be at the centerline of each paving lane for lanes less than 20 feet wide and at the third points for lanes 20 feet or wider. Also test other areas having obvious deviations. Longitudinal testing lines shall be continuous across all joints.

3.11.4.2.1 Straightedge Testing

Hold the straightedge in contact with the surface and move it ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points.

3.11.4.2.2 Profilograph Testing

Perform profilograph testing using approved equipment and procedures described in [CTM 526](#). The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must-grind" bumps and the Profile Index for each [0.1 mile](#) segment of each pavement lot. Grade breaks on parking lots shall be accommodated by breaking the profile segment into shorter sections and repositioning the blanking band on each segment. The "blanking band" shall be [0.2 inches](#) wide and the "bump template" shall span [1 inch](#) with an offset of [0.3 inch](#). Compute the Profile Index for each pass of the profilograph in each [0.1 mile](#) segment. The Profile Index for each segment shall be the average of the Profile Indices for each pass in each segment. The profilograph shall be operated by a DOT approved operator. Furnish a copy of the reduced tapes to the Government at the end of each day's testing.

-- End of Section --

SECTION 32 13 13.06

PORTLAND CEMENT CONCRETE PAVEMENT FOR ROADS AND SITE FACILITIES
05/20

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN CONCRETE INSTITUTE (ACI)

- ACI 211.1 (1991; R 2009) Standard Practice for
Selecting Proportions for Normal,
Heavyweight and Mass Concrete
- ACI 305R (2010) Guide to Hot Weather Concreting
- ACI 306R (2016) Guide to Cold Weather Concreting

ASTM INTERNATIONAL (ASTM)

- ASTM A615/A615M (2020) Standard Specification for Deformed
and Plain Carbon-Steel Bars for Concrete
Reinforcement
- ASTM A966/A966M (2015; R 2020) Standard Test Method for
Magnetic Particle Examination of Steel
Forgings Using Alternating Current
- ASTM C31/C31M (2019a) Standard Practice for Making and
Curing Concrete Test Specimens in the Field
- ASTM C33/C33M (2018) Standard Specification for Concrete
Aggregates
- ASTM C78/C78M (2018) Standard Test Method for Flexural
Strength of Concrete (Using Simple Beam
with Third-Point Loading)
- ASTM C88 (2018) Standard Test Method for Soundness
of Aggregates by Use of Sodium Sulfate or
Magnesium Sulfate
- ASTM C94/C94M (2020) Standard Specification for
Ready-Mixed Concrete
- ASTM C143/C143M (2020) Standard Test Method for Slump of
Hydraulic-Cement Concrete
- ASTM C171 (2016) Standard Specification for Sheet
Materials for Curing Concrete
- ASTM C172/C172M (2017) Standard Practice for Sampling
Freshly Mixed Concrete

ASTM C231/C231M	(2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494/C494M	(2019) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2020) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2019) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C881/C881M	(2015) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C1017/C1017M	(2013; E 2015) Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1260	(2014) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1567	(2013) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2018) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM D2995	(1999; R 2009) Determining Application Rate of Bituminous Distributors
ASTM E1274	(2018) Standard Test Method for Measuring Pavement Roughness Using a Profilograph

NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA QC 3	(2015) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete

Production Facilities

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00.05 20 SUBMITTAL PROCEDURES:

SD-03 Product Data

Curing Materials

Epoxy Resin

Dowel Bars

SD-04 Samples

Test Section

SD-05 Design Data

Mix Design Report

SD-06 Test Reports

Concrete Slump Tests

Concrete Uniformity

Flexural Strength

Air Content

SD-07 Certificates

Batch Tickets

NRMCA Certificate Of Conformance

SD-08 Manufacturer's Instructions

Diamond Grinding Plan

1.3 QUALITY CONTROL

1.3.1 NRMCA Certificate of Conformance

Provide a batching and mixing plant consisting of a stationary-type central mix plant, including permanent installations and portable or relocatable plants installed on stable foundations. Provide a plant designed and operated to produce concrete within the specified tolerances, with a minimum capacity of 250 cubic yards per hour. Submit NRMCA Certificate of Conformance that conforms to the requirements of NRMCA QC 3 including provisions addressing:

1. Material Storage and Handling
2. Batching Equipment
3. Central Mixer
4. Ticketing System
5. Delivery System

1.3.2 Qualifications

1.3.2.1 Laboratory Accreditation

Perform sampling and testing using an approved commercial testing laboratory or on-site facilities that are accredited in accordance with [ASTM C1077](#). Do not start work requiring testing until the facilities have been inspected and approved. The Government will inspect all laboratories requiring validation for equipment and test procedures prior to the start of any concreting operations for conformance to [ASTM C1077](#). Schedule and provide payment for laboratory inspections. Additional payment or a time extension due to failure to acquire the required laboratory validation is not allowed. Maintain this certification for the duration of the project.

1.3.2.2 Field Technicians

Provide field technicians meeting one of the following criteria:

- a. Have at least one National Ready Mixed Concrete Association (NRMCA) certified concrete craftsman and at least one American Concrete Institute (ACI) Flatwork Finisher Certified craftsman on site, overseeing each placement crew during all concrete placement.
- b. Have no less than three NRMCA certified concrete installers and at least two American Concrete Institute (ACI) Flatwork Finisher Certified installers on site working as members of each placement crew during all concrete placement.

1.3.3 Batch Tickets

Submit [batch tickets](#) for each load of ready-mixed concrete in accordance with [ASTM C94/C94M](#).

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver concrete paving in accordance with [ASTM C94/C94M](#).

1.5 ACCEPTANCE

1.5.1 Tolerances

Acceptance of Portland cement concrete pavement is based on compliance with the tolerances presented in Table 1. Remove and replace concrete pavement represented by the failing tests or submit repair plan for approval.

Edge Slump	85 percent less than $\frac{1}{4}$ inch and 100 percent less than $\frac{3}{8}$ inch.

1.5.2 Test Section

Construct a minimum 400 square feet test section to demonstrate typical joints, surface finish, texture, color, thickness, and standard of workmanship using the mixture proportions, materials, and equipment as proposed for the project. Test in accordance with requirements in FIELD QUALITY CONTROL.

When a test section does not meet one or more of the tolerances in Table 1, remove and reconstruct the test section. If the test section is acceptable, it may be incorporated into the project.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

2.1.1.1 Portland Cement

Provide portland cement in accordance with NCDOT Standard Specifications, Section 1024-1, January 2018.

2.1.1.2 Blended Cement

Provide blended cement in accordance with NCDOT Standard Specifications, Section 1024-1, January 2018 and also conforming to ASTM C595/C595M, Type IP or IS, including the optional requirement for mortar expansion. Provide pozzolan added to the Type IP blend consisting of ASTM C618 Class F or Class N and that is interground with the cement clinker. Include in written statement from the manufacturer that the amount of pozzolan in the finished cement does not vary more than plus or minus 5 mass percent of the finished cement from lot to lot or within a lot. The percentage and type of mineral admixture used in the blend are not allowed to change from that submitted for the aggregate evaluation and mixture proportioning. The requirements of paragraph Supplementary Cementitious Materials (SCM) Content do not apply to the SCM content of blended cement.

2.1.1.3 Fly Ash and Pozzolan

Provide fly ash and pozzolan in accordance with NCDOT Standard Specifications, Section 1024-5, January 2018.

2.1.1.4 Ultra Fine Fly Ash and Ultra Fine Pozzolan

Ultra Fine Fly Ash (UFFA) and Ultra Fine Pozzolan (UFP) conforming to ASTM C618, Class F or N, and the following additional requirements:

- The strength activity index at 28 days of age at least 95 percent of the control specimens.
- The average particle size not exceeding 6 microns.
- Loss on ignition not exceeding 6 percent.

2.1.1.5 Silica Fume

Provide silica fume in accordance with NCDOT Standard Specifications, Section 1024-7, January 2018.

2.1.1.6 Slag

Provide ground granulated blast furnace slag in accordance with NCDOT Standard Specifications, Section 1024-6, January 2018.

2.1.1.7 Supplementary Cementitious Materials (SCM) Content

Include one of the SCMs listed in Table 2 within the range specified therein, whether or not the aggregates are found to be reactive in accordance with the paragraph Alkali Reactivity Test.

TABLE 2 SUPPLEMENTARY CEMENTITIOUS MATERIALS CONTENT		
Supplementary Cementitious Material	Minimum Content (percent)	Maximum Content (percent)
Class N Pozzolan and Class F Fly Ash		
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃ greater than 70 percent	25	35
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃ greater than 80 percent	20	35
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃ greater than 90 percent	15	35
UFFA and UFP	7	16
GGBF Slag	40	50
Silica Fume	7	10

2.1.1.2 Water

Water conforming to ASTM C1602/C1602M and in accordance with NCDOT Standard Specifications, Section 1024-4, January 2018.

2.1.1.3 Aggregate

2.1.1.3.1 Durability

Evaluate and test all fine and coarse aggregates to be used in all concrete for durability in accordance with ASTM C88. Provide fine and coarse aggregates with a maximum of 18 percent loss when subjected to 5 cycles using Magnesium Sulfate or a maximum of 12 percent loss when subjected to 5 cycles of Sodium Sulfate.

2.1.1.3.2 Alkali Reactivity Test

Evaluate and test fine and coarse aggregates to be used in all concrete for alkali-aggregate reactivity. Test all size groups and sources proposed for use.

- a. Evaluate the fine and coarse aggregates separately, using [ASTM C1260](#). Reject individual aggregates with test results that indicate an expansion of greater than 0.08 percent after 28 days of immersion in 1N NaOH solution, or perform additional testing as follows: utilize the proposed low alkali portland cement, blended cement, or SCM in combination with each individual aggregate. Test in accordance with [ASTM C1567](#). Determine the quantity that meets all the requirements of these specifications and that lowers the expansion equal to or less than 0.08 percent after 28 days of immersion in a 1N NaOH solution. Base the mixture proportioning on the highest percentage of SCM required to mitigate ASR-reactivity.
- b. If any of the above options does not lower the expansion to less than 0.08 percent after 28 days of immersion in a 1N NaOH solution, reject the aggregate(s) and submit new aggregate sources for retesting. Submit the results of testing for evaluation and acceptance.

2.1.3.3 Fine Aggregates

Provide in accordance with NCDOT Standard Specifications, Section 1014-1, January 2018 and Conforming to the quality and gradation of [ASTM C33/C33M](#).

2.1.3.4 Coarse Aggregates

Coarse aggregate provided in accordance with NCDOT Standard Specifications, Section 1014-2, January 2018.

2.1.4 Chemical Admixtures

2.1.4.1 Water Reducing Admixtures

Provide admixture conforming to [ASTM C494/C494M](#): Type A, water reducing; Type B, retarding; Type C, accelerating; Type D, water-reducing and retarding; and Type E, water-reducing and accelerating admixture. Do not use calcium chloride admixtures. [ASTM C494/C494M](#) Type S specific performance admixtures and [ASTM C1017/C1017M](#) flowable admixtures are not allowed.

2.1.4.2 Air Entraining Admixture

Conforming to [ASTM C260/C260M](#): Air-entraining.

2.1.4.3 High Range Water Reducing Admixture

[ASTM C494/C494M](#) Type F and G high range water reducing admixtures are not allowed.

2.1.5 Reinforcement

2.1.5.1 Dowel Bars

Dowel bars conforming to [ASTM A615/A615M](#), Grade 60 for plain billet-steel bars of the size and length indicated. Remove all burrs and projections from the bars.

2.1.5.2 Tie Bars

Billet or axle steel deformed bars conforming to [ASTM A615/A615M](#) or [ASTM A966/A966M](#) Grade 60.

2.1.6 Curing Materials

Provide curing materials consisting of:

2.1.6.1 White-Burlap-Polyethylene Sheet

Conforming to ASTM C171, 0.004 inch thick white opaque polyethylene bonded to 10 oz/linear yard (40 inch) wide burlap.

2.1.6.2 Liquid Membrane-Forming Compound

Conforming to ASTM C309, white pigmented, Type 2, Class B, free of paraffin or petroleum.

2.1.6.3 Liquid Chemical Sealer-Hardener Compound

Compound consisting of magnesium fluosilicate which when mixed with water seals and hardens the surface of the concrete. Do not use on exterior slabs exposed to freezing conditions.

2.1.7 Joint Fillers and Sealants

Provide in accordance with NCDOT Standard Specifications, Section 1028, January 2018.

2.1.8 Biodegradable Form Release Agent

Provide form release agent that is colorless and biodegradable. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces. Provide form release agent with a minimum of 87 percent biobased material and does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene.

2.1.9 Epoxy Resin

Provide epoxy-resin materials that consist of two-component materials conforming to the requirements of ASTM C881/C881M, Class as appropriate for each application temperature to be encountered, except that in addition, the materials meet the following requirements:

- a. Type IV, Grade 3, for use for embedding dowels and anchor bolts.
- b. Type III, Grade as approved, for use as patching materials for complete filling of spalls and other voids and for use in preparing epoxy resin mortar.
- c. Type IV, Grade 1, for use for injecting cracks.
- d. Type V, Grade as approved, for bonding freshly mixed portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete.

2.1.10 Joint Materials

2.1.10.1 Expansion Joint Materials

Provide in accordance with NCDOT Standard Specifications, Section 1028, January 2018.

2.1.10.2 Slip Joint Material

Provide slip joint material that is 1/4 inch thick expansion joint filler, unless otherwise indicated, conforming to paragraph EXPANSION JOINT MATERIAL.

2.2 MIX DESIGN

Proportion concrete mix in accordance with ACI 211.1 except as modified herein.

2.2.1 Specified Concrete Properties

2.2.1.1 Flexural Strength

Provide concrete with a minimum flexural strength of 650 psi at 28 days of age.

2.2.1.2 Air Entrainment

Provide an entrained air content of 6.0 percent.

2.2.1.3 Slump

For fixed form and hand placement, provide a maximum slump of 3 inches. For slipformed pavement, at the start of the project, select a maximum allowable slump which will produce in-place pavement meeting the specified tolerances for control of edge slump. The selected slump is applicable to both pilot and fill-in lanes.

2.2.1.4 Water/Cementitious Materials Ratio

Maximum allowable water-cementitious material ratio is 0.40 . The water-cementitious material ratio is based on absolute volume equivalency, where the ratio is determined using the weight of cement for a cement only mix, or using the total volume of cement plus pozzolan converted to an equivalent weight of cement by the absolute volume equivalency method described in ACI 211.1.

2.2.2 Mix Design Report

Perform trial design batches, mixture proportioning studies, testing, and include test results demonstrating that the proposed mixture proportions produce concrete of the qualities indicated. An existing mix design may be submitted if developed within the previous 12 months. Submit test results in a mix design report to include:

- a. Coarse and fine aggregate gradations and plots.
- b. Coarse and fine aggregate quality test results, include deleterious materials and ASR testing.
- c. Mill certificates for cement and supplemental cementitious materials.
- d. Certified test results for all proposed admixtures.
- e. Specified flexural strength, slump, and air content.

- f. Recommended proportions and volumes for proposed mixture and each of three trial water-cementitious materials ratios.
- g. Individual beam breaks.
- h. Flexural strength summaries and plots.
- i. Historical record of test results, documenting production standard deviation (if available).
- j. Narrative discussing methodology on how the mix design was developed.

2.2.3 Mix Verification

Mix verification tests may be performed by the Government. Provide quantities of cementitious materials, aggregates and admixtures as requested.

2.3 EQUIPMENT

2.3.1 Batching and Mixing

Provide truck mixers. Provide a batch plant conforming to [ASTM C94/C94M](#) and as specified. Do not weigh water or measure cumulatively with another ingredient. Batch all concrete materials in accordance with [ASTM C94/C94M](#) requirements. Verify batching, mixers, mixing time, permitted reduction of mixing time, and [concrete uniformity](#) in accordance with the requirements of [ASTM C94/C94M](#), and document in the initial weekly QC Report.

2.3.2 Transporting Equipment

Provide transporting equipment in conformance with [ASTM C94/C94M](#) and as specified herein. Transport concrete to the paving site in rear-dump trucks, in truck mixers designed with extra large blading and rear opening specifically for low slump concrete, or in agitators. Do not permit bottom-dump trucks for delivery of concrete.

2.3.3 Delivery Equipment

When concrete transport equipment cannot operate on the paving lane, provide side-delivery transport equipment consisting of self-propelled moving conveyors to deliver concrete from the transport equipment and discharge it in front of the paver. Do not permit front-end loaders, dozers, or similar equipment to distribute the concrete.

2.3.4 Paver-Finisher

Provide a heavy-duty, self-propelled paver-finisher machine designed specifically for paving and finishing high quality pavement and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in one pass. Equip the paver-finisher with a full width "knock-down" auger, capable of operating in both directions, which will evenly spread the fresh concrete in front of the screed or extrusion plate. Gang-mount immersion vibrators at the front of the paver on a frame equipped with suitable controls so that all vibrators can be operated at any desired depth within the slab or completely withdrawn from the concrete. Automatically control the vibrators so they will be immediately stopped as forward motion of the paver ceases. Space the

immersion vibrators across the paving lane as necessary to properly consolidate the concrete, but limit the clear distance between vibrators not to exceed 30 inches, and the outside vibrators not to exceed 12 inches from the edge of the lane. Vibrators may be pneumatic, gas driven, or electric, and operated at frequencies within the concrete between 6,000 and 7,000 vibrations per minute, with an amplitude of vibration such that noticeable vibrations occur at 1.5 foot radius when the vibrator is inserted in the concrete to the depth specified. Equip the paver-finisher with a transversely oscillating screed or an extrusion plate to shape, compact, and smooth the surface.

2.3.4.1 Paver-Finisher with Fixed Forms

Equip the paver-finisher with wheels designed to ride the forms, keep it aligned with the forms, and to prevent deformation of the forms.

2.3.4.2 Slipform Paver-Finisher

Provide a track-mounted slipform paver-finisher with automatic controls and padded tracks. Electronically reference horizontal alignment to a taut wire guideline. Electronically reference vertical alignment on both sides of the paver to a taut wire guideline, to an approved laser control system, or to a ski operating on a completed lane. Do not control from a slope-adjustment control or from the underlying material.

2.3.4.3 Other Types of Finishing Equipment

Heavy duty vibratory truss screeds may be approved for use if successfully demonstrated on the test section to consolidate the slab full depth and without segregation. Clary screeds, rotating tube floats, or laser screeds will not be allowed on the project. Provide hand floats that are not less than 12 feet long and 6 inches wide and stiffened to prevent flexing and warping.

2.3.4.4 Work Bridge

Provide a self-propelled work bridge capable of spanning the paving lane and supporting the workmen without excessive deflection.

2.3.5 Texturing Equipment

Provide texturing equipment as specified below.

2.3.5.1 Fabric Drag

Clean, reasonably new burlap measuring from 3 to 10 feet long, 2 feet wider than the width of the pavement, and securely attached to a separate wheel mounted frame spanning the paving lane or to one of the other similar pieces of equipment. Select dimension of burlap drag so that at least 3 feet of the material is in contact with the pavement.

2.3.5.2 Deep Texturing Equipment

Provide texturing equipment consisting of pattern in accordance with BEAP which will produce true, even grooves. Mount this drag in a wheeled frame spanning the paving lane and constructed to mechanically pull the drag in a straight line across the paving lane perpendicular to the centerline.

2.3.6 Curing Equipment

Provide equipment for applying membrane-forming curing compound mounted on a self-propelled frame that spans the paving lane. Constantly agitate the curing compound reservoir mechanically (not air) during operation and provide a means for completely draining the reservoir. Provide a spraying system that consists of a mechanically powered pump which maintains constant pressure during operation, an operable pressure gauge, and either a series of spray nozzles evenly spaced across the lane to provide uniformly overlapping coverage or a single spray nozzle which is mounted on a carriage which automatically traverses the lane width at a speed correlated with the forward movement of the overall frame. Protect all spray nozzles with wind screens. Calibrate the spraying system in accordance with [ASTM D2995](#), Method A, for the rate of application required in subpart CURING AND PROTECTION. Provide hand-operated sprayers powered by compressed air supplied by a mechanical air compressor. Immediately replace curing equipment if it fails to apply an even coating of compound at the specified rate.

2.3.7 Sawing Equipment

Provide equipment for sawing joints and for other similar sawing of concrete consisting of standard diamond-type concrete saws mounted on a wheeled chassis which can be easily guided to follow the required alignment. Provide diamond tipped blades. If demonstrated to operate properly, abrasive blades may be used. Provide spares as required to maintain the required sawing rate. Early-entry saws may be used, subject to demonstration and approval. No change to the initial sawcut depth is permitted.

2.3.8 Straightedge

Furnish one [12 foot](#) straightedge constructed of aluminum or magnesium alloy, having blades of box or box-girder cross section with flat bottom, adequately reinforced to insure rigidity and accuracy. Provide handles for operation on the pavement.

PART 3 EXECUTION

3.1 PREPARATION FOR PAVING

3.1.1 Weather Limitations

When windy conditions during paving appear probable, have equipment and material at the paving site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.1.1 Inclement Weather

Do not commence placing operations when heavy rain or other damaging weather conditions appear imminent. At all times when placing concrete, maintain on-site sufficient waterproof cover and means to rapidly place it over all unhardened concrete or concrete that might be damaged by rain. Suspend placement of concrete whenever rain, high winds, or other damaging weather commences to damage the surface or texture of the placed unhardened concrete, washes cement out of the concrete, or changes the water content of the surface concrete. Immediately cover and protect all unhardened concrete from the rain or other damaging weather. Completely

remove and replace any slab damaged by rain or other weather full depth, by full slab width, to the nearest original joint.

3.1.1.2 Hot Weather

Maintain required concrete temperature in accordance with [ACI 305R](#) to prevent evaporation rate from exceeding [0.2 pound of water per square foot](#) of exposed concrete per hour. Cool ingredients before mixing, place concrete during cooler night time hours, or use other suitable means to control concrete temperature and prevent rapid drying of newly placed concrete. Water is not allowed to be added after the initial introduction of mixing water except, when on arrival at the job site, the slump is less than specified and the water-cement ratio is less than that given as a maximum in the approved mixture. Additional water may be added to bring the slump within the specified range provided the approved water-cement ratio is not exceeded. Inject water into the head of the mixer (end opposite the discharge opening) drum under pressure, and turn the drum or blades a minimum of 30 additional revolutions at mixing speed. The addition of water to the batch at any later time is not allowed. After placement, use fog spray, apply monomolecular film, or use other suitable means to reduce the evaporation rate. Start curing when surface of fresh concrete is sufficiently hard to permit curing without damage. Cool underlying material by sprinkling lightly with water before placing concrete. Follow practices found in [ACI 305R](#).

3.1.1.3 Prevention of Plastic Shrinkage Cracking

During weather with low humidity, and particularly with high temperature and appreciable wind, develop and institute measures to prevent plastic shrinkage cracks from developing. If plastic shrinkage cracking occurs, halt further placement of concrete until protective measures are in place to prevent further cracking. Periods of high potential for plastic shrinkage cracking can be anticipated by use of [ACI 305R](#). In addition to the protective measures specified in the previous paragraph, the concrete placement may be further protected by erecting shades and windbreaks and by applying fog sprays of water, the addition of monomolecular films, or wet covering. Apply monomolecular films after finishing is complete, do not use in the finishing process. Immediately commence curing procedures when such water treatment is stopped.

3.1.1.4 Cold Weather

Do not place concrete when ambient temperature is below [40 degrees F](#) or when concrete is likely to be subjected to freezing temperatures within 24 hours. When authorized, when concrete is likely to be subjected to freezing within 24 hours after placing, heat concrete materials so that temperature of concrete when deposited is between [65 and 80 degrees F](#). Methods of heating materials are subject to approval. Do not heat mixing water above [165 degrees F](#). Remove lumps of frozen material and ice from aggregates before placing aggregates in mixer. Follow practices found in [ACI 306R](#).

3.1.2 Conditioning of Underlying Material

Verify the underlying material, upon which concrete is to be placed is clean, damp, and free from debris, waste concrete or cement, frost, ice, and standing or running water. Prior to setting forms or placement of concrete, verify the underlying material is well drained and has been satisfactorily graded by string-line controlled, automated, trimming

machine and uniformly compacted in accordance with the applicable Section of these specifications. Test the surface of the underlying material to crown, elevation, and density in advance of setting forms or of concrete placement using slip-form techniques. Trim high areas to proper elevation. Fill and compact low areas to a condition similar to that of surrounding grade, or fill with concrete monolithically with the pavement. Low areas filled with concrete are not to be cored for thickness to avoid biasing the average thickness used for evaluation and payment adjustment. Rework and compact any underlying material disturbed by construction operations to specified density immediately in front of the paver. If a slipform paver is used, continue the same underlying material under the paving lane beyond the edge of the lane a sufficient distance that is thoroughly compacted and true to grade to provide a suitable trackline for the slipform paver and firm support for the edge of the paving lane.

3.1.3 Forms

Use steel forms, except that wood forms may be used for curves having a radius of 150 feet or less, and for fillets. Forms may be built up with metal or wood, added only to the base, to provide an increase in depth of not more than 25 percent. Provide forms with the base width not less than eight-tenths of the vertical height of the form, except that for forms 8 inches or less in vertical height, provide forms with a base width not less than the vertical height of the form. Provide wood forms adequate in strength and rigidly braced for curves and fillets. Set forms on firm material cut true to grade so that each form section when placed will be firmly in contact with the underlying layer for its entire base. Do not set forms on blocks or on built-up spots of underlying material. Set and secure forms in place with stakes or by other approved methods for overlay pavements and for other locations where forms are set on existing pavements. Carefully drill holes in existing pavements for form stakes without cracking or spalling the existing pavement. Prior to setting forms for paving operations, demonstrate the proposed form setting procedures at an approved location and do not proceed further until the proposed method is approved. Before placing the concrete, coat the contact surfaces of forms except existing pavement sections where bonding is required, with a non-staining mineral oil, non-staining form coating compound, biodegradable form release agent, or two coats of nitro-cellulose lacquer. When using existing pavement as a form, clean existing concrete and then coat with asphalt emulsion bondbreaker before concrete is placed. Check and correct grade elevations and alignment of the forms immediately before placing concrete.

3.1.4 Reinforcement

3.1.4.1 Dowel Bars

Install dowels with horizontal and vertical alignment plus or minus 1 inch. Except as otherwise specified, maintain location of dowels within a skew alignment of 1/4 inch over 1 foot length. Omit Dowels and tie bars when the center of the dowel tie bar is located within a horizontal distance from an intersecting joint equal to or less than one-fourth of the slab thickness. Maintain dowels in position during concrete placement and curing. Before concrete placement, thoroughly grease the entire length of each dowel secured in a dowel basket or fixed form.

3.1.4.2 Tie Bars

Install bars, accurately aligned horizontally and vertically, and to the tolerances shown on the drawings, at indicated locations. For slipform construction, insert bent tie bars by hand or other approved means.

3.2 MEASURING, MIXING, CONVEYING, AND PLACING CONCRETE

3.2.1 Measuring

Conform to [ASTM C94/C94M](#).

3.2.2 Mixing

Conform to [ASTM C94/C94M](#), except as modified herein. Begin mixing within 30 minutes after cement has been added to aggregates. When the air temperature is greater than [85 degrees F](#), place concrete within 60 minutes. With approval, a hydration stabilizer admixture meeting the requirements of [ASTM C494/C494M](#) Type D, may be used to extend the placement time to 90 minutes. Additional water may be added to bring slump within required limits as specified in [ASTM C94/C94M](#), provided that the specified water-cement ratio is not exceeded.

3.2.3 Conveying

Conform to [ASTM C94/C94M](#).

3.2.4 Placing

Do not exceed a free vertical drop of [5 feet](#) from the point of discharge. Deposit concrete either directly from the transporting equipment or by conveyor on to the pre-wetted subgrade or subbase, unless otherwise specified. Deposit the concrete between the forms to an approximately uniform height. Place concrete continuously at a uniform rate, without damage to the grade and without unscheduled stops except for equipment failure or other emergencies. If an unscheduled stop occurs within [10 feet](#) of a previously placed expansion joint, remove concrete back to joint, repair any damage to grade, install a construction joint and continue placing concrete only after cause of the stop has been corrected.

3.3 PAVING

Construct pavement with paving and finishing equipment utilizing fixed forms .

3.3.1 Paving Plan

Submit for approval a paving plan identifying the following items:

- a. A description of the placing and protection methods proposed when concrete is to be placed in or exposed to hot, cold, or rainy weather conditions.
- b. A detailed paving sequence plan and proposed paving pattern showing all planned construction joints.
- c. Plan and equipment proposed to control alignment of formed or sawn joints within the specified tolerances.

3.3.2 Required Results

Operate the paver-finisher to produce a thoroughly consolidated slab throughout, true to line and grade within specified tolerances. Adjust the paver-finishing operation to produce a surface finish free of irregularities, tears, voids of any kind, and other discontinuities, with only a minimum of paste at the surface. Do not permit multiple passes of the paver-finisher. Produce a finished surface requiring no hand finishing, other than the use of cutting straightedges, except in very infrequent instances. Do not apply water, other than true fog sprays (mist), to the concrete surface during paving and finishing.

3.3.3 Operation

When the paver is operated between or adjacent to previously constructed pavement (fill-in lanes), make provisions to prevent damage to the previously constructed pavement, including keeping the existing pavement surface free of debris, and placing rubber mats beneath the paver tracks. Operate transversely oscillating screeds and extrusion plates to overlap the existing pavement the minimum possible, but in no case more than **8 inches**.

3.3.4 Consolidation

Immediately after spreading concrete, consolidate full depth with internal type vibrating equipment along the boundaries of all slabs regardless of slab thickness, and interior of all concrete slabs. For pavements less than **10 inches** thick, operate vibrators at mid-depth parallel with or at a slight angle to the base course. For thicker pavements, angle vibrators toward the vertical, with vibrator tip preferably about **2 inches** above the base course, and top of vibrator a few **inches** below pavement surface. Automatically control the vibrators or tamping units in front of the paver so that they stop immediately as forward motion ceases. Limit duration of vibration to that necessary to produce consolidation of concrete. Do not permit excessive vibration. Vibrate concrete in small, odd-shaped slabs or in locations inaccessible to the paver mounted vibration equipment with a hand-operated immersion vibrator operated from a bridge spanning the area. Do not operate vibrators at one location for more than 15 seconds. Do not use vibrators to transport or spread the concrete.

3.3.5 Fixed Form Paving

Spread and strike off concrete with with the paver. Shape the concrete to the specified and indicated cross section in one pass, and finish the surface and edges so that only a very minimum amount of hand finishing is required. Use single spud hand vibrators to consolidate the concrete adjacent to fixed forms as required to achieve a void-free formed edge. Do not allow vibrators to contact reinforcement, forms, or the grade during vibration.

3.3.6 Slipform Paving

Shape the concrete to the specified and indicated cross section in one pass, and finish the surface and edges so that only a very minimum amount of hand finishing is required. Do not install dowels by dowel inserters attached to the paver or by any other means of inserting the dowels into the plastic concrete.

3.4 JOINTS

3.4.1 Contraction Joints

Hold dowels and tie bars in longitudinal and transverse contraction joints within the paving lane securely in place by means of rigid metal basket assemblies. Weld the dowels and tie bars to the assembly or hold firmly by mechanical locking arrangements that will prevent them from becoming distorted during paving operations. Anchor the basket assemblies securely in the proper location.

3.4.2 Construction Joints - Fixed Form Paving

Install dowels and tie bars by the bonded-in-place method, supported by means of devices fastened to the forms. Do not permit installation by removing and replacing in preformed holes.

3.4.3 Dowels Installed In Hardened Concrete

Install by bonding the dowels into holes drilled into the hardened concrete. Drill holes into the hardened concrete approximately $\frac{1}{8}$ inch greater in diameter than the dowels. Bond the dowels in the drilled holes using epoxy resin injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel is not permitted. Hold the dowels in alignment at the collar of the hole, after insertion and before the epoxy resin hardens, by means of a suitable metal or plastic collar fitted around the dowel. Check the vertical alignment of the dowels by placing the straightedge on the surface of the pavement over the top of the dowel and measuring the vertical distance between the straightedge and the beginning and ending point of the exposed part of the dowel. Where tie bars are required in longitudinal construction joints of slipform pavement, install bent tie bars at the paver, in front of the transverse screed or extrusion plate. If tie bars are required, construct a standard keyway and install the bent tie bars into the plastic concrete through a 26 gauge thick metal keyway liner. Do not install tie bars in preformed holes. Protect the keyway liner and maintain in place and become part of the joint. Before placement of the adjoining paving lane, straighten the tie bars, without spalling the concrete around the bar.

3.5 FINISHING CONCRETE

Start finishing operations immediately after placement of concrete. Use finishing machine, except hand finishing may be used in emergencies and for concrete slabs in inaccessible locations or of such shapes or sizes that machine finishing is impracticable. Immediately halt any operations which produce more than $\frac{1}{8}$ inch of mortar-rich surface (defined as deficient in plus U.S. No. 4 sieve size aggregate) and modify the equipment, mixture, or procedures. Finish pavement surface on both sides of a joint to the same grade. Finish formed joints from a securely supported transverse bridge. Provide hand finishing equipment for use at all times.

3.5.1 Machine Finishing

Strike off and screed concrete to the required slope and cross-section by a power-driven transverse finishing machine. A transverse rotating tube or pipe is not permitted. Maintain elevation of concrete such that, when

consolidated and finished, pavement surface will be adequately consolidated and at the required grade. Equip finishing machine with a screed which is readily and accurately adjustable for changes in pavement slope and compensation for wear and other causes. Do not permit excessive operation over an area, which will result in an excess of mortar and water being brought to the surface.

3.5.1.1 Equipment Operation

Maintain the travel of machine on the forms without lifting, wobbling, or other variation of the machine which tend to affect the precision of concrete finish. Keep the tops of the forms clean by a device attached to the machine. Maintain a uniform ridge of concrete ahead of the front screed for its entire length.

3.5.1.2 Joint Finish

Before concrete is hardened, correct edge slump of pavement, exclusive of edge rounding, in excess of 0.25 inches. Finish concrete surface on each side of construction joints to the same plane, and correct deviations before newly placed concrete has hardened.

3.5.1.3 Hand Finishing

Strike-off and screed surface of concrete to elevations slightly above finish grade so that when concrete is consolidated and finished, the pavement surface is at the indicated elevation. Vibrate entire surface until required compaction and reduction of surface voids is secured with a strike-off template. After initial finishing, further smooth and consolidate concrete by means of hand-operated longitudinal floats.

3.5.2 Texturing

Before the surface sheen has disappeared and before the concrete hardens, provide a texture to the surface of the pavement as described herein. After curing is complete, thoroughly broom all textured surfaces to remove all debris. Finish the concrete in areas of recesses for tie-down anchors, lighting fixtures, and other outlets in the pavement to provide a surface of the same texture as the surrounding area.

3.5.2.1 Burlap Drag Finish

Before concrete becomes non-plastic, finish the surface of the slab by dragging a strip of clean, wet burlap on the surface. Drag the surface so as to produce a finished surface with a fine granular or sandy texture without leaving disfiguring marks. Keep the burlap clean and saturated during use.

3.5.2.2 Brooming

Finish the surface of the slab by brooming the surface with a new wire broom at least 18 inches wide. Gently pull the broom over the surface of the pavement from edge to edge just before the concrete becomes non-plastic. Slightly overlap adjacent strokes of the broom. Broom perpendicular to centerline of pavement so that corrugations produced will be uniform in character and width, and not more than 1/16 inch in depth. Maintain broomed surface free from porous spots, irregularities, depressions, and small pockets or rough spots such as may be caused by accidentally disturbing particles of coarse aggregate embedded near the

surface.

3.5.2.3 Wire-Comb Texturing

Apply surface texture transverse to the pavement center line using a mechanical wire comb drag capable of traversing the full width of the pavement in a single pass at a uniform speed and with a uniform pressure. Overlap successive passes of the comb the minimum necessary to obtain a continuous and uniformly textured surface, with scores $1/16$ to $3/16$ inch deep, $1/16$ to $1/8$ inch wide, and spaced $3/8$ inch apart.

3.5.2.4 Surface Grooving

Groove the areas indicated on the drawings with a spring tine drag producing individual grooves $1/4$ inch deep and $1/4$ inch wide at a spacing between groove centerlines of 2 inches. Cut these grooves perpendicular to the centerline. Before grooving begins, allow the concrete to stiffen sufficiently to prevent dislodging of aggregate. Do not cut grooves within 6 inches of a transverse joint or crack.

3.5.3 Edging

At the time the concrete has attained a degree of hardness suitable for edging, carefully finish slab edges, including edges at formed joints, with an edge having a maximum radius of $1/8$ inch. When brooming is specified for the final surface finish, edge transverse joints before starting brooming, then operate broom to obliterate as much as possible the mark left by the edging tool without disturbing the rounded corner left by the edger. Clean by removing loose fragments and soupy mortar from corners or edges of slabs which have crumbled and areas which lack sufficient mortar for proper finishing. Refill voids solidly with a mixture of suitable proportions and consistency and refinish. Remove unnecessary tool marks and edges. Smooth remaining edges true to line.

3.6 CURING AND PROTECTION

Protect concrete adequately from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks and oil stains, and do not allow it to dry out from the time it is placed until the expiration of the minimum curing periods specified herein. Do not use membrane-forming compound on surfaces where its appearance would be objectionable, on surfaces to be painted, where coverings are to be bonded to concrete, or on concrete to which other concrete is to be bonded.

3.6.1 Moist Curing

Maintain concrete to be moist-cured continuously wet for the entire curing period, or until curing compound is applied, commencing immediately after finishing. If forms are removed before the end of the curing period, provide curing on unformed surfaces, using suitable materials. Cure surfaces by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic coated burlap. Provide burlap and mats that are clean and free from any contamination and completely saturated before being placed on the concrete. Lap sheets to provide full coverage. Provide an approved work system to ensure that moist curing is continuous 24 hours per day and that the entire surface is wet.

3.6.2 White-Burlap-Polyethylene Sheet

Wet entire exposed surface thoroughly with a fine spray of water, saturate burlap but do not have excessive water dripping off the burlap and then cover concrete with White-Burlap-Polyethylene Sheet, burlap side down. Lay sheets directly on concrete surface and overlap **12 inches**. Make sheeting not less than **18 inches** wider than concrete surface to be cured, and weight down on the edges and over the transverse laps to form closed joints. Repair or replace sheets when damaged during curing. Check daily to assure burlap has not lost all moisture. If moisture evaporates, resaturate burlap and re-place on pavement (limit re-saturation and re-placing to less than 10 minutes per sheet). Leave sheeting on concrete surface to be cured for at least 7 days.

3.6.3 Liquid Membrane-Forming Compound Curing

Apply compound immediately after surface loses its water sheen and has a dull appearance and before joints are sawed. Agitate curing compound thoroughly by mechanical means during use and apply uniformly in a two-coat continuous operation by suitable power-spraying equipment. Apply a total coverage for the two coats at least **one gallon** of undiluted compound per **200 square feet** to produce a uniform, continuous, coherent film that will not check, crack, or peel and free from pinholes or other imperfections. The application of curing compound by hand-operated, mechanical powered pressure sprayers is permitted only on odd widths or shapes of slabs and on concrete surfaces exposed by the removal of forms. When the application is made by hand-operated sprayers, apply a second coat in a direction approximately at right angles to the direction of the first coat. Apply an additional coat of compound immediately to areas where film is defective. Respray concrete surfaces that are subject to heavy rainfall within 3 hours after curing compound has been applied in the same manner.

3.6.4 Protection of Treated Surfaces

After the initial saw cut is complete and the slurry has been removed, respray the area with curing compound or restore the white burlap polyethylene sheet to maintain a continuous curing environment in the area of the sawn joints. Keep concrete surfaces to which liquid membrane-forming compounds have been applied free from vehicular traffic and other sources of abrasion for not less than 72 hours. Foot traffic is allowed after 24 hours for inspection purposes. Maintain continuity of coating for entire curing period and repair damage to coating immediately.

3.7 FIELD QUALITY CONTROL

3.7.1 Sampling

Collect samples of fresh concrete in accordance with **ASTM C172/C172M** during each working day as required to perform tests specified herein. Make test specimens in accordance with **ASTM C31/C31M**.

3.7.2 Consistency Tests

Perform **concrete slump tests** in accordance with **ASTM C143/C143M**. Take samples for slump determination from concrete during placement. Perform tests at the beginning of a concrete placement operation and for each batch (minimum) or every **20 cubic yards** (maximum) of concrete to ensure that specification requirements are met. In addition, perform tests each

time test beams are made.

3.7.3 Flexural Strength Tests

Test for [flexural strength](#) in accordance with [ASTM C78/C78M](#). Fabricate and cure four test specimens in accordance with [ASTM C31/C31M](#) for each set of tests. Test two specimens at 7 days, and the other two at 28 days. Concrete strength will be considered satisfactory when the minimum of the 28-day test results equals or exceeds the specified 28-day flexural strength, and no individual strength test is less than the tolerance indicated on Table 1. If the ratio of the 7-day strength test to the specified 28-day strength is less than 65 percent, make necessary adjustments for conformance. Fabricate, cure and test a minimum of one set of four beams for each shift of concrete placement. Remove concrete which is determined to be defective, based on the strength acceptance criteria therein, and replace with acceptable concrete.

3.7.4 Air Content Tests

Test air-entrained concrete for [air content](#) at the same frequency as specified for slump tests. Determine percentage of air in accordance with [ASTM C231/C231M](#) on samples taken during placement of concrete in forms.

3.7.5 Surface Testing

Use the profilograph method for all longitudinal testing, except for paving lanes less than [200 feet](#) in length. Use the straightedge method for transverse testing, for longitudinal testing where the length of each pavement lane is less than [200 feet](#), and at the ends of the paving limits for the project. Smoothness requirements do not apply over crowns, drainage structures, or similar penetrations. Maintain detailed notes of the testing results and submit a copy to the Government after each day's testing.

3.7.5.1 Straightedge Testing Method

Test the surface of the pavement with the straightedge to identify all surface irregularities exceeding the tolerances specified in Table 1. Test the entire area of the pavement in both a longitudinal and a transverse direction on parallel lines approximately [15 feet](#) apart. Hold the straightedge in contact with the surface and move ahead one-half the length of the straightedge for each successive measurement. Determine the amount of surface irregularity by placing the straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length and measuring the maximum gap between the straightedge and the pavement surface, in the area between these two high points.

3.7.5.2 Profilograph Testing Method

Perform profilograph testing using approved California profilograph and procedures described in [ASTM E1274](#). Utilize electronic recording and automatic computerized reduction of data equipment to indicate "must-grind" bumps and the Profile Index for each [0.1 mile](#) segment of the day's paving. Accommodate grade breaks on parking lots by breaking the profile segment into short sections and repositioning the blanking band on each section. Provide the "blanking band" of [0.2 inch](#) wide and the "bump template" span [1 inch](#) with an offset of [0.4 inch](#). Count the profilograph testing of the last [30 feet](#) of a paving lane in the longitudinal direction from each day's paving operation on the following day's continuation

lane. Compute the profile index for each pass of the profilograph (3 per lane) in each 0.1 mile segment. The profile index for each segment is the average of the profile indices for each pass in each segment. Scale and proportion profilographs of unequal lengths to an equivalent 0.1 mile as outlined in the ASTM E1274. Submit a copy of the reduced tapes to the Government at the end of each day's testing.

3.7.5.3 "Bumps" (Must Grind Areas)

Reduce any bumps ("must grind" areas) shown on the profilograph trace which exceed 0.4 inch in height by diamond grinding in accordance with subparagraph Diamond Grinding until they do not exceed 0.3 inch when retested. Taper such diamond grinding in all directions to provide smooth transitions to areas not requiring diamond grinding.

3.7.5.4 Diamond Grinding

Those performing diamond grinding are required to have a minimum of three years experience in diamond grinding of rigid concrete pavements. In areas not meeting the specified limits for surface smoothness and plan grade, reduce high areas to attain the required smoothness and grade, except as depth is limited below. Reduce high areas by diamond grinding the hardened concrete with an approved equipment after the concrete is at a minimum age of 14 days. Perform diamond grinding by sawing with an industrial diamond abrasive which is impregnated in the saw blades. Assemble the saw blades in a cutting head mounted on a machine designed specifically for diamond grinding that produces the required texture and smoothness level without damage to the concrete pavement or joint faces. Provide diamond grinding equipment with saw blades that are 1/8-inch wide, a minimum of 60 blades per 12 inches of cutting head width, and capable of cutting a path a minimum of 3 ft wide. Diamond grinding equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints is not permitted. The maximum area corrected by diamond grinding the surface of the hardened concrete is 10 percent of the total area of a day's production. The maximum depth of diamond grinding is 1/4 inch. Provide diamond grinding machine equipped to flush and vacuum the pavement surface. Dispose of all debris from diamond grinding operations off Government property. Prior to diamond grinding, submit a Diamond Grinding Plan for review and approval. At a minimum, include the daily reports for the deficient areas, the location and extent of deficiencies, corrective actions, and equipment. Remove and replace all pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified in Table 1. All areas in which diamond grinding has been performed are subject to the thickness tolerances specified in Table 1.

3.7.6 Plan Grade Testing and Conformance

Within 5 days after each day's paving, test the finished surface of the pavement area by running lines of levels at intervals corresponding with every longitudinal and transverse joint to determine the elevation at each joint intersection. Record the results of this survey and submit a copy to the Government at the completion of the survey.

3.7.7 Edge Slump

Test the pavement surface to determine edge slump immediately after the concrete has hardened sufficiently to permit walking thereon. Perform testing with a minimum 12 foot straightedge to reveal irregularities exceeding the edge slump tolerance specified in Table 1. Determine the

vertical edge slump at each free edge of each slipformed paving lane constructed. Place the straightedge transverse to the direction of paving and the end of the straightedge located at the edge of the paving lane. Record measurements at 5 to 10 foot spacings, as directed, commencing at the header where paving was started. Initially record measurements at 5 foot intervals in each lane. When no deficiencies are present after 5 measurements, the interval may be increased. The maximum interval is 10 feet. When any deficiencies exist, return the interval to 5 feet. In addition to the transverse edge slump determination above, at the same time, record the longitudinal surface smoothness of the joint on a continuous line 1 inch back from the joint line using the minimum 12 foot straightedge advanced one-half its length for each reading. Perform other tests of the exposed joint face to ensure that a uniform, true vertical joint face is attained. Properly reference all recorded measurements in accordance with paving lane identification and stationing, and submit a report within 24 hours after measurement is made. Identify areas requiring replacement within the report.

3.7.8 Reinforcement

Inspect reinforcement prior to installation to verify it is free of loose flaky rust, loose scale, oil, mud, or other objectionable material.

3.7.9 Dowels

Inspect dowel placement prior to placing concrete to verify that dowels are of the size indicated, and are spaced, aligned and painted and oiled as specified. Do not permit dowels to exceed the tolerances shown in paragraph: DOWEL BARS.

-- End of Section --

SECTION 32 16 19

CONCRETE CURBS, GUTTERS AND SIDEWALKS
05/18

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 182 (2005; R 2017) Standard Specification for
Burlap Cloth Made from Jute or Kenaf and
Cotton Mats

ASTM INTERNATIONAL (ASTM)

ASTM A615/A615M (2020) Standard Specification for Deformed
and Plain Carbon-Steel Bars for Concrete
Reinforcement

ASTM A1064/A1064M (2017) Standard Specification for
Carbon-Steel Wire and Welded Wire
Reinforcement, Plain and Deformed, for
Concrete

ASTM C31/C31M (2019a) Standard Practice for Making and
Curing Concrete Test Specimens in the Field

ASTM C143/C143M (2020) Standard Test Method for Slump of
Hydraulic-Cement Concrete

ASTM C171 (2016) Standard Specification for Sheet
Materials for Curing Concrete

ASTM C172/C172M (2017) Standard Practice for Sampling
Freshly Mixed Concrete

ASTM C173/C173M (2016) Standard Test Method for Air
Content of Freshly Mixed Concrete by the
Volumetric Method

ASTM C231/C231M (2017a) Standard Test Method for Air
Content of Freshly Mixed Concrete by the
Pressure Method

ASTM C309 (2011) Standard Specification for Liquid
Membrane-Forming Compounds for Curing
Concrete

ASTM C920 (2018) Standard Specification for
Elastomeric Joint Sealants

ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D5893/D5893M	(2016) Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements

INTERNATIONAL CODE COUNCIL (ICC)

ICC A117.1 COMM	(2017) Standard And Commentary Accessible and Usable Buildings and Facilities

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

Concrete

Biodegradable Form Release Agent

SD-06 Test Reports

Field Quality Control

1.3 EQUIPMENT, TOOLS, AND MACHINES

1.3.1 General Requirements

Plant, equipment, machines, and tools used in the work will be subject to approval and must be maintained in a satisfactory working condition at all times. Use equipment capable of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Discontinue using equipment that produces unsatisfactory results. Allow the Contracting Officer access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.3.2 Slip Form Equipment

Slip form paver or curb forming machines, will be approved based on trial use on the job and must be self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the

plastic concrete to the desired cross section in one pass.

1.4 ENVIRONMENTAL REQUIREMENTS

1.4.1 Placing During Cold Weather

Do not place concrete when the air temperature reaches 40 degrees F and is falling, or is already below that point. Placement may begin when the air temperature reaches 35 degrees F and is rising, or is already above 40 degrees F. Make provisions to protect the concrete from freezing during the specified curing period. If necessary to place concrete when the temperature of the air, aggregates, or water is below 35 degrees F, placement and protection must be approved in writing. Approval will be contingent upon full conformance with the following provisions. Prepare and protect the underlying material so that it is entirely free of frost when the concrete is deposited. Heat mixing water and aggregates as necessary to result in the temperature of the in-place concrete being between 50 and 85 degrees F. Methods and equipment for heating must be approved. Use only aggregates that are free of ice, snow, and frozen lumps before entering the mixer. Provide covering or other means as needed to maintain the concrete at a temperature of at least 50 degrees F for not less than 72 hours after placing, and at a temperature above freezing for the remainder of the curing period.

1.4.2 Placing During Warm Weather

The temperature of the concrete as placed must not exceed 85 degrees F except where an approved retarder is used. Cool the mixing water and aggregates as necessary to maintain a satisfactory placing temperature. The placing temperature must not exceed 95 degrees F at any time.

PART 2 PRODUCTS

2.1 CONCRETE

Provide concrete conforming to the applicable requirements of Section 03 47 13 TILT-UP CONCRETE except as otherwise specified. Concrete must have a minimum compressive strength of 3500 psi at 28 days. Size of aggregate must not exceed 1-1/2 inches. Submit copies of certified delivery tickets for all concrete used in the construction.

2.1.1 Air Content

Use concrete mixtures that have an air content by volume of concrete of 5 to 7 percent, based on measurements made immediately after discharge from the mixer.

2.1.2 Slump

Use concrete with a slump of 3 inches plus or minus 1 inch for hand placed concrete or 1 inch plus or minus 1/2 inch for slipformed concrete as determined in accordance with ASTM C143/C143M.

2.1.3 Reinforcement Steel

Use reinforcement bars conforming to ASTM A615/A615M. Use wire mesh reinforcement conforming to ASTM A1064/A1064M.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials

Use impervious sheet materials conforming to [ASTM C171](#), type optional, except that polyethylene film, if used, must be white opaque.

2.2.2 Burlap

Use burlap conforming to [AASHTO M 182](#).

2.2.3 White Pigmented Membrane-Forming Curing Compound

Use white pigmented membrane-forming curing compound conforming to [ASTM C309](#), Type 2.

2.3 CONCRETE PROTECTION MATERIALS

Use concrete protection materials consisting of a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the Contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter

Use hard-pressed fiberboard contraction joint filler for curb and gutter.

2.4.2 Expansion Joint Filler, Premolded

Unless otherwise indicated, use [1/2 inch](#) thick premolded expansion joint filler conforming to [ASTM D1751](#) or [ASTM D1752](#).

2.5 JOINT SEALANTS

Use cold-applied joint sealant conforming to [ASTM C920](#) or [ASTM D5893/D5893M](#).

2.6 FORM WORK

Design and construct form work to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Use wood or steel forms that are straight and of sufficient strength to resist springing during depositing and consolidating concrete.

2.6.1 Wood Forms

Use forms that are surfaced plank, [2 inches](#) nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Use forms with a nominal length of [10 feet](#). Radius bends may be formed with [3/4 inch](#) boards, laminated to the required thickness.

2.6.2 Steel Forms

Use channel-formed sections with a flat top surface and welded braces at each end and at not less than two intermediate points. Use forms with

interlocking and self-aligning ends. Provide flexible forms for radius forming, corner forms, form spreaders, and fillers as needed. Use forms with a nominal length of 10 feet and that have a minimum of 3 welded stake pockets per form. Use stake pins consisting of solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.3 Sidewalk Forms

Use sidewalk forms that are of a height equal to the full depth of the finished sidewalk.

2.6.4 Curb and Gutter Forms

Use curb and gutter outside forms that have a height equal to the full depth of the curb or gutter. Use rigid forms for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 10 feet or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 1-1/2 inch benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

2.7 Detectable Warning System

Detectable Warning Systems shown on the Contract plans are to meet requirements of ICC A117.1 COMM - Section 705.

PART 3 EXECUTION

3.1 SUBGRADE PREPARATION

Construct subgrade to the specified grade and cross section prior to concrete placement.

3.1.1 Sidewalk Subgrade

Place and compact the subgrade as indicated in the plans. Test the subgrade for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

3.1.2 Curb and Gutter Subgrade

Place and compact the subgrade in accordance with Section 32 11 23 AGGREGATE BASE COURSES . Test the subgrade for grade and cross section by means of a template extending the full width of the curb and gutter. Use subgrade materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade

Maintain subgrade in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade must be in a moist condition when concrete is placed. Prepare and protect subgrade so that it is free from frost when the concrete is deposited.

3.2 FORM SETTING

Set forms to the indicated alignment, grade and dimensions. Hold forms rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 4 feet. Use additional stakes and braces at corners, deep sections, and radius bends, as required. Use clamps, spreaders, and braces where required to ensure rigidity in the forms. Remove forms in a manner that will not injure the concrete. Do not use bars or heavy tools against the concrete when removing the forms. Promptly and satisfactorily repair concrete found to be defective after form removal. Clean forms and coat with form oil or biodegradable form release agent each time before concrete is placed. Wood forms may, instead, be thoroughly wetted with water before concrete is placed, except that with probable freezing temperatures, oiling is mandatory.

3.2.1 Sidewalks

Set forms for sidewalks with the upper edge true to line and grade with an allowable tolerance of 1/8 inch in any 10 foot long section. After forms are set, grade and alignment must be checked with a 10 foot straightedge. Sidewalks must have a transverse slope as indicated. Do not remove side forms less than 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters

Remove forms used along the front of the curb not less than 2 hours nor more than 6 hours after the concrete has been placed. Do not remove forms used along the back of curb until the face and top of the curb have been finished, as specified for concrete finishing. Do not remove gutter forms while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks

Place concrete in the forms in one layer. When consolidated and finished, the sidewalks must be of the thickness indicated. Use a strike-off guided by side forms after concrete has been placed in the forms to bring the surface to proper section to be compacted. Consolidate concrete by tamping and spading or with an approved vibrator. Finish the surface to grade with a strike off.

3.3.2 Concrete Finishing

After straightedging, when most of the water sheen has disappeared, and just before the concrete hardens, finish the surface with a wood or magnesium float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. Produce a scored surface by brooming with a fiber-bristle brush in a direction transverse to that of the traffic, followed by edging.

3.3.3 Edge and Joint Finishing

Finish all slab edges, including those at formed joints, with an edger having a radius of 1/8 inch. Edge transverse joints before brooming. Eliminate the flat surface left by the surface face of the edger with brooming. Clean and solidly fill corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing with a properly proportioned mortar mixture and then finish.

3.3.4 Surface and Thickness Tolerances

Finished surfaces must not vary more than $\frac{5}{16}$ inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to $\frac{1}{4}$ inch.

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter

Place concrete to the required section in a single lift. Consolidate concrete using approved mechanical vibrators. Curve shaped gutters must be finished with a standard curb "mule".

3.4.2 Curb and Gutter Finishing

Approved slipformed curb and gutter machines may be used in lieu of hand placement.

3.4.3 Concrete Finishing

Float and finish exposed surfaces with a smooth wood float until true to grade and section and uniform in texture. Brush floated surfaces with a fine-hair brush using longitudinal strokes. Round the edges of the gutter and top of the curb with an edging tool to a radius of $\frac{1}{2}$ inch. Immediately after removing the front curb form, rub the face of the curb with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. Brush the front curb surface, while still wet, in the same manner as the gutter and curb top. Finish the top surface of gutter and entrance to grade with a wood float.

3.4.4 Joint Finishing

Finish curb edges at formed joints as indicated.

3.4.5 Surface and Thickness Tolerances

Finished surfaces must not vary more than $\frac{1}{4}$ inch from the testing edge of a 10-foot straightedge. Permissible deficiency in section thickness will be up to $\frac{1}{4}$ inch.

3.5 SIDEWALK JOINTS

Construct sidewalk joints to divide the surface into rectangular areas. Space transverse contraction joints at a distance equal to the sidewalk width or 5 feet on centers, whichever is less, and continuous across the slab. Construct longitudinal contraction joints along the centerline of all sidewalks 10 feet or more in width. Construct transverse expansion joints at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, install transverse expansion joints as indicated. Form expansion joints around structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated. Expansion joints are not required between sidewalks and curb that abut the sidewalk longitudinally.

3.5.1 Sidewalk Contraction Joints

Form contraction joints in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness. Unless otherwise approved or indicated, either use a jointer to cut the groove or saw a groove in the hardened concrete with a power-driven saw. Construct sawed joints by sawing a groove in the concrete with a 1/8 inch blade. Provide an ample supply of saw blades on the jobsite before concrete placement is started. Provide at least one standby sawing unit in good working order at the jobsite at all times during the sawing operations.

3.5.2 Sidewalk Expansion Joints

Form expansion joints using 1/2 inch joint filler strips. Joint filler in expansion joints surrounding structures and features within the sidewalk may consist of preformed filler material conforming to ASTM D1752 or building paper. Hold joint filler in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, round joint edges using an edging tool having a radius of 1/8 inch. Remove any concrete over the joint filler. At the end of the curing period, clean the top of expansion joints and fill with cold-applied joint sealant. Use joint sealant that is gray or stone in color. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Apply joint sealing material only when the concrete at the joint is surface dry and atmospheric and concrete temperatures are above 50 degrees F. Immediately remove any excess material on exposed surfaces of the concrete and clean the concrete surfaces.

3.5.3 Reinforcement Steel Placement

Accurately and securely fasten reinforcement steel in place with suitable supports and ties before the concrete is placed.

3.6 CURB AND GUTTER JOINTS

Construct curb and gutter joints at right angles to the line of curb and gutter.

3.6.1 Contraction Joints

Construct contraction joints directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 5 feet nor greater than 15 feet in length.

- a. Construct contraction joints (except for slip forming) by means of 1/8 inch thick separators and of a section conforming to the cross section of the curb and gutter. Remove separators as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.
- b. When slip forming is used, cut the contraction joints in the top portion of the gutter/curb hardened concrete in a continuous cut across the curb and gutter, using a power-driven saw. Cut the contraction joint to a depth of at least one-fourth of the gutter/curb depth using a 1/8 inch saw blade.

3.6.2 Expansion Joints

Form expansion joints by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Construct expansion joints in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement using the same type and thickness of joints as joints in the pavement. Where curb and gutter do not abut portland cement concrete pavement, provide expansion joints at least **1/2 inch** in width at intervals not less than **30 feet** nor greater than **120 feet**. Seal expansion joints immediately following curing of the concrete or as soon thereafter as weather conditions permit. Seal expansion joints and the top **1 inch** depth of curb and gutter contraction-joints with joint sealant. Thoroughly clean the joint opening before the sealing material is placed. Do not spill sealing material on exposed surfaces of the concrete. Concrete at the joint must be surface dry and atmospheric and concrete temperatures must be above **50 degrees F** at the time of application of joint sealing material. Immediately remove excess material on exposed surfaces of the concrete and clean concrete surfaces.

3.7 CURING AND PROTECTION

3.7.1 General Requirements

Protect concrete against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. All equipment needed for adequate curing and protection of the concrete must be on hand and ready for use before actual concrete placement begins. Protect concrete as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method

Cover the entire exposed surface with two or more layers of burlap. Overlap mats at least **6 inches**. Thoroughly wet the mat with water prior to placing on concrete surface and keep the mat continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method

Wet the entire exposed surface with a fine spray of water and then cover with impervious sheeting material. Lay sheets directly on the concrete surface with the light-colored side up and overlapped **12 inches** when a continuous sheet is not used. Use sheeting that is not less than **18-inches** wider than the concrete surface to be cured. Secure sheeting using heavy wood planks or a bank of moist earth placed along edges and laps in the sheets. Satisfactorily repair or replace sheets that are torn or otherwise damaged during curing. Sheeting must remain on the concrete surface to be cured for not less than 7 days.

3.7.1.3 Membrane Curing Method

Apply a uniform coating of white-pigmented membrane-curing compound to the entire exposed surface of the concrete as soon after finishing as the free water has disappeared from the finished surface. Coat formed surfaces immediately after the forms are removed and in no case longer than 1 hour

after the removal of forms. Do not allow concrete surface to dry before application of the membrane. If drying has occurred, moisten the surface of the concrete with a fine spray of water and apply the curing compound as soon as the free water disappears. Apply curing compound in two coats by hand-operated pressure sprayers at a coverage of approximately 200 square feet/gallon for the total of both coats. Apply the second coat in a direction approximately at right angles to the direction of application of the first coat. The compound must form a uniform, continuous, coherent film that will not check, crack, or peel and must be free from pinholes or other imperfections. If pinholes, abrasion, or other discontinuities exist, apply an additional coat to the affected areas within 30 minutes. Respray concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied by the method and at the coverage specified above. Respray areas where the curing compound is damaged by subsequent construction operations within the curing period. Take precautions necessary to ensure that the concrete is properly cured at sawed joints, and that no curing compound enters the joints. Tightly seal the top of the joint opening and the joint groove at exposed edges before the concrete in the region of the joint is resprayed with curing compound. Use a method used for sealing the joint groove that prevents loss of moisture from the joint during the entire specified curing period. Provide approved standby facilities for curing concrete pavement at a location accessible to the jobsite for use in the event of mechanical failure of the spraying equipment or other conditions that might prevent correct application of the membrane-curing compound at the proper time. Adequately protect concrete surfaces to which membrane-curing compounds have been applied during the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from other possible damage to the continuity of the membrane.

3.7.2 Backfilling

After curing, remove debris and backfill, grade, and compact the area adjoining the concrete to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection

Protect completed concrete from damage until accepted. Repair damaged concrete and clean concrete discolored during construction. Remove and reconstruct concrete that is damaged for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Dispose of removed material as directed.

3.7.4 Protective Coating

Apply a protective coating of linseed oil mixture to the exposed-to-view concrete surface after the curing period, if concrete will be exposed to de-icing chemicals within 6 weeks after placement. Moist cure concrete to receive a protective coating.

3.7.4.1 Application

Complete curing and backfilling operation prior to applying two coats of protective coating. Concrete must be surface dry and clean before each application. Spray apply at a rate of not more than 50 square yards/gallon for first application and not more than 70 square yards/gallon for second application, except that the number of applications and coverage for each

application for commercially prepared mixture must be in accordance with the manufacturer's instructions. Protect coated surfaces from vehicular and pedestrian traffic until dry.

3.7.4.2 Precautions

Do not heat protective coating by direct application of flame or electrical heaters and protect the coating from exposure to open flame, sparks, and fire adjacent to open containers or applicators. Do not apply material at ambient or material temperatures lower than 50 degrees F.

3.8 FIELD QUALITY CONTROL

Submit copies of all test reports within 24 hours of completion of the test.

3.8.1 General Requirements

Perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, take the action and submit reports as required below, and additional tests to ensure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing

Take concrete samples in accordance with ASTM C172/C172M not less than once a day nor less than once for every 250 cubic yards of concrete placed. Mold cylinders in accordance with ASTM C31/C31M for strength testing by an approved laboratory. Each strength test result must be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 500 psi.

3.8.2.2 Air Content

Determine air content in accordance with ASTM C173/C173M or ASTM C231/C231M. Use ASTM C231/C231M with concretes and mortars made with relatively dense natural aggregates. Make two tests for air content on randomly selected batches of each class of concrete placed during each shift. Make additional tests when excessive variation in concrete workability is reported by the placing foreman or the Government inspector. Notify the placing foreman if results are out of tolerance. The placing foreman must take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

3.8.2.3 Slump Test

Perform two slump tests on randomly selected batches of each class of concrete for every 250 cubic yards, or fraction thereof, of concrete placed during each shift. Perform additional tests when excessive variation in the workability of the concrete is noted or when excessive

crumbling or slumping is noted along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation

Determine the anticipated thickness of the concrete prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, construct the subgrade true to grade prior to concrete placement. The thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation

Provide finished surfaces for each category of the completed work that are uniform in color and free of blemishes and form or tool marks.

3.9 SURFACE DEFICIENCIES AND CORRECTIONS

3.9.1 Thickness Deficiency

When measurements indicate that the completed concrete section is deficient in thickness by more than $\frac{1}{4}$ inch the deficient section will be removed, between regularly scheduled joints, and replaced.

3.9.2 High Areas

In areas not meeting surface smoothness and plan grade requirements, reduce high areas either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete must not exceed 5 percent of the area of any integral slab, and the depth of grinding must not exceed $\frac{1}{4}$ inch. Remove and replace pavement areas requiring grade or surface smoothness corrections in excess of the limits specified.

3.9.3 Appearance

Exposed surfaces of the finished work will be inspected by the Contracting Officer and deficiencies in appearance will be identified. Remove and replace areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work.

3.10 DETECTABLE WARNING SYSTEM

Install Detectable Warning Systems required by Contract plans in accordance with ICC A117.1 COMM, Section 705, and by manufacturers' installation instructions.

-- End of Section --

SECTION 32 17 23

PAVEMENT MARKINGS

08/16

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO M 247 (2013) Standard Specification for Glass Beads Used in Pavement Markings

AASHTO M 249 (2012; R2016) Standard Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form)

ASTM INTERNATIONAL (ASTM)

ASTM D4061 (2013) Standard Test Method for Retroreflectance of Horizontal Coatings

ASTM D6628 (2003; R 2015) Standard Specification for Color of Pavement Marking Materials

ASTM E1710 (2011) Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer

ASTM E2177 (2011) Standard Test Method for Measuring the Coefficient of Retroreflected Luminance (RL) of Pavement Markings in a Standard Condition of Wetness

ASTM E2302 (2003; R 2016) Standard Test Method for Measurement of the Luminance Coefficient Under Diffuse Illumination of Pavement Marking Materials Using a Portable Reflectometer

INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

ICRI 03732 (1997) Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

MUTCD (2015) Manual on Uniform Traffic Control Devices

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are Contractor Quality Control review. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

- Surface Preparation Equipment List

- Application Equipment List

- Exterior Surface Preparation

- Reflective media for roads

- Thermoplastic compound

SD-06 Test Reports

- Reflective Media for Roads

- Thermoplastic Compound

SD-07 Certificates

- Qualifications

- Reflective Media for Roads

- Thermoplastic Compound

SD-08 Manufacturer's Instructions

- Thermoplastic Compound

1.3 QUALITY ASSURANCE

1.3.1 Qualifications

Submit documentation certifying that pertinent personnel are qualified for equipment operation and handling of applicable chemicals. The documentation should include experience on five projects of similar size and scope with references for all personnel.

1.4 DELIVERY AND STORAGE

Deliver paint materials, thermoplastic compound materials, and reflective media in original sealed containers that plainly show the designated name, specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer.

Provide storage facilities at the job site, only in areas approved by the Contracting Officer, for maintaining materials at temperatures recommended by the manufacturer.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Environmental Requirements

1.5.1.1 Weather Limitations for Application

Apply pavement markings to clean, dry surfaces, and unless otherwise approved, only when the air and pavement surface temperature is at least 5 degrees F above the dew point and the air and pavement temperatures are within the limits recommended by the pavement marking manufacturer. Allow pavement surfaces to dry after water has been used for cleaning or rainfall has occurred prior to striping or marking. Test the pavement surface for moisture before beginning work each day and after cleaning. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Contracting Officer. Employ the "plastic wrap method" to test the pavement for moisture as specified in paragraph TESTING FOR MOISTURE.

1.5.1.2 Weather Limitations for Removal of Pavement Markings

Pavement surface must be free of snow, ice, or slush; with a surface temperature of at least 40 degrees F and rising at the beginning of operations, except those involving shot or sand blasting or grinding. Cease operation during thunderstorms, or during rainfall, except for waterblasting and removal of previously applied chemicals. Cease waterblasting where surface water accumulation alters the effectiveness of material removal.

1.5.2 Traffic Controls

Place warning signs conforming to MUTCD near the beginning of the worksite and well ahead of the worksite for alerting approaching traffic from both directions. Place small markers along newly painted lines or freshly placed raised markers to control traffic and prevent damage to newly painted surfaces or displacement of raised pavement markers. Mark painting equipment with large warning signs indicating slow-moving painting equipment in operation.

When traffic must be rerouted or controlled to accomplish the work, provide necessary warning signs, flag persons, and related equipment for the safe passage of vehicles.

1.5.3 Lighting

When night operations are necessary, provide all necessary lighting and equipment. The Government reserves the right to accept or reject night work on the day following night activities by the Contractor.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Surface Preparation and Paint Removal

2.1.1.1 Surface Preparation Equipment for Roads and Automotive Parking Areas

Submit a surface preparation equipment list by serial number, type, model, and manufacturer. Include descriptive data indicating area of coverage

per pass, pressure adjustment range, tank and flow capacities, and safety precautions required for the equipment operation. Mobile equipment must allow for removal of markings without damaging the pavement surface or joint sealant. Maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition.

2.1.1.1.1 Waterblasting Equipment

Use mobile waterblasting equipment capable of producing a pressurized stream of water that effectively removes paint from the pavement surface without significantly damaging the pavement. Provide equipment, tools, and machinery which are safe and in good working order at all times.

2.1.1.1.2 Grinding or Scarifying Equipment

Use equipment capable of removing surface contaminants, paint build-up, or extraneous markings from the pavement surface without leaving any residue. Clean the surface by hydro blast to remove surface contaminants and ash after a weed torch is used to remove paint.

2.1.1.1.3 Chemical Removal Equipment

Use chemical equipment capable of applying and removing chemicals and paint from the pavement surface, leaving only non-toxic biodegradable residue without scarring or other damage to the pavement or joints and joint seals.

2.1.2 Application Equipment

Submit [application equipment list](#) appropriate for the material(s) to be used. Include manufacturer's descriptive data and certification for the planned use that indicates area of coverage per pass, pressure adjustment range, tank and flow capacities, and all safety precautions required for operating and maintaining the equipment. Provide and maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition, or remove them from the work site. Provide mobile and maneuverable application equipment to the extent that straight lines can be followed and normal curves can be made in a true arc.

2.1.2.1 Thermoplastic Application Equipment

2.1.2.1.1 Thermoplastic Material

Apply thermoplastic material with equipment that is capable of providing continuous uniformity in the dimensions and reflectorization of the marking.

2.1.2.1.2 Application Equipment

- a. Provide application equipment capable of continuous mixing and agitation of the material, with conveying parts which prevent accumulation and clogging between the main material reservoir and the extrusion shoe or spray gun. All parts of the equipment which come into contact with the material must be easily accessible and exposed for cleaning and maintenance. All mixing and conveying parts up to and including the extrusion shoes and spray guns must maintain the material at the required temperature with heat-transfer oil or electrical-element-controlled heat.

- b. Provide application equipment constructed to ensure continuous uniformity in the dimensions of the stripe. Provide an applicator with a means for cleanly cutting off stripe ends squarely and providing a method of applying "skiplines." Provide equipment capable of applying varying widths of traffic markings.
- c. Provide mobile and maneuverable application equipment allowing straight lines to be followed and normal curves to be made in a true arc. Provide equipment used for the placement of thermoplastic pavement markings of two general types: mobile applicator and portable applicator.
- d. Equip the applicator with a pressurized or drop-on type bead dispenser capable of uniformly dispensing reflective glass spheres at controlled rates of flow. The bead dispenser must operate automatically to begin flow prior to the flow of binder to assure that the strip is fully reflectorized.

2.1.2.1.3 Portable Application Equipment

Provide portable hand-operated equipment, specifically designed for placing special markings such as crosswalks, stop bars, legends, arrows, and short lengths of lane, edge and centerlines; and capable of applying thermoplastic pavement markings by the extrusion method. Equip the portable applicator with all the necessary components, including a materials storage reservoir, bead dispenser, extrusion shoe, and heating accessories, capable of holding the molten thermoplastic at the temperature recommended by the manufacturer, and of extruding a line of 3 to 12 inches in width, and in thickness of not less than 0.120 inch nor more than 0.190 inch and of generally uniform cross section.

2.1.2.2 Reflective Media Dispenser

Attach the dispenser for applying the reflective media to the paint dispenser and designed to operate automatically and simultaneously with the applicator through the same control mechanism. The bead applicator must be capable of adjustment and designed to provide uniform flow of reflective media over the full length and width of the stripe at the rate of coverage specified in paragraph APPLICATION.

2.2 MATERIALS

Use thermoplastic materials for roads and parking areas. Use non-reflectorized markings for automotive parking areas. The maximum allowable VOC content of pavement markings is 150 grams per liter. Color of markings are indicated on the drawings and must conform to ASTM D6628 for roads and automotive parking areas. Provide materials conforming to the requirements specified herein.

2.2.1 Thermoplastic Compound

2.2.1.1 Composition Requirements

Thermoplastic compound must conform to AASHTO M 249. Formulate the binder component as an alkyd resin.

2.2.1.2 Primer

- a. Asphalt concrete primer: Provide thermosetting adhesive primer with

a solids content of pigment reinforced synthetic rubber and synthetic plastic resin dissolved or dispersed in a volatile organic solvent for asphaltic concrete pavements. The solids content must not be less than 10 percent by weight at 70 degrees F and 60 percent relative humidity. A wet film thickness of 0.005 inch, plus or minus 0.001 inch, must dry to a tack-free condition in less than 5 minutes.

- b. Portland cement concrete primer: Provide an epoxy resin primer for Portland cement concrete pavements, of the type recommended by the manufacturer of the thermoplastic composition.2.2.2 Reflective Media

2.2.2.1 Reflective Media for Roads

AASHTO M 247, Type 1.

PART 3 EXECUTION

3.1 EXAMINATION

3.1.1 Testing for Moisture

Test the pavement surface for moisture before beginning pavement marking after each period of rainfall, fog, high humidity, or cleaning, or when the ambient temperature has fallen below the dew point. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Contracting Officer or authorized representative.

Employ the "plastic wrap method" to test the pavement for moisture as follows: Cover the pavement with a 12 inch by 12 inch section of clear plastic wrap and seal the edges with tape. After 15 minutes, examine the plastic wrap for any visible moisture accumulation inside the plastic. Do not begin marking operations until the test can be performed with no visible moisture accumulation inside the plastic wrap. Re-test surfaces when work has been stopped due to rain.

3.1.2 Surface Preparation Demonstration

Prior to surface preparation, demonstrate the proposed procedures and equipment. Prepare areas large enough to determine cleanliness, adhesion of remaining coating and rate of cleaning. Approved demonstration area establishes the standard for the remainder of the work.

3.1.3 Test Stripe Demonstration

Prior to paint application, demonstrate test stripe application within the work area using the proposed materials and equipment. Apply separate test stripes in each of the line widths and configurations required herein using the proposed equipment. Make the test stripes long enough to determine the proper speed and operating pressures for the vehicle(s) and machinery, but not less than 50 feet long.

3.1.4 Application Rate Demonstration

During the Test Stripe Demonstration, demonstrate compliance with the application rates specified herein. Document the equipment speed and operating pressures required to meet the specified rates in each configuration of the equipment and provide a copy of the documentation to the Contracting Officer prior to proceeding with the work.

3.1.5 Retroreflective Value Demonstration

After the test stripes have cured to a "no-track" condition, demonstrate compliance with the average retroreflective values specified herein. Take a minimum of ten readings on each test stripe with a Retroreflectometer with a direct readout in millicandelas per square meter per lux (mcd/m²/lx). Perform testing in accordance with [ASTM D4061](#), [ASTM E1710](#), [ASTM E2177](#), and [ASTM E2302](#).

3.1.6 Level of Performance Demonstration

The Contracting Officer will be present at the application demonstrations to observe the results obtained and to validate the operating parameters of the vehicle(s) and equipment. If accepted by the Contracting Officer, the test stripe is the measure of performance required for this project. Do not proceed with the work until the demonstration results are satisfactory to the Contracting Officer.

3.2 EXTERIOR SURFACE PREPARATION

Allow new pavement surfaces to cure for a period of not less than 30 days before application of marking materials. Thoroughly clean surfaces to be marked before application of the paint. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods as required. Remove rubber deposits, existing paint markings, residual curing compounds, and other coatings adhering to the pavement by water blasting.

- a. For Portland Cement Concrete pavement, grinding, light shot blasting, or light scarification, to a resulting profile equal to [ICRI 03732](#) CSP 2, CSP 3, and CSP 4, respectively, can be used in addition to water blasting on most pavements, to either remove existing coatings, or for surface preparation.

3.2.1 Early Painting of Rigid Pavements

Wait a minimum of 45 days after paving to apply pavement markings.

3.2.2 Early Painting of Asphalt Pavements

Wait a minimum of 45 days after paving to apply pavement markings.

3.3 APPLICATION

Apply pavement markings to dry pavements only.

3.3.1 Thermoplastic Compound

Place thermoplastic pavement markings, free from dirt or tint, upon dry pavement. The temperature must be a minimum of [40 degrees F](#) and rising at the time of installation. Apply all centerline, skipline, edgeline, and other longitudinal type markings with a mobile applicator. Place all special markings, crosswalks, stop bars, legends, arrows, and similar patterns with a portable applicator, using the extrusion method.

3.3.1.1 Primer

After surface preparation has been completed, prime the asphalt or concrete pavement surface with spray equipment. Allow primer materials to

"set-up" prior to applying the thermoplastic composition. Allow the asphalt concrete primer to dry to a tack-free condition, usually occurring in less than 10 minutes. Allow the Portland cement concrete primer to dry in accordance with the thermoplastic manufacturer recommendations. Apply asphalt concrete primer to all asphalt concrete pavements at a wet film thickness of 0.005 inch, plus or minus 0.001 inch (265 to 400 square feet per gallon). Apply Portland cement concrete primer to all concrete pavements (including concrete bridge decks) at a wet film thickness of between 0.04 to 0.05 inch 320 to 400 square feet per gallon.

After the primer has "set-up", apply the thermoplastic at temperatures no lower than 375 degrees F nor higher than 425 degrees F at the point of deposition. Apply all extruded thermoplastic markings at the specified width and at a thickness of not less than 0.125 inch nor more than 0.190 inch. Apply all sprayed thermoplastic markings at the specified width and the thickness designated in the contract plans. If the plans do not specify a thickness, apply centerline markings at a wet thickness of 0.090 inch, plus or minus 0.005 inch, and edgeline markings at a wet thickness of 0.060 inch, plus or minus 0.005 inch.

3.3.1.2 Reflective Media

Immediately after installation of the thermoplastic material, mechanically apply drop-on reflective glass spheres conforming to AASHTO M 247 Type 1 at the rate of one pound per 20 square feet such that the spheres are held by and imbedded in the surface of the molten material. Accomplish drop-on application of the glass spheres to ensure even distribution at the specified rate of coverage. If there is a malfunction of either thermoplastic applicator or reflective media dispenser, discontinue operations until deficiency is corrected.

3.3.2 Cleanup and Waste Disposal

Keep the worksite clean and free of debris and waste from the removal and application operations. Dispose of debris at approved sites.

3.4 FIELD QUALITY CONTROL

3.4.1 Sampling and Testing

As soon as the paint materials and reflective media are available for sampling, obtain by random selection from the sealed containers, two quart samples of each batch in the presence of the Contracting Officer. Accomplish adequate mixing prior to sampling to ensure a uniform, representative sample. A batch is defined as that quantity of material processed by the manufacturer at one time and identified by number on the label. Clearly identify samples by designated name, specification number, batch number, project contract number, intended use, and quantity involved.

At the discretion of the Contracting Officer, samples provided may be tested by the Government for verification.

3.4.2 Material Inspection

Examine material at the job site to determine that it is the material referenced in the report of test results or certificate of compliance. Provide test results substantiating conformance to the specified requirements with each certificate of compliance.

3.4.3 Dimensional Tolerances

Apply all markings in the standard dimensions provide in the drawings. New markings may deviate a maximum of 10 percent larger than the standard dimension. The maximum deviation allowed when painting over an old marking is up to 20 percent larger than the standard dimensions.

3.4.4 Bond Failure Verification

Inspect newly applied markings for signs of bond failure based on visual inspection and comparison to results from Test Stripe Demonstration paragraph.

3.4.5 Reflective Media and Coating Application Verification

Use a wet film thickness gauge to measure the application of wet paint. Use a microscope or magnifying glass to evaluate the embedment of glass beads in the paint. Verify the glass bead embedment with approximately 50 percent of the individual bead spheres embedded and 50 percent of the individual bead spheres exposed.

3.4.6 Retroreflective Markings

Collect and record readings for white and yellow retroreflective markings at the rate of one reading per 1000 linear feet. The minimum acceptable average for white markings is 200 millicandelas per square meter per lux (mcd/m²/lx) (measured with Retroreflectometer). The minimum acceptable average for yellow markings is 175 millicandelas per square meter per lux (mcd/m²/lx). Compute readings by averaging a minimum of 10 readings taken within the area at random locations. Re-mark areas not meeting the retroreflective requirements stated above.

-- End of Section --

SECTION 32 31 13.53

HIGH-SECURITY FENCES AND GATES
02/20

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A702	(2013) Standard Specification for Steel Fence Posts and Assemblies, Hot Wrought
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM C94/C94M	(2020) Standard Specification for Ready-Mixed Concrete
ASTM F567	(2014a) Standard Practice for Installation of Chain Link Fence
ASTM F626	(2014) Standard Specification for Fence Fittings
ASTM F900	(2011; R 2017) Standard Specification for Industrial and Commercial Swing Gates
ASTM F1043	(2018) Standard Specification for Strength and Protective Coatings on Steel Industrial Fence Framework
ASTM F1083	(2018) Standard Specification for Pipe, Steel, Hot-Dipped Zinc Coated (Galvanized) Welded, for Fence Structures
ASTM F1184	(2016) Industrial and Commercial Horizontal Slide Gates
ASTM F2408	(2016) Standard Specification for Ornamental Fences Employing Galvanized Steel Tubular Pickets
ASTM F2814	(2009; R 2015) Standard Guide for Design and Construction of Ornamental Steel Picket Fence Systems for Security Purposes

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fence Installation Drawings; G

SD-03 Product Data

Ornamental Fence Systems

Ornamental Fence

Braces

Swing Gates

Posts

Line Posts

Bottom Rail

Latches

Hinges

Stops

Keepers

Rollers

Wire Ties

SD-07 Certificates

Gate Hardware and Accessories

Concrete

Gate Operator

SD-10 Operation and Maintenance Data

Electro-Mechanical Locks

Gate Operator

Operating and maintenance instructions

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials elevated off of the ground to protect against oxidation caused by ground contact.

PART 2 PRODUCTS

2.1 COMPONENTS

2.1.1 INTENTIONALLY LEFT BLANK

2.1.1.1 INTENTIONALLY LEFT BLANK

2.1.2 Ornamental Fence Systems

Submit manufacturer's catalog data. Provide [ASTM F2814](#) structural components consisting of tubular steel ornamental pickets and rails.

Provide [ASTM F2408](#) industrial class pickets with a minimum cross-sectional area of [1 sq in](#) and a minimum wall thickness of [14 ga](#). Provide pickets with spear-pointed tips extending a minimum of [6 in](#) above the top rail of the fence. Mount pickets to a top and bottom rail spaced a maximum of [80 in](#) apart. Space pickets along rails with a maximum gap not to exceed [4 in](#). Secure pickets to rails by inaccessible, tamper-proof fasteners. Provide all items and accessories finished by painting in black

2.1.3 Posts

2.1.3.1 Metal Posts for Ornamental Fence

Provide posts conforming to [ASTM F1083](#), zinc-coated. Group IA, with external coating Type A steel pipe. Group IC steel pipe, zinc-coated with external coating Type A or Type B meeting the strength and coating requirements of [ASTM F1043](#) and [ASTM A702](#). Provide sizes as shown on the drawings. Use [line posts](#) and terminal (corner, gate, and pull) posts of the same designation throughout the fence. Provide gate post for the gate type specified subject to the limitation specified in [ASTM F900](#) and/or [ASTM F1184](#).

2.1.3.2 Accessories

- a. Provide accessories conforming to [ASTM F626](#). Coat ferrous accessories with zinc coating.
- b. Provide truss rods (with turnbuckles or other means of adjustment) for each terminal post.
- c. Provide 9 gauge steel tie wire for attaching fabric to rails, braces, and posts and match the coating of the fence fabric. Provide miscellaneous hardware coatings which conform to [ASTM A153/A153M](#) unless modified.

2.1.4 Braces and Rails

Braces and [bottom rail](#); Class 1, steel pipe, Grade A.

2.1.5 Gates

2.1.5.1 Gate Assembly

Provide gate assembly conforming to **ASTM F900** and/or **ASTM F1184** of the type and swing shown. Provide gate frames conforming to strength and coating requirements of **ASTM F1083** for Group IA, steel pipe, with external coating Type A, nominal pipe size (NPS) 1-1/2. Provide gate frames conforming to strength and coating requirements of **ASTM F1043**, for Group IC, steel pipe with external coating Type A or Type B, nominal pipe size (NPS) 1-1/2. Use gate fabric that matches the specified **ornamental** fabric.

2.1.5.2 Gate Leaves

For gate leaves, more than **8 feet** wide, provide either intermediate members and diagonal truss rods or tubular members as necessary to provide rigid construction, free from sag or twist. For gate leaves less than **8 feet** wide, provide truss rods or intermediate braces. Provide intermediate braces on all gate frames with an electro-mechanical lock. Attach fabric to the gate frame by method standard with the manufacturer. Welding is not an acceptable method for attaching fabric to gate frames.

2.1.5.3 Gate Hardware and Accessories

Submit manufacturer's catalog data. Furnish and install **latches, hinges, stops, keepers, rollers**, and other hardware items as required for the operation of the gate. All items are required to match the material characteristics of the fence system being installed. Provide stops for holding the gates in the open position.

2.1.6 INTENTIONALLY LEFT BLANK

2.1.7 Ornamental Fence Gates

2.1.7.1 Swing Gates

Submit manufacturer's catalog data. Fabricate swing gates by welding **2 sq in** tubular steel ends and rails. Use pickets that match the adjacent fence construction. Reinforce gates to ensure assembly sags no more than 1% of the gate leaf width or **2 in**, whichever is less. Size gate posts to accommodate the weight and width of each gate leaf. Mount gates to posts with weldable steel plates or blocks, pressed steel, or malleable iron hinges. Hot-dip galvanize all hinges with a minimum zinc weight of **1.20 oz/sq ft**. Secure all tamper points by welding or peening the threads. Use swing gate latches and drop bar guides manufactured of pressed steel, hot-dipped galvanized with a minimum zinc weight of **1.20 oz/sq ft**. Finish all gate hardware in the same color/coating as the fence system.

INTENTIONALLY LEFT BLANK

2.1.9 Gate Operator

Provide electric gate operators for sliding gates as follows: Provide electric gate operators with a right angle gearhead instantly reversing motor with magnetic drum-type brake, friction disc clutch, reversing starter with thermal overload protection, and a chain-driven geared rotary-type automatic limit switch. Use only hardened steel machine cut worm and mating bronze gears that operate in a bath of oil. Gate operators with V-belt pulleys are not allowed. Equip gate operators with

an emergency release to allow the gate to be operated manually that is also capable of being locked in the engaged or disengaged position. Provide positive stops on the gate tracks as a backup to the limit switches.

2.1.10 Electro-Mechanical Locks

Provide electro-mechanical locking devices for sliding gates and personnel gates that are solenoid actuated such that the deadbolt retracts when the solenoid is energized and remains electrically retracted until the gate is closed. Provide continuous duty type solenoid, rated for 120V ac, 60Hz operation. Ensure the locking device is unlockable by key and keyed on both sides. Monitor status of the electro-mechanical lock by two limit switches (integral to the locking device) wired in series. Ensure one switch monitors the deadlock lever and the other monitors the locking tongue.

2.2 MATERIALS

2.2.1 Wire

2.2.1.1 Wire Ties

Submit samples as specified. Provide wire ties constructed of the same material as the fencing fabric.

2.2.1.2 INTENTIONALLY LEFT BLANK

2.2.2 Concrete

ASTM C94/C94M, using 3/4 inch maximum size aggregate, and having minimum compressive strength of 3000 psi at 28 days. Use grout consisting of one part portland cement to three parts clean, well-graded sand and the minimum amount of water to produce a workable mix.

2.3

PART 3 EXECUTION

3.1 PREPARATION

Perform complete installation conforming to ASTM F567.

3.1.1 Line and Grade

Install fence to the lines and grades indicated. Clear the area on either side of the fence line to the extent indicated. Space line posts equidistant at intervals not exceeding 10 feet. Set terminal (corner, gate, and pull) posts whenever abrupt changes in vertical and horizontal alignment are encountered. Provide continuous fabric between terminal posts; however, ensure runs between terminal posts do not exceed 500 feet. Repair any damage to galvanized surfaces, including welding, with paint containing zinc dust in accordance with ASTM A780/A780M.

3.1.2 Excavation

Excavate holes to depths indicated. Clear all post holes of loose material and spread waste material where directed. Eliminate ground surface irregularities along the fence line to the extent necessary to

maintain a 2 inch clearance between the bottom of the fabric and finish grade.

3.2 INSTALLATION

3.2.1 Installation Drawings

Submit complete Fence Installation Drawings for review and approval by the Contracting Officer prior to shipment. Submit drawing details that include, but are not limited to the following information: Fence Installation Drawings, Location of gate, corner, end, and pull posts, Gate Assembly, and Gate Hardware and Accessories. Install fence system per approved drawings.

3.2.2 Security Fencing

Install new security fencing, remove existing security fencing, and perform related work to provide continuous security for facility. Schedule and fully coordinate work with Contracting Officer.

3.2.3 Posts

3.2.3.1 Earth and Bedrock

- a. Set posts plumb and in alignment. Except where solid rock is encountered, set posts in concrete to the depth indicated on the drawings. Where solid rock is encountered with no overburden, set posts to a minimum depth of 18 inches in rock. Where solid rock is covered with an overburden of soil or loose rock, set posts to the minimum depth indicated on the drawing unless a penetration of 18 inches in solid rock is achieved before reaching the indicated depth, in which case terminate depth of penetration. Grout all portions of posts set in rock.
- b. Set portions of posts not set in rock in concrete from the rock to ground level. Set posts in holes not less than the diameter shown on the drawings. Make diameters of holes in solid rock at least 1 inch greater than the largest cross section of the post. Thoroughly consolidate concrete and grout around each post, free of voids and finished to form a dome. Allow concrete and grout to cure for 72 hours prior to attachment of any item to the posts. Group II line posts may be mechanically driven, for temporary fence construction only, if rock is not encountered. Set driven posts to a minimum depth of 3 feet and protect with drive caps when setting.
- c. Test fence post rigidity by applying a 50 pound force on the post, perpendicular to the fabric, at 5 feet above ground. Ensure post movement measured at the point where the force is applied is less than or equal to 3/4 inch from the relaxed position. Test every tenth post for rigidity. When a post fails this test, make further tests on the next four posts on either side of the failed post. Remove, replace, and retest all failed parts at the Contractor's expense.

3.2.4 Rails

Bolt bottom rail to double rail ends and securely fasten double rail ends to the posts. Peen bolts to prevent easy removal. Install bottom rail before fence section.

3.2.5 INTENTIONALLY LEFT BLANK

3.2.6 INTENTIONALLY LEFT BLANK

3.2.7 Gate Installation

- a. Install gates at the locations shown. Mount gates to swing as indicated. Install latches, stops, and keepers as required. Install **swing and lift** gates as recommended by the manufacturer.
- b. Submit 6 copies of **operating and maintenance instructions**. Outline the step-by-step procedures required for system startup, operation, and shutdown. Include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Include in the maintenance instructions routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. Also include the general gate layout, equipment layout and simplified wiring and control diagrams of the system as installed.

3.2.8 Grounding

- a. Ground fencing as indicated on drawings and specified.
- b. Ground fences crossed by overhead powerlines in excess of 600 volts and ground all electrical equipment attached to the fence.
- c. Ground fences on each side of all gates, at each corner, at the closest approach to each building located within **50 feet** of the fence, and where the fence alignment changes more than 15 degrees. Ensure grounding locations are located no more than **650 feet** apart. Bond each gate panel with a flexible bond strap to its gate post. Ground fences crossed by powerlines of 600 volts or more at or near the point of crossing and at distances not exceeding **150 feet** on each side of crossing.
- d. Provide ground conductor consisting of **No. 8 AWG** solid copper wire. Use grounding electrodes that measures **3/4 inch** by **10 foot** long and are a copper-clad steel rod. Drive electrodes into the earth so that the top of the electrode is at least **6 inches** below the grade. Where driving is impracticable, bury electrodes a minimum of **12 inches** deep and radially from the fence. Install the top of the electrode to be less than **2 feet** or more than **8 feet** from the fence. Clamp ground conductor to the fence and electrodes with bronze grounding clamps to create electrical continuity between fence posts, fence fabric, and ground rods. Measure total resistance of the fence to ground and ensure it is not greater than 25 ohms.

3.2.9 INTENTIONALLY LEFT BLANK

3.3 CLOSEOUT ACTIVITIES

3.3.1 Cleanup

Remove waste fencing materials and other debris from the work site each workday.

-- End of Section --

SECTION 32 92 19

TEMPORARY SEEDING
08/17

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM C602 (2019) Agricultural Liming Materials

ASTM D4972 (2018) Standard Test Methods for pH of Soils

U.S. DEPARTMENT OF AGRICULTURE (USDA)

AMS Seed Act (1940; R 1988; R 1998) Federal Seed Act

DOA SSIR 42 (1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

95 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 23 00.00 20 EXCAVATION AND FILL, Section 32 92 23 SODDING, Section 32 93 00 EXTERIOR PLANTS, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 10.05 20 DESIGN SUBMITTAL PROCEDURES:

SD-03 Product Data

Wood Cellulose Fiber Mulch

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil Composition Tests (reports and recommendations).

SD-07 Certificates

State Certification and Approval for Seed

SD-08 Manufacturer's Instructions

Erosion Control Materials

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Seed Protection

Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.2 Fertilizer, Gypsum, Sulfur, Iron and Lime Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws.

1.5.2 Storage

1.5.2.1 Seed, Fertilizer, Gypsum, Sulfur, Iron and Lime Storage

Store in cool, dry locations away from contaminants.

1.5.2.2 Topsoil

Prior to stockpiling topsoil, treat growing vegetation with application of appropriate specified non-selective herbicide. Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.2.3 Handling

Do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions

Do not plant when the ground is frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit.

1.7 TIME LIMITATIONS

1.7.1 Seed

Apply seed within twenty four hours after seed bed preparation.

PART 2 PRODUCTS

2.1 SEED

2.1.1 Classification

Provide State-certified seed of the latest season's crop delivered in original sealed packages, bearing producer's guaranteed analysis for percentages of mixtures, purity, germination, weedseed content, and inert material. Label in conformance with **AMS Seed Act** and applicable state seed laws. Wet, moldy, or otherwise damaged seed will be rejected.

2.1.2 Planting Dates

<u>Planting Season</u>	<u>Planting Dates</u>
Late Winter and Early Spring	December 1 - April 15
Summer	April 15 - August 15
Fall	August 15 - December 30

2.1.3 Seed Purity

Botanical Name	Common Name	Minimum Percent Pure Seed	Minimum Percent Germination and Hard Seed	Maximum Percent Weed Seed
Secale cereale	Cereal (Winter) Rye	98%	85%	1%
Setaria italica	German Millet	98%	85%	1%

2.1.4 Seed Mixture by Weight

<u>Planting Season</u>	<u>Variety</u>	<u>Percent (by Weight)</u>
Late Winter and Early Spring	Secale cereale	100%
Summer	Setaria italica	100%
Fall	Secale cereale	100%

Proportion seed mixtures by weight. Temporary seeding must later be replaced by centipede sod plantings for a permanent stand of grass. The same requirements of turf establishment for apply for temporary seeding.

2.2 TOPSOIL

2.2.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph COMPOSITION. When available topsoil must be existing surface soil stripped and stockpiled on-site in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL.

2.2.2 Off-Site Topsoil

Conform to requirements specified in paragraph COMPOSITION. Additional topsoil must be furnished by the Contractor.

2.2.3 Composition

Containing from 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 3/4 inch, with maximum 3 percent retained on 1/4 inch screen. The pH must be tested in accordance with ASTM D4972. Topsoil must be free of sticks, stones, roots, and other debris and objectionable materials. Other components must conform to the following limits:

Silt	30 to 50 percent
Clay	7 to 20 percent
Sand	50 to 70 percent
pH	6.0 to 7.0
Soluble Salts	600 ppm maximum

2.3 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.3.1 Lime

Commercial grade limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 80 percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental

2.3.4 Iron

100 percent elemental

2.3.5 Sand

Clean and free of materials harmful to plants.

2.3.6 Perlite

Horticultural grade.

2.3.7 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, and soil stabilized with nitrogen and having the following properties:

2.3.7.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

2.3.7.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.3.8 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 80 percent, calcium 18 percent, sulfur 14 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.3.9 Calcined Clay

Calcined clay must be granular particles produced from montmorillonite clay calcined to a minimum temperature of 1200 degrees F. Gradation: A minimum 90 percent must pass a No. 8 sieve; a minimum 99 percent must be retained on a No. 60 sieve; and material passing a No. 100 sieve must not exceed 2 percent. Bulk density: A maximum 40 pounds per cubic foot.

2.4 FERTILIZER

2.4.1 Granular Fertilizer

Organic granular controlled release fertilizer in proportions as indicated in recommendations from the soil testing report.

2.4.2 Hydroseeding Fertilizer

Controlled release fertilizer, to use with hydroseeding and composed of pills coated with plastic resin to provide a continuous release of nutrients for at least 6 months in proportions as indicated in recommendations from the soil testing report.

2.5 MULCH

Mulch must be free from noxious weeds, mold, and other deleterious

materials.

2.5.1 Straw

Stalks from oats, wheat, rye, barley, or rice. Furnish in air-dry condition and of proper consistency for placing with commercial mulch blowing equipment. Straw must contain no fertile seed.

2.5.2 Wood Cellulose Fiber Mulch

Use recovered materials of either paper-based (100 percent post-consumer content) or wood-based (100 percent total recovered content) hydraulic mulch. Processed to contain no growth or germination-inhibiting factors and dyed an appropriate color to facilitate visual metering of materials application. Composition on air-dry weight basis: 9 to 15 percent moisture, pH range from 5.5 to 8.2. Use with hydraulic application of grass seed and fertilizer.

2.6 WATER

Source of water must be approved by Contracting Officer and of suitable quality for irrigation, containing no elements toxic to plant life.

2.7 EROSION CONTROL MATERIALS

Erosion control material must conform to the following:

2.7.1 Erosion Control Blanket

100 percent agricultural straw stitched with a degradable nettings, designed to degrade within 12 months.

2.7.2 Erosion Control Fabric

Fabric must be knitted construction of polypropylene yarn with uniform mesh openings 3/4 to 1 inch square with strips of biodegradable paper. Filler paper strips must have a minimum life of 6 months.

2.7.3 Erosion Control Net

Net must be heavy, twisted jute mesh, weighing approximately 1.22 pounds per linear yard and 4 feet wide with mesh openings of approximately one inch square.

2.7.4 Erosion Control Material Anchors

Erosion control anchors must be as recommended by the manufacturer.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 EXTENT OF WORK

Provide soil preparation prior to planting (including soil conditioners as required), fertilizing, seeding, and surface topdressing of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.1.1 Topsoil

Provide 4 inches of on-site topsoil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer, pH adjusters, soil conditioners into soil a minimum depth of 4 inches by disking, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 3/4 inch in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas from damage by vehicular or pedestrian traffic.

3.1.1.2 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

3.1.1.3 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.

3.2 SEEDING

3.2.1 Seed Application Seasons and Conditions

Immediately before seeding, restore soil to proper grade. Do not seed when ground is muddy frozen, snow covered, or in an unsatisfactory condition for seeding. If special conditions exist that may warrant a variance in the above seeding dates or conditions, submit a written request to the Contracting Officer stating the special conditions and proposed variance. Apply seed within twenty four hours after seedbed preparation. Sow seed by approved sowing equipment. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing.

3.2.2 Seed Application Method

Seeding method must be broadcasted and drop seeding or hydroseeding.

3.2.2.1 Broadcast and Drop Seeding

Seed must be uniformly broadcast at the rate of 120 lb/acre (Cereal Rye), or 40 lb/acre (German Millet). Use broadcast or drop seeders. Sow one-half the seed in one direction, and sow remainder at right angles to the first sowing. Cover seed uniformly to a maximum depth of 1/4 inch in clay soils and 1/2 inch in sandy soils by means of spike-tooth harrow, cultipacker, raking or other approved devices.

3.2.2.2 Hydroseeding

First, mix water and fiber. Wood cellulose fiber, paper fiber, or recycled paper must be applied as part of the hydroseeding operation. Fiber must be added at 1,000 pounds, dry weight, per acre. Then add and mix seed and fertilizer to produce a homogeneous slurry. Seed must be mixed to ensure broadcasting at the rate of 120 lb/acre (Cereal Rye), or 40 lb/acre (German Millet). When hydraulically sprayed on the ground, material must form a blotter like cover impregnated uniformly with grass seed. Spread with one application with no second application of mulch.

3.2.3 Mulching

3.2.3.1 Straw Mulch

Straw mulch must be spread uniformly at the rate of 2 tons per acre. Mulch must be spread by hand, blower-type mulch spreader, or other approved method. Mulching must be started on the windward side of relatively flat areas or on the upper part of steep slopes, and continued uniformly until the area is covered. The mulch must not be bunched or clumped. Sunlight must not be completely excluded from penetrating to the ground surface. All areas installed with seed must be mulched on the same day as the seeding. Mulch must be anchored immediately following spreading.

3.2.4 Rolling

Immediately after seeding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding 90 pounds for each foot of roller width. If seeding is performed with cultipacker-type seeder or by hydroseeding, rolling may be eliminated.

3.2.5 Erosion Control Material

Install in accordance with manufacturer's instructions, where indicated or as directed by the Contracting Officer.

3.2.6 Watering

Start watering areas seeded as required by temperature and wind conditions. Apply water at a rate sufficient to insure thorough wetting of soil to a depth of 2 inches without run off. During the germination process, seed is to be kept actively growing and not allowed to dry out.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 APPLICATION

3.4.1 Overseeding

Apply seed in accordance with and at rates indicated in applicable portions of paragraph SEED APPLICATION METHOD.

3.5 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations at the Contractor's expense. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean other paving when work in adjacent areas is complete.

-- End of Section --

SECTION 32 92 23

SODDING
04/06

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM C602 (2019) Agricultural Liming Materials

ASTM D4972 (2018) Standard Test Methods for pH of Soils

TURFGRASS PRODUCERS INTERNATIONAL (TPI)

TPI GSS (1995) Guideline Specifications to Turfgrass Sodding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42 (1996) Soil Survey Investigation Report No. 42, Soil Survey Laboratory Methods Manual, Version 3.0

1.2 DEFINITIONS

1.2.1 Stand of Turf

100 percent ground cover of the established species.

1.3 RELATED REQUIREMENTS

Section 31 23 00.00 20 EXCAVATION AND FILL, Section 32 92 19 SEEDING, Section 32 93 00 EXTERIOR PLANTS, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 10.05 20 DESIGN SUBMITTAL PROCEDURES:

SD-03 Product Data

Fertilizer

Include physical characteristics, and recommendations.

SD-06 Test Reports

Topsoil composition tests (reports and recommendations).

SD-07 Certificates

Sod farm certification for sods. Indicate type of sod in accordance with TPI GSS.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Sod Protection

Protect from drying out and from contamination during delivery, on-site storage, and handling.

1.5.1.2 Fertilizer, Gypsum, Sulfur, Iron, and Lime Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, trademark, and indication of conformance to state and federal laws.

1.5.2 Storage

1.5.2.1 Sod Storage

Lightly sprinkle with water, cover with moist burlap, straw, or other approved covering; and protect from exposure to wind and direct sunlight until planted. Provide covering that will allow air to circulate so that internal heat will not develop. Do not store sod longer than 24 hours. Do not store directly on concrete or bituminous surfaces.

1.5.2.2 Topsoil

Prior to stockpiling topsoil, treat growing vegetation with application of appropriate specified non-selective herbicide. Clear and grub existing vegetation three to four weeks prior to stockpiling topsoil.

1.5.2.3 Handling

Do not drop or dump materials from vehicles.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

1.6.1 Restrictions

Do not plant when the ground is frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit.

1.7 TIME LIMITATIONS

1.7.1 Sod

Place sod a maximum of thirty six hours after initial harvesting, in

accordance with TPI GSS as modified herein.

PART 2 PRODUCTS

2.1 SODS

2.1.1 Classification

Nursery grown, certified as classified in the TPI GSS. Machine cut sod at a uniform thickness of 3/4 inch within a tolerance of 1/4 inch, excluding top growth and thatch. Each individual sod piece shall be strong enough to support its own weight when lifted by the ends. Broken pads, irregularly shaped pieces, and torn or uneven ends will be rejected. Wood pegs and wire staples for anchorage shall be as recommended by sod supplier.

2.1.2 Purity

Sod species shall be genetically pure, free of weeds, pests, and disease.

2.1.3 Composition

2.1.3.1 Proportion

Proportion grass species as follows.

Botanical Name	Common Name	Percent
Eremochloa ophiuroides	Centipede Grass	100%

2.2 TOPSOIL

2.2.1 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph entitled "Composition." When available topsoil shall be existing surface soil stripped and stockpiled on-site in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL.

2.2.2 Off-Site Topsoil

Conform to requirements specified in paragraph entitled "Composition." Additional topsoil shall be furnished by the Contractor.

2.2.3 Composition

Containing from 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in DOA SSIR 42. Maximum particle size, 3/4 inch, with maximum 3 percent retained on 1/4 inch screen. The pH shall be tested in accordance with ASTM D4972. Topsoil shall be free of sticks, stones, roots, and other debris and objectionable materials. Other components shall conform to the following limits:

Silt	30-50 percent
Clay	7-20 percent
Sand	50-70 percent
pH	6.0 to 7.0
Soluble Salts	600 ppm maximum

2.3 SOIL CONDITIONERS

Add conditioners to topsoil as required to bring into compliance with "composition" standard for topsoil as specified herein.

2.3.1 Lime

Commercial grade limestone containing a calcium carbonate equivalent (C.C.E.) as specified in ASTM C602 of not less than 80 percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental

2.3.4 Iron

100 percent elemental

2.3.5 Sand

Clean and free of materials harmful to plants.

2.3.6 Perlite

Horticultural grade.

2.3.7 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, and soil stabilized with nitrogen and having the following properties:

2.3.7.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen	95
No. 8 mesh screen	80

2.3.7.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7

Fir or Pine Bark 1.0

2.3.8 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 91 percent, calcium 22 percent, sulfur 17 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.3.9 Calcined Clay

Calcined clay shall be granular particles produced from montmorillonite clay calcined to a minimum temperature of 1200 degrees F. Gradation: A minimum 90 percent shall pass a No. 8 sieve; a minimum 99 percent shall be retained on a No. 60 sieve; and a maximum 2 percent shall pass a No. 100 sieve. Bulk density: A maximum 40 pounds per cubic foot.

2.4 FERTILIZER

2.4.1 Granular Fertilizer

Organic, granular controlled release fertilizer in proportions as indicated in recommendations from soil testing report.

2.5 WATER

Source of water shall be approved by Contracting Officer and of suitable quality for irrigation containing no element toxic to plant life.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Extent Of Work

Provide soil preparation (including soil conditioners), fertilizing, and sodding of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.1.2 Soil Preparation

Provide 4 inches of on-site topsoil to meet indicated finish grade. After areas have been brought to indicated finish grade, incorporate fertilizer, pH adjusters, and soil conditioners into soil a minimum depth of 4 inches by disking, harrowing, tilling or other method approved by the Contracting Officer. Remove debris and stones larger than 3/4 inch in any dimension remaining on the surface after finish grading. Correct irregularities in finish surfaces to eliminate depressions. Protect finished topsoil areas from damage by vehicular or pedestrian traffic.

3.1.2.1 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

3.1.2.2 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.

3.2 SODDING

3.2.1 Finished Grade and Topsoil

Prior to the commencement of the sodding operation, the Contractor shall verify that finished grades are as indicated on drawings; the placing of topsoil, smooth grading, and compaction requirements have been completed in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL.

The prepared surface shall be a maximum 1 inch below the adjoining grade of any surfaced area. New surfaces shall be blended to existing areas. The prepared surface shall be completed with a light raking to remove from the surface debris and stones over a minimum 5/8 inch in any dimension.

3.2.2 Placing

Place sod a maximum of 36 hours after initial harvesting, in accordance with TPI GSS as modified herein.

3.2.3 Sodding Slopes and Ditches

For slopes 2:1 and greater, lay sod with long edge perpendicular to the contour. For V-ditches and flat bottomed ditches, lay sod with long edge perpendicular to flow of water. Anchor each piece of sod with wood pegs or wire staples maximum 2 feet on center. On slope areas, start sodding at bottom of the slope.

3.2.4 Finishing

After completing sodding, blend edges of sodded area smoothly into surrounding area. Air pockets shall be eliminated and a true and even surface shall be provided. Frayed edges shall be trimmed and holes and missing corners shall be patched with sod.

3.2.5 Rolling

Immediately after sodding, firm entire area except for slopes in excess of 3 to 1 with a roller not exceeding 90 pounds for each foot of roller width.

3.2.6 Watering

Start watering areas sodded as required by daily temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to minimum depth of 6 inches. Run-off, puddling, and wilting shall be prevented. Unless otherwise directed, watering trucks shall not be driven over turf areas. Watering of other adjacent areas or plant material shall be prevented.

3.3 PROTECTION OF TURF AREAS

Immediately after turfing, protect area against traffic and other use.

3.4 RESTORATION

Restore to original condition existing turf areas which have been damaged during turf installation operations. Keep clean at all times at least one paved pedestrian access route and one paved vehicular access route to each building. Clean other paving when work in adjacent areas is complete.

-- End of Section --

SECTION 32 93 00

EXTERIOR PLANTS

08/17

PART 1 GENERAL

1.1 REFERENCES

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

AMERICANHORT (AH)

ANSI/ANLA Z60.1 (2004) American Standard for Nursery Stock

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M (2018) Standard Specification for
Stainless Steel Wire

ASTM C602 (2019) Agricultural Liming Materials

ASTM D4972 (2018) Standard Test Methods for pH of
Soils

ASTM D5268 (2019) Topsoil Used for Landscaping
Purposes

ASTM D5852 (2000; R 2007; E 2014) Standard Test
Method for Erodibility Determination of
Soil in the Field or in the Laboratory by
the Jet Index Method

ASTM D6629 (2001; R 2012; E 2012) Selection of
Methods for Estimating Soil Loss by Erosion

L.H. BAILEY HORTORIUM (LHBH)

LHBH (1976) Hortus Third

TREE CARE INDUSTRY ASSOCIATION (TCIA)

TCIA A300P1 (2017) ANSI A300 Part1: Tree Care
Operations - Trees, Shrubs and Other Woody
Plant Maintenance Standard Practices -
Pruning

TCIA Z133 (2017) American National Standard for
Arboricultural Operations - Pruning,
Repairing, Maintaining, and Removing
Trees, and Cutting Brush - Safety
Requirements

U.S. DEPARTMENT OF AGRICULTURE (USDA)

DOA SSIR 42 (1996) Soil Survey Investigation Report

No. 42, Soil Survey Laboratory Methods
Manual, Version 3.0

1.2 RELATED REQUIREMENTS

Section 31 23 00.00 20 EXCAVATION AND FILL, Section 32 92 19 SEEDING, Section 32 92 23 SODDING, and Section 32 05 33 LANDSCAPE ESTABLISHMENT applies to this section for pesticide use and plant establishment requirements, with additions and modifications herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 10.05 20 DESIGN SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

State Landscape Contractor's License

Time Restrictions and Planting Conditions

Indicate anticipated dates and locations for each type of planting.

SD-03 Product Data

Composted Derivatives

Rotted Manure

Organic Mulch Materials

Gypsum

Mulch

Ground Stakes

Fertilizer

Root Control Barrier

Staking Material

Antidesiccants

Erosion Control Materials

Photographs; G

SD-04 Samples

Mulch; G

SD-06 Test Reports

Topsoil Composition Tests; Soil Test of proposed area

Percolation Test; Percolation Test of proposed area

SD-07 Certificates

Nursery Certifications

1.4 QUALITY ASSURANCE

1.4.1 Topsoil Composition Tests

Commercial test from an independent testing laboratory including basic soil groups (moisture and saturation percentages, Nitrogen-Phosphorus-Potassium (N-P-K) ratio, pH (ASTM D4972), soil salinity), secondary nutrient groups (calcium, magnesium, sodium, Sodium Absorption Ratio (SAR)), micronutrients (zinc, manganese, iron, copper), toxic soil elements (boron, chloride, sulfate), cation exchange and base saturation percentages, and soil amendment and fertilizer recommendations with quantities for plant material being transplanted. Soil required for each test must include a maximum depth of 18 inches of approximately one quart volume for each test. Areas sampled should not be larger than one acre and should contain at least 6-8 cores for each sample area and be thoroughly mixed. Problem areas should be sampled separately and compared with samples taken from adjacent non-problem areas. The location of the sample areas should be noted and marked on a parcel or planting map for future reference.

1.4.2 Nursery Certifications

- a. Indicate on nursery letterhead the name of plants in accordance with the LHBH, including botanical common names, quality, and size.
- b. Inspection certificate.
- c. Mycorrhizal fungi inoculum for plant material treated

1.4.3 State Landscape Contractor's License

Construction company must hold a landscape contractors license in the state where the work is performed and have a minimum of five years landscape construction experience. Submit copy of license and three references for similar work completed in the last five years.

1.4.4 Plant Material Photographs

Contractor must submit nursery photographs, for government approval prior to ordering, for each tree larger than 24-inch box/ 2-inch caliper size.

1.4.5 Percolation Test

Immediately following rough grading operation, identify a typical location for one of the largest trees and or shrubs and excavate a pit per the project details. Fill the pit with water to a depth of 12 inches. The length of time required for the water to percolate into the soil, leaving the pit empty, must be measured by the project Landscape Architect and

verified by the Contracting Officer. Within six hours of the time the water has drained from the pit, the Contractor, with the Contracting Officer and project Landscape Architect present, must again fill the pit with water to a depth of 12 inches. If the water does not completely percolate into the soil within 9 hours, a determination must be made whether a drainage system or a soil penetrant will be required for each tree and or shrub being transplanted.

1.4.6 Erosion Assessment

Assess potential effects of soil management practices on soil loss in accordance with ASTM D6629. Assess erodibility of soil with dominant soil structure less than 2.8 to 3.1 inches in accordance with ASTM D5852.

1.4.7 Pre-Installation Meeting

Convene a pre-installation meeting a minimum of one week prior to commencing work of this section. Require attendance of parties directly affecting work of this section. Review conditions of operations, procedures and coordination with related work. Agenda must include the following:

- a. Tour, inspect, and discuss conditions of planting materials.
- b. Review planting schedule and maintenance.
- c. Review required inspections.
- d. Review environmental procedures.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery

1.5.1.1 Branched Plant Delivery

Deliver with branches tied and exposed branches covered with material which allows air circulation. Prevent damage to branches, trunks, root systems, and root balls and desiccation of leaves.

1.5.1.2 Soil Amendment Delivery

Deliver to the site in original, unopened containers bearing manufacturer's chemical analysis, name, trade name, or trademark, and indication of conformance to state and federal laws. Store in dry locations away from contaminants.

1.5.1.3 Plant Labels

Deliver plants with durable waterproof labels in weather-resistant ink. Provide labels stating the correct botanical and common plant name and variety as applicable and size as specified in the list of required plants. Attach to plants, bundles, and containers of plants. Groups of plants may be labeled by tagging one plant. Labels must be legible for a minimum of 60 days after delivery to the planting site.

1.5.2 Storage

1.5.2.1 Plant Storage and Protection

Store and protect plants not planted on the day of arrival at the site as follows:

- a. Shade and protect plants in outside storage areas from the wind and direct sunlight until planted.
- b. Heel-in bare root plants.
- c. Protect balled and burlapped plants from freezing or drying out by covering the balls or roots with moist burlap, sawdust, wood chips, shredded bark, peat moss, or other approved material. Provide covering which allows air circulation.
- d. Keep plants in a moist condition until planted by watering with a fine mist spray.
- e. Do not store plant material directly on concrete or bituminous surfaces.

1.5.2.2 Fertilizer, Gypsum, pH Adjusters and Mulch Storage

Store in dry locations away from contaminants.

1.5.2.3 Topsoil

Prior to stockpiling topsoil, eradicate on site undesirable growing vegetation. Clear and grub existing vegetation three to four weeks prior to stockpiling existing topsoil.

1.5.2.4 Root Control Barrier

Store materials on site in enclosures or under protective covering in dry location. Store under cover out of direct sunlight. Do not store materials directly on ground.

1.5.3 Handling

Do not drop or dump plants from vehicles. Avoid damaging plants being moved from nursery or storage area to planting site. Handle balled and burlapped and container plants carefully to avoid damaging or breaking the earth ball or root structure. Do not handle plants by the trunk or stem. Remove damaged plants from the site.

1.5.4 TIME LIMITATION

Except for container-grown plant material, the time limitation from digging to installing plant material must be a maximum of 90 days. The time limitation between installing the plant material and placing the mulch must be a maximum of 24 hours.

1.6 TIME RESTRICTIONS AND PLANTING CONDITIONS

Coordinate installation of planting materials during optimal planting seasons for each type of plant material required.

1.6.1 Planting Dates

1.6.1.1 Deciduous Material

Year round, subject to 1.6.2 Restrictions.

1.6.1.2 Evergreen Material

Year round, subject to 1.6.2 Restrictions.

1.6.2 Restrictions

Do not plant when ground is frozen, snow covered, muddy, or when air temperature exceeds 90 degrees Fahrenheit

1.7 GUARANTEE

All plants must be guaranteed for one year beginning on the date of inspection by the Contracting Officer to commence the plant establishment period, against defects including death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, or abuse by the Government or by weather conditions unusual for the warranty period.

Remove and replace dead planting materials immediately unless required to plant in the succeeding planting season. At end of warranty period, replace planting materials that die or have 25 percent or more of their branches that die during the construction operations or the guarantee period.

1.8 PLASTIC IDENTIFICATION

Provide product data indicating polymeric information in Operation and Maintenance Manual.

Type 1: Polyethylene Terephthalate (PET, PETE).

Type 2: High Density Polyethylene (HDPE).

Type 3: Vinyl (Polyvinyl Chloride or PVC).

Type 4: Low Density Polyethylene (LDPE).

Type 5: Polypropylene (PP).

Type 6: Polystyrene (PS).

Type 7: Other. Use of this code indicates that the package in question is made with a resin other than the six listed above, or is made of more than one resin listed above, and used in a multi-layer combination.

PART 2 PRODUCTS

2.1 PLANTS

2.1.1 Regulations and Varieties

Existing trees and shrubs to remain must be protected and a planting plan be arranged around them. Furnish nursery stock in accordance with ANSI/ANLA Z60.1, except as otherwise specified or indicated. Each plant or group of planting must have a "key" number indicated on the nursery certifications of the plant schedule. Furnish plants, including turf grass, grown under climatic conditions similar to those in the locality of the project. Spray plants budding into leaf or having soft growth with an antidesiccant before digging. Plants of the same specified size must be of uniform size and character of growth. Plants must be chosen with their

mature size and growth habit in mind to avoid over-planting and conflict with other plants, structures or underground utility lines. All plants must comply with all Federal and State Laws requiring inspection for plant diseases and infestation.

2.1.1.2 Shape and Condition

Well-branched, well-formed, sound, vigorous, healthy planting stock free from disease, sunscald, windburn, abrasion, and harmful insects or insect eggs and having a healthy, normal, and undamaged root system.

2.1.2.1 Deciduous Trees and Shrubs

Symmetrically developed and of uniform habit of growth, with straight boles or stems, and free from objectionable disfigurements.

2.1.2.2 Evergreen Trees and Shrubs

Well developed symmetrical tops with typical spread of branches for each particular species or variety.

2.1.2.3 Ground Covers and Vines

Number and length of runners and clump sizes indicated, and of the proper age for the grade of plants indicated, furnished in removable containers, integral containers, or formed homogeneous soil section.

2.1.3 Plant Size

Minimum sizes measured after pruning and with branches in normal position, must conform to measurements indicated, based on the average width or height of the plant for the species as specified in [ANSI/ANLA Z60.1](#). Plants larger in size than specified may be provided with approval of the Contracting Officer. When larger plants are provided, increase the ball of earth or spread of roots in accordance with [ANSI/ANLA Z60.1](#).

2.1.4 Root Ball Size

All box-grown, field potted, field boxed, collected, plantation grown, bare root, balled and burlapped, container grown, processed-balled, and in-ground fabric bag-grown root balls must conform to [ANSI/ANLA Z60.1](#). All wrappings and ties must be biodegradable. Root growth in container grown plants must be sufficient to hold earth intact when removed from containers. Root bound plants will not be accepted.

2.1.4.1 Mycorrhizal fungi inoculum

Before shipment, root systems must contain mycorrhizal fungi inoculum.

2.1.5 Growth of Trunk and Crown

2.1.5.1 Deciduous Trees

A height to caliper relationship must be provided in accordance with [ANSI/ANLA Z60.1](#). Height of branching must bear a relationship to the size and species of tree specified and with the crown in good balance with the trunk. The trees must not be "poled" or the leader removed.

- a. Single stem: The trunk must be reasonably straight and symmetrical

with crown and have a persistent main leader.

- b. Multi-stem: All countable stems, in aggregate, must average the size specified. To be considered a stem, there must be no division of the trunk which branches more than 6 inches from ground level.

2.1.5.2 Deciduous Shrubs

Deciduous shrubs must have the height and number of primary stems recommended by ANSI/ANLA Z60.1. Acceptable plant material must be well shaped, with sufficient well-spaced side branches, and recognized by the trade as typical for the species grown in the region of the project.

2.1.5.3 Coniferous Evergreen Plant Material

Coniferous Evergreen plant material must have the height-to-spread ratio recommended by ANSI/ANLA Z60.1. The coniferous evergreen trees must not be "poled" or the leader removed. Acceptable plant material must be exceptionally heavy, well shaped and trimmed to form a symmetrical and tightly knit plant. The form of growth desired must be as indicated.

2.1.5.4 Broadleaf Evergreen Plant Material

Broadleaf evergreen plant material must have the height-to-spread ratio recommended by ANSI/ANLA Z60.1. Acceptable plant material must be well shaped and recognized by the trade as typical for the variety grown in the region of the project.

2.1.5.5 Ground Cover and Vine Plant Material

Ground cover and vine plant material must have the minimum number of runners and length of runner recommended by ANSI/ANLA Z60.1. Plant material must have heavy, well developed and balanced crown with vigorous, well developed root system and must be furnished in containers.

2.2 TOPSOIL

2.2.1 Existing Soil

Modify to conform to requirements specified in paragraph COMPOSITION.

2.2.2 On-Site Topsoil

Surface soil stripped and stockpiled on site and modified as necessary to meet the requirements specified for topsoil in paragraph COMPOSITION. When available topsoil must be existing surface soil stripped and stockpiled on-site in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL.

2.2.3 Off-Site Topsoil

Conform to requirements specified in paragraph COMPOSITION. Additional topsoil must be furnished by the Contractor.

2.2.4 Composition

Evaluate soil for use as topsoil in accordance with ASTM D5268. From 5 to 10 percent organic matter as determined by the topsoil composition tests of the Organic Carbon, 6A, Chemical Analysis Method described in

DOA SSIR 42. Maximum particle size, **3/4 inch**, with maximum 3 percent retained on **1/4 inch** screen. The pH must be tested in accordance with **ASTM D4972**. Topsoil must be free of sticks, stones, roots, plants, and other debris and objectionable materials. Other components must conform to the following limits:

Silt	30 to 50 percent
Clay	7 to 20 percent
Sand	50 to 70 percent
pH	6.0 to 7.0
Soluble Salts	600 ppm maximum

2.3 SOIL CONDITIONERS

Provide singly or in combination as required to meet specified requirements for topsoil. Soil conditioners must be nontoxic to plants.

2.3.1 Lime

Commercial grade limestone containing a calcium carbonate equivalent (C.C.E.) as specified in **ASTM C602** of not less than 80 percent.

2.3.2 Aluminum Sulfate

Commercial grade.

2.3.3 Sulfur

100 percent elemental

2.3.4 Iron

100 percent elemental

2.3.5 Sand

Clean and free of materials harmful to plants.

2.3.6 Perlite

Horticultural grade.

2.3.7 Composted Derivatives

Ground bark, nitrolized sawdust, humus or other green wood waste material free of stones, sticks, invasive species, including seeds, and soil stabilized with nitrogen and having the following properties:

2.3.7.1 Particle Size

Minimum percent by weight passing:

No. 4 mesh screen 95

No. 8 mesh screen 80

2.3.7.2 Nitrogen Content

Minimum percent based on dry weight:

Fir Sawdust	0.7
Fir or Pine Bark	1.0

2.3.8 Gypsum

Coarsely ground gypsum comprised of calcium sulfate dihydrate 80 percent, calcium 18 percent, sulfur 14 percent; minimum 96 percent passing through 20 mesh screen, 100 percent passing thru 16 mesh screen.

2.3.9 Vermiculite

Horticultural grade for planters.

2.3.10 Rotted Manure

Well rotted horse or cattle manure containing maximum 25 percent by volume of straw, sawdust, or other bedding materials; free of seeds, stones, sticks, soil, and other invasive species.

2.4 PLANTING SOIL MIXTURES

100 percent on-site topsoil.

2.5 FERTILIZER

Fertilizer for groundcover, wildflowers and grasses is not permitted. Fertilizer for trees, plants, and shrubs must be as recommended by plant supplier, except synthetic chemical fertilizers are not permitted. Fertilizers containing petrochemical additives or that have been treated with pesticides or herbicides are not permitted.

2.5.1 Granular Fertilizer

Organic, granular controlled release fertilizer in proportions as indicated in recommendations from soil testing report.

2.5.2 Fertilizer Tablets

Organic, plant tablets composed of tightly compressed fertilizer chips forming a tablet that is insoluble in water, is designed to provide a continuous release of nutrients for at least 24 months and in proportions as indicated in recommendations from soil testing report.

2.6 MULCH

Free from noxious weeds, mold, pesticides, or other deleterious materials.

2.6.1 Organic Mulch Materials

Provide double shredded hardwood bark mulch. Mulch shall not be dyed or stained.

2.7 STAKING AND GUYING MATERIAL

2.7.1 Staking Material

2.7.1.1 Tree Support Stakes

Rough sawn hard wood free of knots, rot, cross grain, bark, long slivers, or other defects that impair strength. Stakes must be minimum 2 inches square or 2-1/2 inch diameter by 8 feet long, pointed at one end.

2.7.1.2 Ground Stakes

Rough sawn hard wood or plastic, 2 inches square are by 3 feet long, pointed at one end.

2.7.2 Guying Material

2.7.2.1 Guying Wire

12 gauge annealed galvanized steel, ASTM A580/A580M.

2.7.2.2 Guying Cable

Minimum five-strand, 3/16 inch diameter galvanized steel cable plastic coated.

2.7.3 Hose Chafing Guards

New or used 2 ply 3/4 inch diameter reinforced rubber or plastic hose, black or dark green, all of same color.

2.7.4 Flags

White surveyor's plastic tape, 6 inches long, fastened to guying wires or cables.

2.8 ANTIDESICCANTS

Sprayable, water insoluble vinyl-vinledine complex which produce a moisture retarding barrier not removable by rain or snow. Film must form at temperatures commonly encountered out of doors during planting season and have a moisture vapor transmission rate (MVT) of the resultant film of maximum 10 grams per 24 hours at 70 percent humidity.

2.9 EROSION CONTROL MATERIALS

Erosion control material must conform to the following:

2.9.1 Erosion Control Blanket

100 percent agricultural straw stitched with a degradable nettings, designed to degrade within 12 months.

2.9.2 Erosion Control Fabric

Fabric must be knitted construction of polypropylene yarn with uniform mesh openings 3/4 to 1 inch square with strips of biodegradable paper. Filler paper strips must have a minimum life of 6 months.

2.9.3 Erosion Control Net

Net must be heavy, twisted jute mesh, weighing approximately 1.22 pounds per linear yard and 4 feet wide with mesh openings of approximately one inch square.

2.9.4 Hydrophilic Colloids

Hydrophilic colloids must be physiologically harmless to plant and animal life without phytotoxic agents. Colloids must be naturally occurring, silicate powder based, and must form a water insoluble membrane after curing. Colloids must resist mold growth.

2.9.5 Erosion Control Material Anchors

Erosion control anchors must be as recommended by the manufacturer.

2.10 ROOT CONTROL BARRIER

Linear barrier with integral vertical root deflecting ribs constructed of ultraviolet resistant polypropylene material. Color to be black. Provide root barrier for all trees planted within 8 feet of any utility, wall, curb or pavement. Do not encircle tree root balls with root barriers.

2.11 WATER

Source of water to be approved by Contracting Officer and suitable quality for irrigation and must not contain elements toxic to plant life, including acids, alkalis, salts, chemical pollutants, and organic matter. Use collected storm water or graywater when available.

2.12 MYCORRHIZAL FUNGI INOCULUM

Mycorrhizal fungi inoculum must be composed of multiple-fungus inoculum as recommended by the manufacturer for the plant material specified.

2.13 SOURCE QUALITY CONTROL

The Contracting Officer and Landscape Architect of Record will inspect plant materials at the project site and approve them. Tag plant materials for size and quality.

PART 3 EXECUTION

3.1 EXTENT OF WORK

Provide soil preparation, including soil conditioners and soil amendments prior to planting. Provide tree, shrub, groundcover, seed, and sod planting, post-planting fertilizer, edging, staking, guying, erosion control material, root control barrier installation, and mulch topdressing of all newly graded finished earth surfaces, unless indicated otherwise, and at all areas inside or outside the limits of construction that are disturbed by the Contractor's operations.

3.2 ALTERNATIVE HERBICIDE TREATMENT (SOLARIZING SOIL)

Within 48 hours of subsoil preparation, saturate soil with water to a depth of 3 feet. Immediately stake polyethylene sheeting over area to be planted. Stake tightly to surface of soil. Maintain sheeting in place

for a minimum of 6 weeks. Immediately after removing sheeting, cover area to be planted with topsoil. Do not till soil prior to applying topsoil.

3.3 PREPARATION

3.3.1 Protection

Protect existing and proposed landscape features, elements, and sites from damage or contamination. Protect trees, vegetation, and other designated features by erecting high-visibility, reusable construction fencing. Locate fence no closer to trees than the drip line. Plan equipment and vehicle access to minimize and confine soil disturbance and compaction to areas indicated on Drawings.

3.3.2 Layout

Stake out approved plant material locations and planter bed outlines on the project site before digging plant pits or beds. The Contracting Officer reserves the right to adjust plant material locations to meet field conditions. Do not plant closer than **12 inches** to a building wall. Provide on-site locations for excavated rock, soil, and vegetation.

3.3.3 Erosion Control

Provide erosion control and seeding with native plant species to protect slopes.

3.3.4 Soil Preparation

3.3.4.1 pH Adjuster Application Rates

Apply pH adjuster at rates as determined by laboratory soil analysis of the soils at the job site.

3.3.4.2 Soil Conditioner Application Rates

Apply soil conditioners at rates as determined by laboratory soil analysis of the soils at the job site.

3.3.4.3 Fertilizer Application Rates

Apply fertilizer at rates as determined by laboratory soil analysis of the soils at the job site.

3.3.5 Root Control Barrier

Install geotextile fabric in the soil in a horizontal application. Use appropriate holding device to assure fabric position. For vertical or horizontal application, a minimum **2 inch** soil cover is required over the top surface. A minimum **18 inch** extension of fabric beyond the structure area to be protected is required to prevent root growth from growing around fabric edges. Install linear polypropylene barrier **2 inches below finished grade**. For linear barrier application use appropriate device to connect two pieces.

3.4 PLANT BED PREPARATION

Verify location of underground utilities prior to excavation. Protect existing adjacent turf before excavations are made. Do not disturb

topsoil and vegetation in areas outside those indicated on Drawings. Where planting beds occur in existing turf areas, remove turf to a depth that will ensure removal of entire root system. Measure depth of plant pits from finished grade. Depth of plant pit excavation must be as indicated and provide proper relation between top of root ball and finished grade. Install plant material as specified in paragraph PLANT INSTALLATION. Do not install trees within 10 feet of any utility lines or building walls.

3.5 PLANT INSTALLATION

3.5.1 Individual Plant Pit Excavation

Excavate pits at least twice as large in diameter as the size of ball or container to depth shown.

3.5.2 Plant Beds with Multiple Plants

Excavate plant beds continuously throughout entire bed as outlined to depth shown.

3.5.3 Handling and Setting

Move plant materials only by supporting the root ball or container. Set plant materials, in relation to surrounding finish grade, one inch above depth at which they were grown in the nursery, collecting field or container. Replace plant material whose root balls are cracked or damaged either before or during the planting process.

Plant material must be set in plant beds according to the drawings. Backfill soil mixture must be placed on previously scarified subsoil to completely surround the root balls, and must be brought to a smooth and even surface, blending to existing areas.

3.5.3.1 Balled and Burlapped Stock

Backfill with prepared soil mixture to approximately half the depth of ball and then tamp and water. Carefully remove or fold back excess burlap and tying materials from the top a minimum 1/3 depth from the top of the rootball. Tamp and complete backfill, place mulch topdressing, and water. Remove wires and non-biodegradable materials from plant pit prior to backfill operations.

3.5.3.2 Bare-Root Stock

Plant so roots are arranged in a natural position. Place roots in water a minimum of 30 minutes prior to planting. Carefully work prepared soil mixture among roots. Tamp remainder of backfill, place mulch topdressing and water.

3.5.3.3 Container Grown Stock

Remove from container and prevent damage to plant or root system.

3.5.3.4 Ground Covers and Vines

Plant after placing mulch topdressing. Do not remove plant materials from flats or containers until immediately before planting. Space at intervals indicated. Plant at a depth to sufficiently cover all roots. Start

watering areas planted as required by temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to a depth of 6 inches without run off or puddling. Smooth planting areas after planting to provide even, smooth finish. Mulch as indicated.

Smooth planting areas before planting to provide even, smooth finish. Do not remove plant material from flats or containers until immediately before planting. Space at the intervals indicated. Plant at a depth to sufficiently cover all roots. Start watering areas planted as required by temperature and wind conditions. Apply water at a rate sufficient to ensure thorough wetting of soil to a depth of 6 inches without run off or puddling. Add mulch topdressing as needed.

3.5.4 Earth Mounded Watering Basin for Individual Plant Pits

Form with topsoil around each plant by replacing a mound of topsoil around the edge of each plant pit. Watering basins must be 6 inches deep for trees and 4 inches deep for shrubs. Eliminate basins around plants in plant beds containing multiple plants.

3.5.5 Erosion Control Material

Install in accordance with manufacturer's instructions.

3.5.6 Placement of Mulch Topdressing

Place mulch topdressing to a depth of 3 inches.

3.5.7 Mulch Topdressing

Provide mulch topdressing over entire planter bed surfaces and individual plant surfaces including earth mound watering basin around plants to a depth of 3 inches after completion of plant installation and before watering. Keep mulch out of the crowns of shrubs. Place mulch a minimum 2 to 3 inches away from trunk of shrub or tree.

3.5.8 Installation of Edging

Uniformly edge beds of plants to provide a clear cut division line between planted area and adjacent lawn. Construct bed shapes as indicated. Install metal edging material as indicated and as per manufacturer's instructions. Install edging with minimum one inch left above ground level.

3.5.9 Fertilization

3.5.9.1 Fertilizer Tablets

Place fertilizer planting tablets evenly spaced around the plant pits to the manufacturer's recommended depth.

3.5.9.2 Granular Fertilizer

Apply granular fertilizer as a top coat prior to placing mulch layer and water thoroughly.

3.5.10 Watering

Start watering areas planted as required by temperature and wind

conditions. Slow deep watering must be used. Apply water at a rate sufficient to ensure thorough wetting of soil to a depth of **12 inches** without run off or puddling. Watering of other plant material or adjacent areas must be prevented.

3.5.11 Staking and Guying

3.5.11.1 Staking

Stake plants with the number of stakes indicated complete with double strand of 12 gage guy wire as detailed. Attach guy wire half the tree height but not more than **5 feet** high. Drive stakes to a depth of **2-1/2 to 3 feet** into the ground outside the plant pit. Do not injure the root ball. Use hose chafer guards where guy wire comes in contact with tree trunk.

3.5.11.2 Guying

Guy plants as indicated. Attach two strands of guying wire around the tree trunk at an angle of **45 degrees** at approximately 1/2 of the trunk height. Protect tree trunks with chafing guards where guying wire contacts the tree trunk. Anchor guys to wood ground stakes. Fasten flags to each guying wire approximately 2/3 of the distance up from ground level.

3.5.11.3 Chafing Guards

Use hose chafing guards, as specified where guy wire will contact the plant.

3.5.11.4 Wood Ground Stakes

Drive wood ground stakes into firm ground outside of plant pit with top of stake flush with ground. Place equal distance from tree trunk and around the plant pit.

3.5.11.5 Flags

Securely fasten flags on each guy wire approximately two-thirds of the distance up from ground level.

3.5.12 Pruning

Prune in accordance with safety requirement of **TCIA Z133**.

3.5.12.1 Trees and Shrubs

Remove dead and broken branches. Prune to correct structural defects only. Retain typical growth shape of individual plants with as much height and spread as practical. Do not cut central leader on trees. Make cuts with sharp instruments. Do not flush cut with trunk or adjacent branches. Collars must remain in place. Pruning must be accomplished by trained and experienced personnel and must be accordance with **TCIA A300P1**.

3.5.12.2 Wound Dressing

Do not apply tree wound dressing to cuts.

3.6 RESTORATION AND CLEAN UP

3.6.1 Restoration

Turf areas, pavements and facilities that have been damaged from the planting operation must be restored to original condition at the Contractor's expense.

3.6.2 Clean Up

Excess and waste material must be removed from the installed area and must be disposed offsite at an approved landfill, recycling center, or composting center. Adjacent paved areas must be cleared.

-- End of Section --

SECTION 33 01 30.16

TV INSPECTION OF SEWER PIPELINES
08/16

PART 1 GENERAL

1.1 DEFINITIONS

1.1.1 CCTV Video

CD or DVD storage media containing the recorded video.

1.1.2 Cleaning

To remove soil or solid deposited materials from a pipe segment **prior to video inspection.**

1.1.3 Defects

Defects in the pipe, manholes, structures, and services include cracks, separation of joints, collapsed pipe, grade irregularities, leaks, roots, grease buildup, offset joints, reverse grades, obstructions, delamination, missing pipe, restrictions, fractures and similar structural irregularities.

1.1.4 Entry Point

The leading edge of the access point or the manhole or structure wall where the pipe segment begins. Only the pipe is video inspected from manhole or structure wall to manhole or structure wall and does not include any portion of the manhole or structure.

1.1.5 Exit Point

The point where the downstream access manhole or structure wall is encountered. Only the pipe is video inspected from manhole or structure wall to manhole or structure wall and does not include any portion of the manhole or structure.

1.1.6 National Association of Sewer Service Companies (NASSCO)

National Association of Sewer Service Companies (NASSCO) identifies the generally accepted industry standards for CCTV inspection, observation coding, and certification.

1.1.7 Pipe Segment

The length of pipe from entry point to exit point along the main or service.

1.1.8 Pipeline Assessment and Certification Program (PACP)

A CCTV Inspection standardization certification and observation coding system sponsored by NASSCO.

1.1.9 Point Repair

The location of a failure where a repair is has occurred.

1.1.10 Post-Installation CCTV (Post-TV)

Post-TV inspection is used to determine **that installation** of sanitary or storm sewers has been completed in accordance with the contract documents.

1.1.11 Pre-Installation CCTV (Pre-TV)

Pre-TV inspection is a video inspection of existing sewer lines to confirm cleaning activities, locations of service connections, and identify defects in the existing sewer system infrastructure prior to any work being performed.

1.1.12 Re-TV Inspection

Upon the completion of repairs made after performing a Post-TV Inspection or Warranty TV inspection, the mains or services are re-inspected by performing a Re-TV inspection. Also, refers to rework for a TV-Inspection that has video interruptions, gaps, or is not continuous.

1.1.13 TV Inspection Log

Information collected and recorded by the CCTV operator for each CCTV inspection effort and includes pertinent information for the respective inspection section; such as, date of inspection, location of site, CCTV technician, direction of CCTV inspection with manhole or structure identifiers, weather conditions, pipe size(s), pipe materials, conditions found, locations where the conditions were found.

1.1.14 Warranty CCTV (Warranty-TV)

Warranty-TV inspection is used to determine the slip lining of sanitary or storm sewers does not have any defects present, remains in compliance with project specifications and Post-TV inspection.

1.2 ADMINISTRATIVE REQUIREMENTS

1.2.1 Disposal Plan

Submit a disposal plan prior to performing any work that might generate waste materials. Include a complete description of the materials that are expected to be encountered and their proposed disposal sites. No changes to the disposal plan will be made without prior written acceptance by the Contracting Officer.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval.. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section **01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD**. Submit the following in accordance with Section **01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES**:

SD-07 Certificates

Disposal Plan

CCTV Technician's Qualifications

Post-TV Inspection; G

Pre-Tv Inspection

SD-11 Closeout Submittals

Post Installation CCTV Video logs

1.4 QUALITY CONTROL

1.4.1 CCTV Technician's Qualifications

Provide a CCTV technician with three years of total experience with the CCTV technology. Submit a current PACP Operator certification for personnel performing closed circuit television inspection and pipeline assessments.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

TV inspection of sewer pipelines encompasses cleaning, CCTV inspection and video recording of the new sanitary sewer mains included in the contract documents. This work includes any required pre-inspection cleaning, by-pass pumping or diversion of sanitary sewer, inspection logs, video requirements, permits, traffic control and the legal disposal of materials removed from the mains.

2.2 EQUIPMENT

2.2.1 Cleaning Equipment

Utilize mechanically powered equipment necessary for the proper rodding, bucketing, brushing, root cutting, and flushing of the sewers, including a heavy duty power rodding machine that is compatible with the cleaning to be performed.

2.2.1.1 Rodding

Provide rodding equipment capable of rodding distances of up to 1000 feet in one set-up and having the following capabilities:

- a. The ability to spin the rod either clockwise or counter-clockwise, and be able to be pushed straight out or pulled back without rotating the machine.
- b. The capability of pulling pipe-size swabs or brushes back through the pipeline for cleaning and flushing purposes.

2.2.1.2 Bucket Machine

Provide heavy-duty bucket machines for use on dragline work to clean the pipeline with buckets, brushes, scrapers, swabs or other similar devices in order to effectively remove debris and provide a clean sewer for the CCTV inspection, repair, or lining activities.

2.2.1.3 Hydraulic Flusher

Provide hydraulic high-pressure sewer cleaners used for sewer cleaning, specifically designed and constructed for such cleaning, that have a minimum usable water capacity of 600 gallons and a pump capable of delivering at least 30 gallons per minute (gpm) at 100 psi and having the following capabilities:

- a. Pressure regulator nozzle capable of adjustment from 1 psi to 1500 psi.
- b. Constructed for ease of use and safety of operation with two or more high-velocity nozzles capable of producing a scouring action from 15 to 45 degrees in lines designated to be cleaned.
- c. A high-velocity gun for washing and scouring the manhole or structure walls and floor capable of producing flows from a fine spray to a solid stream.
- d. Carry its own water tank, auxiliary engines, pumps, and hydraulically driven hose reel.

2.2.1.4 Sanitary Sewer Cleaning Equipment

Provide movable dam type hydraulically propelled equipment constructed in such a way that a portion of the dam may be collapsed at any time during the cleaning operation to protect against flooding of the sanitary sewer and having the following capabilities:

- a. A movable dam equal in diameter to the pipe being cleaned.
- b. A flexible scraper around the periphery to ensure the removal of grease.

Sewer cleaning balls or other equipment, which cannot be collapsed, are not allowed when cleaning sanitary sewer.

2.2.2 CCTV Equipment

Provide a video system capable of producing a sharply focused, well-lit and color balanced picture in accordance with the following requirements:

2.2.2.1 Pipe Inspection Camera and Associated Equipment

- a. Provide a pipe inspection camera system that produces a video using a pan and tilt, radial viewing, that pans a minimum of 275 degrees and rotates 360 degrees. Illumination sensitivity of 3 Lux or less and a minimum of 460 lines of resolution is required.
- b. Utilize video cameras specifically designed and constructed for CCTV inspection.
- c. Provide a camera that is operative in 100 percent humidity conditions.
- d. Provide a camera with an accurate footage counter that displays on the monitor the exact distance of the camera to the nearest 1/10 of a foot.
- e. Provide a camera with a height adjustment so that the camera lens is typically centered in the pipe, or higher depending on water levels in the pipe.

- f. Provide equipment that will produce digital color images and allows the CCTV technician to remotely balance the iris and color to produce a clear and true video of the pipeline.
- g. Provide lighting for the camera that is suitable to provide a clear color picture of the entire periphery of the pipe.
- h. Provide a reflector in front of the camera as necessary to enhance the lighting on dark or large diameter pipes.
- i. Provide an accompanying computer and recording device capable of projecting and recording the facility location, project name, Contractor's name, date, line size, material type, line identification, manhole or structure ID numbers and ongoing footage counter onto the video screen.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Sewer Line Cleaning

Immediately prior to conducting CCTV activities, thoroughly clean the segment of sewer pipe to be video inspected. Clean the segments using hydraulically propelled, high-velocity jet, or mechanically powered equipment.

- a. During cleaning and preparation operations, undertake precautions to protect the sewer system and property from damage. Restore property damaged as a result of such cleaning and preparation operations to pre-existing conditions.
- b. During the course of normal cleaning operations immediately report pre-existing damage such as broken or missing pipe to the Contracting Officer.
- c. When hydraulically propelled cleaning tools or tools which retard the flow in the sewer line are utilized, take precautions to ensure that the water pressure created does not damage or cause flooding on the adjacent site.
- d. Maintain access to firehydrants for the purpose of fire protection at all times.
- e. If cleaning of an entire sewer section cannot be successfully performed from one manhole or structure, set up the equipment on the other entry or exit point and attempt cleaning again.
- f. If successful cleaning cannot be performed from the opposite end or the equipment fails to traverse the entire pipeline section, cease cleaning those specific sewer sections, notify the Contracting Officer and CCTV inspect both sides of the pipeline section to determine the cause of the blockage.

3.1.1.1 Sanitary Sewer Cleaning

Minimize the interruptions to the existing flows to perform the cleaning of the sewers. Prevent sewage backups and immediately clear back-ups

resulting from the cleaning operations. When possible, utilize the flow in the sewer system to provide the necessary pressure for the hydraulic cleaning devices. Return sewage diverted during cleaning operations to the sanitary system and do not discharge onto any surface, or into any water body or storm drain system.

3.1.2 Manhole or Structure Cleaning

Clean concrete and masonry surfaces prior to CCTV inspection. Completely remove grease, laitance, loose bricks, mortar, unsound concrete, loose or damaged wall mounted steps (cut flush with wall), and other materials.

Utilize water blasting (minimum 1200 psi) with compatible nozzles as the primary method of cleaning. It is acceptable to use other methods of cleaning such as concrete cleaners, degreasers or mechanical means to clean the surfaces. When other cleaning methods are utilized submit cleaning product data or process for approval. Thoroughly rinse, scrub, and neutralize the surfaces in order to remove cleaning agents and their reactant products. Do not allow material to pass to pipeline sections, which could adversely affect water quality, cause stoppages, accumulations of sand in wet wells, or damage to pumping equipment.

3.1.3 Flow Control

Reduce the flow depth to allow a minimum of 80 percent of the pipe wall to be displayed at all times during inspection so that defects, features, and other notable information can be collected.

3.1.3.1 Flow Reduction

Flow depth reduction can be accomplished by:

- a. Providing bypass pumping.
- b. High-pressure jet nozzle.
- c. Plugging or by pulling the camera with a swab.
- d. Performing the CCTV inspection during periods of minimal flow.

3.1.3.2 Floating the Camera

Video inspection performed while floating the camera is not acceptable. Lower water levels as indicated in paragraph FLOW CONTROL.

3.1.4 Material Removal and Disposal

Remove sludge, dirt, roots, grease, and other solid or semi-solid material resulting from cleaning operations at the downstream manhole or structure of the section being cleaned.

3.1.4.1 Dams or Weirs

When hydraulic cleaning equipment is used, place dam or weir in the downstream manhole or structure to trap such materials. Do not allow material to pass from pipeline section to pipeline section, which could cause stoppages, accumulations of sand in wet wells, or damage to pumping equipment.

3.1.4.2 Sludge and Debris Storage

Under no circumstances is sludge or other debris removed during these operations to be stored, dumped or spilled into streets, ditches, storm drains, or other sanitary sewer systems.

- a. Dispose of solids and semi-solids resulting from the cleaning operations no less often than the end of each work day in accordance with the approved Disposal Plan.
- b. Under no circumstances will debris be allowed to accumulate on the work site beyond the end of each work day, except in totally enclosed containers and as acceptable by the Contracting Officer.
- c. Continuously maintain the haul route and work areas neat, clean, and reasonably free of odor. Cleanup any spill which occurs during the transport of cleaning or surface preparation by-products. Perform the cleanup of any such material pursuant to this Contract and in accordance with applicable law and environmental regulations.
- d. Immediately notify the Contracting Officer of any spill and begin clean up any such spill or waste.
- e. The Government will charge to the Contractor for any costs incurred or penalties imposed upon the Government as a result of the spill, dump or discard.
- f. Under no circumstances is this material to be discharged into the waterways or any place other than where authorized to do so in accordance with the approved Disposal Plan.

3.1.4.3 Hauling of Waste Material

Provide vehicles hauling such waste material that meet the following requirements:

- a. Provide transport vehicles of the type(s) approved for this application by the jurisdictions where those vehicles will be operated in the performance of activities associated with this Contract.
- b. Provide transport vehicles with watertight bodies equipped and fitted with seals and covers to prohibit material spillage or drainage.
- c. Clean vehicles to prevent deposits of material on roadways.
- d. Load vehicles within legal weight limits and operate safely within traffic speed regulations.
- e. The routes used for the conveyance of this material on a regular basis is subject to approval by the local governing bodies having jurisdiction over such routes.

3.2 APPLICATION

3.2.1 Inspection of Sewer Lines

Inspection of sewer lines applies to Pre-TV inspection, Post-TV inspection, RE-TV inspection and Warranty-TV inspection. Perform inspections of sewer lines in the presence of the Contracting Officer.

3.2.1.1 Communication

Set up hand operated radios, telephones, or other means of communication between the entry and exit points being inspected to ensure uninterrupted communication between members of the CCTV crew when manually operated winches are used to pull the television camera through the line.

3.2.1.2 Flush Main

Introduce a minimum of 1000 gallons of clear, potable water into the upstream manhole or structure or access structure of the mains to be CCTV inspected just prior to inserting the camera. The Contractor is responsible for collecting and disposing of the water in accordance with the approved disposal plan.

3.2.1.3 Camera Operation

Set counter to 0.00 feet at the entry point, which is the beginning manhole or structure wall. Move the camera through the line in either direction at a moderate speed, stopping to permit proper documentation of the sewer's condition or service connection locations. In no case will the camera be operated at a speed greater than 30 feet per minute. Slowly pan and tilt the camera at the beginning and ending manhole, structure connections, service connections, joints, visible defects, and pipe arterial transitions. Provide a full 360 degree view of the pipe, joints, and service connections.

Utilize manual winches, power winches, cable, powered rewinds or other devices that do not obstruct the camera view or interfere with camera operation or CCTV inspection of the pipe conditions as the camera is moved through the sewer line.

3.2.1.3.1 Recording Defects

During CCTV inspection, temporarily stop the camera at each defect or feature along the line.

3.2.1.4 Documentation of CCTV Inspection

Documentation of CCTV inspection applies to Pre-TV inspection, Post-TV inspection, RE-TV inspection and Warranty-TV inspection.

Utilize a data logger and reporting system that is PACP compliant to make a video and audio recording of the CCTV inspections. Submit video recordings, inspection logs and digital photographs as indicated below.

3.2.1.4.1 Video Recordings

Provide a color video showing the completed work and document the inspection on a digital recorder. Capture inspection video in either MPEG4 or Windows Media Video (WMV) format with a minimum resolution of 352 x 240 pixels and an interlaced frame rate at a minimum of 24 frames per second. Save video on CD or DVD. However, the CCTV inspection video of a segment must be wholly contained on a single CD or DVD. The video recording must meet the following requirements:

- a. Provide a continuous and uninterrupted recorded video for the pipe segment being examined. Include the official project title,

Contracting party, Contractor's name, street name, manhole or structure ID numbers, direction of video and flow, date and time video was recorded, continuous counter text, pipe size and material, material changes in the pipe segment, audio and text call outs of laterals, fixtures and problem areas in the recorded video.

- b. Include an audio track recorded by the CCTV technician during the actual inspection work with a description of the parameters of the line being inspected on the video recordings. The audio may be from the voice of the CCTV technician or it may be computer generated.
- c. Include the location, pipe diameter, pipe material, defects, service lateral locations and any unusual conditions found in PACP format.
- d. Submit labeled CDs or DVDs of the video inspections.
- e. Without exception, CCTV inspections must be continuous without video interruption or gaps for pipe segments.
- f. Clean, flush, and RE-TV pipe segments with video interruptions or gaps.

3.2.1.4.2 TV Inspection Logs

Submit computer generated records that clearly show the location and orientation in relation to an adjacent manhole or structure of each infiltration point observed during the inspection.

Record other points of significance such as locations and orientations of service connections, missing or broken pipe, roots, the presence of grease, scale or corrosion, bellies, fractures, cracks, and other discernible features using PACP designations.

3.2.1.4.3 Digital Photographs

Submit JPEG images at a minimum resolution of 640 x 480 pixels. Save digital photographs in JPEG file format on CD or DVD. Document noted defects and lateral connections as color digital files and hard copy print-outs. Photo logs are to accompany each photo submitted.

3.2.2 Pre-TV Inspection

Immediately after cleaning has been performed, complete a Pre-TV inspection, in accordance with paragraph INSPECTION OF SEWER LINES. Submit Pre-TV inspection documentation in accordance with paragraph DOCUMENTATION OF CCTV INSPECTION.

3.2.3 Post-TV Inspection

Immediately after visual, deflection, pressure and leak testing and service reconnections are complete on a pipe segment, complete Post-TV inspection accordance with paragraph INSPECTION OF SEWER LINES. Submit Post-TV inspection documentation in accordance with paragraph DOCUMENTATION OF CCTV INSPECTION. **Must follow NASSCO Standards.**

3.2.3.1 Post-TV Defects

If defects are found in the mains or services during the Post-TV inspection make repairs according to the specifications. RE-TV all repairs accordance with paragraph INSPECTION OF SEWER LINES. Provide additional RE-TV inspections of complete pipe segments as follows:

- a. Perform a RE-TV inspection of the complete pipe segment. If no additional defects are found in the Re-TV inspections, then the Post-TV inspection is complete.
- b. If defects are found in these additional inspections make repairs according to the specifications and provide Re-TV inspection for the complete pipe segment.
- c. If defects are found in these additional inspections make repairs according to the specifications and Re-TV the repaired pipe segments until no Post-TV defects are found.

3.2.4 RE-TV Inspection

After repairs are made to a main or service, complete RE-TV inspection accordance with paragraph INSPECTION OF SEWER LINES and DOCUMENTATION OF CCTV INSPECTION.

3.3 FIELD QUALITY CONTROL

3.4 CLOSEOUT ACTIVITIES

3.4.1 CCTV Video Records

Submit Post Installation CCTV Video logs and copies of sewer CCTV inspections in PACP format to Contracting Officer.

-- End of Section --

SECTION 33 05 23

TRENCHLESS UTILITY INSTALLATION
08/15

PART 1 GENERAL

Provide utility installation using **boring and jacking** techniques at locations indicated. The Contractor is responsible for all work related to the provision of utilities installed, including assessing surface, subsurface, and environmental (seasonal) conditions.

1.1 REFERENCES

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

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 13A (2010; Errata 1 2014; Errata 2-3 2015)
Specification for Drilling-Fluid Materials

API Spec 5L (2018; 46th Ed; ERTA 2018) Line Pipe

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION
(AREMA)

AREMA Eng Man (2017) Manual for Railway Engineering

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 27-00 (2000) Standard Practice for Direct Design
of Precast Concrete Pipe for Jacking in
Trenchless Construction

ASCE 28-00 (2001) Standard Practice for Direct Design
of Precast Concrete Box Sections for
Jacking in Trenchless Construction

ASCE 36-15 (2015) Standard Design and Construction
Guidelines for Microtunneling

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020) **Structural Welding Code - Steel**

AWS D1.5M/D1.5 (2015) Bridge Welding Code

ASTM INTERNATIONAL (ASTM)

ASTM A139/A139M (2016) Standard Specification for
Electric-Fusion (ARC)-Welded Steel Pipe
(NPS 4 and over)

ASTM C1091 (2003a; R 2013) Standard Test Method for
Hydrostatic Infiltration Testing of
Vitrified Clay Pipe Lines

ASTM C150/C150M (2020) Standard Specification for Portland Cement

ASTM C33/C33M (2018) Standard Specification for Concrete Aggregates

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1 (2014) Safety and Health Requirements Manual

1.2 DEFINITIONS

As used herein, the terms "shaft" and "pit" are synonymous.

1.2.1 Microtunneling

Unless otherwise specified or indicated, see ASCE 36-15 for definitions.

1.2.2 Jacking Precast Concrete Pipe

Unless otherwise specified or indicated, see ASCE 27-00 for definitions.

1.2.3 Jacking Precast Concrete Box Sections

Unless otherwise specified or indicated, see ASCE 28-00 for definitions.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES: AND 01 33 10.05 20 DESIGN SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Boring and Jacking Plan; G

Statement of Contractor Qualifications; G

SD-03 Product Data

Pipe casing and couplings; G

Lubricating Fluid for pipe exterior; G

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on and rubber-gasketed bell-and-spigot joints. Include information concerning gaskets with submittal for joints and couplings.

SD-05 Design Data

Design calculations for pipe casing; G

Access Shaft Construction Plan; G

SD-06 Test Reports

Monitoring Survey; G

SD-08 Manufacturer's Instructions

Installation procedures for pipe casing; G

Safety Data Sheets; G

SD-11 Closeout Submittals

Record Drawings; G

Daily Work Logs of installation operations, including records of the volume of materials removed, daily progress and grout volumes used, and as-built drawings of location and alignment of pipeline; G

1.4 PRE-CONSTRUCTION

No later than 45 days prior to commencement of the work, submit the following to the Contracting Officer for review and approval:

Boring and Jacking Plan

Access Shaft Construction Plan

Statement of Contractor Qualifications

Submit a complete list of all drilling fluids, additives, and mixtures to be used along with Safety Data Sheets.

1.5 QUALITY CONTROL

1.5.1 STATEMENT OF CONTRACTOR QUALIFICATIONS

Contractors are required to have proven and successful experience in boring and jacking. The experience is the successful completion of similar projects to the tolerances indicated for the size of pipe and quantities shown on the plans, in the anticipated soil conditions indicated in the geotechnical report included in the contract documents. Submit a description of at least three such projects which include, at a minimum, a listing of the location(s), date of projects, owner with contact information, pipe type, size installed, length of installation, type, and manufacturer of equipment used, and other information relevant to the successful completion of the project.

1.5.2 RECORDS

1.5.2.1 DAILY WORK LOG

Maintain a work log of construction events and observations. Include the following information for each days work:

- a. Hours worked.

- b. Location of boring machine face or shield by station and progress made in advancing pipe.
- c. Completed field forms, such as steering control logs, for checking line and grade of boring operation, showing achieved alignment relative to design alignment.
- d. Maximum pipe jacking pressures per drive.
- e. Ground water control operations and piezometric levels.
- f. Descriptions of soil conditions encountered.
- g. Any unusual conditions or events, including observed ground movement.
- h. Reasons for operational shutdown in event drive is halted.

1.6 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials on site in enclosures or under protective covering. Store jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes free of dirt and debris.

1.6.1 Handling

Handle pipe in a manner to ensure delivery to the excavation site in sound undamaged condition. Avoid damage to coatings and linings on pipe; make repairs if coatings or linings are damaged. Carry, do not drag pipe to the excavation site. Store jointing materials and

1.7 SAFETY

1.7.1 General

Provide procedures for safe conduct of the work in accordance with [EM 385-1-1](#). When and where installations temporarily disrupt pedestrian use of sidewalk areas for periods exceeding two consecutive work days, provide an alternate route that meets current ABA Accessibility Standard for Department of Defense Facilities.

1.7.2 Equipment

Utilize equipment that employs a common grounding system to prevent electrical shock in the event of underground electrical cable strike. Ensure the grounding system connects all pieces of interconnecting machinery; the drill, mud mixing system, drill power unit, drill rod trailer, operators booth, worker grounding mats, and any other interconnected equipment to a common ground. Utilize equipment having an "electrical strike" audible and visual warning system that notifies the system operators of an electrical strike.

1.7.3 Sheet piling, Shoring and Dewatering

Provide sheet piling, shoring and dewatering as specified in Section [31 23 00.00 20](#), EXCAVATION AND FILL, and as specified herein.

1.7.4 Tunnel Bore

Unprotected mining of the tunnel bore is not permitted. Fully support the tunnel face and bore at all times.

1.8 QUALITY ASSURANCE

1.8.1 Boring and Jacking Plan

Provide a plan prepared, signed and sealed by a licensed Professional Engineer and include the following:

1.8.1.1 Operational Layout

1.8.1.1.1 Layout Plan

Provide a plan location of the operation, discussing relationship of equipment, the method of construction and details for the following:

- a. Access pits configurations and details, including equipment layout.
- b. Location of intermediate jacking stations, if required.
- c. Casing pipe with connection details.

1.8.1.1.2 Pedestrian Access Around Site

When and where installations disrupt pedestrian use of sidewalk areas for periods exceeding two consecutive days, provide an alternate route that meets current ADA requirements.

1.8.1.2 Method and Procedures

Provide an outline of the methods and procedures, including drawings, schedule of operations, specifications, and manufacturer's catalog data for products in lieu of specifications, methods of operation for **boring and jacking** operations, and specifically the following:

- a. Jacking Equipment and Methods: Provide drawings of the jacking frame, jacking head, reaction blocks, jacking installation, pipe guides, procedures for lubricating exterior of pipe during jacking (if applicable), maximum force that jacking equipment can deliver.
- b. Boring Equipment and Methods: Provide a discussion of the methods of operation, design and specifications for boring operation, steerage control, line and grade control methods, proposed procedures for removing or clearing obstructions, and a description of proposed methods for ground stabilization and minimizing overexcavation and loss of ground. Submit **safety data sheets** for fluids, grout, or chemical products.
- c. Casing Annulus and Interior Space Grouting: Identify casing insulators/spacers/centralizers/tiedowns (type, number, spacing and installation instructions,) grout materials and method of placement, description of equipment used and grout pressure employed.
- d. Survey Alignment Control: Identify method and equipment to install pipe within specified tolerances.

- e. Ground Stabilization: Discuss dewatering and grouting, identification of measures and methods used to stabilize face at heading (if necessary), narrative of equipment, procedure and grout mix, and identification of subcontractor who will perform any required stabilization grouting.
- f. Excavation Support System Plan: Provide a plan and discussion of methods to be employed, including design drawings and calculations, sealed and signed by a licensed Professional Engineer.
- g. Monitoring/Survey Plan: Develop and provide a discussion of the monitoring/survey plan to be employed to protect structures and utilities from settlement and/or heave, including the following. Incorporate into the plan any supplemental requirements specified in Part 3, paragraph entitled "Field Quality Control".
 - (1) Structures Assessment: Provide a discussion of structures and utilities to be protected, and measures to be employed for preconstruction and postconstruction assessment of critical structures, namely those located within the zone of active excavation a distance equal to 5 times the depth of the boring from the ground surface from proposed pipe centerline. Include photographs or video of existing damage to structures in the vicinity of sewer alignment in assessment reports.
 - (2) Instrumentation Monitoring Plan: Describe of instrumentation design, layout of instrumentation points, equipment installation details, manufacturer's catalog literature, and monitoring report forms.
 - (3) Surface Settlement Monitoring Plan: Identify on a plan the location of settlement monitoring points, reference benchmarks, survey frequency and procedures, and reporting formats.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The work includes providing labor, materials, and specialized equipment for the installation of utility pipelines utilizing the boring and jacking methods of installation.

2.1.1 Design Requirements

2.1.1.1 Excavations

Design excavations, including access shaft walls, considering loadings from reaction blocks, traffic loads and any surcharge loads.

2.1.1.1.1 Highway Crossing Criteria

For loadings under highways use HS20 vehicle loading distribution in accordance with AASHTO.

2.1.1.1.2 Railway Crossing Criteria

For pipe crossings under railways use Cooper E-80 locomotive loading distributions in accordance with AREMA Eng Man specifications for culverts. Account for loading due to any multiple tracks.

2.1.1.2 Design Calculations of Pipe Casing

Submit **design calculations for pipe casing** demonstrating that the equipment used in installing the pipe will not distort or otherwise damage the pipe. Provide calculations of maximum allowable jacking force to be used based on pipe materials to be used. The calculations are to be sealed by a licensed Professional Engineer using soil properties derived from subsurface investigations performed along the utility route.

2.2 EQUIPMENT

2.2.1 Boring and Jacking System

Utilize a continuously monitored boring and jacking system matched to the expected subsurface conditions, a hydraulic jacking system to jack the pipeline, an auger to remove boring spoils, a guidance system to provide installation accuracy within the indicated tolerances, excavation equipment, material handling equipment, a dewatering system, and sheeting/shoring required to provide the work indicated.

2.2.2 Pipe Jacking Equipment

Provide main jacking equipment with a capacity greater than the anticipated jacking load. Provide intermediate jacking stations when the total anticipated jacking force needed to complete the installation may exceed the capacity of the main jacks or the designed maximum jacking force for the pipe. The jacking system is to supply a uniform distribution of jacking forces on the end of the pipe by use of thruster rings and cushioning material.

2.3 MATERIALS

2.3.1 Pipe Casing

Provide straight wall pipe casing of type and diameter indicated of steel pipe.

2.3.1.1 Steel Pipe

2.3.1.1.1 Pipe

Provide steel pipe in conformance with **ASTM A139/A139M**, Grade B with a minimum yield strength of **35,000 psi**. Weld steel pipe seamless, square cut with even lengths that complies with Articles 4.2, 4.3, and 4.4 of the **API Spec 5L**. Pipe shall have an inside diameter as indicated **in the drawings**.

2.3.1.1.2 Joints

Accomplish the connection of adjacent pieces of microtunneling steel pipe by field butt welding, by a certified welder, in compliance with **AWS D1.1/D1.1M** as long as loading and installation design criteria are met.

Grouting Plugs: On large pipe, (**24-inch** diameter or greater), provide pipe with **2-inch** diameter tapped holes with threaded plugs for exterior grouting.

2.3.1.1.3 Roundness

The maximum difference between the major and minor outside diameters cannot exceed one percent of the specified nominal outside diameter or 0.25 inch, whichever is less.

2.3.1.1.4 Circumference

Ensure that the outside circumference is within plus one percent of the nominal circumference or within plus 0.50 inches, whichever is less.

2.3.1.1.5 Straightness

The maximum allowable straightness deviation in any 10 foot length cannot exceed 1/8 inch. For lengths over 10 feet, the maximum allowable deviation of the entire pipe length is computed by the following formula, but not to exceed 3/8 inch in any length exceeding 30 foot length:
Maximum Allowable Deviation in inches equals (1/8) times (total length in feet) divided by 10.

2.3.1.1.6 Pipe Ends

Ensure that the end of the pipe is perpendicular to the longitudinal axis of the pipe and within 1/16 inch per foot of diameter, with a maximum allowable deviation of 1/4 inch measured with a square and straightedge across the end of the pipe.

2.3.2 Grout

Provide cement grout for pressure grouting to fill the voids around the casing and for filling the interior annular space between carrier pipe and the casing composed of Portland cement conforming to ASTM C150/C150M, Type II, and sand meeting requirements of ASTM C33/C33M for fine aggregate, sufficiently fluid to inject through the casing and fill voids, with prompt setting to control grout flow. Utilize a grout with a minimum compressive strength of 100 psi attained within 24 hours. Admixtures are to be free of chlorides, corrosive or other material detrimental to the materials the grout contacts.

2.3.3 CONCRETE

Provide 3000 psi concrete in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.3.4 Lubricating Fluid (Bentonite or Polymer)

Provide material for lubricating the exterior of pipe. Provide bentonite machine requirements of API Spec 13A and having the capacity of mixing with water to form a stable and homogeneous suspension.

2.3.5 SOIL MATERIALS

Provide soil materials in accordance with the requirements specified in Section 31 23 00.00 20 EXCAVATION AND BACKFILL.

2.4 Incidental Materials

2.4.1 Casing Insulators/Bore Spacers

Provide carbon steel with polyvinyl chloride coating or stainless steel casing insulators/bore spacers 8 inches in length for pipe 12 inches and less in diameter, and 12 inches in length for pipe 14 inches and greater in diameter, having a 2 inch minimum runner width. Orient spacers to allow for grout to flow easily to completely fill the casing pipe with grout throughout its length.

2.4.2 End Closures/Bulkheads

Provide Temporary End Closures to contain grout used for filling the annular space between conduits and the casing. Provide Permanent End Closures as indicated consisting of brick and mortar (one part cement/two parts sand/water) to completely encapsulate the conduits transition into the casing. Center the closure on the casing pipe end.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Access Shaft and Pit Construction Plan

No later than 45 days prior to start of construction submit an [Access Shaft Construction Plan](#). Include in the plan a discussion of the method of construction of access shafts used for [boring and jacking](#). Address the excavation methods, dewatering system, sheeting/shoring and bracing systems proposed for use, and any ground stabilization to be employed for the shaft work area or thrust block. Acceptable construction methods include the use of interlocked steel sheetpiling or precast circular concrete segments lowered in place during excavation.

3.1.1.1 Design Requirements

- a. Construct shafts of a size commensurate with safe working practices at locations indicated. Coordinate shaft locations with the Contracting Officer. The Contractor may propose to relocate shafts to better suit the capabilities of the equipment/methods proposed, but may not alter either the indicated pipeline alignment or structures associated with the installed pipeline, nor result in additional claims for compensation.
- b. To the extent possible, keep shaft locations clear of pavements and within a single traffic lane, in order to minimize disruption to the flow of traffic. Locate support equipment, spoil piles, and materials to minimize disruption to traffic.
- c. Support all excavations and prevent movement of the soil, pavement, utilities or structures outside of the excavation. Furnish, place, and maintain sheeting, bracing, and lining required to support the sides of all shafts and to provide adequate protection of the work, personnel, and the general public. Provide a concrete floor in the jacking access shaft. Design loads on the sides of the jacking and receiving pit walls are dependent on the construction method and flexibility of the wall systems.
- d. Consider the loading from boring or pipe jacking when preparing the

design of the jacking and receiving pit supports as well as special provisions and reinforcement around the breakout location. Design the base of the pits to withstand uplift forces from the full design head of water, unless approved dewatering or other ground modification methods are employed.

- e. Construct a thrust block to transfer jacking loads into the soil. Ensure that the backstop and the proposed pipe alignment are square to each other and are designed to withstand the maximum jacking pressure to be used with a factor of safety of at least 2.5. Also, design the thrust block to minimize excessive deflections in such a manner as to avoid disturbance of adjacent structures or utilities or excessive ground movement. Begin jacking operations only after concrete thrust block or treated soil has attained the required strength.

3.2 CONSTRUCTION

3.2.1 Access Shafts

3.2.1.1 Construction Requirements

- a. Provide ground stabilization in the work area and the thrust block as required to accomplish the work.
- b. Construct a jacking access shaft to accommodate the installation of pipe casings, equipment and piping jacking device. Install thrust blocks(s) as required and consolidate the ground (grout) where the casings exit the shaft. Provide a dry jacking work area having a stable concrete floor that drains to a recessed sump pump to handle nuisance inflow. Groundwater inflows into the jacking shaft are not to exceed 5 gallons/minute; soil inflows are not to exceed a total volume of 2 cubic feet.
- c. Construct a receiver shaft to accommodate the installation of pipe casings and the equipment used in the work. Consolidate the ground (grout) where the casings enter the shaft.
- d. Furnish, install, and maintain equipment to keep the jacking shaft free of excess water. Provide surface protection during the period of construction to ensure that surface runoff does not enter shafts. Adhere to the dewatering plan and do not affect surrounding soils or structures beyond the tolerances stated in paragraph entitled "Tolerances."
- e. Provide security fence around all access shaft areas and provide shaft cover(s) when the shaft area is not in use.
- f. Pit Backfill and Compaction: Upon completion of the pipe jacking and all tests or inspections are complete remove all equipment, debris, and unacceptable materials from the pits and commence backfilling operation. Complete backfilling, compaction, and pavement repairs in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL.

3.3 INSTALLATION

3.3.1 Installation of Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe in accordance with the American Public Works

Association Uniform Color Code. Attach wire to top of pipe in such a manner that will not be displaced during construction operations.

3.3.2 Connections to Existing Lines

Schedule connections to existing lines with the Contracting Officer to cause a minimum interruption of service on the existing line.

3.3.3 Advancing the Pipe

Jack each pipe casing section forward as the excavation progresses in such a way to provide complete and adequate, ground support at all times. Utilize a bentonite slurry applied to the external surface of the pipe to reduce skin friction. Provide a jacking frame for developing a uniform distribution of jacking forces around the periphery of the pipe. Place a plywood spacer on the outer shoulder of the pipe casing joint. Design and construct the thrust reaction backstop to withstand the jacking forces. Continuously maintain a square alignment between the backstop and pipe casing and support the maximum obtainable jacking pressure with a safety factor at least 2.0. Continuously monitor the jacking pressure and rate of cutter head advancement. Exercise special care when setting the pipe guard rails in the jacking pit to ensure correctness of the alignment, grade and stability.

3.3.3.1 Installation Requirements

- a. Utilize boring equipment capable of fully supporting the face of the tunnel.
- b. Maintain face pressure exerted at the heading by the MTBM as required to prevent loss of ground, groundwater inflows, and settlement or heave of the ground surface by balancing soils and groundwater pressures present.
- c. Dewatering for groundwater control is allowed at the jacking and receiving pits only.
- d. Do not jack pipe casing until the concrete thrust block and tremie seal (if selected), and grouted soil zone in jacking and receiving shafts have attained the required strength.
- e. Jack the pipe into place without causing damage to the coatings, joints or completed pipe section.
- f. After completion of the jacking operation between jacking and receiving shafts, displace the lubricate material from between the pipe casing exterior and the surrounding ground with a cement grout. Control pressure and the amount of grout to avoid pipe damage and displacement of the pipe and soil beyond the tolerances specified in paragraph "Tolerances." Grout within 48 hours after pipe installation has been completed to prevent any surface settlement due to movement of soil material into the void space or loosened zone around the pipe casing.
- g. Replace pipe casings damaged during installation.
- h. Ensure that the welds of steel pipe attain the full strength of the pipe and are watertight before jacking of the pipe section. Ensure that the inner face of the internal weld seam is flush with the pipe

to facilitate the installation of the carrier pipe in the pipe casing.

- i. Perform all welding in accordance with requirements for shielded metal arc welding of AWS D1.5M/D1.5 for bridges and AWS D1.1/D1.1M for buildings and other structures.
- j. Provide a pipeline that has a consistent diameter across assembled joints.
- k. Once the tunneling process has begun, continue with that process uninterrupted until the pipe reaches the receiving shaft. Continue to push any damaged pipe until that damaged pipe section is pushed into the receiving shaft and is removed. Notify the Contracting Officer immediately if any pipe is known to be or believed to be damaged.

3.3.4 Carrier Pipe Installation

3.3.4.1 Cleaning

Clean the inside of the casing of all foreign matter by using a pipe cleaning plug.

3.3.4.2 Carrier Pipe

Inspect with the Contracting Officer, prior to backfilling trenches, the transition of carrier pipe within the casing to non-cased trenching.

3.3.4.3 Casing Insulators/Spacers

Install casing insulators/spacers in accordance with approved submittals and the drawings. On center spacing is not to exceed 4 feet.

3.3.4.4 End Closures/Bulkheads and Grouting of Casing Pipe

- a. Closures: Seal ends of casing with brick and mortar.
- b. After installing, inspecting and acceptance of the carrier pipe and spacers within the casing pipe, pressure fill the annular space between the carrier pipe and the casing pipe, with cement grout specified herein. Regulate pump pressures to refusal or in accordance with the approved grouting plan. Place grout in a sequence and manner that will preclude voids or pockets of entrapped air or water. Use a refusal pressure equal to 0.5 psf per foot of overburden.

3.3.5 INTENTIONALLY LEFT BLANK

3.3.6 Lighting

Provide adequate lighting for the nature of the activity being conducted by workers. Separate and insulate with ground fault interrupters power and lighting circuits. Comply with requirements with regards to shatter resistance and illumination requirements.

3.3.7 Spoil Transportation

Match the excavation rate with rate of spoil removal. Utilize a system capable of balancing groundwater pressures and adjustment to maintain face stability for the particular soil conditions of the project.

3.4 TOLERANCES

3.4.1 Tolerances

Maximum allowable lateral deviation is 5 inches; maximum allowable vertical deviation is 1 inches in the position of every completed 300 foot section of jacked pipe casings.

3.5 FIELD QUALITY CONTROL

Employ the monitoring/survey plan. Maintain daily records in accordance with the paragraph titled RECORDS.

3.5.1 Instrumentation/Survey

3.5.1.1 Mandatory Requirements

Include the following, as a minimum, to supplement Contractor Quality Control measures employed to monitor ground surface heave or settlement in the monitoring/survey plan.

- a. Monitor ground movements associated with the project using established survey points and make changes in the construction methods that control ground movements and prevent damage or detrimental movement to the work and adjacent structures and pavements.
- b. Record in the daily work log a summary of monitoring survey results. Clearly identify work not meeting specified requirements, out-of-tolerance results, and impacts on new or existing work from settlement or heave.
- c. Install instrumentation and perform monitoring to determine ground settlement surrounding each jacking and receiving pit.
- d. Prior to any excavation activities, perform a pre-construction survey of the areas in and surrounding excavations and along the proposed utility alignment to identify any structures, facilities, underground or above ground utilities to be protected within a radius of five times either the depth of any excavation or the depth of trenchless excavation.

3.5.1.2 Supplemental Requirements

3.5.2 Field Tests

Perform field tests, and provide labor, equipment, and incidentals required for testing Section. Submit test results, identifying any results that do not meet specified requirements, to the Contracting Officer within four days of test completion. Provide corrective action and retest pipe not meeting specified requirements. Provide corrective action as recommended by the pipe manufacturer and subject to approval by the Contracting Officer.

3.5.2.1 Pipe Casing

Inspect and verify that pipe material meets the dimensional tolerances specified prior to use. Record each days inspection results in the daily work log.

3.5.2.1.1 Testing Requirements for Gravity Mains

Perform low pressure air test of all gravity mains (structure to structure) in accordance with [ASTM C1091](#) Standard Test method for Hydrostatic Infiltration testing of Vitrified Clay Pipe Lines.

3.5.2.1.2 Non-Standard Pipe Lengths

Cut non-standard joint lengths from full length pipe having satisfactorily passed the hydrostatic test.

3.5.2.1.3 Elevations

Prior to removal of MTBM equipment, sheeting, and backfilling of access shafts, collect invert information on pipeline installed. Confirm that the elevations meet stated tolerances.

3.6 CLEANUP AND FINAL CLOSEOUT

3.6.1 Site Cleanup

Immediately clean "blow holes" or "breakouts" of drilling fluid to the surface and fill depressions with satisfactory fill material. Dispose of all drilling fluids, soils, and separated materials in compliance with Federal, State, and local environmental regulations.

3.6.2 Drilling Fluid

Immediately upon completion of work of this section, remove all rubbish and debris from the job site. Remove all construction equipment and materials leaving the entire area involved in a neat condition equal to existing conditions prior to construction, unless indicated otherwise.

3.6.3 Record Drawings and Daily Work Logs

Submit an electronic copy and three hard copies of the [record drawings](#) to the Contracting Officer within five days after completing the work. Include in the record drawings a plan, profile, and all information recorded during the progress of the work. Clearly tie the record drawings to the project's survey control. Maintain and submit upon completion final [Daily Work Logs of installation operations](#), signed by the superintendent.

3.7 DISPOSITION OF MATERIAL

. Remove from Government property surplus or other soil material not required or suitable for fill or backfilling.

Store or legally dispose of excavated material and fluids used in the boring process and shaft construction away from the construction site and in compliance with all permits and applicable Federal, State, and local regulations. Comply with Section [01 57 19](#) TEMPORARY ENVIRONMENTAL CONTROLS.

-- End of Section --

SECTION 33 11 00

WATER UTILITY DISTRIBUTION PIPING
02/18

PART 1 GENERAL

1.1 REFERENCES

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

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B1.20.3	(1976; R 2013) Dryseal Pipe Threads (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.18	(2018) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B18.2.2	(2015) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B18.5.2.1M	(2006; R 2011) Metric Round Head Short Square Neck Bolts
ASME B18.5.2.2M	(1982; R 2010) Metric Round Head Square Neck Bolts

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA B300	(2018) Hypochlorites
AWWA B301	(2010) Liquid Chlorine
AWWA C104/A21.4	(2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2011) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(2017) Ductile-Iron Pipe, Centrifugally Cast

AWWA C153/A21.53	(2019) Ductile-Iron Compact Fittings for Water Service
AWWA C213	(2015) Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
AWWA C500	(2009) Metal-Seated Gate Valves for Water Supply Service
AWWA C502	(2018) Dry-Barrel Fire Hydrants
AWWA C504	(2015) Standard for Rubber-Seated Butterfly Valves
AWWA C509	(2015) Resilient-Seated Gate Valves for Water Supply Service
AWWA C511	(2017) Reduced-Pressure Principle Backflow Prevention Assembly
AWWA C515	(2015) Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
AWWA C550	(2017) Protective Interior Coatings for Valves and Hydrants
AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C655	(2009) Field Dechlorination
AWWA C700	(2015) Cold-Water Meters - Displacement Type, Metal Alloy Main Case
AWWA C701	(2015) Cold-Water Meters - Turbine Type for Customer Service
AWWA C706	(2010) Direct-Reading, Remote-Registration Systems for Cold-Water Meters
AWWA C707	(2010; R 2016) Encoder-Type Remote-Registration Systems for Cold-Water Meters
AWWA C800	(2014) Underground Service Line Valves and Fittings
AWWA M6	(2012) Water Meters - Selection, Installation, Testing, and Maintenance
AWWA M41	(2009; 3rd Ed) Ductile-Iron Pipe and Fittings
AWWA M55	(2006) PE Pipe - Design and Installation

ASTM INTERNATIONAL (ASTM)

ASTM A47/A47M	(1999; R 2018; E 2018) Standard Specification for Ferritic Malleable Iron Castings
ASTM A48/A48M	(2003; R 2016) Standard Specification for Gray Iron Castings
ASTM A307	(2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B61	(2015) Standard Specification for Steam or Valve Bronze Castings
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM C94/C94M	(2020) Standard Specification for Ready-Mixed Concrete
ASTM C1433	(2016b) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM F1674	(2011) Standard Test Method for Joint Restraint Products for Use with PVC Pipe

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR List	(continuously updated) List of Approved Backflow Prevention Assemblies
FCCCHR Manual	(10th Edition) Manual of Cross-Connection Control

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 24 (2019; TIA 19-1) Standard for the Installation of Private Fire Service Mains and Their Appurtenances

NSF INTERNATIONAL (NSF)

NSF 372 (2016) Drinking Water System Components - Lead Content

NSF/ANSI 14 (2019) Plastics Piping System Components and Related Materials

NSF/ANSI 61 (2020) Drinking Water System Components - Health Effects

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-600-01 (2016; with Change 6, 2021) Fire Protection Engineering for Facilities

UNDERWRITERS LABORATORIES (UL)

UL 246 (2011; Reprint Dec 2018) UL Standard for Safety Hydrants for Fire-Protection Service

UL 262 (2004; Reprint Oct 2011) Gate Valves for Fire-Protection Service

1.2 DEFINITIONS

1.2.1 Water Mains

Water mains include water piping having diameters 4 through 14 inch, specific materials, methods of joining and any appurtenances deemed necessary for a satisfactory system.

1.2.2 Water Service Lines

Water service lines include water piping from a water main to a building service at a point approximately 5 feet from building or the point indicated on the drawings, specific materials, methods of joining and any appurtenances deemed necessary for a satisfactory system.

1.2.3 Additional Definitions

For additional definitions refer to the definitions in the applicable referenced standard.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

System Connection and Outage Plan

SD-03 Product Data

Pipe, Fittings, Joints and Couplings

Valves

Valve Boxes

Fire Hydrants

Pipe Restraint

Tapping Sleeves

Corporation Stops

Disinfection Procedures

SD-06 Test Reports

Backflow Preventer Tests; G

Bacteriological Samples; G

Hydrostatic Sewer Test; G

Leakage Test; G

Hydrostatic Test; G

Leakage Test; G

Hydrostatic Test; G

Hydrostatic Sewer Test; G

SD-07 Certificates

Pipe, Fittings, Joints and Couplings

Lining

Valves

Fire Hydrants

Turbine Type Meters

Backflow CertificateSD-08 Manufacturer's Instructions

Ductile Iron Piping

Copper Pipe For Service Lines

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

Comply with NSF/ANSI 14 or NSF/ANSI 61 and NSF 372 for materials for potable water systems; comply with lead content requirements for "lead-free" plumbing as defined by the U.S. Safe Drinking Water Act effective January 2014. Provide materials bearing the seal of the National Sanitation Foundation (NSF) for potable water service.

Comply with NFPA 24 for materials, installation, and testing of fire main piping and components.

1.4.2 Qualifications

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

Inspect materials delivered to site for damage. Unload and store with minimum handling and in accordance with manufacturer's instructions. Store materials on site in enclosures or under protective covering. Store plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, valves, fire hydrants, and other accessories free of dirt and debris.

1.5.2 Handling

Handle pipe, fittings, valves, fire hydrants, and other accessories in accordance with manufacturer's instructions and in a manner to ensure delivery to the trench in sound undamaged condition. Avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged. Do not place other material, hooks, or pipe inside a pipe or fitting after the coating has been applied. Inspect the pipe for defects before installation. Carry, do not drag pipe to the trench. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe. Clean the interior of pipe and accessories of foreign matter before being lowered into the trench and keep them clean during laying operations by plugging. Replace defective material without additional expense to the Government. Store rubber gaskets, not immediately installed, under cover or out of direct sunlight.

Handle ductile iron pipe, fittings, and accessories in accordance with AWWA C600 and AWWA M41. Handle PE pipe, fittings, and accessories in accordance with AWWA M55.

PART 2 PRODUCTS

2.1 MATERIALS

Provide all materials in accordance with AWWA C800 and as indicated herein. Provide valves and fittings with pressure ratings equivalent to the pressure ratings of the pipe.

2.1.1 Pipe, Fittings, Joints And Couplings

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on joints. Include information concerning

gaskets with submittal for joints and couplings.

2.1.1.1.1 Ductile-Iron Piping

2.1.1.1.1.1 Pipe and Fittings

Pipe, except flanged pipe, AWWA C151/A21.51. Flanged pipe, AWWA C115/A21.15. Fittings, AWWA C110/A21.10 or AWWA C153/A21.53; fittings with push-on joint ends are to meet the same requirements as fittings with mechanical-joint ends, except for the factory modified bell design. Provide fittings with pressure ratings equivalent to that of the pipe. Provide compatible pipe ends and fittings for the specified joints. Provide cement-mortar lining, AWWA C104/A21.4, standard thickness on pipe and fittings.

2.1.1.1.1.2 Joints and Jointing Material

Provide push-on joints or mechanical joints for pipe and fittings unless otherwise indicated.

- a. Push-On Joints: Shape of pipe ends and fitting ends, gaskets, and lubricant for joint assembly as recommended in AWWA C111/A21.11.
- b. Mechanical Joints: Dimensional and material requirements for pipe ends, glands, bolts and nuts, and gaskets as recommended in AWWA C111/A21.11.
- c. Flanged Joints: Bolts, nuts, and gaskets for flanged connections as recommended in Appendix A of AWWA C115/A21.15. Provide AWWA C115/A21.15 ductile iron flanges and conform to ASME B16.1, Class 125. Provide ASTM A536 epoxy coated steel set screw flanges. Gasket and lubricants for set screw flanges, in accordance with mechanical-joint gaskets specified in AWWA C111/A21.11.
- d. Insulating Joints: Designed to prevent metal-to-metal contact at the joint between adjacent sections of piping. Provide flanged type joint with insulating gasket, insulating bolt sleeves, and insulating washers. Provide full face dielectric type gaskets, as recommended in the Appendix to AWWA C115/A21.15. Bolts and nuts, as recommended in the Appendix to AWWA C115/A21.15.
- e. Sleeve-Type Mechanical Coupled Joints: As specified in the paragraph SLEEVE-TYPE MECHANICAL COUPLINGS.

2.1.1.1.2 Copper Pipe For Service Lines

2.1.1.1.2.1 Copper Tubing and Associated Fittings

Provide ASTM B88, Type K copper tubing. Provide AWWA C800 fittings. AWWA C800 includes ASME B1.20.3, ASME B1.20.1, ASME B16.18 solder-type joint fittings.

2.1.1.2 Valves

Provide a protective interior coating in accordance with AWWA C550.

2.1.1.2.1 Gate Valves 3 Inch Size and Larger

AWWA C500, AWWA C509, AWWA C515, or UL 262 and:

- a. **AWWA C500**: nonrising stem type with double-disc gate and mechanical-joint ends or push-on joint ends compatible for the adjoining pipe.
- b. **AWWA C509** or **AWWA C515**: nonrising stem type with mechanical-joint ends or resilient-seated gate valves **3 to 12 inches** in size.
- c. **UL 262**: inside-screw type with operating nut, double-disc or split-wedge type gate, designed for a hydraulic working pressure of **175 psi**, and have mechanical-joint ends or push-on joint ends as appropriate for the pipe to which it is joined.

Match materials for **UL 262** gate valves to the reference standards specified in **AWWA C500**. Gate valves open by counterclockwise rotation of the valve stem. Stuffing boxes have O-ring stem seals. Stuffing boxes are bolted and constructed so as to permit easy removal of parts for repair. Provide valve ends and gaskets for connection to sleeve-type mechanical couplings that conform to the requirements specified for the joint or coupling. **Provide gate valves with threaded ends.** Provide all valves from one manufacturer.

2.1.2.2 Rubber-Seated Butterfly Valves

Provide rubber-seated butterfly valves and wafer type valves that match the performance requirements of **AWWA C504**. Wafer type valves not meeting laying length requirements are acceptable if supplied and installed with a spacer, providing the specified laying length. Meet all tests required by **AWWA C504**. Flanged-end valves are required in a pit. Provide a union or sleeve-type coupling in the pit to permit removal. Direct-bury mechanical-end valves **3 through 10 inches** in diameter. Provide a valve box, means for manual operation, and an adjacent pipe joint to facilitate valve removal. Provide valve operators that restrict closing to a rate requiring approximately 60 seconds, from fully open to fully closed.

2.1.2.3 Water Service Valves

2.1.2.3.1 Gate Valves Smaller than 3 Inch in Size on Buried Piping

Gate valves smaller than **3 inch** size on Buried Piping **MSS SP-80**, Class 150, solid wedge, nonrising stem, with flanged or threaded end connections, a union on one side of the valve, and a handwheel operator.

2.1.2.3.2 Gate Valves Smaller Than 3 Inch Size in Valve Pits

MSS SP-80, Class 150, solid wedge, inside screw, rising stem. Provide valves with flanged or threaded end connections, a union on one side of the valve, and a handwheel operator.

2.1.2.3.3 Check Valves Smaller than 2 Inch in Size

Provide check valves with a minimum working pressure of **150 psi** or as indicated with a clear waterway equal to the full nominal diameter of the valve. Valves open to permit flow when inlet pressure is greater than the discharge pressure, and close tightly to prevent return flow when discharge pressure exceeds inlet pressure. Cast the size of the valve, working pressure, manufacturer's name, initials, or trademark on the body of each valve.

Provide valves for screwed fittings, made of lead-free bronze and in conformance with MSS SP-80, Class 150, Types 3 and 4 compatible for the application.

2.1.1.2.4 Valve Boxes

Provide a valve box for each gate valve on buried piping, except where indicator post is shown. Construct adjustable valve boxes manufactured from cast iron of a size compatible for the valve on which it is used. Provide cast iron valve boxes with a minimum cover and wall thickness of 3/16 inch and conforming to ASTM A48/A48M, Class 35B. Coat the cast-iron box with a heavy coat of bituminous paint. Provide a round head. Cast the word "WATER" on the lid. The minimum diameter of the shaft of the box is 5 1/4 inches. Provide precast concrete valve box.

2.1.1.2.5 Valve Pits

Construct the valve pits at locations indicated or as required above and in accordance with the details shown.

2.1.1.3 Fire Hydrants

2.1.1.3.1 Fire Hydrants

Provide fire hydrants where indicated. Paint fire hydrants with at least one coat of primer and two coats of enamel paint. Paint barrel and bonnet colors in accordance with UFC 3-600-01. Stencil fire hydrant number and main size on the fire hydrant barrel using black stencil paint.

2.1.1.3.1.1 Dry-Barrel Type Fire Hydrants

Provide Dry-barrel type fire hydrants, AWWA C502 or UL 246, "Base Valve" with 6 inch inlet, 5 1/4 inch valve opening, one 4 1/2 inch pumper connection, and two 2 1/2 inch hose connections. Provide mechanical-joint or push-on joint end inlet; with end matching requirements as specified in AWWA C502 or UL 246 for size and shape of operating nut, cap nuts, and threads on hose and pumper connections. Provide fire hydrants with frangible sections as mentioned in AWWA C502. Provide fire hydrant with special couplings joining upper and lower sections of fire hydrant barrel that break from a force imposed by a moving vehicle.

2.1.1.4 Meters

Submit certificates certifying all required and recommended tests set forth in the referenced standard and AWWA M6 have been performed and comply with all applicable requirements of the referenced standard and AWWA M6 within the past three years. Include certification that each meter has been tested for accuracy of registration and that each meter complies with the accuracy and capacity requirements of the referenced standard when tested in accordance with AWWA M6.

Include a register with all meters whether they are or are not connected to a remote reading system.

2.1.1.4.1 Turbine Type Meters

Provide AWWA C701 Class I Advanced Metering Infrastructure (AMI) and Direct Digital Communication (DDC) compatible meter with a strainer screen. Main casing constructed of copper alloy containing not less than

75 percent copper, or cast iron with protective coating in accordance with AWWA C213 or AWWA C550.

2.1.4.2 Register

Provide AWWA C700 permanently sealed straight-reading register for use in a submerged environment supplied by the meter manufacturer. Equip register with U.S. gallons readings. Use a direct reading remote register designed in accordance with AWWA C706 with an encoder type remote register designed in accordance with AWWA C707.

2.1.4.3 Strainers

Provide AWWA C701 strainer recommended and supplied by the meter manufacturer. Provide strainer of the same material as the meter body (i.e., bronze, ductile, or stainless).

2.1.4.4 Meter Connections

Provide connections compatible with the type of pipe and conditions encountered.

2.1.4.5 Advanced Metering Infrastructure

Contractor is to ensure that the meter(s) transmit the specified data to the DAS.

2.1.4.6 Direct Digital Control System Interface

Provide all meters with the capability of providing pulse output to the DDC system provided in Section 23 09 23.13 22 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

2.1.4.7 Meter Setter

Provide AWWA C800 meter setter with inlet and outlet valves.

2.1.4.8 Meter Boxes

Provide meter boxes of sufficient size to completely enclose the meter and shutoff valve or service stop and in accordance with the details shown on the drawings. Provide a meter boxes or vaults with a height equal to the distance from invert of the service line to finished grade at the meter location.

2.1.4.8.1 Cast Iron

Provide ASTM A48/A48M, Class 25 cast iron meter box and lid. Provide a round lid with precast holes for remote electronic meter reading modules having the word "WATER" cast on the top surface.

2.1.4.8.2 Precast Concrete Meter Boxes

Provide ASTM C1433 precast concrete meter boxes with ASTM A48/A48M, Class 25 cast iron lid. Provide a ASTM A48/A48M, Class 25 cast iron with precast holes for remote electronic meter reading modules round lid having the word "WATER" cast on it. Provide meter boxes of sufficient size to completely enclose the meter and shutoff valve or service stop and in

accordance with the details shown on the drawings.

2.1.4.8.2.1 Fittings

Provide flanged fittings for pipe 3 inches and larger.

2.1.4.8.2.2 Vault Valves

Provide ball or outside screw and yoke (OS&Y) valves in meter vault.

2.1.4.8.3 Plastic Meter Boxes

Provide manufactured plastic boxes and lids meeting the following requirements:

- a. One-piece molded construction
- b. Vertical load rating for medium duty use of 15,000 lbs
- c. Ultraviolet (UV) exterior surface protection
- d. White interior surface

Provide a ASTM A48/A48M, Class 25 cast iron ring and round lid.

2.1.5 Backflow Preventers

Provide a bronze cast iron, or ductile iron body AWWA C511 reduced pressure principle type backflow preventer as specified on drawings. Include shutoff and bypass valves as required for device certification and testing. Provide strainer upstream of device to protect valves from damage.

The particular make, model, and size of backflow preventers to be installed must be included in the latest edition of the List of Approved Backflow Prevention Assemblies issued by the FCCCHR List and be accompanied by a backflow certificate of full approval from FCCCHR List. Select materials for piping, strainers, and valves used in assembly installation that are galvanically compatible. Materials joined, connected, or otherwise in contact are to have no greater than 0.25 V difference on the Anodic Index, unless separated by a dielectric type union or fitting.

2.1.5.1 Backflow Preventer Enclosure

Provide an insulated, heated enclosure for freeze protection of all outdoor backflow preventor installations.

2.1.6 Disinfection

Chlorinating materials are to conform to: Chlorine, Liquid: AWWA B301; Hypochlorite, Calcium and Sodium: AWWA B300.

2.2 ACCESSORIES

2.2.1 Pipe Restraint

2.2.1.1 Thrust Blocks

Use ASTM C94/C94M concrete having a minimum compressive strength of 2,500

psi at 28 days.

2.2.1.2 Joint Restraint

Provide restrained joints in accordance with NFPA 24, Chapter 10 and in accordance with ASTM F1674.

Provide mechanical joint restraint or metal harness fabricated by the pipe manufacturer.

2.2.2 Protective Enclosures

Provide Freeze-Protection Enclosures that are insulated and designed to protect aboveground water piping, equipment, or specialties from freezing and damage, with heat source to maintain minimum internal temperature of 40 degrees F when external temperatures reach as low as -5 degrees F.

2.2.2.1 Housing

Reinforced and insulated aluminum or fiberglass construction; with anchoring devices for attaching housing to concrete base, access doors with locking devices, sized to allow access and service of the protected unit, drain openings, and an electric heating cable or heater with self-limiting temperature control.

2.2.3 Tapping Sleeves

Provide cast gray, ductile, malleable iron or stainless steel, split-sleeve type tapping sleeves of the sizes indicated for connection to existing main with flanged or grooved outlet, and with bolts, follower rings and gaskets on each end of the sleeve. Utilize similar metals for bolts, nuts, and washers to minimize the possibility of galvanic corrosion. Provide dielectric gaskets where dissimilar metals adjoin. Provide a tapping sleeve assembly with a maximum working pressure of 150 psi. Provide bolts with square heads and hexagonal nuts. Longitudinal gaskets and mechanical joints with gaskets as recommended by the manufacturer of the sleeve. When using grooved mechanical tee, utilize an upper housing with full locating collar for rigid positioning which engages a machine-cut hole in pipe, encasing an elastomeric gasket which conforms to the pipe outside diameter around the hole and a lower housing with positioning lugs, secured together during assembly by nuts and bolts as specified, pre-torqued to 50 foot-pounds.

2.2.4 Sleeve-Type Mechanical Couplings

Use couplings to join plain-end piping by compression of a ring gasket at each end of the adjoining pipe sections. The coupling consists of one middle ring flared or beveled at each end to provide a gasket seat; two follower rings; two resilient tapered rubber gaskets; and bolts and nuts to draw the follower rings toward each other to compress the gaskets. Provide true circular middle ring and the follower rings sections free from irregularities, flat spots, and surface defects; provide for confinement and compression of the gaskets. For ductile iron pipe, the middle ring is cast-iron. Malleable and ductile iron are to meet the requirements of ASTM A47/A47M and ASTM A536, respectively. Use gaskets for resistance to set after installation and to meet the requirements specified for gaskets for mechanical joint in AWWA C111/A21.11. Provide track-head type bolts ASTM A307, Grade A, with nuts, ASTM A563, Grade A; or round-head square-neck type bolts, ASME B18.5.2.1M and ASME B18.5.2.2M

with hex nuts, ASME B18.2.2. Provide 5/8 inch diameter bolts; minimum number of bolts for each coupling is per manufacturer's recommendations. Shape bolt holes in follower rings to hold fast to the necks of the bolts used. Do not use mechanically coupled joints using a sleeve-type mechanical coupling as an optional method of jointing except where pipeline is adequately anchored to resist tension pull across the joint. Provide a tight flexible joint with mechanical couplings under reasonable conditions, such as pipe movements caused by expansion, contraction, slight settling or shifting in the ground, minor variations in trench gradients, and traffic vibrations. Match coupling strength to that of the adjoining pipeline.

2.2.5 Insulating Joints

Provide a rubber-gasketed insulating joint or dielectric coupling between pipe of dissimilar metals which will effectively prevent metal-to-metal contact between adjacent sections of piping.

2.2.6 Dielectric Fittings

Install dielectric fittings between threaded ferrous and nonferrous metallic pipe, fittings and valves, except where corporation stops join mains to prevent metal-to-metal contact of dissimilar metallic piping elements and compatible with the indicated working pressure.

2.2.7 Water Service Line Appurtenances

2.2.7.1 Corporation Stops

Ground key type; lead-free bronze, ASTM B61 or ASTM B62; compatible with the working pressure of the system and solder-joint, or flared tube compression type joint. Threaded ends for inlet and outlet of corporation stops, AWWA C800; coupling nut for connection to flared copper tubing, ASME B16.26.

2.2.7.2 Curb or Service Stops

Ground key, round way, inverted key type; made of lead-free bronze, ASTM B61 or ASTM B62; and compatible with the working pressure of the system. Provide compatible ends for connection to the service piping. Cast an arrow into body of the curb or service stop indicating direction of flow.

2.2.7.3 Goosenecks

Manufacture goosenecks from Type K copper tubing; provide joint ends for goosenecks compatible with connecting to corporation stop and service line.

2.2.7.4 Curb Boxes

Provide a curb box for each curb or service stop manufactured from cast iron, size capable of containing the stop where it is used. Provide a round head. Cast the word "WATER" on the lid. Factory coat the box with a heavy coat of bituminous paint.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Connections to Existing System

Perform all **connections** to the existing water system in the presence of the Contracting Officer. **Provide System Connection and Outage Plan.**

3.1.2 Operation of Existing Valves

Do not operate valves within or directly connected to the existing water system unless expressly directed to do so by the Contracting Officer.

3.1.3 Earthwork

Perform earthwork operations in accordance with Section **31 23 00.00 20 EXCAVATION AND FILL.**

3.2 INSTALLATION

Install all materials in accordance with the applicable reference standard, manufacturers instructions and as indicated herein.

3.2.1 Piping

3.2.1.1 General Requirements

Install pipe, fittings, joints and couplings in accordance with the applicable referenced standard, the manufacturer's instructions and as specified herein.

3.2.1.1.1 Termination of Water Lines

Terminate the work covered by this section at a point approximately **5 feet** from the building, unless otherwise indicated.

Do not lay water lines in the same trench with gas lines, fuel lines, electric wiring, or any other utility. **Do not install copper tubing in the same trench with ferrous piping materials.** Where nonferrous metallic pipe (i.e., copper tubing) crosses any ferrous piping, provide a minimum vertical separation of **12 inches** between pipes.

3.2.1.1.2 Pipe Laying and Jointing

Remove fins and burrs from pipe and fittings. Before placing in position, clean pipe, fittings, valves, and accessories, and maintain in a clean condition. Provide proper facilities for lowering sections of pipe into trenches. Under no circumstances is it permissible to drop or dump pipe, fittings, valves, or other water line material into trenches. Cut pipe cleanly, squarely, and accurately to the length established at the site and work into place without springing or forcing. Replace a pipe or fitting that does not allow sufficient space for installation of jointing material. Blocking or wedging between bells and spigots is not permitted. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying. Grade the pipeline in straight lines; avoid the formation of dips and low points. Support pipe at the design elevation and grade. Secure firm, uniform support. Wood support blocking is not permitted. Lay pipe so that the full length of each section of pipe and

each fitting rests solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings. Provide anchors and supports for fastening work into place. Make provision for expansion and contraction of pipelines. Keep trenches free of water until joints have been assembled. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Do not lay pipe when conditions of trench or weather prevent installation. Provide a minimum of 36 to 42 inches depth of cover over top of pipe.

3.2.1.1.3 Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such manner that it will not be displaced during construction operations.

3.2.1.1.4 Connections to Existing Water Lines

Make connections to existing water lines after coordination with the facility and with a minimum interruption of service on the existing line. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped and as indicated. Tap existing waterlines only as authorized by Contracting Officer, all active waterlines shall be secured from service prior to tapping, cut-in-sleeves shall be used unless wet taps are specifically authorized.

3.2.1.1.5 Sewer Manholes

No water piping is to pass through or come in contact with any part of a sewer manhole and shall be laid with a horizontal clearance of 10 feet (edge to edge distance) unless alternative piping materials or encasement is utilized as described in UNUSUAL CONDITIONS paragraph below.

3.2.1.1.6 Water Piping Parallel With Sewer Piping

- a. Normal Conditions: Lay water piping at least 10 feet horizontally from sewer or sewer manhole whenever possible (edge to edge distance). Measure the distance from outside edge to outside edge of pipe or outside edge of manhole. When local conditions prevent horizontal separation install water piping in a separate trench with the bottom of the water piping at least 18 inches above the top of the sewer piping.
- b. Unusual Conditions: When local conditions prevent required horizontal or vertical separation, construct sewer piping of AWWA compliant ductile iron water piping and perform hydrostatic sewer test, without leakage, prior to backfilling. When local conditions prevent vertical separation, test the sewer manhole in place to ensure watertight construction.

3.2.1.1.7 Water Piping Crossing Sewer Piping

- a. Normal Conditions: Provide a separation of at least 18 inches between the bottom of the water piping and the top of the sewer piping in cases where water piping crosses above sewer piping.
- b. Unusual Conditions: When local conditions prevent a vertical separation described above, construct sewer piping passing over or under water piping of AWWA compliant ductile iron water piping and

perform hydrostatic sewer test, without leakage, prior to backfilling. Construct sewer crossing with a minimum 20 feet length of the AWWA compliant ductile iron water piping, centered at the point of the crossing so that joints are equidistant and as far as possible from the water piping. Protect water piping passing under sewer piping by providing a vertical separation of at least 18 inches between the bottom of the sewer piping and the top of the water piping; adequate structural support for the sewer piping to prevent excessive deflection of the joints and the settling on or damage to the water piping.

3.2.1.1.8 Penetrations

Provide ductile-iron or Schedule 40 steel wall sleeves for pipe passing through walls of valve pits and structures. Fill annular space between walls and sleeves with rich cement mortar. Fill annular space between pipe and sleeves with mastic.

3.2.1.1.9 Flanged Pipe

Only install flanged pipe aboveground or with the flanges in valve pits.

3.2.1.2 Ductile-Iron Piping

Unless otherwise specified, install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the requirements of AWWA C600 for pipe installation, joint assembly, valve-and-fitting installation, and thrust restraint.

- a. Jointing: Make push-on joints with the gaskets and lubricant specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 and AWWA M41 for joint assembly. Make mechanical joints with the gaskets, glands, bolts, and nuts specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 and AWWA M41 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11.
- b. Allowable Deflection: Follow AWWA C600 and AWWA M41 for the maximum allowable deflection. If the alignment requires deflection in excess of the above limitations, provide special bends or a sufficient number of shorter lengths of pipe to achieve angular deflections within the limit set forth.

3.2.1.3 Metallic Piping for Service Lines

Install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the applicable requirements of AWWA C600 for pipe installation, unless otherwise specified.

3.2.1.3.1 Screwed Joints

Make screwed joints up tight with a stiff mixture of graphite and oil, inert filler and oil, or graphite compound; apply to male threads only or with PTFE Tape, for use with threaded pipe. Threads are to be full cut; do not leave more than three threads on the pipe exposed after assembling the joint.

3.2.1.3.2 Joints for Copper Tubing

Cut copper tubing with square ends; remove fins and burrs. Replace dented, gouged, or otherwise damaged tubing with undamaged tubing. Make solder joints using [ASTM B32](#), 95-5 tin-antimony or Grade Sn96 solder. Use solder and flux containing less than 0.2 percent lead. Before making joint, clean ends of tubing and inside of fitting or coupling with wire brush or abrasive. Apply a rosin flux to the tubing end and on recess inside of fitting or coupling. Insert tubing end into fitting or coupling for the full depth of the recess and solder. For compression joints on flared tubing, insert tubing through the coupling nut and flare tubing.

3.2.1.3.3 Flanged Joints

Make flanged joints up tight, avoid undue strain on flanges, valves, fittings, and accessories.

3.2.1.4 Fire Protection Service Lines for Sprinkler Supplies

Connect water service lines used to supply building sprinkler systems for fire protection to the water main in accordance with [NFPA 24](#).

3.2.1.5 Water Service Piping

3.2.1.5.1 Location

Connect water service piping to the building service where the building service has been installed. Where building service has not been installed, terminate water service lines approximately [5 feet](#) from the building line at the points indicated; close such water service lines with plugs or caps.

3.2.1.5.2 Water Service Line Connections to Water Mains

Connect water service lines to ductile-iron water mains in accordance with [AWWA C600](#) for service taps.

3.2.2 Meters

Install meters and meter boxes at the locations shown on the drawings. Center meters in the boxes to allow for reading and ease of removal or maintenance. Set top of box or vault at finished grade.

3.2.3 Backflow Preventers

Install backflow preventers of type, size, and capacity indicated a minimum of [12 inch](#) and a maximum of [36 inch](#) above concrete base. Include valves and test cocks. Install, [test and certify](#) according to the manufacturers requirements and the requirements of plumbing and health department and authorities having jurisdiction [using currently certified backflow prevention technician](#). Support NPS [2 1/2 inch](#) and larger backflow preventers, valves, and piping near floor with [12 inch](#) minimum air gap, and on concrete piers or steel pipe supports. Do not install backflow preventers that have a relief drain in vault or in other spaces subject to flooding. Do not install by-pass piping around backflow preventers.

3.2.3.1 Backflow Preventer Enclosure

Install a level concrete base with top of concrete surface approximately 6 inches above grade. Install protective enclosure over valve and equipment. Anchor protective enclosure to concrete base.

3.2.4 Disinfection

Prior to disinfection, provide disinfection procedures, proposed neutralization and disposal methods of waste water from disinfection as part of the disinfection submittal. Disinfect new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651. Disinfect new water piping using the AWWA C651 continuous-feed method of chlorination. Ensure a free chlorine residual of not less than 10 parts per million after 24 hour holding period and prior to performing bacteriological tests.

3.2.5 Flushing

Perform bacteriological tests prior to flushing. Flush solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 to 0.5 parts per million, the residual chlorine content of the distribution system, or acceptable for domestic use. Use AWWA C655 neutralizing chemicals for all flushing water prior to discharge to ground, do not allow superchlorinated water to be discharged to surface waters, construction temporary dikes to contain and treat superchlorinated water with dechlorinating agent prior to discharge in accordance with local water quality standards.

3.2.6 Pipe Restraint

3.2.6.1 Concrete Thrust Blocks

Install concrete thrust blocks where indicated.

3.2.6.2 Restrained Joints

Install restrained joints in accordance with the manufacturer's instructions where indicated. Provide metal harness fabricated by the pipe manufacturer and furnished with the pipe.

3.2.7 Valves

3.2.7.1 Gate Valves

Install gate valves, AWWA C500 and UL 262, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C500. Install gate valves, AWWA C509 or AWWA C515, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C509 or AWWA C515. Make and assemble joints to gate valves as specified for making and assembling the same type joints between pipe and fittings.

3.2.7.2 Check Valves

Install check valves in accordance with the applicable requirements of AWWA C600 for valve-and-fitting installation, except as otherwise

indicated. Make and assemble joints to check valves as specified for making and assembling the same type joints between pipe and fittings.

3.2.8 Blowoff Valve Assemblies

Install blowoff valve assemblies as indicated on the drawings or in accordance with the manufactures recommendations. Install discharge fitting on the end of riser pipe to direct the flow of water so as to minimize damage to surrounding areas.

3.2.9 Fire Hydrants

Install fire hydrants in accordance with AWWA C600 for fire hydrant installation and as indicated. Make and assemble joints as specified for making and assembling the same type joints between pipe and fittings. Install fire hydrants with the 4 1/2 inch connections facing the adjacent paved surface. If there are two paved adjacent surfaces, install fire hydrants with the 4 1/2 inch connection facing the paved surface where the connecting main is located.

3.3 FIELD QUALITY CONTROL

3.3.1 Tests

Notify the Contracting Officer a minimum of five days in advance of hydrostatic testing. Coordinate the proposed method for disposal of waste water from hydrostatic testing. Perform field tests, and provide labor, equipment, and incidentals required for testing. Provide documentation that all items of work have been constructed in accordance with the Contract documents.

3.3.1.1 Hydrostatic Test

Test the water system in accordance with the applicable AWWA standard specified below. Where water mains provide fire service, test in accordance with the special testing requirements given in the paragraph SPECIAL TESTING REQUIREMENTS FOR FIRE SERVICE. Test ductile-iron water mains in accordance with the requirements of AWWA C600 for hydrostatic testing. The amount of leakage on ductile-iron pipelines with mechanical-joints or push-on joints is not to exceed the amounts given in AWWA C600; no leakage will be allowed at joints made by any other methods. Test water service lines in accordance with requirements of AWWA C600 for hydrostatic testing. No leakage will be allowed at copper pipe joints, copper tubing joints (soldered, compression type, brazed), flanged joints, .Do not backfill utility trench or begin testing on any section of a pipeline where concrete thrust blocks have been provided until at least 7 days after placing of the concrete.

3.3.1.2 Leakage Test

For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

3.3.1.3 Bacteriological Testing

Perform bacteriological tests in accordance with AWWA C651 Option A. For

new water mains use Option A and obtain two sets of samples for coliform analysis, each sample being collected at least 16 hours apart. Take samples every 1,200 ft plus one set from the end of the line and at least one from each branch greater than one pipe length. Analyze samples by a certified laboratory, and submit the results of the bacteriological samples.

3.3.1.4 Backflow Preventer Tests

After installation conduct Backflow Preventer Tests and provide test reports verifying that the installation meets the FCCCHR Manual Standards.

3.3.1.5 Special Testing Requirements for Fire Service

Test water mains and water service lines providing fire service or water and fire service in accordance with NFPA 24. The additional water added to the system must not exceed the limits given in NFPA 24

3.3.1.6 Tracer Wire Continuity Test

Test tracer wire for continuity after service connections have been completed and prior to final pavement or restoration. Verify that tracer wire is locatable with electronic utility locating equipment. Repair breaks or separations and re-test for continuity.

3.4 SYSTEM STARTUP

Water mains and appurtenances must be completely installed, disinfected, flushed, and satisfactory bacteriological sample results received prior to permanent connections being made to the active distribution system. Obtain approval by the Contracting Officer prior to the new water piping being placed into service.

3.5 CLEANUP

Upon completion of the installation of water lines and appurtenances, remove all debris and surplus materials resulting from the work.

-- End of Section --

SECTION 33 11 23

NATURAL GAS AND LIQUID PETROLEUM PIPING
11/09

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN GAS ASSOCIATION (AGA)

- AGA ANSI B109.1 (2000) Diaphragm Type Gas Displacement Meters (Under 500 cubic ft./hour Capacity)
- AGA ANSI B109.2 (2000) Diaphragm Type Gas Displacement Meters (500 cubic ft./hour Capacity and Over)
- AGA ANSI B109.3 (2019) Rotary-Type Gas Displacement Meters
- AGA XR0603 (2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

- ANSI Z21.41/CSA 6.9 (2014; R 2019) Quick-Disconnect Devices for Use with Gas Fuel Appliances
- ANSI Z21.45 (1995) Flexible Connectors of Other Than All-Metal Construction for Gas Appliances
- ANSI Z21.69/CSA 6.16 (2015; R 2020) Connectors for Movable Gas Appliances

ASME INTERNATIONAL (ASME)

- ASME B1.1 (2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
- ASME B16.40 (2019) Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
- ASME B18.2.1 (2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
- ASME B18.2.2 (2015) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
- ASME B31.8 (2018; Supplement 2018) Gas Transmission and Distribution Piping Systems

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2020a) Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM D2513	(2018a) Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings
ASTM D2683	(2014) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders

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

49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards

1.2 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS applies to

this section, with additions and modifications specified herein.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval.. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance with Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-03 Product Data

Valve Box

Gas Equipment Connectors

Warning and Identification Tape

Risers

Transition Fittings

Gas meter

SD-07 Certificates

Welder's Qualifications

PE Welder's Qualifications

Welder's Identification Symbols

SD-08 Manufacturer's Instructions

PE Pipe and Fittings

Submit manufacturer's installation instructions and manufacturer's visual joint appearance chart.

1.4 QUALITY ASSURANCE

1.4.1 Welder's Qualifications

Comply with ASME B31.8. The steel welder shall have a copy of a certified ASME B31.8 qualification test report. The PE welder shall have a certificate from a PE pipe manufacturer's sponsored training course. Contractor shall also conduct a qualification test. Submit each welder's identification symbols, assigned number, or letter, used to identify work of the welder. Affix symbols immediately upon completion of welds. Welders making defective welds after passing a qualification test shall be given a requalification test and, upon failing to pass this test, shall not be permitted to work this contract.

1.4.2 PE Welder's Qualifications

Prior to installation, Contractor shall have supervising and installing personnel trained by a PE pipe manufacturer's sponsored course of not less than one week duration, or present proof satisfactory to the Contracting

Officer that personnel are currently working in the installation of PE gas distribution lines.

1.4.3 Safety Standards

49 CFR 192 .

1.5 DELIVERY, STORAGE, AND HANDLING

Handle, transport, and store plastic pipe and fittings carefully. Plug or cap pipe ends during transportation or storage to minimize dirt and moisture entry. Do not subject to abrasion or concentrated external loads. Discard PE pipe sections and fittings that have been damaged.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Conform to NFPA 54 and with requirements specified herein. Supply piping to appliances or equipment shall be at least as large as the inlets thereof.

2.2 PIPE AND FITTINGS

2.2.1 Underground Polyethylene (PE)

PE pipe and fittings are as follows:

- a. Pipe: ASTM D2513, 100 psig working pressure, Standard Dimension Ratio (SDR), the ratio of pipe diameter to wall thickness, 11.5 maximum.
- b. Socket Fittings: ASTM D2683.
- c. Butt-Fusion Fittings: ASTM D2513, molded.

2.2.2 Risers

Manufacturer's standard riser, transition from plastic to steel pipe with 7 to 12 mil thick epoxy coating. Use swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Provide remote bolt-on or bracket or wall-mounted riser supports as indicated.

2.2.3 Transition Fittings

- a. Steel to Plastic (PE): As specified for "riser" except designed for steel-to-plastic with tapping tee or sleeve. Coat or wrap exposed steel pipe with heavy plastic coating.
- b. Plastic to Plastic: Manufacturer's standard slip-on PE mechanical coupling, molded, with stainless-steel ring support, O-ring seals, and rated for 150 psig gas service.

2.3 SHUTOFF VALVES, BELOW GROUND

2.3.1 PE Ball or Plug Valves

ASME B16.40 and ASTM D2513, Class C materials (PE 2306 or PE 3406), strength rating of Class 1 location with class factor of 0.32 2 location with class factor of 0.25 3 location with class factor of 0.25 4 location

with class factor of 0.20, and SDR matching PE pipe dimensions and working pressure.

2.4 GAS METER

AGA ANSI B109.1 AGA ANSI B109.2 AGA ANSI B109.3 pipe pedestal mounted, diaphragm or bellow style, enamel coated steel aluminum case. Provided with a strainer immediately upstream. Provide rotary-type displacement meter conforming to AGA ANSI B109.3 as required by local gas utility supplier. Provide combined odometer-type register totalizer index, UV-resistant index cover, water escape hole in housing, and means for sealing against tampering. Provide temperature-compensated type meters sized for the required volumetric flow rate and suitable for accurately measuring and handling gas at pressures, temperatures, and flow rates indicated. Provide meters with over-pressure protection as specified in 49 CFR 192 and ASME B31.8. Provide meters that are tamper-proof with frost protection fungus protection seismic protection. Provide meters with a pulse switch initiator capable of operating up to speeds of 500 maximum pulses per minute with no false pulses and requiring no field adjustments. Provide not less than one pulse per 100 cubic feet of gas. Minimum service life shall be 30,000,000 cycles.

2.4.1 Utility Monitoring and Control System (UMCS) / Energy Monitoring and Control (EMCS) or Automatic Meter Reading Interfaces

Provide gas meters capable of interfacing the output signal, equivalent to volumetric flow rate, with the existing UMCS / EMCS for data gathering in units of cubic meters cubic feet. Provide meters that do not require power to function and deliver data. Output signal shall be either a voltage or amperage signal that can be converted to volumetric flow by using an appropriate scaling factor.

2.4.2 Measurement Configuration

For buildings that already have a gas meter with a pulse output, ensure that the pulse output is connected to a data gathering device (i.e. electric meter). For buildings where a natural gas meter already exists but does not have a pulse output, add a pulse kit to the existing meter and tie the output to a data gathering device. If the existing gas meter will not accept a pulse kit or if no meter exists a new natural gas meter shall be installed, also requiring a pulse output to a data gathering device. Ensure the pulse frequency and electronic characteristics are compatible with the existing data gathering device, if any.

2.5 GAS EQUIPMENT CONNECTORS

- a. Flexible Connectors: ANSI Z21.45.
- b. Quick Disconnect Couplings: ANSI Z21.41/CSA 6.9.
- c. Semi-Rigid Tubing and Fittings: ANSI Z21.69/CSA 6.16.

2.6 VALVE BOX

Provide street valve box with cast-iron cover and two-piece 5 1/4 inch shaft-slip valve box extension. Cast the word "Gas" into the box cover. Use valve box for areas as follows:

- a. Roads and Traffic Areas: Heavy duty, cast iron cover.

- b. Other Areas: Standard duty, concrete cover.

2.7 CASING

Where indicated at railroad or other crossing, provide [ASTM A53/A53M](#), galvanized pipe, Schedule 40 .

2.8 BURIED UTILITY [WARNING AND IDENTIFICATION TAPE](#)

Provide detectable aluminum-foil plastic-backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, [3 inch](#) minimum width, color-coded yellow for natural gas, with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall be "CAUTION BURIED GAS PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

2.9 HANGERS AND SUPPORTS

[MSS SP-58](#), as required by [MSS SP-69](#).

2.10 WELDING FILLER METAL

[ASME B31.8](#).

2.11 PIPE-THREAD TAPE

Antiseize and sealant tape of polytetrafluoroethylene (PTFE).

2.12 BOLTING (BOLTS AND NUTS)

Stainless steel bolting; [ASTM A193/A193M](#), Grade B8M or B8MA, Type 316, for bolts; and [ASTM A194/A194M](#), Grade 8M, Type 316, for nuts. Dimensions of bolts, studs, and nuts shall conform with [ASME B18.2.1](#) and [ASME B18.2.2](#) with coarse threads conforming to [ASME B1.1](#), with Class 2A fit for bolts and studs and Class 2B fit for nuts. Bolts or bolt-studs shall extend through the nuts and may have reduced shanks of a diameter not less than the diameter at root of threads. Bolts shall have American Standard regular square or heavy hexagon heads; nuts shall be American Standard heavy semifinished hexagonal.

2.13 GASKETS

Fluorinated elastomer, compatible with flange faces.

2.14 IDENTIFICATION FOR ABOVEGROUND PIPING

[MIL-STD-101](#) for legends and type and size of characters. For pipes [3/4 inch](#) [0.D.](#) and larger, provide printed legends to identify contents of pipes and arrows to show direction of flow. Color code label backgrounds to signify levels of hazard. Make labels of plastic sheet with pressure-sensitive adhesive suitable for the intended application. For pipes smaller than [3/4 inch](#) od, provide brass identification tags [1 1/2 inches](#) in diameter with legends in depressed black-filled characters.

PART 3 EXECUTION

3.1 INSTALLATION

Install gas piping, appliances, and equipment in accordance with NFPA 54, Piedmont Natural Gas (PNG) shall provide and install all natural gas piping outside of building up to and including meter set location, Contractor shall comply with PNG standards for building service connections.

3.1.1 Excavating and Backfilling

Perform excavating and backfilling of pipe trenches as specified in Section 31 23 00.00 20 EXCAVATION AND FILL. Place pipe directly in trench bottom and cover with minimum 3 inches of sand to top of pipe. If trench bottom is rocky, place pipe on a 3 inch bed of sand and cover as above. Provide remaining backfilling. Coordinate provision of utility warning and identification tape with backfill operation. Bury utility warning and identification tape with printed side up at a depth of 12 inches below the top surface of earth or the top surface of the subgrade under pavements.

3.1.2 Piping

Cut pipe to actual dimensions and assemble to prevent residual stress. Provide supply connections entering the buildings as indicated. Within buildings, run piping parallel to structure lines and conceal in finished spaces. Terminate each vertical supply pipe to burner or appliance with tee, nipple and cap to form a sediment trap. To supply multiple items of gas-burning equipment, provide manifold with inlet connections at both ends.

3.1.2.1 Cleanliness

Clean inside of pipe and fittings before installation. Blow lines clear using 80 to 100 psig clean dry compressed air. Rap steel lines sharply along entire pipe length before blowing clear. Cap or plug pipe ends to maintain cleanliness throughout installation.

3.1.2.2 Buried Plastic Lines

Provide totally PE piping. Prior to installation, obtain printed instructions and technical assistance in proper installation techniques from pipe manufacturer. When joining new PE pipe to existing pipe line, ascertain what procedural changes in the fusion process is necessary to attain optimum bonding.

- a. Jointing Procedures: Use jointing procedures conforming to AGA XR0603 and 49 CFR 192 that have been qualified by test in accordance with 49 CFR 192.283 and proven to make satisfactory joints. Personnel make joints in plastic pipe shall be qualified in accordance with 49 CFR 192.285, under the submitted and approved procedure by making a satisfactory specimen joint that passes the required inspection and test. Joints in plastic pipe shall be inspected by a person qualified by 49 CFR 192.287 under the applicable procedure. Certificates that qualify the applicable procedures, joining personnel, and inspectors shall be submitted and approved and shall be on file with the Contracting Officer prior to making these joints.
- b. PE Piping: Prior to installation, Contractor shall have supervising

and installing personnel, certified in accordance with paragraph WELDER'S QUALIFICATIONS. Provide fusion-welded joints except where transitions have been specified. Use electrically heated tools, thermostatically controlled and equipped with temperature indication. (Where connection must be made to existing plastic pipe, contractor shall be responsible for determination of compatibility of materials and procedural changes in fusion process necessary to attain maximum integrity of bond.)

- c. Laying PE Pipe: Bury pipe 24 inches below finish grade or deeper when indicated. Lay in accordance with manufacturer's printed instructions.

3.1.2.3 Connections to Existing Pipeline

When making connections to live gas mains, use pressure tight installation equipment operated by workmen trained and experienced in making hot taps. For connections to existing underground pipeline or service branch, use transition fittings for dissimilar materials.

3.1.2.4 Wrapping

Where connection to existing steel line is made underground, tape wrap new steel transition fittings and exposed existing pipe having damaged coating. Clean pipe to bare metal. Initially stretch first layer of tape to conform to the surface while spirally half-lapping. Apply a second layer, half-lapped and spiraled as the first layer, but with spirals perpendicular to first wrapping. Use 10 mil minimum thick polyethylene tape. In lieu of tape wrap, heat shrinkable 10 mil minimum thick polyethylene sleeve may be used.

3.1.3 Valves

Install valves approximately at locations indicated. Orient stems vertically, with operators on top, or horizontally. Provide support for valves to resist operating torque applied to PE pipes.

3.1.3.1 Stop Valve and Shutoff Valve

Provide stop valve on service branch at connection to main and shut-off valve on riser outside of building.

3.1.4 Gas Service Installation

Installations shall be in accordance with 49 CFR 192 and ASME B31.8. Contractor shall submit and use only tested and approved work procedures. Contractor shall use only welders and jointers who have been recently qualified by training and test for joining and installing the gas pipe material used on this job. The finished product shall be inspected by a person qualified to inspect joints made by the particular procedures used to make joints.

3.1.4.1 Service Line

Install service line, branch connection to the main, and riser in accordance with 49 CFR 192 and ASME B31.8. Provide a minimum of 18 inches cover or encase the service line so that it is protected. Install service line so that no undue stress is applied to the pipe, connection, or riser. Install approved riser and terminate with an approved isolation valve, EFV and automatic shutoff device. After laying of pipe and

testing, backfill the trench in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL.

Where steel pipe is used as service line, install corrosion prevention coating and cathodic protect for the steel service line. Where connected to an existing cathodically protected steel pipe, ensure electrical continuity from the riser to the branch connection to the main. Install a dielectric fitting on the riser to prevent electrical continuity to the above ground piping.

Where plastic pipe is used as the service line, make joints in accordance with procedures qualified by test. Personnel joining plastic pipe shall be qualified by making a satisfactory specimen joint that passes the required inspection and test listed in 49 CFR 192.285. Inspection shall be made by inspectors qualified in evaluating joints made under the specific joining procedure, as required by 49 CFR 192.287.

3.1.4.2 Service Regulator

Install service regulator in accordance with 49 CFR 192 and ASME B31.8 and this specification ensuring that the customer's piping is protected from over pressurization should the service regulator fail. A 3/8 inch tapped fitting equipped with a plug shall be provided on both sides of the service regulator for installation of pressure gauges for adjusting the regulator. For inside installations, route the regulator vent pipe through the exterior wall to the atmosphere, and seal building penetrations for service line and vent. Terminate the regulator vent so that it is protected from precipitation and insect intrusion, so that it is not submerged during floods, and so that gas escaping will not create a hazard or enter the building through openings.

3.1.4.3 Gas Meter

Install shutoff valve, meter set assembly, and service regulator on the service line inside the building, a minimum of 3 feet from any potential ignition source, 18 inches above the finished floor on the riser. An insulating joint (dielectric connection) shall be installed on the inlet side of the meter set assembly and service regulator and shall be constructed to prevent flow of electrical current.

3.1.5 Pipe Sleeves

Where piping penetrates concrete or masonry wall, floor or firewall, provide pipe sleeve poured or grouted in place. Make sleeve of steel or cast-iron pipe of such size to provide 1/4 inch or more annular clearance around pipe. Extend sleeve through wall or slab and terminate flush with both surfaces. Pack annular space with oakum, and caulk at ends with silicone construction sealant.

3.1.6 Piping Hangers and Supports

Selection, fabrication, and installation of piping hangers and supports shall conform with MSS SP-69 and MSS SP-58, unless otherwise indicated. Provide seismic restraints in accordance with SMACNA 1981.

3.1.7 Final Connections

Make final connections to equipment and appliances using rigid pipe and fittings, except for the following:

3.1.7.1 Domestic Water Heaters

Connect with AGA-Approved semi-rigid tubing and fittings.

3.1.7.2 Kitchen Equipment

Install AGA-Approved gas equipment connectors. Connectors shall be long enough to permit movement of equipment for cleaning and to afford access to coupling.

3.2 FIELD QUALITY CONTROL

3.2.1 Metal Welding Inspection

Inspect for compliance with NFPA 54 and ASME B31.8 and 49 CFR 192. Replace, repair, and then re-inspect defective welds.

3.2.2 PE Fusion Welding Inspection

Visually inspect butt joints by comparing with, manufacturer's visual joint appearance chart. Inspect fusion joints for proper fused connection. Replace defective joints by cutting out defective joints or replacing fittings. Inspect 100 percent of all joints and reinspect all corrections. Arrange with the pipe manufacturer's representative in the presence of the Contracting Officer to make first time inspection.

3.2.3 Pressure Tests

Use test pressure of 1 1/2 times maximum working pressure, but in no case less than 50 psig. Do not test until every joint has set and cooled at least 8 hours at temperatures above 50 degrees F. Conduct testing before backfilling; however, place sufficient backfill material between fittings to hold pipe in place during tests. Test system gas tight in accordance with NFPA 54 or ASME B31.8. Use clean dry air or inert gas, such as nitrogen or carbon dioxide, for testing. Systems which may be contaminated by gas shall first be purged as specified. Make tests on entire system or on sections that can be isolated by valves. After pressurization, isolate entire piping system from sources of air during test period. Maintain test pressure for at least 8 hours between times of first and last reading of pressure and temperature. Take first reading at least one hour after test pressure has been applied. Do not take test readings during rapid weather changes. Provide temperature same as actual trench conditions. There shall be no reduction in the applied test pressure other than that due to a change in ambient temperature. Allow for ambient temperature change in accordance with the relationship $PF + 14.7 = (P1 + 14.7) (T2 + 460) / (T1 + 460)$, in which "T" and "PF" represent Fahrenheit temperature and gage pressure, respectively, subscripts "1" and "2" denote initial and final readings, and "PF" is the calculated final pressure. If "PF" exceeds the measured final pressure (final gage reading) by 1/2 psi or more, isolate sections of the piping system, retest each section individually, and apply a solution of warm soapy water to joints of each section for which a reduction in pressure occurs after allowing for ambient temperature change. Repair leaking joints and repeat test until no reduction in pressure occurs. In performing tests, use a test gage calibrated in one psi increments and readable to 1/2 psi.

3.2.4 System Purging

After completing pressure tests, and before testing a gas contaminated line, purge line with nitrogen at junction with main line to remove all air and gas. Clear completed line by attaching a test pilot fixture at capped stub-in line at building location and let gas flow until test pilot ignites. Procedures shall conform to [NFPA 54](#) and [ASME B31.8](#).

-CAUTION-
Failure to purge may result in explosion within line when air-to-gas is at correct mixture.

-- End of Section --

SECTION 33 30 00

SANITARY SEWERAGE
05/18

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2016) Standard Specification for Gray Iron Castings
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C94/C94M	(2020) Standard Specification for Ready-Mixed Concrete
ASTM C150/C150M	(2020) Standard Specification for Portland Cement
ASTM C270	(2019) Standard Specification for Mortar for Unit Masonry
ASTM C443	(2020) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C478M	(2018) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C923	(2008; R 2013; E 2016) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C972	(2000; R 2011) Compression-Recovery of Tape Sealant

ASTM C990	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM D412	(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D624	(2000; R 2020) Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2007; R 2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM F477	(2014) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F949	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

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

29 CFR 1910.27	(Nov 2016) Scaffolds and Roope Descent Systems

UNI-BELL PVC PIPE ASSOCIATION (UBPPA)

UBPPA UNI-B-6	(1998) Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Contractor's License

SD-02 Shop Drawings

Installation Drawings

SD-03 Product Data

Precast Concrete Manholes

Frames, Covers, and Gratings

Gravity Pipe

SD-06 Test Reports

Infiltration Tests And Exfiltration Tests; G

Low-Pressure Air Tests; G

Deflection Testing; G

SD-07 Certificates

Portland Cement

Post-Installation Inspection; G

1.3 QUALITY CONTROL

1.3.1 Installer Qualifications

Install specified materials by a licensed underground utility Contractor licensed for such work in the state where the work is to be performed. Verify installing [Contractor's License](#) is current and state certified or state registered.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Delivery and Storage

Check upon arrival; identify and segregate as to types, functions, and sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.

1.4.1.1 Piping

Inspect materials delivered to site for damage; store with minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping and jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

1.4.1.2 Cement, Aggregate, and Reinforcement

As specified in Section [03 30 00](#) CAST-IN-PLACE CONCRETE.

1.4.2 Handling

Handle pipe, fittings, and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition. Take special care

not to damage linings of pipe and fittings; if lining is damaged, make satisfactory repairs. Carry, do not drag, pipe to trench. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install the plastic pipe in accordance with the manufacturer's recommendation and discard those materials if the storage period exceeds the recommended shelf life. Discard solvents in use when the recommended pot life is exceeded.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Sanitary Sewer Gravity Pipeline

Provide mains and laterals of or polyvinyl chloride (PVC) plastic pipe. Provide building connections of polyvinyl chloride (PVC) plastic pipe. Provide new and modify existing exterior sanitary gravity sewer piping and appurtenances. Provide each system complete and ready for operation. The exterior sanitary gravity sewer system includes equipment, materials, installation, and workmanship as specified herein more than 5 feet outside of building walls.

2.2 MATERIALS

Provide materials conforming to the respective specifications and other requirements specified below. Submit manufacturer's product specification, standard drawings or catalog cuts.

2.2.1 Gravity Pipe

2.2.1.1 PVC Gravity Sewer Piping

2.2.1.1.1 PVC Gravity Pipe and Fittings

ASTM D3034, SDR 35, or ASTM F949 with ends suitable for elastomeric gasket joints.

2.2.1.1.2 PVC Gravity Joints and Jointing Material

Provide joints conforming to ASTM D3212. Gaskets are to conform to ASTM F477.

2.2.2 Cement Mortar

Provide cement mortar conforming to ASTM C270, Type M with Type II cement.

2.2.3 Portland Cement

Submit certificates of compliance stating the type of cement used in manufacture of concrete pipe, fittings, septic tanks, and precast manholes. Provide portland cement conforming to ASTM C150/C150M, Type II for concrete used in concrete pipe, concrete pipe fittings, septic tanks, and manholes and type optional for cement used in concrete cradle, concrete encasement, and thrust blocking. Use a cement containing less than 0.60 percent alkalies where aggregates are alkali reactive, as determined by Appendix XI of ASTM C33/C33M.

2.2.4 Portland Cement Concrete

Provide portland cement concrete conforming to [ASTM C94/C94M](#), compressive strength of [4000 psi](#) at 28 days, except for concrete cradle and encasement or concrete blocks for manholes. Concrete used for cradle and encasement is to have a compressive strength of [2500 psi](#) minimum at 28 days. Protect concrete in place from freezing and moisture loss for 7 days.

2.2.5 Precast Concrete Manholes

Provide [precast concrete manholes](#), risers, base sections, and tops conforming to [ASTM C478](#).

2.2.6 Gaskets and Connectors

Provide gaskets for joints between manhole sections conforming to [ASTM C443](#). Resilient connectors for making joints between manhole and pipes entering manhole are to conform to [ASTM C923](#) or [ASTM C990](#).

2.2.7 External Preformed Rubber Joint Seals

An external preformed rubber joint seal is an accepted method of sealing cast iron covers to precast concrete sections to prevent ground water infiltration into sewer systems. All finished and sealed manholes constructed in accordance with paragraph entitled "Manhole Construction" are to be tested for leakage in the same manner as pipelines as described in paragraph entitled "Leakage Tests." The seal is to be multi-section with a neoprene rubber top section and all lower sections made of Ethylene Propylene Diene Monomer (EPDM) rubber with a minimum thickness of [60 mils](#). Each unit is to consist of a top and bottom section and have mastic on the bottom of the bottom section and mastic on the top and bottom of the top section. The mastic is to be a non-hardening butyl rubber sealant and seal to the cone/top slab of the manhole/catch basin and over the lip of the casting. Extension sections are to cover up to two more adjusting rings. Properties and values are listed in the following table:

Properties, Test Methods and Minimum Values for Rubber used in Preformed Joint Seals				
Physical Properties	Test Methods	EPDM	Neoprene	Butyl Mastic
Tensile, psi	ASTM D412	1840	2195	--
Elongation, percent	ASTM D412	553	295	350
Tear Resistance, ppi	ASTM D624 (Die B)	280	160	--
Rebound, percent, 5 minutes	ASTM C972 (mod.)	--	--	11
Rebound, percent, 2 hours	ASTM C972	--	--	12

2.2.8 [Frames, Covers, and Gratings](#) for Manholes

Submit certification on the ability of frame and cover to carry the

imposed live load. Frame and cover are to be cast gray iron, [ASTM A48/A48M](#), Class 35B, cast ductile iron, [ASTM A536](#), Grade 65-45-12, or reinforced concrete, [ASTM C478](#) [ASTM C478M](#). Frames and covers are to be circular without vent holes. Size are to be as indicated on the plans. Stamp or cast the words "Sanitary Sewer" into covers so that it is plainly visible.

2.2.9 Manhole Steps

as indicated conforming to [29 CFR 1910.27](#) Aluminum steps or rungs will not be permitted. Steps are not required in manholes less than [4 feet](#) deep.

2.2.10 Manhole Ladders

Provide a steel ladder where the depth of a manhole exceeds [12 feet](#). The ladder is not to be less than [16 inches](#) in width, with [3/4 inch](#) diameter rungs spaced [12 inches](#) apart. The two stringers are to be a minimum [3/8 inch](#) thick and [2 inches](#) wide. Galvanize ladders and inserts after fabrication in conformance with [ASTM A123/A123M](#).

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Installation Drawings

Submit [Installation Drawings](#) showing complete detail, both plan and side view details with proper layout and elevations.

3.2 INSTALLATION

Backfill after inspection by the Contracting Officer. Before, during, and after installation, protect plastic pipe and fittings from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer.

3.2.1 Connections to Existing Lines

Obtain approval from the Contracting Officer before making connection to existing line. Conduct work so that there is minimum interruption of service on existing line.

3.2.2 General Requirements for Installation of Pipelines

These general requirements apply except where specific exception is made in the following paragraphs entitled "Special Requirements."

3.2.2.1 Location

Terminate the work covered by this section at a point approximately [5 feet](#) from the building, unless otherwise indicated.

3.2.2.1.1 Sanitary Piping Installation Parallel with Water Line

3.2.2.1.1.1 Normal Conditions

Install sanitary piping or manholes at least [10 feet](#) horizontally from a

water line whenever possible. Measure the distance from edge-to-edge.

3.2.2.1.1.2 Unusual Conditions

When local conditions prevent a horizontal separation of **10 feet**, the sanitary piping or manhole may be laid closer to a water line provided that:

- a. The top (crown) of the sanitary piping is to be at least **18 inches** below the bottom (invert) of the water main.
- b. Where this vertical separation cannot be obtained, construct the sanitary piping with AWWA-approved ductile iron water pipe pressure and conduct a hydrostatic sewer test without leakage prior to backfilling.
- c. The sewer manhole is to be of watertight construction and tested in place.

3.2.2.1.2 Installation of Sanitary Piping Crossing a Water Line

3.2.2.1.2.1 Normal Conditions

Lay sanitary sewer piping by crossing under water lines to provide a separation of at least **18 inches** between the top of the sanitary piping and the bottom of the water line whenever possible.

3.2.2.1.2.2 Unusual Conditions

When local conditions prevent a vertical separation described above, use the following construction:

- a. Construct sanitary piping passing over or under water lines with AWWA-approved ductile iron water pressure piping and conduct a hydrostatic sewer test without leakage prior to backfilling.
- b. Protect sanitary piping passing over water lines by providing:
 - (1) A vertical separation of at least **18 inches** between the bottom of the sanitary piping and the top of the water line.
 - (2) Adequate structural support for the sanitary piping to prevent excessive deflection of the joints and the settling on and breaking of the water line.
 - (3) That the length, minimum **20 feet**, of the sanitary piping be centered at the point of the crossing so that joints are equidistant and as far as possible from the water line.

3.2.2.1.3 Sanitary Sewer Manholes

No water piping shall pass through or come in contact with any part of a sanitary sewer manhole.

3.2.2.2 Earthwork

Perform earthwork operations in accordance with Section **31 23 00.00 20 EXCAVATION AND FILL**.

3.2.2.3 Pipe Laying and Jointing

Inspect each pipe and fitting before and after installation; replace those found defective and remove from site. Provide proper facilities for lowering sections of pipe into trenches. Lay nonpressure pipe with the bell or groove ends in the upgrade direction. Adjust spigots in bells and tongues in grooves to give a uniform space all around. Blocking or wedging between bells and spigots or tongues and grooves will not be permitted. Replace by one of the proper dimensions, pipe or fittings that do not allow sufficient space for installation of joint material. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Provide batterboards not more than 25 feet apart in trenches for checking and ensuring that pipe invert elevations are as indicated. Laser beam method may be used in lieu of batterboards for the same purpose. Construct branch connections by use of regular fittings or solvent cemented saddles as approved. Provide saddles for PVC pipe conforming to Table 4 of ASTM D3034.

3.2.3 Special Requirements

3.2.3.1 Installation of PVC Piping

Install pipe and fittings in accordance with paragraph entitled "General Requirements for Installation of Pipelines" of this section and with the requirements of ASTM D2321 for laying and joining pipe and fittings. Make joints with the gaskets specified for joints with this piping and assemble in accordance with the requirements of ASTM D2321 for assembly of joints. Make joints to other pipe materials in accordance with the recommendations of the plastic pipe manufacturer.

3.2.4 Concrete Work

Cast-in-place concrete is included in Section 03 30 00 CAST-IN-PLACE CONCRETE. Support the pipe on a concrete cradle, or encased in concrete where indicated or directed.

3.2.5 Manhole Construction

Construct base slab of cast-in-place concrete or use precast concrete base sections. Make inverts in cast-in-place concrete and precast concrete bases with a smooth-surfaced semi-circular bottom conforming to the inside contour of the adjacent sewer sections. For changes in direction of the sewer and entering branches into the manhole, make a circular curve in the manhole invert of as large a radius as manhole size will permit. For cast-in-place concrete construction, either pour bottom slabs and walls integrally or key and bond walls to bottom slab. No parging will be permitted on interior manhole walls. For precast concrete construction, make joints between manhole sections with the gaskets specified for this purpose; install in the manner specified for installing joints in concrete piping. Parging will not be required for precast concrete manholes. Perform cast-in-place concrete work in accordance with the requirements specified under paragraph entitled "Concrete Work" of this section. Make joints between concrete manholes and pipes entering manholes with the resilient connectors specified for this purpose; install in accordance with the recommendations of the connector manufacturer. Where a new manhole is constructed on an existing line, remove existing pipe as necessary to construct the manhole. Cut existing pipe so that pipe ends are approximately flush with the interior face of manhole wall, but not protruding into the manhole. Use resilient connectors as previously

specified for pipe connectors to concrete manholes.

3.2.6 Miscellaneous Construction and Installation

3.2.6.1 Connecting to Existing Manholes

Connect pipe to existing manholes such that finish work will conform as nearly as practicable to the applicable requirements specified for new manholes, including all necessary concrete work, cutting, and shaping. Center the connection on the manhole. Holes for the new pipe are to be of sufficient diameter to allow packing cement mortar around the entire periphery of the pipe but no larger than 1.5 times the diameter of the pipe. Cut the manhole in a manner that will cause the least damage to the walls.

3.2.6.2 Metal Work

3.2.6.2.1 Workmanship and Finish

Perform metal work so that workmanship and finish will be equal to the best practice in modern structural shops and foundries. Form iron to shape and size with sharp lines and angles. Do shearing and punching so that clean true lines and surfaces are produced. Make castings sound and free from warp, cold shuts, and blow holes that may impair their strength or appearance. Give exposed surfaces a smooth finish with sharp well-defined lines and arises. Provide necessary rabbets, lugs, and brackets wherever necessary for fitting and support.

3.2.6.2.2 Field Painting

After installation, clean cast-iron frames, covers, gratings, and steps not buried in concrete to bare metal, remove mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint. Do not paint surfaces subject to abrasion.

3.2.7 Installations of Wye Branches

Install wye branches in an existing sewer using a method which does not damage the integrity of the existing sewer. Do not cut into piping for connections except when approved by the Contracting Officer. When the connecting pipe cannot be adequately supported on undisturbed earth or tamped backfill, support on a concrete cradle as directed by the Contracting Officer. Provide and install concrete required because of conditions resulting from faulty construction methods or negligence without any additional cost to the Government. Do not damage the existing sewer when installing wye branches in an existing sewer.

3.3 FIELD QUALITY CONTROL

The Contracting Officer will conduct field inspections and witness field tests specified in this section. Be able to produce evidence, when required, that each item of work has been constructed in accordance with the drawings and specifications.

3.3.1 Tests

Perform field tests and provide labor, equipment, and incidentals required for testing.

3.3.1.1 Leakage Tests for Nonpressure Lines

Test lines for leakage by either infiltration tests and exfiltration tests, negative air pressure tests or by low-pressure air tests. When necessary to prevent pipeline movement during testing, place additional backfill around pipe sufficient to prevent movement, but leaving joints uncovered to permit inspection. When leakage or pressure drop exceeds the allowable amount specified, make satisfactory correction and retest pipeline section in the same manner. Correct visible leaks regardless of leakage test results.

3.3.1.1.1 Infiltration Tests and Exfiltration Tests

3.3.1.1.2 Low-Pressure Air Tests

3.3.1.1.2.1 PVC Pipelines

Test PVC pipe in accordance with **UBPPA UNI-B-6**. The allowable pressure drop is located in **UBPPA UNI-B-6**. Make calculations in accordance with the Appendix to **UBPPA UNI-B-6**.

3.3.1.2 Dye Test

Perform a dye test from the projects sanitary sewer point of connection to the first downstream manhole on the next active sanitary sewer branch main. Use nontoxic non-staining sewer tracing dye. Test results are to be noted in the daily Construction Quality Control (CQC) Report as required in **01 45 00.05 20 Design and Construction Quality Control**.

- a. Continue testing until it can be visually confirmed by way of the dye that the sewer connection is appropriate or until deficiencies are discovered.
- b. During the test, monitor the storm drainage system downstream from the project, either manholes or outfalls, for any sign of cross-connection.

3.3.1.3 Deflection Testing

Conduct deflection test no sooner than 30 days after completion of final backfill and compaction testing. Clean or flush all lines prior to testing. Perform a deflection test on entire length of installed flexible pipeline upon completion of work adjacent to and over the pipeline, including backfilling, placement of fill, grading, paving, placement of concrete, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads shall not exceed limits in paragraph PLACING PIPE above as percent of the average inside diameter of pipe. Use a laser profiler or mandrel to determine if allowable deflection has been exceeded.

3.3.2 Inspection

3.3.2.1 INTENTIONALLY LEFT BLANK

3.3.2.2 Post-Installation Inspection

Perform a post-installation inspection after connection has been made and before the connection is buried. Submit **post-installation inspection** request for field support at least 14 days in advance. The Installation's Utilities Field Support personnel will perform the post-connection

inspection.

-- End of Section --

SECTION 33 40 00
STORM DRAINAGE UTILITIES
02/10

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO MP 20 (2013; R 2017) Standard Specification for Steel-Reinforced Polyethylene (PE) Ribbed Pipe, 300- to 1500-mm (12- to 60-in) Diameter

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION
(AREMA)

AREMA Eng Man (2017) Manual for Railway Engineering

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M (2003; R 2016) Standard Specification for Gray Iron Castings

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A536 (1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings

ASTM A929/A929M (2018) Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe

ASTM B26/B26M (2014; E 2015) Standard Specification for Aluminum-Alloy Sand Castings

ASTM C32 (2013; R 2017) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)

ASTM C55 (2017) Standard Specification for Concrete Building Brick

ASTM C62 (2017) Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)

ASTM C76 (2020) Standard Specification for

**Reinforced Concrete Culvert, Storm Drain,
and Sewer Pipe**

ASTM C139	(2017) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C231/C231M	(2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C270	(2019) Standard Specification for Mortar for Unit Masonry
ASTM C425	(2004; R 2013) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C443	(2020) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C478	(2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C655	(2014) Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
ASTM C877	(2008) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections
ASTM C923	(2008; R 2013; E 2016) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C990	(2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C1433	(2016b) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D1751	(2004; E 2013; R 2013) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	(2018) Standard Specification for

	Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2729	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3034	(2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D3212	(2007; R 2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM F679	(2016) Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F794	(2003; R 2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F949	(2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings
ASTM F2562/F2562M	(2015) Specification for Steel Reinforced Thermoplastic Ribbed Pipe and Fittings for Non-Pressure Drainage and Sewerage

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00.05 20 SUBMITTAL PROCEDURES:

SD-04 Samples

Pipe for Culverts and Storm Drains

SD-06 Test Reports

Deflection Testing; G

SD-07 Certificates

Resin Certification

Oil Resistant Gasket

HYDROSTATIC TEST ON WATERTIGHT JOINTS; G

Determination of Density

Frame and Cover for Gratings

Post-Installation Inspection Report: G

SD-08 Manufacturer's Instructions

Placing Pipe

SD-11 Closeout Submittals

LID Verification Report

1.3 DELIVERY, STORAGE, AND HANDLING

1.3.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.3.2 Handling

Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

PART 2 PRODUCTS

2.1 PIPE FOR CULVERTS AND STORM DRAINS

Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

2.1.1 Concrete Pipe

Manufactured in accordance with and conforming to ASTM C76, Class III , or ASTM C655, 2,000 D-Load.

2.1.2 Poly Vinyl Chloride (PVC) Pipe

Submit the pipe manufacturer's resin certification, indicating the cell classification of PVC used to manufacture the pipe, prior to installation of the pipe.

2.1.2.1 Type PSM PVC Pipe

ASTM D3034, Type PSM, maximum SDR 35, produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.2.2 Profile PVC Pipe

ASTM F794, Series 46, produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.2.3 Smooth Wall PVC Pipe

ASTM F679 produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.2.4 Corrugated PVC Pipe

ASTM F949 produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.3 Steel Reinforced Polyethylene (SRPE) Pipe

SRPE pipe will meet the requirements of ASTM F2562/F2562M 8 - 120 inch diameter pipe and AASHTO MP 20 (12 - 60 inch diameter pipe).

2.2 PERFORATED PIPING

2.2.1 Polyvinyl Chloride (PVC) Pipe

ASTM D2729.

2.3 DRAINAGE STRUCTURES

2.3.1 Flared End Sections

Sections shall be of a standard design fabricated from zinc coated steel sheets meeting requirements of ASTM A929/A929M.

2.3.2 Precast Reinforced Concrete Box

Manufactured in accordance with and conforming to [ASTM C1433](#).

2.4 MISCELLANEOUS MATERIALS

2.4.1 Concrete

Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements for [4,000 psi](#) concrete under Section [03 30 00](#) CAST-IN-PLACE CONCRETE. The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds [1-1/2 inches](#). Air content shall be determined in accordance with [ASTM C231/C231M](#). The concrete covering over steel reinforcing shall not be less than [1 inch](#) thick for covers and not less than [1-1/2 inches](#) thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least [3 inches](#) between steel and ground. Expansion-joint filler material shall conform to [ASTM D1751](#), or [ASTM D1752](#), or shall be resin-impregnated fiberboard conforming to the physical requirements of [ASTM D1752](#).

2.4.2 Mortar

Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to [ASTM C270](#), Type M, except that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar but in no case shall exceed [manufacturer's recommendations for gallons](#) of water per sack of cement. Water shall be clean and free of harmful acids, alkalis, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

2.4.3 Precast Concrete Segmental Blocks

Precast concrete segmental block shall conform to [ASTM C139](#), not more than [8 inches](#) thick, not less than [8 inches](#) long, and of such shape that joints can be sealed effectively and bonded with cement mortar.

2.4.4 Brick

Brick shall conform to [ASTM C62](#), Grade SW; [ASTM C55](#), Grade S-I or S-II; or [ASTM C32](#), Grade MS. Mortar for jointing and plastering shall consist of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement. The joints shall be filled completely and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with [1/2 inch](#) of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course. For round structures, brick shall be laid radially with every sixth course a stretcher course.

2.4.5 Precast Reinforced Concrete Manholes

Conform to [ASTM C478](#). Joints between precast concrete risers and tops

shall be made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph JOINTS.

2.4.6 Frame and Cover for Gratings

Submit certification on the ability of frame and cover or gratings to carry the imposed live load. Frame and cover for gratings shall be cast gray iron, [ASTM A48/A48M](#), Class 35B; cast ductile iron, [ASTM A536](#), Grade 65-45-12; or cast aluminum, [ASTM B26/B26M](#), Alloy 356.0-T6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans. The word "Storm Sewer" shall be stamped or cast into covers so that it is plainly visible.

2.4.7 Joints

2.4.7.1 Flexible Watertight Joints

- a. Flexible watertight joints shall be made with plastic or rubber-type gaskets for concrete pipe and with factory-fabricated resilient materials for clay pipe. The design of joints and the physical requirements for preformed flexible joint sealants shall conform to [ASTM C990](#), and rubber-type gaskets shall conform to [ASTM C443](#). Factory-fabricated resilient joint materials shall conform to [ASTM C425](#). Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are permitted if the nominal diameter of the pipe being gasketed exceeds [54 inches](#).
- b. Rubber gaskets shall comply with the [oil resistant gasket](#) requirements of [ASTM C443](#). Certified copies of test results shall be delivered to the Contracting Officer before gaskets or jointing materials are installed. Alternate types of watertight joint may be furnished, if specifically approved.

2.4.7.2 External Sealing Bands

Requirements for external sealing bands shall conform to [ASTM C877](#).

2.4.7.3 PVC Plastic Pipes

Joints shall be solvent cement or elastomeric gasket type in accordance with the specification for the pipe and as recommended by the pipe manufacturer.

2.5 STEEL LADDER

Steel ladder shall be provided where the depth of the storm drainage structure exceeds [12 feet](#). These ladders shall be not less than [16 inches](#) in width, with [3/4 inch](#) diameter rungs spaced [12 inches](#) apart. The two stringers shall be a minimum [3/8 inch](#) thick and [2-1/2 inches](#) wide. Ladders and inserts shall be galvanized after fabrication in conformance with [ASTM A123/A123M](#).

2.6 RESILIENT CONNECTORS

Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to [ASTM C923](#).

2.7 EROSION CONTROL RIP RAP

Provide non-erodible rock not exceeding 15 inches in its greatest dimension and choked with sufficient small rocks to provide a dense mass with a minimum thickness of as indicated.

PART 3 EXECUTION

3.1 INSTALLATION OF PIPE CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of Section , 31 23 00.00 20 EXCAVATION AND FILL and the requirements specified below.

3.1.1 Trenching

The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 12 inches to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheet piling and bracing, where required, shall be placed within the trench width as specified, without any overexcavation. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

3.1.2 Removal of Rock

Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe of at least 8 inches or 1/2 inch for each foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined in Section 31 23 00.00 20 EXCAVATION AND FILL .

3.1.3 Removal of Unstable Material

Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheet piling, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Government.

3.2 BEDDING

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.

3.2.1 Concrete Pipe Requirements

When no bedding class is specified or detailed on the drawings, concrete

pipe shall be bedded in granular material minimum 4 inch in depth in trenches with soil foundation. Depth of granular bedding in trenches with rock foundation shall be 1/2 inch in depth per foot of depth of fill, minimum depth of bedding shall be 8 inch up to maximum depth of 24 inches. The middle third of the granular bedding shall be loosely placed. Bell holes and depressions for joints shall be removed and formed so entire barrel of pipe is uniformly supported. The bell hole and depressions for the joints shall be not more than the length, depth, and width required for properly making the particular type of joint.

3.2.2 Plastic Pipe

Bedding for PVC, PE, SRPE and PP pipe shall meet the requirements of ASTM D2321. Use Class IB or II material for bedding, haunching, and initial backfill.

3.3 PLACING PIPE

Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe, excluding SRPE pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed the 5%.

TYPE OF PIPE MAXIMUM ALLOWABLE DEFLECTION (percent)

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (percent)
Plastic (PVC, PE, SRPE, and PP)	5

3.3.1 Bell and Spigot or Tongue-and-Groove Pipe

Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.2 Elliptical and Elliptical Reinforced Concrete Pipe

The manufacturer's reference lines, designating the top of the pipe, shall be within 5 degrees of a vertical plane through the longitudinal axis of the pipe, during placement. Damage to or misalignment of the pipe shall be prevented in all backfilling operations.

3.3.3 Multiple Culverts

Where multiple lines of pipe are installed, adjacent sides of pipe shall be at least half the nominal pipe diameter or 3 feet apart, whichever is

less.

3.3.4 Jacking Pipe Through Fills

Methods of operation and installation for jacking pipe through fills shall conform to requirements specified in Volume 1, Chapter 1, Part 4 of AREMA Eng Man.

3.4 JOINTING

3.4.1 Concrete Pipe

3.4.1.1 Cement-Mortar Bell-and-Spigot Joint

The first pipe shall be bedded to the established grade line, with the bell end placed upstream. The interior surface of the bell shall be thoroughly cleaned with a wet brush and the lower portion of the bell filled with mortar as required to bring inner surfaces of abutting pipes flush and even. The spigot end of each subsequent pipe shall be cleaned with a wet brush and uniformly matched into a bell so that sections are closely fitted. After each section is laid, the remainder of the joint shall be filled with mortar, and a bead shall be formed around the outside of the joint with sufficient additional mortar. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint shall be wrapped or bandaged with cheesecloth to hold mortar in place.

3.4.1.2 Cement-Mortar Oakum Joint for Bell-and-Spigot Pipe

A closely twisted gasket shall be made of jute or oakum of the diameter required to support the spigot end of the pipe at the proper grade and to make the joint concentric. Joint packing shall be in one piece of sufficient length to pass around the pipe and lap at top. This gasket shall be thoroughly saturated with neat cement grout. The bell of the pipe shall be thoroughly cleaned with a wet brush, and the gasket shall be laid in the bell for the lower third of the circumference and covered with mortar. The spigot of the pipe shall be thoroughly cleaned with a wet brush, inserted in the bell, and carefully driven home. A small amount of mortar shall be inserted in the annular space for the upper two-thirds of the circumference. The gasket shall be lapped at the top of the pipe and driven home in the annular space with a caulking tool. The remainder of the annular space shall be filled completely with mortar and beveled at an angle of approximately 45 degrees with the outside of the bell. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint thus made shall be wrapped with cheesecloth. Placing of this type of joint shall be kept at least five joints behind laying operations.

3.4.1.3 Cement-Mortar Diaper Joint for Bell-and-Spigot Pipe

The pipe shall be centered so that the annular space is uniform. The annular space shall be caulked with jute or oakum. Before caulking, the inside of the bell and the outside of the spigot shall be cleaned.

- a. Diaper Bands: Diaper bands shall consist of heavy cloth fabric to hold grout in place at joints and shall be cut in lengths that extend one-eighth of the circumference of pipe above the spring line on one side of the pipe and up to the spring line on the other side of the pipe. Longitudinal edges of fabric bands shall be rolled and stitched

around two pieces of wire. Width of fabric bands shall be such that after fabric has been securely stitched around both edges on wires, the wires will be uniformly spaced not less than 8 inches apart. Wires shall be cut into lengths to pass around pipe with sufficient extra length for the ends to be twisted at top of pipe to hold the band securely in place; bands shall be accurately centered around lower portion of joint.

- b. Grout: Grout shall be poured between band and pipe from the high side of band only, until grout rises to the top of band at the spring line of pipe, or as nearly so as possible, on the opposite side of pipe, to ensure a thorough sealing of joint around the portion of pipe covered by the band. Silt, slush, water, or polluted mortar grout forced up on the lower side shall be forced out by pouring, and removed.
- c. Remainder of Joint: The remaining unfilled upper portion of the joint shall be filled with mortar and a bead formed around the outside of this upper portion of the joint with a sufficient amount of additional mortar. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind actual laying of pipe. No backfilling around joints shall be done until joints have been fully inspected and approved.

3.4.1.4 Cement-Mortar Tongue-and-Groove Joint

The first pipe shall be bedded carefully to the established grade line with the groove upstream. A shallow excavation shall be made underneath the pipe at the joint and filled with mortar to provide a bed for the pipe. The grooved end of the first pipe shall be thoroughly cleaned with a wet brush, and a layer of soft mortar applied to the lower half of the groove. The tongue of the second pipe shall be cleaned with a wet brush; while in horizontal position, a layer of soft mortar shall be applied to the upper half of the tongue. The tongue end of the second pipe shall be inserted in the grooved end of the first pipe until mortar is squeezed out on interior and exterior surfaces. Sufficient mortar shall be used to fill the joint completely and to form a bead on the outside.

3.4.1.5 Cement-Mortar Diaper Joint for Tongue-and-Groove Pipe

The joint shall be of the type described for cement-mortar tongue-and-groove joint in this paragraph, except that the shallow excavation directly beneath the joint shall not be filled with mortar until after a gauze or cheesecloth band dipped in cement mortar has been wrapped around the outside of the joint. The cement-mortar bead at the joint shall be at least 1/2 inch, thick and the width of the diaper band shall be at least 8 inches. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind the actual laying of the pipe. Backfilling around the joints shall not be done until the joints have been fully inspected and approved.

3.4.1.6 Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe

Sealing compounds shall follow the recommendation of the particular manufacturer in regard to special installation requirements. Surfaces to receive lubricants, primers, or adhesives shall be dry and clean. Sealing compounds shall be affixed to the pipe not more than 3 hours prior to installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Sealing compounds shall be inspected before installation of the pipe, and any loose or improperly

affixed sealing compound shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pulled together. If, while making the joint with mastic-type sealant, a slight protrusion of the material is not visible along the entire inner and outer circumference of the joint when the joint is pulled up, the pipe shall be removed and the joint remade. After the joint is made, all inner protrusions shall be cut off flush with the inner surface of the pipe. If non-mastic-type sealant material is used, the "Squeeze-Out" requirement above will be waived.

3.4.1.7 Flexible Watertight Joints

Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

3.4.1.8 External Sealing Band Joint for Noncircular Pipe

Surfaces to receive sealing bands shall be dry and clean. Bands shall be installed in accordance with manufacturer's recommendations.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets

Construction shall be of reinforced concrete, plain concrete, brick, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal; complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.

3.5.2 Walls and Headwalls

Construction shall be as indicated.

3.6 STEEL LADDER INSTALLATION

Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 6 feet vertically, and shall be installed to provide at least 6 inches of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

3.7 BACKFILLING

3.7.1 Backfilling Pipe in Trenches

After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 6 inches in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation equal to the midpoint (spring line) of concrete pipe or has reached an elevation of at least 12 inches above the top of the pipe for flexible pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 6 inches. Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

3.7.2 Backfilling Pipe in Fill Sections

For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified below. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 6 inches in compacted depth, and shall be compacted by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 12 inches above the top of the pipe shall extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 12 feet, whichever is less. After the backfill has reached at least 12 inches above the top of the pipe, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 6 inches. Use select granular material for this entire region of backfill for flexible pipe installations.

3.7.3 Movement of Construction Machinery

When compacting by rolling or operating heavy equipment parallel with the pipe, displacement or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.7.4 Compaction

3.7.4.1 General Requirements

Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

3.7.4.2 Minimum Density

Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

- a. Under airfield and heliport pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.
- b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.
- c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.8 FIELD PAINTING

3.8.1 Cast-Iron Covers, Frames, Gratings, And Steps

After installation, clean cast-iron, not buried in masonry or concrete, of mortar, rust, grease, dirt, and other deleterious materials to bare metal and apply a coat of bituminous paint.

3.9 FIELD QUALITY CONTROL

3.9.1 Tests

Testing is the responsibility of the Contractor. Perform all testing and retesting at no additional cost to the Government.

3.9.1.1 HYDROSTATIC TEST ON WATERTIGHT JOINTS

Watertight joints shall be tested and shall meet test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS. Rubber gaskets shall comply with the oil resistant gasket requirements of [ASTM C443](#). Certified copies of test results shall be delivered to the Contracting Officer before gaskets or jointing materials are installed.

3.9.1.1.1 Concrete, Clay, PVC, PE, SRPE and PP Pipe

A hydrostatic test shall be made on the watertight joint types as proposed. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Performance requirements for joints in reinforced and nonreinforced concrete pipe shall conform to [ASTM C990](#) or [ASTM C443](#). Test requirements for joints in clay pipe shall conform to [ASTM C425](#). Test requirements for joints in PVC, PE, and PP plastic pipe shall conform to [ASTM D3212](#).

3.9.1.2 Determination of Density

Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D698 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D6938. When ASTM D6938 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D6938 results in a wet unit weight of soil and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D6938. Test results shall be furnished the Contracting Officer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

3.9.1.3 Deflection Testing

Conduct deflection test no sooner than 30 days after completion of final backfill and compaction testing. Clean or flush all lines prior to testing. Perform a deflection test on entire length of installed flexible pipeline upon completion of work adjacent to and over the pipeline, including backfilling, placement of fill, grading, paving, placement of concrete, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads shall not exceed limits in paragraph PLACING PIPE above as percent of the average inside diameter of pipe. Use a laser profiler or mandrel to determine if allowable deflection has been exceeded.

3.9.2 Inspection

3.9.2.1 Post-Installation Inspection

Visually inspect each segment of concrete pipe for alignment, settlement, joint separations, soil migration through the joint, cracks, buckling, bulging and deflection. An engineer must evaluate all defects to determine if any remediation or repair is required.

3.9.2.1.1 Concrete

Cracks with a width greater than 0.01 inches. An engineer must evaluate all pipes with cracks with a width greater than 0.01 inches but less than 0.10 inches to determine if any remediation or repair is required.

3.9.2.1.2 Flexible Pipe

Check each flexible pipe (PE, PVC, PP, Corrugated Steel And Aluminum) for rips, tears, joint separations, soil migration through the joint, cracks, localized bucking, bulges, settlement and alignment.

3.9.2.1.3 Post-Installation Inspection Report

The deflection results and final post installation inspection report must include: pipe location identification, equipment used for inspection, inspector name, deviation from design, grade, deviation from line,

deflection and deformation of flexible pipe, inspector notes, condition of joints, condition of pipe wall (e.g. distress, cracking, wall damage dents, bulges, creases, tears, holes, etc.).

3.9.2.2 Low Impact Development Inspection

Inspect Low Impact Development (LID) features indicated on the design portion of the [LID Verification Report](#). Certify LID features were constructed according to plans and specifications or by submitting as-built drawings in accordance with UFGS 01 78 00 Closeout Submittals. When as-built drawings show deviations to the LID features, document the deviations on the [LID Verification Report](#).

3.9.3 Repair Of Defects

3.9.3.1 Leakage Test

When leakage exceeds the maximum amount specified, correct source of excess leakage by replacing damaged pipe and gaskets and retest.

3.9.3.2 Deflection Testing

When deflection readings are in excess of the allowable deflection of average inside diameter of pipe are obtained, remove pipe which has excessive deflection and replace with new pipe. Retest 30 days after completing backfill, leakage testing and compaction testing.

3.9.3.3 Inspection

Replace pipe or repair defects indicated in the Post-Installation Inspection Report.

3.9.3.3.1 Concrete

Replace pipes having cracks with a width greater than [0.1 inches](#).

3.9.3.3.2 Flexible Pipe

Replace pipes having cracks or splits.

3.10 PROTECTION

Protect storm drainage piping and adjacent areas from superimposed and external loads during construction.

3.11 WARRANTY PERIOD

Pipe segments found to have defects during the warranty period must be replaced with new pipe and retested.

-- End of Section --

SECTION 33 61 14

EXTERIOR BURIED PREINSULATED WATER PIPING
02/10

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM C591 (2020) Standard Specification for Unfaced
Preformed Rigid Cellular Polyisocyanurate
Thermal Insulation

ASTM D3350 (2012) Polyethylene Plastics Pipe and
Fittings Materials

1.2 SYSTEM DESCRIPTION

Provide exterior buried factory-prefabricated preinsulated water piping system to the first piping connection aboveground or within each building complete and ready for operation. Piping system includes chilled water piping, and related work from chillers / Chilled water mechanical yard to the building. Hot domestic water piping within each building is specified under Section 22 00 00 PLUMBING, GENERAL PURPOSE. Section 23 64 26 CONDENSER WATER PIPING SYSTEMS.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD. Submit the following in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Factory-prefabricated preinsulated water piping system

Preinsulated plastic pipe field joints

SD-03 Product Data

Pipe, fittings, and end connections

Factory-prefabricated preinsulated water piping system

SD-07 Certificates

Certification of welders' qualifications

SD-08 Manufacturer's Instructions

Installation manual for buried factory-prefabricated preinsulated water piping system

1.4 QUALITY ASSURANCE

1.4.1 Certification of Welders' Qualifications

Submit prior to site welding of steel piping; certifications shall be not more than one year old.

PART 2 PRODUCTS

2.1 BURIED FACTORY-PREFABRICATED PREINSULATED WATER PIPING SYSTEM

Piping (pipe, fittings, and end connections) system shall be suitable for working pressure of 125 psig at 250 degrees F, except plastic polyvinyl chloride (PVC) or High Density Polyethylene (HDPE) chilled water piping shall be suitable for working pressure of 125 psig at 73 degrees F. Piping system shall withstand H-20 highway loading with 2 feet of compacted backfill over top of conduit. Mark each section of conduit with fabricator's name, product identification, and publications to which the items conform. Provide each section of carrier pipe including factory-applied insulation and conduit, with waterproof conduit ends at both ends of each section of carrier pipe, except for piping systems which have the field joints insulated and covered with waterproof shrink sleeves.

2.1.1 Factory-Applied Insulation

Insulation shall be polyurethane foam either spray applied or injected with one shot into the annular space between carrier pipe and jacket with a minimum thickness of one inch. Insulation shall be rigid, 90-95% closed cell polyurethane with a 2.0 to 3.0 pounds per cubic foot density and coefficient of thermal conductivity (K- Factor) of 0.16 and shall conform to ASTM C591. Maximum operating temperature shall not exceed 250°F. Insulation thickness shall be specified by calling out appropriate carrier pipe and jacket size combinations, and shall not result in less than 1" thickness.

2.1.2 Jacketing Material

Jacketing material shall be extruded, black, high density polyethylene (HDPE), having a minimum wall thickness of 100 mils for pipe sizes equal to or less than 12", 125 mils for jacket sizes greater than 12" to 24", and 150 mils for jacket sizes greater than 24". The inner surface of the HDPE jacket shall be oxidized by means of corona treatment, flame treatment (patent pending), or other approved methods. This will ensure a secure bond between the jacket and foam insulation preventing any ingress of water at the jacket/ foam interface.

2.1.3 Joints and Fittings

Straight run joints consisting of pipe and jacket are butt fusion welded and field insulated using urethane foam to the thickness specified and jacketed with a heat shrinkable sleeve over the HDPE sleeve mold. Joints can be made beside the trench or inside the trench. Carrier pipe fittings of the same material and pressure rating shall be heat fusion butt-welded to adjacent pipe sections. Fittings that are butt fusion welded are to be field insulated or, at engineer's option, factory insulated. If fittings

are factory manufactured, fittings are pre-insulated using factory PE fitting covers welded to the jackets.

2.1.4 Factory-Applied End Seals

Provide watertight end seal, or factory lay-up type end seal between carrier pipe and conduit. Provide sufficient surface bonding area between carrier pipe and conduit to ensure permanent watertight end seal suitable for use with temperature limits of carrier pipe.

2.1.5 Factory-Prefabricated Carrier Piping

Pipe, fittings, flanges, and couplings shall be marked with manufacturer's name, product identification, and publication to which items conform. Carrier piping shall be as specified in this section. Buried carrier pipe connections between straight sections of pipe beyond 5 feet exterior of buildings may be manufacturer's standard O-ring connections designed to absorb pipe expansion and contraction at working pressure of 125 psig with no leakage. Connections at elbows and tees shall be other than O-ring connections.

2.2 CARRIER PIPING

2.2.1 HDPE Piping

Carrier pipe shall be high density polyethylene (HDPE), conforming to ASTM D3350 and the specification standards listed below. Pipe and fittings are manufactured from extra high molecular weight polyethylene compound and fabricated to Standard Dimensional Ratio (SDR) wall thickness in standard IPS sizes. Available pressure ratings range from 50 psi (SDR-32.5) to 255 psi (SDR-7.3) at 73°F, with operating temperatures from -50°F and lower, to +140°F by applying an appropriate design factor.

2.3 BURIED WARNING AND IDENTIFICATION TAPE

Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 3 inches minimum width, color coded for the utility involved with warning and identification imprinted in bold black letters continuously and repeatedly over entire tape length. Warning and identification shall read "CAUTION BURIED PREINSULATED WATER PIPING BELOW" or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

2.4 CONCRETE THRUST BLOCKS

Provide concrete thrust blocks as specified in Section 03 47 13 TILT-UP CONCRETE. Concrete shall be of 4000 psi minimum 28 day compressive strength, air-entrained admixture (3.6 ounces per cubic yard) with water-reducing admixture (22 ounces per cubic yard).

2.5 PIPE SLEEVES

Provide where piping passes entirely through walls and floors. Provide sleeves of sufficient length to pass through entire thickness of walls and floors. Provide one inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack

space with mineral wool insulation. Seal space at both ends of sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of sleeves or core-drilled holes with UL listed fill, void, or cavity material.

- a. Sleeves in masonry and concrete walls and floors: Provide hot-dip galvanized steel, ductile-iron, or cast-iron sleeves. Core drilling of masonry and concrete may be provided in lieu of sleeves when cavities in the core-drilled hole are grouted smooth.
- b. Sleeves in other than masonry and Concrete walls and floors: Provide 26 gage galvanized steel sheet.

2.6 ESCUTCHEON PLATES

Provide split hinge type metal plates for piping entering walls and floors in exposed spaces. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces. Provide paint finish on metal plates in unfinished spaces.

PART 3 EXECUTION

3.1 INSTALLATION

Installation of exterior buried factory-prefabricated preinsulated water piping systems shall be in accordance with manufacturer's installation manual. Deviations shall not be permitted unless authorized in writing by Contracting Officer. Install piping straight and true to bear evenly on sand bedding material. Field-engineered piping systems shall be fabricated from factory insulated sections of straight pipe and fittings. When practical, piping shall be provided in 40-foot double-random lengths. All HDPE piping shall have ends cut square in preparation for butt fusion welding.

- a. Cleaning of piping: Keep interior and ends of new piping and existing piping affected by the Contractor's operations, cleaned of water and foreign matter during installation by means of plugs or other approved methods. When work is not in progress, securely close open ends of pipe and fittings to prevent entry of water and foreign matter. Inspect piping before placing into position.
- b. Demolition: Remove materials so as not to damage materials which are to remain. Replace existing work damaged by the Contractor's operations with new work of the same construction.

3.2 FIELD JOINTS

Carrier pipe joining shall be accomplished using an authorized butt fusion welding machine preheated to the correct pipe temperature for fusion welding. All heating surfaces shall be clean and free of dirt and residue before applying to ends of pipe to be joined. After heating, the softened ends are pressed together by the machine and held until the joint has hardened. Improperly accomplished, uneven, or joints with questionable appearance shall be cut out and re-accomplished. Transitions to other piping materials shall be accomplished using suitable flanged or mechanical adapters.

3.3 BURIED FACTORY-PREFABRICATED PREINSULATED PIPE INSTALLATION

- a. Assembly and alignment: Assemble carrier pipe and fittings according to manufacturer's installation manual; assemble plastic RTR piping in accordance with the Federal Agency Approved Brochure. Maintain proper alignment during assembly of joints.
- b. Bedding: Accurately grade trench bedding with a minimum of 6 inches of manufactured or natural sand. Backfill sand to a minimum of 6 inches above and below conduit. Lay bedding to firmly support conduit along entire length.
- c. Concrete thrust blocks: Encase each elbow and tee of carrier pipe in thrust block with minimum of 3 square feet of thrust-bearing surface cast against undisturbed soil, minimum pipe-to-bearing surface single dimension of 10 inches perpendicular to bearing surface, and minimum volume of 9 cubic feet, except as indicated otherwise. Disturbed soil under and around thrust blocks shall be compacted.

3.4 FIELD QUALITY CONTROL

Before final acceptance of work, test each system to demonstrate compliance with contract requirements. Thoroughly flush and clean piping before placing in operation. Flush piping at minimum velocity of 8 fps. Correct defects in the work and repeat tests until work is in compliance with contract requirements. Furnish potable water, electricity, instruments, connecting devices, and personnel for tests.

- a. Field tests of carrier piping: Do not cover carrier piping joints with insulation or concrete anchors (thrust blocks), until carrier piping joints pass field tests.
- b. Hydrostatic pressure test: A hydrostatic pressure test shall be performed before insulating the field joints or burying the system and shall be performed per the Engineer's specifications. The factory recommended pressure test consists of an expansion phase and a test phase. Care shall be taken to insure all trapped air is removed from the system prior to the test. The expansion phase consists of an initial pressurization period of three hours at on and one-half times the normal system operating pressure. Makeup water shall be added to the system during this period to maintain the desired pressure. The test shall commence immediately after the expansion phase. The pressure shall be reduced by 10 psi and the test clock started. System pressure remaining within 5% of the target test pressure for one hour indicates no leakage has occurred. If the entire test procedure cannot be completed within eight hours of the initial pressurization, the system shall be de-pressurized and allowed to relax for a minimum of eight hours before another test is attempted. The piping system shall be restrained from uncontrolled movement in the event of a failure. Appropriate safety precautions shall be taken to guard against possible injury to personnel in the event of a failure.
- c. Thrust blocks: If O-ring connections are used, provide temporary thrust blocks prior to hydrostatic pressure testing of piping system. Place bedding and backfill around center portion of piping system, leaving thrust blocks and field joints clear for observation. After successful completion of hydrostatic pressure test, cast concrete thrust blocks.

- d. Field inspections: Prior to initial operation, inspect piping system for compliance with drawings, specifications, and manufacturer's submittals.

-- End of Section --

SECTION 33 71 01

OVERHEAD TRANSMISSION AND DISTRIBUTION

01/07

PART 1 GENERAL

1.1 REFERENCES

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

ALLIANCE FOR TELECOMMUNICATIONS INDUSTRY SOLUTIONS (ATIS)

ATIS 05.1 (2002) Wood Products - Specifications and Dimensions

ASME INTERNATIONAL (ASME)

ASME B16.11 (2016) Forged Fittings, Socket-Welding and Threaded

ASTM INTERNATIONAL (ASTM)

ASTM A 53/A 53M (2002) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A 153/A 153M (2001; Rev. A) Zinc Coating (Hot-Dip) on Iron and Steel Hardware - AASHTO No.: M232

ASTM A 475 (1998) Zinc-Coated Steel Wire Strand

ASTM B 1 2013) Standard Specification for Hard-Drawn Copper Wire

ASTM B 2 (2000) Medium-Hard-Drawn Copper Wire

ASTM B 3 (2013) Standard Specification for Soft or Annealed Copper Wire

ASTM B 8 (2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM B 231/B 231M (1999) Concentric-Lay-Stranded Aluminum 1350 Conductors

ASTM B 397 (1985; R 1999) Concentric-Lay-Stranded Aluminum-Alloy 5005-H19 Conductors

ASTM B 399/B 399M (1999) Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 Conductors

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

- AWPA C1 (2003) All Timber Products - Preservative Treatment by Pressure Processes
- AWPA C4 (1995) Poles - Preservative Treatment by Pressure Processes
- AWPA C25 (1995) Sawn Crossarms, - Preservative Treatment by Pressure Processes

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

- IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
- IEEE C62.11 (2020) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
- IEEE C135.22 (1988) Zinc-Coated Ferrous Pole-Top Insulator Pins with Lead Threads for Overhead Line Construction

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- NEMA C29.5 (1984; R 2002) Wet-Process Porcelain Insulators - Low- and Medium-Voltage Types
- NEMA C37.42 (1996) High Voltage Expulsion Type Distribution Class Fuses, Cutouts, Fuse Disconnecting Switches and Fuse Links

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

U.S. DEPARTMENT OF AGRICULTURE (USDA)

- RUS 202-1 (2001; Supp. 2002) List of Materials Acceptable for Use on Systems of RUS Electrification Borrowers
- RUS 1728F-700 (1993) Wood Poles, Stubs, and Anchor Logs

UNDERWRITERS LABORATORIES (UL)

- UL 6 (2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
- UL 510 (2020) UL Standard for Safety Polyvinyl

Chloride, Polyethylene and Rubber
Insulating Tape

1.2 RELATED REQUIREMENTS

Section 26 08 00, "Apparatus Inspection and Testing" applies to this section with additions and modifications specified herein.

1.3 SUBMITTALS

The following shall be submitted in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

Public Works (Code 404), Building 1005 Michael Road, Camp Lejeune, North Carolina will review and approve transformer submittals. As an exception to this paragraph, transformers manufactured by ABB in Athens, GA; by Cooper Power Systems in Waukesha, WI or Nacogdoches, TX; or by Howard Industries in Laurel, MS need not meet the submittal requirements of this contract. Instead, the following shall be submitted.

- a. A certification, from the manufacturer, that the technical requirements of this specification shall be met.
- b. Routine and other tests (paragraph entitled "Routine and Other Tests, shall be conducted by the manufacturer and may be witnessed by the Government (paragraph entitled "Source Quality Control"). Provide certified copies of the tests.
- c. Provide field test reports (paragraph entitled "Field Quality Control").

SD-03 Product Data

Conductors; G

Insulators; G

Wood Poles; G

Cutouts; G

Surge arresters; G

Guy strand

Anchors

SD-06 Test Reports

Field Test Plan

Field Quality Control

Utility Contractor Qualifications

Ground resistance test reports

SD-07 Certificates

Wood poles

Composite crossarms

1.4 QUALITY ASSURANCE

1.4.1 Ground Resistance Test Reports

Submit the measured ground resistance of grounding system. When testing grounding electrodes and grounding systems, identify each grounding electrode and each grounding system for testing. Include the test method and test setup (i.e. pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

1.4.2 Field Test Plan

Provide a proposed field test plan 20 days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

1.4.3 Utility Contractor Qualifications

The utility contractor must have a North Carolina Public Utility Electrical Contractor's License.

1.5 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Oil filled transformers and switches shall be stored in accordance with the manufacturer's requirements.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Consider materials specified herein or shown on contract drawings which are identical to materials listed in [RUS 202-1](#) as conforming to requirements.

2.2 POLES

Poles shall be of lengths and classes indicated.

2.2.1 Wood Poles

Wood poles machine trimmed by turning, Southern Yellow Pine conforming to [ATIS 05.1](#) and [RUS 1728F-700](#). Gain, bore and roof poles before treatment. Should additional gains be required subsequent to treatment, metal gain plates shall be provided. Pressure treat poles with chromated copper arsenate (CCA), except that Douglas Fir and Western Larch poles shall not be treated with CCA in accordance with [AWPA C1](#) and [AWPA C4](#) as referenced in [RUS 1728F-700](#). The quality of each pole shall be ensured with "WQC" (wood quality control) brand on each piece, or by an approved inspection agency report.

2.3 CROSSARMS

2.3.1 Composite Crossarms

2.3.2 Crossarm Braces

Provide steel angle as indicated. Provide braces with 38 inch span for 8 foot crossarms and 60 inch span for 10 foot crossarms.

2.3.3 Armless Construction

Pole mounting brackets for line-post or pin insulators and eye bolts for suspension insulators shall be as shown. Brackets shall be attached to poles with a minimum of two bolts. Brackets may be either provided integrally as part of an insulator or attached to an insulator with a suitable stud. Bracket mounting surface shall be suitable for the shape of the pole. Brackets for wood poles shall have wood gripping members. Horizontal offset brackets shall have a 5-degree uplift angle. Pole top brackets shall conform to IEEE C135.22, except for modifications necessary to provide support for a line-post insulator. Brackets shall provide a strength exceeding that of the required insulator strength, but in no case less than a 2800 pound cantilever strength.

2.4 HARDWARE

Hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M.

2.5 INSULATORS

Provide wet-process porcelain insulators which are radio interference free.

a. Pin insulators: NEMA C29.5, Class 55-5.

2.6 OVERHEAD CONDUCTORS

Conductors of bare copper and aluminum alloy (AAAC) of sizes and types indicated.

2.6.1 Solid Copper

ASTM B 1, ASTM B 2, and ASTM B 3, hard-drawn, medium-hard-drawn, and soft-drawn, respectively. ASTM B 8, stranded.

2.6.2 Aluminum

ASTM B 231/B 231M.

2.6.2.1 Aluminum Alloy

ASTM B 397 or ASTM B 399/B 399M.

2.7 GUY STRAND

ASTM A 475, high-strength, Class A or B, galvanized strand steel cable. Guy strand shall be 3/8 inch in diameter with a minimum breaking strength of 12,000 pounds. Provide guy terminations designed for use with the particular strand and developing at least the ultimate breaking strength of the strand.

2.8 ROUND GUY GUARDS

Vinyl or PVC material, yellow colored, 8 feet long and shatter resistant at sub-zero temperatures.

2.8.1 Guy Attachment

Thimble eye guy attachment.

2.9 ANCHORS AND ANCHOR RODS

Anchors shall be screw anchors presenting holding area indicated on drawings as a minimum. Anchor rods shall be triple thimble-eye, 3/4 inch diameter by 8 feet long. Anchors and anchor rods shall be hot dip galvanized.

2.9.1 Screw Anchors

Screw type anchors having a manufacturer's rating of not less than 6,000 pounds in loose to medium sand/clay soil, Class 6 and extra heavy pipe rods conforming to ASTM A 53/A 53M, Schedule 80, and couplings conforming to ASME B16.11.

2.10 GROUND RODS

Copper clad steel ground rods at least 3/4 inch in diameter and 10 feet long. Die-stamp each near top with name or trademark of manufacturer and length of rod in feet. Rods shall have a hard, clean, smooth, continuous, surface throughout length of rod.

2.10.1 Ground Wire

Provide soft drawn copper wire ground conductors a minimum No. 4 AWG. Ground wire protectors may be either PVC or half round wood molding. Wood molding shall be fir, pressure treated in accordance with AWPAC25, or shall be cypress or cedar.

2.11 SURGE ARRESTERS

IEEE C62.11, metal oxide, porcelain housed, surge arresters arranged for crossarm mounting. RMS voltage rating shall be 10 kV. Arresters shall be Distribution class.

2.12 FUSED CUTOUTS

Open type fused cutouts rated 100 amperes and 12,000 amperes symmetrical interrupting current at 7.8 kV ungrounded, conforming to NEMA C37.42. Type K fuses conforming to NEMA C37.42 with ampere ratings equal to 150 percent of the transformer full load rating. Open link type fuse cutouts are not acceptable.

2.13 CONDUIT RISERS AND CONDUCTORS

The riser shield shall be PVC containing a PVC back plate and PVC extension shield or a rigid galvanized steel conduit, as indicated, and conforming to UL 6. Provide conductors and terminations as specified in Section 33 71 02 "Underground Transmission and Distribution."

2.14 ELECTRICAL TAPES

Tapes shall be UL listed for electrical insulation and other purposes in wire and cable splices. Terminations, repairs and miscellaneous purposes, electrical tapes shall comply with UL 510.

2.15 CALKING COMPOUND

Compound for sealing of conduit risers shall be of a puttylike consistency workable with hands at temperatures as low as 35 degrees F, shall not slump at a temperature of 300 degrees F, and shall not harden materially when exposed to air. Compound shall readily calk or adhere to clean surfaces of the materials with which it is designed to be used. Compound shall have no injurious effects upon the workmen or upon the materials.

PART 3 EXECUTION

3.1 INSTALLATION

Provide overhead pole line installation conforming to requirements of IEEE C2 for Grade B construction of overhead lines in medium loading districts and NFPA 70 for overhead services. Provide material required to make connections into existing system and perform excavating, backfilling, and other incidental labor. Consider street, alleys, roads and drives "public." Pole configuration shall be as indicated.

3.1.1 Wood Pole Installation

Provide pole holes at least as large at the top as at the bottom and large enough to provide 4 inch clearance between the pole and side of the hole. Provide a 6 inch band of soil around and down to the base of the pole treated with 2 to 3 gallons of a one percent dursban TC termiticide solution.

3.1.1.1 Setting Depth of Pole

Pole setting depths shall be as follows:

Length of Pole (feet)	Setting in Soil (feet)	Setting in Solid Rock (feet)
40	6.0	4.0

3.1.1.2 Setting in Soil, Sand, and Gravel

"Setting in Soil" depths, as specified in paragraph entitled "Setting Depth of Pole," apply where the following occurs:

- Where pole holes are in soil, sand, or gravel or any combination of these;
- Where soil layer over solid rock is more than 2 feet deep;
- Where hole in solid rock is not substantially vertical; or
- Where diameter of hole at surface of rock exceeds twice the diameter of pole at same level. At corners, dead ends and other points of extra strain, poles 40 feet or more long shall be set 6 inches deeper.

3.1.1.3 Setting in Solid Rock

"Setting in Solid Rock," as specified in paragraph entitled "Setting Depth of Pole," applies where poles are to be set in solid rock and where hole is substantially vertical, approximately uniform in diameter and large enough to permit use of tamping bars the full depth of hole.

3.1.1.4 Setting With Soil Over Solid Rock

Where a layer of soil **2 feet** or less in depth over solid rock exists, depth of hole shall be depth of soil in addition to depth specified under "Setting in Solid Rock" in paragraph entitled "Setting Depth of Pole," provided, however, that such depth shall not exceed depth specified under "Setting in Soil."

3.1.1.5 Setting on Sloping Ground

On sloping ground, always measure hole depth from low side of hole.

3.1.1.6 Backfill

Thoroughly tamp pole backfill for full depth of the hole and mound excess fill around the pole.

3.1.1.7 Setting Poles

Set poles so that alternate crossarm gains face in opposite directions, except at terminals and dead ends where gains of last two poles shall be on side facing terminal or dead end. On unusually long spans, set poles so that crossarm comes on side of pole away from long span. Where pole top pins are used, they shall be on opposite side of pole from gain, with flat side against pole.

3.1.1.8 Alignment of Poles

Set poles in alignment and plumb except at corners, terminals, angles, junctions, or other points of strain, where they shall be set and raked against the strain. Set not less than **2 inches** for each **10 feet** of pole length above grade, nor more than **4 inches** for each **10 feet** of pole length after conductors are installed at required tension. When average ground run is level, consecutive poles shall not vary more than **5 feet** in height. When ground is uneven, poles differing in length shall be kept to a minimum by locating poles to avoid the highest and lowest ground points. If it becomes necessary to shorten a pole, a piece shall be sawed off the top. Holes shall be dug large enough to permit the proper use of tampers to full depth of hole.

3.1.2 Anchors and Guys

Place anchors in line with strain. The length of the guy lead (distance from base of pole to the top of the anchor rod) shall be as indicated.

3.1.2.1 Setting Anchors

Set anchors in place with anchor rod aligned with, and pointing directly at, guy attachment on the pole with the anchor rod projecting **6 to 9 inches** out of ground to prevent burial of rod eye.

3.1.2.2 Screw Anchors

Install screw anchors by torquing with boring machine.

3.1.2.3 Swamp Anchors

Install swamp anchors by torquing with boring machine or wrenches, adding sections of pipe as required until anchor helix is fully engaged in firm soil.

3.1.2.4 Setting Guy Strands

Complete anchor and guy installation, dead end to dead end, and tighten guy before wire stringing and sagging is begun on that line section. Provide strain insulators at a point on guy strand 8 feet minimum from the ground and 6 feet minimum from the surface of pole.

3.1.3 Hardware

Provide hardware with washer against wood and with nuts and lock nuts applied wrench tight. Provide locknuts on threaded hardware connections. Locknuts shall be M-F style and not palnut style.

3.1.4 Grounding

Unless otherwise indicated, grounding shall conform to IEEE C2. Pole grounding electrodes shall have a resistance to ground not exceeding 25 ohms. When work in addition to that indicated or specified is directed in order to obtain specified ground resistance, provisions of the contract covering changes shall apply.

3.1.4.1 Ground Rod Connections

Make ground rod connections on pole lines by exothermic weld or by using a compression connector for ground wire or wire to rod connections. Make exothermic welds strictly in accordance with manufacturer's written recommendations. Welds which have puffed up or which show convex surfaces indicating improper cleaning, are not acceptable. No mechanical connectors are required at exothermic weldments. Compression connectors shall be type that uses a hydraulic compression tool to provide correct pressure. Provide tools and dies recommended by compression connector manufacturer. An embossing die code or similar method shall provide visible indication that a connector has been fully compressed on ground wire.

3.1.4.2 Grounding and Grounded Connections

- a. Where no primary or common neutral exists, surge arresters and frames of equipment operating at over 750 volts shall be bonded together and connected to a dedicated primary grounding electrode.
- b. Where no primary or common neutral exists, transformer secondary neutral bushing, secondary neutral conductor, and frames of equipment operating at under 750 volts shall be bonded together and connected to a dedicated secondary grounding electrode.
- c. When a primary or common neutral exists, connect all grounding and grounded conductors to a common grounding electrode.

3.1.4.3 Protective Molding

Protect grounding conductors which are run on surface of wood poles by wood molding extending from ground line throughout communication and transformer spaces.

3.1.5 CONDUCTOR INSTALLATION

3.1.5.1 Line Conductors

Conductors shall be handled with care necessary to prevent nicking, kinking, gouging, abrasions, sharp bends, cuts, flattening, or otherwise deforming or weakening conductor or any damage to insulation or impairing its conductivity. Remove damaged sections of conductor and splice conductor. Conductors shall be paid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Bend radius for any insulated conductor shall not be less than the applicable NEMA specification recommendation. Conductors shall not be drawn over rough or rocky ground, nor around sharp bends.

3.1.5.2 Connectors and Splices

Conductor splices, as installed, shall exceed ultimate rated strength of conductor and shall be of type recommended by conductor manufacturer. No splice shall be permitted within 10 feet of a support. Connectors and splices shall be mechanically and electrically secure under tension and shall be of the nonbolted compression type. The tensile strength of any splice shall be not less than the rated breaking strength of the conductor. Splice materials, sleeves, fittings, and connectors shall be noncorrosive and shall not adversely affect conductors. Aluminum-composition conductors shall be wire brushed and an oxide inhibitor applied before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable. Inhibitors and compression tools shall be of types recommended by the connector manufacturer. Primary line apparatus taps shall be by means of hot line clamps attached to compression type bail clamps (stirrups). Low-voltage connectors for copper conductors shall be of the solderless pressure type. Noninsulated connectors shall be smoothly taped to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors. On overhead connections of aluminum and copper, the aluminum shall be installed above the copper.

3.1.5.3 Conductor-To-Insulator Attachments

Conductors shall be attached to insulators by means of clamps, shoes or tie wires, in accordance with the type of insulator. For insulators requiring conductor tie-wire attachments, tie-wire sizes shall be as indicated in TABLE II.

TABLE II

TIE-WIRE REQUIREMENTS

CONDUCTOR Copper (AWG)	TIE WIRE Soft-Drawn Copper (AWG)
6	8
4 and 2	6
1 through 3/0	4

TABLE II

TIE-WIRE REQUIREMENTS

CONDUCTOR	TIE WIRE
Copper (AWG)	Soft-Drawn Copper (AWG)
4/0 and larger	2
AAC, AAAC, or ACSR (AWG)	AAAC OR AAC (AWG)
Any size	6 or 4

3.1.5.4 Armor Rods

Armor rods shall be provided for AAC and AAAC. Armor rods shall be installed at supports, except armor rods will not be required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used. Lengths and methods of fastening armor rods shall be in accordance with the manufacturer's recommendations. For span lengths of less than 200 feet, flat aluminum armor rods may be used. Flat armor rods, not less than 0.03 by 0.25 inch shall be used on No. 1 AWG AAC and AAAC and smaller conductors and on No. 5 AWG ACSR and smaller conductors. On larger sizes, flat armor rods shall be not less than 0.05 by 0.30 inches. For span lengths of 200 feet or more, preformed round armor rods shall be used.

3.1.5.5 Ties

Provide ties on pin insulators tight against conductor and insulator and ends turned down flat against conductor so that no wire ends project.

3.1.5.6 Reinstalling Conductors

Existing conductors to be reinstalled or resagged shall be strung to "final" sag table values indicated for the particular conductor type and size involved.

3.1.5.7 New Conductor Installation

String new conductors to "initial" sag table values recommended by the manufacturer for conductor type and size of conductor and ruling span indicated.

3.1.5.8 Fittings

Dead end fittings, clamp or compression type, shall conform to written recommendations of conductor manufacturer and shall develop full ultimate strength of conductor.

3.1.5.9 Aluminum Connections

Make aluminum connections to copper or other material using only splices, connectors, lugs, or fittings designed for that specific purpose. Keep a copy of manufacturer's instructions for applying these fittings at job site for use of the inspector.

3.1.6 Risers

Secure galvanized steel conduits on poles by two hole galvanized steel

pipe straps spaced as indicated and within 3 feet of any outlet or termination. Ground metallic conduits.

3.2 FIELD QUALITY CONTROL

3.2.1 General

The Contractor shall notify the Contracting Officer 14 days prior to conducting tests. The Contractor shall furnish materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field reports will be signed and dated by the Contractor.

3.2.2 Safety

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

3.2.3 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.2.3.1 Current Transformers

a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical and mechanical condition.
- (3) Verify correct connection.
- (4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
- (5) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

- (1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter
- (2) Perform insulation-resistance tests.
- (3) Perform polarity tests.
- (4) Perform ratio-verification tests.

3.2.3.2 Metering

a. Visual and Mechanical Inspection

- (1) Compare equipment nameplate data with specifications and approved shop drawings.
- (2) Inspect physical and mechanical condition.
- (3) Verify tightness of electrical connections.

b. Electrical Tests

- (1) Verify accuracy of meters at 25 percent, 50 percent, 75 percent, and 100 percent of full scale.
- (2) Calibrate watthour meters according to manufacturer's published data.
- (3) Verify all instrument multipliers.

3.2.3.3 Grounding System

a. Visual and mechanical inspection

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

b. Electrical tests

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

3.2.4 Devices Subject to Manual Operation

Each device subject to manual operation shall be operated at least three times, demonstrating satisfactory operation each time.

3.2.5 Follow-Up Verification

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

-- End of Section --

SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION

12/10

PART 1 GENERAL

1.1 REFERENCES

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

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8 (2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM B1 (2013) Standard Specification for Hard-Drawn Copper Wire

ASTM B3 (2013) Standard Specification for Soft or Annealed Copper Wire

ASTM B8 (2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM F 512 (2006) Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

IEEE C37.20.3 (2001; R 2006) Metal-Enclosed Interrupter Switchgear

IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms

IEEE 386 (2016) Separable Insulated Connector Systems for Power Distribution Systems Rated 2.5 kV through 35 kV

IEEE Std 400.2 (2004) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)

IEEE Std 404 (2006) Extruded and Laminated Dielectric

Shielded Cable Joints Rated 2500 V Through
500 000 V

IEEE Std 48

(2009) Test Procedures and Requirements
for Alternating-Current Cable Terminations
2.5 kV through 765 kV

IEEE Std 81

(1983) Guide for Measuring Earth
Resistivity, Ground Impedance, and Earth
Surface Potentials of a Ground System
(Part 1) Normal Measurements

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C119.1

(2006) Sealed Insulated Underground
Connector Systems Rated 600 Volts

NEMA RN 1

(2017; Errata 2017) Standard for
Polyvinyl-Chloride (PVC) Externally Coated
Galvanized Rigid Steel Conduit and
Intermediate Metal Conduit

NEMA TC 6 & 8

(2003) Standard for Polyvinyl Chloride PVC
Plastic Utilities Duct for Underground
Installations

NEMA TC 9

(2004) Standard for Fittings for Polyvinyl
Chloride (PVC) Plastic Utilities Duct for
Underground Installation

NEMA WC 71

(1999) Nonshielded Power Cables Rated
2001-5000 Volts for Use in the
Distribution of Electric Energy ICEA
S-96-659-1999

NEMA WC 74

(2006) Standard for 5-46 kV Shielded Power
Cable for use in the Transmission and
Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70

(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA
20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758-A

(2004) Customer-Owned Outside Plant
Telecommunications Cabling Standard

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644

(2002) Underground Plant Construction

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-60005

(Basic; Notice 1) Frames, Covers,
Gratings, Steps, Sump And Catch Basin,
Manhole

UNDERWRITERS LABORATORIES (UL)

UL 1072

(2006; Rev thru Sep 2007) Medium-Voltage
Power Cables

UL 1242

(2006; Reprint Aug 2020) Standard for
Electrical Intermediate Metal Conduit --
Steel

UL 44

(2018) UL Standard for Safety
Thermoset-Insulated Wires and Cables

UL 467

(2013; Reprint Jun 2017) UL Standard for
Safety Grounding and Bonding Equipment

UL 486A-486B

(2018) UL Standard for Safety Wire
Connectors

UL 510

(2020) UL Standard for Safety Polyvinyl
Chloride, Polyethylene and Rubber
Insulating Tape

UL 514A

(2013; Reprint Aug 2017) UL Standard for
Safety Metallic Outlet Boxes

UL 514B

(2012; Reprint May 2020) Conduit, Tubing
and Cable Fittings

UL 6

(2007; Reprint Sep 2019) UL Standard for
Safety Electrical Rigid Metal Conduit-Steel

UL 651

(2011; Reprint Mar 2020) UL Standard for
Safety Schedule 40, 80, Type EB and A
Rigid PVC Conduit and Fittings

UL 83

(2017; Reprint Mar 2020) UL Standard for
Safety Thermoplastic-Insulated Wires and
Cables

UL 854

(2020) Standard for Service-Entrance Cables

1.2 DEFINITIONS

- a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.
- b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.
- c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have

the same meaning.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

SD-03 Product Data

Medium voltage cable; G

Medium voltage cable joints; G

Medium voltage cable terminations; G

Precast concrete structures; G

Manhole frames and covers; G

Handhole frames and covers; G

Composite/fiberglass handholes; G

Cable supports (racks, arms and insulators); G

SD-06 Test Reports

Arc-proofing test for cable fireproofing materials

Medium voltage cable qualification and production tests

Field Acceptance Checks and Tests

Arc-proofing test for cable fireproofing tape

Cable Installation Plan and Procedure

Six copies of the information described below in 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Sections shall be separated by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

- a. Site layout drawing with cable pulls numerically identified.
- b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.
- c. The cable manufacturer and type of cable.
- d. The dates of cable pulls, time of day, and ambient temperature.
- e. The length of cable pull and calculated cable pulling

tensions.

f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Cable splicer/terminator

Cable Installer Qualifications

1.4 QUALITY ASSURANCE

1.4.1 Certificate of Competency for Cable Splicer/Terminator

Certification of the qualification of the cable splicer/terminator shall be submitted, for approval, 30 days before splices or terminations are to be made in medium voltage (5 kV to 35 kV) cables. The certification shall include the training, and experience of the individual on the specific type and classification of cable to be provided under this contract. The certification shall indicate that the individual has had three or more years recent experience splicing and terminating medium voltage cables. The certification shall also list a minimum of three splices/terminations that have been in operation for more than one year. In addition, the individual may be required to perform a dummy or practice splice/termination in the presence of the Contracting Officer, before being approved as a qualified cable splicer. If that additional requirement is imposed, the Contractor shall provide short sections of the approved types of cables along with the approved type of splice/termination kit, and detailed manufacturer's instructions for the cable to be spliced. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for certification of an alternate cable splicer.

1.4.2 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers. **The utility contractor must have a North Carolina Public Utility Electrical Contractor's License.**

1.4.3 Regulatory Requirements

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

1.4.4 Standard Products

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

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

1.4.4.1 Alternative Qualifications

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

1.4.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6, galvanized steel, threaded type.

2.1.1.1 Rigid Metallic Conduit, PVC Coated

UL 6, galvanized steel, threaded type, coat with polyvinyl chloride (PVC) sheath bonded to galvanized exterior surface, nominal 40 mil thick conforming to NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A durometer, dielectric strength shall be minimum 400 volts per mil at 60 Hz, and tensile strength shall be minimum 3500 psi and aging shall be minimum 1000 hours in an Atlas Weatherometer.

2.1.2 Intermediate Metal Conduit

UL 1242, galvanized steel, threaded type..

2.1.2.1 Intermediate Metal Conduit, PVC Coated

UL 1242, galvanized steel, threaded type, coated with polyvinyl chloride (PVC) sheath bonded to the galvanized exterior surface, nominal 40 mil thick, conforming to NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A durometer, dielectric strength shall be minimum 400 volts per mil at 60 Hz, and tensile strength shall be minimum 3500 psi and aging shall be minimum 1000 hours in an Atlas Weatherometer.

2.1.3 Plastic Conduit for Direct Burial

UL 651, Schedule 40.

2.1.4 Plastic Duct for Concrete Encasement

NEMA TC 6 & 8 and ASTM F 512, UL 651, EPC-40-PVC.

2.1.5 Conduit Sealing Compound

Compounds for sealing ducts and conduit shall have a putty-like consistency workable with the hands at temperatures as low as 35 degrees F, shall neither slump at a temperature of 300 degrees F, nor harden materially when exposed to the air. Compounds shall adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds shall form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect upon the hands of workmen or upon materials. Inflatable bladders may be used as an option.

2.1.6 Fittings

2.1.6.1 Metal Fittings

UL 514B, threaded type.

2.1.6.2 PVC Conduit Fittings

UL 514B, UL 651.

2.1.6.3 PVC Duct Fittings

NEMA TC 9.

2.1.6.4 Outlet Boxes for Steel Conduit

Outlet boxes for use with rigid or flexible steel conduit shall be cast-metal cadmium or zinc-coated if of ferrous metal with gasketed closures and shall conform to UL 514A.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors shall be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements. Wires and cables manufactured more than 12 months prior to date of delivery to the site shall not be accepted. Service entrance conductors shall conform to UL 854, type USE.

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller shall be solid copper. Conductors No. 8 AWG and larger shall be stranded copper. All conductors shall be copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, shall be 600-volt, Type THWN/THHN conforming to UL 83 or Type XHHW or RHW conforming to UL 44. Copper conductors shall be annealed copper complying with ASTM B3 and ASTM B8.

2.2.3 Jackets

Multiconductor cables shall have an overall PVC outer jacket.

2.2.4 Cable Marking

Insulated conductors shall have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Each cable shall be identified by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag shall contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

Conductors shall be color coded. Conductor identification shall be provided within each enclosure where a tap, splice, or termination is made. Conductor identification shall be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves, or colored electrical tape. Control circuit terminations shall be properly identified. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals shall be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems shall be as follows

a. 208/120 volt, three-phase

- (1) Phase A - black
- (2) Phase B - red
- (3) Phase C - blue

b. 480/277 volt, three-phase

- (1) Phase A - brown
- (2) Phase B - orange
- (3) Phase C - yellow

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

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Shall provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

- a. For use with copper conductors: UL 486A-486B.

2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply NEMA C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which shall be applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrink Rubber Splice

Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation shall not require heat or flame, or any additional materials such as covering or adhesive. It shall be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors shall have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than 12 months prior to date of delivery to the site shall not be accepted. Provide single conductor type cables unless otherwise indicated.

2.5.1 Cable Configuration

Provide Type MV 105 cable, conforming to NEMA WC 74 and UL 1072 with concentric neutral underground distribution cable conforming to ICEA S-94-649. Provide cables manufactured for use in duct applications. Cable shall be rated 15 kV with 133 percent insulation level.

2.5.2 Conductor Material

Provide concentric-lay-stranded, Class B conductors. Provide soft drawn copper cables complying with ASTM B3 and ASTM B8 for regular concentric and compressed stranding.

2.5.3 Insulation

Provide ethylene-propylene-rubber (EPR) insulation conforming to the requirements of NEMA WC 71 and AEIC CS8.

2.5.4 Shielding

Cables rated for 2 kV and above shall have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape shield for each phase.

2.5.5 Neutrals

Concentric neutral conductors must be copper, having a combined ampacity equal to the phase number ampacity rating.

2.5.6 Jackets

Cables shall be provided with a PVC jacket. Direct buried cables shall be

rated for direct burial. Provide PVC jackets with a separator that prevents contact when underlying semiconducting insulating shield.

2.6 MEDIUM VOLTAGE CABLE TERMINATIONS

IEEE Std 48 Class 1; of the molded elastomer, prestretched elastomer, or heat-shrinkable elastomer. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Terminations shall be provided in a kit, including: skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations shall be the product of one manufacturer, suitable for the type, diameter, insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.6.1 Cold-Shrink Type

Terminator shall be a one-piece design, utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is integrated within a skirted insulator made of silicone rubber. Termination shall not require heat or flame for installation. Termination kit shall contain all necessary materials (except for the lugs). Termination shall be designed for installation in low or highly contaminated indoor and outdoor locations and shall resist ultraviolet rays and oxidative decomposition.

2.6.2 Separable Insulated Connector Type

IEEE 386. Provide connector with steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material. Provide connectors of the loadbreak or deadbreak type as indicated, of suitable construction for the application and the type of cable connected, and that include cable shield adaptors. Provide external clamping points and test points.

- a. 200 Ampere loadbreak connector ratings: Voltage: 15 kV, 95 kV BIL.
Short time rating: 10,000 rms symmetrical amperes.

2.7 MEDIUM VOLTAGE CABLE JOINTS

Provide joints (splices) in accordance with **IEEE Std 404** suitable for the rated voltage, insulation level, insulation type, and construction of the cable. Joints shall be certified by the manufacturer for waterproof, submersible applications. Upon request, supply manufacturer's design qualification test report in accordance with **IEEE Std 404**. Connectors for joint shall be tin-plated electrolytic copper, having ends tapered and having center stops to equalize cable insertion.

2.7.1 Cold-Shrink Rubber-Type Joint

Joint shall be of a cold shrink design that does not require any heat source for its installation. Splice insulation and jacket shall be of a

one-piece factory formed cold shrink sleeve made of black EPDM rubber. Splice shall be packaged three splices per kit, including complete installation instructions.

2.8 TELECOMMUNICATIONS CABLING

Provide telecommunications cabling in accordance with Section 33 82 00.00 22 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

2.9 TAPE

2.9.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.9.2 Buried Warning and Identification Tape

Provide metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width, Red in color for electrica and Orange for telecommunications for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

2.9.3 Fireproofing Tape

Provide tape composed of a flexible conformable unsupported intumescent elastomer. Tape shall be not less than .030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, and shall not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.10 PULL ROPE

Shall be plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds. Leave a minimum of 24 inches of slack at each end of the pull wires.

2.11 GROUNDING AND BONDING

2.11.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length. Sectional type rods may be used for rods 20 feet or longer.

2.11.2 Grounding Conductors

Stranded-bare copper conductors shall conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors shall conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors shall be of the same material as phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Aluminum is not acceptable.

2.12 Precast concrete structures

Provide precast concrete support pad for transformer.

2.12.1 Precast Concrete Transformer Support (Pad)

In lieu of cast-in-place, Contractors, shall provide precast concrete structures designed for transformer support and subject to the requirements specified below. Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes.

2.12.1.1 General

Precast concrete structures shall have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures shall have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction shall be the same as for cast-in-place concrete construction, as modified herein. Concrete for precast work shall have a 28-day compressive strength of not less than 4000 psi. Structures shall be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.12.2 Manhole Frames and Covers

Provide cast iron frames and covers for manholes conforming to CID A-A-60005. Cast the words "ELECTRIC" or "TELECOMMUNICATIONS" in the top face of power and telecommunications manhole covers, respectively.

2.12.3 Handhole Frames and Covers

Frames and covers of steel shall be welded by qualified welders in accordance with standard commercial practice. Steel covers shall be rolled-steel floor plate having an approved antislip surface. Hinges shall be of stainless steel with bronze hinge pin, 5 by 5 inches by approximately 3/16 inch thick, without screw holes, and shall be for full surface application by fillet welding. Hinges shall have nonremovable pins and five knuckles. The surfaces of plates under hinges shall be true after the removal of raised antislip surface, by grinding or other approved method.

2.12.4 Composite/Fiberglass Handholes and Covers

Provide handholes and covers of polymer concrete, reinforced with heavy weave fiberglass.

2.13 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS)

The metal portion of racks and arms shall be zinc-coated after fabrication.

2.13.1 Cable Racks

The wall bracket shall be 4 inches by approximately 1-1/2 inch by 3/16 inch channel steel, 48 inches long (minimum) in manholes. Slots for mounting cable rack arms shall be spaced at 8 inch intervals.

2.13.2 Rack Arms

Cable rack arms shall be steel or malleable iron or glass reinforced nylon and shall be of the removable type. Rack arm length shall be a minimum of 8 inches and a maximum of 12 inches.

2.13.3 Insulators

Insulators for metal rack arms shall be dry-process glazed porcelain. Insulators are not required for nylon arms.

2.14 CABLE TERMINATING CABINETS

Cable terminating cabinets shall be hook-stick operable, deadfront construction conforming to the requirements of IEEE C37.20.3, Category A. Cabinets shall be provided with with 200 A. loadbreak junctions and elbow-type separable loadbreak connectors, cable parking stands, and grounding lugs. Provide cable terminating equipment in conformance with IEEE 386.

Ratings at 60 Hz shall be:

Nominal voltage (kV).....	12.47
Rated maximum voltage (kV).....	15
Rated continuous current (A).....	200
Three-second short-time current-carrying capacity (kA).....	10
BIL (kV).....	125

2.15 SOURCE QUALITY CONTROL

2.15.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer shall test one sample assembly consisting of a straight lead tube 12 inches long with a 2 1/2 inch outside diameter, and a 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing material per manufacturer's instructions. The arc and fireproofing tape shall withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode shall be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc shall be directed toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly shall be tested at three unrelated points. Start time for tests shall be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time shall be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape shall indicate that the test has been performed and passed by the manufacturer.

2.15.2 Medium Voltage Cable Qualification and Production Tests

Results of **AEIC CS8** qualification and production tests as applicable for each type of medium voltage cable.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of **NFPA 70** and **IEEE C2** as applicable. In addition to these requirements, install telecommunications in accordance with **TIA-758-A** and **RUS Bull 1751F-644**.

3.2 CABLE INSPECTION

Prior to installation, each cable reel shall be inspected for correct storage positions, signs of physical damage, and broken end seals. If end seal is broken, moisture shall be removed from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

The Contractor shall obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure. The Contractor shall then perform pulling calculations and prepare a pulling plan which shall be submitted along with the manufacturers instructions in accordance with SUBMITTALS. Cable shall be installed strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

Calculations and pulling plan shall include:

- a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.
- b. List of cable installation equipment.
- c. Lubricant manufacturer's application instructions.
- d. Procedure for resealing cable ends to prevent moisture from entering cable.
- e. Cable pulling tension calculations of all cable pulls.
- f. Cable percentage conduit fill.
- g. Cable sidewall bearing pressure.
- h. Cable minimum bend radius and minimum diameter of pulling wheels used.
- i. Cable jam ratio.

- j. Maximum allowable pulling tension on each different type and size of conductor.
- k. Maximum allowable pulling tension on pulling device.

3.4 UNDERGROUND FEEDERS SUPPLYING BUILDINGS

Terminate underground feeders supplying building at a point **5 feet** outside the building and projections thereof, except that conductors shall be continuous to the terminating point indicated. Coordinate connections of the feeders to the service entrance equipment with Section **26 20 00** INTERIOR DISTRIBUTION SYSTEM. Conduit shall be PVC, Type **schedule-40** from the supply equipment to a point **5 feet** outside the building and projections thereof. Protect ends of underground conduit with plastic plugs until connections are made.

3.5 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.5.1 Requirements

Depths to top of the conduit shall be in accordance with NFPA 70. Run conduit in straight lines except where a change of direction is necessary. Numbers and sizes of ducts shall be as indicated. Ducts shall have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of **3 inches per 100 feet**. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be **18 inches** for ducts of less than **3 inch** diameter, and **36 inches** for ducts **3 inches** or greater in diameter. Otherwise, long sweep bends having a minimum radius of **25 feet** shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever duct lines terminate in structures.

3.5.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer shall be used whenever an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.5.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes **3 inches** and larger, draw a flexible testing mandrel approximately **12 inches** long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than **3 inches**, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and

gravel; then immediately install conduit plugs.

3.5.4 Jacking and Drilling Under Roads and Structures

Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, shall be zinc-coated, rigid steel, jacked into place. Where ducts are jacked under existing pavement, rigid steel conduit will be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 50 feet in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 4 feet on centers. Hydraulic jet method shall not be used.

3.5.5 Galvanized Conduit Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations shall be PVC coated and shall extend from at least 2 inches within the concrete to the first coupling or fitting outside the concrete (minimum of 6 inches from penetration).

3.5.6 Multiple Conduits

Separate multiple conduits by a minimum distance of 2 1/2 inches, except that light and power conduits shall be separated from control, signal, and telephone conduits by a minimum distance of 12 inches. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.5.7 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty shall be provided with plugs on each end. Plugs shall contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of unused or empty conduits.

3.5.8 Conduit and Duct Without Concrete Encasement

Provide not less than 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 1/4 inch sieve. The first 6 inch layer of backfill cover shall be sand compacted as previously specified. The rest of the excavation shall be backfilled and compacted in 3 to 6 inch layers. Provide color, type and depth of warning tape as specified above.

3.5.8.1 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in

concrete encasement of rectangular cross-section providing a minimum of 3 inch concrete cover around ducts. Concrete encasement shall extend at least 5 feet beyond the edges of paved areas and roads, and 12 feet beyond the rails on each side of railroad tracks.

3.5.9 Duct Encased in Concrete

Construct underground duct lines of individual conduits encased in concrete. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank shall be rectangular in cross-section and shall provide at least 3 inches of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 2 1/2 inches, except separate light and power conduits from control, signal, and telecommunications conduits by a minimum concrete thickness of 3 inches. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring shall be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly. Provide color, type and depth of warning tape as specified above.

3.6 CABLE PULLING

Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape shield shall have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.6.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.7 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes, handholes, or aboveground termination cabinets.

3.8 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.9 MEDIUM VOLTAGE CABLE JOINTS

Provide power cable joints (splices) suitable for continuous immersion in water. Make joints only in accessible locations in manholes or handholes by using materials and methods in accordance with the written instructions of the joint kit manufacturer.

3.9.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. Provide a bare copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods shall be as specified elsewhere in this section. Wire shall be trained to the sides of the enclosure to prevent interference with the working area.

3.10 CABLE END CAPS

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cables ends shall be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.11 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures.

3.11.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

3.11.2 Tape-Wrap

Tape-wrap metallic-sheathed or metallic armored cables without a nonmetallic protective covering over the sheath or armor prior to application of fireproofing. Wrap shall be in the form of two tightly applied half-lapped layers of a pressure-sensitive 10 mil thick plastic tape, and shall extend not less than one inch into the duct. Even out irregularities of the cable, such as at splices, with insulation putty before applying tape.

3.12 GROUNDING SYSTEMS

Provide grounding system as indicated, in accordance with NFPA 70 and IEEE C2, and as specified herein.

Noncurrent-carrying metallic parts associated with electrical equipment shall have a maximum resistance to solid earth ground not exceeding the following values:

Pad-mounted transformers without protective fences	5 ohms
Ground in manholes	5 ohms
Grounding other metal enclosures of primary voltage electrical and electrically-operated equipment	5 ohms

3.12.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 6 inches, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.

If the specified ground resistance is not met, an additional ground rod shall be provided in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately.

3.12.2 Grounding Connections

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

- a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.
- b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

3.12.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.12.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

3.12.5 Fence Grounding

Fences shall be grounded with a ground rod at each fixed gate post and at each corner post. Drive ground rods until the top is 12 inches below grade. Attach a No. 4 AWG copper conductor, by exothermic weld to the ground rods and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 12 inches of fence mesh and fasten by two approved bronze compression fittings, one to bond wire to post and the other to bond wire to fence. Each gate section shall be bonded to its gatepost by a 1/8 by one inch flexible braided copper strap and ground post clamps. Clamps shall be of the anti-electrolysis type.

3.13 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and PART 4 of the RFP.

3.13.1 Reconditioning of Surfaces

3.13.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct . Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

3.13.1.2 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists , restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.

3.14 FIELD QUALITY CONTROL

3.14.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.14.1.1 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

- (1) Inspect exposed cable sections for physical damage.
- (2) Verify that cable is supplied and connected in accordance with contract plans and specifications.
- (3) Inspect for proper shield grounding, cable support, and cable termination.
- (4) Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius.
- (5) Inspect for proper fireproofing.
- (6) Visually inspect jacket and insulation condition.
- (7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10 ohms per 1000 feet of cable must be investigated and justified.

(2) Perform acceptance test on new cables before the new cables are connected to existing cables and placed into service, including terminations and joints. Perform maintenance test on complete cable system after the new cables are connected to existing cables and placed into service, including existing cable, terminations, and joints. Tests shall be very low frequency (VLF) alternating voltage withstand tests in accordance with **IEEE Std 400.2**. VLF test frequency shall be 0.05 Hz minimum for a duration of 60 minutes using a sinusoidal waveform. Test voltages shall be as follows:

CABLE RATING AC TEST VOLTAGE for ACCEPTANCE TESTING

5 kV	10kV rms(peak)
8 kV	13kV rms(peak)
15 kV	20kV rms(peak)
25 kV	31kV rms(peak)
35 kV	44kV rms(peak)

CABLE RATING AC TEST VOLTAGE for MAINTENANCE TESTING

5 kV	7kV rms(peak)
8 kV	10kV rms(peak)
15 kV	16kV rms(peak)
25 kV	23kV rms(peak)
35 kV	33kV rms(peak)

3.14.1.2 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with **IEEE Std 81**. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable megohmmeter tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

3.14.2 Follow-Up Verification

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

dates and times of checking and testing.

-- End of Section --

SECTION 33 82 00.00 22.00 22

TELECOMMUNICATIONS OUTSIDE PLANT (OSP)

06/17

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

- ASTM B1 (2013) Standard Specification for Hard-Drawn Copper Wire
- ASTM B8 (2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
- ASTM D1557 (2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³) (2700 kN-m/m³)
- ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

- IEEE 100 (2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
- IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

- ICEA S-87-640 (2016) Optical Fiber Outside Plant Communications Cable; 4th Edition
- ICEA S-98-688 (2012) Broadband Twisted Pair Telecommunication Cable, Aircore, Polyolefin Insulated, Copper Conductors Technical Requirements
- ICEA S-99-689 (2012) Broadband Twisted Pair Telecommunication Cable Filled, Polyolefin Insulated, Copper Conductors Technical Requirements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- ANSI C62.61 (1993) American National Standard for Gas Tube Surge Arresters on Wire Line Telephone Circuits

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4)
National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-455-107 (1999a) FOTP-107 Determination of Component Reflectance or Link/System Return Loss using a Loss Test Set

TIA-455-46A (1990) FOTP-46 Spectral Attenuation Measurement for Long-Length, Graded-Index Optical Fibers

TIA-455-78-B (2002) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation

TIA-472D000 (2007b) Fiber Optic Communications Cable for Outside Plant Use

TIA-492AAAD (2009) Detail Specification for 850-nm Laser- Optimized, 50-µm Core Diameter/ 125-µm Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers Suitable for Manufacturing OM4 Cabled Optical Fiber

TIA-492CAAB (2000) Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak

TIA-492E000 (1996; R 2002) Sectional Specification for Class IVd Nonzero-Dispersion Single-Mode Optical Fibers for the 1550 nm Window

TIA-526-14 (2015c) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant

TIA-526-7 (2015a) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant

TIA-568-C.1 (2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard

TIA-568-C.2 (2009; Errata 2010; Add 2 2014; Add 1 2016) Balanced Twisted-Pair Telecommunications Cabling and Components Standards

TIA-568-C.3 (2008; Add 1 2011) Optical Fiber Cabling Components Standard

TIA-569	(2015d) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-590	(1997a) Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant
TIA-606	(2012b; Add 1 2015) Administration Standard for the Telecommunications Infrastructure
TIA-607	(2015c; Addendum 1 2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard
TIA/EIA-455	(1998b) Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
TIA/EIA-455-204	(2000) Standard for Measurement of Bandwidth on Multimode Fiber
TIA/EIA-598	(2014d) Optical Fiber Cable Color Coding

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS 1755	Telecommunications Standards and Specifications for Materials, Equipment and Construction
RUS Bull 1751F-630	(1996) Design of Aerial Plant
RUS Bull 1751F-640	(1995) Design of Buried Plant, Physical Considerations
RUS Bull 1751F-643	(2002) Underground Plant Design
RUS Bull 1751F-815	(1979) Electrical Protection of Outside Plant
RUS Bull 1753F-201	(1997) Acceptance Tests of Telecommunications Plant (PC-4)
RUS Bull 1753F-401	(1995) Splicing Copper and Fiber Optic Cables (PC-2)
RUS Bull 345-50	(1979) Trunk Carrier Systems (PE-60)
RUS Bull 345-65	(1985) Shield Bonding Connectors (PE-65)
RUS Bull 345-72	(1985) Filled Splice Closures (PE-74)
RUS Bull 345-83	(1979; Rev Oct 1982) Gas Tube Surge Arrestors (PE-80)

UNDERWRITERS LABORATORIES (UL)

UL 497	(2001; Reprint Jul 2013) Protectors for Paired Conductor Communication Circuits
UL 510	(2020) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables

1.2 RELATED REQUIREMENTS

Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM, Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION, and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-569, TIA-606, and IEEE 100 and herein.

1.3.1 Campus Distributor (CD)

A distributor from which the campus backbone cabling emanates. (International expression for main cross-connect - (MC).) On Camp Lejeune the main cross-connect is established in Area Distribution Nodes (ADN), network operation centers (NOC), or telephone central office serving predesignated areas of the base. Designers should not design any new main cross-connects without approval from TSD (Telecommunications Support Division aka Base Telephone). The campus backbone is outside plant (OSP) back to TSD and a network operations center.

1.3.2 Entrance Facility (EF) (Telecommunications)

An entrance to the building for both private and public network service cables (including antennae, CATV, CCTV, IDS) including the entrance point at the building wall and continuing to the entrance room or space.

1.3.3 Entrance Room (ER) (Telecommunications)

A centralized space for telecommunications equipment that serves the occupants of a building. Equipment housed therein is considered distinct from a telecommunications room because of the nature of its complexity but could be combined within the communications room if additional space needed is allotted.

1.3.4 Building Distributor (BD)

A distributor in which the building backbone cables terminate and at which connections to the campus backbone cables may be made. (International expression for intermediate cross-connect - (IC).)

1.3.5 Pathway

A physical infrastructure utilized for the placement and routing of telecommunications cable.

1.4 SYSTEM DESCRIPTION

The telecommunications outside plant consists of cable, conduit, manholes, **splices, protection, riser points, load coils**, etc. required to provide signal paths from the closest point of presence (**demarcation**) to the new facility, including free standing frames or backboards, interconnecting hardware, terminating cables, lightning and surge protection modules at **one or both ends of the cable, installed from the entrance facility in building to designated demarcation point**. The work consists of providing, testing and making operational cabling, interconnecting hardware and lightning and surge protection necessary to form a complete outside plant telecommunications system for continuous use. The telecommunications contractor must coordinate with **TSD** concerning layout and configuration of the EF telecommunications and OSP. The telecommunications contractor may be required to coordinate work effort for access to the EF telecommunications and OSP with **TSD**.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section **01 33 29.05 20 SUSTAINABILITY REPORTING FOR DESIGN-BUILD**. Submit the following in accordance with Section **01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES**:

- a. Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph "Regulatory Requirements" and as required for certificates in Section **01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES**.
- b. Commercial off-the-shelf manuals shall be provided for operation, installation, configuration, and maintenance of products provided as a part of the communications outside plant (OSP). Submit operations and maintenance data in accordance with Section **01 78 23 OPERATION AND MAINTENANCE DATA** and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data package 5, include the requirements of paragraphs "Telecommunications Outside Plant Shop Drawings" and "Telecommunications Entrance Facility Drawings".

SD-02 Shop Drawings

Telecommunications Outside Plant; G

Telecommunications Entrance Facility Drawings; G

In addition to Section **01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES**, provide shop drawings in accordance with paragraph **SHOP DRAWINGS**.

SD-03 Product Data

Wire and cable; G
Cable splices, and connectors; G
Closures; G
Building protector assemblies; G
Protector modules; G
Cross-connect terminal cabinets; G
Spare Parts; G

Submittals shall include the manufacturer's name, trade name, place of manufacture, and catalog model or number. Submittals shall also include applicable federal, military, industry, and technical society publication references. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified in paragraph REGULATORY REQUIREMENTS and as required for certificates in Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES.

SD-06 Test Reports

Pre-installation tests; G
Acceptance tests; G
Outside Plant Test Plan; G

SD-07 Certificates

Telecommunications Contractor Qualifications; G
Key Personnel Qualifications; G
Minimum Manufacturer's Qualifications; G

SD-08 Manufacturer's Instructions

Building protector assembly installation; G
Cable tensions; G
Fiber Optic Splices; G
Submit instructions prior to installation.

SD-09 Manufacturer's Field Reports

Factory Reel Test Data; G

SD-10 Operation and Maintenance Data

Telecommunications outside plant (OSP), Data Package 5; G

Commercial off-the-shelf manuals shall be provided for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications outside plant (OSP). Submit operations and maintenance data in accordance with Section 01 78 23, OPERATION AND MAINTENANCE DATA and as specified herein not later than 2 months prior to the date of beneficial occupancy. In addition to requirements of Data package 5, include the requirements of paragraphs TELECOMMUNICATIONS OUTSIDE PLANT SHOP DRAWINGS and TELECOMMUNICATIONS ENTRANCE FACILITY DRAWINGS.

SD-11 Closeout Submittals

Record Documentation; G

In addition to other requirements, provide in accordance with paragraph RECORD DOCUMENTATION.

1.5.1 ADDITIONAL SUBMITTAL REQUIREMENTS

All submittals of material, equipment and design must be approved by the TSD Office prior to installing any telecommunications cabling and equipment.

1.6 QUALITY ASSURANCE

Ensure compliance with Section 01 45 00.05 20 DESIGN AND CONSTRUCTION QUALITY CONTROL.

1.6.1 Shop Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

1.6.1.1 Telecommunications Outside Plant Shop Drawings

Provide Outside Plant Design in accordance with TIA-758, RUS Bull 1751F-630 for aerial system design, and RUS Bull 1751F-643 for underground duct system design and for direct buried system design. Provide T0 shop drawings that show the physical and logical connections from the perspective of an entire campus, such as actual building locations, exterior pathways and campus backbone cabling on plan view drawings, major system nodes, and related connections on the logical system drawings in accordance with TIA-606. Drawings shall include wiring and schematic diagrams for fiber optic and copper cabling and splices, copper conductor gauge and pair count, load coils, fiber pair count and type, pathway duct and innerduct arrangement, associated construction materials, and any details required to demonstrate that cable system has been coordinated and will properly support the switching and transmission system identified in specification and drawings. Provide Registered Communications Distribution Designer (RCDD) approved drawings of the telecommunications

outside plant. Update existing telecommunication Outside Plant T0 drawings to include information modified, deleted or added as a result of this installation in accordance with TIA-606. The telecommunications outside plant (OSP) shop drawings shall be included in the operation and maintenance manuals.

1.6.1.2 Telecommunications Entrance Facility Drawings

Provide T3 drawings for EF Telecommunications in accordance with TIA-606 that include telecommunications entrance facility plan views, pathway layout (cable tray, racks, ladder-racks, etc.), mechanical/electrical layout, and cabinet, rack, backboard and wall elevations. Drawings shall show layout of applicable equipment including incoming cable connector blocks, building protector assembly, outgoing cable connector blocks, patch panels and equipment spaces and cabinet/racks. Drawings shall include a complete list of equipment and material, equipment rack details, proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation. Drawings may also be an enlargement of a congested area of T1 or T2 drawings. Provide T3 drawings for EF Telecommunications as specified in the paragraph TELECOMMUNICATIONS SPACE DRAWINGS of Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS. The telecommunications entrance facility shop drawings shall be included in the operation and maintenance manuals.

1.6.2 Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, the supervisor (if different from the installer), and the cable splicing and terminating personnel. A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

1.6.2.1 Telecommunications Contractor Qualifications

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems that include outside plant and broadband cabling within the past 3 years. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems in accordance with TIA-758 within the past 3 years.

1.6.2.2 Key Personnel Qualifications

Provide key personnel who are regularly and professionally engaged in the business of the application, installation and testing of the specified telecommunications systems and equipment. There may be one key person or more key persons proposed for this solicitation depending upon how many of the key roles each has successfully provided. Each of the key personnel shall demonstrate experience in providing successful telecommunications systems within the past 3 years.

Cable splicing and terminating personnel assigned to the installation of this system or any of its components shall have training in the proper techniques, shall be Building Industry Consulting Services International (BICSI) Certified Cabling Installation Technicians, Installer Level 2, or have a minimum of 3 years current consecutive experience in the installation of the specified copper and fiber optic cable and components for products used.

Supervisors and installers assigned to the installation of this system or any of its components shall have factory or factory approved certification from each equipment manufacturer indicating that they are qualified to install and test the provided products.

Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for each of the key personnel. Documentation for each key person shall include at least two successful system installations provided that are equivalent in system size and in construction complexity to the telecommunications system proposed for this solicitation. Include specific experience in installing and testing telecommunications outside plant systems, including broadband cabling, and provide the names and locations of at least two project installations successfully completed using optical fiber and copper telecommunications cabling systems. All of the existing telecommunications system installations offered by the key persons as successful experience shall have been in successful full-time service for at least 18 months prior to the issuance date for this solicitation. Provide the name and role of the key person, the title, location, and completed installation date of the referenced project, the referenced project owner point of contact information including name, organization, title, and telephone number, and generally, the referenced project description including system size and construction complexity.

Indicate that all key persons are currently employed by the telecommunications contractor, or have a commitment to the telecommunications contractor to work on this project. All key persons shall be employed by the telecommunications contractor at the date of issuance of this solicitation, or if not, have a commitment to the telecommunications contractor to work on this project by the date that the bid was due to the Contracting Officer.

Note that only the key personnel approved by the Contracting Officer in the successful proposal shall do work on this solicitation's telecommunications system. Key personnel shall function in the same roles in this contract, as they functioned in the offered successful experience. Any substitutions for the telecommunications contractor's key personnel requires approval from the Contracting Officer.

1.6.2.3 Minimum Manufacturer's Qualifications

Cabling, equipment and hardware manufacturers shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of components which comply with, TIA-568-C.1, TIA-568-C.2 and TIA-568-C.3. In addition, cabling manufacturers shall have a minimum of 3 years experience in the manufacturing and factory testing of cabling which comply with ICEA S-87-640, ICEA S-98-688, and ICEA S-99-689.

1.6.3 Outside Plant Test Plan

Prepare and provide a complete and detailed test plan for field tests of the outside plant including a complete list of test equipment for the copper conductor and optical fiber cables, components, and accessories for approval by **Telecommunications Support Division (aka Base Telephone)** via the Contracting Officer. Include a cut-over plan with procedures and schedules for relocation of facility station numbers without interrupting service to any active location. Submit the plan at least 30 days prior to tests for Contracting Officer approval. Provide outside plant testing and performance measurement criteria in accordance with **TIA-568-C.1** and **RUS Bull 1753F-201**. Include procedures for certification, validation, and testing that includes fiber optic link performance criteria.

1.6.4 Standard Products

Provide materials and equipment that are standard products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and shall be the manufacturer's latest standard design that has been in satisfactory commercial or industrial use for at least 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section. **Product submission must be approved for use by TSD via Contracting Officer prior to install.**

1.6.4.1 Alternative Qualifications

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

1.6.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.5 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the **TSD via the Contracting Officer**. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of **NFPA 70** unless more stringent requirements are specified or indicated by references or AHJ. **Because references are living documents use of most current version shall be enforced.**

1.6.5.1 Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.7 DELIVERY, STORAGE, AND HANDLING

Ship cable on reels in 5000 feet length with a minimum overage of 10 percent for 25, 50 or 100 pair configuration and 1250 feet length for larger cables. Radius of the reel drum shall not be smaller than the minimum bend radius of the cable. Wind cable on the reel so that unwinding can be done without kinking the cable. Two meters of cable at both ends of the cable shall be accessible for testing. Attach permanent label on each reel showing length, cable identification number, cable size, cable type, and date of manufacture. Provide water resistant label and the indelible writing on the labels. Apply end seals to each end of the cables to prevent moisture from entering the cable. Reels with cable shall be suitable for outside storage conditions when temperature ranges from minus 40 degrees C to plus 65 degrees C, with relative humidity from 0 to 100 percent. Equipment, other than cable, delivered and placed in storage shall be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants in accordance with manufacturer's requirements.

1.8 MAINTENANCE

1.8.1 Record Documentation

Provide the activity responsible for telecommunications system maintenance and administration (TSD via the Contracting Officer) a single complete and accurate set of record documentation for the entire telecommunications system for each structure with respect to this project.

Provide record documentation as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

Provide T5 drawings including documentation on cables and termination hardware in accordance with TIA-606. T5 drawings shall include schedules to show information for cut-overs and cable plant management, patch panel layouts, cross-connect information and connecting terminal layout as a minimum. T5 drawings shall be provided in both hard copy format and on electronic media using Windows based computer cable management software. A licensed copy of the cable management software including documentation, shall be provided. Update existing record documentation to reflect campus distribution T0 drawings and T3 drawing schedule information modified, deleted or added as a result of this installation. Provide the following T5 drawing documentation as a minimum:

- a. Cables - A record of installed cable shall be provided in accordance with TIA-606. The cable records shall include the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility for the soft copy in accordance with TIA-606. Include manufacture date of cable with submittal.

- b. Termination Hardware - Provide a record of installed patch panels, cross-connect points, campus distributor and terminating block arrangements and type in accordance with TIA-606. Documentation shall include the required data fields as a minimum in accordance with TIA-606.

Provide record documentation as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

1.8.2 Spare Parts

In addition to the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA, provide a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking. Spare parts shall be provided no later than the start of field testing.

1.9 WARRANTY

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

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Products supplied shall be specifically designed and manufactured for use with outside plant telecommunications systems. All product data must be supplied in the submittal process and no product can be used without approval from TSD via the Contracting Officer.

2.2 TELECOMMUNICATIONS ENTRANCE FACILITY

2.2.1 Building Protector Assemblies

Building protector assembly (BEP) shall be self-contained and have interconnecting hardware (710 input and 66 output) for connection to all Outside Plant rated cabling at full capacity. Provide and follow manufacturers instructions for building protector assembly installation. If Multiple BEPs are used, arrange and connect with lowest count high and to left and highest to bottom right. Provide copper cable interconnecting hardware as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. There will be no service loops or splicing of copper cable outside of the building protector assembly within the telecommunications room (pigtail BEPs are not authorized).

2.2.2 Protector Modules

Provide in accordance with UL 497 three-electrode gas tube type, 5 pin, rated for the application. Provide gas tube protection modules in accordance with RUS Bull 345-83 and shall be heavy duty, A>10kA, B>400, C>65A where A is the maximum single impulse discharge current, B is the impulse life and C is the AC discharge current in accordance with ANSI C62.61. The gas modules shall shunt high voltage to ground, fail short, and be equipped with an external spark gap and heat coils in accordance with UL 497. Provide the number of surge protection modules equal to the number of pairs of exterior cable of the building protector

assembly. Recommend 4B1E type.

2.2.3 Fiber Optic Terminations

Provide fiber optic cable terminations as specified in 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM. Ensure terminations within the Fiber Distribution Center (FDC) are logical left to right and top to bottom (OSP SM/Backbone SM then MM/Row to Row SM then MM).

2.2.4 Pathways

Underground applications for single buildings: provide a minimum of (3) four inch ducts (copper, fiber, maintenance duct... in that order), one of which (fiber) contains (2)- three cell fabric inner duct. The (3) four inch ducts shall enter the Main Communications Room (entrance facility) to the far left of the communications backboard (longest farthest wall from the door) and shall be 3-6 inches above floor and 3-6 inches away from wall, aligned parallel to the communications backboard wall. The underground ducts must have 3" concrete encasing, with 24 inches minimum backfill below grade from the Communications Entrance Facility to the maintenance hole that will be providing service to the building (Demarcation point).

For campus distribution between maintenance holes, ducts may need to be 5" to support larger cables, also there will be no less than 4, and up to xx ducts as needed for distribution to the area serviced. All new ducts will include bell ends and terminators flush with MH walls sealed water tight. Both ends of new duct shall be plugged with compression plugs or duct seal around cables (no expanding foam). All new pathway shall be visibly marked and provided on area map with GPS coordinates. All ducts shall be installed as straight through runs between holes and shall not cross each other allowing a straight pull through. All duct banks where fiber cables are installed shall include fabric innerduct to maximize the pathway.

For direct buried applications (only in remote areas where there is no manhole duct systems and none is in project contract), provide a minimum of three (3) four inch ducts from the Communications Entrance Facility to outside the bldg foot print past any obstructions, footers, or sidewalks by at least 5 feet into clear soil/entryway, 24 inches below grade. The ducts will be plugged at both ends and clearly marked on outside end. For distribution to demarcation, between handholes, and riser points cables need to be 36" below grade with metal locating tape at 24" below grade. Cables need to be in HDDPE direct bored, HDDPE direct buried, concrete encased in conduit, or concrete encased split duct under all roadways and pavement. All new cables need to be provided on area map with GPS coordinates for riser points or hand holes. Handholes and maintenance holes shall be traffic rated (MIN tier 22). Handhole size min 4'x4'x4'. Maintenance hole size 6'x7'x8' and all penetrations should be splayed.

If utility pathway conflicts necessitate placement of a manhole below the typical/normal depth (6-12 inches), the roof of the manhole shall be placed at normal depth and riser extensions shall be used to increase the depth of the manhole. If a deep collar is unavoidable and the depth of the collar will exceed 24 inches, the Designer shall obtain written permission from TSD (Base Telephone) and ensure that the collar is equipped with permanent galvanized steps (rungs). Also do not drill hole in bottom of maintenance/handhole for grounding rod, use grounding ribbon built into the concrete structure itself that is in full contact with the ground.

2.3 CLOSURES

2.3.1 Copper Conductor Closures

2.3.1.1 Aerial Cable Closures

Provide cable closure assembly consisting of a frame with clamps, a lift-off polyethylene cover, cable nozzles, and drop wire rings. Closure shall be suitable for use on Figure 8 cables. Closures shall be free breathing and suitable for housing either straight-through type or branch type splices of non-pressurized communications cables and shall be sized as indicated. The closure shall be constructed with ultraviolet resistant PVC.

NOTE: The installation of aerial cabling aboard Marine Corps Base, Camp Lejeune and Marine Corps Air Station, New River is not authorized.

2.3.1.2 Underground Cable Closures

- a. Aboveground: Provide aboveground closures constructed of not less than 14 gauge steel and acceptable for pole or stake mounting in accordance with RUS 1755.910. Closures shall be sized and contain a marker as indicated. Covers shall be secured to prevent unauthorized entry. PVC type closures are to be used in beach areas. All pedestals shall contain a minimum 4 foot x 3/8 inch pigtailed ground rod.
- b. Direct burial: Provide buried closure suitable for enclosing a straight, butt, and branch splice in a container into which can be poured an encapsulating compound. Closure shall have adequate strength to protect the splice and maintain cable shield electrical continuity in the buried environment. Encapsulating compound shall be reenterable and shall not alter the chemical stability of the closure. Provide filled splice cases in accordance with RUS Bull 345-72.

NOTE: The installation of a direct buried closure aboard Marine Corps Base, Camp Lejeune and Marine Corps Air Station, New River is not authorized; all closures shall be in a riser point, handhole, or manhole.

- c. In vault or manhole: Provide underground closure suitable to house a straight, butt, and branch splice in a protective housing into which air can be pumped for flash testing. Closure shall be of suitable thermoplastic or stainless steel material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. Heat shrinkable type closures shall not be used. Provide filled splice cases in accordance with RUS Bull 345-72.

2.3.2 Fiber Optic Closures

2.3.2.1 Aerial

Provide aerial closure that is free breathing and suitable for housing splice organizer of non-pressurized cables. Closure shall be constructed from heavy PVC with ultraviolet resistance.

NOTE: The installation of new aerial cabling aboard Marine Corps Base,

Camp Lejeune and Marine Corps Air Station, New River is not authorized.

2.3.2.2 Direct Burial

Provide buried closure suitable to house splice organizer in protective housing into which can be poured an encapsulating compound. Closure shall have adequate strength to protect the splice and maintain cable shield electrical continuity, when metallic, in buried environment. Encapsulating compound shall be reenterable and shall not alter chemical stability of the closure.

NOTE: The installation of a direct buried closure aboard Marine Corps Base, Camp Lejeune and Marine Corps Air Station, New River is not authorized; all closures shall be in a riser point, handhold, or manhole.

2.3.2.3 In Vault or Manhole

Provide underground closure suitable to house splice organizer in a protective housing into which **air can be pumped for flash testing**. Closure shall be of thermoplastic material supplying structural strength necessary to pass the mechanical and electrical requirements in a vault or manhole environment. **Provide 60' slack coils on fiber in every 3rd manhole/handhole or in any which a turn is made.**

2.4 PAD MOUNTED CROSS-CONNECT TERMINAL CABINETS

Provide in accordance with **RUS 1755.910** and the following:

- a. Constructed of 14 gauge steel.
- b. Equipped with a double set of hinged doors with closed-cell foam weatherstripping. Doors shall be locked and contain a marker as indicated.
- c. Equipped with spool spindle bracket, mounting frames, binding post log, jumpering instruction label, and load coil mounting provisions.
- d. Complete with cross connect modules to terminate number of pairs as indicated.
- e. Sized as indicated.

2.5 CABLE SPLICES, AND CONNECTORS

2.5.1 Copper Cable Splices

In vaults or manholes or entrance protectors provide multi-pair, in-line fold back to maximize length of accessible conductors for maintenance or single pair, in-line splices of a moisture resistant, three-wire insulation displacement connector held rigidly in place to assure maximum continuity in accordance with **RUS Bull 1753F-401**. Cables greater than 25 pairs shall be spliced using multipair splicing connectors, which accommodate 25 pairs of conductors at a time (**typical 710**). Provide correct connector size to accommodate the cable gauge of the supplied cable. **Provide enough cable slack suitable for splicing operations to maximize length of accessible conductors for maintenance operations.** In above ground splices use three wire insulation displacement single pair connectors no matter what size the cable. In longer runs of copper provide proper load coils to balance the load as needed to ensure line

quality in accordance with [RUS Bull 1753F-201](#).

2.5.2 Copper Cable Splice Connector

Provide splice connectors with a polycarbonate body and cap and a tin-plated brass contact element. Connector shall accommodate 19 to 26 AWG solid wire with a maximum insulation diameter of [0.065 inch](#) and shall only be installed with manufacturer recommended crimp/cut tool. Fill connector with sealant grease to make a moisture resistant connection, in accordance with [RUS Bull 1753F-401](#).

2.5.3 Fiber Optic Cable Splices

Provide fiber optic cable splices and splicing materials for fusion methods at locations shown on the construction drawings. The splice insertion loss shall be 0.3 dB maximum when measured in accordance with [TIA-455-78-B](#) using an Optical Time Domain Reflectometer (OTDR). Splices shall be designed for a return loss of [40.0 db max](#) for single mode fiber when tested in accordance with [TIA-455-107](#). Physically protect each fiber optic splice by a splice kit specially designed for the splice. [Provide enough cable slack suitable for splicing operations, but in no case less than 30 feet at each end.](#)

2.5.4 Fiber Optic Splice Organizer

Provide splice organizer suitable for housing fiber optic splices in a neat and orderly [logical](#) fashion. Splice organizer shall allow for a minimum of [3 feet](#) of fiber for each fiber within the cable to be neatly stored without kinks or twists. Splice organizer shall accommodate individual strain relief for each splice and allow for future maintenance or modification, without damage to the cable or splices. Provide splice organizer hardware, such as splice trays, protective glass shelves, and shield bond connectors in a splice organizer kit.

2.5.5 Shield Connectors

Provide connectors with a stable, low-impedance electrical connection between the cable shield and the bonding conductor in accordance with [RUS Bull 345-65](#).

2.6 CONDUIT

Provide conduit as specified in Section [33 71 02](#) UNDERGROUND ELECTRICAL DISTRIBUTION.

2.7 PLASTIC INSULATING TAPE

[Tape shall be premium quality, heavy-duty, weather-resistant designed for use on electrical and telecommunications applications and \[UL 510\]\(#\) compliant.](#)

2.8 WIRE AND CABLE

2.8.1 Copper Conductor Cable

Solid copper conductors, covered with an extruded solid insulating compound. Insulated conductors shall be twisted into pairs which are then stranded or oscillated to form a cylindrical core. For special high frequency applications, the cable core shall be separated into compartments. Cable shall be completed by the application of a suitable

core wrapping material, a corrugated copper or plastic coated aluminum shield, and an overall extruded jacket. Telecommunications contractor shall verify distances between splice points, slack required, and pair count required prior to ordering cable. Gauge of conductor shall be determined by the distance from the central office. In all cases the installed cable shall be of the same gauge as the cable it is being spliced into at the Demarcation point. The cable range available is; numbers of pairs specified; 19 gauge (6 to 400 pairs), 22 gauge (6 to 1200 pairs), 24 gauge (6 to 2100 pairs), and 26 gauge (6 to 3000 pairs). **26 AWG is not used on Camp Lejeune** Copper conductors shall conform to the following: All outside plant copper conductor cable available in PE-39 type shall be used; PE-89 is only approved for large pair counts when PE-39 is not manufactured due to large count.

2.8.1.1 Underground

Provide filled cable (type PE-39/89) meeting the requirements of ICEA S-99-689, RUS 1755.390, and RUS 1755.890. Provide enough cable slack suitable for splicing operations, but in no case less than 10 feet.

2.8.1.2 Aerial

Provide filled cable meeting the requirements of ICEA S-99-689, ICEA S-98-688, and RUS 1755.390 except that it shall be suitable for aerial installation and shall be Figure 8 distribution wire with 6,000 pound Class A galvanized steel or 6,000 pound aluminum-clad steel strand.

2.8.1.3 Screen

Provide screen-compartmental core cable filled cable meeting the requirements of ICEA S-99-689 and RUS 1755.390.

2.8.2 Fiber Optic Cable

Provide single-mode, 8/125-um, 0.10 aperture 1310 nm fiber optic cable in accordance with TIA-492CAAB, and single-mode, 8/125-um, 0.10 aperture 1550 nm fiber optic cable in accordance with TIA-492E000 and multimode 50/125-um, 0.275 aperture fiber optic cable in accordance with TIA-492AAAD, TIA-472D000, and ICEA S-87-640 including any special requirements made necessary by a specialized design. Provide a minimum of 24 optical fibers or more as indicated by drawings but never less without a waiver from local authority having jurisdiction. Fiber optic cable shall be specifically designed for outside use with preferred double jacket (if buried), single armor, loose buffer construction, and must be shielded. Provide fiber optic color code in accordance with TIA/EIA-598. Provide minimum 60' slack coil in every 3rd MH or any one where a turn is made.

NOTE: The installation of Multi-mode OSP Fiber Optic cables aboard Marine Corps Base, Camp Lejeune and Marine Corps Air Station, New River is not authorized; except as Backbone Underground Cabling between Communications Rooms within the same building, which is allowed, but not recommended.

2.8.2.1 Strength Members

Provide central/non-central, non-metallic/metallic strength members with sufficient tensile strength for installation and residual rated loads to meet the applicable performance requirements in accordance with ICEA S-87-640. The strength member is included to serve as a cable core foundation to reduce strain on the fibers, and shall not serve as a

pulling strength member.

2.8.2.2 Shielding or Other Metallic Covering

Provide continuous, conductive or locatable, single tape covering and shield in accordance with ICEA S-87-640 on all cables.

2.8.2.3 Performance Requirements

Provide fiber optic cable with optical and mechanical performance requirements in accordance with ICEA S-87-640.

2.8.3 Grounding and Bonding Conductors

Provide grounding and bonding conductors in accordance with RUS 1755.200, TIA-607, IEEE C2, and NFPA 70. Solid bare copper wire meeting the requirements of ASTM B1 for sizes No. 8 AWG and smaller and stranded bare copper wire meeting the requirements of ASTM B8, for sizes No. 6 AWG and larger. Conductors should be installed so as not to exceed minimum bend radius and shall be attached to most suitable bond available at location. Do not install field modified ground rods in maintenance holes that already have factory grounding. Insulated conductors shall have 600-volt, Type TW insulation meeting the requirements of UL 83.

2.9 T-SPAN LINE TREATMENT REPEATERS

Provide as indicated. Repeaters shall be pedestal mounted with pressurized housings, sized as indicated and shall meet the requirements of RUS Bull 345-50.

2.10 POLES AND HARDWARE

Provide poles and hardware as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

2.11 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each telecommunications cable or wire located in manholes, handholes, and vaults. Cable tags shall be stainless steel or polyethylene and labeled in accordance with TIA-606. Coordinate actual cable tag information with TSD. Handwritten labeling is unacceptable.

2.11.1 Stainless Steel

Provide stainless steel, cable tags 1 5/8 inches in diameter 1/16 inch thick minimum, and circular in shape. Tags shall be die stamped with numbers, letters, and symbols not less than 0.25 inch high and approximately 0.015 inch deep in normal block style.

2.11.2 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F. Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 175 pounds. The cable tags shall have black block letters, numbers, and symbols one inch high on a

yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags orientation.

2.12 BURIED WARNING AND IDENTIFICATION TAPE

Provide fiber optic media marking and protection in accordance with TIA-590. Provide color, type and depth of tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section 31 23 00.00 20 EXCAVATION AND FILL.

2.13 GROUNDING BRAID

Provide grounding braid that provides low electrical impedance connections for dependable shield bonding in accordance with RUS 1755.200. Braid shall be made from flat tin-plated copper properly attached to factory ground in maintenance/handhole, TMGB, building steel, electrical bus, or approved grounding rods in riser points.

2.14 MANUFACTURER'S NAMEPLATE

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

2.15 FIELD FABRICATED NAMEPLATES

Provide laminated plastic nameplates in accordance with ASTM D709 for each patch panel, protector assembly, rack, cabinet and other equipment or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

2.16 TESTS, INSPECTIONS, AND VERIFICATIONS

2.16.1 Factory Reel Test Data

Test 100 percent OTDR test of FO media at the factory in accordance with TIA-568-C.1 and TIA-568-C.3. Use TIA-526-7 for single mode fiber and TIA-526-14 Method B for multi mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Enhanced performance filled OSP copper cables, referred to as Broadband Outside Plant (BBOSP), shall meet the requirements of ICEA S-99-689. Enhanced performance air core OSP copper cables shall meet the requirements of ICEA S-98-688. Submit test reports, including manufacture date for each cable reel and receive approval before delivery of cable to the project site.

PART 3 EXECUTION

3.1 INSTALLATION

Install all system components and appurtenances in accordance with manufacturer's instructions, IEEE C2, NFPA 70, and as indicated. Provide all necessary interconnections, services, and adjustments required for a complete and operable telecommunications system from designated demarcation point to building entrance facility, to include lightning

protection terminations at one or both ends of the cable as required per paragraph: SYSTEM DESCRIPTION.

3.1.1 Contractor Damage

Promptly repair indicated utility lines or systems damaged during site preparation and construction. Damages to lines or systems not indicated, which are caused by Contractor operations, shall be treated as "Changes" under the terms of the Contract Clauses. When Contractor is advised in writing of the location of a nonindicated line or system, such notice shall provide that portion of the line or system with "indicated" status in determining liability for damages. In every event, immediately notify Base Telephone via the Contracting Officer of damage.

3.1.2 Cable Inspection and Repair

Handle cable and wire provided in the construction of this project with care. Inspect cable reels for cuts, nicks or other damage. Damaged cable shall be replaced or repaired to the satisfaction of the Contracting Officer. Reel wraps shall remain intact on the reel until the cable is ready for placement.

3.1.3 Direct Burial System

Installation shall be in accordance with RUS Bull 1751F-640. Under railroad tracks, paved areas, and roadways install cable in conduit encased in concrete. Slope ducts to drain. Excavate trenches by hand or mechanical trenching equipment after proper locates and pothole methods are used. Provide a minimum cable cover of 36 inches below finished grade for both fiber and copper cable. Trenches shall be not less than 6 inches wide and in straight lines between cable markers. Do not use cable plows. Bends in trenches shall have a radius of not less than 36 inches. Where two or more cables are laid parallel in the same trench, space laterally at least 3 inches apart. When rock is encountered, remove it to a depth of at least 3 inches below the cable and fill the space with sand or clean earth free from particles larger than 1/4 inch. Do not unreel and pull cables into the trench from one end. Cable may be unreeled on grade and lifted into position. Provide color, type and depth of warning tape as specified in paragraph BURIED WARNING AND IDENTIFICATION TAPE in Section 31 23 00.00 20 EXCAVATION AND FILL. Fiber optic cable will not be direct buried, it will be installed in a smooth wall HDPE type duct.

3.1.3.1 Cable Placement

- a. Prior to design and installation of any copper or optical fiber cable systems, cable routes and pathways must be approved by the Base Telephone via Contracting Officer. Manhole layouts (butterflies) shall be provided for review and approval. Cable route shall include which conduits are to be used for which cables using a logical bottom up and straight run approach.
- b. Separate cables crossing other cables or metal piping from the other cables or pipe by not less than 3 inches of well tamped earth. Do not install circuits for communications under or above traffic signal loops.
- c. Cables shall be in one piece without splices between connections except where the distance exceeds the lengths in which the cable is furnished.

- d. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.
- e. Leave a horizontal slack of approximately 10 feet in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought aboveground. Where cable is brought aboveground, leave additional slack to make necessary connections. (For fiber, provide a minimum of 30 feet at each end.)

3.1.3.2 Identification Slabs (Markers)

Provide a marker at each change of direction of the cable, over the ends of ducts or conduits which are installed under paved areas and roadways and over each splice. Identification markers shall be of concrete, approximately 20 inches square by 6 inches thick.

3.1.3.3 Backfill for Rocky Soil

When placing cable in a trench in rocky soil, the cable shall be cushioned by a fill of sand or selected soil at least 2 inches thick on the floor of the trench before placing the cable or wire. The backfill for at least 4 inches above the wire or cable shall be free from stones, rocks, or other hard or sharp materials which might damage the cable or wire. If the buried cable is placed less than 24 inches in depth, a protective cover of concrete shall be used.

3.1.4 Cable Protection

Provide direct burial cable protection in accordance with NFPA 70 and as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Galvanized conduits which penetrate concrete (slabs, pavement, and walls) shall be PVC coated and shall extend from the first coupling or fitting outside either side of the concrete minimum of 6 inches per 12 inches burial depth beyond the edge of the surface where cable protection is required; all conduits shall be sealed on each end. Where additional protection is required, cable may be placed in galvanized iron pipe (GIP) sized on a maximum fill of 40 percent of cross-sectional area, or in concrete encased 4 inches PVC pipe. Conduit may be installed by jacking or trenching. Trenches shall be backfilled with earth and mechanically tamped at 6 inches lift so that the earth is restored to the same density, grade and vegetation as adjacent undisturbed material.

3.1.4.1 Cable End Caps

Cable ends shall be sealed at all times with coated heat shrinkable end caps. Cables ends shall be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.1.5 Underground Duct

Provide underground duct and connections (terminators and bell ends) to existing manholes or handholes, as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION with any additional requirements as

specified herein. Minimum size of ducts shall be 4 inch and minimum number will be three (3) into any building.

3.1.6 Reconditioning of Surfaces

Provide reconditioning of surfaces as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.1.7 Penetrations

Caulk and seal cable access penetrations in walls, ceilings and other parts of the building. Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings in accordance with Section 07 84 00 FIRESTOPPING.

3.1.8 Cable Pulling

Test duct lines with a mandrel (SHALL BE WITNESSED BY GOVERNMENT) and swab out to remove foreign material before the pulling of cables. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on cables when entering or leaving the manhole. Do not place cables in ducts other than those shown without prior written approval of Base Telephone via the Contracting Officer. Roll cable reels in the direction indicated by the arrows painted on the reel flanges. Set up cable reels on the same side of the manhole as the conduit section in which the cable is to be placed. Level the reel and bring into proper alignment with the conduit section so that the cable pays off from the top of the reel in a long smooth bend into the duct without twisting. Under no circumstances shall the cable be paid off from the bottom of a reel. Check the equipment set up prior to beginning the cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between cable reel and face of duct to protect cable and guide cable into the duct as it is paid off the reel. As cable is paid off the reel, lubricate and inspect cable for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Cable pulling shall also be stopped when reel binds or does not pay off freely. Rectify cause of binding before resuming pulling operations. Provide cable lubricants recommended by the cable manufacturer. Avoid bends in cables of small radii and twists that might cause damage. Do not bend cable and wire in a radius less than 10 times the outside diameter of the cable or wire.

3.1.8.1 Cable Tensions

Obtain from the cable manufacturer and provide to the Contracting Officer, the maximum allowable pulling tension. This tension shall not be exceeded.

3.1.8.2 Pulling Eyes

Equip cables 1.25 inches in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide cables with diameter smaller than 1.25 inches with heat shrinkable type end caps or seals on cable ends when using cable pulling grips. Rings to prevent grip from slipping shall not be beaten into the cable sheath. Use a swivel of 3/4 inch links between pulling-in eyes or grips and pulling strand.

3.1.8.3 Installation of Cables in Manholes, Handholes, and Vaults

Do not install cables utilizing the shortest route, but route along those

walls providing the longest route and the maximum spare cable lengths. Do not install slack coils in copper unless approved or requested by AHJ. Fiber slack coils should be min 60' in every 3rd MH or any MH where a turn is made. Form cables to closely parallel walls, not to interfere with duct entrances, and support cables on brackets and cable insulators at a maximum of 4 feet. Install cable or cables in corresponding ducts entering and exiting the manholes in straight lines, do not cross ducts or manhole. In existing manholes, handholes, and vaults where new ducts are to be terminated, or where new cables are to be installed, modify the existing installation of cables, cable supports, and grounding as required with cables arranged and supported as specified for new cables. Identify each cable with corrosion-resistant embossed metal tags. All fiber optic cables will be installed in fabric innerduct measuring min 1 inch (or larger) with min of three cells (but should maximize pathways).

3.1.9 Aerial Cable Installation

Pole installation shall be as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Where physical obstructions make it necessary to pull distribution wire along the line from a stationary reel, use cable stringing blocks to support wire during placing and tensioning operations. Do not place ladders, cable coils, and other equipment on or against the distribution wire. Wire shall be sagged in accordance with the data shown. Protect cable installed outside of building less than 8 feet above finished grade against physical damage.

NOTE: The installation of aerial cabling aboard Marine Corps Base, Camp Lejeune and Marine Corps Air Station, New River is not authorized.

3.1.9.1 Figure 8 Distribution Wire

Perform spiraling of the wire within 24 hours of the tensioning operation. Perform spiraling operations at alternate poles with the approximate length of the spiral being 15 feet. Do not remove insulation from support members except at bonding and grounding points and at points where ends of support members are terminated in splicing and dead-end devices. Ground support wire at poles to the pole ground.

3.1.9.2 Suspension Strand

Place suspension strand as indicated. Tension in accordance with the data indicated. When tensioning strand, loosen cable suspension clamps enough to allow free movement of the strand. Place suspension strand on the road side of the pole line. In tangent construction, point the lip of the suspension strand clamp toward the pole. At angles in the line, point the suspension strand clamp lip away from the load. In level construction place the suspension strand clamp in such a manner that it will hold the strand below the through-bolt. At points where there is an up-pull on the strand, place clamp so that it will support strand above the through-bolt. Make suspension strand electrically continuous throughout its entire length, bond to other bare cables suspension strands and connect to pole ground at each pole.

3.1.9.3 Aerial Cable

Keep cable ends sealed at all times using cable end caps. Take cable from reel only as it is placed. During placing operations, do not bend cables in a radius less than 10 times the outside diameter of cable. Place temporary supports sufficiently close together and properly tension the

cable where necessary to prevent excessive bending. In those instances where spiraling of cabling is involved, accomplish mounting of enclosures for purposes of loading, splicing, and distribution after the spiraling operation has been completed.

NOTE: The installation of aerial cabling aboard Marine Corps Base, Camp Lejeune and Marine Corps Air Station, New River is not authorized.

3.1.10 Cable Splicing

3.1.10.1 Copper Conductor Splices

Perform splicing in accordance with manufacturer, best known practices, and requirements of RUS Bull 1753F-401 except that direct buried splices and twisted and soldered splices are not allowed. Exception does not apply for pairs assigned for carrier application.

3.1.10.2 Fiber Optic Splices

Fiber optic splicing shall be in accordance with manufacturer's recommendation and shall exhibit an insertion loss not greater than 0.2 dB for fusion splices.

NOTE: The installation of Mechanical Fiber Optic Splices aboard Marine Corps Base, Camp Lejeune and Marine Corps Air Station, New River is not authorized.

3.1.11 Surge Protection

All cables and conductors, except fiber optic cable, which serve as communication lines through off-premise lines, shall have surge protection (710 input/66 output) installed at each end which meet the requirements of RUS Bull 1751F-815.

3.1.12 Grounding

Provide grounding and bonding in accordance with RUS 1755.200, TIA-607, IEEE C2, and NFPA 70. Ground exposed noncurrent carrying metallic parts of telephone equipment, cable sheaths, cable splices, and terminals.

3.1.12.1 Telecommunications Master Ground Bar (TMGB)

The TMGB is the hub of the basic telecommunications grounding system providing a common point of connection for ground from outside cable, CD, and equipment. Establish a TMGB for connection point for cable stub shields to connector blocks and CD protector assemblies as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. The TMGB will at a minimum be 4 inches by 10 inches by 1/4 inch as shown in TIA-607.

3.1.12.2 Incoming Cable Shields

Shields shall not be bonded across the splice to the cable stubs at the main distribution frame. Ground shields of incoming cables in the EF Telecommunications to the TMGB.

3.1.12.3 Campus Distributor Grounding

- a. Protection assemblies: Mount CD protector assemblies directly on the telecommunications backboard. Connect assemblies mounted on each

vertical frame with No. 6 AWG copper conductor to provide a low resistance path to TMGB.

- b. TMGB connection: Connect TMGB to TGB with copper conductor with a total resistance of less than 0.01 ohms.

3.1.13 Cut-Over

All necessary transfers and cut-overs, shall be accomplished by the telecommunications contractor **except government owned cables with active service which must be done by TSD.**

3.2 LABELING

3.2.1 Labels

Provide labeling for new cabling and termination hardware located within the facility in accordance with **TIA-606**. Handwritten labeling is unacceptable. Stenciled lettering for cable and termination hardware shall be provided using **either** thermal ink transfer process **or** laser printer. **Actual information on labels shall be obtained from TSD via contracting office.**

3.2.2 Cable Tag Installation

Install cable tags for each telecommunications cable or wire located in manholes, handholes, and vaults including each splice. Tag new wire and cable provided under this contract and existing wire and cable which are indicated to have splices and terminations provided by this contract. The labeling of telecommunications cable tag identifiers shall be in accordance with **TIA-606**. Tag legend shall be as indicated. Do not provide handwritten letters. Install cable tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

3.2.3 Termination Hardware

Label patch panels, distribution panels, connector blocks and protection modules using color coded labels with identifiers in accordance with **TIA-606**.

3.3 FIELD FABRICATED NAMEPLATE MOUNTING

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

3.4 FIELD QUALITY CONTROL

Provide the Contracting Officer 10 working days notice prior to each test. Provide labor, equipment, and incidentals required for testing. Correct defective material and workmanship disclosed as the results of the tests. Furnish a signed copy of the test results to the Contracting Officer within 3 working days after the tests for each segment of construction are completed. Perform testing as construction progresses and do not wait until all construction is complete before starting field tests.

3.4.1 Pre-Installation Tests

Perform the following tests on cable at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, these tests shall be performed at the factory and certified test results shall accompany the cable.

3.4.1.1 Cable Capacitance

Perform capacitance tests on **all** pairs within a cable to determine if cable capacitance is within the limits specified.

3.4.1.2 Loop Resistance

Perform DC-loop resistance on **all** of the pairs within a cable to determine if DC-loop resistance is within the manufacturer's calculated resistance.

3.4.1.3 Pre-Installation Test Results

Provide results of pre-installation tests to the Contracting Officer at least 5 working days before installation is to start. Results shall indicate reel number of the cable, manufacturer, size of cable, pairs tested, and recorded readings. When pre-installation tests indicate that cable does not meet specifications, remove cable from the job site.

3.4.2 Acceptance Tests

Perform acceptance testing in accordance with **RUS Bull 1753F-201** and as further specified in this section. Provide personnel, equipment, instrumentation, and supplies necessary to perform required testing. Notification of any planned testing shall be given to the Contracting Officer at least 14 days prior to any test unless specified otherwise. Testing shall not proceed until after the Contractor has received written Contracting Officer's approval of the test plans as specified. Test plans shall define the tests required to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested. Provide test reports **to TSD via Contracting officer in soft and hard copy in .pdf or .xls form** showing all field tests performed, upon completion and testing of the installed system. Measurements shall be tabulated on a pair by pair or strand by strand basis. **Blank forms can be provided from Base Telephone upon request.**

3.4.2.1 Copper Conductor Cable

Perform the following acceptance tests in accordance with **TIA-758**:

- a. Wire map (pin to pin continuity)
- b. Continuity to remote end
- c. Crossed pairs
- d. Reversed pairs
- e. Split pairs
- f. Shorts between two or more conductors

g. Grounded pairs.

3.4.2.2 Fiber Optic Cable

Test fiber optic cable in accordance with TIA/EIA-455 and as further specified in this section. Two optical tests shall be performed on all optical fibers: Optical Time Domain Reflectometry (OTDR) Test, and Attenuation Test. These tests shall be performed on the completed end-to-end spans which include the near-end pre-connectorized single fiber cable assembly, outside plant as specified, outside plant field un-terminated at demarcation point, and the far-end pre-connectorized single fiber cable assembly.

- a. OTDR Test: The OTDR test shall be used to determine the adequacy of the cable installations by showing any irregularities, such as discontinuities, micro-bendings or improper splices for the cable span under test. Hard copy fiber signature records shall be obtained from the OTDR for each fiber in each span and shall be included in the test results. The OTDR test shall be measured in both directions. A reference length of fiber, 1000 feet minimum, used as the delay line shall be placed before the new end connector and after the far end patch panel connectors for inspection of connector signature. Conduct OTDR test and provide calculation or interpretation of results in accordance with TIA-526-7 for single-mode fiber and TIA-526-14 for multimode fiber. Splice losses shall not exceed 0.2 db.
- b. Attenuation Test: End-to-end attenuation measurements shall be made on all fibers, in both directions, using a 850 & 1300 for 62.5 multi-mode fiber and 1310 & 1550 for single mode nanometer light source at one end and the optical power meter on the other end to verify that the cable system attenuation requirements are met in accordance with TIA-455-46A for multimode and TIA-526-7 for single-mode fiber optic cables. The measurement method shall be in accordance with TIA-455-78-B. Attenuation losses shall not exceed 0.5 db/km at 1310 nm and 1550 nm for single-mode fiber. Attenuation losses shall not exceed 5.0 db/km at 850 nm and 1.5 db/km at 1300 nm for multimode fiber.
- c. Bandwidth Test: The end-to-end bandwidth of all multimode fiber span links shall be measured by the frequency domain method. The bandwidth shall be measured in both directions on all fibers. The bandwidth measurements shall be in accordance with TIA/EIA-455-204.

3.4.3 Soil Density Tests

- a. Determine soil-density relationships for compaction of backfill material in accordance with ASTM D1557, Method D.
- b. Determine soil-density relationships as specified for soil tests in Section 31 23 00.00 20 EXCAVATION AND FILL.

-- End of Section --