UNITED STATES MILITARY ACADEMY
WEST POINT®

PROJECT SPECIFICATIONS

100% Design Submission
Date: May 18, 2022
Volume 2 of 2

W911SD-21-D-0007 – MICC WP FP 1
Renovation/Upgrade of Fire Station
Two, Building Number 1203
US Army Garrison
West Point, NY

EYP

500 SUMMIT LAKE DRIVE SUITE 180
VALHALLA, NEW YORK 10595-1352

EYP
eypae.com

DOCUMENT 00 01 07

SEALS PAGE

1.1 DESIGN PROFESSIONALS OF RECORD

A. Architect:

1. Robert A. Muscatello
2. NY 020639
3. Responsible for Divisions 01-09 Sections, except Division 03.

B. Structural Engineer:

1. Mark C. Kanonik.
2. NY 72076
3. Responsible for Division 03 Section.

C. Fire-Protection Engineer:

1. Daniel Joseph Lazarz
2. NY 094830
3. Responsible for Division 21 and 28 Sections.

Daniel J. Lazarz Digitally signed by Daniel J. Lazarz DN: C=US, E=dlazarz@eypae.com, O=EYP Architecture & Engineering, OU=Fire Protection, CN=Daniel J. Lazarz Date: 2022.05.17 15:11:33-04'00'

D. Mechanical Engineer:

1. Scott A Wilson
2. NY 077777
3. Responsible for Divisions 22, 23 and 25.

E. Electrical Engineer:

1. Steven Shapiro
2. NY 073725
3. Responsible for Division 26 Sections.

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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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety 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
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

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 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.
]
[1.6 ELECTRICAL INSTALLATION REQUIREMENTS

Electrical installations must conform to IEEE C2, NFPA 70, and requirements specified herein.

1.6.1 New Work

Provide electrical components of mechanical equipment, such as motors, motor starters [(except starters/controllers which are indicated as part of a motor control center)], control or push-button stations, float or pressure switches, solenoid valves, integral disconnects, and other devices functioning to control mechanical equipment, as well as control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors are not to be permitted. The interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit, [the motor control equipment forming a part of motor control centers,] and the electrical power circuits must be provided under Division 26, except internal wiring for components of package equipment must be provided as an integral part of the equipment. When motors and equipment furnished are larger than sizes indicated, provide any required changes to the electrical service as may be necessary and related work as a part of the work for the section specifying that motor or equipment.

1.6.2 Modifications to Existing Systems

Where existing mechanical systems and motor-operated equipment require modifications, provide electrical components under Division 26.

1.6.3 High Efficiency Motors

1.6.3.1 High Efficiency Single-Phase Motors

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

1.6.3.2 High Efficiency Polyphase Motors

Unless otherwise specified, polyphase motors must be selected based on high efficiency characteristics relative to the applications as listed in NEMA MG 10. Additionally, polyphase squirrel-cage medium induction motors with continuous ratings must meet or exceed energy efficient ratings in accordance with Table 12-6C of NEMA MG 1.

1.6.4 Three-Phase Motor Protection

Provide controllers for motors rated one 1 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.

]1.7 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.

1.8 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 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.

3.1.1 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 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.

3.1.2 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 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.

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SECTION 23 05 15

COMMON PIPING FOR HVAC
02/14

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2017) Steel Construction Manual

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A112.18.1/CSA B125.1	(2018) Plumbing Supply Fittings
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 B1.20.7	(1991; R 2013) Standard for Hose Coupling Screw Threads (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 B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.22	(2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.25	(2017) Buttwelding Ends
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 B31.3	(2020) Process 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
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 A6/A6M	(2017a) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
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 A126	(2004; R 2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A197/A197M	(2000; R 2019) Standard Specification for Cupola Malleable Iron
ASTM A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A276/A276M	(2017) Standard Specification for Stainless Steel Bars and Shapes
ASTM A278/A278M	(2001; R 2020) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 degrees F (350 degrees C)
ASTM A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A312/A312M	(2021) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes

ASTM A480/A480M	(2020a) Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM A563	(2015) Standard Specification for Carbon and Alloy Steel Nuts
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
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 B749	(2020) Standard Specification for Lead and Lead Alloy Strip, Sheet and Plate Products
ASTM C67/C67M	(2021) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM C109/C109M	(2021) Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or (50-mm) Cube Specimens)
ASTM C404	(2018) Standard Specification for Aggregates for Masonry Grout
ASTM C476	(2020) Standard Specification for Grout for Masonry
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications
ASTM E1	(2014) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM E814	(2013a; R 2017) Standard Test Method for Fire Tests of Penetration Firestop Systems
ASTM F104	(2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials

ASTM F2389 (2021) Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

FLUID SEALING ASSOCIATION (FSA)

FSA-0017 (1995e6) Standard for Non-Metallic Expansion Joints and Flexible Pipe Connectors Technical Handbook

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

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-67 (2017; Errata 1 2017) Butterfly Valves

MSS SP-70 (2011) Gray Iron Gate 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-125 (2010) Gray Iron and Ductile Iron In-Line, Spring-Loaded, Center-Guided Check Valves

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 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 DEFENSE (DOD)

MIL-C-18480 (1982; Rev B; Notice 2 2009) Coating Compound, Bituminous, Solvent, Coal-Tar

Base

MIL-DTL-17813 (2009; Rev H; Supp 1 2009; Notice 1 2013) Expansion Joints, Pipe, Metallic Bellows, General Specification for

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1922 (Rev A; Notice 3) Shield, Expansion (Caulking Anchors, Single Lead)

CID A-A-1923 (Rev A; Notice 3) Shield, Expansion (Lag, Machine and Externally Threaded Wedge Bolt Anchors)

CID A-A-1924 (Rev A; Notice 3) Shield, Expansion (Self Drilling Tubular Expansion Shell Bolt Anchors

CID A-A-1925 (Rev A; Notice 3) Shield Expansion (Nail Anchors)

CID A-A-55614 (Basic; Notice 2) Shield, Expansion (Non-Drilling Expansion Anchors)

CID A-A-55615 (Basic; Notice 3) Shield, Expansion (Wood Screw and Lag Bolt Self-Threading Anchors

UNDERWRITERS LABORATORIES (UL)

UL 1479 (2015; Reprint May 2021) Fire Tests of Through-Penetration Firestops

1.2 GENERAL REQUIREMENTS

[Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section

][Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT applies to work specified in this section.

][Section 40 17 30.00 40 WELDING GENERAL PIPING applies to work specified in this section.

] Submit Records of Existing Conditions consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work constitutes acceptance of the existing conditions.

Include with Equipment Foundation Data for piping systems all plan dimensions of foundations and relative elevations, equipment weight and operating loads, horizontal and vertical loads, horizontal and vertical clearances for installation, and size and location of anchor bolts.

Submit Fabrication Drawings for pipes, valves and specialties consisting of fabrication and assembly details to be performed in the factory.

Submit Material, Equipment, and Fixture Lists for pipes, valves and specialties including manufacturer's style or catalog numbers,

specification and drawing reference numbers, warranty information, and fabrication site information. Provide a complete list of construction equipment to be used.

Submit Manufacturer's Standard Color Charts for pipes, valves and specialties showing the manufacturer's recommended color and finish selections.

Include with Listing of Product Installations for piping systems identification of at least 5 units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. Include in the list purchaser, address of installation, service organization, and date of installation.

Submit Record Drawings for pipes, valves and accessories providing current factual information including deviations and amendments to the drawings, and concealed and visible changes in the work.

Submit Connection Diagrams for pipes, valves and specialties indicating the relations and connections of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Submit Coordination Drawings for pipes, valves and specialties showing coordination of work between different trades and with the structural and architectural elements of work. Detail all drawings sufficiently to show overall dimensions of related items, clearances, and relative locations of work in allotted spaces. Indicate on drawings where conflicts or clearance problems exist between various trades.

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. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists; G, AE

SD-02 Shop Drawings

Record Drawings; G, AE

Connection Diagrams; G, AE

Coordination Drawings; G, AE

Fabrication Drawings; G, AE

Installation Drawings; G, AE

SD-03 Product Data

Pipe and Fittings; G, AE

Piping Specialties; G, AE

Valves; G, AE

Miscellaneous Materials; G

Supporting Elements; G, AE

Equipment Foundation Data; G, AE

SD-04 Samples

Manufacturer's Standard Color Charts; G, AE

SD-05 Design Data

Pipe and Fittings; G, AE

Piping Specialties; G, AE

Valves; G, AE

SD-06 Test Reports

Hydrostatic Tests; G, AE

Air Tests; G, AE

Valve-Operating Tests; G, AE

Drainage Tests; G, AE

Pneumatic Tests; G, AE

Non-Destructive Electric Tests; G, AE

System Operation Tests; G, AE

SD-07 Certificates

Record of Satisfactory Field Operation; G, AE

List of Qualified Permanent Service Organizations; G, AE

Listing of Product Installations; G, AE

Records of Existing Conditions; G, AE

Surface Resistance; G, AE

Shear and Tensile Strengths; G, AE

Temperature Ratings; G, AE

Bending Tests; G, AE

Flattening Tests; G, AE

Transverse Guided Weld Bend Tests; G, AE

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, AE

1.4 QUALITY ASSURANCE

1.4.1 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. Provide standard products in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.4.2 Alternative Qualifications

Products having less than a two-year field service record are 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.

1.4.3 Service Support

Ensure the equipment items are supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. Select service organizations that are 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.

1.4.4 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.

1.4.5 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.

1.4.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions are considered mandatory, the word "should" is interpreted as "shall." Reference to the "code official" is interpreted to mean the "Contracting Officer." For Navy owned property, interpret references to the "owner" to mean the "Contracting Officer."

For leased facilities, references to the "owner" is interpreted to mean the "lessor." References to the "permit holder" are interpreted to mean the "Contractor."

1.4.5.2 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, are applied as appropriate by the Contracting Officer and as authorized by his administrative cognizance and the FAR.

1.5 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.

[1.6 ELECTRICAL REQUIREMENTS

Furnish motors, controllers, disconnects and contactors with their respective pieces of equipment. Ensure motors, controllers, disconnects and contactors 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 is not permitted. Provide controllers and contactors with a maximum of 120 volt control circuits, and auxiliary contacts for use with the controls furnished. When motors and equipment furnished are larger than sizes indicated, include the cost of additional electrical service and related work under the section that specified that motor or equipment. Provide power wiring and conduit for field installed equipment under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

][1.7 ELECTRICAL INSTALLATION REQUIREMENTS

Ensure electrical installations conform to IEEE C2, NFPA 70, and requirements specified herein.

1.7.1 New Work

Provide electrical components of mechanical equipment, such as motors, motor starters [(except starters/controllers which are indicated as part of a motor control center)], control or push-button stations, float or pressure switches, solenoid valves, integral disconnects, and other devices functioning to control mechanical equipment, as well as control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors are not permitted. Provide under Division 26, the interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit, [the motor control equipment forming a part of motor control centers,] and the electrical power circuits, except internal wiring for components of package equipment is provided as an integral part of the equipment. When motors and equipment furnished are

larger than sizes indicated, provide any required changes to the electrical service as may be necessary and related work as a part of the work for the section specifying that motor or equipment.

1.7.2 Modifications to Existing Systems

Where existing mechanical systems and motor-operated equipment require modifications, provide electrical components under Division 26.

1.7.3 High Efficiency Motors

1.7.3.1 High Efficiency Single-Phase Motors

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

1.7.3.2 High Efficiency Polyphase Motors

Unless otherwise specified, select polyphase motors based on high efficiency characteristics relative to the applications as listed in NEMA MG 10. Additionally, ensure polyphase squirrel-cage medium induction motors with continuous ratings meet or exceed energy efficient ratings in accordance with Table 12-6C of NEMA MG 1.

1.7.4 Three-Phase Motor Protection

Provide controllers for motors rated one one 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.

]1.8 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. Provide instructors thoroughly familiar with all parts of the installation and trained in operating theory as well as practical operation and maintenance work.

Give 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 is 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

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 [Enter Appropriate Subpart Title Here]

2.2 PIPE AND FITTINGS

Submit equipment and performance data for pipe and fittings consisting of corrosion resistance, life expectancy, gage tolerances, and grade line analysis. Submit design analysis and calculations consisting of surface resistance, rates of flow, head losses, inlet and outlet design, required radius of bend, and pressure calculations. Also include in data pipe size, shape, and dimensions, as well as temperature ratings, vibration and thrust limitations minimum burst pressures, shut-off and non-shock pressures and weld characteristics.

2.2.1 Type BCS, Black Carbon Steel

Ensure pipe 1/8 through 12 inches is Schedule 40 black carbon steel, conforming to ASTM A53/A53M.

Ensure pipe 1/8 through 10 inches is Schedule 40 seamless or electric-resistance welded black carbon steel, conforming to ASTM A53/A53M, [Type E, Grade B (electric-resistance welded)] [Type S (seamless)]. Grade A should be used for permissible field bending, in both cases.

Ensure pipe 12 through 24 inches is 0.375-inch wall seamless black carbon steel, conforming to ASTM A53/A53M, [Type E, Grade B (electric-resistance welded)] [Type S (seamless)].

Ensure fittings 2 inches and under are 150-pounds per square inch, gage (psig) working steam pressure (wsp) banded black malleable iron screwed, conforming to ASTM A197/A197M and ASME B16.3.

Ensure unions 2 inches and under are 250 pounds per square inch, wsp female, screwed, black malleable iron with brass-to-iron seat, and ground joint, conforming to ASME B16.39.

Ensure fittings 2-1/2 inches and over are Steel butt weld, conforming to ASTM A234/A234M and ASME B16.9 to match pipe wall thickness.

Ensure flanges 2-1/2 inches and over are 150-pound forged-steel conforming to ASME B16.5, welding neck to match pipe wall thickness.

2.2.2 [Enter Appropriate Subpart Title Here]

2.2.3 Type CPR, Copper

2.2.3.1 Type CPR-A, Copper Above Ground

Ensure tubing 2 inches and under is seamless copper tubing, conforming to ASTM B88, Type L (hard-drawn for all horizontal and all exposed vertical lines, annealed for concealed vertical lines).

Ensure fittings 2 inches and under are 150-psig wsp wrought-copper solder joint fittings conforming to ASME B16.22.

Ensure unions 2 inches and under are 150-psig wsp wrought-copper solder

joint, conforming to ASME B16.22.

[Provide brazing rod with Classification BCuP-5, conforming to AWS A5.8/A5.8M.

][Use solder, alloy Sb-5, conforming to ASTM B32.

]2.2.3.2 Type CPR-U, Copper Under Ground

Provide Type K seamless copper tube piping, conforming to ASTM B88. Use wrought copper socket-joint fittings, conforming to ASME B16.22. Ensure fittings for connection to corporation cocks are cast bronze, flared-type, conforming to ASME B16.26. Braze the joints.

2.2.3.3 Type CPR-INS, Copper Under Ground Insulated

Provide insulated Type K seamless copper tube piping conforming to ASTM B88. Use wrought copper socket-joint fittings, conforming to ASME B16.22. Braze the joints.

Provide insulation not less than 2 inches thick, suitable for continuous service temperatures of not less than 250 degrees F. Use factory-molded, closed-cell polyurethane foam insulation of not less than 2.5 pounds per cubic foot density. Waterproof insulation with an extruded rigid Type II virgin polyvinylchloride, with minimum wall thickness of 60 mils through 4 inches outside diameter, 85 mils through 6.625 inches and 110 mils through 12.750 inches. Provide fitting covers fabricated from the same materials and thickness as adjacent pipe covering according to the manufacturer's directions.

2.2.4 [Enter Appropriate Subpart Title Here]

2.2.5 Grooved Pipe Couplings and Fittings

Provide housing for all couplings, fabricated in two or more parts, of black, ungalvanized malleable iron castings. Ensure coupling gasket is molded synthetic rubber, conforming to ASTM D2000. Ensure coupling bolts are oval-neck, track-head type, with hexagonal heavy nuts conforming to ASTM A183.

Fabricate all pipe fittings used with couplings of black, ungalvanized malleable iron castings. Where a manufacturer's standard-size malleable iron fitting pattern is not available, approved fabricated fittings may be used.

Fabricate fittings from Schedule 40 or 0.75-inch wall ASTM A53/A53M, Grade B seamless steel pipe; long radius seamless welding fittings with wall thickness to match pipe, conforming to ASTM A234/A234M and ASME B16.9.

2.3 PIPING SPECIALTIES

Submit equipment and performance data for piping specialties consisting of corrosion resistance, life expectancy, gage tolerances, and grade line analysis. Submit design analysis and calculations consisting of surface resistance, rates of flow, head losses, inlet and outlet design, required radius of bend, and pressure calculations. Also include in data pipe size, shape, and dimensions, as well as temperature ratings, vibration and thrust limitations minimum burst pressures, shut-off and non-shock pressures and weld characteristics.

2.3.1 Air Separator

Air separated from converter discharge water is ejected by a reduced-velocity device vented to the compression tank.

[Provide a commercially constructed separator, designed and certified to separate not less than 80 percent of entrained air on the first passage of water and not less than 80 percent of residual on each successive pass. Provide shop drawings detailing all piping connections proposed for this work.

][Ensure the air separator is carbon steel, designed, fabricated, tested, and stamped in conformance with ASME BPVC SEC VIII D1 for service pressures not less than 125 psi.

]2.3.2 Air Vents

[Provide manual air vents using 3/8-inch globe valves.

][Provide automatic air vents on pumps, mains, and where indicated using ball-float construction. Ensure the vent inlet is not less than 3/4-inch ips and the outlet not less than 1/4-inch ips. Orifice size is 1/8 inch. Provide corrosion-resistant steel trim conforming to [ASTM A276/A276M] [ASTM A480/A480M]. Fit vent with try-cock. Ensure vent discharges air at any pressure up to 150 psi. Ensure outlet is copper tube routed.

]2.3.3 Compression Tank

Provide compression tank designed, fabricated, tested, and stamped for a working pressure of not less than 125 psi in accordance with ASME BPVC SEC VIII D1. Ensure tank is hot-dip galvanized after fabrication to produce not less than 1.5 ounces of zinc coating per square foot of single-side surface.

Tank accessories include red-lined gage-glass complete with glass protectors and shutoff valves, air charger and drainer, and manual vent.

2.3.4 Dielectric Connections

Electrically insulate dissimlar pipe metals from each other by couplings, unions, or flanges commercially manufactured for that purpose and rated for the service pressure and temperature.

2.3.5 Expansion Vibration Isolation Joints

Construct single or multiple arch-flanged expansion vibration isolation joints of steel-ring reinforced chloroprene-impregnated cloth materials. Design joint to absorb the movement of the pipe sections in which installed with no detrimental effect on the pipe or connected equipment. Back flanges with ferrous-metal backing rings. Provide control rod assemblies to restrict joint movement. Coat all nonmetallic exterior surfaces of the joint with chlorosulphinated polyethylene. Provide grommets in limit bolt hole to absorb noise transmitted through the bolts.

Ensure joints are suitable for continuous-duty working temperature of at least 250 degrees F.

Fill arches with soft chloroprene.

Ensure joint, single-arch, movement limitations and size-related, pressure characteristics conform to FSA-0017.

2.3.6 Flexible Pipe

Construct flexible pipe vibration and pipe-noise eliminators of wire-reinforced, rubber-impregnated cloth and cord materials and be flanged. Back the flanges with ferrous-metal backing rings. Ensure service pressure-rating is a minimum 1.5 times actual service, with surge pressure at 180 degrees F.

Construct flexible pipe vibration and pipe noise eliminators of wire-reinforced chloroprene-impregnated cloth and cord materials. Ensure the pipe is flanged. Provide all flanges backed with ferrous-metal backing rings. Coat nonmetallic exterior surfaces of the flexible pipe with an acid- and oxidation-resistant chlorosulphinated polyethylene. Rate the flexible pipe for continuous duty at 130 psi and 250 degrees F.

Ensure unit pipe lengths, face-to-face, are not less than the following:

INSIDE DIAMETER	UNIT PIPE LENGTH
[To 2-1/2 inches, inclusive	12 inches
3 to 4 inches, inclusive	18 inches
5 to 12 inches, inclusive	24 inches]
[To 3 inches, inclusive	18 inches
4 to 10 inches, inclusive	24 inches
12 inches and larger	36 inches]

2.3.7 Flexible Metallic Pipe

Ensure flexible pipe is the bellows-type with wire braid cover and designed, constructed, and rated in accordance with the applicable requirements of ASME B31.3.

Minimum working pressure rating is [50] [100] psi at 300 degrees F.

[Ensure minimum burst pressure is four times working pressure at 300 degrees F. Bellows material is AISI Type 316L corrosion-resistant steel. Ensure braid is AISI 300 series corrosion-resistant steel wire.

][Ensure welded end connections are Schedule 80 carbon steel pipe, conforming to ASTM A106/A106M, Grade [B] [C].

][Provide threaded end connections; hex-collared Schedule 40, AISI Type 316L corrosion-resistant steel, conforming to ASTM A312/A312M.

][Ensure flanged end connection rating and materials conform to specifications for system primary-pressure rating.

]2.3.8 Flexible Metal Steam Hose

Provide a bellows type hose with wire braid cover and designed,

constructed, and rated in accordance with the applicable requirements of ASME B31.3.

Ensure the working steam pressure rating is 125 psi at 500 degrees F.

[Ensure minimum burst pressure is nine times working steam pressure at 300 degrees F.

] Ensure bellows material is AISI Type 316L corrosion-resistant steel. Braid is AISI Type 300-series corrosion-resistant steel wire.

[Provide welded end connections; Schedule 80 carbon steel pressure tube, conforming to ASTM A106/A106M, Grade [B] [C].

][Provide threaded end connections; hex-collared Schedule 40, AISI Type 316L corrosion-resistant steel, conforming to ASTM A312/A312M.

][Ensure flanged end connection rating and materials conform to specifications for system primary-pressure rating.

]2.3.9 Metallic Expansion Joints

[Provide metallic-bellows expansion joints conforming to MIL-DTL-17813.

][Provide Type I expansion joints; (corrugated bellows, unreinforced), [Class 1 (single bellows, expansion joint)], [Class 2 (double bellows, expansion joint)].

] Design and construct joints to absorb all of the movements of the pipe sections in which installed, with no detrimental effect on pipe or supporting structure.

Rate, design, and construct joints for pressures to 125 psigand temperatures to 500 degrees F.

Ensure joints have a designed bursting strength in excess of [four] [_____] times their rated pressure.

Ensure joints are capable of withstanding a hydrostatic test of 1.5 times their rated pressure while held at their uncompressed length without leakage or distortion that may adversely affect their life cycle.

Ensure life expectancy is not less than 10,000 cycles.

Ensure movement capability of each joint exceeds calculated movement of piping by [100] [_____] percent.

Provide bellows and internal sleeve material of AISI Type 304, 304L, or 321 corrosion-resistant steel.

End connections require no field preparation other than cleaning.

[Butt weld end preparation of expansion joints conform to the same codes and standards requirements as applicable to the piping system materials at the indicated joint location.

][Flanges of flanged-end expansion joints conforms to the same codes and standard requirements as are applicable to companion flanges specified for the given piping system at the indicated joint location.

] Provide joints, 2-1/2 inches and smaller, with internal guides and limit stops.

Provide joints, 3 inches and larger, with removable external covers, internal sleeves, and purging connection. Size sleeves to accommodate lateral clearance required, with minimum reduction of flow area, and with oversized bellows where necessary. When a sleeve requires a gasket as part of a locking arrangement, provide the gasket used by the manufacturer. Joints without purging connection may be provided; however, remove these from the line prior to, or not installed until, cleaning operations are complete.

[Provide the cylindrical end portion of the reinforced bellows element with a thrust sleeve of sufficient thickness to bring that portion within applicable code-allowable stress. Provide 360 degrees support for the element and end-reinforcing ring with the sleeve.

][Ensure expansion joints have four, equidistant, permanent tram points clearly marked on each joint end. Locate points to prevent obliteration during installation. Include distance between tram points indicating installed lengths in shop drawings. Overall dimension after joint installation is subject to approval from the Contracting Officer.

] Ensure each expansion joint has adjustable clamps or yokes provided at quarter points, straddling the bellows. Overall joint length is set by the manufacturer to maintain joints in manufacturer's recommended position during installation.

Permanently and legibly mark each joint with the manufacturer's name or trademark and serial number; the size, series, or catalog number; bellows material; and directional-flow arrow.

2.3.10 Hose Faucets

Construct hose faucets with 1/2 inch male inlet threads, hexagon shoulder, and 3/4 inch hose connection, conforming to ASME A112.18.1/CSA B125.1. Ensure hose-coupling screw threads conform to ASME B1.20.7.

Provide vandal proof, atmospheric-type vacuum breaker on the discharge of all potable water lines.

2.3.11 Pressure Gages

Ensure pressure gages conform to ASME B40.100 and to requirements specified herein. Pressure-gage size is 3-1/2 inches nominal diameter. Ensure case is corrosion-resistant steel, conforming to any of the AISI 300 series of ASTM A6/A6M, with an ASM No. 4 standard commercial polish or better. Equip gages with adjustable red marking pointer and damper-screw adjustment in inlet connection. Align service-pressure reading at midpoint of gage range. Ensure all gages are Grade B or better and be equipped with gage isolators.

[Fit steam gages with black steel syphons and steam service pressure-rated gage cocks or valves.

]2.3.12 Sight-Flow Indicators

Construct sight-flow indicators for pressure service on 3-inch ips and

smaller of bronze with specially treated single- or double-glass sight windows and have a bronze, nylon, or tetrafluoroethylene rotating flow indicator mounted on an AISI Type [304] [316] corrosion-resistant steel shaft. Body may have screwed or flanged end. Provide pressure- and temperature-rated assembly for the applied service. Flapper flow-type indicators are not acceptable.

2.3.13 Sleeve Couplings

Sleeve couplings for plain-end pipe consist of one steel middle ring, two steel followers, two chloroprene or Buna-N elastomer gaskets, and the necessary steel bolts and nuts.

2.3.14 Thermometers

Ensure thermometers conform to ASTM E1, except for being filled with a red organic liquid. Provide an industrial pattern armored glass thermometer, (well-threaded and seal-welded). Ensure thermometers installed 6 feet or higher above the floor have an adjustable angle body. Ensure scale is not less than 7 inches long and the case face is manufactured from manufacturer's standard polished aluminum or AISI 300 series polished corrosion-resistant steel. Thermometer range is [_____]. Provide thermometers with nonferrous separable wells. Provide lagging extension to accommodate insulation thickness.

2.3.15 Pump Suction Strainers

Provide a cast iron strainer body, rated for not less than 25 psig at 100 degrees F, with flanges conforming to ASME B16.1, Class 125. Strainer construction is such that there is a machined surface joint between body and basket that is normal to the centerline of the basket.

Ensure minimum ratio of open area of each basket to pipe area is 3 to 1. Provide a basket with AISI 300 series corrosion-resistant steel wire mesh with perforated backing.

Ensure mesh is capable of retaining all particles larger than 1,000 micrometer, with a pressure drop across the strainer body of not more than 0.5 psi when the basket is two-thirds dirty at maximum system flow rate. Provide reducing fittings from strainer-flange size to pipe size.

Provide a [differential-pressure gage] [pressure gage with 0.25-pound graduations] fitted with a two-way brass cock across the strainer.

Provide manual air vent cocks in cap of each strainer.

2.3.16 Line Strainers, Water Service

Install Y-type strainers with removable basket. Ensure strainers in sizes 2-inch ips and smaller have screwed ends; in sizes 2-1/2-inch ipsand larger, strainers have flanged ends. Ensure body working-pressure rating exceeds maximum service pressure of installed system by at least 50 percent. Ensure body has cast-in arrows to indicate direction of flow. Ensure all strainer bodies fitted with screwed screen retainers have straight threads and gasketed with nonferrous metal. For strainer bodies 2-1/2-inches and larger, fitted with bolted-on screen retainers, provide offset blowdown holes. Fit all strainers larger than 2-1/2-inches with manufacturer's standard ball-type blowdown valve. Ensure body material is [cast bronze conforming to ASTM B62] [cast iron conforming to Class 30

ASTM A278/A278M]. Where system material is nonferrous, use nonferrous metal for the metal strainer body material.

Ensure minimum free-hole area of strainer element is equal to not less than 3.4 times the internal area of connecting piping. Strainer screens perforation size is not to exceed 0.045-inch. Ensure strainer screens have finished ends fitted to machined screen chamber surfaces to preclude bypass flow. Strainer element material is [AISI Type [304] [316] corrosion-resistant steel] [Monel metal].

2.3.17 [Enter Appropriate Subpart Title Here]

2.4 VALVES

Submit equipment and performance data for valves consisting of corrosion resistance and life expectancy. Submit design analysis and calculations consisting of rates of flow, head losses, inlet and outlet design, and pressure calculations. Also include in data, pipe dimensions, as well as temperature ratings, vibration and thrust limitations, minimum burst pressures, shut-off and non-shock pressures and weld characteristics.

Polypropylene valves will comply with the performance requirements of ASTM F2389.

2.4.1 Ball and Butterfly Valves

Ensure ball valves conform to MSS SP-72 for Figure [1A], 1 piece body [1B], vertically split body [1C], top entry [1D], three piece body and are rated for service at not less than 175 psig at 200 degrees F. For valve bodies in sizes 2 inches and smaller, use screwed-end connection-type constructed of Class A copper alloy. For valve bodies in sizes 2-1/2 inches and larger, use flanged-end connection type, constructed of Class [D] [E] [F] material. Balls and stems of valves 2 inches and smaller are manufacturer's standard with hard chrome plating finish. Balls and stems of valves 2-1/2 inches and larger are manufacturer's standard Class C corrosion-resistant steel alloy with hard chrome plating. Balls of valves 6 inches and larger may be Class D with 900 Brinell hard chrome plating. Ensure valves are suitable for flow from either direction and seal equally tight in either direction. Valves with ball seals held in place by spring washers are not acceptable. Ensure all valves have adjustable packing glands. Seats and seals are fabricated from tetrafluoroethylene.

Ensure butterfly valves conform to MSS SP-67and are the wafer type for mounting between specified flanges. Ensure valves are rated for 150-psig shutoff and nonshock working pressure. Select bodies of cast ferrous metal conforming to ASTM A126, Class B, and to ASME B16.1 for body wall thickness. Seats and seals are fabricated from resilient elastomer designed for field removal and replacement.

2.4.2 Drain, Vent, and Gage Cocks

Provide [T-head] [lever handle] drain, vent, and gage cocks, ground key type, with washer and screw, constructed of polished ASTM B62 bronze, and rated 125-psi wsp. Ensure end connections are rated for specified service pressure.

Ensure pump vent cocks, and where spray control is required, are UL umbrella-hood type, constructed of manufacturer's standard polished brass. Ensure cocks are 1/2-inch ips male, end threaded, and rated at not less

than 125 psi at 225 degrees F.

2.4.3 Gate Valves (GAV)

Ensure gate valves 2 inches and smaller conform to MSS SP-80. For valves located in tunnels, equipment rooms, factory-assembled equipment, and where indicated use union-ring bonnet, screwed-end type. Make packing of non-asbestos type materials. Use rising stem type valves.

Ensure gate valves 2-1/2 inches and larger, are Type I, (solid wedge disc, tapered seats, steam rated); Class 125 (125-psig steam-working pressure at 353 degrees F saturation); and 200-psig, wog (nonshock), conforming to MSS SP-70 and to requirements specified herein. Select flanged valves, with bronze trim and outside screw and yoke (OS&Y) construction. Make packing of non-asbestos type materials.

2.4.4 Globe and Angle Valves (GLV-ANV)

Ensure globe and angle valves 2 inches and smaller, are 125-pound, 125-psi conforming to MSS SP-80 and to requirements specified herein. For valves located in tunnels, equipment rooms, factory-assembled equipment, and where indicated, use union-ring bonnet, screwed-end type. Ensure disc is free to swivel on the stem in all valve sizes. Composition seating-surface disc construction may be substituted for all metal-disc construction. Make packing of non-asbestos type materials. Ensure disk and packing are suitable for pipe service installed.

Ensure globe and angle valves, 2-1/2 inches and larger, are cast iron with bronze trim. Ensure valve bodies are cast iron conforming to ASTM A126, Class A, as specified for Class 1 valves under MSS SP-80. Select flanged valves in conformance with ASME B16.1. Valve construction is outside screw and yoke (OS&Y) type. Make packing of non-asbestos type materials.

2.4.5 Standard Check Valves (SCV)

Ensure standard check valves in sizes 2 inches and smaller are 125-psi swing check valves except as otherwise specified. Provide lift checks where indicated. Ensure swing-check pins are nonferrous and suitably hard for the service. Select composition type discs. Ensure the swing-check angle of closure is manufacturer's standard unless a specific angle is needed.

Use cast iron, bronze trim, swing type check valves in sizes 2-1/2 inches and larger. Ensure valve bodies are cast iron, conforming to ASTM A126, Class A and valve ends are flanged in conformance with ASME B16.1. Swing-check pin is AISI Type or approved equal corrosion-resistant steel. Angle of closure is manufacturer's standard unless a specific angle is needed. Ensure valves have bolted and gasketed covers.

Provide check valves with [external spring-loaded] [lever-weighted], positive-closure devices and valve ends are [mechanical joint] [push-on] [flanged].

2.4.6 Nonslam Check Valves (NSV)

Provide check valves at pump discharges in sizes 2 inches and larger with nonslam or silent-check operation conforming to MSS SP-125. Select a valve disc or plate that closes before line flow can reverse to eliminate slam and water-hammer due to check-valve closure. Ensure valve is Class

125 rated for 200-psi maximum, nonshock pressure at 150 degrees F in sizes to 12 inches. Use valves that are [wafer type to fit between flanges conforming to ASME B16.1] [fitted with flanges conforming to ASME B16.1]. Valve body may be cast iron, or equivalent strength ductile iron. Select disks using manufacturer's standard bronze, aluminum bronze, or corrosion-resistant steel. Ensure pins, springs, and miscellaneous trim are manufacturer's standard corrosion-resistant steel. Disk and shaft seals are Buna-N elastomer tetrafluoroethylene.

2.5 MISCELLANEOUS MATERIALS

Submit equipment and performance data for miscellaneous materials consisting of corrosion resistance, life expectancy, gage tolerances, and grade line analysis.

2.5.1 Bituminous Coating

Ensure the bituminous coating is a solvent cutback, heavy-bodied material to produce not less than a 12-mil dry-film thickness in one coat, and is recommended by the manufacturer to be compatible with factory-applied coating and rubber joints.

For previously coal-tar coated and uncoated ferrous surfaces underground, use bituminous coating solvent cutback coal-tar type, conforming to MIL-C-18480.

2.5.2 Bolting

Ensure flange and general purpose bolting is hex-head and conforms to ASTM A307, Grade B (bolts, for flanged joints in piping systems where one or both flanges are cast iron). Heavy hex-nuts conform to ASTM A563. Square-head bolts and nuts are not acceptable. Ensure threads are coarse-thread series.

2.5.3 Elastomer Caulk

Use two-component polysulfide- or polyurethane-base elastomer caulking material, conforming to ASTM C920.

2.5.4 Escutcheons

Manufacture escutcheons from nonferrous metals and chrome-plated except when AISI 300 series corrosion-resistant steel is provided. Ensure metals and finish conforms to ASME A112.19.2/CSA B45.1.

Use one-piece escutcheons where mounted on chrome-plated pipe or tubing, and one-piece of split-pattern type elsewhere. Ensure all escutcheons have provisions consisting of [internal spring-tension devices] [setscrews] for maintaining a fixed position against a surface.

2.5.5 Flashing

Ensure sheetlead conforms to ASTM B749, [UNS Alloy Number L50049 (intended for use in laboratories and shops in general application)] [UNS Alloy Number L51121 (for use where lead sheet of high purity and improved structural strength is indicated)].

Ensure sheet copper conforms to ASTM B370 and be not less than 16 ounces per square foot weight.

2.5.6 Flange Gaskets

Provide compressed non-asbestos sheets, conforming to ASTM F104, coated on both sides with graphite or similar lubricant, with nitrile composition, binder rated to 750 degrees F.

2.5.7 Grout

Provide shrink-resistant grout as a premixed and packaged metallic-aggregate, mortar-grouting compound conforming to ASTM C404 and ASTM C476.

Ensure shrink-resistant grout is a combination of pre-measured and packaged epoxy polyamide or amine resins and selected aggregate mortar grouting compound conforming to the following requirements:

Tensile strength		1,900 psi, minimum
Compressive strength	ASTM C109/C109M	14,000 psi, minimum
Shrinkage, linear		0.00012 inch per inch, maximum
Water absorption	ASTM C67/C67M	0.1 percent, maximum
Bond strength to		1,000 psi, minimum steel in shear minimum

2.5.8 Pipe Thread Compounds

Use polytetrafluoroethylene tape not less than 2 to 3 mils thick in potable and process water and in chemical systems for pipe sizes to and including 1-inch ips. Use polytetrafluoroethylene dispersions and other suitable compounds for all other applications upon approval by the Contracting Officer; however, do not use lead-containing compounds in potable water systems.

2.6 SUPPORTING ELEMENTS

Submit equipment and performance data for the supporting elements consisting of corrosion resistance, life expectancy, gage tolerances, and grade line analysis.

Provide all necessary piping systems and equipment supporting elements, including but not limited to: building structure attachments; supplementary steel; hanger rods, stanchions, and fixtures; vertical pipe attachments; horizontal pipe attachments; anchors; guides; and spring-cushion, variable, or constant supports. Ensure supporting elements are suitable for stresses imposed by systems pressures and temperatures and natural and other external forces normal to this facility without damage to supporting element system or to work being supported.

Ensure supporting elements conform to requirements of ASME B31.3, and MSS SP-58, except as noted.

Ensure attachments welded to pipe are made of materials identical to that of pipe or materials accepted as permissible raw materials by referenced code or standard specification.

Ensure supporting elements exposed to weather are hot-dip galvanized or stainless steel. Select materials of such a nature that their apparent and latent-strength characteristics are not reduced due to galvanizing process. Electroplate supporting elements in contact with copper tubing with copper.

Type designations specified herein are based on MSS SP-58. Ensure masonry anchor group-, type-, and style-combination designations are in accordance with CID A-A-1922, CID A-A-1923, CID A-A-1924, CID A-A-1925 , CID A-A-55614, and CID A-A-55615. Provide support elements, except for supplementary steel, that are cataloged, load rated, commercially manufactured products.

2.6.1 Building Structure Attachments

2.6.1.1 Anchor Devices, Concrete and Masonry

Ensure anchor devices conform to CID A-A-1922, CID A-A-1923, CID A-A-1924, CID A-A-1925 , CID A-A-55614, and CID A-A-55615

For cast-in, floor mounted, equipment anchor devices, provide adjustable positions.

[Provide built-in masonry anchor devices.

] Do not use powder-actuated anchoring devices to support any mechanical systems components.

2.6.1.2 Beam Clamps

Ensure beam clamps are center-loading MSS SP-58 Type [20] [21] [28] [29] [30] [_____].

[When it is not possible to use center-loading beam clamps, eccentric-loading beam clamps, MSS SP-58 Type [19] [20] [25] [27] may be used for piping sizes 2 inches and less and for piping sizes 2 through 10 inches provided two counterbalancing clamps are used per point of pipe support. Where more than one rod is used per point of pipe support, determine rod diameter in accordance with referenced standards.

]2.6.1.3 C-Clamps

Do not use C-clamps.

2.6.1.4 Inserts, Concrete

Use concrete MSS SP-58 Type [18] [_____] inserts When applied to piping in sizes 2 inches ips and larger and where otherwise required by imposed loads, insert and wire a 1-foot length of 1/2-inch reinforcing rod through wing slots. Submit proprietary-type continuous inserts for approval.

2.6.2 Horizontal Pipe Attachments

2.6.2.1 Single Pipes

Support piping in sizes to and including 2-inch ips by MSS SP-58 Type 6 solid malleable iron pipe rings, except that, use split-band-type rings in sizes up to 1-inch ips.

Support piping in sizes through 8-inch ips inclusive by MSS SP-58 Type [1]

[3] [4] attachments.

Use MSS SP-58 Type 1 and Type 6 assemblies on vapor-sealed insulated piping and have an inside diameter larger than pipe being supported to provide adequate clearance during pipe movement.

Where thermal movement of a point in a piping system 4 inches and larger would cause a hanger rod to deflect more than 4 degrees from the vertical or where a horizontal point movement exceeds 1/2 inch, use MSS SP-58 Type [41] [44 through 46] [49] pipe rolls.

Support piping in sizes larger than 8-inch ips with MSS SP-58 Type [41] [44 through 46] [49] pipe rolls.

Use MSS SP-58 Type 40 shields on all insulated piping. Ensure area of the supporting surface is such that compression deformation of insulated surfaces does not occur. Roll away longitudinal and transverse shield edges from the insulation.

Provide insulated piping without vapor barrier on roll supports with MSS SP-58 Type 39 saddles.

Provide spring supports as indicated.

2.6.2.2 Parallel Pipes

Use trapeze hangers fabricated from structural steel shapes, with U-bolts, in congested areas and where multiple pipe runs occur. Ensure structural steel shapes [conform to supplementary steel requirements] [be of commercially available, proprietary design, rolled steel].

2.6.3 Vertical Pipe Attachments

Ensure vertical pipe attachments are MSS SP-58 Type 8.

Include complete fabrication and attachment details of any spring supports in shop drawings.

2.6.4 Hanger Rods and Fixtures

Use only circular cross section rod hangers to connect building structure attachments to pipe support devices. Use pipe, straps, or bars of equivalent strength for hangers only where approved by the Contracting Officer.

Provide turnbuckles, swing eyes, and clevises as required by support system to accommodate temperature change, pipe accessibility, and adjustment for load and pitch. Rod couplings are not acceptable.

2.6.5 Supplementary Steel

Where it is necessary to frame structural members between existing members or where structural members are used in lieu of commercially rated supports, design and fabricate such supplementary steel in accordance with AISC 325.

PART 3 EXECUTION

3.1 PIPE INSTALLATION

Submit certificates for pipes, valves and specialties showing conformance with test requirements as contained in the reference standards contained in this section. Provide certificates verifying Surface Resistance, Shear and Tensile Strengths, Temperature Ratings, Bending Tests, Flattening Tests and Transverse Guided Weld Bend Tests.

Provide test reports for Hydrostatic Tests, Air Tests, Valve-Operating Tests, Drainage Tests, Pneumatic Tests, Non-Destructive Electric Tests and System Operation Tests, in compliance with referenced standards contained within this section.

Fabricate and install piping systems in accordance with ASME B31.3, MSS SP-58, and AWS WHB-2.9.

Submit Installation Drawings for pipes, valves and specialties. Drawings include the manufacturer's design and construction calculations, forces required to obtain rated axial, lateral, or angular movements, installation criteria, anchor and guide requirements for equipment, and equipment room layout and design. Ensure drawings specifically advise on procedures to be followed and provisions required to protect expansion joints during specified hydrostatic testing operations.

Ensure connections between steel piping and copper piping are electrically isolated from each other with [dielectric couplings (or unions)] [flanged with gaskets] rated for the service.

Make final connections to equipment with [unions] [flanges] provided every 100 feet of straight run. Provide unions in the line downstream of screwed- and welded-end valves.

Ream all pipe ends before joint connections are made.

Make screwed joints with specified joint compound with not more than three threads showing after joint is made up.

Apply joint compounds to the male thread only and exercise care to prevent compound from reaching the unthreaded interior of the pipe.

Provide screwed unions, welded unions, or bolted flanges wherever required to permit convenient removal of equipment, valves, and piping accessories from the piping system for maintenance.

Securely support piping systems with due allowance for thrust forces, thermal expansion and contraction. Do not subject the system to mechanical, chemical, vibrational or other damage as specified in ASME B31.3.

Ensure field welded joints conform to the requirements of the AWS WHB-2.9, ASME B31.3, and ASME BPVC SEC IX.

[Make piping systems butt weld joints with backing rings. Use compatible backing ring materials with materials being joined. Ensure joint configuration conforms to ASME B16.25.

For polyropylene pipe, make fusion-weld joints in accordance with the pipe

and fitting manufacturer's specifications and product standards. Use fusion-weld tooling, welding machines, and electrofusion devices specified by the pipe and fittings manufacturer. Prior to joining, prepare the pipe and fittings in accordance with ASTM F2389 and the manufacturer's specifications. Ensure joint preparation, setting and alignment, fusion process, cooling times and working pressure are in accordance with the pipe and fitting manufacturer's specifications.

][Accomplish preheat and postheat treatment of welds in accordance with ASME BPVC SEC IX and ASME B31.3.

][Take all necessary precautions during installation of flexible pipe and hose including flushing and purging with water, steam, and compressed air to preclude bellows failure due to pipe line debris lodged in bellows. Ensure installation conforms to manufacturer's instructions.

]3.2 VALVES

Provide valves in piping mains and all branches and at equipment where indicated and as specified.

Provide valves to permit isolation of branch piping and each equipment item from the balance of the system.

Provide riser and downcomer drains above piping shutoff valves in piping 2-1/2 inches and larger. Tap and fit shutoff valve body with a 1/2-inch plugged globe valve.

Provide valves unavoidably located in furred or other normally inaccessible places with access panels adequately sized for the location and located so that concealed items may be serviced, maintained, or replaced.

3.3 SUPPORTING ELEMENTS INSTALLATION

Provide supporting elements in accordance with the referenced codes and standards.

Support piping from building structure. Do not support piping from roof deck or from other pipe.

Run piping parallel with the lines of the building. Space and install piping and components so that a threaded pipe fitting may be removed between adjacent pipes and so that there is no less than 1/2 inch of clear space between the finished surface and other work and between the finished surface of parallel adjacent piping. Arrange hangars on different adjacent service lines running parallel with each other in line with each other and parallel to the lines of the building.

Install piping support elements at intervals specified hereinafter, at locations not more than 3 feet from the ends of each runout, and not over 1 foot from each change in direction of piping.

Base load rating for all pipe-hanger supports on insulated weight of lines filled with water and forces imposed. Deflection per span is not exceed slope gradient of pipe. Ensure supports are in accordance with the following minimum rod size and maximum allowable hanger spacing for specified pipe. For concentrated loads such as valves, reduce the allowable span proportionately:

PIPE SIZE INCHES	ROD SIZE INCHES	STEEL PIPE FEET	COPPER PIPE FEET
1 and smaller	3/8	8	6
1-1/4 to 1-1/2	3/8	10	8
2	3/8	10	8
2-1/2 to 3-1/2	1/2	12	12
4 to 5	5/8	16	14
6	3/4	16	16
8 to 12	7/8	20	20
14 to 18	1	20	20
20 and over	1-1/4	20	20

Provide vibration isolation supports where needed. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT where A/C equipment and piping is installed.

Support vertical risers independently of connected horizontal piping, whenever practicable, with fixed or spring supports at the base and at intervals to accommodate system range of thermal conditions. Ensure risers have guides for lateral stability. For risers subject to expansion, provide only one rigid support at a point approximately one-third down from the top. Place clamps under fittings unless otherwise specified. Support carbon-steel pipe at each floor and at not more than 15-foot intervals for pipe 2 inches and smaller and at not more than 20-foot intervals for pipe 2-1/2 inches and larger.

3.4 PENETRATIONS

Provide effective sound stopping and adequate operating clearance to prevent structure contact where piping penetrates walls, floors, or ceilings into occupied spaces adjacent to equipment rooms; where similar penetrations occur between occupied spaces; and where penetrations occur from pipe chases into occupied spaces. Occupied spaces include space above ceilings where no special acoustic treatment of ceiling is provided. Finish penetrations to be compatible with surface being penetrated.

[Accomplish sound stopping and vapor-barrier sealing of pipe shafts and large floor and wall openings by packing to high density with properly supported fibrous-glass insulation or, where ambient or surface temperatures do not exceed 120 degrees F, by foaming-in-place with self-extinguishing, 2-pound density polyurethane foam to a depth not less than 6 inches. Finish foam with a rasp. Ensure vapor barrier is not less than 1/8-inch thick vinyl coating applied to visible and accessible surfaces. Where high temperatures and fire stopping are a consideration, use only mineral wool with openings covered by 16-gage sheet metal.

]3.5 SLEEVES

Provide sleeves where piping passes through roofs, masonry, concrete walls

and floors.

Continuously [weld] [braze] sleeves passing through steel decks to the deck.

Ensure sleeves that extend through floors, roofs, load bearing walls, and fire barriers are continuous and fabricated from Schedule 40 steel pipe, with welded anchor lugs. Form all other sleeves by molded linear polyethylene liners or similar materials that are removable. Ensure diameter of sleeves is large enough to accommodate pipe, insulation, and jacketing without touching the sleeve and provides a minimum 3/8-inch clearance. Install a sleeve size to accommodate mechanical and thermal motion of pipe precluding transmission of vibration to walls and the generation of noise.

Pack the space between a pipe, bare or insulated, and the inside of a pipe sleeve or a construction surface penetration solid with a mineral fiber conforming to ASTM C553 Type V (flexible blanket), (to 1,000 degrees F). Provide this packing wherever the piping passes through firewalls, equipment room walls, floors, and ceilings connected to occupied spaces, and other locations where sleeves or construction-surface penetrations occur between occupied spaces. Where sleeves or construction surface penetrations occur between conditioned and unconditioned spaces, fill the space between a pipe, bare or insulated, and the inside of a pipe sleeve or construction surface penetration with an elastomer caulk to a depth of 1/2 inch. Ensure all caulked surfaces are oil- and grease-free.

Ensure through-penetration fire stop materials and methods are in accordance with ASTM E814 and UL 1479.

Caulk exterior wall sleeves watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed metal components.

[Ensure sleeve height above roof surface is a minimum of 12 and a maximum of 18-inches.

]3.6 ESCUTCHEONS

Provide escutcheons at all penetrations of piping into finished areas. Where finished areas are separated by partitions through which piping passes, provide escutcheons on both sides of the partition. Where suspended ceilings are installed, provide plates at the underside only of such ceilings. For insulated pipes, select plates large enough to fit around the insulation. Use chrome-plated escutcheons in all occupied spaces and of size sufficient to effectively conceal openings in building construction. Firmly attach escutcheons with setscrews.

3.7 FLASHINGS

[Provide flashings at penetrations of building boundaries by mechanical systems and related work.

]3.8 UNDERGROUND PIPING INSTALLATION

Prior to being lowered into a trench, clean all piping, visually inspected for apparent defects, and tapped with a hammer to audibly detect hidden defects.

Further inspect suspect cast-ferrous piping by painting with kerosene on

external surfaces to reveal cracks.

Distinctly mark defective materials found using a road-traffic quality yellow paint; promptly remove defective material from the site.

After conduit has been inspected, and not less than 48 hours prior to being lowered into a trench, coat all external surfaces of cast ferrous conduit with a compatible bituminous coating for protection against brackish ground water. Apply a single coat, in accordance with the manufacturer's instructions, to result in a dry-film thickness of not less than 12 mils.

Ensure excavations are dry and clear of extraneous materials when pipe is being laid.

Use wheel cutters for cutting of piping or other machines designed specifically for that purpose. Electric-arc and oxyacetylene cutting is not permitted.

Begin laying of pipe at the low point of a system. When in final acceptance position, ensure it is true to the grades and alignment indicated, with unbroken continuity of invert. Blocking and wedging is not permitted.

[Point bell or grooved ends of piping upstream.

] Make changes in direction with long sweep fittings.

Provide necessary socket clamping, piers, bases, anchors, and thrust blocking. Protect rods, clamps, and bolting with a coating of bitumen.

Support underground piping below supported or suspended slabs from the slab with a minimum of two supports per length of pipe. Protect supports with a coating of bitumen.

On excavations that occur near and below building footings, provide backfilling material consisting of 2,000-psi cured compressive-strength concrete poured or pressure-grouted up to the level of the footing.

Properly support vertical downspouts; soil, waste, and vent stacks; water risers; and similar work on approved piers at the base and provided with approved structural supports attached to building construction.

[Provide cleanout, flushing, and observation risers.

3.9 [Enter Appropriate Subpart Title Here]

3.10 DISINFECTION

[Disinfect water piping, including all valves, fittings, and other devices, with a solution of chlorine and water. Ensure the solution contains not less than 50 parts per million (ppm) of available chlorine. Hold solution for a period of not less than 8 hours, after which the solution contains not less than 10 ppm of available chlorine or redisinfect the piping. After successful sterilization, thoroughly flush the piping before placing into service. Flushing is complete when the flush water contains less than 0.5 ppm of available chlorine. Water for disinfected will be furnished by the Government. Approve disposal of contaminated flush water in accordance with written instructions received from the Environmental authority having jurisdiction through the Contracting Officer and all

local, State and Federal Regulations.

][Flush piping with potable water until visible grease, dirt and other contaminants are removed (visual inspection).

3.11 [Enter Appropriate Subpart Title Here]
3.12 OPERATION AND MAINTENANCE

Provide Operation and Maintenance Manuals consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions. Submit test data that is clear and readily legible.

3.13 PAINTING OF NEW EQUIPMENT

Factory or shop apply new equipment painting, as specified herein, and provided under each individual section.

3.13.1 Factory Painting Systems

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

Ensure the film thickness of the factory painting system applied on the equipment is not 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, design the factory painting system for the temperature service.

3.13.2 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 clean to bare 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. Selected color of finish coat is 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 receives 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 Receives 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 receives 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 48.00 40

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
08/15

PART 1 GENERAL

Section 23 30 00 HVAC AIR DISTRIBUTIONapplies to work specified in this section to the extent applicable.

Section 23 05 15 COMMON PIPING FOR HVAC applies to work specified in this section to the extent applicable.

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

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

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

1.2 ADMINISTRATIVE REQUIREMENTS

Within ten [10] working days of Contract Award, submit equipment and performance data for vibration isolator systems including equipment base design; inertia-block mass relative to support equipment weight; spring loads and free, operating, and solid heights of spring; spring diameters; nonmetallic isolator loading and deflection; disturbing frequency; natural frequency of mounts; deflection of working member; and anticipated amount of physical movement at the reference points.

Ensure the data includes information on the following:

a. Mountings

b. Bases

c. Isolators

d. Floor-Mounted Piping

e. Vertical Piping

Five [5] working days prior to commencement of installation, submit installation drawings for vibration isolator systems including equipment and performance requirements.

Indicate within outline drawings for vibration isolator systems, overall

physical features, dimensions, ratings, service requirements, and weights of equipment.

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. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G, AE

Outline Drawings; G, AE

SD-03 Product Data

Equipment and Performance Data; G, AE]

Isolators; G, AE

SD-06 Test Reports

Type of Isolator; G, AE

Type of Base; G, AE

Allowable Deflection; G, AE

Measured Deflection; G, AE

1.4 QUALITY CONTROL

Ensure all vibration-control apparatus is the product of a single manufacturing source, where possible. Human exposure levels should be

2.1 SYSTEM DESCRIPTION

Scheduled isolation mounting is in inches and is a minimum static deflection.

Spans referred to in paragraph EQUIPMENT, means longest bay dimension.

Determine exact mounting sizes and number of isolators by the isolator manufacturer based on equipment that will be installed. Check equipment revolutions per minute (rpm) and spring deflections to verify that resonance cannot occur.

2.1.1 Design Requirements

Design for vibration isolation using NEBB PROCEDURAL STANDARDS and ASHRAE HVAC APP IP HDBK, Chapter 48, as applicable to the following sections.

2.1.1.1 Mountings

Provide the following mountings:

[Type A: Composite pad, with 0.25-inch thick elastomer top and bottom layers, molded to contain a pattern with nonslip characteristics in all horizontal directions. Elastomer loading is not to exceed 40 pounds per square inch (psi). Ensure minimum overall thickness is 1 inch. Maximum deflections up to 0.25-inch are allowed.

][Type B: Double [rubber-in-shear] [elastomer-in-shear] with molded-in steel reinforcement in top and bottom. Maximum deflections up to 0.50-inch are allowed.

][Type C: Free-standing laterally stable open-spring type for deflections over 0.50-inch, with built-in bearing and leveling provisions, 0.25-inch thick Type A base elastomer pads, and accessories. Ensure outside diameter of each spring is equal to or greater than 0.9 times the operating height of the spring under rated load.

][Type D: Partially housed type, containing one or more vertically restrained springs with at least 0.50-inch clearance maintained around springs, with adjustable limit stops, 0.25-inch thick Type A base elastomer pads, and accessories.

][Type E: Pendulum-suspension configuration with free-standing stable spring with resilient horizontal and vertical restraints to allow maximum movements of 0.25-inch in each direction, 0.25-inch thick Type A base elastomer pads.

][Type F: Combination [spring and rubber-in-shear] [elastomer-in-shear] steel framed for hanger-rod mounting, with minimum total static deflection of 1-inch.
]
[Type G: Air spring with body constructed of reinforced elastomer specifically suitable for application environment. Select air spring to provide a natural frequency equal to 5-inches of deflection of conventional specified steel springs. Provide facilities for dead-level adjustment and height-control of supported equipment.

]2.1.1.2 Bases

Provide the following bases:

[Type U: Unit isolators without rails, structural-steel bases, or inertia blocks.

][Type R: Rails, [connected] [disconnected] mill-rolled structural steel, of sufficient dimension to preclude deflection at midpoint of unsupported span in excess of 1/1,440th of the span between isolators, power transmission, component misalignment, and any overhung weight. Where Type R bases are specified and the equipment proposed requires additional base support, use a Type S base.

][Type S: Structural-steel bases common to a supported assembly, made from welded-joint mill-rolled structural steel with closed-perimeter configuration, isolators attached to outrigger supports.

] Ensure height of steel members is sufficient to provide stiffness required to maintain equipment manufacturer's recommended alignment and duty efficiency of power-transmission components. Ensure height of steel member does not result in member deflection at midpoint of unsupported span of more than 1/1,440th of the span between isolators. Minimum height is 5-inches.

[Type CIB: Provide concrete inertia blocks common to the entire assembly, with welded-joint construction, mill-rolled structural-steel perimeters, welded-in No. 4 reinforcing bars 8-inches on center each way near the bottom of the block, outrigger-isolator mounting provisions, anchor bolts. Fill with 3,000 psi cured-strength concrete.

] Configure rectangular inertia bases to accommodate equipment supported.

Ensure minimum thickness of inertia base, in addition to providing suitable mass, is sufficient to provide stiffness to maintain equipment manufacturer's recommended alignment and duty efficiency of power-transmission components, and is sufficient to result in base deflection at midpoint of unsupported span of not more than 1/1,440th of the span between isolators. Verify minimum thickness, the preceding requirements not withstanding, is 8 percent of the longest base dimension.

Ensure pumps with flexible couplings do not have inertia base less than 8-inches thick, and the minimum mass of concrete inertia block is equal in weight to supported equipment.

2.2 EQUIPMENT

Vibration isolation design per [NEBB PROCEDURAL STANDARDS][ASHRAE HVAC APP IP HDBK, Chapter 37,].

2.2.1 [Enter Appropriate Subpart Title Here]
2.2.2 [Enter Appropriate Subpart Title Here]
2.2.3 Centrifugal Pump Locations

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON/ABOVE GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
Close-couple through 5 hp	None	-R-0.35	C-S-1.0	C-S-1.0
Bedplate-mounted through 5 hp	None	C-CIB-1.0	C-CIB-1.5	C-CIB-1.75
7-1/2 hp	None	C-CIB-1.0	C-CIB-1.75	C-CIB-2.5
*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES				

2.2.4 Air-Cooled Condensing Unit Locations

TYPE EQUIPMENT	20-FOOT ROOF-SPAN PROVISIONS*	30-FOOT ROOF-SPAN PROVISIONS*	40-FOOT ROOF-SPAN PROVISIONS*
Through 5 hp over 900 rpm	B-U-0.5	D-U-1.0	D-U-1.75
Over 5 hp to 500 rpm	B-U-0.5	D-U-1.75	D-U-2.5
500 rpm and over	B-U-0.5	D-U-1.0	D-U-1.75
*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES			

2.2.5 [Enter Appropriate Subpart Title Here]

2.2.6 Low-Pressure AHU Locations

Vibration-isolation provisions apply to floor-mounted Air Moving and Conditioning Association Class A packaged central-station units.

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON/ABOVE GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
Through 5 hp	B-U-0.35	C-U-1.0	C-U-1.0	C-U-1.0
7-1/2 hp and over 250 to 500 rpm	B-U-0.35	C-U-1.75	C-U-1.75	C-U-1.75
500 rpm	B-U-0.35	C-U-1.0	C-U-1.5	
*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES				

2.2.7 Medium- and High-Pressure AHU Locations

Vibration-isolation provisions apply to floor-mounted Air Moving and Conditioning Association Classes B and C packaged central-station units.

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON/ABOVE GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
Through 20 hp 250 to 300 rpm	B-U-0.35	C-U-2.5	C-U-2.5	C-U-3.5
300 to 500 rpm	B-U-0.35	C-U-1.75	C-U-1.75	C-U-2.5
500 rpm and over	B-U-0.35	C-U-1.0	C-U-1.0	C-U-1.75
Over 20 hp 250 to 300 rpm	B-U-0.35	C-U-2.5	C-CIB-3.5	C-CIB-3.5
300 to 500 rpm	B-U-0.35	C-U-2.5	C-CIB-2.5	C-CIB-3.5

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON/ABOVE GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
500 rpm and over	B-U-0.35	C-U-1.0	C-CIB-1.75	C-CIB-2.5
*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES				

2.2.8 Air-Moving Device Locations

Vibration-isolation provisions apply to [housed] [unhoused] free-standing fans of any pressure rating, located in [field-erected [field-] [factory-] fabricated central-station units] [unhoused [return-air] [supply-air] service].

TYPE EQUIPMENT	BASEMENT BELOW-GRADE PROVISIONS*	ON/ABOVE GRADE 20-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 30-FOOT FLOOR-SPAN PROVISIONS*	ON/ABOVE GRADE 40-FOOT FLOOR-SPAN PROVISIONS*
Through 20 hp 250 to 300 rpm	B-U-0.35	C-S-2.5	C-S-2.5	C-S-3.5
300 to 500 rpm	B-U-0.35	C-S-1.75	C-S-1.75	C-S-2.5
500 rpm and over	B-U-0.35	C-S-1.0	C-S-1.5	C-S-1.75
Over 20 hp 250 to 300 rpm	B-U-0.35	C-S-2.75	C-CIB-3.5	C-CIB-5.0
300 to 500 rpm	B-U-0.35	C-S-1.75	C-CIB-2.5	C-CIB-3.5
500 rpm and over	B-U-0.35	C-S-1.0	C-CIB-1.75	C-CIB-2.5
*TYPE OF MOUNTING, BASE, AND MINIMUM DEFLECTION IN INCHES				

2.2.9 [Enter Appropriate Subpart Title Here]
2.2.10 Pipe And Duct Vibration Isolation

[Type G: Provide isolators with in-series contained steel springs and preformed fibrous-glass or chloroprene-elastomer elements for connecting to building-structure attachments. Load devices by supported system during operating conditions to produce a minimum spring and elastomer static deflection of 1-inch and 3/8-inch, respectively.
]
[Type H: Provide isolators with contained chloroprene-elastomer elements for connecting to building-structure attachments. Load devices by supported system during operating conditions to produce a minimum elastomer static deflection of 3/8-inch.

][Type J: Provide isolators with elastomers mounted on floor-supported columns or directly on the floor. Load devices by supported system during operating conditions to produce a minimum elastomer static deflection of 3/8-inch.

][2.2.10.1 Floor-Mounted Piping

Type K: Provide isolators with springs mounted on floor-supported columns or directly on the floor. Load devices by supported system during operating conditions to produce a minimum spring static deflection of 1-inch.

]2.2.10.2 Vertical Piping

[Type L: Provide isolators which are pipe base-support devices with one or more contained steel springs. Load devices by supported system during operating conditions to produce a minimum static deflection of 1-inch. Equip devices with precompression and vertical-limit features, as well as a minimum 1/4-inch thick elastomer sound pad and isolation washers, for mounting to floor.

][Type M: Provide isolators which are elastomer mounted baseplate and riser pipe-guide devices, with contained double acting elastomer elements which under rated load have a minimum static deflection of 3/8-inch. Size isolator to accommodate thermal insulation within the stationary guide ring.
]

2.3 MATERIALS

Ensure rubber is natural rubber and elastomer is chloroprene. Shore A durometer measurement of both materials and range between 40 and 60.

Inorganic materials such as precompressed, high-density, fibrous glass encased in a resilient moisture-impervious membrane may be used in lieu of specified natural rubber and elastomers. Where this substitution is made, ensure specified deflections are modified by the manufacturing source to accommodate physical characteristics of inorganic materials and to provide equal or better vibration isolation.

Ensure weather-exposed metal vibration-isolator parts are corrosion protected. Chloroprene coat springs.

2.4 TESTS, INSPECTIONS, AND VERIFICATIONS

Submit test reports for testing vibration isolation for each type of isolator and each type of base. Meet referenced standards contained within this section. Include in test reports allowable deflection and measured deflection also meeting referenced standards within this section.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment in accordance with manufacturer's recommendations.

[Ensure rails, structural steel bases, and concrete inertia blocks are raised not less than 1-inch above the floor and are level when equipment supported is under operating load.

][Ensure vibration-isolation installation and deflection testing after equipment start-up is directed by a competent representative of the manufacturer.

][3.2 FIELD QUALITY CONTROL

3.2.1 Tests and Reports

Ensure vibration-isolation devices are deflection tested. Submit test reports substantiating that all equipment has been isolated as specified and that minimum specified deflections have been met. Make all measurements in the presence of the Contracting Officer.

] -- End of Section --

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC
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.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.4	(1983; Amendment 1985; R 2006) Specification for Sound Level Meters (ASA 47)
ASA S1.11 PART 1	(2014) American National Standard Electroacoustics – Octave-Band and Fractional-Octave-Band Filters – Part 1: Specifications

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	(2002; 6th ed) National Standards for Total System Balance
AABC MN-4	(1996) Test and Balance Procedures

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. HVAC: Heating, ventilating, and air conditioning; or heating, ventilating, and cooling

f. NEBB: National Environmental Balancing Bureau

g. Out-of-tolerance data: Pertains only to field acceptance testing of Final DALT or TAB report. When applied to DALT work, this phase means "a leakage rate measured during DALT field acceptance testing which exceeds the leakage rate allowed by SMACNA Leak Test Manual for an indicated duct construction and sealant class." When applied to TAB work this phase means "a measurement taken during TAB field acceptance testing which does not fall within the range of plus 5 to minus 5 percent of the original measurement reported on the TAB Report for a specific parameter."

h. Season of maximum heating load: The time of year when the outdoor temperature at the project site remains within plus or minus 30 degrees Fahrenheit of the project site's winter outdoor design temperature, throughout the period of TAB data recording.

i. 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.

j. 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.

k. Sound measurements terminology: Defined in AABC MN-1, NEBB MASV, or SMACNA 1858 (TABB).

l. TAB: Testing, adjusting, and balancing (of HVAC systems)

m. TAB'd: HVAC Testing/Adjusting/Balancing procedures performed

n. TAB Agency: TAB Firm

o. TAB team field leader: TAB team field leader

p. TAB team supervisor: TAB team engineer

q. TAB team technicians: TAB team assistants

r. 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	International Standards for Environmental Systems Balance
TAB Specialist	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][and existing] 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, including records of existing conditions.

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 system[s] (TAB) 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 system[s] 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 TAB SCHEMATIC DRAWINGS

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 in air handling unit schedules.

4. Water quantities and temperatures in thermal energy transfer equipment schedules.

5. Water quantities and heads in pump schedules.

6. Water flow measurement fittings and balancing fittings.

7. Ductwork Construction and Leakage Testing Table that defines the DALT test requirements, including each applicable HVAC duct system ID or mark, duct pressure class, duct seal class, and duct leakage test pressure. This table is included in the file for Graphics for Unified Facilities Guide Specifications: http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/forms-gra

The Testing, Adjusting, and Balancing (TAB) Specialist must review the Contract Plans and Specifications and advise the Contracting Officer of any deficiencies that would prevent the effective and accurate TAB of the system, including records of existing conditions, and systems readiness

check. The TAB Specialist must provide a Design Review Report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

Submit three copies of the TAB Schematic Drawings and Report Forms to the Contracting Officer, no later than 21 days prior to the start of TAB field measurements.

1.3.4 Related Requirements

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. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Records of Existing Conditions; G, AE

TAB Firm; G, AE

Designation of TAB Team Assistants; G, AE

Designation of TAB Team Engineer; G, AE or TAB Specialist; G, AE

Designation of TAB Team Field Leader; G, AE

SD-02 Shop Drawings

TAB Schematic Drawings and Report Forms; G, AE

SD-03 Product Data

Equipment and Performance Data; G, AE

TAB Related HVAC Submittals; G, AE

A list of the TAB Related HVAC Submittals, no later than 7 7_ days after the approval of the TAB team engineer and assistant.

TAB Procedures; G, AE

Proposed procedures for TAB, submitted with the TAB Schematic Drawings and Report Forms.

Calibration; G, AE

Systems Readiness Check; G, AE

TAB Execution; G, AE

TAB Verification; G, AE

SD-06 Test Reports

Completed Pre-Final DALT Report; G, AE

Certified Final DALT Report; G, AE

TAB Design Review Report; G, AE

TAB Report for Season 1; G, AE

TAB Report for Season 2; G, AE

SD-07 Certificates

Independent TAB Agency and Personnel Qualifications; G, AE

DALT and TAB Submittal and Work Schedule; G, AE

TAB Pre-Field Engineering Report; G, AE

TAB Firm; G, AE

Design Review Report; G, AE

[Pre-field DALT Preliminary Notification; G, AE

] Advanced Notice for [Season 1] TAB Field Work; G, AE

Prerequisite HVAC Work Check Out List [For Season 1]; G, AE

[Advanced Notice for Season 2 TAB Field Work; G, AE

][Prerequisite HVAC Work Check Out List For Season 2; G, AE
]

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, 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.

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 documented evidence 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 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.

b. TAB Team Members: TAB team approved to accomplish work on this contract are full-time employees of the TAB agency. No other personnel is allowed to do 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 Qualifications

1.5.3.1 TAB Firm

The TAB Firm must be either a member of AABC or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications, including [TAB of environmental systems] [the performance of clean rooms and clean air devices] [building systems commissioning] [and] [the measuring of sound and vibration in environmental systems].

Certification must be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor must immediately notify

the Contracting Officer and submit another TAB Firm for approval. Any firm that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award is not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections to be performed by the TAB Firm will be considered invalid if the TAB Firm loses its certification prior to Contract completion and must be performed by an approved successor.

These TAB services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The TAB Firm must be a prime subcontractor of the Contractor and be financially and corporately independent of the mechanical subcontractor, reporting directly to and paid by the Contractor.

1.5.3.2 TAB Specialist

The TAB Specialist must be either a member of AABC,an experienced technician of the Firm certified by the NEBB, or a Supervisor certified by the TABB. The certification must be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, immediately notify the Contracting Officer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC, the NEBB, or the TABB within the five years preceding Contract Award is not eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB Specialist will be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by the approved successor.

1.5.3.3 TAB Specialist Responsibilities

TAB Specialist responsibilities include all TAB work specified herein and in related sections under his direct guidance. The TAB specialist is required to be onsite on a daily basis to direct TAB efforts. The TAB Specialist must participate in the commissioning process[specified in Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING].

1.5.3.4 TAB Related HVAC Submittals

The TAB Specialist must prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all HVAC TAB. Accompany the submittals identified on this list with a letter of approval signed and dated by the TAB Specialist when submitted to the Government. Ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.

1.5.4 Responsibilities

The Contractor is responsible for ensuring compliance with the requirements of this section. The following delineation of specific work responsibilities is specified to facilitate TAB execution of the various work efforts by personnel from separate organizations. This breakdown of specific duties is specified to facilitate adherence to the schedule listed in the paragraph TAB SUBMITTAL AND WORK SCHEDULE.

1.5.4.1 Contractor

a. TAB personnel: Ensure that the DALT work and the TAB work is accomplished by a group meeting the requirements specified in the paragraph TAB PERSONNEL QUALIFICATION REQUIREMENTS.

b. Pre-DALT/TAB meeting: Attend the meeting with the TAB Supervisor, and ensure that a representative is present for the sheetmetal contractor, mechanical contractor, electrical contractor, and automatic temperature controls contractor.

c. HVAC documentation: Furnish one complete set of the following HVAC-related documentation to the TAB agency:

(1) Contract drawings and specifications

(2) Approved submittal data for equipment

(3) Construction work schedule

(4) Up-to-date revisions and change orders for the previously listed items

d. Submittal and work schedules: Ensure that the schedule for submittals and work required by this section and specified in the paragraph TAB SUBMITTAL AND WORK SCHEDULE is met.

e. Coordination of supporting personnel:

Provide the technical personnel, such as factory representatives or HVAC controls installer required by the TAB field team to support the DALT and the TAB field measurement work.

Provide equipment mechanics to operate HVAC equipment and ductwork mechanics to provide the field designated test ports to enable TAB field team to accomplish the DALT and the TAB field measurement work. Ensure these support personnel are present at the times required by the TAB team, and cause no delay in the DALT and the TAB field work.

Conversely, ensure that the HVAC controls installer has required support from the TAB team field leader to complete the controls check out.

f. Deficiencies: Ensure that the TAB Agency supervisor submits all Design/Construction deficiency notifications directly to the Contracting officer within 3 days after the deficiency is encountered. Further, ensure that all such notification submittals are complete with explanation, including documentation, detailing deficiencies.

g. Prerequisite HVAC 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 prerequisite work items, the deficiencies pointed out by the TAB team supervisor in the design review report.

h. Prior to the TAB field team's arrival, ensure completion of the

applicable inspections and work items listed in the TAB team supervisor's pre-field engineering report. Do not allow the TAB team to commence TAB field work until all of the following are completed.

(1) HVAC system installations are fully complete.

(2) HVAC prerequisite checkout work lists specified in the paragraph PRE-FIELD TAB ENGINEERING REPORT are completed, submitted, and approved. Ensure that the TAB Agency gets a copy of the approved prerequisite HVAC work checklist.

(3) DALT field checks for all systems are completed.

(4) HVAC system filters are clean for both Season 1 and Season 2 TAB field work.

i. Advance notice: Furnish to the Contracting Officer with advance written notice for the commencement of the DALT field work and for the commencement of the TAB field work.

j. Insulation work: For required DALT work , ensure that insulation is not installed on ducts to be DALT'd until DALT work on the subject ducts is complete. Later, ensure that openings in duct and machinery insulation coverings for TAB test ports are marked, closed and sealed.

1.5.4.2 TAB Agency

Provide the services of a TAB team which complies with the requirements of the paragraph INDEPENDENT TAB AGENCY PERSONNEL QUALIFICATIONS. The work to be performed by the TAB agency is limited to testing, adjusting, and balancing of HVAC air and water systems to satisfy the requirements of this specification section.

1.5.4.3 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. Pre-DALT/TAB meeting: Attend meeting with Contractor.

c. Design review report: Review project specifications and accompanying drawings to verify that the air systems and water systems are designed in such a way that the TAB engineer can accomplish the work 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, and manual volume dampers.

d. 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 design review report, or the pre-field engineering report, the during the DALT or TAB field work.

e. Pre-field DALT preliminary notification: Monitor the completion of the duct installation of each system and provide the necessary written

notification to the Contracting Officer.

f. Pre-field engineering report: Utilizing the following HVAC-related documentation; contract drawings and specifications, approved submittal data for equipment, up-to-date revisions and change orders; prepare this report.

g. Prerequisite HVAC work checklist: Ensure the Contractor gets a copy of this checklist at the same time as the pre-field engineering report is submitted.

h. Technical assistance for DALT work.

(1) Technical assistance: Provide immediate technical assistance to TAB field team.

(2) DALT field visit: Near the end of the DALT field work effort, visit the contract site to inspect the HVAC installation and the progress of the DALT field work. Conduct a site visit to the extent necessary to verify correct procedures are being implemented and to confirm the accuracy of the Pre-final DALT Report data which has been reported. Also, perform sufficient evaluation to allow the TAB supervisor to issue certification of the final report. Conduct the site visit full-time for a minimum of [one] [two] [_____] 8 hour workday[s] duration.

i. Final DALT report: Certify the DALT report. This certification includes the following work:

(1) Review: Review the Pre-final DALT report data. From these field reports, prepare the Certified Final DALT report.

(2) TAB Verification: Verify adherence, by the TAB field team, to the procedures specified in this section.

j. Technical Assistance for TAB Work: Provide immediate technical assistance to the TAB field team for the TAB work.

[(1) TAB field visit: At the midpoint of the Season 1 and Season 2 TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work. Conduct site visit full-time for a minimum of [one] [two] [_____] 8 hour workday[s] duration.

][(2) TAB field visit: Near the end of the TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work. Conduct site visit full-time for a minimum of [one] [two] [_____] 8 hour workday[s] duration. Review the TAB final report data and certify the TAB final report.
]
[(1) TAB field visit: Near the end of the TAB field work effort, visit the contract site to inspect the HVAC installation and the progress of the TAB field work. Conduct site visit full-time for a minimum of [one] [two] [_____] 8 hour workday[s] duration. Review the TAB final report data and certify the TAB final report.

] k. Certified TAB report: Certify the TAB report. This certification includes the following work:

(1) Review: Review the TAB field data report. From this field report, prepare the certified TAB report.

(2) Verification: Verify adherence, by the TAB field team, to the TAB plan prescribed by the pre-field engineering report and verify adherence to the procedures specified in this section.

l. Design/Construction deficiencies: Within 3 working days after the TAB Agency has encountered any design or construction 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 TAB, the TAB Agency must issue notice and request direction in the notification submittal.

m. TAB Field Check: The TAB team supervisor must attend and supervise [Season 1] [and Season 2] TAB field check.

1.5.4.4 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 a copy of the prerequisite HVAC Checklist, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

1.5.5 Test Reports

1.5.5.1 Data from DALT Field Work

Report the data for the Pre-final DALT Report and Certified Final DALT Report in compliance the following requirements:

a. Report format: Submit report data on Air Duct Leakage Test Summary Report Forms as shown on Page 6-2 of SMACNA 1972 CD. 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. Include node numbers in the completed report forms to identify each duct section. The TAB supervisor must review and certify the report.

b. The TAB supervisor must include a copy of all calculations prepared in determining the duct surface area of each duct test section. In addition,provide the ductwork air leak testing (DALT) reports with a copy(s) of the calibration curve for each of the DALT test orifices used for testing.

c. Instruments: 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 must have been calibrated within one year of the date of use in the field. Instrument calibration must be traceable to

the measuring standards of the National Institute of Standards and Technology.

d. Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

1.5.5.2 Certified TAB Reports

Submit: TAB Report for Season 1 and TAB Report for Season 2 in the following manner:

a. Report format: Submit the completed pre-field data forms approved in the pre-field TAB Engineering Report completed by TAB field team, reviewed and certified by the TAB supervisor. Bind the report with a waterproof front and back cover. Include a table of contents identifying by page number the location of each report. Report forms and report data must be typewritten. Handwritten report forms or report data are not acceptable.

b. Temperatures: On each TAB report form reporting TAB work accomplished on HVAC thermal energy transfer equipment, include the indoor and outdoor dry bulb temperature range and indoor and outdoor wet bulb temperature range within which the TAB data was recorded. Include in the TAB report continuous time versus temperature recording data of wet and dry bulb temperatures for the rooms, or zones, as designated in the following list:

(1) [Specifier: List desired rooms and/or zones here]. Measure and compile data on a continuous basis for the period in which TAB work affecting those rooms is being done.

(2) Measure and record data only after the HVAC systems installations are complete, the systems fully balanced and the HVAC systems controls operating in fully automatic mode.

(3) Data may be compiled using direct digital controls trend logging where available. Otherwise, temporarily install calibrated time versus temperature/humidity recorders for this purpose. The HVAC systems and controls must be fully operational a minimum of 24 hours in advance of commencing data compilation. Include the specified data in the [Season I TAB Report] [Season I and Season 2 TAB Report].

[c. System Diagrams: Provide updated diagrams with final installed locations of all terminals and devices, any numbering changes, and actual test locations. Use a key numbering system on the diagram which identifies each outlet contained in the outlet airflow report sheets.

][d. Static Pressure Profiles: Report static pressure profiles for air duct systems including: [_____]. Report static pressure data for all supply, return, relief, exhaust and outside air ducts for the systems listed. Include the following in the static pressure report data, in addition to AABC/NEBB/TABB required data:

(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.[and also at the following locations:

Main Duct: Take readings at four locations along the full length of the main duct, 25 percent, 50 percent, 75 percent, and 100 percent of the total duct length.

Floor Branch Mains: Take readings at floor branch mains served by a main duct vertical riser.

Branch Main Ducts: Take readings at branch main ducts.

VAV Terminals: Take readings at inlet static pressure at VAV terminal box primary air branch ducts.

VAV Terminals, Fan Powered: Take readings at fan discharge and inlet static pressures for series and parallel fan powered VAV terminal boxes.]

]

e. Duct Traverses: Report duct traverses for main [and branch main] supply, return, exhaust, relief and outside air ducts. This includes 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. The TAB Agency must evaluate and report findings on the duct traverses taken. Evaluate the suitability of the duct traverse measurement based on satisfying the qualifications for a pilot traverse plane as defined by AMCA 203, "Field Measurements", Section 8, paragraph 8.3, "Location of Traverse Plane."

f. 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 must provide accuracy of plus or minus 5 percent at the measured face velocities. Submit instrument manufacturer's literature to document instrument accuracy performance is in compliance with that specified.

g. Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

h. Performance Curves: The TAB Supervisor must include, in the TAB Reports, factory pump curves and fan curves for pumps and fans TAB'd on the job.

i. Calibration Curves: The TAB Supervisor must include, in the TAB Reports, a factory calibration curve for installed flow control balancing valves, flow venturi's and flow orifices TAB'd on the job.

[1.6 PROJECT/SITE CONDITIONS

1.6.1 DALT and TAB Services to Obtain Existing Conditions

Conduct DALT and TAB of the indicated existing systems and equipment and submit the specified DALT and TAB reports for approval. Conduct this DALT and TAB work in accordance with the requirements of this section.

]1.7 SEQUENCING AND SCHEDULING

[1.7.1 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.

1.7.1.1 Phasing of Work

This specification section is structured as though the HVAC construction, and thereby the TAB work, is going to be completed in a single phase[in spite of the fact that there will be two seasons]. All elements of the TAB work are addressed on this premise. When a contract is to be completed in construction phases, including the TAB work, and the DALT work, the TAB work and DALT work must be planned for, completed and approved by the Contracting Officer with each phase. An example of this case would be one contract that requires the rehabilitation of the HVAC in each of several separated buildings. At the completion of the final phase, compile all approved reports and submit as one document.

]1.7.2 DALT and TAB Submittal and Work Schedule

Submit this schedule,and TAB Schematic Drawings, adapted for this particular contract, to the Contracting Officer (CO) for review and approval. Include with the submittal the planned calendar dates for each submittal or work item. Resubmit an updated version for CO approval every 90 calendar days. Compliance with the following schedule is the Contractor's responsibility.

Qualify TAB Personnel: Within [45] [_____] calendar days after date

of contract award, submit TAB agency and personnel qualifications.

Pre-DALT/TAB Meeting: Within [30] [_____] calendar days after the date of approval of the TAB agency and personnel, meet with the COTR.

Design Review Report: Within [60] [_____] calendar days after the date of the TAB agency personnel qualifications approval, submit design review report.

Pre-Field DALT Preliminary Notification: On completion of the duct installation for each system, notify the Contracting Officer in writing within 5 days after completion.

Ductwork Selected for DALT: Within 7 calendar days of Pre-Field DALT Preliminary Notification, the COTR will select which of the project ductwork must be DALT'd.

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

Submit Pre-final DALT Report: Within one working day 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.

DALT Work Field Check: Upon approval of the Pre-final DALT Report, schedule the COTR's DALT field check work with the Contracting Officer.

Submit Final DALT Report: Within [15] [_____] calendar days after completion of successful DALT Work Field Check, submit [Season 1] TAB report.

Pre-Field TAB Engineering Report: Within [_____] calendar days after approval of the TAB agency Personnel Qualifications, submit the Pre-Field TAB Engineering Report.

Prerequisite HVAC Work Check Out List [For Season 1] and Advanced Notice For [Season 1] TAB Field Work: At a minimum of [115] [_____] calendar days prior to CCD, submit [Season 1] prerequisite HVAC work check out list certified as complete, and submit advance notice of commencement of [Season 1] TAB field work.

[[Season 1] TAB Field Work: At a minimum of [90] [_____] calendar days prior to CCD, [and when the ambient temperature is within Season 1 limits,] accomplish [Season 1] TAB field work.

Submit [Season 1] TAB Report: Within [15] [_____] calendar days after completion of [Season 1] TAB field work, submit [Season 1] TAB report.

[Season 1] TAB Field Check: [30] [_____] calendar days after Season 1 TAB report is approved by the Contracting Officer, conduct [Season 1] field check.

Complete [Season 1] TAB Work: Prior to CCD, complete all TAB work [except Season 2 TAB work].
]
[[Season 1] TAB Field Work: At a minimum of [90] [_____] calendar days prior to CCD, [and when the ambient temperature is within Season

1 limits,] accomplish [Season 1] TAB field work; submit [Season 1] TAB report; and conduct [Season 1] field check.

Complete [Season 1] TAB Work: Prior to CCD, complete all TAB work [except Season 2 TAB work].

]

[Prerequisite HVAC Work Check Out List For Season 2 and Advanced Notice For Season 2 TAB Field Work: Within [150] [_____] calendar days after date of the commencement of the Season 1 TAB field work, submit the Season 2 prerequisite HVAC work check out list certified as complete and submit advance notice of commencement of Season 2 TAB field work.

]

[Season 2 TAB Field Work: Within [180] [_____] calendar days after date of commencement of the Season 1 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 [15] [_____] calendar days after completion of Season 2 TAB field work, submit Season 2 TAB report.

Season 2 TAB Field Check: [30] [_____] calendar days after the Season 2 TAB report is approved by the Contracting Officer, conduct Season 2 field check.

Complete Season 2 TAB Work: Within [15] [_____] calendar days after the completion of Season 2 TAB field data check, complete all TAB work.

]

[Season 2 TAB Field Work: Within [180] [_____] calendar days after date of commencement of the Season 1 TAB field work and when the ambient temperature is within Season 2 limits, accomplish [Season 2] TAB field work; submit [Season 2] TAB report; and conduct Season 2 field check.

Complete Season 2 TAB Work: Within [15] [_____] calendar days after the completion of Season 2 field data check, complete TAB work.

]1.7.2.1 TAB Design Review Report

Submit typed report describing omissions and deficiencies in the HVAC system's design that would preclude the TAB team from accomplishing the duct leakage testing work and the TAB work requirements of this section. Provide a complete explanation including supporting documentation detailing the design deficiency. State that no deficiencies are evident if that is the case.

1.7.2.2 Pre-Field DALT Preliminary Notification

Notification: On completion of the installation of each duct system indicated to be DALT'd, notify the Contracting Officer in writing within 7 calendar days after completion.

1.7.2.3 TAB Pre-Field Engineering Report

Submit report containing the following information:

a. Step-by-step TAB procedure:

(1) Strategy: Describe the method of approach to the TAB field work from start to finish. Include in this description a complete

methodology for accomplishing each seasonal TAB field work session.

(2) Air System Diagrams: Use the contract drawings and duct fabrication drawings if available to provide air system diagrams in the report showing the location of all terminal outlet supply, return, exhaust and transfer registers, grilles and diffusers. Use a key numbering system on the diagrams which identifies each outlet contained in the outlet airflow report sheets. Show intended locations of all traverses and static pressure readings.

(3) Procedural steps: Delineate fully the intended procedural steps to be taken by the TAB field team to accomplish the required TAB work of each air distribution system and each water distribution system. Include intended procedural steps for TAB work for subsystems and system components.

b. Pre-field data: Submit AABC or NEBB or SMACNA 1780 data report forms with the following pre-field information filled in:

(1) Design data obtained from system drawings, specifications, and approved submittals.

(2) Notations detailing additional data to be obtained from the contract site by the TAB field team.

(3) Designate the actual data to be measured in the TAB field work.

(4) Provide a list of the types of instruments, and the measuring range of each, which are anticipated to be used for measuring in the TAB field work. By means of a keying scheme, specify on each TAB data report form submitted, which instruments will be used for measuring each item of TAB data. If the selection of which instrument to use, is to be made in the field, specify from which instruments the choice will be made. Place the instrument key number in the blank space where the measured data would be entered.

c. Prerequisite HVAC work checkout list: Provide a list of inspections and work items which are to be completed by the Contractor. This list must be acted upon and completed by the Contractor and then submitted and approved by the Contracting Officer prior to the TAB team coming to the contract site.

At a minimum, a list of the applicable inspections and work items listed in the NEBB PROCEDURAL STANDARDS, Section III, "Preliminary TAB Procedures" under paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" must be provided for each separate system to be TAB'd.

1.8 WARRANTY

Furnish workmanship and performance warranty for the [DALT and] TAB system work performed for a period not less than [1] [2] [3] [5] [_____] years from the date of Government acceptance of the work; issued directly to the Government. Include provisions that if within the warranty period the system shows evidence of major performance deterioration, or is significantly out of tolerance, resulting from defective TAB or DALT workmanship, the corrective repair or replacement of the defective materials and correction of the defective workmanship is the responsibility of the TAB firm. Perform corrective action that becomes

necessary because of defective materials and workmanship while system TAB and DALT is under warranty 7 days after notification, unless additional time is approved by the Contracting Officer. Failure to perform repairs within the specified period of time constitutes grounds for having the corrective action and repairs performed by others and the cost billed to the TAB firm. The Contractor must also provide a [1] [2] [3] [5] [_____] year contractor installation warranty.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 WORK DESCRIPTIONS OF PARTICIPANTS

Comply with requirements of this section.

3.2 PRE-DALT/TAB MEETING

Meet with the Contracting Officer's technical representative (COTR)[and the designing engineer of the HVAC systems] 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 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, accuracy of measurements, preliminary procedures, field work, workmanship and treatment of deficiencies. Calibrate and maintain instruments in accordance with manufacturer's written procedures.

3.3.2 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.

3.3.3 Ductwork To Be DALT'd

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, branch main ducts, branch ducts and plenums for supply, return, exhaust, and plenum ductwork.

[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.

]3.3.4 DALT Testing

Perform DALT on the HVAC duct sections of each 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 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.

3.3.5 Completed Pre-Final DALT Report

After completion of the DALT work, prepare a Pre-final DALT Report using the reporting forms specified. TAB team to furnish data required by those data report forms. Prepare the report neatly and legibly; the Pre-final DALT report is the basis for the Final DALT Report. TAB supervisor must review and certify the Pre-final DALT Report and submit this report within one day of completion of DALT field work. Verbally notify the COTR that the field check of the Pre-final DALT Report data can commence.

3.3.6 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 data on the Pre-final DALT report form for a given duct section is out-of-tolerance, then field acceptance testing shall be conducted on data for one additional duct section, preferably in the same duct system, in the presence of the COTR.

3.3.7 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.

3.3.8 Certified Final DALT Report

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

3.3.9 Prerequisite for TAB Field Work

Do not commence TAB field work prior to the completion and approval, for all systems, of the Final DALT Report.

3.4 TAB PROCEDURES

3.4.1 TAB Field Work

Test, adjust, and balance the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents.

That is, comply with the the requirements of AABC MN-1 or SMACNA 1780 (TABB) and SMACNA 1858 (TABB),except as supplemented and modified by this section.

[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 the HVAC systems until measured flow rates (air and water flow) are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. Conduct TAB work, including measurement accuracy, and sound measurement work in conformance with the AABC MN-1 and AABC MN-4, or NEBB TABES 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 water flow and air flow reporting which can be deferred until the Season 2 is that data which would be affected in terms of accuracy due to outside ambient conditions.]

3.4.2 Preliminary Procedures

Use the approved pre-field engineering report 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 sheet metal contractor to provide and install test ports as required by the TAB engineer.

3.4.3 TAB Air Distribution Systems

3.4.3.1 Units With Coils

Report heating and cooling performance capacity tests for hot water, chilled water, DX and steam coils for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

a. For air handlers with capacities greater than 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing."

   Do not determine entering and leaving wet and dry bulb temperatures by single point measurement, but by the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of AABC MN-4, Procedure 3.5, "Coil Capacity Testing."

   Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with AABC MN-4, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in

subparagraph c.).

b. For units with capacities of 7.5 tons (90,000 Btu) 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 coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.4.3.2 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.

[3.4.3.3 Rooftop Air Conditioning

Rooftop air conditioning systems including fans, coils, ducts, plenums, and air distribution devices for supply air, return air, and outside air.

For refrigeration compressors/condensers/condensing units/evaporators, report data as required by NEBB, AABC, and TABB standard procedures, including refrigeration operational data.

][3.4.3.4 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.

][3.4.3.5 Makeup Air Units

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

][3.4.3.6 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.

][3.4.3.7 Fan Coils

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

][3.4.3.8 Exhaust Fans

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

][3.4.4 TAB Water Distribution Systems

3.4.4.1 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.

3.4.4.2 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.

3.4.4.3 Dual Temperature Water

Dual temperature water systems including boilers, converters, chillers, condensers, cooling towers, pumps, coils, and system balancing valves, and flow measuring devices.

][3.4.5 Sound Measurement Work

3.4.5.1 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.

[c. AHU No. 1 System: Rooms: [_____]

][d. [_____] System: Rooms: [_____]

][e. [_____] System: Rooms: [_____]

]3.4.5.2 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.

3.4.5.3 Timing

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

3.4.5.4 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.

3.4.5.5 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.

3.4.5.6 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.

][3.4.6 TAB Work on Performance Tests Without Seasonal Limitations

3.4.6.1 Performance Tests

In addition to the TAB proportionate 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].

3.4.6.2 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.

[3.4.6.3 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.

][3.4.6.4 Water Chillers

For water chillers, report data as required by NEBB Form TAB 15-83, NEBB PROCEDURAL STANDARDS, including refrigeration operational data.

][3.4.6.5 Refrigeration Units

For refrigeration compressors/condensers/condensing units, report data as required by NEBB Form TAB 15-83, NEBB PROCEDURAL STANDARDS, including refrigeration operational data.

]3.4.6.6 Coils

Report heating and cooling performance capacity tests for [hot water], [chilled water], [DX] [and steam coils] for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

[a. For Central station air handlers with capacities greater than 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing".

Entering and leaving wet and dry bulb temperatures are not determined by single point measurement, but the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of AABC MN-4, Procedure 3.5, "Coil Capacity Testing."

Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with AABC MN-4, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

][b. For units with capacities of 7.5 tons (90,000 Btu) 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 coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

]][3.4.7 TAB Work on Performance Tests With Seasonal Limitations

3.4.7.1 Performance Tests

Accomplish proportionate balancing TAB work on the air distribution systems and water distribution systems, in other words, accomplish adjusting and balancing of the air flows and water flows, any time during the duration of this contract, subject to the limitations specified elsewhere in this section. However, accomplish, within the following seasonal limitations, TAB work on HVAC systems which directly transfer thermal energy.

3.4.7.2 Season Of Maximum Load

Visit the contract site for at least two TAB work sessions for TAB field measurements. [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].

3.4.7.3 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.

3.4.7.4 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.

[3.4.7.5 Water Chillers

Water chillers: For water chillers,report data as required by NEBB Form TAB 15-83, NEBB PROCEDURAL STANDARDS, including refrigeration operational data.

][3.4.7.6 Refrigeration Units

For refrigeration compressors/condensers/condensing units,report data as required by NEBB Form TAB 15-83, NEBB PROCEDURAL STANDARDS, including refrigeration operational data.

][3.4.7.7 Coils

Report heating and cooling performance capacity tests for [hot water], [chilled water], [DX] [and steam coils] for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

a. For Central station air handlers with capacities greater than 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units and rooftop units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing."

   Entering and leaving wet and dry bulb temperatures are not determined by single point measurement, but by the average of multiple readings in compliance with paragraph 3.5-5, "Procedures", (in subparagraph d.) of AABC MN-4, Procedure 3.5, "Coil Capacity Testing."

   Submit part-load coil performance data from the coil manufacturer converting test conditions to design conditions; use the data for the purpose of verifying that the coils meet the indicated design capacity in compliance with AABC MN-4, Procedure 3.5, "Coil Capacity Testing," paragraph 3.5.7, "Actual Capacity Vs. Design Capacity" (in subparagraph c.).

b. For units with capacities of 7.5 tons (90,000 Btu) 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 coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

]][3.4.8 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. 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.

]3.4.9 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.

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.

3.4.10 TAB Reports

[After completion of the TAB field work, prepare the TAB field data for TAB supervisor's review and certification, using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms is to be furnished by the TAB team. Except as approved otherwise in writing by the Contracting Officer, the TAB work and thereby the TAB report is considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph WORKMANSHIP.
]
[After completion of the TAB work, prepare a pre-final TAB report using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms is to be furnished by the TAB team. Except as approved otherwise in writing by the Contracting Officer, the TAB work and the TAB report is considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph WORKMANSHIP of this section.

Prepare the report neatly and legibly; the pre-final TAB report is the final TAB report minus the TAB supervisor's review and certification. Obtain, at the contract site, the TAB supervisor's review and certification of the TAB report.

Verbally notify the COTR that the field check of the TAB report data can commence; give this verbal notice 48 hours in advance of field check commencement. Do not schedule field check of the TAB report until the specified workmanship requirements have been met or written approval of the deviations from the requirements have been received from the Contracting Officer.
]
3.4.11 Quality Assurance - COTR TAB Field Acceptance Testing

3.4.11.1 TAB Field Acceptance Testing

During the field acceptance testing, verify, in the presence of the COTR, random selections of data (water, air quantities, air motion, [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 approved 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, return fans, computer room units, and air handling units (rooftop and central stations).

Group 2: 25 percent of the VAV terminal boxes and associated diffusers and registers.

Group 3: 25 percent of the supply diffusers, registers, grilles associated with constant volume air handling units.

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

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

Further, if any data on the TAB Report for Groups 2 through 5 is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, additional group data verification is required in the presence of the COTR. Verify TAB Report data for one additional piece of equipment in that group. Continue this additional group data verification until out-of-tolerance data ceases to be found.

3.4.11.2 Additional COTR TAB Field Acceptance Testing

If any of the acceptance testing measurements for a given equipment group is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, 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.

Further, if any data on the TAB Report for a given field acceptance test group is out-of-tolerance, then field test data for one additional field test group as specified herein. Continue this increase field test work until out-of-tolerance data ceases to to be found. This additional field testing is up and above the original 25 percent of the of reported data entries to be field tested.

If there are no more similar field test groups from which to choose, additional field testing from another, but different, type of field testing group must be tested.

3.4.11.3 Prerequisite for Approval

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

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. 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.

-- End of Section --

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SECTION 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS
02/13, CHG 7: 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. 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 - SI	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.2	(2020) Energy-Efficient Design of 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 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 C533	(2017) Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation
ASTM C534/C534M	(2020a) Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

ASTM C547	(2019) Standard Specification for Mineral Fiber Pipe Insulation
ASTM C552	(2021) Standard Specification for Cellular Glass Thermal Insulation
ASTM C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C585	(2010) Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing
ASTM C591	(2021) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C592	(2016) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C610	(2015) Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation
ASTM C612	(2014; R 2019) Standard Specification for Mineral Fiber Block and Board Thermal Insulation
ASTM C647	(2008; R 2013) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM C755	(2019b) Standard Practice for Selection of Water Vapor Retarders 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 C1126	(2018) Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
ASTM C1136	(2021) 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 D882	(2012) Tensile Properties of Thin Plastic Sheeting
ASTM D2863	(2019) 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 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
ASTM E2231	(2019) Standard Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics
ASTM E2336	(2020) Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems

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

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 2758	(2014) Paper - Determination of Bursting Strength

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
NFPA 96	(2021) Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

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-3316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation
MIL-A-24179	(1969; Rev A; Am 2 1980; Notice 1 1987; Notice 2 2020) Adhesive, Flexible Unicellular-Plastic Thermal Insulation
MIL-PRF-19565	(1988; Rev C) Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

UNDERWRITERS LABORATORIES (UL)

UL 94	(2013; Reprint May 2021) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of

	Building Materials
UL 2818	(2013) GREENGUARD Certification Program For Chemical Emissions For Building Materials, Finishes And Furnishings

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 13 PRE-ENGINEERED UNDERGROUND HEAT DISTRIBUTION SYSTEM, Section 33 63 13.19 CONCRETE TRENCH HYDRONIC AND STEAM ENERGY DISTRIBUTION, Section 33 60 02 ABOVEGROUND HEAT DISTRIBUTION SYSTEM, and Section 33 61 13.13 PREFABRICATED UNDERGROUND HYDRONIC ENERGY DISTRIBUTION. 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" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 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, AE

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, AE

Duct Insulation Systems; G, AE

Equipment Insulation Systems; G[, AE

SD-04 Samples

Thermal Insulation; G, AE

Display Samples; G, AE

SD-07 Certificates

Indoor air quality for adhesives; S

SD-08 Manufacturer's Instructions

Pipe Insulation Systems; G, AE

Duct Insulation Systems; G, AE

Equipment Insulation Systems; G, AE

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 90.2]. 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] [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 20X20 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] [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/Weatherproofing Jacket

Vapor barrier/weatherproofing jacket shall be laminated self-adhesive, greater than 3 plies standard grade, silver, white, black and embossed or greater than 8 ply (minimum 2.9 mils adhesive); with 0.0000 permeability when tested in accordance with ASTM E96/E96M, using the water transmission rate test method; heavy duty, white or natural; and UV resistant. Flexible Elastomeric exterior foam with factory applied, UV Jacket made with a cold weather acrylic adhesive. Construction of laminate designed to provide UV resistance, high puncture, tear resistance and excellent Water Vapor Transmission (WVT) rate.

2.2.8.4 Vapor Barrier/Vapor Retarder

Apply the following criteria to determine which system is required.

a. On ducts, piping and equipment operating below [_____] 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 [_____] 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 in accordance with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions. 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 determined pursuant to 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] [ISO 2758]. 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 - SI][ASHRAE 90.2]. 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 [Enter Appropriate Subpart Title Here]

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.

2.3.2.3 Mineral Fiber Insulation with Integral Wicking Material (MFIWM)

ASTM C547. Install in accordance with manufacturer's instructions. Do not use in applications exposed to outdoor ambient conditions in climatic zones 1 through 4.

2.3.2.4 Polyisocyanurate Insulation

ASTM C591, Type I. Supply the insulation with a factory applied vapor retarder/barrier that complies with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation and all covering must pass the flame spread index of 25 and the smoke developed index of 50 when tested in accordance with ASTM E84.

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 [Enter Appropriate Subpart Title Here]

2.3.3.3 [Enter Appropriate Subpart Title Here]

2.3.3.4 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 to 220 degrees F service. Type I for tubular materials. Type II for sheet materials.

2.3.3.5 Phenolic Insulation

ASTM C1126 Type III to 250 degrees F service shall comply with ASTM C795. Supply the insulation with manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.6 [Enter Appropriate Subpart Title Here]

2.3.3.7 Polyisocyanurate Insulation

ASTM C591, Type I. Supply the insulation with a factory applied vapor retarder/barrier that complies with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation and all covering must pass the flame spread index of 25 and the smoke developed index of 50 when tested in accordance with ASTM E84.

2.3.4 [Enter Appropriate Subpart Title Here]

2.3.5 [Enter Appropriate Subpart Title Here]

2.4 DUCT INSULATION SYSTEMS

2.4.1 Factory Applied Insulation

Provide factory-applied [ASTM C552, cellular glass thermal] [ASTM C534/C534M Grade 1, Type II, flexible elastomeric closed cell] insulation according to manufacturer's recommendations for insulation with insulation manufacturer's standard reinforced fire-retardant vapor barrier[, with identification of installed thermal resistance (R) value and out-of-package R value].

2.4.1.1 Rigid Insulation

Calculate the minimum thickness in accordance with [ASHRAE 90.2][].

2.4.1.2 Blanket Insulation

Calculate minimum thickness in accordance with [ASHRAE 90.2][][ASTM C553].

2.4.2 Kitchen Exhaust Ductwork Insulation

Insulation thickness shall be a minimum of 2 inches, blocks or boards, either mineral fiber conforming to ASTM C612, Class 5, 20 pcf average [or calcium silicate conforming to ASTM C533, Type II. Provide vapor barrier for outside air connection to kitchen exhaust hood]. The enclosure materials and the grease duct enclosure systems shall meet testing requirements of ASTM E2336 for noncombustibility, fire resistance, durability, internal fire, and fire-engulfment with a through-penetration fire stop.

2.4.3 Acoustical Duct Lining

2.4.3.1 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).

2.4.3.2 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.

2.4.4 Duct Insulation Jackets

2.4.4.1 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.

2.4.4.2 Metal Jackets

2.4.4.2.1 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.

2.4.4.2.2 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.

2.4.4.3 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).

2.4.5 Weatherproof Duct Insulation

Provide [ASTM C552, cellular glass thermal insulation] [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 in coordination with the submitted MICA Insulation Stds plates booklet. Annotate their installation instructions to indicate which product data and which MICA plate are applicable. 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] [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

Install pipe insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions.

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 rom 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] [stainless steel], 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. [Other areas that specifically require protection to the 6 foot level are [_____].]

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 90.2].

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
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		Yes
	[Mineral Fiber with Wicking Material][Do not use in applications exposed to outdoor ambient conditions in climatic zones 1 through 4.]	[ASTM C547]	[I]		[Yes]
Heating Hot Water Supply & Return, Heated Oil (Max 250 F)					
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Cellular Glass	ASTM C552	II	2	No
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
Cold Domestic Water Piping, Makeup Water & Drinking Fountain Drain Piping					
	Cellular Glass	ASTM C552	II	2	No
	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
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Faced Phenolic Foam	ASTM C1126	III		Yes
Refrigerant Suction Piping (35 degrees F nominal)					
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
	Cellular Glass	ASTM C552	II	1	Yes
Compressed Air Discharge, Steam and Condensate Return (201 to 250 Degrees F					
	Cellular Glass	ASTM C552	II		No
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
	Faced Phenolic Foam	ASTM C1126	III		Yes
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
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					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Medium Temperature Hot Water, Steam and Condensate (251 to 350 Degrees F)					
	Mineral Fiber	ASTM C547	I	1	No
	Calcium Silicate	ASTM C533	I		No
	Cellular Glass	ASTM C552	I or II		No
	Perlite	ASTM C610			No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No
High Temperature Hot Water & Steam (351 to 700 Degrees F)					
	Mineral Fiber	ASTM C547	I	2	No
	Calcium Silicate	ASTM C533	I		No
	Perlite	ASTM C610			No
	Cellular Glass	ASTM C552			No
Brine Systems Cryogenics (-30 to 0 Degrees F)					
	Cellular Glass	ASTM C552	II	2	No
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No
Brine Systems Cryogenics (0 to 34 Degrees F)					

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, Dual Temperature Piping, 40 Degrees F nominal)]						
	Cellular Glass	1.5	2	2	2.5	3
	Mineral Fiber with Wicking Material	1	1.5	1.5	2	2
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
[Chilled Water (Supply & Return, Dual Temperature Piping, 40 Degrees F nominal)]						
	Cellular Glass	1.5	1.5	1.5	1.5	2
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
	Mineral Fiber with Wicking Material	1	1.5	1.5	2	2
Heating Hot Water Supply & Return, Heated Oil (Max 250 F)						
	Mineral Fiber	1.5	1.5	2	2	2

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
	Calcium Silicate	2.5	2.5	3	3	3
	Cellular Glass	2	2.5	3	3	3
	Perlite	2.5	2.5	3	3	3
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
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
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Refrigerant Suction Piping (35 degrees F nominal)						
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
Compressed Air Discharge, Steam and Condensate Return (201 to 250 Degrees F						
	Mineral Fiber	1.5	1.5	2	2	2
		1.5*	2*	2.5*	3*	3.5*
	Calcium Silicate	2.5	3	4	4	4.5
	Cellular Glass	2	2.5	3	3	3
	Perlite	2.5	3	4	4	4.5

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
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						
	Cellular Glass	1.5	1.5	1.5	1.5	1.5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
Medium Temperature Hot Water, Steam and Condensate (251 to 350 Degrees F)						
	Mineral Fiber	1.5	3	3	4	4
		2.5*	*	3.5*		
	Calcium Silicate	2.5	3.5	4.5	4.5	5
	Perlite	2.5	3.5	4.5	4.5	5
	Flexible Elastomeric Cellular	1	1	1	N/A	N/A
High Temperature Hot Water & Steam (351 to 700 Degrees F)						
	Mineral Fiber	2.5	3	3	4	4
	Calcium Silicate	4	4.5	6	6	6
	Perlite	4	4.5	6	6	6

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
Brine Systems Cryogenics (-30 to 0 Degrees F)						
	Cellular Glass	2.5	2.5	3	3	3.5
	Flexible Elastomeric Cellular	1	1	N/A	N/A	N/A
Brine Systems Cryogenics (0 to 34 Degrees F)						
	Cellular Glass	2	2	2	2.5	3
	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. Horizontal and vertical portions of interior roof drains.

c. Refrigerant suction lines.

d. Chilled water.

e. Dual temperature water, i.e. HVAC hot/chilled water.

f. Air conditioner condensate drains.

g. Brine system cryogenics

h. Exposed lavatory drains and domestic water lines serving plumbing fixtures for handicap persons.

[i. 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, sliver, white, black and embossed for use with Mineral Fiber, Cellular Glass, and Phenolic Foam Insulated Pipe. Insulation inside the building, to be protected with an 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 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. Other areas that specifically require protection to the 6 ft level are [_____].

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 - 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. Steam.

c. Condensate & compressed air discharge.

d. Hot water heating.

e. Heated oil.

f. Water defrost lines in refrigerated rooms.

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, stainless steel 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 PVC Jacket

PVC jacket shall be ultraviolet resistant and adhesive welded weather tight with manufacturer's recommended adhesive. Installation shall include provision for thermal expansion.

3.2.4.4 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.

3.2.5 Below Ground Pipe Insulation

Below ground pipes shall be insulated in accordance with Table 2, except as precluded in subparagraph Pipe Insulation in PART 3. This includes, but is not limited to the following:

a. Heated oil.

b. Domestic hot water.

c. Heating hot water.

d. Dual temperature water.

e. Steam.

f. Condensate.

3.2.5.1 Type of Insulation

Below ground pipe shall be insulated with Cellular Glass insulation, in accordance with manufacturer's instructions for application with thickness as determined from Table 2 (whichever is the most restrictive).

3.2.5.2 Installation of Below ground Pipe Insulation

a. Bore surfaces of the insulation shall be coated with a thin coat of gypsum cement of a type recommended by the insulation manufacturer. Coating thickness shall be sufficient to fill surface cells of insulation. Mastic type materials shall not be used for this coating. Note that unless this is for a cyclic application (i.e., one that fluctuates between high and low temperature on a daily process basis) there is no need to bore coat the material.

b. Stainless steel bands, 3/4 inch wide by 0.020 inch thick shall be used to secure insulation in place. A minimum of two bands per section of insulation shall be applied. As an alternate, fiberglass reinforced tape may be used to secure insulation on piping up to 12 inches in diameter. A minimum of two bands per section of insulation shall be applied.

c. Insulation shall terminate at anchor blocks but shall be continuous through sleeves and manholes.

d. At point of entry to buildings, underground insulation shall be terminated 2 inches inside the wall or floor, shall butt tightly against the aboveground insulation and the butt joint shall be sealed with high temperature silicone sealant and covered with fibrous glass tape.

e. Provision for expansion and contraction of the insulation system shall be made in accordance with the insulation manufacturer's recommendations.

f. Flanges, couplings, valves, and fittings shall be insulated with factory pre-molded, prefabricated, or field-fabricated sections of insulation of the same material and thickness as the adjoining pipe insulation. Insulation sections shall be secured as recommended by the manufacturer.

g. Insulation, including fittings, shall be finished with three coats of asphaltic mastic, with 6 by 5.5 mesh synthetic reinforcing fabric embedded between coats. Fabric shall be overlapped a minimum of 2 inches at joints. Total film thickness shall be a minimum of 3/16 inch. As an alternate, a prefabricated bituminous laminated jacket, reinforced with internal reinforcement mesh, shall be applied to the insulation. Jacketing material and application procedures shall match manufacturer's written instructions. Vapor barrier - less than 0.0000 permeability self adhesive (minimum 2 mils adhesive, 3 mils embossed) jacket 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). Application procedures shall match the manufacturer's written instructions.

h. At termination points, other than building entrances, the mastic and cloth or tape shall cover the ends of insulation and extend 2 inches

along the bare pipe.

3.3 DUCT INSULATION SYSTEMS INSTALLATION

Install duct insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions. Duct insulation minimum thickness and insulation level must be as listed in Table 3 and must meet or exceed the requirements of[][ASHRAE 90.2].

Except for oven hood exhaust duct insulation, corner angles shall be installed on external corners of insulation on ductwork in exposed finished spaces before covering with jacket. [Duct insulation shall be omitted on exposed supply and return ducts in air conditioned spaces [where the difference between supply air temperature and room air temperature is less than 15 degrees F] unless otherwise shown.] 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.

o. Exhaust ducts passing through concealed spaces exhausting conditioned air.

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 Insulation for Evaporative Cooling Duct

Evaporative cooling supply duct located in spaces not evaporatively cooled, shall be insulated. Material and installation requirements shall be as specified for duct insulation for warm air duct.

3.3.6 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.

3.3.7 Duct Exposed to Weather

3.3.7.1 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.

3.3.7.2 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.

3.3.7.3 Fittings

Fittings and other irregular shapes shall be finished as specified for rectangular ducts.

3.3.7.4 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.

3.3.8 Kitchen Exhaust Duct Insulation

NFPA 96 for [ovens,] [griddles,] [deep fat fryers,] [steam kettles,] [vegetable steamers,] [high pressure cookers,] [and] [mobile serving units]. Provide insulation with 3/4 inch wide, minimum 0.15 inch thick galvanized steel bands spaced not over 12 inches o.c.; or 16 gauge galvanized steel wire with corner clips under the wire; or with heavy welded pins spaced not over 12 inches apart each way. Do not use adhesives.

3.4 EQUIPMENT INSULATION SYSTEMS INSTALLATION

Install equipment insulation systems in accordance with the approved MICA Insulation Stds plates as supplemented by the manufacturer's published installation instructions.

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. Water softeners.

f. Duct mounted coils.

g. Cold and chilled water pumps.

h. Pneumatic water tanks.

i. Roof drain bodies.

j. Air handling equipment parts that are not factory insulated.

k. 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

TABLE 5		
Insulation Thickness for Cold Equipment (inches)		
Equipment handling media at indicated temperature		
	Material	Thickness (inches)
	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. Fuel oil heaters.

g. Hot water storage tanks.

h. Air separation tanks.

i. Surge tanks.

j. Flash tanks.

k. Feed-water heaters.

l. Unjacketed boilers or parts of boilers.

m. Boiler flue gas connection from boiler to stack (if inside).

n. Induced draft fans.

o. Fly ash and soot collectors.

p. Condensate receivers.

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)

	Material	Thickness (inches)
Equipment handling steam or media at indicated pressure or temperature limit		
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
	Flexible Elastomeric Cellular (<200 F)	1
200psig or 400 degrees F		
	Rigid Mineral Fiber	3
	Flexible Mineral Fiber	3
	Calcium Silicate/Perlite	4
	Cellular Glass	4
600 degrees F		
	Rigid Mineral Fiber	5
	Flexible Mineral Fiber	6
	Calcium Silicate/Perlite	6
	Cellular Glass	6

600 degrees F: Thickness necessary to limit the external temperature of the insulation to 120 F. Heat transfer calculations shall be submitted to substantiate insulation and thickness selection.

3.4.3.2 Insulation of Boiler Stack and Diesel Engine Exhaust Pipe

Inside [boiler House] [mechanical Room], bevel insulation neatly around openings and provide sheet metal insulation stop strips around such openings. Apply a skim coat of hydraulic setting cement directly to insulation. Apply a flooding coat of adhesive over hydraulic setting

cement, and while still wet, press a layer of glass cloth or tape into adhesive and seal laps and edges with adhesive. Coat glass cloth with adhesive. When dry, apply a finish coat of adhesive at can-consistency so that when dry no glass weave shall be observed. Provide metal jackets for [stacks] [and] [exhaust pipes] that are located above finished floor and spaces outside [boiler house] [mechanical room]. Apply metal jackets directly over insulation and secure with 3/4 inch wide metal bands spaced on 18 inch centers. Do not insulate name plates. Insulation type and thickness shall be in accordance with the following Table 7.

TABLE 7

Insulation and Thickness for
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees F)						
	Material	Outside Diameter (Inches)				
		0.25 - 1.25	1 - 1.67	3.5-5	6 - 10	> or = 11 - 36
Boiler Stack (Up to 400 degrees F)						
	Mineral Fiber ASTM C585 Class B-3, ASTM C547 Class 1, or ASTM C612 Class 1	N/A	N/A	3	3.5	4
	Calcium Silicate ASTM C533, Type 1	N/A	N/A	3	3.5	4
	Cellular Glass ASTM C552, Type II	1.5	1.5	1.5	2	2.5
Boiler Stack (401 to 600 degrees F)						
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	N/A	N/A	4	4	5
	Calcium Silicate ASTM C533, Type I or II	N/A	N/A	4	4	4
	Mineral Fiber/Cellular Glass Composite:					

TABLE 7

Insulation and Thickness for
Boiler Stack and Diesel Engine Exhaust Pipe

	Material	Outside Diameter (Inches)				
		0.25 - 1.25	1 - 1.67	3.5-5	6 - 10	> or = 11 - 36
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	1	1	1	1	2
	Cellular Glass ASTM C552, Type II	2	2	2	2	2
Boiler Stack (601 to 800 degrees F)						
	Mineral Fiber ASTM C547 Class 3, ASTM C592 Class 1, or ASTM C612 Class 3	N/A	N/A	4	4	6
	Calcium Silicate ASTM C533, Type I or II	N/A	N/A	4	4	6
	Mineral Fiber/Cellular Glass Composite:					
	Mineral Fiber ASTM C547 Class 2, ASTM C592 Class 1, or ASTM C612 Class 3	2	2	2	3	3
	Cellular Glass ASTM C552, Type II	2	2	2	2	2
Diesel Engine Exhaust (Up to 700 degrees F)						
	Calcium Silicate ASTM C533, Type I or II	3	3.5	4	4	4

TABLE 7

Insulation and Thickness for
Boiler Stack and Diesel Engine Exhaust Pipe

Service & Surface Temperature Range (Degrees F)

	Material	Outside Diameter (Inches)				
		0.25 - 1.25	1 - 1.67	3.5-5	6 - 10	> or = 11 - 36
	Cellular Glass ASTM C552, Type II	2.5	3.5	4	4.5	6

3.4.3.3 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.

3.4.3.4 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 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 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.

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SECTION 23 08 00.00 20

COMMISSIONING OF MECHANICAL AND PLUMBING SYSTEMS
02/21, CHG 1: 05/21

PART 1 GENERAL

Total Building Commissioning (TBCx) is a systematic, quality-focused process for enhancing the delivery of a project that focuses on verifying and documenting that all of the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the project requirements. The purpose is to reduce the cost and performance risks associated with delivering facilities projects, and to increase value to owners, occupants, and users.

1.1 DEFINITIONS

Commissioning Process (Cx) - a quality-focused process for enhancing the delivery of a project. Refer to ASHRAE 202 for a comprehensive description of the commissioning process.

Commissioning Provider (CxC)- The entity hired by the Government, who leads, plans, and coordinates the Commissioning Team. The terms Commissioning Provider, Commissioning Firm, Lead Commissioning Specialist, Commissioning Specialist, and Commissioning Authority (CA or CxA) when used by sustainable Third Party Certification (TPC) programs, are interchangeable.

Commissioning Authority - The Government retains the authority for oversight and assurance of the entire commissioning process, and final approval of all commissioning deliverables.

1.2 SEQUENCING AND SCHEDULING

Complete the following prior to starting Functional Performance Tests of mechanical systems:

a. All equipment and systems completed, cleaned, flushed, disinfected, calibrated, tested, and operate in accordance with contract documents and construction plans and specifications

b. Final DALT Report submitted and approved in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC

c. Performance Verification Tests of the controls systems have been completed and the Performance Verification Test Report has been submitted and approved in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

d. The Certificate of Readiness submitted and approved in accordance with Section TOTAL BUILDING COMMISSIONING

e. Pre-final Testing, Adjusting, and Balancing Report submitted in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC

[f. Air Leakage Test Reports and Diagnostic Test Reports submitted and

approved in accordance with Section 07 05 23 PRESSURE TESTING AN AIR BARRIER SYSTEM FOR AIR TIGHTNESS

][g. Tests, Flushing, and Disinfection in accordance with Section [22 00 00 PLUMBING, GENERAL PURPOSE][22 00 70 PLUMBING FOR HEALTHCARE FACILITIES]

][h. Inspection and Testing in accordance with Section 22 33 30.00 10 SOLAR WATER HEATING EQUIPMENT

]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. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Test Equipment; G, AE

SD-06 Test Reports

Pipe Flushing, Testing, And Water Treatment Reports; G[, AE

[Seasonal Test Report; G, AE

][Full-Load Test Report; G, AE

]1.4 ACCESSIBILITY REQUIREMENTS

Equipment, systems, and devices for commissioned systems must be accessible. Make necessary modifications if systems and devices are not accessible for inspections and testing.

Assist commissioning team in testing by removing equipment covers, opening access panels, and other required activities that assist with visual oversight. Furnish ladders, flashlights, meters, gauges, or other inspection equipment as necessary.

1.5 COORDINATION

Refer to Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING for requirements pertaining to coordination during the commissioning process. Coordinate with the Commissioning Provider in accordance with Section 01 91 00.15 10 and in accordance with the Commissioning Plan to schedule inspections as required to support the commissioning process. Furnish additional information requested by the Commissioning Provider. Coordinate scheduling of Functional Performance Testing with the commissioning team. Upload plans, reports, notes, and other documentation to the Commissioning Provider's web-based commissioning software, or as specified in the commissioning plan, as it is completed.

1.6 PIPE FLUSHING, TESTING, AND WATER TREATMENT REPORTS

Test requirements are specified in Division [22 and]23 piping Sections. Prepare a pipe system cleaning, flushing, and hydrostatic testing log. Provide cleaning, flushing, testing, and water treatment log and final

reports.

Include the following in the pipe system cleaning, flushing, and hydrostatic testing log:

a. Minimum flushing water velocity.

b. Water treatment reports.

c. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

1.7 CERTIFICATE OF READINESS DOCUMENTATION

Submit Certificate of Readiness documentation in accordance with Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING for all equipment and systems including start-up reports; completed Pre-Functional Checklists; Testing, Adjusting, and Balancing (TAB) Report; HVAC Controls Start-Up Reports. Do not schedule Functional Performance Tests for the system until the Certificate of Readiness for that system receives approval by the Contracting Officer. The Mechanical, Electrical, Controls, and TAB subcontractor representatives must sign and date the Certificate of Readiness.

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

Provide all testing equipment required to perform testing for the systems to be commissioned, except for equipment specific to and used by TAB as required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Provide a sufficient quantity of two-way radios for each subcontractor. Submit list of Test Equipment and instrumentation to be used for testing including equipment/instrument identification number, equipment application or planned use, manufacturer, make, model, and serial number, and calibration history with certificates. Also list special equipment and proprietary tools specific to a piece of equipment required for testing.

2.1.1 Proprietary Equipment

Provide manufacturer's proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not. Provide manufacturer test equipment, demonstrate its use, and assist in the commissioning process as needed. Provide data logging equipment and software required to test equipment.

2.1.2 Calibration and Accuracy

Comply with equipment manufacturer's test equipment calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to Contracting Officer upon request.

Provide all testing equipment of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. Unless otherwise noted, the following minimum requirements apply: Provide

temperature sensors and digital thermometers with a certified calibration within the past year to an accuracy of 0.5 degrees F and a resolution of plus or minus 0.1 degrees F. Provide pressure sensors with an accuracy of plus or minus 2.0 percent of the value range being measured (not full range of meter) and calibrated within the last year.

PART 3 EXECUTION

3.1 MEETINGS

Attend all meetings in accordance with Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING.

Provide timely updates on construction schedule changes so Commissioning Provider has scheduling information needed to execute commissioning process efficiently. Notify Contracting Officer of anticipated construction delays to commissioning activities not yet performed or not yet scheduled.

3.2 PREFUNCTIONAL CHECKS

Complete and sign Pre-Functional Checklists using the Commissioning Provider's web-based commissioning software, or as specified by the commissioning plan. Provide manufacturer's installation manual for each type of unit. Perform all work in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements.

3.3 STARTUP AND INITIAL CHECKOUT

Document start-up and initial testing procedures including:

a. Startup tests and factory testing reports.

b. Manufacturer's representative start-up, operating, troubleshooting and maintenance procedures.

[c. Additional documentation necessary for third party certification programs.

] d. Perform and clearly document system operational checks and quality control checks as they are completed, and providing a copy to the commissioning team.

e. Correct deficiencies and sign the Certificate of Readiness for each system before functional performance testing

3.4 COMMISSIONING TESTING

Conduct Functional Performance Testing in accordance with Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING and requirements in this section. Prior to Functional Performance Testing, complete all prerequisites in accordance with paragraph SEQUENCING AND SCHEDULING.

3.4.1 Preparation

Put equipment and systems into operation and continue operation during each working day of commissioning, as required. Verify temperature and pressure taps in accordance with Contract Documents. Provide a pressure/temperature plug at each water sensor which is an input point to control system.

Perform minor adjustments to equipment and systems during Functional Performance Tests as deemed necessary by the commissioning team. Where calibrated DDC sensors cannot be used to record test data, provide measuring instruments, logging devices, and data acquisition equipment to record data for the complete range of test data for the required test period.

3.4.2 Test Setup

Perform each test under conditions that simulate actual conditions as close as is practically possible. Provide all necessary materials and system modifications to produce the necessary flows, pressures, temperatures, and other conditions necessary to execute the test according to the specified conditions. At completion of the test, return the affected building equipment and systems to their pre-test condition.

3.4.3 Manufacturer's Representative

Provide a factory trained representative authorized by the equipment manufacturer to perform Functional Performance Testing for the following equipment:

[Chillers

][Cooling towers and evaporatively cooled condensers

][Boilers

][Packaged Direct-Expansion Refrigeration Equipment, including variable refrigerant flow (VRF) systems

][Packaged Computer Room [Air Handlers (CRAH)] [Air Conditioners (CRAC)]

][Booster Pumps

][Packaged Air Compressors

][Water Quality and Chemical Treatment Systems

][Solar Water Heating Systems

][Ensure the test representative reviews, approves, and signs the completed field test report. Include person's name with signatures.

]3.4.4 Sample Strategy

Perform Functional Performance Tests using the sample strategy described in Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING. Prepare and complete a Functional Performance Test for each item of equipment or system to be tested. During testing, Government representatives may select the specific equipment or system to be tested for sample sizes less than 100 percent.

3.4.5 Simulating Conditions

Functional performance testing is conducted by simulating conditions at control devices to initiate a control system response. Before testing, calibrate all sensors, transducers and devices. Over-writing control

input values through the control system is not acceptable unless approved by the Contracting Officer. Specific examples of simulating conditions are provided below. Do not simulate conditions when damage to the system or building may result.

a. When varying static pressures inside ductwork cannot be simulated within the duct, and where a sensor signals the controls system to initiate sequences at various duct static pressures, it is acceptable to simulate the various pressures with a Pneumatic Squeeze-Bulb Type Signaling Device with gauge temporarily attached to the sensing tube leading to the transmitter. It is not acceptable to reset the various set-points, nor to simulate an electric analog signal (unless approved as noted above).

b. Dirty filter pressure drops can be simulated by partially blocking filter face.

c. Freeze-stat safeties can be simulated by packing portion of sensor with ice.

d. High outside air temperatures can be simulated with a hair blower.

e. Raising entering cooling coil temperatures by activating a heating/preheat coil can be used to simulate entering cooling coil conditions.

f. Do not use signal generators to simulate sensor signals unless approved by the Contracting Officer, as noted above, for special cases.

g. Control set points can be altered. For example, to see the air conditioning compressor lockout work at an outside air temperature below 55 degrees F, when the outside air temperature is above 55 degrees F, temporarily change the lockout set point to be 0 degrees F above the current outside air temperature. Caution: Set points are not to be raised or lowered to a point to cause damage to the components, systems, or the building structure and/or contents.

h. Test duct mounted smoke detectors in accordance with the manufacturer's recommendations. Perform the tests with air system at minimum airflow condition.

i. Test current sensing relays used for fan and pump status signals to control system to indicate unit failure and run status by resetting the set point on the relay to simulate a lost belt or unit failure while the unit is running. Confirm that the failure alarm was generated and received at the control system. After the test is conducted, return the set point to its original set-point or a set-point as indicated by the Contracting Officer.

[3.4.6 Duct Air Leakage Test (DALT) Report Review

The Commissioning Specialist is responsible for reviewing the pre-final TAB Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to DALT Report approval.

][3.4.7 Duct Air Leakage Test (DALT) Report Verification

The Commissioning Specialist is responsible for witnessing the DALT Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to DALT Report approval.

][3.4.8 Testing, Adjusting, and Balancing (TAB) Report Review

The Commissioning Specialist is responsible for reviewing the pre-final TAB Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to TAB Report approval.

][3.4.9 Testing, Adjusting, and Balancing (TAB) Report Verification

The Commissioning Specialist is responsible for witnessing the TAB Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to TAB Report approval.

][3.4.10 HVAC Controls Test Procedures, Reports, and Trends Review

The Commissioning Specialist is responsible for reviewing the Start-Up Testing Report, PVT Procedures and PVT Reports including endurance testing trend data required by Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC[and Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION] and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to final acceptance.

]3.5 RETESTING REQUIREMENTS

Abort tests if any deficiency prevents successful completion of the test or if any required commissioning team member is not present for the test. Re-test only after all deficiencies identified during the original tests have been corrected.

If sequence of operation in any of Functional Performance Tests fails, the Government's costs for witnessing further demonstration of that test procedure may be assigned to the Contractor as a deduct to their contracted price, including salary, travel costs, and per diem for Government commissioning team members. Correct deficiencies as identified by the commissioning team and retest the systems to be commissioned.

3.6 SYSTEM ACCEPTANCE

Systems may be partially accepted prior to seasonal testing if they comply with all construction contract and accepted design requirements that can be tested during initial Functional Performance Tests. All test procedures must be successful completed prior to full systems acceptance.

[3.7 SEASONAL TESTS

Perform Initial Functional Performance Tests as soon as all contract work is completed, but prior to facility turnover, regardless of the season.

In addition to the Initial Functional Performance Tests, perform Functional Performance Tests of HVAC systems during season of maximum [heating][and][cooling] as defined by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Schedule Seasonal Functional Performance Tests in coordination with the Contracting Officer. Submit Seasonal Test Report within 14 days of test completion.

Execute seasonal functional performance testing, witnessed by the Contracting Officer. Correct deficiencies and make adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

][3.8 FULL-LOAD TESTS

Perform Initial Functional Performance Tests as soon as all contract work is completed, but prior to facility turnover. In addition to the Initial Functional Performance Tests, perform Functional Performance Tests of HVAC systems under full-load conditions.[Develop and implement means of artificial loading to demonstrate the ability of the process cooling systems to handle peak process loads.] Schedule Full-Load Functional Performance Tests in coordination with the Contracting Officer. Submit Full-Load Test Report within 14 days of test completion.

Execute full-load functional performance testing, witnessed by the Contracting Officer. Correct deficiencies and make adjustments to O&M manuals and as-built drawings for applicable issues identified in any full load testing.

]3.9 TRAINING

The Commissioning Provider is responsible for overseeing and approving the training plan required by Section 01 78 00 OPERATION AND MAINTENANCE DATA and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel.

Coordinate, schedule, and document all required training. At a minimum, include the following items in the training report for commissioned systems:

a. Complete commissioning documentation

b. Complete O&M data

c. Complete Training

d. Purpose of equipment.

e. Principle of how the equipment works.

f. Important parts and assemblies.

g. How the equipment achieves its purpose and necessary operating conditions.

h. Most likely failure modes, causes and corrections.

i. On site demonstration.

j. Provide updates to O&M manuals based on field modifications.

k. Provide training of the post-occupancy operations and maintenance staff.

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SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC
02/19, CHG 3: 05/21

PART 1 GENERAL

1.1 SUMMARY

Provide a complete Direct Digital Control (DDC) system, except for the Front End which is specified in Section 25 10 10 UTILITY MONITORING AND CONTROL (UMCS) FRONT END AND INTEGRATION, suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as indicated and shown and in accordance with Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC,[Section 23 09 93 SEQUENCES OF OPERATION FOR HVAC CONTROL,] Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for LNS LonWorks systems or Niagara LonWorks systems, and other referenced Sections.

1.1.1 Proprietary Systems

1.1.1.1 Proprietary Systems Exempted From Open Protocol Requirements

The following systems are specifically exempted from the open protocol requirements of Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS :

a. A simple split (DX) system consisting of a single indoor unit and a single outdoor unit from the same manufacturer.

b. Systems in Table I (previously approved by the designer in accordance with UFC 3-410-02).

TABLE I: Systems Approved to Use Proprietary Communications

System	Type (Multi-Split/VRF or Chiller/Boiler Plant)	Proprietary Multi-Split Engineering Tool Software Required (for Multi-Split/VRF only)

c. A system (not already shown Table I) of multiple boilers or multiple chillers communicating with a proprietary network for which an approved request has been obtained and for which: all units are from the same manufacturer, they are all co-located in the same room, the network connecting them is fully contained in that room, and the units are operating using a common "plant" sequence of operation which stages the units in a manner that requires operational parameters be shared between them and which cannot be accomplished with a single lead-lag command from a third-party controller.

1.1.1.2 Implementation of Proprietary Systems

For proprietary systems exempted from open protocol requirements, a proprietary network and DDC hardware communicating via proprietary protocol are permitted. For these systems a building control network meeting the requirements of Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS must also be provided, along with a gateway or interface to connect the proprietary system to the open building control network.

The proprietary system gateway or interface must provide the required functionaliality as shown on the points schedule. Scheduling, alarming, trending, overrides, network inputs, network outputs and other protocol related requirements must be met on the open protocol control system as specified in Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS .

1.1.1.3 Proprietary Multi-Split Engineering Tool Software

For each permitted proprietary systems in Table 1 shown as requiring Proprietary Multi-Split Engineering Tool Software, provide the software needed to replace a unit and configure the replacement. Submit hard copies of the software user manuals with the software submittal.

Submit Proprietary Multi-Split Engineering Tool Software on CD-ROM as a Technical Data Package. Submit [_____] hard copies of the software user manual for each piece of software.

1.1.2 System Requirements

Provide systems meeting the requirements this Section and other Sections referenced by this Section, and which have the following characteristics:

a. The system implements the control sequences of operation [shown in the Contract Drawings][___] using DDC hardware to control mechanical and electrical equipment

b. The system meet the requirements of this specification as a stand-alone system and does not require connection to any other system.

c. Control sequences reside in DDC hardware in the building. The building control network is not dependent upon connection to a Utility Monitoring and Control System (UMCS) Front End or to any other system for performance of control sequences. To the greatest extent practical, the hardware performs control sequences without reliance on the building network.

d. The hardware is installed such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.

e. All necessary documentation, configuration information, programming tools, programs, drivers, and other software are licensed to and otherwise remain with the Government such that the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer.

f. Sufficient documentation and data, including rights to documentation

and data, are provided such that the Government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer.

g. Hardware is installed and configured such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the Contractor, Vendor or Manufacturer.

h. All Niagara Framework components have an unrestricted interoperability license with a Niagara Compatibility Statement (NiCS) following the Tridium Open NiCS Specification and have a value of "ALL" for "Station Compatibility In", "Station Compatibility Out", "Tool Compatibility In" and "Tool Compatibility Out". Note that this will result in the following entries in the license file:
    accept.station.in="*"
    accept.station.out="*"
    accept.wb.in="*"
    accept.wb.out="*"

1.1.3 End to End Accuracy

Select products, install and configure the system such that the maximum error of a measured value as read from the DDC Hardware over the network is less than the maximum allowable error specified for the sensor or instrumentation.

1.1.4 Verification of Dimensions

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 any work.

1.1.5 Drawings

The Government will not indicate all offsets, fittings, and accessories that may be required on the drawings. Carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, arrange such work accordingly, and provide all work necessary to meet such conditions.

1.2 RELATED SECTIONS

Related work specified elsewhere:

a. Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for LonWorks Systems using LNS or Niagara Framework.

b. Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

c. Section 23 09 93 SEQUENCES OF OPERATIONS FOR HVAC CONTROLS

d. Section 25 08 10 UTILITY MONITORING AND CONTROL SYSTEMS TESTING

e. Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEMS (UMCS) FRONT END AND INTEGRATION

f. Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS

g. [Section [01 91 00.15 10][01 91 00.15 20] TOTAL BUILDING COMMISSIONING][_____]

1.3 REFERENCES

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

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

ASHRAE FUN IP	(2017) Fundamentals Handbook, I-P Edition

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1-D	(2014) Control Network Protocol Specification
CEA-709.3	(1999; R 2015) Free-Topology Twisted-Pair Channel Specification

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

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 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

TRIDIUM, INC (TRIDIUM)

Niagara Framework	(2012) NiagaraAX User's Guide
Tridium Open NiCS	(2005) Understanding the NiagaraAX Compatibility Statement (NiCS)

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-410-02	(2018; with Change 2, 2021) Direct Digital Control for HVAC and Other Building Control Systems

UNDERWRITERS LABORATORIES (UL)

UL 5085-3	(2006; Reprint Nov 20121) Low Voltage Transformers - Part 3: Class 2 and Class 3 Transformers

1.4 DEFINITIONS

The following list of definitions includes terms used in Sections referenced by this Section and are included here for completeness.The definitions contained in this Section may disagree with how terms are defined or used in other documents, including documents referenced by this Section. The definitions included here are the authoritative definitions for this Section and all Sections referenced by this Section.

After each term the protocol related to that term is included in parenthesis.

1.4.1 Alarm Generation (All protocols)

Alarm Generation is the monitoring of a value, comparison of the value to alarm conditions and the creation of an alarm when the conditions set for the alarm are met. Note that this does NOT include delivery of the alarm to the final destination (such as a user interface) - see paragraph ALARM ROUTING in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION.

1.4.2 Application Generic Controller (AGC) (LonWorks)

A device that is furnished with a (limited) pre-established application that also has the capability of being programmed. Further, the ProgramID and XIF file of the device are fixed. The programming capability of an AGC may be less flexible than that of a General Purpose Programmable Controller (GPPC).

1.4.3 Application Specific Controller (ASC) (LonWorks)

A device that is furnished with a pre-established built in application that is configurable but not re-programmable. An ASC has a fixed factory-installed application program (i.e Program ID) with configurable settings.

1.4.4 Binary (All protocols)

A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. 'Digital' is sometimes used interchangeably with 'binary'.

1.4.5 Binding (LonWorks)

The act of establishing communications between CEA-709.1-D devices by associating the output of a device to the input of another so that information is automatically (and regularly) sent.

1.4.6 Building Control Network (BCN) (All protocols)

The network connecting all DDC Hardware within a building (or specific

group of buildings).

1.4.7 Building Point of Connection (BPOC) (All protocols)

A FPOC for a Building Control System. (This term is being phased out of use in preference for FPOC but is still used in some specifications and criteria. When it was used, it typically referred to a piece of control hardware. The current FPOC definition typically refers instead to IT hardware.)

1.4.8 Channel (LonWorks)

A portion of the control network consisting of one or more segments connected by repeaters. Channels are separated by routers. The device quantity limitation is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 128 devices per channel.

1.4.9 Commandable (All protocols)

See Overridable.

1.4.10 Configurable (All protocols)

A property, setting, or value is configurable if it can be changed via hardware settings on the device, via the use of engineering software or over the control network from the front end, and is retained through (after) loss of power.

1.4.11 Configuration Property (LonWorks)

Controller parameter used by the application which is usually set during installation/testing and seldom changed. For example, the P and I settings of a P-I control loop. Also see paragraph STANDARD CONFIGURATION PROPERTY TYPE (SCPT).

1.4.12 Control Logic Diagram (All protocols)

A graphical representation of control logic for multiple processes that make up a system.

1.4.13 Digital Controller (All protocols)

An electronic controller, usually with internal programming logic and digital and analog input/output capability, which performs control functions.

1.4.14 Direct Digital Control (DDC) (All protocols)

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.

1.4.15 Domain (LonWorks)

A grouping of up to 32,385 nodes that can communicate directly with each other. (Devices in different domains cannot communicate directly with each other.) See also Node Address.

1.4.16 Explicit Messaging (LonWorks)

A non-standard and often vendor (application) specific method of communication between devices where each message contains a message code that identifies the type of message and the devices use these codes to determine the action to take when the message is received.

1.4.17 External Interface File (XIF) (LonWorks)

A file which documents a device's external interface, specifically the number and types of LonMark objects, the number, types, directions, and connection attributes of network variables, and the number of message tags.

1.4.18 Field Point of Connection (FPOC) (All protocols)

The FPOC is the point of connection between the UMCS IP Network and the field control network (either an IP network, a non-IP network, or a combination of both). The hardware at this location which provides the connection is generally an IT device such as a switch, IP router, or firewall.

In general, the term "FPOC Location" means the place where this connection occurs, and "FPOC Hardware" means the device that provides the connection. Sometimes the term "FPOC" is used to mean either and its actual meaning (i.e. location or hardware) is determined by the context in which it is used.

1.4.19 Fox Protocol (Niagara Framework)

The protocol used for communication between components in the Niagara Framework. By default, Fox uses TCP port 1911.

1.4.20 Functional Profile (LonWorks)

A standard description, defined by LonMark, of one or more LonMark Objects used to classify and certify devices.

1.4.21 Gateway (All protocols)

A device that translates from one protocol application data format to another. Devices that change only the transport mechanism of the protocol - "translating" from TP/FT-10 to Ethernet/IP or from BACnet MS/TP to BACnet over IP for example - are not gateways as the underlying data format does not change. Gateways are also called Communications Bridges or Protocol Translators.

A Niagara Framework Supervisory Gateway is one type of Gateway.

1.4.22 General Purpose Programmable Controller (GPPC) (LonWorks)

Unlike an ASC or AGC, a GPPC is not furnished with a fixed application program and does not have a fixed ProgramID or XIF file. A GPPC can be (re-)programmed, usually using vendor-supplied software. When a change to the program affects the external interface (and the XIF file) the ProgramID will change.

1.4.23 IEEE 802.3 Ethernet (All protocols)

A family of local-area-network technologies providing high-speed networking features over various media, typically Cat 5, 5e or Cat 6 twisted pair copper or fiber optic cable.

1.4.24 Internet Protocol (IP, TCP/IP, UDP/IP) (All protocols)

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 connections, also known as "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

1.4.25 Input/Output (I/O) (All protocols)

Physical inputs and outputs to and from a device, although the term sometimes describes network or "virtual" inputs or outputs. See also "Points".

1.4.26 I/O Expansion Unit (All protocols)

An I/O expansion unit provides additional point capacity to a digital controller

1.4.27 IP subnet (All protocols)

A group of devices which share a defined range IP addresses. Devices on a common IP subnet can share data (including broadcasts) directly without the need for the traffic to traverse an IP router.

1.4.28 JACE (Niagara Framework)

Java Application Control Engine. See paragraph NIAGARA FRAMEWORK SUPERVISORY GATEWAY

1.4.29 Local-Area Network (LAN) (All protocols)

A communication network that spans a limited geographic area and uses the same basic communication technology throughout.

1.4.30 Local Display Panels (LDPs) (All protocols)

A DDC Hardware with a display and navigation buttons, and must provide display and adjustment of points as shown on the Points Schedule and as indicated.

1.4.31 LonMark (LonWorks)

See paragraph LONMARK INTERNATIONAL. Also, a certification issued by LonMark International to CEA-709.1-D devices.

1.4.32 LonMark International (LonWorks)

Standards committee consisting of numerous independent product developers, system integrators and end users dedicated to determining and maintaining

the interoperability guidelines for LonWorks. Maintains guidelines for the interoperability of CEA-709.1-D devices and issues the LonMark Certification for CEA-709.1-D devices.

1.4.33 LonMark Interoperability Association (LonWorks)

See paragraph LONMARK INTERNATIONAL.

1.4.34 LonMark Object (LonWorks)

A collection of network variables, configuration properties, and associated behavior defined by LonMark International and described by a Functional Profile. It defines how information is exchanged between devices on a network (inputs from and outputs to the network).

1.4.35 LonWorks (LonWorks)

The term used to refer to the overall technology related to the CEA-709.1-D protocol (sometimes called "LonTalk"), including the protocol itself, network management, interoperability guidelines and products.

1.4.36 LonWorks Network Services (LNS) (LonWorks)

A network management and database standard for CEA-709.1-D devices.

1.4.37 LonWorks Network Services (LNS) Plug-in (LonWorks)

Software which runs in an LNS compatible software tool, typically a network configuration tool. Device configuration plug-ins provide a user friendly method to edit a device's configuration properties.

1.4.38 MAC Address (All protocols)

Media Access Control address. The physical device address that identifies a device on a Local Area Network.

1.4.39 Monitoring and Control (M&C) Software (All protocols)

The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

1.4.40 Network Variable (LonWorks)

See paragraph STANDARD NETWORK VARIABLE TYPE (SNVT).

1.4.41 Network Configuration Tool (LonWorks)

The software used to configure the control network and set device configuration properties. This software creates and modifies the control network database (LNS Database).

1.4.42 Niagara Framework (Niagara Framework)

A set of hardware and software specifications for building and utility control owned by Tridium Inc. and licensed to multiple vendors. The Framework consists of front end (M&C) software, web based clients, field level control hardware, and engineering tools. While the Niagara Framework is not adopted by a recognized standards body and does not use

an open licensing model, it is sufficiently well-supported by multiple HVAC vendors to be considered a de-facto Open Standard.

1.4.43 Niagara Framework Supervisory Gateway (Niagara Framework)

DDC Hardware component of the Niagara Framework. A typical Niagara architecture has Niagara specific supervisory gateways at the IP level and other (non-Niagara specific) controllers on field networks (TP/FT-10, MS/TP, etc.) beneath the Niagara supervisory gateways. The Niagara specific controllers function as a gateway between the Niagara framework protocol (Fox) and the field network beneath. These supervisory gateways may also be used as general purpose controllers and also have the capability to provide a web-based user interface.

Note that different vendors refer to this component by different names. The most common name is "JACE"; other names include (but are not limited to)"EC-BOS", "FX-40", "TMN", "SLX" and "UNC".

1.4.44 Node (LonWorks)

A device that communicates using the CEA-709.1-D protocol and is connected to a CEA-709.1-D network.

1.4.45 Node Address (LonWorks)

The logical address of a node on the network, consisting of a Domain number, Subnet number and Node number. Note that the "Node number" portion of the address is the number assigned to the device during installation and is unique within a subnet. This is not the factory-set unique Node ID (see Node ID).

1.4.46 Node ID (LonWorks)

A unique 48-bit identifier assigned (at the factory) to each CEA-709.1-D device. Sometimes called the Neuron ID.

1.4.47 Operator Configurable (All protocols)

Operator configurable values are values that can be changed from a single common front end user interface across multiple vendor systems.

For Niagara Framework Systems, a property, setting, or value is Operator Configurable when it is configurable from a Niagara Framework Front End.

For LNS LonWorks systems, Operator Configurable is defined the same as Configurable. See paragraph CONFIGURABLE.

1.4.48 Override (All protocols)

Changing the value of a point outside of the normal sequence of operation where the change has priority over the sequence and where there is a mechanism for releasing the change such that the point returns to the normal value. Overrides persist until released or overridden at the same or higher priority but are not required to persist through a loss of power. Overrides are often used by operators to change values, and generally originate at a user interface (workstation or local display panel).

1.4.49 Packaged Equipment (All protocols)

Packaged equipment is a single piece of equipment provided by a manufacturer in a substantially complete and operable condition, where the controls (DDC Hardware) are factory installed, and the equipment is sold and shipped from the manufacturer as a single entity. Disassembly and reassembly of a large piece of equipment for shipping does not prevent it from being packaged equipment. Package units may require field installation of remote sensors. Packaged equipment is also called a "packaged unit".

Note industry may use the term "Packaged System" to mean a collection of equipment that is designed to work together where each piece of equipment is packaged equipment and there is a network that connects the equipment together. A "packaged system" of this type is NOT packaged equipment; it is a collection of packaged equipment, and each piece of equipment must individually meet specification requirements.

1.4.50 Packaged Unit (All protocols)

See packaged equipment.

1.4.51 Performance Verification Test (PVT) (All protocols)

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.

1.4.52 Polling (All protocols)

A device periodically requesting data from another device.

1.4.53 Points (All protocols)

Physical and virtual inputs and outputs. See also paragraph INPUT/OUTPUT (I/O).

1.4.54 Program ID (LonWorks)

An identifier (number) stored in the device that identifies the node manufacturer, functionality of device (application & sequence), transceiver used, and the intended device usage.

1.4.55 Proportional, Integral, and Derivative (PID) Control Loop (All protocols)

Three parameters used to control modulating equipment to maintain a setpoint. Derivative control is often not required for HVAC systems (leaving "PI" control).

1.4.56 Repeater (All protocols)

A device that connects two control network segments and retransmits all information received on one side onto the other.

1.4.57 Router (All protocols)

A device that connects two CEA-709.1-D channels and controls traffic

between the two by retransmitting signals received from one side onto the other based on the signal destination. Routers are used to subdivide a LonWorks control network and to limit network traffic.

1.4.58 Segment (All protocols)

A 'single' section of a control network that contains no repeaters or routers. There is generally a limit on the number of devices on a segment, and this limit is dependent on the topology/media and device type. For example, in a LonWorks system a TP/FT-10 network with locally powered devices is limited to 64 devices per segment.

1.4.59 Service Pin (LonWorks)

A hardware push-button on a device which causes the device to broadcast a message (over the control network) containing its Node ID and Program ID.

1.4.60 Standard Configuration Property Type (SCPT) (LonWorks)

Pronounced skip-it. A standard format type (maintained by LonMark International) for Configuration Properties.

1.4.61 Standard Network Variable Type (SNVT) (LonWorks)

Pronounced snivet. A standard format type (maintained by LonMark International) used to define data information transmitted and received by the individual nodes. The term SNVT is used in two ways. Technically it is the acronym for Standard Network Variable Type, and is sometimes used in this manner. However, it is often used to indicate the network variable itself (i.e. it can mean "a network variable of a standard network variable type"). In general, the intended meaning should be clear from the context.

1.4.62 Subnet (LonWorks)

Consists of a logical grouping of up to 127 nodes, where the logical grouping is defined by node addressing. Each subnet is assigned a number which is unique within the Domain. See also paragraph NODE ADDRESS.

1.4.63 TP/FT-10 (LonWorks)

A Free Topology Twisted Pair network defined by CEA-709.3. This is the most common media type for a CEA-709.1-D control network.

1.4.64 TP/XF-1250 (LonWorks)

A high speed (1.25 Mbps) twisted pair, doubly-terminated bus network defined by the LonMark Interoperability Guidelines. This media is typically used only as a backbone media to connect multiple TP/FT-10 networks.

1.4.65 User-defined Configuration Property Type (UCPT) (LonWorks)

Pronounced u-keep-it. A Configuration Property format type that is defined by the device manufacturer.

1.4.66 User-defined Network Variable Type (UNVT) (LonWorks)

A network variable format defined by the device manufacturer. Note that

UNVTs create non-standard communications (other vendor's devices may not correctly interpret it) and may close the system and therefore are not permitted by this specification.

1.4.67 UMCS (All protocols)

UMCS stands for Utility Monitoring and Control System. The term refers to all components by which a project site monitors, manages, and controls real-time operation of HVAC and other building systems. These components include the UMCS "front-end" and all field building control systems connected to the front-end. The front-end consists of Monitoring and Control Software (user interface software), browser-based user interfaces and network infrastructure.

The network infrastructure (the "UMCS Network"), is an IP network connecting multiple building or facility control networks to the Monitoring and Control Software.

1.4.68 UMCS Network (All protocols)

The UMCS Network connects multiple building or facility control networks to the Monitoring and Control Software.

1.5 PROJECT SEQUENCING

TABLE II: PROJECT SEQUENCING lists the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3 EXECUTION (denoted by an 'E' in the 'TYPE' column). TABLE II does not specify overall project milestone and completion dates[; these dates are specified in the contract documents][_____].

a. Sequencing for Submittals: The sequencing specified for submittals is the deadline by which the submittal must be initially submitted to the Government. Following submission there will be a Government review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, revise the submittal and resubmit it to the Government within [14][_____] days of notification that the submittal has been rejected. Upon resubmittal there will be an additional Government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.

b. Sequencing for Activities: The sequencing specified for activities indicates the earliest the activity may begin.

c. Abbreviations: In TABLE II the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

TABLE II. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE FOR SUBMITTAL)
1	S	Existing Conditions Report	

TABLE II. PROJECT SEQUENCING			
ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE FOR SUBMITTAL)
2	S	DDC Contractor Design Drawings	
3	S	Manufacturer's Product Data	
4	S	Pre-construction QC Checklist	
5	E	Install Building Control System	AAO #1 thru #4
6	E	Start-Up and Start-Up Testing	ACO #5
7	S	Post-Construction QC Checklist	[[_____] days]ACO #6
8	S	Programming Software Configuration Software Niagara Framework Engineering Tool Niagara Framework Wizards XIF Files LNS Plug-Ins	[[_____] days]ACO #6
9	S	Draft As-Built Drawings Draft LNS Database	[[_____] days]ACO #6
10	S	Start-Up Testing Report	[[_____] days]ACO #6
11	S	PVT Procedures	[[_____] days]before schedule start of #12 and AAO #10
12	E	Execute PVT	AAO #9 and #11
13	S	PVT Report	[[_____] days]ACO #12
14	S	Controller Application Programs Controller Configuration Settings Niagara Framework Supervisory Gateway Backups Final LNS Database	[[_____] days]AAO #13

TABLE II. PROJECT SEQUENCING			
ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE FOR SUBMITTAL)
15	S	Final As-Built Drawings	[[_____] days]AAO #13
16	S	O&M Instructions	AAO #15
17	S	Training Documentation	AAO #10 and [[_____] days]before scheduled start of #18
18	E	Training	AAO #16 and #17
19	S	Closeout QC Checklist	ACO #18

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. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

DDC Contractor Design Drawings; G, AE

Draft As-Built Drawings; G, AE

Final As-Built Drawings; G, AE

SD-03 Product Data

Programming Software; G, AE

Controller Application Programs; G, AE

Configuration Software; G, AE

Proprietary Multi-Split Engineering Tool Software; G, AE

Manufacturer's Product Data; G, AE

XIF files; G, AE

Draft LNS Database; G, AE

Final LNS Database; G, AE

LNS Plug-ins; G, AE

Niagara Framework Supervisory Gateway Backups; G, AE

[Niagara Framework Engineering Tool; G, AE

Niagara Framework Wizards; G, AE

SD-05 Design Data

Boiler Or Chiller Plant Gateway Request

SD-06 Test Reports

Existing Conditions Report

Pre-Construction Quality Control (QC) Checklist; G, AE

Post-Construction Quality Control (QC) Checklist; G, AE

Start-Up Testing Report; G, AE

PVT Procedures; G, AE

PVT Report; G, AE

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G, AE

Training Documentation; G, AE

SD-11 Closeout Submittals

Enclosure Keys; G, AE

Password Summary Report; G, AE

Closeout Quality Control (QC) Checklist; G, AE

1.7 DATA PACKAGE AND SUBMITTAL REQUIREMENTS

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 must be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered must 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 must contain no proprietary information and be delivered with unrestricted rights.

1.8 SOFTWARE FOR DDC HARDWARE AND GATEWAYS

Provide all software related to the programming and configuration of DDC Hardware and Gateways as indicated. License all Software to the project site. The term "controller" as used in these requirements means both DDC Hardware and Gateways.

1.8.1 Programming Software

For each type of General Purpose Programmable Controller (GPPC), provide the programming software in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. For each type of Application Generic Controller (AGC) provided as part of without a configuration and programming Wizard, provide the programming and configuration software in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copies of user manuals for each software with the software submittal.

Submit Programming Software on CD-ROM as a Technical Data Package. Submit [_____] hard copies of the software user manual for each piece of software.

1.8.2 Controller Application Programs

For each General Purpose Programmable Controller (GPPC), provide copies of the application program as source code compatible with the programming software for that GPPC in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. For each Application Generic Controller (AGC), provide copies of the application program as source code compatible with the programming and configuration tool (LNS plug-in) for that AGC in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Controller Application Programs on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which application program is associated with each device. Submit [2][_____] copies of the Controller Application Programs CD-ROM.

1.8.3 LNS Plug-Ins (for LNS-based LonWorks systems)

Provide LNS Plug-ins in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for each Application Specific Controller and each Application Generic Controller. For LNS Plug-ins distributed under a license, license the Plug-In to the project site. Submit hard copy manuals, if available, for each plug-in provided as part of the LNS- Plug-Ins submittal.

Submit LNS Plug-ins on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which files are associated with each device.

1.8.4 Niagara Framework Wizards (for Niagara LonWorks systems)

For each Application Generic Controller with a Niagara Framework Wizard and for each Application Specific Controller provide Niagara Framework Wizards in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copy manuals, if available, for each Wizard provided as part of the Niagara Framework Wizards submittal.

Submit Niagara Framework Wizards on CD-ROM as a Technical Data Package. Include on the CD-ROM a list or table of contents clearly indicating which files are associated with each device. Submit [_____] hard copies of the software user manual, if available, for each Wizard.

1.8.5 Niagara Framework Supervisory Gateway Backups

For each Niagara Framework Supervisory Gateway, provide a backup of all software within the Niagara Framework Supervisory Gateway, including configuration settings. This backup must be sufficient to allow the restoration of the Niagara Framework Supervisory Gateway or the replacement of the Niagara Framework Supervisory Gateway.

Submit backups for each Niagara Framework Supervisory Gateway on CD-ROM as a Technical Data Package. Mark each backup indicating clearly the source Niagara Framework Supervisory Gateway.

[1.8.6 Niagara Framework Engineering Tool(for all Niagara Framework system)

Provide a Niagara Framework Engineering Tool in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMSSection 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit software user manuals with the Niagara Framework Engineering Tool submittal.

Submit the Niagara Framework Engineering Tool on CD-ROM as a Technical Data Package. Submit [_____] hard copies of the software user manual for the Niagara Framework Engineering Tool.

]1.9 BOILER OR CHILLER PLANT GATEWAY REQUEST

If requesting the use of a gateway to a boiler or chiller plant as indicated in paragraph Proprietary Systems Exempted From Open Protocol Requirements, submit a Boiler or Chiller Plant Gateway Request describing the configuration of the boilers or chillers including model numbers for equipment and controllers, the sequence of operation for the units, and a justification for the need to operate the units on a shared non-LonWorks network.

1.10 QUALITY CONTROL CHECKLISTS

The QC Checklist for LNS-Based LonWorks Systems in APPENDIX A of this Section must be completed by the Contractor's Chief Quality Control (QC) Representative and submitted as indicated.

The QC Checklist for Niagara Framework Based LonWorks Systems in APPENDIX A of this Section must be completed by the Contractor's Chief Quality

Control (QC) Representative and submitted as indicated.

The QC Representative must verify each item indicated and initial in the space provided to indicate that the requirement has been met. The QC Representative must sign and date the Checklist prior to submission to the Government.

1.10.1 Pre-Construction Quality Control (QC) Checklist

Complete items indicated as Pre-Construction QC Checklist items in the QC Checklist. Submit [four][_____] copies of the Pre-Construction QC Checklist.

1.10.2 Post-Construction Quality Control (QC) Checklist

Complete items indicated as Post-Construction QC Checklist items in the QC Checklist. Submit [four][_____] copies of the Post-Construction QC Checklist.

1.10.3 Closeout Quality Control (QC) Checklist

Complete items indicated as Closeout QC Checklist items in the QC Checklist. Submit [four][_____] copies of the Closeout QC Checklist.

PART 2 PRODUCTS

Provide products meeting the requirements of Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for LNS LonWorks systems or Niagara LonWorks systems, other referenced Sections, and this Section.

2.1 GENERAL PRODUCT REQUIREMENTS

Units of the same type of equipment must be products of a single manufacturer. Each major component of equipment must have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment must be standard products of a manufacturer regularly engaged in the manufacturing of these and similar products. The standard products must have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two year use must include applications of equipment and materials under similar circumstances and of similar size. DDC Hardware not meeting the two-year field service requirement is acceptable provided it has been successfully used by the Contractor in a minimum of two previous projects. The equipment items must be supported by a service organization. Items of the same type and purpose must be identical, including equipment, assemblies, parts and components.

2.2 PRODUCT DATA

Provide manufacturer's product data sheets documenting compliance with product specifications for each product provided under Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS, or this Section. Provide product data for all products in a single indexed compendium, organized by product type.

For all LonWorks hardware: for each manufacturer, model and version (revision) of DDC Hardware indicate the type or types of DDC Hardware the product is being provided as in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS

.

Submit Manufacturer's Product Data on CD-ROM.

2.2.1 XIF Files

Provide External Interface Files (XIF Files) for DDC Hardware in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit external interface files (XIF files) as a technical data package for each model of DDC Hardware provided under this specification. Submit XIF files on CD-ROM.

2.3 OPERATION ENVIRONMENT

Unless otherwise specified, provide products rated for continuous operation under the following conditions:

a. Pressure: Pressure conditions normally encountered in the installed location.

b. Vibration: Vibration conditions normally encountered in the installed location.

c. Temperature:

(1) Products installed indoors: Ambient temperatures in the range of 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.

(2) Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of [-35 to +151 degrees F] [_____] and temperature conditions outside this range normally encountered at the installed location.

d. Humidity: 10 to 95 percent relative humidity, noncondensing and humidity conditions outside this range normally encountered at the installed location.

2.4 WIRELESS CAPABILITY

For products incorporating any wireless capability (including but not limited to radio frequency (RF), infrared and optical), provide products for which wireless capability can be permanently disabled at the device. Optical and infrared capabilities may be disabled via a permanently affixed opaque cover plate.

2.5 ENCLOSURES

Enclosures supplied as an integral (pre-packaged) part of another product are acceptable. Provide two Enclosure Keys for each lockable enclosure on a single ring per enclosure with a tag identifying the enclosure the keys operate. Provide enclosures meeting the following minimum requirements:

2.5.1 Outdoors

For enclosures located outdoors, provide enclosures meeting NEMA 250 [Type 3][Type 4] requirements.

2.5.2 Mechanical and Electrical Rooms

For enclosures located in mechanical or electrical rooms, provide enclosures meeting NEMA 250 [Type 2][Type 4] requirements.

2.5.3 Other Locations

For enclosures in other locations including but not limited to occupied spaces, above ceilings, and in plenum returns, provide enclosures meeting NEMA 250 Type 1 requirements.

2.6 WIRE AND CABLE

Provide wire and cable meeting the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification and referenced specifications.

2.6.1 Terminal Blocks

For terminal blocks which are not integral to other equipment, provide terminal blocks which are insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, suitable for DIN rail mounting, and which have enclosed sides or end plates and partition plates for separation.

2.6.2 Control Wiring for Binary Signals

For Control Wiring for Binary Signals, provide 18 AWG copper or thicker wire rated for 300-volt service.

2.6.3 Control Wiring for Analog Signals

For Control Wiring for Analog Signals, provide 18 AWG or thicker, copper, single- or multiple-twisted wire meeting the following requirements:

a. minimum 2 inch lay of twist

b. 100 percent shielded pairs

c. at least 300-volt insulation

d. each pair has a 20 AWG tinned-copper drain wire and individual overall pair insulation

e. cables have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.6.4 Power Wiring for Control Devices

For 24-volt circuits, provide insulated copper 18 AWG or thicker wire rated for 300 VAC service. For 120-volt circuits, provide 14 AWG or thicker stranded copper wire rated for 600-volt service.

2.6.5 Transformers

Provide UL 5085-3 approved transformers. Select transformers sized so that the connected load is no greater than 80 percent of the transformer rated capacity.

PART 3 EXECUTION

[3.1 EXISTING CONDITIONS

3.1.1 Existing Conditions Survey

Perform a field survey, including testing and inspection of the equipment to be controlled and submit an Existing Conditions Report documenting the current status and its impact on the Contractor's ability to meet this specification. For those items considered nonfunctional, document the deficiency in the report including explanation of the deficiencies and estimated costs to correct the deficiencies. As part of the report, define the scheduled need date for connection to existing equipment. Make written requests and obtain Government approval prior to disconnecting any controls and obtaining equipment downtime.

Submit [four][_____] copies of the Existing Conditions Report.

3.1.2 Existing Equipment Downtime

Make written requests and obtain Government approval prior to disconnecting any controls and obtaining equipment downtime.

3.1.3 Existing Control System Devices

Inspect, calibrate, and adjust as necessary to place in proper working order all existing devices which are to be reused.

]3.2 INSTALLATION

Fully install and test the control system in accordance Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC, Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for LNS LonWorks systems or Niagara LonWorks systems, and this Section.

3.2.1 Dielectric Isolation

Provide dielectric isolation where dissimilar metals are used for connection and support. Install control system in a matter that provides clearance for control system maintenance by maintaining access space required to calibrate, remove, repair, or replace control system devices. Install control system such that it does not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.2.2 Penetrations in Building Exterior

Make all penetrations through and mounting holes in the building exterior watertight.

3.2.3 Device Mounting Criteria

Install devices in accordance with the manufacturer's recommendations and as indicated and shown. Provide a weathershield for all devices installed

outdoors. Provide clearance for control system maintenance by maintaining access space required to calibrate, remove, repair, or replace control system devices. Provide clearance for mechanical and electrical system maintenance; do not not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.2.4 Labels and Tags

Key all labels and tags to the unique identifiers shown on the As-Built drawings. For labels exterior to protective enclosures provide engraved plastic labels mechanically attached to the enclosure or DDC Hardware. Labels inside protective enclosures may be attached using adhesive, but must not be hand written. For tags, provide plastic or metal tags mechanically attached directly to each device or attached by a metal chain or wire.

a. Label all Enclosures and DDC Hardware.

b. Tag Airflow measurement arrays (AFMA) with flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient.

c. Tag duct static pressure taps at the location of the pressure tap

3.2.5 Surge Protection

3.2.5.1 Power-Line Surge Protection

Protect equipment connected to AC circuits to withstand power-line surges in accordance with IEEE C62.41. Do not use fuses for surge protection.

3.2.5.2 Surge Protection for Transmitter and Control Wiring

Protect DDC hardware against or provided DDC hardware capable of withstanding surges induced on control and transmitter wiring installed outdoors and as shown. Protect equipment against the following two waveforms:

a. A waveform with a 10-microsecond rise time, a 1000-microsecond decay time and a peak current of 60 amps.

b. A waveform with an 8-microsecond rise time, a 20-microsecond decay time and a peak current of 500 amperes.

3.2.6 Basic Cybersecurity Requirements

3.2.6.1 Passwords

For all devices with a password, change the password from the default password. Do not use the same password for more than one device. Coordinate selection of passwords with [_____]. Provide a Password Summary Report documenting the password for each device and describing the procedure to change the password for each device.

Provide [two][_____] hardcopies of the Password Summary Report, each copy in its own sealed envelope.

3.2.6.2 Wireless Capability

Unless otherwise indicated, disable wireless capability (including but not

limited to radio frequency (RF), infrared and optical) for all devices with wireless capability. Optical and infrared capabilities may be disabled via a permanently affixed opaque cover plate. Password protecting a wireless connections does not meet this requirement; the wireless capability must be disabled.

3.2.6.3 IP Network Physical Security

Install all IP Network media in conduit. Install all IP devices including but not limited to IP-enabled DDC hardware and IP Network Hardware in lockable enclosures.

3.3 DRAWINGS AND CALCULATIONS

Provide drawings in the form and arrangement indicated and shown. Use the same abbreviations, symbols, nomenclature and identifiers shown. Assign a unique identifier as shown to each control system element on a drawing. When packaging drawings, group schedules by system. When space allows, it is permissible to include multiple schedules for the same system on a single sheet. Except for drawings covering all systems, do not put information for different systems on the same sheet.

Submit hardcopy drawings on [ISO A1 34 by 22 inches][or][A3 17 by 11 inches] sheets, and electronic drawings in PDF and in [AutoCAD][Microstation][Bentley BIM V8][Autodesk Revit 2013] format. In addition, submit electronic drawings in editable Excel format for all drawings that are tabular, including but not limited to the Point Schedule and Equipment Schedule.

a. Submit DDC Contractor Design Drawings consisting of each drawing indicated with pre-construction information depicting the intended control system design and plans. Submit DDC Contractor Design Drawings as a single complete package: [_____] hard copies and [_____] copies on CD-ROM.

b. Submit Draft As-Built Drawings consisting of each drawing indicated updated with as-built data for the system prior to PVT. Submit Draft As-Built Drawings as a single complete package: [_____] hard copies and [_____] copies on CD-ROM.

c. Submit Final As-Built Drawings consisting of each drawing indicated updated with all final as-built data. Final As-Built Drawings as a single complete package: [_____] hard copies and [_____] copies on CD-ROM.

3.3.1 Sample Drawings

Sample drawings in electronic format are available at the Whole Building Design Guide page for this section: http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-23-09-00 These drawings may prove useful in demonstrating expected drawing formatting and example content and are provided for illustrative purposes only. Note that these drawings do not meet the content requirements of this Section and must be completed to meet project requirements.

3.3.2 Drawing Index and Legend

Provide an HVAC Control System Drawing Index showing the name and number of the building, military site, State or other similar designation, and

Country. In the Drawing Index, list all Contractor Design Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. In the Design Drawing Legend, show and describe all symbols, abbreviations and acronyms used on the Design Drawings. Provide a single Index and Legend for the entire drawing package.

3.3.3 Thermostat and Occupancy Sensor Schedule

Provide a thermostat and occupancy sensor schedule containing each thermostat's unique identifier, room identifier and control features and functions as shown. Provide a single thermostat and occupancy sensor schedule for the entire project.

3.3.4 Valve Schedule

Provide a valve schedule containing each valve's unique identifier, size, flow coefficient Kv (Cv), pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure to torque data, dimensions, and access and clearance requirements data. In the valve schedule include actuator selection data supported by calculations of the force required to move and seal the valve, access and clearance requirements. Provide a single valve schedule for the entire project.

3.3.5 Damper Schedule

Provide a damper schedule containing each damper's unique identifier, type (opposed or parallel blade), nominal and actual sizes, orientation of axis and frame, direction of blade rotation, actuator size and spring ranges, operation rate, positive positioner range, location of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. Include the AMCA 511 maximum leakage rate at the operating static-pressure differential for each damper in the Damper Schedule. Provide a single damper schedule for the entire project.

3.3.6 Project Summary Equipment Schedule

Provide a project summary equipment schedule containing the manufacturer, model number, part number and descriptive name for each control device, hardware and component provided under this specification. Provide a single project equipment schedule for the entire project.

3.3.7 Equipment Schedule

Provide system equipment schedules containing the unique identifier, manufacturer, model number, part number and descriptive name for each control device, hardware and component provided under this specification. Provide a separate equipment schedule for each HVAC system.

3.3.8 Occupancy Schedule

Provide an occupancy schedule drawing containing the same fields as the occupancy schedule Contract Drawing with Contractor updated information. Provide a single occupancy schedule for the entire project.

3.3.9 DDC Hardware Schedule

Provide a single DDC Hardware Schedule for the entire project and

including following information for each device.

3.3.9.1 DDC Hardware Identifier

The Unique DDC Hardware Identifier for the device.

3.3.9.2 HVAC System

The system "name" used to identify a specific system (the name used on the system schematic drawing for that system).

3.3.9.3 LonWorks Device Information

3.3.9.3.1 Network Address

The LonWorks Domain, Subnet and Node address for the device.

3.3.9.3.2 Unique Node ID

The Unique 48-bit Node ID associated with the device. (Also referred to as the Neuron ID for some devices)

3.3.9.4 Niagara Station ID

The Niagara Station ID for each Niagara Framework Supervisory Gateway

3.3.10 Points Schedule

Provide a Points Schedule in tabular form for each HVAC system, with the indicated columns and with each row representing a hardware point, network point or configuration point in the system.

a. When a Points Schedule was included in the Contract Drawing package, use the same fields as the Contract Drawing with updated information in addition to the indicated fields.

b. When Point Schedules are included in the contract package, items requiring contractor verification or input have been shown in angle brackets ("<" and ">"), such as <___> for a required entry or <value> for a value requiring confirmation. Complete all items in brackets as well as any blank cells. Do not modify values which are not in brackets without approval.

Points Schedule Columns must include:

3.3.10.1 Point Name

The abbreviated name for the point using the indicated naming convention.

3.3.10.2 Description

A brief functional description of the point such as "Supply Air Temperature".

3.3.10.3 DDC Hardware Identifier

The Unique DDC Hardware Identifier shown on the DDC Hardware Schedule and used across all drawings for the DDC Hardware containing the point.

3.3.10.4 Settings

The value and units of any setpoints, configured setpoints, configuration parameters, and settings related to each point.

3.3.10.5 Range

The range of values, including units, associated with the point, including but not limited to a zone temperature setpoint adjustment range, a sensor measurement range, occupancy values for an occupancy input, or the status of a safety.

3.3.10.6 Input or Output (I/O) Type

The type of input or output signal associated with the point. Use the following abbreviations for entries in this column:

a. AI: The value comes from a hardware (physical) Analog Input

b. AO: The value is output as a hardware (physical) Analog Output

c. BI: The value comes from a hardware (physical) Binary Input

d. BO: The value is output as a hardware (physical) Binary Output

e. PULSE: The value comes from a hardware (physical) Pulse Accumulator Input

f. NET-IN: The value is provided from the network (generally from another device). Use this entry only when the value is received from another device as part of scheduling or as part of a sequence of operation, not when the value is received on the network for supervisory functions such as trending, alarming, override or display at a user interface.

g. NET-OUT: The value is provided to another controller over the network. Use this entry only when the value is transmitted to another device as part of scheduling or as part of a sequence of operation, not when the value is transmitted on the network for supervisory functions such as trending, alarming, override or display at a user interface.

3.3.10.7 Primary Point Information: SNVT Name

The name of the SNVT used for the point. Any point that is displayed at the front end or on an LDP, is trended, is used by another device on the network, or has an alarm condition must be documented here.

3.3.10.8 Primary Point Information: SNVT Type

The SNVT type used by the point. Provide this information whenever SNVT Name is required.

3.3.10.9 Niagara Station ID

The Niagara Station ID of the Niagara Framework Supervisory Gateway the point is mapped into.

3.3.10.10 Override Information (SNVT Name and Type)

For each point requiring an Override and not residing in a Niagara Framework Supervisory Gateway, indicate the SNVT Name and SNVT Type of the network variable used for the override.

3.3.10.11 Configuration Information

Indicate the means of configuration associated with each point. For points in a Niagara Framework Supervisory Gateway, indicate the point within the Niagara Framework Supervisory Gateway used to configure the value. For other points:

a. Indicate "Plug-In" if the point is configurable via an LNS plug-in. Indicate "Niagara Framework Wizard" if the point is configurable via a Niagara Framework Wizard.

b. If the point is not configurable through an LNS plug-ina Niagara Framework Wizard, indicate the network variable or configuration property used to configure the value.

3.3.11 Riser Diagram

The Riser Diagram of the Building Control Network may be in tabular form, and must show all DDC Hardware and all Network Hardware, including network terminators. For each item, provide the unique identifier, common descriptive name, physical sequential order (previous and next device on the network), room identifier and location within room. A single riser diagram must be submitted for the entire system.

3.3.12 Control System Schematics

Provide control system schematics in the same form as the control system schematic Contract Drawing with Contractor updated information. Provide a control system schematic for each HVAC system.

3.3.13 Sequences of Operation[Including Control Logic Diagrams]

Provide HVAC control system sequence of operation and [control logic diagrams] in the same format as the Contract Drawings. Within these drawings, refer to devices by their unique identifiers. Submit sequences of operation[and control logic diagrams] for each HVAC system

3.3.14 Controller, Motor Starter and Relay Wiring Diagram

Provide controller wiring diagrams as functional wiring diagrams which show the interconnection of conductors and cables to each controller and to the identified terminals of input and output devices, starters and package equipment. Show necessary jumpers and ground connections and the labels of all conductors. Identify sources of power required for control systems and for packaged equipment control systems back to the panel board circuit breaker number, controller enclosures, magnetic starter, or packaged equipment control circuit. Show each power supply and transformer not integral to a controller, starter, or packaged equipment. Show the connected volt-ampere load and the power supply volt-ampere rating. Provide wiring diagrams for each HVAC system.

3.4 CONTROLLER TUNING

Tune each controller in a manner consistent with that described in the ASHRAE FUN IP and in the manufacturer's instruction manual. Tuning must consist of adjustment of the proportional, integral, and where applicable, the derivative (PID) settings to provide stable closed-loop control. Each loop must be tuned while the system or plant is operating at a high gain (worst case) condition, where high gain can generally be defined as a low-flow or low-load condition. Upon final adjustment of the PID settings, in response to a change in controller setpoint, the controlled variable must settle out at the new setpoint with no more than two (2) oscillations above and below setpoint. Upon settling out at the new setpoint the controller output must be steady. With the exception of naturally slow processes such as zone temperature control, the controller must settle out at the new setpoint within five (5) minutes. Set the controller to its correct setpoint and record and submit the final PID configuration settings with the O&M Instructions and on the associated Points Schedule.

3.5 START-UP

3.5.1 Start-Up Test

Perform the following startup tests for each control system to ensure that the described control system components are installed and functioning per this specification.

Adjust, calibrate, measure, program, configure, set the time schedules, and otherwise perform all necessary actions to ensure that the systems function as indicated and shown in the sequence of operation and other contract documents.

3.5.1.1 Systems Check

An item-by-item check must be performed for each HVAC system

3.5.1.1.1 Step 1 - System Inspection

With the system in unoccupied mode and with fan hand-off-auto switches in the OFF position, verify that power and main air are available where required and that all output devices are in their failsafe and normal positions. Inspect each local display panel [and each M&C Client] to verify that all displays indicate shutdown conditions.

3.5.1.1.2 Step 2 - Calibration Accuracy Check

Perform a two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter by comparing the value from the test instrument to the network value provided by the DDC Hardware. Use digital indicating test instruments, such as digital thermometers, motor-driven psychrometers, and tachometers. Use test instruments with accuracy at least twice as accurate as the specified sensor accuracy and with calibration traceable to National Institute of Standards and Technology standards. Check one the first check point in the bottom one-third of the sensor range, and the second in the top one-third of the sensor range. Verify that the sensing element-to-DDC readout accuracies at two points are within the specified product accuracy tolerances, and if not recalibrate or replace the device and repeat the calibration check.

3.5.1.1.3 Step 3 - Actuator Range Check

With the system running, apply a signal to each actuator through the DDC Hardware controller. Verify proper operation of the actuators and positioners for all actuated devices and record the signal levels for the extreme positions of each device. Vary the signal over its full range, and verify that the actuators travel from zero stroke to full stroke within the signal range. Where applicable, verify that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other. For valve actuators and damper actuators, perform the actuator range check under normal system pressures.

3.5.1.2 Weather Dependent Test

Perform weather dependent test procedures in the appropriate climatic season.

3.5.2 Start-Up Testing Report

Submit [4] [_____] copies of the Start-Up Testing Report. The report may be submitted as a Technical Data Package documenting the results of the tests performed and certifying that the system is installed and functioning per this specification, and is ready for the Performance Verification Test (PVT).

3.5.3 Draft LNS Database

Upon completion of the Start-Up Test, submit the Draft LNS Database reflecting the system as installed and configured at the completion of the Start-Up and Start-Up-Testing. The Draft LNS Database must be a complete, fully commissioned LNS database for the complete control network provided under this specification. The Draft LNS database submittal must consist of the entire folder structure of the LNS database (e.g. c:\Lm\DB\{database name}. For versions of LNS which use credits, the provided LNS Database must include all device credits.

Submit two copies of the fully commissioned, valid draft LNS Database (including all LNS credits) as a Technical Data Package. Submit each copy on a CD-ROM and clearly mark the CD-ROM identifying it as the LNS Database for the work covered under this specification and with the date of the most recent database modification.

3.6 PERFORMANCE VERIFICATION TEST (PVT)

3.6.1 PVT Procedures

Prepare PVT Procedures based on Section 25 08 10 UTILITY MONITORING AND CONTROL SYSTEM TESTING explaining step-by-step, the actions and expected results that will demonstrate that the control system performs in accordance with the sequences of operation, and other contract documents. Submit [4] [_____] copies of the PVT Procedures. The PVT Procedures may be submitted as a Technical Data Package.

3.6.1.1 Sensor Accuracy Checks

Include a one-point accuracy check of each sensor in the PVT procedures.

3.6.1.2 Temporary Trending Hardware

Unless trending capability exists within the building control system or the building control system is connected to a UMCS or other system which can perform trending, temporarily install hardware on the building control network to perform trending during the endurance test as indicated. Remove the temporary hardware at the completion of all commissioning activities.

3.6.1.3 Endurance Test

Include a [one-week] [_____] endurance test as part of the PVT during which the system is operated continuously.

Use the building control system Niagara Trend Log Objects to trend all points shown as requiring a trend on the Point Schedule for the entire endurance test. If insufficient buffer capacity exists to trend the entire endurance test, upload trend logs during the course of the endurance test to ensure that no trend data is lost. The PVT must include a methodology to measure and record the network bandwidth usage on each TP/FT-10 channel during the endurance test.

Use the existing trending capabilities or the Temporary Trending Hardware as indicated to trend all points shown as requiring a trend on the Point Schedule for the entire endurance test. The PVT must include a methodology to measure and record the network bandwidth usage on each TP/FT-10 channel during the endurance test.

3.6.1.4 PVT Equipment List

Include in the PVT procedures a control system performance verification test equipment list that lists the equipment to be used during performance verification testing. For each piece of equipment, include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration

3.6.2 PVT Execution

Demonstrate compliance of the control system with the contract documents. Using test plans and procedures approved by the Government, software capable of reading and writing COV Notification Subscriptions, Notification Class Recipient List Properties, event enrollments, demonstrate all physical and functional requirements of the project. Show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. Do not start the performance verification test until after receipt of written permission by the Government, based on Government approval of the PVT Plan and Draft As-Builts and completion of balancing. UNLESS GOVERNMENT WITNESSING OF A TEST IS SPECIFICALLY WAIVED BY THE GOVERNMENT, PERFORM ALL TESTS WITH A GOVERNMENT WITNESS. Do not conduct tests during scheduled seasonal off periods of base heating and cooling systems. If the system experiences any failures during the endurance test portion of the PVT, repair the system repeat the endurance test portion of the PVT until the system operates continuously and without failure for the specified endurance test period.

3.6.3 PVT Report

Prepare and submit a PVT report documenting all tests performed during the PVT and their results. Include all tests in the PVT procedures and any additional tests performed during PVT. Document test failures and repairs conducted with the test results.

Submit [four][_____] copies of the PVT Report. The PVT Report may be submitted as a Technical Data Package.

3.6.4 Final LNS Database

Submit a Final LNS Database consisting of the complete, fully commissioned LNS database for the complete control network provided under this specification. Provide the the entire folder structure of the LNS database (e.g. c:\Lm\DB\{database name}. For versions of LNS which use credits, include all device credits in the provided LNS Database.

Submit two copies of the fully commissioned, valid as-built LNS Database (including all LNS credits) for the complete control network provided under this specification as a Technical Data Package. Submit each copy on CD-ROM and clearly mark the CD-ROM identifying it as the LNS Database for the work covered under this specification and with the date of the most recent database modification.

3.7 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Provide HVAC control System Operation and Maintenance Instructions which include:

a. "Data Package 3" as indicated in Section 01 78 23 OPERATION AND MAINTENANCE DATA for each piece of control equipment.

b. "Data Package 4" as described in Section 01 78 23 OPERATION AND MAINTENANCE DATA for all air compressors.

c. HVAC control system sequences of operation formatted as indicated.

d. Procedures for the HVAC system start-up, operation and shut-down including the manufacturer's supplied procedures for each piece of equipment, and procedures for the overall HVAC system.

e. As-built HVAC control system detail drawings formatted as indicated.

f. Routine maintenance checklist. Provide the routine maintenance checklist arranged in a columnar format, where the first column lists all installed devices, the second column states the maintenance activity or that no maintenance required, the third column states the frequency of the maintenance activity, and the fourth column is used for additional comments or reference.

g. Qualified service organization list, including at a minimum company name, contact name and phone number.

h. Start-Up Testing Report.

i. Performance Verification Test (PVT) Procedures and Report.

Submit [2] [_____] copies of the Operation and Maintenance Instructions, indexed and in booklet form. The Operation and Maintenance Instructions may be submitted as a Technical Data Package.

[3.8 MAINTENANCE AND SERVICE

Provide services, materials and equipment as necessary to maintain the entire system in an operational state as indicated for a period of one year from the date of final acceptance of the project. Minimize impacts on facility operations.

a. The integration of the system specified in this section into a Utility Monitoring and Control System must not, of itself, void the warranty or otherwise alter the requirement for the one year maintenance and service period. Integration into a UMCS includes but is not limited to establishing communication between devices in the control system and the front end or devices in another system.

b. The changing of configuration properties must not, of itself, void the warranty or otherwise alter the requirement for the one year maintenance and service period.

3.8.1 Description of Work

Provide adjustment and repair of the system including the manufacturer's required sensor and actuator (including transducer) calibration, span and range adjustment.

3.8.2 Personnel

Use only service personnel qualified to accomplish work promptly and satisfactorily. Advise the Government in writing of the name of the designated service representative, and of any changes in personnel.

3.8.3 Scheduled Inspections

Perform two inspections at six-month intervals and provide work required. Perform inspections in [June and December][_____]. During each inspection perform the indicated tasks:

a. Perform visual checks and operational tests of equipment.

b. Clean control system equipment including interior and exterior surfaces.

c. Check and calibrate each field device. Check and calibrate 50 percent of the total analog inputs and outputs during the first inspection. Check and calibrate the remaining 50 percent of the analog inputs and outputs during the second major inspection. Certify analog test instrumentation accuracy to be twice the specified accuracy of the device being calibrated. Randomly check at least 25 percent of all binary inputs and outputs for proper operation during the first inspection. Randomly check at least 25 percent of the remaining binary inputs and outputs during the second inspection. If more than 20 percent of checked inputs or outputs failed the calibration check during any inspection, check and recalibrate all inputs and outputs during that inspection.

d. Run system software diagnostics and correct diagnosed problems.

e. Resolve any previous outstanding problems.

3.8.4 Scheduled Work

This work must be performed [during regular working hours, Monday through Friday, excluding Federal holidays][_____].

3.8.5 Emergency Service

The Government will initiate service calls when the system is not functioning properly. Qualified personnel must be available to provide service to the system. A telephone number where the service supervisor can be reached at all times must be provided. Service personnel must be at the site within 24 hours after receiving a request for service. The control system must be restored to proper operating condition as required per Section 01 78 00 CLOSEOUT SUBMITTALS.

3.8.6 Operation

After performing scheduled adjustments and repairs, verify control system operation as demonstrated by the applicable tests of the performance verification test.

3.8.7 Records and Logs

Keep dated records and logs of each task, with cumulative records for each major component, and for the complete system chronologically. Maintain a continuous log for all devices, including initial analog span and zero calibration values and digital points. Keep complete logs and provide logs for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

3.8.8 Work Requests

Record each service call request as received and include its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. Submit a record of the work performed within 5 days after work is accomplished.

3.8.9 System Modifications

Submit recommendations for system modification in writing. Do not make system modifications, including operating parameters and control settings, without prior approval of the Government.

]3.9 TRAINING

Conduct a training course for [_____] operating staff members designated by the Government in the maintenance and operation of the system, including specified hardware and software. Conduct [32] [_____] hours of training at the project site within 30 days after successful completion of the performance verification test. The Government reserves the right to make audio and visual recordings (using Government supplied equipment)of the training sessions for later use. Provide audiovisual equipment and

other training materials and supplies required to conduct training. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

3.9.1 Training Documentation

Prepare training documentation consisting of:

a. Course Attendee List: Develop the list of course attendees in coordination with and signed by the [Controls][HVAC][Electrical] shop supervisor.

b. Training Manuals: Provide training manuals which include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. When presenting portions of the course material by audiovisuals, deliver copies of those audiovisuals as a part of the printed training manuals.

3.9.2 Training Course Content

For guidance in planning the required instruction, assume that attendees will have a high school education, and are familiar with HVAC systems. During the training course, cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each controller enclosure, the layout of one of each type of equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, and repair procedures. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. Present the results of the performance verification test and the Start-Up Testing Report as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

3.9.3 Training Documentation Submittal Requirements

Submit hardcopy training manuals and all training materials on CD-ROM. Provide one hardcopy manual for each trainee on the Course Attendee List and [2][_____] additional copies for archive at the project site. Provide [2][_____] copies of the Course Attendee List with the archival copies. Training Documentation may be submitted as a Technical Data Package.

APPENDIX A

QC CHECKLIST FOR LNS-BASED LONWORKS SYSTEMS

This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such.

Instructions: Initial each item in the space provided (|____|) verifying that the requirement has been met.

This checklist is for (circle one:)

Pre-Construction QC Checklist Submittal

Post-Construction QC Checklist Submittal

Close-out QC Checklist Submittal

Items verified for Pre-Construction, Post-Construction and Closeout QC Checklist Submittals:

1	All DDC Hardware is numbered on Control System Schematic Drawings.	|____|
2	Signal lines on Control System Schematic are labeled with the signal type.	|____|
3	Local Display Panel (LDP) Locations are shown on Control System Schematic drawings.	|____|

Items verified for Post-Construction and Closeout QC Checklist Submittals:

4	All sequences are performed as specified using DDC Hardware.	|____|
5	Training schedule and course attendee list has been developed and coordinated with shops and submitted.	|____|
6	All DDC Hardware is installed on a TP/FT-10 Channel.	|____|
7	All Application Specific Controllers (ASCs) are LonMark certified.	|____|
8	Communication between DDC Hardware is only via CEA-709.1-D using SNVTs. Other protocols have not been used. Network variables other than SNVTs have not been used.	|____|
9	Explicit messaging has not been used.	|____|
10	Scheduling is performed in DDC Hardware meeting the Simple Schedule Functional Profile	|____|

Items verified for Closeout QC Checklist Submittal:

QC CHECKLIST FOR LNS-BASED LONWORKS SYSTEMS		
11	Final As-built Drawings, including all Points Schedule drawings, accurately represent the final installed system.	|____|
12	Programming software has been submitted for all programmable controllers.	|____|
13	All software has been licensed to the Government.	
14	O&M Instructions have been completed and submitted.	|____|
15	Training course has been completed.	|____|
16	LonWorks Network Services (LNS) Database is up-to-date and accurately represents the final installed system.	|____|
17	LNS Plug-ins have been submitted for all Application Specific Controllers (ASCs).	|____|
18	Programming software has been submitted for all General Purpose Programmable Controllers (GPPCs) and all Application Generic Controllers (AGCs).	|____|
	_____ _____	
	(QC Representative Signature) (Date)	

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED LONWORKS SYSTEMS		
This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such. Instructions: Initial each item in the space provided (|____|) verifying that the requirement has been met.		
This checklist is for (circle one:) Pre-Construction QC Checklist Submittal Post-Construction QC Checklist Submittal Close-out QC Checklist Submittal		
Items verified for Pre-Construction, Post-Construction and Closeout QC Checklist Submittals:		
1	All DDC Hardware is numbered on Control System Schematic Drawings.	|____|

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED LONWORKS SYSTEMS			
2	Signal lines on Control System Schematic are labeled with the signal type.		|____|
3	Local Display Panel (LDP) Locations are shown on Control System Schematic drawings.		|____|
Items verified for Post-Construction and Closeout QC Checklist Submittals:			
4	All sequences are performed as specified using DDC Hardware.		|____|
5	Training schedule and course attendee list has been developed and coordinated with shops and submitted.		|____|
6	All DDC Hardware except Niagara Framework Supervisory Gateways is installed on a TP/FT-10 Channel.		|____|
7	All Application Specific Controllers (ASCs) are LonMark certified.		|____|
8	Except for communication between two Niagara Framework Supervisory Gateways, Communication between DDC Hardware is only via CEA-709.1-D using SNVTs. Other protocols have not been used. Network variables other than SNVTs have not been used. Communication between Niagara Framework Supervisory Gateways is via Fox Protocol.		|____|
9	Explicit messaging has not been used.		|____|
10	Scheduling, Alarming, and Trending have been implemented using Niagara Framework objects and services.		|____|
Items verified for Closeout QC Checklist Submittal:			
11	Final As-built Drawings, including all Points Schedule drawings, accurately represent the final installed system.		|____|
12	Programming software has been submitted for all programmable controllers.		|____|
13	All software has been licensed to the Government.		
14	O&M Instructions have been completed and submitted.		|____|
15	Training course has been completed.		|____|
16	The database in each Niagara Framework Supervisory Gateway is up-to-date and accurately represents the building control network beneath that Niagara Framework Supervisory Gateway.		|____|
17	Niagara Wizards have been submitted for all Application Specific Controllers (ASCs) for which a Wizard is available and for all Application Generic Controllers (AGCs).		|____|
18	Programming software has been submitted for all General Purpose Programmable Controllers (GPPCs) and all Application Generic Controllers (AGCs).		|____|

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED LONWORKS SYSTEMS	
_____	_____
(QC Representative Signature)	(Date)

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SECTION 23 09 13

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC
11/15, CHG 2: 05/21

PART 1 GENERAL

1.1 SUMMARY

This section provides for the instrumentation control system components excluding direct digital controllers, network controllers, gateways etc. that are necessary for a completely functional automatic control system. When combined with a Direct Digital Control (DDC) system, the Instrumentation and Control Devices covered under this section must be a complete system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and indicated.

a. Install hardware to perform the control sequences as specified and indicated and to provide control of the equipment as specified and indicated.

b. Install hardware such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.

c. Install and configure hardware such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the installing Contractor.

1.1.1 Verification of Dimensions

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 any work.

1.1.2 Drawings

The Government will not indicate all offsets, fittings, and accessories that may be required on the drawings. Carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, arrange such work accordingly, and provide all work necessary to meet such conditions.

1.2 RELATED SECTIONS

Related work specified elsewhere.

Section 01 30 00 ADMINISTRATIVE REQUIREMENTS

Section 23 30 00 HVAC AIR DISTRIBUTION

Section 23 05 15 COMMON PIPING FOR HVAC

Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

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.

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

AMCA 500-D	(2018) Laboratory Methods of Testing Dampers for Rating
AMCA 511	(2010; R 2016) Certified Ratings Program for Air Control Devices

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

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 B16.22	(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 B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A269/A269M	(2015; R 2019) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
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 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
ASTM D1238	(2013) Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D1693	(2015) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics

FLUID CONTROLS INSTITUTE (FCI)

FCI 70-2	(2021) Control Valve Seat Leakage

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.20	(2015; E 2018) Electricity Meters - 0.1, 0.2, and 0.5 Accuracy Classes
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA/ANSI C12.10	(2011; R 2021) Physical Aspects of Watthour Meters - Safety 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 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 94	(2013; Reprint May 2021) UL Standard for Safety Tests for Flammability of Plastic

	Materials for Parts in Devices and Appliances
UL 555	(2006; Reprint Aug 2016) UL Standard for Safety Fire Dampers
UL 555S	(2014; Reprint Oct 2020) UL Standard for Safety Smoke Dampers
UL 1820	(2004; Reprint May 2013) UL Standard for Safety Fire Test of Pneumatic Tubing for Flame and Smoke Characteristics
UL 5085-3	(2006; Reprint Nov 20121) Low Voltage Transformers - Part 3: Class 2 and Class 3 Transformers

1.4 SUBMITTALS

Submittal requirements are specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.5 DELIVERY AND STORAGE

Store and protect products from the weather, humidity, and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer.

1.6 INPUT MEASUREMENT ACCURACY

Select, install and configure sensors, transmitters and DDC Hardware such that the maximum error of the measured value at the input of the DDC hardware is less than the maximum allowable error specified for the sensor or instrumentation.

1.7 SUBCONTRACTOR SPECIAL REQUIREMENTS

Perform all work in this section in accordance with the paragraph entitled CONTRACTOR SPECIAL REQUIREMENTS in Section 01 30 00 ADMINISTRATIVE REQUIREMENTS.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 General Requirements

All products used to meet this specification must meet the indicated requirements, but not all products specified here will be required by every project. All products must meet the requirements both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section.

2.1.2 Operation Environment Requirements

Unless otherwise specified, provide products rated for continuous operation under the following conditions:

2.1.2.1 Pressure

Pressure conditions normally encountered in the installed location.

2.1.2.2 Vibration

Vibration conditions normally encountered in the installed location.

2.1.2.3 Temperature

a. Products installed indoors: Ambient temperatures in the range of 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.

b. Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of [-35 to +151 degrees F] [_____] and temperature conditions outside this range normally encountered at the installed location.

2.1.2.4 Humidity

10 to 95 percent relative humidity, non-condensing and also humidity conditions outside this range normally encountered at the installed location.

2.2 WEATHERSHIELDS

Provide weathershields constructed of galvanized steel painted white, unpainted aluminum, aluminum painted white, or white PVC.

[2.3 TUBING

2.3.1 Copper

Provide ASTM B75/B75M or ASTM B88 rated tubing meeting the following requirements:

a. For tubing 0.375 inch outside diameter and larger provide tubing with minimum wall thickness equal to ASTM B88, Type M

b. For tubing less than 0.375 inch outside diameter provide tubing with minimum wall thickness of 0.025 inch

c. For exposed tubing and tubing for working pressures greater than 30 psig provide hard copper tubing.

d. Provide fittings which are ASME B16.18 or ASME B16.22 solder type using ASTM B32 95-5 tin-antimony solder, or which are ASME B16.26 compression type.

2.3.2 Stainless Steel

For stainless steel tubing provide tubing conforming to ASTM A269/A269M

2.3.3 Plastic

Provide plastic tubing with the burning characteristics of linear low-density polyethylene tubing which is self-extinguishing when tested in

accordance with ASTM D635, has UL 94 V-2 flammability classification or better, and which withstands stress cracking when tested in accordance with ASTM D1693. Provide plastic-tubing bundles with Mylar barrier and flame-retardant polyethylene jacket.

2.3.4 Polyethylene Tubing

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, or for systems with working pressures over 30 psig. Provide compression or brass barbed push-on type fittings. Provide extruded seamless polyethylene tubing conforming 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

g. Flame Propagation: UL 1820, less than 5 feet ASTM D635

h. Average Optical Density: UL 1820, less than 0.15 ASTM D635

]2.4 WIRE AND CABLE

Provide wire and cable meeting the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification and referenced specifications.

2.4.1 Terminal Blocks

For terminal blocks which are not integral to other equipment, provide terminal blocks which are insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, suitable for DIN rail mounting, and which have enclosed sides or end plates and partition plates for separation.

2.4.2 Control Wiring for Binary Signals

For Control Wiring for Binary Signals, provide 18 AWG copper or thicker wire rated for 300-volt service.

2.4.3 Control Wiring for Analog Signals

For Control Wiring for Analog Signals, provide 18 AWG or thicker, copper, single- or multiple-twisted wire meeting the following requirements:

a. minimum 2 inch lay of twist

b. 100 percent shielded pairs

c. at least 300-volt insulation

d. each pair has a 20 AWG tinned-copper drain wire and individual overall pair insulation

e. cables have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.4.4 Power Wiring for Control Devices

For 24-volt circuits, provide insulated copper 18 AWG or thicker wire rated for 300 VAC service. For 120-volt circuits, provide 14 AWG or thicker stranded copper wire rated for 600-volt service.

2.4.5 Transformers

Provide UL 5085-3 approved transformers. Select transformers sized so that the connected load is no greater than 80 percent of the transformer rated capacity.

2.5 AUTOMATIC CONTROL VALVES

Provide valves with stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Provide valves with bodies meeting ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure. Unless otherwise specified or indicated, provide valves meeting FCI 70-2 [Class III leakage rating][Class IV leakage rating]. Provide valves rated for modulating or two-position service as indicated, which close against a differential pressure indicated as the Close-Off pressure and which are Normally-Open, Normally-Closed, or Fail-In-Last-Position as indicated.

2.5.1 Valve Type

2.5.1.1 Liquid Service 150 Degrees F or Less

Use either globe valves or ball valves except that butterfly valves may be used for sizes 4 inch and larger.

2.5.1.2 Liquid Service Above 150 Degrees F

a. Two-position valves: Use either globe valves or ball valves except that butterfly valves may be used for sizes 4 inch and larger.

b. Modulating valves: Use globe valves except that butterfly valves may be used for sizes 4 inch and larger.

2.5.1.3 Steam Service

Use globe valves except that butterfly valves may be used for sizes 4 inch and larger.

2.5.2 Valve Flow Coefficient and Flow Characteristic

2.5.2.1 Two-Way Modulating Valves

Provide the valve coefficient (Cv) indicated. Provide equal-percentage flow characteristic for liquid service except for butterfly valves. Provide linear flow characteristic for steam service except for butterfly valves.

2.5.2.2 Three-Way Modulating Valves

Provide the valve coefficient (Cv) indicated. Provide linear flow characteristic with constant total flow throughout full plug travel.

2.5.3 Two-Position Valves

Use full line size full port valves with maximum available (Cv).

2.5.4 Globe Valves

2.5.4.1 Liquid Service Not Exceeding 150 Degrees F

a. Valve body and body connections:

(1) valves 1-1/2 inches and smaller: brass or bronze body, with threaded or union ends

(2) valves from 2 inches to 3 inches inclusive: brass, bronze, or iron bodies. 2 inch valves with threaded connections; 2-1/2 to 3 inches valves with flanged connections

b. Internal valve trim: Brass or bronze.

c. Stems: Stainless steel.

d. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol.

2.5.4.2 Liquid Service Not Exceeding 250 Degrees F

a. Valve body and body connections:

(1) valves 1-1/2 inches and smaller: brass or bronze body, with threaded or union ends

(2) valves from 2 inches to 3 inches inclusive: brass, bronze, or iron bodies. 2 inch valves with threaded connections; 2-1/2 to 3 inches valves with flanged connections

b. Internal trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.

c. Provide valves with non-metallic parts suitable for a minimum continuous operating temperature of 250 degrees F or 50 degrees F above the system design temperature, whichever is higher.

d. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol

2.5.4.3 Hot water service 250 Degrees F and above

a. Provide valve bodies conforming to ASME B16.34 Class 300. For valves 1 inch and larger provide valves with bodies which are carbon steel, globe type with welded ends. For valves smaller than 1 inch provide valves with socket-weld ends. Provide valves with virgin polytetrafluoroethylene (PTFE) packing. Provide valve and actuator combinations which are normally closed.

b. Internal trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.

2.5.4.4 Steam Service

For steam service, provide valves meeting the following requirements:

a. Valve body and connections:

(1) valves 1-1/2 inches and smaller: complete body of brass or bronze, with threaded or union ends

(2) valves from 2 inches to 3 inches inclusive: body of brass, bronze, or carbon steel

(3) valves 4 inches and larger: body of carbon steel. 2 inch valves with threaded connections; valves2-1/2 inches and larger with flanged connections.

b. Internal Trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.

c. Valve sizing: sized for [15 psig] [_____] inlet steam pressure with a maximum [12 psi] [_____] differential through the valve at rated flow, except where indicated otherwise.

2.5.5 Ball Valves

2.5.5.1 Liquid Service Not Exceeding 150 Degrees F

a. Valve body and connections:

(1) valves 1-1/2 inches and smaller: bodies of brass or bronze, with threaded or union ends

(2) valves from 2 inches to 3 inches inclusive: bodies of brass, bronze, or iron. 2 inch valves with threaded connections; valves from 2-1/2 to 3 inches with flanged connections.

b. Ball: Stainless steel or nickel-plated brass or chrome-plated brass.

c. Seals: Reinforced Teflon seals and EPDM O-rings.

d. Stem: Stainless steel, blow-out proof.

e. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol.

2.5.6 Butterfly Valves

Provide butterfly valves which are threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies or with ductile iron bodies in accordance with ASTM A536. Provide butterfly valves with non-corrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from -20 to +250 degrees F. Provide valves with rated Cv of the Cv at 70 percent (60 degrees) open position. Provide valves meeting FCI 70-2 Class VI leakage rating.

2.5.7 Pressure Independent Control Valves (PICV)

Provide pressure independent control valves which include a regulator valve which maintains the differential pressure across a flow control valve. Pressure independent control valves must accurately control the flow from 0-100 percent full rated flow regardless of changes in the piping pressure and not vary the flow more than plus or minus 5 percent at any given flow control valve position when the PICV differential pressure lies between the manufacturer's stated minimum and maximum. The rated minimum differential pressure for steady flow must not exceed 5 psid across the PICV. Provide either globe or ball type valves meeting the indicated requirements for globe and ball valves. Provide valves with a flow tag listing full rated flow and minimum required pressure drop. Provide valves with factory installed Pressure/Temperature ports ("Pete's Plugs") to measure the pressure drop to determine the valve flow rate.

2.5.8 Duct-Coil and Terminal-Unit-Coil Valves

For duct or terminal-unit coils provide control valves with either [flare-type][screw type] or solder-type ends. Provide flare nuts for each flare-type end valve.

2.6 DAMPERS

2.6.1 Damper Assembly

Provide single damper sections with blades no longer than 48 inches and which are no higher than 72 inches and damper blade width of 8 inches or less. When larger sizes are required, combine damper sections. Provide dampers made of steel, or other materials where indicated and with assembly frames constructed of 0.07 inch minimum thickness [galvanized][stainless] steel channels with mitered and welded corners. Steel channel frames constructed of 0.06 inch minimum thickness are acceptable provided the corners are reinforced.

a. Flat blades must be made rigid by folding the edges. Blade-operating linkages must be within the frame so that blade-connecting devices within the same damper section must not be located directly in the air stream.

b. Damper axles must be 1/2 inch minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically must be supported by thrust bearings.

c. Provide dampers which do not exceed a pressure drop through the damper of 0.04 inches water gauge at 1000 ft/min in the wide-open position. Provide dampers with frames not less than 2 inch in width. Provide dampers which have been tested in accordance with AMCA 500-D.

2.6.2 Operating Linkages

For operating links external to dampers, such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, provide links able to withstand a load equal to at least 300 percent of the maximum required damper-operating force without deforming. Rod lengths must be adjustable. Links must be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises must be brass, bronze, or stainless steel. Adjustments of crank arms must control the open and closed positions of dampers.

2.6.3 Damper Types

2.6.3.1 Flow Control Dampers

Provide parallel-blade or opposed blade type dampers for outside air, return air, relief air, exhaust, face and bypass dampers as indicated on the Damper Schedule. Blades must have interlocking edges. The channel frames of the dampers must be provided with jamb seals to minimize air leakage. Unless otherwise indicated, dampers must meet AMCA 511 [Class 1A][Class 1][Class 2] requirements. Outside air damper seals must be suitable for an operating temperature range of -40 to +167 degrees F. Dampers must be rated at not less than 2000 ft/min air velocity.

2.6.3.2 Mechanical Rooms and Other Utility Space Ventilation Dampers

Provide utility space ventilation dampers as indicated. Unless otherwise indicated provide AMCA 511 class 3 dampers. Provide dampers rated at not less than 1500 ft/min air velocity.

2.6.3.3 Smoke Dampers

Provide smoke-damper and actuator assemblies which meet the current requirements of NFPA 90A, UL 555, and UL 555S. For combination fire and smoke dampers provide dampers rated for 250 degrees F Class II leakage per UL 555S.

2.7 SENSORS AND INSTRUMENTATION

Unless otherwise specified, provide sensors and instrumentation which incorporate an integral transmitter. Sensors and instrumentation, including their transmitters, must meet the specified accuracy and drift requirements at the input of the connected DDC Hardware's analog-to-digital conversion.

2.7.1 Analog and Binary Transmitters

Provide transmitters which match the characteristics of the sensor. Transmitters providing analog values must produce a linear 4-20 mAdc, 0-10 Vdc signal corresponding to the required operating range and must have zero and span adjustment. Transmitters providing binary values must have dry contacts rated at 1A at 24 Volts AC.

2.7.2 Network Transmitters

Sensors and Instrumentation incorporating an integral network connection are considered DDC Hardware and must meet the DDC Hardware requirements of Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER

BUILDING CONTROL SYSTEMS when used in a Lonworks network, or the requirements of 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS when used in a BACnet network.

2.7.3 Temperature Sensors

Provide the same sensor type throughout the project. Temperature sensors may be provided without transmitters. Where transmitters are used, the range must be the smallest available from the manufacturer and suitable for the application such that the range encompasses the expected range of temperatures to be measured. The end to end accuracy includes the combined effect of sensitivity, hysteresis, linearity and repeatability between the measured variable and the end user interface (graphic presentation) including transmitters if used.

2.7.3.1 Sensor Accuracy and Stability of Control

2.7.3.1.1 Conditioned Space Temperature

Plus or minus 0.5 degree F over the operating range.

2.7.3.1.2 Unconditioned Space Temperature

a. Plus or minus 1 degree F over the range of 30 to 131 degrees F AND

b. Plus or minus 4 degrees F over the rest of the operating range.

2.7.3.1.3 Duct Temperature

Plus or minus 0.5 degree F

2.7.3.1.4 Outside Air Temperature

a. Plus or minus 2 degrees F over the range of -30 to +130 degrees F AND

b. Plus or minus 1 degree F over the range of 30 to 130 degrees F.

2.7.3.1.5 High Temperature Hot Water

Plus or minus 3.6 degrees F.

2.7.3.1.6 Chilled Water

Plus or minus 0.8 degrees F over the range of 35 to 65 degrees F.

2.7.3.1.7 Dual Temperature Water

Plus or minus 2 degrees F.

2.7.3.1.8 Heating Hot Water

Plus or minus 2 degrees F.

2.7.3.1.9 Condenser Water

Plus or minus 2 degrees F.

2.7.3.2 Transmitter Drift

The maximum allowable transmitter drift: 0.25 degrees F per year.

2.7.3.3 Point Temperature Sensors

Point Sensors must be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.

2.7.3.4 Temperature Sensor Details

2.7.3.4.1 Room Type

Provide the sensing element components within a decorative protective cover suitable for surrounding decor.

2.7.3.4.2 Duct Probe Type

Ensure the probe is long enough to properly sense the air stream temperature.

2.7.3.4.3 Duct Averaging Type

Continuous averaging sensors must be one foot in length for each 1 square foot of duct cross-sectional area, and a minimum length of 5 feet.

2.7.3.4.4 Pipe Immersion Type

For pipes with larger than 3 inch diameter, provide minimum 3 inch immersion. For pipes with less than 3 inch diameter, provide immersion at least half the diameter of the pipe. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells must be stainless steel when used in steel piping, and brass when used in copper piping.

2.7.3.4.5 Outside Air Type

Provide the sensing element rated for outdoor use

2.7.4 Relative Humidity Sensor

Relative humidity sensors must use bulk polymer resistive or thin film capacitive type non-saturating sensing elements capable of withstanding a saturated condition without permanently affecting calibration or sustaining damage. The sensors must include removable protective membrane filters. Where required for exterior installation, sensors must be capable of surviving below freezing temperatures and direct contact with moisture without affecting sensor calibration. When used indoors, the sensor must be capable of being exposed to a condensing air stream (100 percent relative humidity) with no adverse effect to the sensor's calibration or other harm to the instrument. The sensor must be of the wall-mounted or duct-mounted type, as required by the application, and must be provided with any required accessories. Sensors used in duct high-limit applications must have a bulk polymer resistive sensing element. Duct-mounted sensors must be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. Relative humidity (RH) sensors must measure relative humidity over a range of 0 percent to 100 percent with an accuracy of plus or minus [2][3] percent. RH sensors must function over a temperature range of 40

to 135 degrees F and must not drift more than 1 percent per year.

2.7.5 Carbon Dioxide (CO2) Sensors

Provide photometric type CO2 sensors with integral transducers and linear output. Carbon dioxide (CO2) sensors must measure CO2 concentrations between 0 to 2000 parts per million (ppm) using non-dispersible infrared (NDIR) technology with an accuracy of plus or minus 50 ppm and a maximum response time of 1 minute. The sensor must be rated for operation at ambient air temperatures within the range of 32 to 122 degrees F and relative humidity within the range of 20 to 95 percent (non-condensing). The sensor must have a maximum drift of 2 percent per year. The sensor chamber must be manufactured with a non-corrosive material that does not affect carbon dioxide sample concentration. Duct mounted sensors must be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. The sensor must have a calibration interval no less than 5 years.

2.7.6 Differential Pressure Instrumentation

2.7.6.1 Differential Pressure Sensors

Provide Differential Pressure Sensors with ranges as indicated or as required for the application. Pressure sensor ranges must not exceed the high end range indicated on the Points Schedule by more than 50 percent. The over pressure rating must be a minimum of 150 percent of the highest design pressure of either input to the sensor. The accuracy must be plus or minus 1 percent of full scale. The sensor must have a maximum drift of 2 percent per year

2.7.6.2 Differential Pressure Switch

Provide differential pressure switches with a user-adjustable setpoint which are sized for the application such that the setpoint is between 25 percent and 75 percent of the full range. The over pressure rating must be a minimum of 150 percent of the highest design pressure of either input to the sensor. The switch must have two sets of contacts and each contact must have a rating greater than it's connected load. Contacts must open or close upon rise of pressure above the setpoint or drop of pressure below the setpoint as indicated.

2.7.7 Flow Sensors

2.7.7.1 Airflow Measurement Array (AFMA)

2.7.7.1.1 Airflow Straightener

Provide AFMAs which contain an airflow straightener if required by the AFMA manufacturer's published installation instructions. The straightener must be contained inside a flanged sheet metal casing, with the AFMA located as specified according to the published recommendation of the AFMA manufacturer. In the absence of published documentation, provide airflow straighteners if there is any duct obstruction within 5 duct diameters upstream of the AFMA. Air-flow straighteners, where required, must be constructed of 0.125 inch aluminum honeycomb and the depth of the straightener must not be less than 1.5 inches.

2.7.7.1.2 Resistance to Airflow

The resistance to air flow through the AFMA, including the airflow straightener must not exceed 0.085 inch water gauge at an airflow of 2,000 fpm. AFMA construction must be suitable for operation at airflows of up to 5000 fpm over a temperature range of 40 to 120 degrees F.

2.7.7.1.3 Outside Air Temperature

In outside air measurement or in low-temperature air delivery applications, provide an AFMA certified by the manufacturer to be accurate as specified over a temperature range of [-20 to +120 degrees F] [_____].

2.7.7.1.4 Pitot Tube AFMA

Each Pitot Tube AFMA must contain an array of velocity sensing elements. The velocity sensing elements must be of the multiple pitot tube type with averaging manifolds. The sensing elements must be distributed across the duct cross section in the quantity and pattern specified or recommended by the published installation instructions of the AFMA manufacturer.

a. Pitot Tube AFMAs for use in airflows over 600 fpm must have an accuracy of plus or minus 5 percent over a range of 500 to 2500 fpm.

b. Pitot Tube AFMAs for use in airflows under 600 fpm must have an accuracy of plus or minus 5 percent over a range of 125 to 2500 fpm.

2.7.7.1.5 Electronic AFMA

Each electronic AFMA must consist of an array of velocity sensing elements of the resistance temperature detector (RTD) or thermistor type. The sensing elements must be distributed across the duct cross section in the quantity and pattern specified or recommended by the published application data of the AFMA manufacturer. Electronic AFMAs must have an accuracy of plus or minus 5 percent over a range of 125 to 5,000 fpm and the output must be temperature compensated over a range of 32 to 212 degrees F.

2.7.7.1.6 Fan Inlet Measurement Devices

Fan inlet measurement devices cannot be used unless indicated on the drawings or schedules.

2.7.7.2 Orifice Plate

Orifice plate must be made of an austenitic stainless steel sheet of 0.125 inch nominal thickness with an accuracy of plus or minus 1 percent of full flow. The orifice plate must be flat within 0.002 inches. The orifice surface roughness must not exceed 20 micro-inches. The thickness of the cylindrical face of the orifice must not exceed 2 percent of the pipe inside diameter or 12.5 percent of the orifice diameter, whichever is smaller. The upstream edge of the orifice must be square and sharp. Where orifice plates are used, concentric orifice plates must be used in all applications except steam flow measurement in horizontal pipelines.

2.7.7.3 Flow Nozzle

Flow nozzle must be made of austenitic stainless steel with an accuracy of plus or minus 1 percent of full flow. The inlet nozzle form must be elliptical and the nozzle throat must be the quadrant of an ellipse. The

thickness of the nozzle wall and flange must be such that distortion of the nozzle throat from strains caused by the pipeline temperature and pressure, flange bolting, or other methods of installing the nozzle in the pipeline must not cause the accuracy to degrade beyond the specified limit. The outside diameter of the nozzle flange or the design of the flange facing must be such that the nozzle throat must be centered accurately in the pipe.

2.7.7.4 Venturi Tube

Venturi tube must be made of cast iron or cast steel and must have an accuracy of plus or minus 1 percent of full flow. The throat section must be lined with austenitic stainless steel. Thermal expansion characteristics of the lining must be the same as that of the throat casting material. The surface of the throat lining must be machined to a plus or minus 50 micro inch finish, including the short curvature leading from the converging entrance section into the throat.

2.7.7.5 Annular Pitot Tube

Annular pitot tube must be made of austenitic stainless steel with an accuracy of plus or minus 2 percent of full flow and a repeatability of plus or minus 0.5 percent of measured value. The unit must have at least one static port and no less than four total head pressure ports with an averaging manifold.

2.7.7.6 Insertion Turbine Flowmeter

Provide dual axial turbine flowmeter with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. All parts must meet or exceed the pressure classification of the pipe system it is installed in. Insertion Turbine Flowmeter accuracy must be plus or minus 0.5 percent of rate at calibrated velocity., within plus or minus of rate over a 10:1 turndown and within plus or minus 2 percent of rate over a 50:1 turndown. Repeatability must be plus or minus 0.25 percent of reading. The meter flow sensing element must operate over a range suitable for the installed location with a pressure loss limited to 1 percent of operating pressure at maximum flow rate. The flowmeter ,must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc outputs. The turbine rotor assembly must be constructed of Series 300 stainless steel and use Teflon seals.

2.7.7.7 Vortex Shedding Flowmeter

Vortex Shedding Flowmeter accuracy must be within plus or minus 0.8 percent of the actual reading over the range of the meter. Steam meters must contain density compensation by direct measurement of temperature. Mass flow inferred from specified steam pressure are not acceptable. The flow meter body must be made of austenitic stainless steel and include a weather tight NEMA 4X electronics enclosure. The vortex shedding flowmeter body must not require removal from the piping in order to replace the shedding sensor.

2.7.7.8 Ultrasonic Flow Meter

Provide Ultrasonic Flow Meters complete with matched transducers, self aligning installation hardware and transducer cables. Ultrasonic transducers must be optimized for the specific pipe and process conditions for the application. The flow meter accuracy must plus or minus 1 percent

of rate from 0 to 40 ft/sec. The flowmeter must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc output.

2.7.7.9 Insertion Magnetic Flow Meter

Provide insertion type magnetic flowmeters with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. All parts must meet or exceed the pressure classification of the pipe system it is installed in. Flowmeter accuracy must be no greater than plus or minus 1 percent of rate from 2 to 20 feet/sec. Wetted material parts must be 300 series stainless steel. The flowmeter must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc outputs.

2.7.7.10 Positive Displacement Flow Meter

The flow meter must be a direct reading, gerotor, nutating disc or vane type displacement device rated for liquid service as indicated. A counter must be mounted on top of the meter, and must consist of a non-resettable mechanical totalizer for local reading, and a pulse transmitter for remote reading. The totalizer must have a six digit register to indicate the volume passed through the meter in [liters] [gallons], and a sweep-hand dial to indicate down to 0.25 gallons. The pulse transmitter must have a hermetically sealed reed switch which is activated by magnets fixed on gears of the counter. The meter must have a bronze body with threaded or flanged connections as required for the application. Output accuracy must be plus or minus 2 percent of the flow range. The maximum pressure drop at full flow must be 5 psig.

2.7.7.11 Flow Meters, Paddle Type

Sensor must be non-magnetic, with forward curved impeller blades designed for water containing debris. Sensor accuracy must be plus or minus 1 percent of rate of flow, minimum operating flow velocity must be 1 foot per second. Sensor repeatability and linearity must be plus or minus 1 percent. Materials which will be wetted must be made from non-corrosive materials and must not contaminate water. The sensor must be rated for installation in pipes of 3 to 40 inch diameters. The transmitter housing must be a NEMA 250 Type 4 enclosure.

2.7.7.12 Flow Switch

Flow switch must have a repetitive accuracy of plus or minus 10 percent of actual flow setting. Switch actuation must be adjustable over the operating flow range, and must be sized for the application such that the setpoint is between 25 percent and 75 percent of the full range.. The switch must have Form C snap-action contacts, rated for the application. The flow switch must have non flexible paddle with magnetically actuated contacts and be rated for service at a pressure greater than the installed conditions. Flow switch for use in sewage system must be rated for use in corrosive environments encountered.

2.7.7.13 Gas Flow Meter

Gas flow meter must be diaphragm or bellows type (gas positive displacement meters) for flows up to 2500 SCFH and axial flow turbine type for flows above 2500 SCFH, designed specifically for natural gas supply metering, and rated for the pressure, temperature, and flow rates of the installation. Meter must have a minimum turndown ratio of 10 to 1 with an

accuracy of plus or minus 1 percent of actual flow rate. The meter index must include a direct reading mechanical totalizing register and electrical impulse dry contact output for remote monitoring. The electrical impulse dry contact output must not require field adjustment or calibration. The electrical impulse dry contact output must have a minimum resolution of 100 cubic feet of gas per pulse and must not exceed 15 pulses per second at the design flow.

2.7.8 Electrical Instruments

Provide Electrical Instruments with an input range as indicated or sized for the application. Unless otherwise specified, AC instrumentation must be suitable for 60 Hz operation.

2.7.8.1 Current Transducers

Current transducers must accept an AC current input and must have an accuracy of plus or minus [0.5] [2] percent of full scale. The device must have a means for calibration. Current transducers for variable frequency applications must be rated for variable frequency operation.

2.7.8.2 Current Sensing Relays (CSRs)

Current sensing relays (CSRs) must provide a normally-open contact with a voltage and amperage rating greater than its connected load. Current sensing relays must be of split-core design. The CSR must be rated for operation at 200 percent of the connected load. Voltage isolation must be a minimum of 600 volts. The CSR must auto-calibrate to the connected load or be adjustable and field calibrated. Current sensors for variable frequency applications must be rated for variable frequency operation.

2.7.8.3 Voltage Transducers

Voltage transducers must accept an AC voltage input and have an accuracy of plus or minus 0.25 percent of full scale. The device must have a means for calibration. Line side fuses for transducer protection must be provided.

2.7.8.4 Energy Metering

2.7.8.4.1 Watt or Watthour Transducers

Watt transducers must measure voltage and current and must output kW or kWh or both kW and kWh as indicated. kW outputs must have an accuracy of plus or minus 0.5 percent over a power factor range of 0.1 to 1. kWh outputs must have an accuracy of plus or minus 0.5 percent over a power factor range of 0.1 to 1.

2.7.8.4.2 Watthour Revenue Meter (with and without Demand Register)

All Watthour revenue meters must measure voltage and current and must be in accordance with ANSI C12.1 with an ANSI C12.20 Accuracy class of [0.5] [0.2] and must have pulse initiators for remote monitoring of Watthour consumption. Pulse initiators must consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets must be in accordance with NEMA/ANSI C12.10. Watthour revenue meters with demand registers must output instantaneous demand in addition to the pulse initiators.

2.7.8.4.3 Steam Meters

Steam meters must be the vortex type, with pressure compensation, a minimum turndown ratio of 10 to 1, and an output signal compatible with the DDC system.

2.7.8.4.4 Hydronic BTU Meters

The BTU meter is to be supplied with wall mount hardware and be capable of being installed remote from the flow meter. The BTU meter must include an LCD display for local indication of energy rate and for display of parameters and settings during configuration. Each BTU meter must be factory configured for its specific application and be completely field configurable by the user via a front panel keypad (no special interface device or computer required). The unit must output Energy Rate, Energy Total, Flow Rate, Supply Temperature, and Return Temperature. An integral transmitter is to provide a linear analog or configurable pulse output signal representing the energy rate; and the signal must be compatible with building automation system DDC Hardware to which the output is connected.

2.7.9 pH Sensor

The sensor must be suitable for applications and chemicals encountered in water treatment systems of boilers, chillers and condenser water systems. Construction, wiring, fittings and accessories must be corrosion and chemical resistant with fittings for tank or suspension installation. Housing must be polyvinylidene fluoride with O-rings made of chemical resistant materials which do not corrode or deteriorate with extended exposure to chemicals. The sensor must be encapsulated. Periodic replacement must not be required for continued sensor operation. Sensors must use a ceramic junction and pH sensitive glass membrane capable of withstanding a pressure of 100 psig at 150 degrees F. The reference cell must be double junction configuration. Sensor range must be 0 to 12 pH, stability 0.05, sensitivity 0.02, and repeatability of plus or minus 0.05 pH value, response of 90 percent of full scale in one second and a linearity of 99 percent of theoretical electrode output measured at 76 degrees F.

2.7.10 Oxygen Analyzer

Oxygen analyzer must consist of a zirconium oxide sensor for continuous sampling and an air-powered aspirator to draw flue gas samples. The analyzer must be equipped with filters to remove flue air particles. Sensor probe temperature rating must be 815 degrees F. The sensor assembly must be equipped for flue flange mounting.

2.7.11 Carbon Monoxide Analyzer

Carbon monoxide analyzer must consist of an infrared light source in a weather proof steel enclosure for duct or stack mounting. An optical detector/analyzer in a similar enclosure, suitable for duct or stack mounting must be provided. Both assemblies must include internal blower systems to keep optical windows free of dust and ash at all times. The third component of the analyzer must be the electronics cabinet. Automatic flue gas temperature compensation and manual/automatic zeroing devices must be provided. Unit must read parts per million (ppm) of carbon monoxide in the range of [_____] to [_____] ppm and the response

time must be less than 3 seconds to 90 percent value. Unit measurement range must not exceed specified range by more that 50 percent. Repeatability must be plus or minus 1 percent of full scale with an accuracy of plus or minus 1 percent of full scale.

2.7.12 Occupancy Sensors

Occupancy sensors must have occupancy-sensing sensitivity adjustment and an adjustable off-delay timer with a setpoint of 15 minutes. Adjustments accessible from the face of the unit are preferred. Occupancy sensors must be rated for operation in ambient air temperatures ranging from 40 to 95 degrees F or temperatures normally encountered in the installed location. Sensors integral to wall mount on-off light switches must have an auto-off switch. Wall switch sensors must be decorator style and must fit behind a standard decorator type wall plate. All occupancy sensors, power packs, and slave packs must be UL listed. In addition to any outputs required for lighting control, the occupancy sensor must provide an output for the HVAC control system.

2.7.12.1 Passive Infrared (PIR) Occupancy Sensors

PIR occupancy sensors must have a multi-level, multi-segmented viewing lens and a conical field of view with a viewing angle of 180 degrees and a detection of at least 20 feet unless otherwise indicated or specified. PIR Sensors must provide field-adjustable background light-level adjustment with an adjustment range suitable to the light level in the sensed area, room or space. PIR sensors must be immune to false triggering from RFI and EMI.

2.7.12.2 Ultrasonic Occupancy Sensors

Ultrasonic sensors must operate at a minimum frequency 32 kHz and must be designed to not interfere with hearing aids.

2.7.12.3 Dual-Technology Occupancy Sensor (PIR and Ultrasonic)

Dual-Technology Occupancy Sensors must meet the requirements of both PIR and Ultrasonic Occupancy Sensors.

2.7.13 Vibration Switch

Vibration switch must be solid state, enclosed in a NEMA 250 Type 4 or Type 4X housing with sealed wire entry. Unit must have two independent sets of Form C switch contacts with one set to shutdown equipment upon excessive vibration and a second set for monitoring alarm level vibration. The vibration sensing range must be a true rms reading, suitable for the application. The unit must include either displacement response for low speed or velocity response for high speed application. The frequency range must be at least 3 Hz to 500 Hz. Contact time delay must be 3 seconds. The unit must have independent start-up and running delay on each switch contact. Alarm limits must be adjustable and setpoint accuracy must be plus or minus 10 percent of setting with repeatability of plus or minus 2 percent.

2.7.14 Conductivity Sensor

Sensor must include local indicating meter and must be suitable for measurement of conductivity of water in boilers, chilled water systems, condenser water systems, distillation systems, or potable water systems as

indicated. Sensor must sense from 0 to 10 microSeimens per centimeter (µS/cm) for distillation systems, 0 to 100 µS/cm for boiler, chilled water, and potable water systems and 0 to 1000 µS/cm for condenser water systems. Contractor must field verify the ranges for particular applications and adjust the range as required. The output must be temperature compensated over a range of 32 to 212 degrees F. The accuracy must be plus or minus 2 percent of the full scale reading. Sensor must have automatic zeroing and must require no periodic maintenance or recalibration.

2.7.15 Compressed Air Dew Point Sensor

Sensor must be suitable for measurement of dew point from -40 +80 degrees F over a pressure range of 0 to 150 psig. The transmitter must provide both dry bulb and dew point temperatures on separate outputs. The end to end accuracy of the dew point must be plus or minus 5 degrees F and the dry bulb must be plus or minus 1 degree F. Sensor must be automatic zeroing and must require no normal maintenance or periodic recalibration.

2.7.16 NOx Monitor

Monitor must continuously monitor and give local indication of boiler stack gas for NOx content. It must be a complete system designed to verify compliance with the Clean Air Act standards for NOx normalized to a 3 percent oxygen basis and must have a range of from 0 to 100 ppm. Sensor must be accurate to plus or minus 5 ppm. Sensor must output NOx and oxygen levels and binary output that changes state when the NOx level is above a locally adjustable NOx setpoint. Sensor must have normal, trouble and alarm lights. Sensor must have heat traced lines if the stack pickup is remote from the sensor. Sensor must be complete with automatic zero and span calibration using a timed calibration gas system, and must not require periodic maintenance or recalibration.

2.7.17 Turbidity Sensor

Sensor must include a local indicating meter and must be suitable for measurement of turbidity of water. Sensor must sense from 0 to 1000 Nephelometric Turbidity Units (NTU). Range must be field-verified for the particular application and adjusted as required. The output must be temperature compensated over a range of 32 to 212 degrees F. The accuracy must be plus or minus 5 percent of full scale reading. Sensor must have automatic zeroing and must not require periodic maintenance or recalibration.

2.7.18 Chlorine Detector

The detector must measure concentrations of chlorine in water in the range 0 to 20 ppm with a repeatability of plus or minus 1 percent of full scale and an accuracy of plus or minus 2 percent of full scale. The Chlorine Detector transmitter must be housed in a non-corrosive NEMA 250 Type 4X enclosure. Detector must include a local panel with adjustable alarm trip level, local audio and visual alarm with silence function.

2.7.19 Floor Mounted Leak Detector

Leak detectors must use electrodes mounted at slab level with a minimum built-in-vertical adjustment of 0.125 inches. Detector must have a binary output. The indicator must be manual reset type.

2.7.20 Temperature Switch

2.7.20.1 Duct Mount Temperature Low Limit Safety Switch (Freezestat)

Duct mount temperature low limit switches (Freezestats) must be manual reset, low temperature safety switches at least 1 foot long per square foot of coverage which must respond to the coldest 18 inch segment with an accuracy of plus or minus 3.6 degrees F. The switch must have a field-adjustable setpoint with a range of at least 30 to 50 degrees F. The switch must have two sets of contacts, and each contact must have a rating greater than its connected load. Contacts must open or close upon drop of temperature below setpoint as indicated and must remain in this state until reset.

2.7.20.2 Pipe Mount Temperature Limit Switch (Aquastat)

Pipe mount temperature limit switches (aquastats) must have a field adjustable setpoint between 60 and 90 degrees F, an accuracy of plus or minus 3.6 degrees F and a 10 degrees F fixed deadband. The switch must have two sets of contacts, and each contact must have a rating greater than its connected load. Contacts must open or close upon change of temperature above or below setpoint as indicated.

2.7.21 Damper End Switches

Each end switch must be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure must be suitable for mounting on the duct exterior and must permit setting the position of the trip lever that actuates the switch. The trip lever must be aligned with the damper blade.

End switches integral to an electric damper actuator are allowed as long as at least one is adjustable over the travel of the actuator.

2.7.22 Air Quality Sensors

Provide full spectrum air quality sensors using a hot wire element based on the Taguchi principle. The sensor must 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 must 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.

[2.8 INDICATING DEVICES

All indicating devices must display readings in [metric (SI)][English (inch-pound)] units.

2.8.1 Thermometers

Provide bi-metal type thermometers at locations indicated. Thermometers must have either 9 inch long scales or 3.5 inch diameter dials, with insertion, immersion, or averaging elements. Provide matching thermowells for pipe-mounted installations. Select scale ranges suitable for the intended service, with the normal operating temperature near the scale's midpoint. The thermometer's accuracy must be plus or minus 2 percent of the scale range.

2.8.1.1 Piping System Thermometers

Piping system thermometers must have brass, malleable iron or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 9 inch scale. Piping system thermometers must have an accuracy of plus or minus 1 percent of scale range. Thermometers for piping systems must have rigid stems with straight, angular, or inclined pattern. Thermometer stems must have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem must be filled with a heat-transfer medium.

2.8.1.2 Air-Duct Thermometers

Air-duct thermometers must have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.8.2 Pressure Gauges

Provide pipe-mounted pressure gauges at the locations indicated. Gauges must conform to ASME B40.100 and have a 4 inch diameter dial and shutoff cock. Select scale ranges suitable for the intended service, with the normal operating pressure near the scale's midpoint. The gauge's accuracy must be plus or minus 2 percent of the scale range.

Gauges must be suitable for field or panel mounting as required, must have black legend on white background, and must have a pointer traveling through a 270-degree arc. Gauge range must be suitable for the application with an upper end of the range not to exceed 150 percent of the design upper limit. Accuracy must be plus or minus 3 percent of scale range. Gauges must meet requirements of ASME B40.100.

2.8.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements must be a minimum of 3.5 inch (nominal) size with two sets of pressure taps, and must have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauge range must be suitable for the application with an upper end of the range not to exceed 150 percent of the design upper limit. Accuracy must be plus or minus two percent of scale range.

[2.8.4 Pressure Gauges for Pneumatic Controls

Gauges must [have a 0 to 30 psi scale][sufficient scale to display the full range of expected pressures] with 1 psi graduations.

]]2.9 OUTPUT DEVICES

2.9.1 Actuators

Actuators must be electric (electronic) [or pneumatic as indicated]. All actuators must be normally open (NO), normally closed (NC) or fail-in-last-position (FILP) as indicated. Normally open and normally closed actuators must be of mechanical spring return type. Electric actuators must have an electronic cut off or other means to provide burnout protection if stalled. Actuators must have a visible position indicator. [Electric actuators must provide position feedback to the controller as indicated.] Actuators must smoothly and fully open or close

the devices to which they are applied. Electric actuators must have a full stroke response time in both directions of 90 seconds or less at rated load. Electric actuators must be of the foot-mounted type with an oil-immersed gear train or the direct-coupled type. Where multiple electric actuators operate from a common signal, the actuators must provide an output signal identical to its input signal to the additional devices. [Pneumatic actuators must be rated for 25 psi operating pressure except for high-pressure cylinder-type actuators.] All actuators must be rated for their operating environment. Actuators used outdoors must be designed and rated for outdoor use. Actuators under continuous exposure to water, such as those used in sumps, must be submersible.

Actuators incorporating an integral network connection are considered DDC Hardware and must meet the DDC Hardware requirements of Section [23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] [23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS].

2.9.1.1 Valve Actuators

Valve actuators must provide shutoff pressures and torques as indicated on the Valve Schedule.

2.9.1.2 Damper Actuators

Damper actuators must provide the torque necessary per damper manufacturer's instructions to modulate the dampers smoothly over its full range of operation and torque must be at least 6 inch-pounds/1 square foot of damper area for opposed blade dampers and 9 inch-pounds/1 square foot of damper area for parallel blade dampers.

[2.9.1.3 Positive Positioners

Positive positioners must be a pneumatic relay with a mechanical position feedback mechanism and an adjustable operating range and starting point.

]2.9.1.4 Electric Actuators

Each actuator must have distinct markings indicating the full-open and full-closed position Each actuator must deliver the torque required for continuous uniform motion and must have internal end switches to limit the travel, or be capable of withstanding continuous stalling without damage. Actuators must 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..

a. Two-position actuators must be single direction, spring return, or reversing type. Two position actuator signals may either be the control power voltage or line voltage as needed for torque or appropriate interlock circuits.

b. Modulating actuators must be capable of stopping at any point in the cycle, and starting in either direction from any point. Actuators must 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. Modulating actuator input signals can either be a 4 to 20 mAdc or a 0-10 VDC signal.

c. Floating or pulse width modulation actuators are acceptable for non-fail safe applications unless indicated otherwise provided that the floating point control (timed actuation) must have a scheduled re-calibration of span and position no more than once a day and no less than once a week. The schedule for the re-calibration should not affect occupied conditions and be staggered between equipment to prevent falsely loading or unloading central plant equipment.

[2.9.1.5 Pneumatic Actuators

Provide piston or diaphragm type actuators with replaceable diaphragm/piston.

]2.9.2 Solenoid-Operated Electric to Pneumatic Switch (EPS)

Solenoid-Operated Electric to Pneumatic Switches (EPS) must accept a voltage input to actuate its air valve. Each valve must have three-port operation: common, normally open, and normally closed. Each valve must have an outer cast aluminum body and internal parts of brass, bronze, or stainless steel. The air connection must be a 0.38 inch NPT threaded connection. Valves must be rated for 50 psig.

2.9.3 Electric to Pneumatic Transducers (EP)

Electric to Pneumatic Transducers (EPs) must convert either a 4-20 mAdc input signal, a 0-10 Vdc input signal to a proportional 0 to 20 psig pneumatic output. The EP must withstand pressures at least 150 percent of the system supply air pressure (main air). EPs must include independent offset and span adjustment. Steady state air consumption must not be greater than 0.05 scfm. EPs must have a manual adjustable override for the EP pneumatic output. EPs must have sufficient output capacity to provide full range stroke of the actuated device in both directions within [90][_____] seconds.

2.9.4 Relays

Relays must have contacts rated for the intended application, indicator light, and dust proof enclosure. The indicator light must be lit when the coil is energized and off when coil is not energized.

Control relay contacts must have utilization category and ratings selected for the application. Each set of contacts must incorporate a normally open (NO), normally closed (NC) and common contact. Relays must be rated for a minimum life of one million operations.

2.10 USER INPUT DEVICES

User Input Devices, including potentiometers, switches and momentary contact push-buttons. Potentiometers must be of the thumb wheel or sliding bar type. Momentary Contact Push-Buttons may include an adjustable timer for their output. User input devices must be labeled for their function.

2.11 MULTIFUNCTION DEVICES

Multifunction devices are products which combine the functions of multiple sensor, user input or output devices into a single product. Unless otherwise specified, the multifunction device must meet all requirements

of each component device. Where the requirements for the component devices conflict, the multifunction device must meet the most stringent of the requirements.

2.11.1 Current Sensing Relay Command Switch

The Current Sensing Relay portion must meet all requirements of the Current Sensing Relay input device. The Command Switch portion must meet all requirements of the Relay output device except that it must have at least one normally-open (NO) contact.

Current Sensing Relays used for Variable Frequency Drives must be rated for Variable Frequency applications unless installed on the source side of the drive. If used in this situation, the threshold for showing status must be set to allow for the VFD's control power when the drive is not enabled and provide indication of operation when the drive is enabled at minimum speed.

2.11.2 Space Sensor Module

Space Sensor Modules must be multifunction devices incorporating a temperature sensor and one or more of the following as specified and indicated on the Space Sensor Module Schedule:

a. A temperature indicating device.

b. A User Input Device which must adjust a temperature setpoint output.

c. A User Input Momentary Contact Button and an output to the control system indicating zone occupancy.

d. A three position User Input Switch labeled to indicate heating, cooling and off positions ('HEAT-COOL-OFF' switch) and providing corresponding outputs to the control system.

e. A two position User Input Switch labeled with 'AUTO' and 'ON' positions and providing corresponding output to the control system..

f. A multi-position User Input Switch with 'OFF' and at least two fan speed positions and providing corresponding outputs to the control system.

Space Sensor Modules cannot contain mercury (Hg).

[2.12 COMPRESSED AIR STATIONS

2.12.1 Air Compressor Assembly

Air compressors for pneumatic control systems must be the tank-mounted, electric motor driven, air cooled, reciprocating type with integral [duplex motors and compressors][single motor and compressor], tank, controller, [alternator switch,]pressure switch, belt guard[s], pressure relief valve, automatic moisture drain valve and must be supported by a steel base mounted on an air storage tank. Compressor piston speeds must not exceed 450 fpm. Provide compressors with a dry-type combination intake air filter and silencer with baked enamel steel housing. The filter must be 99 percent efficient at 10 microns. The pressure switch must start the compressor[s] at 70 psig and stop the compressor[s] at 90 psig. The relief valve must be set for 10 to 25 psig above the control

switch cut-off pressure. Provide compressor capacity suitable for not more than a [33] [50] percent run time, at full system control load. Compressors must have a combination type magnetic starter with undervoltage protection and thermal-overload protection for each phase and must automatically restart after a power outage. Motors 0.5 hp and larger must be three-phase.[

A second (duplex arrangement) compressor of capacity equal to the primary compressor must be provided, with interlocked control to provide automatic changeover upon malfunction or failure of either compressor. A manual selector switch must be provided to index the lead compressor including the automatic changeover.]

2.12.2 Compressed Air Station Specialties

2.12.2.1 Refrigerated Air Dryers

Provide each air compressor tank with a refrigerant air dryer sized for continuous operation at full delivery capacity of the compressor. The air must be dried at a pressure of not less than 70 psi to a temperature not greater than 35 degrees F and an ambient air temperature between 55 and 95 degrees F. The dryer must be provided with an automatic condensate drain trap with manual override feature with an adjustable cycle and drain time. Locate each dryer in the air piping between the tank and the pressure-reducing station. The refrigerant used in the dryer must be one of the fluorocarbon gases and have an Ozone Depletion Potential of not more than 0.05. A five micron pre-filter and coalescing-type 0.03 micron oil removal filter with shut-off valves must be provided in the dryer discharge.

2.12.2.2 Compressed Air Discharge Filters

Provide a disposable type in-line filter in the incoming pneumatic main at each pneumatic control panel. The filter must be capable of eliminating 99.99 percent of all liquid or solid contaminants 0.1 micron or larger. Provide the filter with fittings that allow easy removal/replacement. Each filter bowl must be rated for 150 psi maximum working pressure. A pressure regulator, with high side and low side pressure gauges, and a safety valve must be provided downstream of the filter.

2.12.2.3 Air Pressure-Reducing Stations

Provide air compressors with a pressure-reducing valve (PRV) with a field adjustable range of 0 to 50 psig discharge pressure, at an inlet pressure of 70 to 90 psig. Provide a factory-set pressure relief valve downstream of the PRV to relieve over-pressure. Provide a pressure gage upstream of the PRV with range of 0 to 100 psig and downstream of the PRV with range of. For two-pressure control systems, provide an additional PRV and downstream pressure gage. Pressure regulators of the relieving type must not be used.

2.12.2.4 Flexible Pipe Connections

The flexible pipe connections must be designed for 150 psi and 250 degrees F service, and must be constructed of rubber or tetrafluoroethylene resin tubing with a reinforcing protective cover of braided corrosion-resistant steel, bronze, monel, or galvanized steel. The connectors must be suitable for the service intended and must have threaded or soldered ends. The length of the connectors must be as recommended by the manufacturer for the service intended.

2.12.2.5 Vibration Isolation Units

The vibration isolation units must be standard products with published loading ratings, and must be single rubber-in-shear, double rubber-in-shear, or spring type.

2.12.3 Compressed Air Tanks

The air storage tank must be fabricated for a working pressure of not less than 200 psi and constructed and certified in accordance with ASME BPVC SEC VIII D1. The tank must be of sufficient volume so that no more than six compressor starts per hour are required with the starting pressure switch differential set at 20 psi. The tank must be provided with an automatic condensate drain trap with manual override feature. Provide drain valve and piping routing the drainage to a floor sink or other safe and visible drainage location.

]PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 General Installation Requirements

Perform the installation under the supervision of competent technicians regularly employed in the installation of DDC systems.

3.1.1.1 Device Mounting Criteria

All devices must be installed in accordance with manufacturer's recommendations and as specified and indicated. Control devices to be installed in piping and ductwork must be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements must not be used except as specified. Spare thermowells must be installed adjacent to each thermowell containing a sensor and as indicated. Devices located outdoors must have a weathershield.

3.1.1.2 Labels and Tags

Match labels and tags to the unique identifiers indicated on the As-Built drawings. Label all enclosures and instrumentation. Tag all sensors and actuators in mechanical rooms. Tag airflow measurement arrays to show flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient. Tag duct static pressure taps at the location of the pressure tap. Provide plastic or metal tags, mechanically attached directly to each device or attached by a metal chain or wire. Labels exterior to protective enclosures must be engraved plastic and mechanically attached to the enclosure or instrumentation. Labels inside protective enclosures may attached using adhesive, but must not be hand written.

3.1.2 Weathershield

Provide weathershields for sensors located outdoors. Install weathershields such that they prevent the sun from directly striking the sensor and prevent rain from directly striking or dripping onto the sensor. Install weather shields with adequate ventilation so that the

sensing element responds to the ambient conditions of the surroundings. When installing weathershields near outside air intake ducts, install them such that normal outside air flow does not cause rainwater to strike the sensor.

3.1.3 Room Instrument Mounting

Mount room instruments, including but not limited to wall mounted non-adjustable space sensor modules and sensors located in occupied spaces, [60][48] inches above the floor unless otherwise indicated. Install adjustable devices to be ADA compliant unless otherwise indicated on the Room Sensor Schedule:

a. Space Sensor Modules for Fan Coil Units may be either unit or wall mounted but not mounted on an exterior wall.

b. Wall mount all other Space Sensor Modules.

3.1.4 Indication Devices Installed in Piping and Liquid Systems

Provide snubbers for gauges in piping systems subject to pulsation. For gauges for steam service use pigtail fittings with cock. Install thermometers and temperature sensing elements in liquid systems in thermowells. Provide spare Pressure/Temperature Ports (Pete's Plug) for all temperature and pressure sensing elements installed in liquid systems for calibration/testing.

3.1.5 Occupancy Sensors

Provide a sufficient quantity of occupancy sensors to provide complete coverage of the area (room or space). Occupancy sensors are to be ceiling mounted. Install occupancy sensors in accordance with NFPA 70 requirements and the manufacturer's instructions. Do not locate occupancy sensors within 6 feet of HVAC outlets or heating ducts, or where they can "see" beyond any doorway. Installation above doorway(s) is preferred. Do not use ultrasonic sensors in spaces containing ceiling fans. Install sensors to detect motion to within 2 feet of all room entrances and to not trigger due to motion outside the room. Set the off-delay timer to [15][_____] minutes unless otherwise indicated. Adjust sensors prior to beneficial occupancy, but after installation of furniture systems, shelving, partitions, etc. For each controlled area, provide one hundred percent coverage capable of detecting small hand-motion movements, accommodating all occupancy habits of single or multiple occupants at any location within the controlled room.

3.1.6 Switches

3.1.6.1 Temperature Limit Switch

Provide a temperature limit switch (freezestat) to sense the temperature at the location indicated. Provide a sufficient number of temperature limit switches (freezestats) to provide complete coverage of the duct section but no less than 1 foot in length per square foot of cross sectional area. Install manual reset limit switches in approved, accessible locations where they can be reset easily. Install temperature limit switch (freezestat) sensing elements in a side-to-side (not top-to-bottom) serpentine pattern with the relay section at the highest point and in accordance with the manufacturer's installation instructions.

3.1.6.2 Hand-Off Auto Switches

Wire safety controls such as smoke detectors and freeze protection thermostats to protect the equipment during both hand and auto operation.

3.1.7 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 and install sensors according to manufacturer’s instructions. Select sensors only for intended application as designated or recommended by manufacturer.

3.1.7.1 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 all user-adjustable sensors [5 feet above the finished floor][48 inches above the floor to meet ADA requirements][at the height[s] indicated]. Non user-adjustable sensors can be mounted as indicated in paragraph ROOM INSTRUMENT MOUNTING.

3.1.7.2 Duct Temperature Sensors

3.1.7.2.1 Probe Type

Place tip of the sensor in the middle of the airstream or in accordance with manufacturer's recommendations or instructions.Provide a gasket between the sensor housing and the duct wall. Seal the duct penetration air tight. When installed in insulated duct, provide enclosure or stand off fitting to accommodate the thickness of duct insulation to allow for maintenance or replacement of the sensor and wiring terminations. Seal the duct insulation penetration vapor tight.

3.1.7.2.2 Averaging Type

Weave the sensing element in a serpentine fashion from side to side perpendicular to the flow, across the duct or air handler cross-section, using durable non-metal supports in accordance with manufacturer's installation instructions. Avoid tight radius bends or kinking of the sensing element. Prevent contact between the sensing element and the duct or air handler internals. Provide a duct access door at the sensor location. The access door must 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 must be fully accessible through the air handler's access doors without removing any of the air handler's internals.

3.1.7.3 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. When installed on insulated piping, provide stand enclosure or stand off fitting to accommodate the thickness of the pipe insulation and allow for maintenance or replacement of the sensor or wiring terminations. 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 must not restrict flow area to

less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide the sensor well with a heat-sensitive transfer agent between the sensor and the well interior ensuring contact between the sensor and the well.

3.1.7.4 Outside Air Temperature Sensors

Provide outside air temperature sensors on the building's north side with a protective weather shade that does not inhibit free air flow across the sensing element, and protects the sensor from snow, ice, and rain. Location must not be near exhaust hoods and other areas such that it is not influenced by radiation or convection sources which may affect the reading. Provide a shield to shade the sensor from direct sunlight.

3.1.8 Air Flow Measurement Arrays (AFMA)

Locate Outside Air AFMAs downstream from the Outside Air filters.

Install AFMAs with the manufacturer's recommended minimum distances between upstream and downstream disturbances. Airflow straighteners may be used to reduce minimum distances as recommended by the AFMA manufacturer.

3.1.9 Duct Static Pressure Sensors

Locate the duct static pressure sensing tap at 75 percent of the distance between the first and last air terminal units [as indicated on the design documents]. If the transmitter output is a 0-10Vdc signal, locate the transmitter in the same enclosure as the air handling unit (AHU) controller for the AHU serving the terminal units. If a remote duct static pressure sensor is to be used, run the signal wire back to the controller for the air handling unit.

3.1.10 Relative Humidity Sensors

Install relative humidity sensors in supply air ducts at least 10 feet downstream of humidity injection elements.

3.1.11 Meters

3.1.11.1 Flowmeters

Install flowmeters to ensure minimum straight unobstructed piping for at least 10 pipe diameters upstream and at least 5 pipe diameters downstream of the flowmeter, and in accordance with the manufacturer's installation instructions.

3.1.11.2 Energy Meters

Locate energy meters as indicated. Connect each meter output to the DDC system, to measure both instantaneous demand/energy and other variables as indicated.

3.1.12 Dampers

3.1.12.1 Damper Actuators

Provide spring return actuators which fail to a position that protects the served equipment and space on all control dampers related to freeze

protection or force protection. For all outside, makeup and relief dampers provide dampers which fail closed. Terminal fan coil units, terminal VAV units, convectors, and unit heaters nay be non-spring return unless indicated otherwise. Do not mount actuators in the air stream. Do not connect multiple actuators to a common drive shaft. Install actuators so that their action seal the damper to the extent required to maintain leakage at or below the specified rate and so that they move the blades smoothly throughout the full range of motion.

3.1.12.2 Damper Installation

Install dampers straight and true, level in all planes, and square in all dimensions. Dampers must move freely without undue stress due to twisting, racking (parallelogramming), bowing, or other installation error. External linkages must operate smoothly over the entire range of motion, without deformation or slipping of any connecting rods, joints or brackets that will prevent a return to it's normal position. Blades must close completely and leakage must not exceed that specified at the rated static pressure. Provide structural support for multi-section dampers. Acceptable methods of structural support include but are not limited to U-channel, angle iron, corner angles and bolts, bent galvanized steel stiffeners, sleeve attachments, braces, and building structure. Where multi-section dampers are installed in ducts or sleeves, they must not sag due to lack of support. Do not use jackshafts to link more than three damper sections. Do not use blade to blade linkages. Install outside and return air dampers such that their blades direct their respective air streams towards each other to provide for maximum mixing of air streams.

3.1.13 Valves

Install the valves in accordance with the manufacturer's instructions.

3.1.13.1 Valve Actuators

Provide spring return actuators on all control valves where freeze protection is required. Spring return actuators for terminal fan coil units, terminal VAV units, convectors, and unit heaters are not required unless indicated otherwise.

3.1.14 Thermometers and Gauges

[3.1.14.1 Local Gauges for Actuators

Provide a pressure gauge at each pneumatic control input and output. Pneumatic actuators must have an accessible and visible pressure gauge installed in the tubing lines at the actuator as indicated.

]3.1.14.2 Thermometers

Mount devices to allow reading while standing on the floor or ground, as applicable.

3.1.15 Wire and Cable

Provide complete electrical wiring for the Control System, including wiring to transformer primaries. Wire and Cable must be installed without splices between control devices and in accordance with NFPA 70 and NFPA 90A. Instrumentation grounding must be installed per the device manufacturer's instructions and as necessary to prevent ground loops, noise, and surges

from adversely affecting operation of the system. Test installed ground rods as specified in IEEE 142. Cables and conductor wires must be tagged at both ends, with the identifier indicated on the shop drawings. Electrical work must be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as indicated. Wiring external to enclosures must be run in raceways[, except low-voltage control and low-voltage network wiring may be installed as follows:

a. plenum rated cable in suspended ceilings over occupied spaces may be run without raceways

b. nonmetallic-sheathed cables or metallic-armored cables may be installed as permitted by NFPA 70.]

Install control circuit wiring not in raceways in a neat and safe manner. Wiring must not use the suspended ceiling system (including tiles, frames or hangers) for support. Where conduit or raceways are required, control circuit wiring must not run in the same conduit/raceway as power wiring over 50 volts. Run all circuits over 50 volts in conduit, metallic tubing, covered metal raceways, or armored cable.

3.1.16 Copper Tubing

Provide hard-drawn copper tubing in exposed areas and either hard-drawn or annealed copper tubing in concealed areas. Use only tool-made bends. Use only brass or copper solder joint type fittings, except for connections to apparatus. For connections to apparatus use brass compression type fittings.

3.1.17 Plastic Tubing

Install plastic tubing within covered raceways or conduit except when otherwise specified. Do not use plastic tubing for applications where the tubing could be subjected to a temperature exceeding 130 degrees F. For fittings, use brass or acetal resin of the compression or barbed push-on type for instrument service. Except in walls and exposed locations, plastic multitube instrument tubing bundle without conduit or raceway protection may be used where a number of air lines run to the same points, provided the multitube bundle is enclosed in a protective sheath, is run parallel to the building lines and is adequately supported as specified.

[3.1.18 Pneumatic Lines

Run tubing concealed in finished areas, run tubing exposed in unfinished areas like mechanical rooms. 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. With the compressor turned off, test each tubing system pneumatically at 1.5 times the working pressure and prove it air tight, locating and correcting leaks as applicable. Caulking joints is not permitted. Do not run tubing and electrical power conductors in the same conduit.

a. Install pneumatic lines must such that they are not exposed to outside air temperatures. Conceal pneumatic lines except in mechanical rooms and other areas where other tubing and piping is exposed.

b. Install all tubes and tube bundles exposed to view in lines parallel to the lines of the building. Route tubing in mechanical/electrical so that the lines are easily traceable.

c. Purge air lines of dirt, impurities and moisture before connecting to the control equipment. Number-code or color-code air lines and key the coding in the As-Built Drawings for future identification and servicing the control system.

3.1.18.1 Pneumatic Lines In Mechanical/Electrical Spaces

In mechanical/electrical spaces, use plastic or copper tubing for pneumatic lines. Install horizontal and vertical runs of plastic tubing or soft copper tubing min raceways or rigid conduit dedicated to tubing. Support dedicated raceways, conduit, and hard copper tubing not installed in raceways every 6 feet for horizontal runs and every 8 feet for vertical runs.

3.1.18.2 Pneumatic Lines External to Mechanical/Electrical Spaces

External to mechanical/electrical spaces, use plastic tubing in raceways not containing power wiring or copper tubing with sweat fittings. Support raceways and tubing not in raceways every 8 feet. For pneumatic lines concealed in walls use hard-drawn copper tubing or plastic tubing in rigid conduit. Plastic tubing in a protective sheath, run parallel to the building lines and supported as specified, may be used above accessible ceilings and in other concealed but accessible locations.

3.1.18.3 Terminal Single Lines

For terminal single lines use hard-drawn copper tubing, except when the run is less than 12 inches in length, flexible polyethylene may be used.

3.1.18.4 Connection to Liquid and Steam Lines

Use [copper][Series 300 stainless steel] with [brass compression][stainless-steel compression] fittings for connection of sensing elements and transmitters to liquid and steam lines.

3.1.18.5 Connection to Ductwork

Use plastic tubing for connections to sensing elements in ductwork.

3.1.18.6 Tubing in Concrete

Install tubing in concrete in rigid conduit. Install tubing in walls containing insulation, fill, or other packing materials in raceways dedicated to tubing.

3.1.18.7 Tubing Connection to Actuators

For final connections to actuators use plastic tubing no more than 12 inches long and unsupported at the actuator.

]3.1.19 Compressed Air Stations

Mount the air compressor assembly on vibration eliminators, in accordance with ASME BPVC SEC VIII D1 for tank clearance. Connect the air line to the tank with a flexible pipe connector. Provide compressed air station specialties with required tubing, including condensate tubing to a floor drain. Compressed air stations must deliver control air meeting the requirements of ISA 7.0.01. Provide foundations and housekeeping pads for

the HVAC control system air compressors [in accordance with the air compressor manufacturer's instructions][as specified in Section 23 30 00 HVAC AIR DISTRIBUTION].

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SECTION 23 09 23.01

LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS
02/19, CHG 1: 02/20

PART 1 GENERAL

1.1 SUMMARY

Provide a complete Direct Digital Control (DDC) system, except for the Front End which is specified in Section 25 10 10 UTILITY MONITORING AND CONTROL (UMCS) FRONT END AND INTEGRATION, suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and shown and in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.1.1 System Requirements

Provide a system meeting the requirements of both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section and with the following characteristics:

a. The control system must be an open implementation of LonWorks technology using CEA-709.1-D as the communications protocol. The system must use LonMark Standard Network Variable Types as defined in LonMark SNVT List exclusively for communication over the network.

   The control system must be an open implementation of LonWorks technology using CEA-709.1-D and Fox as the communications protocols. Except for communication between Niagara Framework components (between Niagara Framework Supervisory Gateways or between a Niagara Framework Supervisory Gateway and a Niagara Framework Front End) which must use the Fox Protocol, the system must use LonMark Standard Network Variable Types as defined in LonMark SNVT List exclusively for communication over the network.

b. Use LonWorks Network Services (LNS) for all network management including addressing and binding of network variables. As specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC, submit copies of the complete, fully-commissioned, valid, as-built Final LNS database, including all LNS credits, for the complete control system provided under this specification. All devices must be on-line and commissioned into the LNS database.

   Use the Niagara Framework for all network management including addressing and binding of network variables. Each Niagara Framework Supervisory Gateway must contain a database for all controllers connected to its non-IP ports.

c. Install and configure control hardware, except as specified for Niagara Framework Supervisory Gateways, to provide all input and output Standard Network Variables (SNVTs) as indicated and as needed to meet the requirements of this specification. Points in Niagara Framework Supervisory Gateways which do not communicate with non-Niagara Framework DDC Hardware may be exposed via Fox instead.

d. All DDC hardware installed under this specification must communicate via CEA-709.1-D, and Niagara Framework Supervisory Gateways must also communicate over the IP network via Fox. Install the control system such that a SNVT output from any node on the network can be bound to any other node in the same domain.

e. Use Niagara Framework hardware and software exclusively for alarming, scheduling, trending, and communication with a front end (UMCS). Use the Fox protocol for all communication between Niagara Framework Supervisory Gateways; use the CEA-709.1-D protocol for all other building communication. [Niagara Framework Supervisory Gateway must serve web pages as specified.]

f. Use Niagara Framework [AX][Version 4.0 or later][either AX or Version 4.0 or later].

1.1.2 Verification of Specification Requirements

Review all specifications related to the control system installation and advise the Contracting Officer of any discrepancies before performing any work. If Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC or any other Section referenced in this specification is not included in the project specifications advise the Contracting Officer and either obtain the missing Section or obtain Contracting Officer approval before performing any 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.

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1-D	(2014) Control Network Protocol Specification
CEA-709.3	(1999; R 2015) Free-Topology Twisted-Pair Channel Specification
CEA-852-C	(2014) Tunneling Device Area Network Protocols Over Internet Protocol Channels

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 802.3	(2018) Ethernet

INTERNET ENGINEERING TASK FORCE (IETF)

IETF RFC 4361	(2006) Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)
IETF RFC 7465	(2015) Prohibiting RC4 Cipher Suites

LONMARK INTERNATIONAL (LonMark)

LonMark Interoperability Guide	(2005) LonMark Application-Layer

	Interoperability Guide and LonMark Layer 1-6 Interoperability Guide; Version 3.4
LonMark SCPT List	(2014) LonMark SCPT Master List; Version 15
LonMark SNVT List	(2014) LonMark SNVT Master List; Version 15
LonMark XIF Guide	(2001) LonMark External Interface File Reference Guide; Revision 4.402

TRIDIUM, INC (TRIDIUM)

Niagara Framework	(2012) NiagaraAX User's Guide
Tridium Open NiCS	(2005) Understanding the NiagaraAX Compatibility Statement (NiCS)

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 916	(2015) Standard for Energy Management Equipment

1.3 DEFINITIONS

For definitions related to this section, see Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.4 SUBMITTALS

Submittals related to this Section are specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

PART 2 PRODUCTS

All products used to meet this specification must meet the specified requirements, but not all products specified here will be required by every project. Provide products which meet the requirements of both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section.

2.1 NETWORK HARDWARE

2.1.1 CEA-709.1-D Routers

CEA-709.1-D Routers must meet the requirements of CEA-709.1-D and must provide connection between two or more CEA-709.3 TP/FT-10 channels, or between one or more CEA-709.3 TP/FT-10 channels and a LonMark Interoperability Guide TP/XF-1250 channel.

2.1.2 CEA-709.1-D Repeaters

CEA-709.1-D Repeaters must be CEA-709.1-D Routers configured as repeaters. Physical layer repeaters are prohibited.

2.1.3 CEA-709.1-D Gateways

In addition to the requirements for DDC Hardware, CEA-709.1-D gateways must be a Niagara Framework Supervisory Gateway or must:

a. Allow bi-directional mapping of data between the non-CEA-709.1-D protocol and SNVTs

b. Incorporate a network connection to a TP/FT-10 network in accordance with CEA-709.3 and a separate connection appropriate for the a non-CEA-709.1-D network

Although Gateways must meet DDC Hardware requirements, except for Niagara Framework Supervisory Gateways, they are not DDC Hardware and must not be used when DDC Hardware is required. (Niagara Framework Supervisory Gateways are both Gateways and DDC Hardware.)

2.1.4 CEA-852-C Router

CEA-852-C Routers must perform layer 3 routing of CEA-709.1-D packets over an IP network in accordance with CEA-852-C. The router must provide the appropriate connection to the IP network and connections to the CEA-709.3 TP/FT-10 or LonMark Interoperability Guide TP/XF-1250 network. CEA-852-C Routers must support the Dynamic Host Configuration Protocol (DHCP; IETF RFC 4361 for IP configuration and the use of an CEA-852-C Configuration Server (for CEA-852-C configuration), but must not rely on these services for configuration. CEA-852-C Routers must be capable of manual configuration via a console RS-232 or USB port.

2.1.5 Ethernet Switch

Ethernet Switches [must be managed switches and]must autoconfigure between 10,100 and 1000 megabits per second (MBPS).

2.2 CONTROL NETWORK WIRING

a. Provide TP/FT-10 control wiring in accordance with CEA-709.3.

b. Provide TP/XF-1250 control wiring in accordance with the LonMark Interoperability Guide.

c. For the Building Control Network IP Network provide media that is CAT-5e Ethernet media at a minimum and meets all requirements of IEEE 802.3 [and [_____]].

2.3 DIRECT DIGITAL CONTROL (DDC) HARDWARE

All DDC Hardware must meet the following general requirements:

a. Except for Niagara Framework Supervisory Gateways, it It must incorporate a "service pin" which, when pressed will cause the DDC Hardware to broadcast its 48-bit NodeID and its ProgramID over the network. The service pin must be distinguishable and accessible.

b. It must incorporate a light to indicate the device is receiving power.

c. Except for Niagara Framework Supervisory Gateways, it must It must incorporate a TP/FT-10 transceiver in accordance with CEA-709.3 and connections for TP/FT-10 control network wiring. Niagara Framework

Supervisory Gateways must incorporate an IP connection and at least one other transceiver. These other transceivers must be either a TP/FT-10 transceiver in accordance with CEA-709.3 or a TP/XF-1250 transceiver in accordance with LonMark Interoperability Guide. Niagara Framework Supervisory gateways must have connection of the appropriate type for each transceiver.

d. It must communicate on the network using only the CEA-709.1-D protocol or the Fox protocol.

e. It must be capable of having network communications configured via LNS the Niagara Framework.

f. It must be locally powered; link powered devices are not acceptable.

g. LonMark external interface files (XIF files), as defined in the LonMark XIF Guide, must be submitted for each type of DDC Hardware except Niagara Framework Supervisory Gateways.

h. Application programs and configuration settings must be stored in a manner such that a loss of power does not result in a loss of the application program or configuration settings:

(1) Loss of power must never result in the loss of application programs, regardless of the length of time power is lost.

(2) Loss of power for less than 2,500 hours must not result in the loss of configured settings.

i. It must have all functionality specified and required to support the application (Sequence of Operation or portion thereof) in which it is used, including but not limited to:

(1) It must provide input and output SNVTs or Niagara Framework Points as specified, as indicated on the Points Schedule, and as otherwise required to support the sequence and application in which it is used. All SNVTs and Niagara Framework Points must have meaningful names identifying the value represented by the SNVT or Niagara Framework Points . Unless a standard network variable type of an appropriate engineering type is not available, all network variables must be of a standard network variable type with engineering units appropriate to the value the variable represents.

(2) All settings and parameters used by the application in which the DDC hardware is used must be configurable via one of the following: standard configuration properties (SCPTs) as defined in the LonMark SCPT List, user-defined configuration properties (UCPTs), network configuration inputs (*nci*s) of a SNVT type as defined in the LonMark SNVT List, network configuration inputs (*nci* s) of a user defined network variable type, or hardware settings on the controller itself. Niagara Framework Supervisory Gateways may instead be configurable via the Niagara Framework.

j. It must meet FCC Part 15 requirements and have UL 916 or equivalent safety listing.

k. In addition to these general requirements and the DDC Hardware Input-Output (I/O) Function requirements, all DDC Hardware

must also meet the requirements of a Niagara Framework Supervisory Gateway, a Local Display Panel (LDP), Application Specific Controller (ASC), General Purpose Programmable Controller (GPPC), or an Application Generic Controller (AGC). All pieces of DDC Hardware must have their DDC Hardware Type identified as part of the Manufacturer's Product Data submittal as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Except for Local Display Panels provided as part of another controller, where a single device meets the requirements of multiple types, select a single type for that specific device based on it's use. Where a Local Display Panel is provided as part of another device, indicate both the controller type and local display panel. One model of DDC hardware may be submitted as different DDC Hardware types when used in multiple applications.

l. The user interface on all DDC Hardware with a user interface which allows for modification of a value must be password protected.

m. Clocks in DDC Hardware incorporating a Clock must continue to function for 120 hours upon loss of power to the DDC Hardware.

2.3.1 Hardware Input-Output (I/O) Functions

DDC Hardware incorporating hardware input-output (I/O) functions must meet the following requirements:

2.3.1.1 Analog Inputs

DDC Hardware analog inputs (AIs) must perform analog to digital (A-to-D) conversion with a minimum resolution of 8 bits plus sign or better as needed to meet the accuracy requirements specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Signal conditioning including transient rejection must be provided for each analog input. Analog inputs must be capable of being individually calibrated for zero and span. Calibration via software scaling performed as part of point configuration is acceptable. The AI must incorporate common mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10,000 ohms.

2.3.1.2 Analog Outputs

DDC Hardware analog outputs (AOs) must perform digital to analog (D-to-A) conversion with a minimum resolution of 8 bits plus sign, and output a signal with a range of 4-20 mAdc or 0-10 Vdc. Analog outputs must be capable of being individually calibrated for zero and span. Calibration via software scaling performed as part of point configuration is acceptable. DDC Hardware with Hand-Off-Auto (H-O-A) switches for analog outputs must provide for overriding the output [to 0 percent and to 100 percent][through the range of 0 percent to 100 percent]

2.3.1.3 Binary Inputs

DDC Hardware binary inputs (BIs) must accept contact closures and must ignore transients of less than 5 milli-second duration. Protection against a transient of 50 Vac must be provided.

2.3.1.4 Binary Outputs

DDC Hardware binary outputs (BOs) must provide relay contact closures or

triac outputs for momentary and maintained operation of output devices. DDC Hardware with H-O-A switches for binary outputs must provide for overriding the output open or closed.

2.3.1.4.1 Relay Contact Closures

Closures must have a minimum duration of 0.1 second. Relays must provide at least 180V of isolation. Electromagnetic interference suppression must be provided on all output lines to limit transients to 50 Vac. Minimum contact rating must be 0.5 amperes at 24 Vac.

2.3.1.4.2 Triac Outputs

Triac outputs must provide at least 180 V of isolation. Minimum contact rating must be 0.5 amperes at 24 Vac.

2.3.1.5 Pulse Accumulator

DDC Hardware pulse accumulators must have the same characteristics as the BI. In addition, a buffer must be provided to totalize pulses. The pulse accumulator must accept rates of at least 20 pulses per second. The totalized value must be resettable via a configurable parameter.

[2.3.1.6 Integrated H-O-A Switches

Where integrated H-O-A switches are provided on hardware outputs, controller must provide means of monitoring position or status of H-O-A switch. This feedback may be provided via the Niagara Framework or via network variable.

]2.3.2 Local Display Panel (LDP)

The Local Display Panels (LDPs) must be DDC Hardware with a display and navigation buttons or a touch screen display, and must provide display and adjustment of Niagara Framework points or network variables as indicated on the Points Schedule and as specified. LDPs must be provided as stand-alone DDC Hardware or as an integral part of another piece of DDC Hardware. LDPs must come factory installed with all applications necessary for the device to function as an LDP.

The adjustment of values using display and navigation buttons must be password protected.

2.3.3 Application Specific Controller (ASC)

Application Specific Controllers (ASCs) have a fixed factory-installed application program (i.e. ProgramID) with configurable settings and do not have the ability to be programmed for custom applications. ASCs must meet the following requirements in addition to the General DDC Hardware and DDC Hardware Input-Output (I/O) Function requirements:

a. ASCs must be LonMark Certified.

b. Unless otherwise approved, all necessary Configuration Properties and network configuration inputs (*nci*s) for the sequence and application in which the ASC is used must be fully configurable through the Niagara Framework. Application Specific Controller configurable via a Niagara Framework Wizard is preferred. Wizards must be submitted for each type (manufacturer and model) of Application Specific Controller

which has a Wizard available for configuration. Wizards distributed under a license must be licensed to the project site. (Note: configuration accomplished via hardware settings does not require configuration via Niagara Framework Wizard.)

Unless otherwise approved, all necessary Configuration Properties and network configuration inputs (*nci*s) for the sequence and application in which the ASC is used must be fully configurable through an LNS plug-in. LNS Plug-ins must be submitted for each type (manufacturer and model) of Application Specific Controller. LNS Plug-ins distributed under a license must be licensed to the project site. (Note: configuration accomplished via hardware settings does not require configuration via plug-in)

c. ASCs may include an integral or tethered Local Display Panel

2.3.4 General Purpose Programmable Controller (GPPC)

A General Purpose Programmable Controller (GPPC) must be programmed for the application. GPPCs must meet the following requirements in addition to the general DDC Hardware requirements and Hardware Input-Output (I/O) Functions:

a. The programmed GPPC must conform to the LonMark Interoperability Guide.

b. All programming software required to program the GPPC must be delivered to and licensed to the project site in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Submit the most recent version of the Programming software for each type (manufacturer and model) of General Purpose Programmable Controller (GPPC).

c. Submit copies of the installed GPPC application programs (all software that is not common to every controller of the same manufacturer and model) as source code compatible with the supplied programming software in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. The submitted GPPC application program must be the complete application necessary for the GPPC to function as installed and be sufficient to allow replacement of the installed controller with a GPPC of the same type.

d. GPPCs may be include an integral or tethered Local Display Panel

2.3.5 Application Generic Controller (AGC)

An Application Generic Controller (AGC) has a fixed application program which includes the ability to be programmed for custom applications. AGCs must meet the following requirements in addition to the general DDC Hardware requirements and Hardware Input-Output (I/O) Functions:

a. The programmed AGC must conform to the LonMark Interoperability Guide.

b. The AGC must have a fixed ProgramID and fixed XIF file.

c. Unless otherwise approved, the ACG must be fully configurable and programmable for the application using one or more LNS plug-ins Niagara Framework Wizards, all of which must be submitted as specified for each type of AGC (manufacturer and model).

d. Submit copies of the installed AGC application programs as source code compatible with the supplied LNS plug-in Niagara Framework Wizard used for programming the device in accordance with Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. The submitted AGC application program must be the complete application program necessary for the AGC to function as installed and be sufficient to allow replacement of the installed controller with an AGC of the same type.

e. AGCs may be include an integral or tethered Local Display Panel

2.3.6 Niagara Framework Supervisory Gateway

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 Comparability 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) One 10/100 Mbps Ethernet Port

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 this project; see requirements in PART 3, EXECUTION of this Section.

g. Submit a backup of each Niagara Framework Supervisory Gateway as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. 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.

2.4 NIAGARA FRAMEWORK ENGINEERING TOOL

The Niagara Framework Engineering Tool must be Niagara Workbench or an equivalent Niagara Framework engineering tool software 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.

Monitoring and Control Software is specified in Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION.

PART 3 EXECUTION

3.1 CONTROL SYSTEM INSTALLATION

3.1.1 Niagara Framework Engineering Tool

[The project site currently has the [_____] Niagara Framework Engineering Tool. If this software is not adequate for programming the Niagara Framework Supervisory Gateways provided under this project, provide a Niagara Framework Engineering Tool as specified.][Provide a Niagara Framework Engineering Tool as specified.]

3.1.2 Building Control Network (BCN)

Provide a Building Control Network (BCN) connecting all DDC hardware as specified. The Building Control Network (BCN) must consist of an IP Network, one or more Niagara Framework Supervisory Gateways CEA-852-C Routers, and one or more Non-IP Building Control Network Channels:

3.1.2.1 Building Control Network (BCN) Installation

Provide building control networks meeting the following requirements:

a. Provide a Building Control Network IP Network, Non-IP Building Control Network Channels and Niagara Framework Supervisory Gateways CEA-852-C Routers to a create a single building control network connecting all DDC Hardware.

b. In addition to the connection to the Niagara Framework Supervisory Gateway CEA-852-C Router, each Non-IP Building Control Network (BCN) Channel directly connected to a Niagara Framework Supervisory Gateway CEA-852-C Router must be directly connected to either DDC Hardware or to CEA-709.1-D Routers, but not to both. A channel containing only CEA-709.1-D Routers is a backbone channel and a channel containing DDC Hardware is a non-backbone channel.

c. When only a single Niagara Framework Supervisory Gateway CEA-852-C Router is required, the IP network consists of only the Niagara Framework Supervisory Gateway CEA-852-C Router. When multiple Niagara Framework Supervisory Gateways CEA-852-C Routers are required, provide an IP Network connecting all Niagara Framework Supervisory Gateways CEA-852-C Routers.

d. Connect all DDC Hardware other than Niagara Framework Supervisory Gateways to a non-backbone BCN Channel. Connect all Niagara Framework Supervisory Gateways to the Building Control Network (BCN) IP Network.

e. Install components such that there is no more than than one CEA-709.1-D Router between any DDC Hardware and a Niagara Framework Supervisory Gateway CEA-852-C Router

f. Install the network such that the peak expected bandwidth usage for each and every channel is less than 70 percent, including device-to-device traffic and traffic to the Utility Monitoring and Control System (UMCS) as indicated on the Points Schedule.

g. Where multiple pieces of DDC Hardware are used in the execution of a single sequence of operation, directly connect all DDC Hardware used to execute the sequence to the same channel and do not install other DDC Hardware, other than a Niagara Framework Supervisory Gateway, to that channel.

3.1.2.2 Non-IP Building Control Network (BCN) Channel

Provide Non-IP Building Control Network (BCN) Channels meeting the following requirements:

a. For each non-backbone channel, provide a TP/FT-10 channel in doubly terminated bus topology in accordance with CEA-709.3. For each backbone channel, provide either a TP/FT-10 channel in doubly terminated bus topology in accordance with CEA-709.3 or a TP/XF-1250 channel in accordance with the LonMark Interoperability Guide.

b. Connect no more than 2/3 the maximum number of devices permitted by CEA-709.3 to each TP/FT-10 channel. Connect no more than 2/3 the maximum number of devices permitted by LonMark Interoperability Guide to TP/XF-1250 channel.

c. Connect no more than 2/3 the maximum number of devices permitted by the manufacturer of the device transceivers to each channel. When more than one type of transceiver is used on the same channel, use the transceiver with the lowest maximum number of devices to calculate the 2/3 limit.

3.1.2.3 Building Control Network (BCN) IP Network

Install IP Network Cabling in conduit. Install Ethernet Switches in lockable enclosures. Install the Building Control Network (BCN) IP Network so that it is available at the Facility Point of Connection (FPOC) location [as specified][_____]. When the FPOC location is a room number, provide sufficient additional media to ensure that the Building Control Network (BCN) IP Network can be extended to any location in the room.

3.1.3 DDC Hardware

Install Niagara Framework Supervisory Gateways CEA-852-C Routers in lockable enclosures. Install other DDC Hardware which is not is suspended ceilings in [lockable]enclosures.

Configure and commission all DDC Hardware on the Building Control Network via the Niagara Frameworkvia LNS using an LNS-based Network Configuration Tool. Use Application Specific Controllers whenever an Application Specific Controller suitable for the application exists. When an Application Specific Controller suitable for the application does not exist use a Niagara Framework Supervisory Gateway [or [Application Generic Controllers, General Purpose Programmable Controllers or multiple Application Specific Controllers][Application Generic Controllers or General Purpose Programmable Controllers][multiple Application Specific Controllers]].

3.1.3.1 Hand-Off-Auto (H-O-A) Switches

Provide Hand-Off-Auto (H-O-A) switches [for all DDC Hardware analog outputs and binary outputs used for control of systems other than terminal units,]as specified and as indicated on the Points Schedule. H-O-A switches must be integral to the controller hardware, an external device co-located with (in the same enclosure as) the controller, integral to the controlled equipment, or an external device co-located with (in the same enclosure as) the controlled equipment.

a. For H-O-A switches integral to DDC Hardware, meet the requirements specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE.

b. For external H-O-A switches for binary outputs, provide switches capable of overriding the output open or closed.

c. For external H-O-A switches for analog outputs, provide switches capable of overriding [to 0 percent or 100 percent][through the range of 0 percent to 100 percent].

3.1.3.2 Local Display Panels

Provide LDPs to display and override values of points in a Niagara Framework Supervisory Gateway or Network Variables as indicated on the Points Schedule. Install LDPs displaying points for anything other than a terminal unit in the same room as the equipment. Install LDPs displaying points for only terminal units [in a mechanical room central to the group of terminal units it serves][_____].

[3.1.3.3 Graphics and Web Pages

Configure Niagara Framework Supervisory Gateways to use web pages to

provide a graphical user interface including System Displays[using the project site sample displays], including overrides, as indicated on the Points Schedule and as specified. Label all points on displays with [full English language descriptions][the point name as indicated on the Points Schedule][the point description as indicated on the Points Schedule][_____]. Configure user permissions for access to and executions of action using graphic pages. Coordinate user permissions with [the [Controls] [HVAC] [Electrical] shop supervisor][_____]. Configure the web server to use HTTPS based on the Transport Layer Security (TLS) protocol in accordance with IETF RFC 7465 using a Government furnished certificate.

]3.1.3.4 Overrides for GPPCs and AGCs

Provide the capability to override points for all General Purpose Programmable Controllers and Application Generic Controllers as specified and as indicated on the Points Schedule using one of the following methods:

a. Override SNVT of Same SNVT Type method:

(1) Use this method for all setpoint overrides and for overrides of inputs and outputs whenever practical.

(2) Provide a SNVT input to the DDC hardware containing the point to be overridden of the same SNVT type as the point to be overridden.

(3) Program and configure the DDC hardware such that:

(a) If the value of the SNVT on the override input is the *Invalid Value* defined for that SNVT by the LonMark SNVT List, then the point is not overridden (its value is determined from the sequence).

(b) If the value of the SNVT on the override input is not the *Invalid Value* defined for that SNVT by the LonMark SNVT List then set the value of the point to be overridden to the value of the SNVT on the override input.

b. HVAC Override SNVT method:

(1) Use this method for override of inputs and outputs when the "Override SNVT Shares SNVT Type" method is impractical.

(2) Provide a SNVT input to the DDC hardware containing the point to be overridden of SNVT type *SNVT hvac overid*. Show on the Points Schedule how to perform the specified override using this SNVT.

3.1.3.5 Overrides for ASCs

Whenever possible use the methods specified for General Purpose Programmable Controllers and Application Generic Controllers to perform overrides for all Application Specific Controllers. If neither the "Override SNVT of Same SNVT Type" method or "HVAC Override SNVT" method are supported by the Application Specific Controller show this on the Points Schedule and perform overrides as follows:

a. Provide one or more SNVT input(s) to the DDC hardware containing the point to be overridden. Document the number and type of each SNVT provided on the Points Schedule.

b. Configure the Application Specific Controller such that:

(1) For some specific combination or combinations of values at the SNVT override input(s) the point is not overridden, and its value is determined from the sequence as usual. Show on the Points Schedule the values required at the SNVT override input(s) to not override the point.

(2) For other specific combinations of SNVT override input(s), the value of the point to be overridden is determined from the value of the override input(s). Show on the Points Schedule the correlation between the SNVT override input(s) and the resulting value of the overridden point.

3.1.4 Scheduling, Alarming, Trending and Overrides

3.1.4.1 Scheduling

Configure schedules in Niagara Framework Supervisory Gateway using Niagara Schedule Objects as indicated on the Points Schedule and as specified. When the schedule is controlling occupancy modes in DDC Hardware other than a Niagara Framework Supervisory Gateway use a network variable of type SNVT_Occupancy.
Provide DDC Hardware with LonMark Objects meeting the Simple Scheduler Functional Profile and configure schedules as specified on the Points Schedule and as specified.

3.1.4.1.1 Schedule Groupings

Provide a separate schedule for each AHU including it's associated Terminal Units and for each stand-alone Terminal Unit (those not dependent upon AHU service)[or group of stand-alone Terminal Units acting according to a common schedule[as indicated]].

3.1.4.1.2 Occupancy Mode Mapping to SNVT Values

Use the following mapping between SNVT_Occupancy enumerations and occupancy modes:

a. OCCUPIED mode: Enumeration value of OC_OCCUPIED
b. UNOCCUPIED mode: Enumeration value of OC_UNOCCUPIED
c. WARM-UP/COOL-DOWN (PRE-OCCUPANCY) mode: Enumeration value of OC_STANDBY

3.1.4.2 Alarming

For each point which is shown on the Points Schedule with an alarm condition, provide a SNVT output for the point to be used for alarm generation by the UMCS Front End

For each point not in a Niagara Framework Supervisory Gateway which is shown on the Points Schedule with an alarm condition, provide a SNVT output for the point to be used for alarm generation. For each point which is shown on the Points Schedule with an alarm condition, configure alarms in Niagara Framework Supervisory Gateway using Niagara Alarm Extensions and Alarm Services.

3.1.4.3 Trending

For each point which is shown on the Points Schedule as requiring a trend,

provide a SNVT output for the point to be used for trending by the UMCS Front End.

For each point not in a Niagara Framework Supervisory Gateway which is shown on the Points Schedule as requiring a trend, provide a SNVT output for the point to be used for trending. For each point which is shown on the Points Schedule as requiring a trend, configure a trend in a Niagara Framework Supervisory Gateway using Niagara Framework History Extensions and the Niagara Framework History Service.

3.1.4.4 Overrides

For each point shown on the Points Schedule as requiring an override, provide an override as specified in paragraphs "Overrides for GPPCs and AGCs" and "Overrides for ASCs".

Provide overrides for points as indicated on the Points Schedule. For overrides to points in Niagara Framework Supervisory Gateways, use the Niagara Framework. For overrides to other points, provide an override to a point in a Niagara Framework Supervisory Gateway via the Niagara Framework where the Niagara Framework Supervisory Gateway overrides the other point as specified in paragraphs "Overrides for GPPCs and AGCs" and "Overrides for ASCs"

3.1.5 Gateways

The requirements in this paragraph do not themselves permit the installation of hardware not meeting the other requirements of this section. Except for proprietary systems specifically indicated in Section 23 09 00, all control hardware installed under this project must meet the requirements of this specification, including the control hardware providing the network interface for a package unit or split system specified under this Section or another Section. Only use gateways to connect to pre-existing control devices and to proprietary systems specifically permitted by Section 23 09 00.

Provide Gateways to connect non-CEA-709.1-D control hardware in accordance with the following:

a. Configure gateway to map writeable data points in the controlled equipment to Network Variable Inputs of Standard Network Variable Types as defined by the LonMark SNVT List, or to Niagara Framework points, as indicated in the Points Schedule and as specified.

b. Configure gateway to map readable data points in the controlled equipment to Network Variable Outputs of Standard Network Variable Types as defined by the LonMark SNVT List, or to Niagara Framework points, as indicated in the Points Schedule and as specified.

c. Do not use non-CEA-709.1-D control hardware for controlling built-up units or any other equipment that was not furnished with factory-installed controls. (Note: A Niagara Framework Supervisory Gateway is CEA-709.1-D control hardware.)

d. Do not use non-CEA-709.1-D control hardware for system scheduling functions.

e. Each gateway must communicate with and perform protocol translation for non-CEA-709.1-D control hardware controlling one and only one

package unit or a single non-CEA-709.1-D system specifically permitted by Section 23 09 00.

f. Connect one network port on the gateway to the Building Control Network and the other port to the single piece of controlled equipment or the non-CEA-709.1-D network specifically permitted by Section 23 09 00.

g. For gateways to existing package units or simple split systems, non-CEA-709.1-D network wiring connecting the gateway to the package unit or split system interface must not exceed 10 feet in length and must connect to exactly two devices: the controlled equipment or split system interface and the gateway.

3.1.6 Network Interface Jack

Provide standard network interface jacks such that each node on the control network is within 10 ft of an interface jack. For terminal unit controllers with hardwired thermostats this network interface jack may instead be located at the thermostat. Locating the interface jack [at the thermostat][near the controller] is preferred. If the network interface jack is other than a 1/8 inch phone jack, provide an interface cable with a standard 1/8 inch phone jack on one end and a connector suitable for mating with installed network interface jack on the other. No more than one type of interface cable must be required to access all network interface jacks. Furnish [one] [_____] interface cable(s).

-- End of Section --

SECTION 23 09 93

SEQUENCES OF OPERATION FOR HVAC CONTROL
11/15

PART 1 GENERAL

1.1 DEFINITIONS

For definitions related to this Section, see Section 23 09 00 INTRUMENTATION AND CONTROL FOR HVAC.

1.2 SUBMITTALS

Submittals related to this Section are specified in Section 23 09 00 INTRUMENTATION AND CONTROL FOR HVAC.

PART 2 PRODUCTS

Products related to this Section are specified in Section 23 09 00 INTRUMENTATION AND CONTROL FOR HVAC and related Sections 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC and 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS or 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

PART 3 EXECUTION

3.1 SEQUENCES OF OPERATION FOR OCCUPANCY SCHEDULING

3.1.1 System Mode

Operate air handling units (AHUs) in Occupied, Warm-Up-Cool-Down, or Unoccupied modes as specified. VAV boxes, Fan Coils, and operate other terminal equipment in Occupied or Unoccupied modes as specified. Chillers, boilers, and other sources of heating/cooling for hydronic loads do not require scheduling; these systems receive requests for heating/cooling from their loads.

3.1.2 System Scheduler Requirements

The System Scheduler functionality must reside in either a piece of DDC Hardware dedicated to this functionality or in the DDC Hardware controlling the system AHU. A single piece of DDC Hardware dedicated to scheduling (performing no other control functionality) may contain multiple System Schedulers. Provide a unique System Scheduler for: each AHU including it's associated Terminal Units, and each stand-alone Terminal Unit (those not dependent upon AHU service)[or group of stand-alone Terminal Units acting according to a common schedule]. Each System Scheduler must provide the following functionality:

3.1.2.1 Scheduled Occupancy Input

Accept network variable of type SNVT_occupancy. Support the following possible values: OC_STANDBY, OC_OCCUPIED and OC_UNOCCUPIED.

3.1.2.2 Occupancy Override Input

Accept network variable of type SNVT_occupancy. Support the following possible values: OC_STANDBY, OC_OCCUPIED, OC_UNOCCUPIED, and OC_NUL.

3.1.2.3 Space Occupancy Inputs

For systems with multiple occupancy sensors, accept multiple inputs of network variable type SNVT_Occupancy. Support the following possible values: OC_OCCUPIED, OC_UNOCCUPIED, and OC_NUL. For systems with a single occupancy sensor, accept a network variable input of type SNVT_Occupancy or a hardware binary input (BI) indicating the space occupancy status as Occupied or Unoccupied.

3.1.2.4 Air Handler Occupancy Output

For a System Scheduler for a system containing an air handler, output one or more SNVTs indicating the desired occupancy status as one of the following possible values: Warm-Up-Cool-Down (when required by the AHU Sequence of Operation), Occupied and Unoccupied.

3.1.2.5 Terminal Unit Occupancy Output

For a System Scheduler for a stand-alone terminal unit, [a group of stand-alone terminal units acting according to a common schedule,] or a group of terminal units served by a single air handler, output one or more SNVTs indicating the desired occupancy status as one of the following possible values: Occupied and Unoccupied.

3.1.2.6 Default Schedule

Incorporate a 24-hour 7-day default schedule as shown on the drawings which may be activated and deactivated by the System Scheduler Logic.

3.1.2.7 Communication Determination

Determine the time elapsed between receipts of the scheduled occupancy input SNVT, and use this elapsed time to activate and deactivate the Default Schedule as specified. (This provides the capability for the system scheduler to use its Default Schedule if it loses communication with the UMCS).

3.1.3 System Scheduler Output Determination

For controlling an Air Handler, interpret a SNVT input of OC_STANDBY as Warm-Up-Cool-Down if the sequence of operation supports that mode, otherwise interpret OC_STANDBY as Occupied. For Terminal Units, interpret OC_STANDBY as Occupied.

3.1.3.1 Air Handler Occupancy Output

If more than 95 minutes have passed since the last receipt of the Scheduled Occupancy input, determine the Air Handler Occupancy Output by the default schedule and the Space Occupancy Inputs. Otherwise, determine the output as follows:

a. If the Override Occupancy Input is not OC_NUL, determine the Air Handler Occupancy Output from the Override Occupancy Input.

b. Otherwise, if at least the required number (as shown on the Occupancy Schedule Drawing) of Space Occupancy Inputs are OC_OCCUPIED or the hardware BI is Occupied the Air Handler Occupancy Output must be OC_OCCUPIED.

c. Otherwise, determine the Air Handler Occupancy Output from the Scheduled Occupancy Input SNVT.

3.1.3.2 Terminal Unit Occupancy Output

If more than 95 minutes have passed since the last receipt of the Scheduled Occupancy input, determine the Terminal Unit Occupancy Output by the default schedule. Otherwise, determine the output as follows:

a. If the Override Occupancy Input is not OC_NUL, determine the Terminal Unit Occupancy Output from the Override Occupancy Input SNVT:

b. Otherwise, determine the Terminal Unit Occupancy Output from the Scheduled Occupancy SNVT.

3.1.4 Air Handler System Scheduling

a. Bind the AHU Occupancy Output SNVT from the System Scheduler to the DDC Hardware that executes the Occupancy Mode Determination part of the Air Handler Sequence of Operation

b. For Air Handlers using occupancy sensors, bind the output SNVT (of type SNVT_Occupancy) of each occupancy sensor to a Space Occupancy Input of the System Scheduler.

c. Bind the Terminal Unit Occupancy Output SNVT from the System Scheduler to each AHU-Dependent Terminal Unit.

d. AHU-Dependent Terminal Units with occupancy sensors must have the Effective Occupancy SNVT (of type SNVT_Occupancy) of each Terminal Unit bound to a Space Occupancy Input of the System Scheduler.

3.1.5 Stand-Alone Terminal Unit Scheduling

Bind the Terminal Unit Occupancy Output from the System Scheduler to the DDC Hardware that executes the Occupancy Mode Determination part of the Terminal Unit Sequence of Operation.

3.2 SEQUENCES OF OPERATION FOR AIR HANDLING UNITS
3.2.1 [Enter Appropriate Subpart Title Here]3.2.1.1 Minimum Outside Air Flow Control

When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air follow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.2.1.2 Cold Deck Coil Control

When this loop is enabled the DDC Hardware shall modulate the cooling coil valve to maintain the cold deck supply air temperature (SA-T) at setpoint (SA-T-SP) as shown. When this loop is disabled, the cooling coil valve shall be closed.

3.2.1.3 [Enter Appropriate Subpart Title Here]
3.2.2 Variable Air Volume System [with][without] Return Fan

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.2.2.1 HAND-OFF-AUTO Switches

Supply fan variable frequency drive (VFD) unit shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other VFD inputs and switches and shall cause the VFD to run at 100 percent speed. The VFD shall accept an occupant accessible emergency shutoff switch as shown. The supply fan variable frequency drive (VFD) unit shall have an integral H-O-A switch:

3.2.2.1.1 HAND

With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties. Fan speed shall be under manual-operator control.

3.2.2.1.2 OFF

With the H-O-A switch in OFF position, the supply fan shall stop.

3.2.2.1.3 AUTO

With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop Signal (SF-SS) and Safeties. Fan speed shall be under control of the DDC Hardware.

[3.2.2.2 Return Fan Variable Frequency Drive

Return fan variable frequency drive (VFD) unit shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other VFD inputs and switches and shall cause the VFD to run at 100 percent speed. The return fan variable frequency drive (VFD) unit shall have an integral H-O-A switch:

3.2.2.2.1 HAND

With the H-O-A switch in HAND position, the return fan shall run subject to Safeties. Fan speed shall be under manual-operator control.

3.2.2.2.2 OFF

With the H-O-A switch in OFF position, the return fan shall be off.

3.2.2.2.3 AUTO

With the H-O-A switch in AUTO position, the return fan shall run subject to the supply fan running. Fan speed shall be under control of the DDC Hardware.

]3.2.2.3 Occupancy Modes

The system shall obtain its Occupancy Mode input from the System Scheduler

as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied[, or Warm Up/Cool Down].

3.2.2.4 Proofs and Safeties

The supply fan[, return fan,] and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the VFD as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

3.2.2.4.1 Proofs

a. Supply fan status (SF-S)

[b. Return fan status (RF-S)]

3.2.2.4.2 Safeties

a. Preheat coil discharge air temperature low limit (freezestat) (PH-DA-T-LL) for systems with a preheat coil. Cooling coil discharge air temperature low limit (freezestat) (CLG-DA-T-LL) for all other systems

b. Supply air duct pressure high limit (SA-P-HL)

c. Supply air smoke (SA-SMK)

d. Return air smoke (RA-SMK)

3.2.2.4.3 DDC Hardware Reset

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.2.2.5 System Enable and Loop Enable

3.2.2.5.1 Occupied Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). All control loops shall be enabled.

3.2.2.5.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 5 degrees F deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS), the Supply Duct Static Pressure Control[, Return Fan Volume Control][, Preheat Control] loops shall be enabled. The Minimum Outside Air Flow Control, Mixed Air Temperature Control, and Cooling Coil Control loops shall be disabled.

[3.2.2.5.3 Warm Up/Cool Down

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops shall be enabled.

]3.2.2.6 Fan Capacity Control

3.2.2.6.1 Supply Duct Static Pressure Control

When this loop is enabled the DDC Hardware shall modulate the supply fan variable frequency drive unit to maintain the duct static pressure (SA-P) at setpoint (SA-P-SP) as shown, as measured by the duct static pressure tap and sensor as shown. When this loop is disabled, the DDC Hardware capacity modulation output to the VFD shall be zero percent.

[3.2.2.6.2 Return Fan Volume Control

When this loop is enabled the DDC Hardware shall modulate the return fan variable frequency drive unit to maintain a constant volumetric airflow difference at setpoint (F-DIFF-SP) as shown, as measured by the airflow measurement arrays located in the supply and return ducts as shown. When this loop is disabled, the output to the VFD shall be zero percent.

]3.2.2.7 Minimum Outside Air Flow Control

When this loop is enabled the DDC Hardware shall modulate the minimum outside air damper to maintain the minimum OA volumetric flow (MINOA-F) at setpoint (MINOA-F-SP) as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.2.2.8 Mixed Air Temperature Control With Economizer

3.2.2.8.1 Enabled Loop

When this loop is enabled, and the Economizer is ON as determined by the Economizer Enable Logic, the DDC Hardware shall modulate the economizer outside air, relief, and return air dampers to maintain the mixed air temperature (MA-T) at setpoint (MA-T-SP) as shown.

3.2.2.8.2 Disabled Loop

When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

3.2.2.8.3 Economizer Enable Logic

The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 2 degrees F deadband.

3.2.2.9 Cooling Coil Control

When this loop is enabled the DDC Hardware shall modulate the cooling coil valve to maintain the supply air temperature (SA-T) setpoint (SA-T-SP) as shown. When this loop is disabled, the cooling coil valve shall be closed.

[3.2.2.10 Preheat Coil Control

When this loop is enabled the DDC Hardware shall modulate the preheat coil valve to maintain the preheat coil discharge air temperature (PH-DA-T) at setpoint (PH-DA-T-SP) as shown. When this loop is disabled, the preheat coil valve shall be closed.

]3.3 SEQUENCES OF OPERATION FOR TERMINAL UNITS

3.3.1 [Enter Appropriate Subpart Title Here]3.3.1.1 [Enter Appropriate Subpart Title Here]

3.3.2 Zone Temperature Control - Fan Powered VAV Box

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.3.2.1 Occupancy Modes

3.3.2.1.1 Occupied

The VAV box DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is occupied or when the input from the System Scheduler (SYS-OCC) is occupied.

3.3.2.1.2 Unoccupied

The VAV box DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is unoccupied and the input from the System Scheduler (SYS-OCC) is unoccupied.

3.3.2.2 Safeties

VAV boxes with electric resistance heating elements shall require proof of air flow before activating the heating elements.

3.3.2.3 Fan Control

[Series fans shall run whenever the box is occupied or the Zone Temperature Control loop determines that the box is in heating mode. Prior to starting the fan, the supply damper shall close. The controller shall pause after closing the damper before starting the fan to ensure that the fan is not spinning due to supply air delivered by the AHU. After the fan starts, the supply damper shall be controlled by the Zone Temperature Control loop.][Parallel fans shall run whenever the Zone Temperature Control loop determines that the box is in heating mode.]

3.3.2.4 Zone Temperature Control

3.3.2.4.1 Occupied Mode

In the Occupied Mode the zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

3.3.2.4.2 Unoccupied Mode

In the Unoccupied Mode the zone temperature setpoint (ZN-T-SP)shall be at the configured setpoint as shown.

3.3.2.4.3 Sequencing

3.3.2.4.3.1 Cooling Mode

Upon a rise in zone temperature above zone temperature setpoint (ZN-T-SP), subject to the zone temperature setpoint deadband as shown, the airflow setpoint shall be adjusted between minimum and maximum based on the difference between zone temperature and zone temperature setpoint as shown. The DDC Hardware shall modulate the VAV box damper to mix supply and plenum return air as it maintains VAV box supply airflow (VAV-SA-F) at setpoint as measured by a multi-point flow sensing element at the inlet to the VAV box.

3.3.2.4.3.2 Heating Mode

Upon a fall in zone temperature below zone temperature setpoint, subject to the deadband as shown, the DDC Hardware shall[first turn on the parallel fan and then] modulate the VAV box damper to mix supply and plenum return air to maintain a fixed air flow setpoint (with a setting independent of the cooling minimum air flow), and the heating valve shall modulate towards open or the staged electric resistance heating coil(s) shall cycle on in sequence.

3.3.3 [Enter Appropriate Subpart Title Here]3.3.3.1 [Enter Appropriate Subpart Title Here]3.3.3.1.1 [Enter Appropriate Subpart Title Here]

3.3.4 Unit Heater and Cabinet Unit Heater

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.3.4.1 Off-Auto Switch

3.3.4.1.1 OFF

With the thermostat OFF-AUTO switch in the OFF position, the DDC Hardware shall stop the fan and close the heating control valve.

3.3.4.1.2 AUTO

With the thermostat OFF-AUTO switch in the AUTO position, the DDC Hardware shall control the unit in accordance with its Occupancy Mode.

3.3.4.2 Occupancy Modes

3.3.4.2.1 Occupied

The unit heater DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) indicate that the space is occupied or when the input from the System Scheduler is occupied.

3.3.4.2.2 Unoccupied

The unit heater DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) indicate that the space is unoccupied and when the input from the System Scheduler is unoccupied.

3.3.4.3 Safeties

The unit shall run subject to the unit manufacturer's safeties.

3.3.4.4 Space Temperature Control

3.3.4.4.1 Occupied Mode

In the Occupied Mode the DDC Hardware shall modulate the heating control valve and cycle the multi-speed fan to maintain space temperature at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

3.3.4.4.2 Unoccupied Mode

In the Unoccupied Mode the DDC Hardware shall modulate the heating control valve and cycle the multi-speed fan to maintain space temperature at the configured setpoint as shown.

3.3.5 [Enter Appropriate Subpart Title Here]3.3.5.1 [Enter Appropriate Subpart Title Here]3.3.5.1.1 [Enter Appropriate Subpart Title Here]
3.4 SEQUENCES OF OPERATION FOR HYDRONIC SYSTEMS

3.4.1 [Enter Appropriate Subpart Title Here]3.4.1.1 [Enter Appropriate Subpart Title Here]
3.4.2 Hydronic Heating Hot Water From Single-Building Boiler

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.2.1 System Enable and Loop Enable

a. This system shall monitor the enabled status of all systems served by this system. If one or more systems served by this system are enabled, this system shall be enabled (SYS-ENA). If no systems served by this system are enabled, this system shall be disabled.

b. When this system is enabled (SYS-ENA) and the hot water pump is proofed on, the boiler control and hot water temperature control loops shall be enabled.

3.4.2.2 HAND-OFF-AUTO Switch

The hot water pump motor starter shall have an H-O-A switch:

3.4.2.2.1 HAND

With the H-O-A switch in HAND position, the pump shall start and run continuously.

3.4.2.2.2 OFF

With the H-O-A switch in OFF position, the pump shall stop.

3.4.2.2.3 AUTO

With the H-O-A switch in AUTO position, the pump shall run subject to the Hot Water Pump Start/Stop (HW-PMP-SS) command.

3.4.2.3 Proofs and Safeties

DDC Hardware shall monitor all proofs and safeties.

3.4.2.3.1 Proofs

Hot water pump

3.4.2.3.2 Safeties

None

3.4.2.3.3 DDC Hardware Reset

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.2.4 Boiler Control

When this loop is enabled, the DDC Hardware shall turn the boiler on. When this loop is disabled, the boiler shall be off.

3.4.2.5 Hot Water Temperature Control

When this loop is enabled the DDC Hardware shall modulate the 3-way mixing valve to maintain hot water supply temperature (HWS-T) at setpoint (HWS-T-SP). The Hot Water Supply Temperature Setpoint (HWS-T-SP) shall be [determined from a linear reset schedule] as shown. When this loop is disabled, the valve shall be in its normal (failsafe) position.

3.4.3 [Enter Appropriate Subpart Title Here]3.4.3.1 [Enter Appropriate Subpart Title Here]

]3.4.4 Hydronic Secondary with Variable Speed Pump

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.4.1 System Enable and Loop Enable:

a. This system shall monitor the enabled status of all systems served by this system. If one or more systems served by this system are enabled, this system shall be enabled (SYS-ENA). If all systems served by this system are not enabled, this system shall not be enabled.

b. When this system is enabled (SYS-ENA) the Pressure Control loop shall be enabled.

3.4.4.2 HAND-OFF-AUTO Switch

The hot water pump variable frequency drive (VFD) unit shall have an integral H-O-A switch:

3.4.4.2.1 HAND

With the H-O-A switch in HAND position, the pump starts and runs continuously. Pump speed shall be under manual-operator control.

3.4.4.2.2 OFF

With the H-O-A switch in OFF position, the pump stops.

3.4.4.2.3 AUTO

With the H-O-A switch in AUTO position, the pump shall run subject to the Hot Water Pump Start/Stop (HW-PMP-SS) command and pump speed shall be under control of the DDC system.

3.4.4.3 Proofs and Safeties

DDC Hardware shall monitor all proofs and safeties.

3.4.4.3.1 Proofs

None

3.4.4.3.2 Safeties

None

3.4.4.3.3 DDC Hardware Reset

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.4.4 Pressure Control

When this loop is enabled the DDC Hardware shall modulate the pump variable frequency drive unit to maintain the pipe system pressure at setpoint as shown, as measured by the differential pressure tap and sensor as shown. When this loop is disabled, the DDC Hardware capacity modulation output to the VFD shall be zero percent.

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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 B109.1	(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 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 Z21.1/CSA 1.1	(2018) Household Cooking Gas Appliances
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	(2019) 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
ANSI Z21.93/CSA 6.30	(2017) Excess Flow Valves for Natural Gas and Propane Gas with Pressures up to 5 psig

AMERICAN PETROLEUM INSTITUTE (API)

API 570	(2016; Addendum 1 2017; Addendum 2 2018; ERTA 1 2018) Piping Inspection Code: In-Service Inspection, Rating, Repair, and Alteration of Piping Systems
API RP 1110	(2013; R 2018) Recommended Practice for the Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids, or Carbon Dioxide
API RP 2009	(2002; R 2007; 7th Ed) Safe Welding, Cutting, and Hot Work Practices in Refineries, Gasoline Plants, and Petrochemical Plants
API Spec 5CT	(2018) Casing and Tubing
API Spec 6D	(June 2018, 4th Ed; Errata 1 July 2018; Errata 2 August 2018) Specification for Pipeline and Piping Valves
API Spec 15LR	(2001; R 2018) Specification for Low Pressure Fiberglass Line Pipe
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

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 25-16	(2016) Earthquake-Activated Automatic Gas Shutoff Devices

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (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 B16.1	(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 B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(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 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
ASME B31.9	(2020) Building Services Piping
ASME B36.10M	(2015; Errata 2016) Welded and Seamless Wrought Steel Pipe
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications

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 01.01	(2019) Steel - Piping, Tubing, Fittings

ASTM A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
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 A513/A513M	(2020a) Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
ASTM A666	(2015) Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B210/B210M	(2019a) Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes
ASTM B241/B241M	(2016) Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
ASTM B280	(2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM D2513	(2018a) Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings
ASTM D2517	(2018) Standard Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings
ASTM F2015	(2000; R 2013) Standard Specification for Lap Joint Flange Pipe End Applications

CSA GROUP (CSA)

ANSI LC 1/CSA 6.26	(2019) Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing (CSST)
CGA 3.11-M88	(2015) Lever Operated Pressure Lubricated Plug Type Gas Shut-Off Valves

CGA 3.16-M88	(2015) Lever Operated Non-Lubricated Gas Shut-Off Valves
CGA 9.2-M88	(1988; R 2009) Manually Operated Shut-Off Valves for Gas Piping Systems

FM GLOBAL (FM)

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

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; TIA 20-1; TIA 20-2; TIA 20-3) 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

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

SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

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
UFC 3-301-01	(2019) Structural Engineering

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

49 CFR 192	Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards

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] [and] [liquid petroleum] 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.

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" or "S" classification. Submittals not having a "G" or "S" classification are or Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Gas Piping System; G, AE

SD-03 Product Data

Pipe and Fittings; G, AE

Gas Equipment Connectors; G, AE

LPG Containers and Accessories; G[, [_____]]

Gas Piping System; G, AE

Pipe Coating Materials; G, AE

Pressure Regulators; G, AE

Risers; G, AE

Transition Fittings; G, AE

Valves; G, AE

Warning and Identification Tape; G[, AE

SD-06 Test Reports

Testing; G, AE

Pressure Tests; G, AE

Pressure Tests for Liquified Petroleum Gas; G[, [_____]]

Test with Gas; G, AE

SD-07 Certificates

Welders Procedures and Qualifications; G, AE

Assigned Number, Letter, or Symbol; G, AE

SD-08 Manufacturer's Instructions

PE Pipe and Fittings; G, AE

Pipe Coating Materials; G, AE

SD-10 Operation and Maintenance Data

Gas Facility System and Equipment Operation; G, AE

Gas Facility System Maintenance; G, AE

Gas Facility Equipment Maintenance; G, AE

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 05 23.16 STRUCTURAL WELDING, and in conformance with AWS A5.8/A5.8M, and AWS WHB-2.9.]

1.5.2 Jointing Thermoplastic and Fiberglass Piping

Perform all jointing of piping using qualified joiners and qualified procedures in accordance with AGA XR0603. Furnish the Contracting Officer with a copy of qualified procedures and list of and identification symbols of qualified joiners. Submit manufacturer's installation instructions and manufacturer's visual joint appearance chart, including all PE pipe and fittings.

1.5.3 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. Include LP storage tank, pad, and mounting details.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 Plastic Pipe

Handle, transport, and store plastic pipe and fittings carefully. Plug or cap pipe and fittings ends during transportation or storage to minimize dirt and moisture entry. Do not subject piping to abrasion or concentrated external loads. Discard PE pipe sections and fittings that have been damaged.

1.6.2 CSST Tubing

Handle, transport and store CSST tubing on the wooden spool or shipping container provided by the manufacturer. Insure tubing ends are capped during transportation and storage to minimize dirt and moisture entry. Discard any tubing segment and fitting that has been damaged.

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

Provide steel pipe conforming to ASME B36.10M; and malleable-iron threaded fittings conforming to ASME B16.1 and ASME B16.3. Provide steel pipe flanges and flanged fittings, including bolts, nuts, and bolt pattern in accordance with ASME B16.5 and ASTM A105/A105M. Provide wrought steel buttwelding fittings conforming to ASME B16.9. Provide socket welding and threaded forged steel fittings conforming to ASME B16.11[and ASTM A181/A181M, Class 60].

][2.2.2 Aluminum Alloy Pipe and Tubing, Joints, and Fittings

Provide aluminum alloy pipe conforming to ASTM B241/B241M, except that alloy 5456 is not allowed. Mark the ends of each length of pipe indicating it conforms to NFPA 54 NFPA 58. Thread, flange, braze, or weld pipe joints. Provide aluminum alloy tubing conforming toASTM B210/B210M, Type A or B, or ASTM B241/B241M, Type A or equivalent, with joints made up with gas tubing fittings recommended by the tubing manufacturer.

][2.2.3 Copper Tubing, Joints and Fittings

Provide copper tubing conforming to ASTM B88, Type K or L, or ASTM B280, with tubing joints made up with tubing fittings recommended by the tubing manufacturer. Provide copper and copper alloy press fittings, with sealing elements of Hydrogenated Nitrile Butadiene Rubber (HNBR), factory installed, or an alternative supplied by the fitting manufacturer. Press fittings are not a permitted connection fitting for natural and LP gas on Army and Navy projects.

][2.2.4 Steel Tubing, Joints and Fittings

Provide steel tubing conforming to ASTM 01.01, and ASTM A513/A513M, with tubing joints made up with gas tubing fittings recommended by the tubing manufacturer.

][2.2.5 Thermoplastic Pipe, Tubing, Joints, and Fittings

Provide thermoplastic pipe, tubing,casing and joints and fittings conforming to ASTM D2513 and API Spec 5CT.

][2.2.6 Fiberglass Pipe, Joints, and Fittings

Provide fiberglass piping systems conforming to ASTM D2517 and API Spec 15LR.

][2.2.7 Corrugated Stainless Steel Tubing, Fittings and Accessories

Provide corrugated stainless steel tubing conforming to ANSI LC 1/CSA 6.26 (austenitic stainless steel of series 300) with tubing joints made with special mechanical fittings as supplied by the tubing manufacturer.

2.2.7.1 Tubing

Austenitic stainless alloy of series 300 with polyethylene jacket/coating in accordance with ANSI LC 1/CSA 6.26 for sizes 3/8-inch through 2-inch

2.2.7.2 Mechanical Fittings

Copper alloy with one end matched to the corrugated tubing and one end with NPT threads in accordance with ASME B1.20.1

2.2.7.3 Striker Plates

Hardened steel designed to protect tubing from mechanical damage in accordance with ANSI LC 1/CSA 6.26

2.2.7.4 Manifolds

Malleable iron, steel or copper alloy with threaded connections/ports in accordance with ASME B1.20.1

][2.2.8 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.

]2.2.9 Warning and Identification

Provide pipe flow markings, warning and identification tape, and metal tags as required.

2.2.10 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.

2.2.11 Pipe Threads

Provide pipe threads conforming to ASME B1.20.1.

2.2.12 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.

2.2.13 Gas Transition Fittings

[a. Provide steel to plastic (PE) designed for steel-to-plastic with tapping tee or sleeve conforming to AGA XR0603 requirements for transitions fittings.. Coat or wrap exposed steel pipe with heavy plastic coating.]

[b. Plastic to Plastic: [Manufacturer's standard bolt-on (PVC to PE) plastic tapping saddle tee, UL listed for gas service, rated for 100 psig, and O-ring seals.] [Manufacturer's standard slip-on PE mechanical coupling, molded, with stainless-steel ring support conforming to ASTM A666, O-ring seals, and rated for 150 psig gas service.] [Manufacturer's standard fused tapping (PE-to-PE) tee assembly with shut-off feature.]]

[c.[Provide lever operated pressure lubricated plug type gas shut-off valve conforming to CGA 3.11-M88.][Provide lever operated non-lubricated gas shut-off valves conforming to CGA 3.16-M88][Provide manually operated shut-off valve conforming to CGA 9.2-M88]]

2.2.14 Insulating Pipe Joints

2.2.14.1 Insulating Joint Material

Provide insulating joint material between flanged or threaded metallic pipe systems where shown to control galvanic or electrical action.

2.2.14.2 Threaded Pipe Joints

Provide threaded pipe joints of steel body nut type dielectric unions with insulating gaskets.

2.2.14.3 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. [Provide lap joint flange pipe ends conforming to ASTM F2015.]

2.2.15 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 [as indicated in the drawings]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.[Provide manually operated household cooking gas appliance valves conforming to ANSI Z21.1/CSA 1.1 and ANSI Z21.15/CSA 9.1.]

[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.

][2.3.3 Valve Support on PE Piping

Provide valve support assembly in accordance with the PE piping maufacturer's requirements at valve terminations points.

]2.4 RISERS

Provide 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].

2.5 PIPE HANGERS AND SUPPORTS

Provide pipe hangers and supports conforming to MSS SP-58.

[2.6 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].

][2.7 NATURAL GAS SERVICE

2.7.1 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 [and overpressure shutoff]. Set pressure relief at a lower pressure than would cause unsafe operation of any connected user.

b. Adjust regulators for liquified petroleum gas to 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.

2.7.2 Gas Meter

[AGA ANSI B109.1][AGA ANSI B109.2][AGA ANSI B109.3] [pipe][pedestal] mounted, [diaphragm] or [bellow][style], [cast-iron][enamel-coated steel][aluminum] case. [Provided with a strainer immediately upstream]. Provide [diaphragm-type meter conforming to AGA ANSI B109.1 for required flow rates less than 500 cfh, or AGA ANSI B109.2, for flow rates 500 cfh and above] [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 must be 30,000,000 cycles.

2.7.2.1 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.

2.7.2.2 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.

][2.8 SEISMIC PROVISIONS

Provide earthquake automatic gas shutoff valve conforming to ASCE 25-16, SMACNA 1981 or excess flow valve (EFV) conforming with ANSI Z21.93/CSA 6.30 and UL listed or AGA listed or International Association of Plumbing and Mechanical Officials (IAPMO) listed. The earthquake valve may be either pendulum or ball construction with [remote [, pneumatic] [electronic] [or] [electric]] actuator. The EFV may be either a bypass (automatic reset) or a non-bypass type (manual reset).

]2.9 AUTOMATIC GAS SHUT-OFF

[Provide low pressure automatic gas shutoff or excess flow valve (EFV) downstream of the point of delivery after the [meter/regulator] [propane tank] conforming to ANSI Z21.93/CSA 6.30 and UL listed or CSA listed or International Association of Plumbing and Mechanical Officials (IAPMO) listed. The EFV may be either a bypass (automatic reset) or a non-bypass type (manual reset).][Provide low pressure automatic gas shutoff or excess flow valve (EFV) at each branch to an appliance.]

2.10 [Enter Appropriate Subpart Title Here]

2.11 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.

2.12 GASKETS

Fluorinated elastomer, compatible with flange faces.

2.13 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 00 00 EARTHWORK.

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,][as specified in Section 33 51 15 NATURAL-GAS / LIQUEFIED PETROLEUM GAS DISTRIBUTION PIPELINES,] to the connections to each gas utilization device that is in compliance with NFPA 54[NFPA 58]..

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 Underground Metallic Pipe

Protect buried metallic piping and tubing from corrosion by either: (1) applying protective coatings as specified in Section 33 51 15 NATURAL-GAS / LIQUEFIED PETROLEUM GAS DISTRIBUTION PIPELINES; (2) encasement in a water tight plastic conduit; or (3) encasement in a protective system designed and listed by the manufacturer for this application. When dissimilar metals are joined underground, use gastight insulating fittings.

3.4.2 Aboveground Metallic Piping Systems

3.4.2.1 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].

3.4.2.2 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 54NFPA 58[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 Metallic Piping Installation

Bury underground piping a minimum of 18 inches below grade. Make changes in direction of piping with fittings only; mitering or notching pipe to form elbows and tees or other similar type construction is not permitted. Branch connection may be made with either tees or forged branch outlet fittings. Provide branch outlet fittings which are forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Do not use aluminum alloy pipe in exterior locations or underground.

3.5.2 Metallic Tubing Installation

Install metallic tubing using gas tubing fittings approved by the tubing manufacturer. CSST gas piping systems must be installed by contractors who have completed the manufacturer's training program as indicated on a

certification card. Make branch connections with tees. Prepare all tubing ends with tools designed for that purpose. Do not use aluminum alloy tubing in exterior locations or underground. Maintain electrical continuity of gas piping system in accordance with NFPA 54 [NFPA 58], paragraph entitled 'Electrical Bonding and Grounding'.

3.5.3 Thermoplastic and Fiberglass Piping, Tubing, and Fittings

Installation of thermoplastic and fiberglass piping, tubing, and fittings is permitted only outside and underground. Bury piping a minimum of 18 inches below grade. Install the piping to avoid excessive stresses due to thermal contraction, and use only where indicated. Installations must be made using qualified procedures, by qualified installers, and in compliance with AGA XR0603 and NFPA 54 [NFPA 58], and must be inspected by a qualified inspector.

3.5.4 Connections Between Metallic and Plastic Piping

Connections between metallic and plastic piping are only allowed outside, underground, and with approved transition fittings.

3.5.5 Piping and Tubing Buried Under Buildings

Run underground piping and tubing installed beneath buildings in a steel pipe casing protected from corrosion with protective coatings as specified in Section 33 51 15 NATURAL-GAS / LIQUEFIED PETROLEUM GAS DISTRIBUTION PIPELINES or installed within a water tight plastic conduit or as part of a listed encasement system. Extend casing or encasement system at least 4 inches outside the building, and provide the pipe with spacers and end bushings to seal at both ends to prevent the entrance of water and/or the escape of gas. Extend a vent line from the annular space above grade outside to a point where gas will not be a hazard, and terminate in a rain/insect-resistant fitting.

3.5.6 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.

3.5.6.1 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.

3.5.6.2 Piping in Floors

Lay piping in solid floors [except where embedment in concrete is indicated] in channels suitably covered to permit access to the piping with minimum damage to the building. [Surround piping embedded in concrete by a minimum of 1-1/2 inches of concrete and do not allow physical contact with other metallic items such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quickset additives or cinder aggregate.]

3.5.7 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.

3.5.8 Final Gas Connections

Unless otherwise specified, make final connections with rigid metallic pipe and fittings. [Make final connections to kitchen ranges using flexible connectors not less than 40 inch long[, to afford access to coupling] [and][to permit movement of equipment for cleaning].][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.

3.5.9 Seismic Requirements

Support and brace piping and attached valves to resist seismic loads in conformance with ASCE 25-16[and][as specified in UFC 3-301-01, and Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC][as indicated]. CSST tubing and fittings that are seismically qualified in accordance with the FM APP GUIDE: Flexible Piping Systems for Flammable Gases must meet the seismic requirements in accordance with the manufacturer's installation instructions.

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 Thermoplastic and Fiberglass Joints

3.6.3.1 Thermoplastic and Fiberglass

Conform jointing procedures to AGA XR0603. Do not make joints with solvent cement or heat of fusion between different kinds of plastics.

3.6.3.2 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, in conformance with API 570, 100 percent of all joints and re-inspect all corrections. Arrange with the pipe manufacturer's representative in the presence of the Contracting Officer to make first time inspection.

3.6.4 Flared Metallic Tubing Joints

Make flared joints in metallic tubing with special tools recommended by the tubing manufacturer. Use flared joints only in systems constructed from nonferrous pipe and tubing, when experience or tests have demonstrated that the joint is suitable for the conditions, and when adequate provisions are made in the design to prevent separation of the joints. Do not use metallic ball sleeve compression-type tubing fittings for tubing joints.

3.6.5 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.

3.6.6 Joining Thermoplastic or Fiberglass to Metallic Piping or Tubing

When compression type mechanical joints are used, provide gasket material in the fittings compatible with the plastic piping and with the gas in the system. Use an internal tubular rigid stiffener in conjunction with the fitting, flush with end of the pipe or tubing, extending at least to the outside end of the compression fitting when installed. Remove all rough or sharp edges from stiffener. Do not force fit stiffener in the plastic. Split tubular stiffeners are not allowed.

3.6.7 Press Connections

Make press connections in accordance with manufacturer's installation instructions using tools approved by the manufacturer. Fully insert the tubing into the fitting and then mark at the shoulder of the fitting. Check the fitting alignment against the mark on the tubing to assure the tubing is fully inserted before the joint is pressed.

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 FIRESTOPPINGG.

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 54NFPA 58. 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[NFPA 58]. 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 GAS SERVICE INSTALLATION

[Gas service line, service regulator and gas company meter must be installed in accordance with Section 33 51 15 NATURAL-GAS / LIQUEFIED PETROLEUM GAS DISTRIBUTION PIPELINES.] Installations must be in accordance with 49 CFR 192 and ASME B31.8. Contractor must submit and use only tested and approved work procedures. Contractor must use only welders and jointers who have been recently qualified by training and test for joining and installing the gas pipe material used on this job. The finished product must be inspected by a person qualified to inspect joints made by the particular procedures used to make joints.

[3.17.1 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 00 00 EARTHWORK.

Were 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 must be qualified by making a satisfactory specimen joint that passes the required inspection and test listed in 49 CFR 192.285. Inspection must be made by inspectors qualified in evaluating joints made under the specific joining procedure, as required by 49 CFR 192.287.

3.17.2 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 must 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.

3.17.3 Gas Meter

Install shutoff valve, meter set assembly, and service regulator on the service line [outside the building] [inside the building, a minimum of 3 feet from any potential ignition source], 18 inches above the [ground] [finished floor] on the riser. An insulating joint (dielectric connection) must be installed on the inlet side of the meter set assembly and service regulator and must be constructed to prevent flow of electrical current.

][3.18 CATHODIC PROTECTION

Provide cathodic protection for underground ferrous gas piping as specified in [Section 26 42 13 GALVANIC (SACRIFICIAL) ANODE CATHODIC PROTECTION (GACP) SYSTEM] [and] [Section 26 42 17 IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) SYSTEM].

]3.19 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.

3.19.1 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 54as 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.

3.19.2 Pressure Tests for Liquified Petroleum Gas

Pressure test system as described above. When appliances are connected to the piping system, use fuel gas for testing appliances to withstand a pressure of not less than 10.0 inches nor more than 14.0 inches water column (0.36 nor more than 0.51 pounds per square inch) for a period of not less than 10 minutes without showing any drop in pressure. Measure pressure with a water manometer or an equivalent device calibrated to be read in increments of not greater than 0.1 inch water column. Isolate the source of pressure before the pressure tests are made.

3.19.3 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 54NFPA 58. If leakage is recorded, shut off the gas supply, repair the leak , and repeat the tests until all leaks have been stopped.

3.19.4 Purging

After testing is completed, and before connecting any appliances, fully purge all gas piping. LPG piping tested using fuel gas with appliances connected does not require purging. Conform testing procedures to API RP 1110. 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 54NFPA 58 are followed.

3.19.5 Labor, Materials and Equipment

Furnish all labor, materials and equipment necessary for conducting the testing and purging.

3.20 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 21 23

HYDRONIC PUMPS
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 SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
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 A307	(2021) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.2	(2014) Rotodynamic (Centrifugal) Pump for Nomenclature and Definitions
HI 1.3	(2013) Rotodynamic (Centrifugal) Pump Applications
HI 9.6.4	(2009) Rotodynamic Pumps for Vibration Analysis and Allowable Values
HI ANSI/HI 2.1-2.2	(2014) Rotodynamic Vertical Pumps of Radial, Mixed, and Axial Flow Types for Nomenclature and Definitions
HI ANSI/HI 9.6.3	(2017) Rotodynamic Pumps - Guideline for Operating Regions - B120
HI ANSI/HI 14.6	(2011) Rotodynamic Pumps for Hydraulic

Performance Acceptance Tests - A136

INTERNATIONAL CODE COUNCIL (ICC)

ICC IgCC	(2018) International Green Construction Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2018) Motors and Generators
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

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 21	(1982; E 2004) White or Colored Silicone Alkyd Paint (Type I, High Gloss and Type II, Medium Gloss)
SSPC Paint 25	(1997; E 2004) Zinc Oxide, Alkyd, Linseed Oil Primer for Use Over Hand Cleaned Steel, Type I and Type II

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

29 CFR 1910.219	Mechanical Power Transmission Apparatus

UNDERWRITERS LABORATORIES (UL)

UL 778	(2016; Reprint Jun 2021) UL Standard for Safety Motor-Operated Water Pumps

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

System Coordination; G, AE

SD-03 Product Data

Instructions; G, AE

Equipment Data; G, AE

Training Period; G, AE

SD-06 Test Reports

Factory Tests

Field Quality Control

SD-07 Certificates

Manufacturer's Representative

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, AE

Training; G, AE

1.3 QUALITY ASSURANCE

1.3.1 Manufacturer Services

Provide the services of a manufacturer's representative experienced in the installation, adjustment, and operation of the equipment specified. The representative must supervise the installation, adjustment, testing of the equipment, and conduct training.

Submit the names and qualifications of the manufacturer's representative and training engineers and written certification from the manufacturer that the representative and trainers are technically qualified.

1.3.2 Standard Products

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate equipment that has been in satisfactory HVAC operation at least 2 years prior to issuance of this solicitation. Support equipment with a service organization that is reasonably convenient to the jobsite. Pumps [and] [motors] of the same types must each be the product of one manufacturer.

1.3.3 Conformance with Agency Requirements

Where materials or equipment are specified to be an approved type, attach the seal or label of approval from a nationally recognized testing agency, adequately equipped and competent to perform such services. A written certificate from the testing agency must accompany the materials or equipment and be submitted stating that the items have been tested and that they conform to the applicable requirements of the specifications and to the standards listed herein. The certificate must indicate the methods of testing used by the testing agency. In lieu of a certificate from a testing agency, published catalog specification data, accompanied by the manufacturer's certified statement to the effect that the items are in accordance with the applicable requirements of the specifications and the referenced standards, will be considered and may be acceptable as evidence that the items conform with agency requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect equipment, delivered and designated for storage, from the weather,

humidity and temperature variations, dirt and dust, or other contaminants.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Hydronic pumps used for heating and air conditioning applications are defined by the type of impeller, number of impellers, type of casing, method of connection to the driver, and mounting position. Provide centrifugal water pumps of the types indicated and specified. Use an electric motor driving unit for each pump as indicated and specified.

2.1.1 Selection Criteria

Select pumps at a point within the maximum efficiency for a given impeller casing combination. Deviations within 3 percent of maximum efficiency are permissible, provided the lesser efficiency is not less than the scheduled efficiency in the construction design documents. Pumps having impeller diameters larger or smaller than manufacturer's published maximum and minimum impeller diameters for a given impeller casing combination will be rejected. Pump performance data, as shown in performance curves, must be based on factory tests using precision instrumentation and exacting procedures as detailed in HI ANSI/HI 14.6.

2.1.2 System Coordination

Submit drawings containing complete wiring and piping schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Show the proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation. Provide a complete listing of equipment, materials and miscellaneous components including mechanical seals, bearings, and couplings.

2.1.3 Safety Requirements

Fully enclose or guard couplings, projecting set-screws, keys, and other rotating parts, that pose an entangling hazards..

2.2 MATERIALS AND EQUIPMENT

2.2.1 Nameplates

Securely affix a standard nameplate to pumps and motors in a conspicuous place showing the manufacturer's name, address, type or style, model, serial number, and catalog number. In addition, for each pump show the capacity in gpm at rated speed in rpm and total head in feet of water. For each electric motor show at least the minimum information required by NEMA MG 1. Show such other information as the manufacturer may consider necessary to complete identification on the nameplate. Pumps must be listed and labeled by UL, and comply with UL 778 for pumps not using universal motors rated more than 250 volts such as circulating pumps.

2.2.2 Framed Instructions

Submit proposed diagrams, instructions, and other sheets, prior to posting. Post approved wiring and control diagrams showing the complete layout of the entire system, including equipment, piping valves, and

control sequence, framed under glass or in approved laminated plastic, where directed. Provide 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, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. Post the framed instructions before acceptance testing of the systems.

2.2.3 Pump Characteristic

Construct hydronic water pumps in accordance with HI 1.1-1.2 and HI ANSI/HI 2.1-2.2. The pumps must be capable of discharging quantities at total discharge heads measured at the discharge flange, between the following limits:

Operate pumps at optimum efficiencies to produce the most economical pumping system under the conditions encountered [and size to make optimum match with the system head curve as shown].[Suction lift on Pump No. [_____] must not be more than [_____] feet.] Pumps must furnish not less than 150 percent of rated capacity at a total discharge head of not less than 65 percent of total rated head.[The shutoff total head must not be greater than 120 percent of total rated head.] Operate pumps at specified system fluid temperatures without vapor binding and cavitation. Operate pumps to HI ANSI/HI 9.6.3 standard for Preferred Operationg Region (POR).

2.2.4 Pump Drivers

Provide electric motors as indicated for each pump and in compliance with Section [26 20 00 INTERIOR DISTRIBUTION SYSTEM] [26 60 13.00 40 LOW-VOLTAGE MOTORS].

2.2.5 Equipment Data

Submit manufacturer's descriptive data and technical literature, performance charts and curves for all impeller sizes for a given casing, catalog cuts, and installation instructions. Provide spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than [_____] months prior to the date of beneficial occupancy. Include a complete list of parts and supplies, with current unit prices and local source of supply with contact information.

Submit catalog information, certified pumps curves, rated capacities, final impeller dimensions, and accessories provided for the product indicated. Indicate operating point of each pump on curves. Furnish pump curves for each pump and combination of pumps designed to operate in parallel. The pump curve must show as a minimum; bhp, flow, total dynamic head, efficiency, NPSH, impeller diameter and system curve (individually and in combination for each pump operating in a parallel application). Select pumps operating in parallel operation to cross the system curve when operating individually.

2.3 HYDRONIC PUMPS

Provide centrifugal, [single-stage type,][or][multi-stage type,] designed for HVAC service in the following configurations:

Configuration	Pump No.
Small In-Line	[_____]
Large In-Line	[_____]

2.3.1 Small In-Line

Provide pumps with capacities as indicated,suitable for 225 degrees F operation at [175][_____] psig working pressure. The pump must be single stage, in-line design, in cast iron bronze fitted construction. The pump internals must be capable of being serviced without disturbing piping connections.

2.3.1.1 Pump Shaft

The pump must have a solid steel shaft with a coupler between the pump and motor shafts. For non-stainless steel shafts, employ a non-ferrous shaft sleeve to completely cover the wetted area under the seal.

2.3.1.2 Bearing

The bearing assembly must house maintenance-free permanently lubricated bearings.

2.3.1.3 Seal Assembly

Equip the pump with an internal self-flushing mechanical seal assembly. Seal assembly must have Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

2.3.1.4 Impeller

Provide impeller of cast bronze or brass material. Impeller must be hydraulically and dynamically balanced to HI 9.6.4 balance grade G6.3, keyed to the shaft and secured by a locking capscrew or nut.

2.3.1.5 Volute

Pump volute must be of cast iron. The connection style on cast iron pumps must be flanged.

2.3.1.6 Motor Mount

To ensure alignment, mount the motor to the bearing assembly via a bolted motor bracket assembly. Use a replaceable resilient rubber motor mount to assist in aligning the motor shaft with the pump shaft.

2.3.1.7 Motors

NEMA MG 1; premium efficiency; non-overloading at any point on the pump curve; maintenance free with permanently lubricated bearings; and resilient mounted for smaller sizes, rigid mounted otherwise.

2.3.2 Large In-Line

Provide pumps with capacities as indicated; [split-coupled] [closed coupled], in-line, single stage, for installation in [vertical] [horizontal (where close coupled)] position, and. suitable for 225 degrees F operation at [175][_____] psig working pressure. The pump internals must be capable of being serviced without disturbing piping connections.

2.3.2.1 Casing

Provide pump casing complying with ASTM A48/A48M Class 30 cast iron, suitable for [175][_____] psig working pressure with integral cast iron flanges drilled for ASME B16.1 [ANSI Class 125] [ANSI Class 250] flanges, with an integrally-cast support ring matching an Class 125 flange for pump support. The pump volute must include gauge tappings at suction and discharge nozzles along with vent and drain tappings at top and bottom.

2.3.2.2 Pump Shaft

Provide carbon or stainless steel pump shaft, guided by a carbon graphite lower throttle bushing. Carbon steel pump shaft must have a bronze shaft sleeve that completely covers the wetted area under the seal.

2.3.2.3 Seal Assembly

Equip the pump with a mechanical seal assembly consisting of a carbon seal rotating ring, stainless steel spring, ceramic seat and flexible bellows and gasket. The liquid cavity must have a tapped flush line with manual valve to remove air from the seal chamber to allow fast initial start-up and insure mechanical seal cooling.

2.3.2.4 Spacer Coupling

The axially split spacer coupling must be of high tensile aluminum, split to allow the servicing of the seal without disturbing the pump or motor. Pump coupler must be aligned by the manufacturer before shipment. The motor bracket must contain a carbon steel coupler guard conforming to 29 CFR 1910.219 standards for safety.

2.3.2.5 Impeller

Hydraulically and dynamically balance the impeller to HI 9.6.4 balance

grade G6.3, closed, single suction, fabricated from cast bronze, keyed to the shaft and secured by a locking capscrew.

2.3.2.6 Motor

Electric motors must meet NEMA MG 1 and the horsepower, speed, voltage, indicated. Motor enclosure must be open drip proof[, totally enclosed fan cooled], with heavy duty grease lubricated ball bearings completely adequate for the maximum load for which the motor is designed. Motor must be non-overloading at any point on the pump curve and premium efficiency. Provide motor efficiencies as shown in the ICC IgCC standard. Totally enclosed fan cooled motor efficiencies must be as shown in NEMA MG 1.

Include one-piece combination motor bracket and volute coverplate in the assembly to ensure concentric alignment of the motor to the pump casing.

2.4 ELECTRICAL WORK

Provide electrical motor driven equipment specified herein complete with motors, motor starters, and controls. Provide electric equipment and wiring in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics must be as indicated. Provide motor starters complete with properly sized thermal overload protection in each phase and other appurtenances necessary for the motor control specified. Each motor must be of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor when operating at proper electrical system voltage and frequency. Manual or automatic control and protective or signal devices required for the operation herein specified and any control wiring required for controls and devices but not indicated must be provided under this section of the specifications.

2.5 ELECTRICAL EQUIPMENT

Provide electrical equipment in conformance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical motor driven equipment herein specified complete with motors, motor starters, and controls. Motor controls, equipment, and wiring must be in accordance with NFPA 70.

2.5.1 Electric Motors

Drive each electric motor-driven pump by a continuous-duty electric motor with enclosure type for specific service as defined in paragraph HYDRONIC PUMPS. Motor must have a [1.5] [_____] service factor. Provide [squirrel-cage induction][synchronous] motors having normal-starting-torque and low-starting-current characteristics, and of sufficient size so that the nameplate horsepower rating will not be exceeded throughout the entire published pump characteristic curve. Integral size motors must be the premium efficiency type in accordance with NEMA MG 1. Pump electric motor efficiencies must meet or exceed the requirements of the ICC IgCC standard. Motor bearings must provide smooth operations under the conditions encountered for the life of the motor. Provide adequate thrust bearing in the motor to carry the weight of all rotating parts plus the hydraulic thrust and be capable of withstanding upthrust imposed during pump starting[and under variable pumping head conditions specified]. Motors must be rated [_____] volts, [_____] phase, 60 Hz and such rating must be stamped on the nameplate. Provide motors in conformance with NEMA MG 1.

2.5.2 Control Equipment

[Manually controlled pumps must have START-STOP pushbutton in cover.][Automatically controlled pumps must have three-position "MANUAL-OFF-AUTOMATIC" selector switch in cover.] Provide additional controls or protective devices as indicated. [Install a pump low-water cutoff [in the well][on the suction pipe] and must shut the pump off when the water level in the well reaches the level shown.]

2.5.3 Variable Speed Control

The variable speed motor controllers must meet the requirements of UFGS 26 29 23 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.

2.6 EQUIPMENT APPURTENANCES

2.6.1 Attachments

Furnish all necessary bolts, nuts, washers, bolt sleeves, and other types of attachments with the equipment for the installation of the equipment. Bolts conform to the requirements of ASTM A307 and hexagonal nuts of the same quality as the bolts used. Threads must be clean-cut and conform to ASME B1.1. Bolts, nuts, and washers specified to be galvanized or not otherwise indicated or specified, must be zinc coated after being threaded, by the hot-dip process conforming to [ASTM A123/A123M][ASTM A153/A153M] as appropriate. Bolts, nuts, and washers specified or indicated to be stainless steel must be Type 316.

2.6.2 Equipment Guards

Provide equipment driven by open shafts, belts, chains, or gears with all-metal guards enclosing the drive mechanism. Secure guards in position with steel braces or straps that permit easy removal for servicing the equipment. Coupler guards must comply with current national safety standards including 29 CFR 1910.219 and NEMA Z535.4. Provide guards with gaps no greater than 0.250 inches, safety orange in color, and have an NEMA Z535.4 compliant warning label.

2.6.3 Tools

Furnish a complete set of all special tools which may be necessary for the adjustment, operation, maintenance, and disassembly of all equipment. Special tools are considered to be those tools which because of their limited use are not normally available, but which are necessary for the particular equipment. Special tools must be high-grade, smooth, forged, alloy, tool steel. Furnish one pressure grease gun for each type of grease required. Deliver all tools at the same time as the equipment to which they pertain. Properly store and safeguard such tools until completion of the work, at which time deliver them to the Contracting Officer.

2.7 FINISHES

All motors, pump casings, and similar parts of equipment must be thoroughly cleaned, primed, and given two finish coats of paint at the factory in accordance with the recommendations of the manufacturer. Give ferrous surfaces not to be painted a shop coat of grease or other suitable rust-resistant coating.

[2.8 FACTORY TESTS

Pumps must be tested by the manufacturer or a nationally recognized testing agency in compliance with HI 1.3. Submit certified test results.

]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

Install each pump and motor in accordance with the written instructions of the manufacturer[and under the direct supervision of the manufacturer's representative]. Provide access space around the device for servicing no less than the minimum recommended by the manufacturer.

[3.2.1 Base Mounted, Long-Coupled Pumps

Set the pump baseplate as follows.

a. Place two sets of shims or wedges for each foundation bolt. Lower baseplate onto foundation bolts and level baseplate both lengthwise and across by adding or removing shims or mount wedges. A maximum difference of 0.125 inches lengthwise and 0.059 inches across is allowable.

b. Mount pump and driver on baseplate if not already mounted at factory. Pump and driver shafts must have initial cold (pump and driver at ambient temperature) alignment check and final hot (pump and driver at operating temperature) alignment check. Perform cold alignment check before baseplate is grouted, after baseplate is grouted, and after piping is connected. Perform final alignment check when pump and driver are at operating temperature. Move or shim only the driver to make adjustments to prevent strain on the piping installations. Initial alignment may be performed with scales, straight edges and calipers. Final alignment must be done with dial gauges or laser alignment devices. Final alignment misalignment may not exceed coupling manufacturer's maximum parallel and angular misalignment values. When using variable frequency drives, reduce the manufacturer's misalignment values by 50 percent. Remove flexible coupling when performing alignment.

c. Support the connecting piping to ensure that there are no piping loads at the pump flange connections and connecting piping is not forced into position. [Use concrete for equipment foundations as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Provide concrete foundations that are integral with and of the same class as that of the building floor unless otherwise indicated. Use concrete having a compressive strength of at least 2,500 psi in foundations that are entirely separated from the surrounding floor. Install a premolded filler strip between the foundation and floor slab as shown. Furnish foundation bolts, as required, for proper positioning during the placement of the concrete.]

]3.3 FIELD QUALITY CONTROL

After installation of the pumping units and appurtenances, including coupling guard, is complete, carry out operating tests to assure that the pumping installation operates properly.[Make arrangements to have the manufacturer's representatives present when field equipment tests are made.] Give each pumping unit a running field test in the presence of the Contracting Officer for a minimum of 2 hours. Operate each pumping unit at its rated capacity or such other point on its head-capacity curve selected by the Contracting Officer. Provide an accurate and acceptable method of measuring the discharge flow. Tests must assure that the units and appurtenances have been installed correctly, that there is no objectionable heating, vibration, or noise from any parts, and that all manual and automatic controls function properly. If any deficiencies are revealed during any tests, correct such deficiencies and reconduct the tests.

Submit 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 must indicate the final position of controls.

3.4 FIELD PAINTING

Do not paint stainless steel, galvanized steel, and nonferrous surfaces.

3.4.1 Touch-up painting

Factory painted items requiring touching up in the field must be thoroughly cleaned of all foreign material, and primed and topcoated with the manufacturer's standard factory finish.

3.4.2 Exposed Ferrous Surfaces

Paint exposed ferrous surfaces with two coats of enamel paint conforming to SSPC Paint 21. Solvent clean factory primed surfaces before painting. Surfaces that have not been factory primed must be prepared and primed with one coat of SSPC Paint 25 or in accordance with the enamel paint manufacturer's recommendations.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Operation and Maintenance Manuals

Submit one complete set at the time the tests procedure is submitted; remaining sets before the contract is completed. Permanently bind each in a hard cover. Inscribe the following identification on the covers: the words "OPERATING AND MAINTENANCE INSTRUCTIONS," name and location of the building, name of the Contractor, and contract number. Place flysheets before instructions covering each subject. Use 8-1/2 by 11 inches paper for instruction sheets, with large sheets of drawings folded in.

Include, but do not limit to, the following in the Instructions:

a. System layout showing piping, valves, and controls.

b. Approved wiring and control diagrams[including variable frequency drives].

c. A control sequence describing startup, operation, and shutdown.

d. Operating and maintenance instructions for each piece of equipment, including task list for routine maintenance, routine inspections, intermediate inspections, and annual inspections; lubrication instructions; and troubleshooting guide.

e. Manufacturer's bulletins, cuts, and descriptive data; and parts list and recommended spare parts.

3.5.2 Training

Upon completion of the work, and at a time designated by the Contracting Officer, provide the services of one or more competent engineers for a training period of not less than [_____] hours to instruct a representative of the Government in the contents of the operation and maintenance manuals for the equipment furnished under these specifications. These field instructions must cover all the items contained in the bound instructions. Submit the training course curriculum and training instructions 14 days prior to the start of training.

-- End of Section --

SECTION 23 23 00

REFRIGERANT PIPING
08/21

PART 1 GENERAL

1.1 REFERENCES

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

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 710 I-P	(2009) Performance Rating of Liquid-Line Driers
AHRI 720	(2002) Refrigerant Access Valves and Hose Connectors
AHRI 750 I-P	(2016) Performance Rating of Thermostatic Refrigerant Expansion Valves
AHRI 760 I-P	(2014) Performance Rating of Solenoid Valves for Use with Volatile Refrigerants
AHRI 1370 I-P	(2017) Performance Rating of Electronic Expansion Valves

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

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 17	(2015) Method of Testing Capacity of Thermostatic Refrigerant Expansion Valves
ASHRAE 90.1 - IP	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

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	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding

Fittings

ASME B16.11 (2016) Forged Fittings, Socket-Welding and Threaded

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 B31.1 (2020) Power Piping

ASME B31.5 (2020) Refrigeration Piping and Heat Transfer Components

ASME B31.9 (2020) 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 WELDING SOCIETY (AWS)

AWS A5.8/A5.8M (2019) Specification for Filler Metals for Brazing and Braze Welding

AWS A5.31/A5.31M (2012) Specification for Fluxes 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 A193/A193M (2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications

ASTM A334/A334M (2004a; R 2016) Standard Specification for Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service

ASTM A653/A653M (2020) Standard Specification for Steel

	Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B32	(2020) Standard Specification for Solder Metal
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B280	(2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
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 D3308	(2012; R 2017) Standard Specification for PTFE Resin Skived Tape
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

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

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019) Structural Engineering

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Refrigerant Piping System; G, AE

SD-03 Product Data

Refrigerant Piping System

Spare Parts

Qualifications

Refrigerant Piping Tests

Verification of Dimensions

SD-06 Test Reports

Refrigerant Piping Tests

SD-07 Certificates

Service Organization

SD-10 Operation and Maintenance Data

Maintenance; G, AE

Operation and Maintenance Manuals; G, AE

Demonstrations; G, AE

1.3 QUALITY ASSURANCE

1.3.1 Qualifications

Submit [_____] copies of qualified procedures, and list of names and identification symbols of qualified welders and welding operators, prior to non-factory welding operations.[Weld piping in accordance with the qualified procedures using performance qualified welders and welding operators. Procedures and welders must 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. Notify the Contracting Officer 24 hours in advance of tests to be performed at the work site, if practical. The welder or welding operator must apply the personally assigned symbol near each weld made, as a permanent record. Weld structural members in accordance with Section [05 05 23.16 STRUCTURAL WELDING][05 12 00 STRUCTURAL STEEL].][Welding and nondestructive testing procedures are specified in Section [40 05 13.96 WELDING PROCESS PIPING][40 17 26.00 20 WELDING PROCESS PIPING].]

1.3.2 Contract Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. 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.

1.4 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 is the Contractor's responsibility. Replace any materials found to be damaged at the Contractor's expense. During installation, cap piping and similar openings to keep out dirt and other foreign matter.

1.5 MAINTENANCE

1.5.1 General

Submit Data Package 2 plus operation and maintenance data complying with the requirements of Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein.

1.5.2 Extra Materials

Submit spare parts data for each different item of equipment specified, after approval of detail drawings and not later than [_____] months prior to the date of beneficial occupancy. 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 in the data.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

a. Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship and that have been in satisfactory commercial or industrial use for 2 years prior to bid opening.

b. The 2 year use must include 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.

c. Products must be supported by a service organization. System components must be environmentally suitable for the indicated locations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. 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.

d. Exposed equipment 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. Install safety devices so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.

e. Provide the manufacturer's standard catalog data, at least [5 weeks] [_____] prior to the purchase or installation of a particular component. Highlight the data to show information such as, but not limited to, material, size, options, performance charts, and curves in adequate detail to demonstrate compliance with contract requirements. Include the manufacturer's recommended installation instructions and procedures in the data provided. Provide data for the following components as a minimum:

(1) Piping and Fittings
(2) Valves
(3) Piping Accessories
(4) Pipe Hangers, Inserts, and Supports

2.2 ELECTRICAL WORK

[Electrical equipment and wiring must be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Field wiring must be in accordance with manufacturer's instructions.] [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.]

2.3 REFRIGERANT PIPING SYSTEM

Provide refrigerant piping, valves, fittings, and accessories in accordance with ASHRAE 15 & 34 and ASME B31.5, except as specified herein. Refrigerant piping, valves, fittings, and accessories must be compatible with the fluids used and capable of withstanding the pressures and temperatures of the service. Refrigerant piping, valves, and accessories used for refrigerant service must be cleaned, dehydrated, and sealed (capped or plugged) prior to shipment from the manufacturer's plant. Submit drawings, at least [5] [_____] weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements. Drawings must consist of:

a. Piping layouts which identify all valves and fittings.

b. Plans and elevations which identify clearances required for maintenance and operation.

2.4 PIPE, FITTINGS AND END CONNECTIONS (JOINTS)

2.4.1 Steel Pipe

Steel pipe for refrigerant service must conform to ASTM A53/A53M, Schedule 40, Type E or S, Grades A or B. Do not use Type F pipe.

2.4.1.1 Welded Fittings and Connections

Butt-welded fittings must conform to ASME B16.9. Socket-welded fittings must conform to ASME B16.11. Identify welded fittings with the appropriate grade and marking symbol. Welded valves and pipe connections (both butt-welds and socket-welds types) must conform to ASME B31.9.

2.4.1.2 Threaded Fittings and Connections

Threaded fitting must conform to ASME B16.3. Threaded valves and pipe connections must conform to ASME B1.20.1.

2.4.1.3 Flanged Fittings and Connections

Flanges must conform to ASME B16.5, Class 150. Gaskets must be non-asbestos compressed material in accordance with ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type. Gaskets must contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). Bolts, nuts, and bolt patterns must conform to ASME B16.5. Bolts must be high or intermediate strength material conforming to ASTM A193/A193M.

2.4.2 Steel Tubing

Tubing must be cold-rolled, electric-forged, welded-steel in accordance with ASTM A334/A334M, Grade 1. Joints and fittings must be socket type provided by the steel tubing manufacturer.

2.4.3 Copper Tubing

Provide copper tubing conforming to ASTM B280 annealed or hard drawn as required. Copper tubing must bear the product identification markings in accordance with ASTM B280, "ACR" must be present on copper tubing. Copper tubing must be soft annealed where bending is required and hard drawn where no bending is required. Soft annealed copper tubing must not be used in sizes larger than 1-3/8 inches. Joints must be brazed except that joints on lines 7/8 inchand smaller may be flared. Cast copper alloy fittings for flared copper tube must conform to ASME B16.26 and ASTM B62. Wrought copper and bronze solder-joint pressure fittings must conform to ASME B16.22 and ASTM B75/B75M. Joints and fittings for brazed joint must be wrought-copper or forged-brass sweat fittings. Cast sweat-type joints and fittings are not allowed for 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.

2.4.4 Solder

Solder must conform to ASTM B32, grade Sb5, tin-antimony alloy for service pressures up to 150 psig. Solder flux must be liquid or paste form, non-corrosive and conform to ASTM B813.

2.4.5 Brazing Filler Metal

Filler metal must conform to AWS A5.8/A5.8M, Type BAg-5 with AWS Type FB3-A or Type FB3-C flux, except Type BCuP-3, BCuP-4, or BCuP-5 may be used for brazing copper-to-copper joints. BAlSi-4 with AWS Type FB1-A flux may be used when joining copper piping to aluminum components.

2.4.6 Brazing Flux

Brazing flux must conform to AWS A5.31/A5.31M, Type FB3-A or Type FB3-C when using Type BAg-5 filler metal. Type FB1-A is to be used with Type BAlSi-4 filler metal.

2.4.7 Press Fittings

Press fittings are not acceptable for use in refrigerant piping systems.

2.5 VALVES

Valves must be designed, manufactured, and tested specifically for refrigerant service. The valve material and all internal components must be compatible with the specific refrigerant and lubricant used. Valve bodies must be of brass, bronze, steel, or ductile iron construction. Valves 1 inch and smaller must have brazed or socket welded connections. Valves larger than 1 inch must have [tongue-and-groove flanged] [butt welded] end connections. Do not use threaded end connections, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Internal parts must be removable for inspection or replacement without applying heat or breaking pipe connections. Valve stems exposed to the atmosphere must be stainless steel or corrosion resistant metal plated carbon steel. Direction of flow must be legibly and permanently indicated on the valve body. Control valve inlets must be fitted with integral or adapted strainer or filter where recommended or required by the manufacturer. Purge, charge and receiver valves must be of manufacturer's standard configuration.

2.5.1 Refrigerant Stop Valves

Valve must be the globe or full-port ball type with a back-seating stem especially packed for refrigerant service. Valve packing must be replaceable under line pressure. Provide valve with a [handwheel] [or] [wrench] operator and a seal cap. Valve must be the straight or angle pattern design as indicated.

2.5.2 Check Valves

Valve must be the swing or lift type as required to provide positive shutoff at the differential pressure indicated. Valve must be provided with resilient seat.

2.5.3 Liquid Solenoid Valves

Provide valves that comply with AHRI 760 I-P and are suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions. Valves must be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions must be furnished. Provide solenoid coils that are moisture-proof, UL approved, totally encapsulated or encapsulated and metal jacketed as required. Valves must have safe working pressure of 610 psi and a maximum operating pressure differential of at least 200 psi at 85 percent rated voltage. Valves must have an operating pressure differential suitable for the refrigerant used.

2.5.4 Expansion Valves

Provide valve conforming to AHRI 750 I-P and ASHRAE 17. Valve must be the diaphragm and spring-loaded type with internal or external equalizers, and bulb and capillary tubing. Provide valve with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 2 degrees F of saturated suction temperature at evaporator conditions. Bulb charge must be determined by the manufacturer for the application and such that liquid will remain in the bulb at all operating conditions. Do not use

gas limited liquid charged valves and other valve devices for limiting evaporator pressure without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body. Pilot-operated valves must have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. Provide an isolatable pressure gauge in the pilot line, at the main valve. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicted or for constant evaporator loads.

2.5.5 Electronic Expansion Valves

Valve must conform to AHRI 1370 I-P and ASHRAE 17. The valve must prevent the return of liquid to the compressor in the event of power loss or low superheat.

2.5.6 Safety Relief Valves

Valve must be the two-way type, unless indicated otherwise. Valve must bear the ASME code symbol. Valve capacity must be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve must be of an automatically reseating design after activation.

2.5.7 Evaporator Pressure Regulators, Direct-Acting

Valve must include a diaphragm/spring assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve must maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load must not exceed the pressure difference corresponding to a 2 degrees F change in saturated refrigerant temperature at evaporator operating suction temperature. Spring must be selected for indicated maximum allowable suction pressure range.

2.5.8 Refrigerant Access Valves

Provide refrigerant access valves and hose connections in accordance with AHRI 720.

2.6 PIPING ACCESSORIES

2.6.1 Filter Driers

Driers must conform to AHRI 710 I-P. Sizes 5/8 inch and larger must be the full flow, replaceable core type. Sizes 1/2 inch and smaller must be the sealed type. Cores must be of suitable desiccant that will not plug, cake, dust, channel, or break down, and must remove water, acid, and foreign material from the refrigerant. Constructfilter driers so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure must be 1,500 psi.

2.6.2 Sight Glass and Liquid Level Indicator

2.6.2.1 Assembly and Components

Assembly must be pressure- and temperature-rated and constructed of materials suitable for the service. Glass must be borosilicate type. Ferrous components subject to condensation must be electro-galvanized.

2.6.2.2 Gauge Glass

Gauge glass must include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

2.6.2.3 Bull's-Eye and Inline Sight Glass Reflex Lens

Provide bull's-eye and inline sight glass reflex lens for dead-end liquid service. For pipe line mounting, provide two plain lenses in one body suitable for backlighted viewing.

2.6.2.4 Moisture Indicator

Indicator must be a self-reversible action, moisture reactive, color changing media. Indicator must be furnished with full-color-printing tag containing color, moisture, and temperature criteria. Unless otherwise indicated, the moisture indicator must be an integral part of each corresponding sight glass.

2.6.3 Vibration Dampeners

Dampeners must be of the all-metallic bellows and woven-wire type.

2.6.4 Flexible Pipe Connectors

Connector must be a composite of interior corrugated phosphor bronze or Type 300 Series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly must be constructed with a safety factor of not less than 4 at300 degrees F. Unless otherwise indicated, the length of a flexible connector must be as recommended by the manufacturer for the service intended.

2.6.5 Strainers

Strainers used in refrigerant service must have brass or cast-iron body, Y-or angle-pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than ten times the pipe diameter with pressure rating compatible with the refrigerant service. Screens must be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

2.6.6 Pressure and Vacuum Gauges

Provide gauges conforming to ASME B40.100 with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge must be a minimum of 3-1/2 inches in diameter with a range from 0 psig to approximately 1.5 times the maximum system working pressure. Select each gauge range so that at normal operating pressure, the needle is within the middle-third of the range.

2.6.7 Temperature Gauges

Provide industrial duty type temperature gauges for the required temperature range. Gauges must have Fahrenheit scale in 2 degrees graduations scale (black numbers) on a white face. The pointer must be adjustable. Provide rigid stem type temperature gauges in thermowells

located within 5 feet of the finished floor. Provide universal adjustable angle type or remote element type temperature gauges in thermowells located 5 to 7 feet above the finished floor. Provide remote element type temperature gauges in thermowells located 7 feet above the finished floor.

2.6.7.1 Stem Cased-Glass

Provide stem cased-glass case composed of polished stainless steel or cast aluminum, 9 inches long, with clear acrylic lens, and non-mercury filled glass tube with indicating-fluid column.

2.6.7.2 Bimetallic Dial

Provide bimetallic dial type case that is greater than 3-1/2 inches, stainless steel, and hermetically sealed with clear acrylic lens. Bimetallic element must be silicone dampened and unit fitted with external calibrator adjustment. Accuracy must be one percent of dial range.

2.6.7.3 Liquid-, Solid-, and Vapor-Filled Dial

Provide liquid-, solid-, and vapor-filled dial type cases that are greater than 3-1/2 inches, stainless steel or cast aluminum with clear acrylic lens. Fill must be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing must be double-braided bronze.

2.6.7.4 Thermowell

Thermowell must 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 must not be used in thermometers. Extended neck thermowells must be of sufficient length to clear insulation thickness by 1 inch.

2.6.8 Pipe Hangers, Inserts, and Supports

Provide pipe hangers, inserts, guides, and supports conforming to MSS SP-58.

2.6.9 Escutcheons

Escutcheons must be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

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 [125] [500] 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

Factory installed insulation must be in accordance with ASHRAE 90.1 - IP. [Refrigerant suction lines between the cooler and each compressor [and cold gas inlet connections to gas cooled motors]] [Refrigerant pumps and exposed chilled water lines on absorption chillers] must be insulated with not less than 1/2 inch thick unicellular plastic foam. 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 25 and a smoke developed index no higher than 50. 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. Test insulation in the same density and installed thickness as the material to be used in the actual construction. Test material supplied by a manufacturer with a jacket as a composite material. Provide jackets, facings, and adhesives that have a flame spread index less than 25 and a smoke developed index less than 50 when tested in accordance with ASTM E84.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, perform a verification of dimensions in the field. Submit a letter, at least [2] [_____] weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found before performing any work.

3.2 INSTALLATION

Pipe and fitting installation must conform to the requirements of ASME B31.1. 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 by reaming, and permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers.

3.2.1 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 must not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted.

3.2.2 Functional Requirements

Install piping 1/2 inch/10 feet of pipe in the direction of flow to ensure adequate oil drainage. Properly cap or plug open ends of refrigerant lines or equipment during installation to keep moisture, dirt, or other foreign material out of the system. Piping must remain capped until installation. Equipment piping must be in accordance with the

equipment manufacturer's recommendations and the contract drawings. Equipment and piping arrangements must fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance.

3.2.3 Fittings and End Connections

3.2.3.1 Threaded Connections

Make threaded connections with tapered threads and make tight with PTFE tape complying with ASTM D3308 or equivalent thread-joint compound applied to the male threads only. Do not show more than three threads after the joint is made.

3.2.3.2 Brazed Connections

Perform brazing in accordance with AWS BRH, except as modified herein. During brazing, fill the pipe and fittings with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, clean both the outside of the tube and the inside of the fitting with a wire fitting brush until the entire joint surface is bright and clean. Do not use brazing flux on copper-to-copper connections. Remove surplus brazing material at all joints. Make steel tubing joints in accordance with the manufacturer's recommendations. Paint joints in steel tubing with the same material as the baked-on coating within 8 hours after joints are made. Protect tubing against oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Support piping prior to brazing and do not spring or force.

3.2.3.3 Welded Connections

Fusion-weld joints in steel refrigerant piping. Make branch connections with welding tees or forged welding branch outlets. Thoroughly clean pipe of all scale and foreign matter before the piping is assembled. During welding, fill the pipe and fittings with an inert gas, such as nitrogen, to prevent the formation of scale. Beveling, alignment, heat treatment, and inspection of weld must conform to ASME B31.1. Remove and reweld weld defects at no additional cost to the Government. Store and dry electrodes in accordance with AWS D1.1/D1.1M or as recommended by the manufacturer. Do not use electrodes that have been wetted or that have lost any of their coating

3.2.3.4 Flared Connections

When flared connections are used, use a suitable lubricant between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.2.3.5 Flanged Connections

When steel refrigerant piping is used, provide union or flange joints in each line immediately preceding the connection to each piece of equipment requiring maintenance, such as compressors, coils, chillers, control valves, and other similar items. Flanged joints must be assembled square end tight with matched flanges, gaskets, and bolts. Provide gaskets that are suitable for use with the refrigerants to be handled.

3.2.4 Valves

3.2.4.1 General

Install refrigerant stop valves on each side of each piece of equipment such as compressors condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Install stop valves with stems horizontal unless otherwise indicated. Install ball valves must be installed with stems positioned to facilitate operation and maintenance. Isolating valves for pressure gauges and switches must be external to thermal insulation. Safety switches must not be fitted with isolation valves. Filter dryers having access ports may be considered a point of isolation. Purge valves must be provided at all points of systems where accumulated non-condensable gases would prevent proper system operation. Valves must be furnished to match line size, unless otherwise indicated or approved.

3.2.4.2 Expansion Valves

Install expansion valves with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 2-1/8 inches in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 2-1/8 inches. Fasten the bulb securely with two clamps. Insulate ehe bulb . Install the bulb in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb must be installed in a vertical line, the bulb tubing must be facing up.

3.2.4.3 Valve Identification

Tag each system valve, including those which are part of a factory assembly. Tags must be in alphanumeric sequence, progressing in direction of fluid flow. Tags must be embossed, engraved, or stamped plastic or nonferrous metal of various shapes, sized approximately 1-3/8 inch diameter, or equivalent dimension, substantially attached to a component or immediately adjacent thereto. Attach tags with nonferrous, heavy duty, bead or link chain, 14 gauge annealed wire, nylon cable bands or as approved. Reference tag numbers in Operation and Maintenance Manuals and system diagrams.

3.2.5 Vibration Dampers

Provide vibration damper in the suction and discharge lines on spring mounted compressors. Install vibration dampers parallel with the shaft of the compressor and anchor firmly at the upstream end on the suction line and the downstream end in the discharge line.

3.2.6 Strainers

Provide strainers immediately ahead of solenoid valves and expansion devices. Strainers may be an integral part of an expansion valve.

3.2.7 Filter Dryer

Provide a liquid line filter dryer on each refrigerant circuit located such that all liquid refrigerant passes through a filter dryer. Size dryers in accordance with the manufacturer's recommendations for the system in which it is installed. Install dryers such that it can be

isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Install dryers in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

3.2.8 Sight Glass

Install a moisture indicating sight glass in all refrigerant circuits down stream of all filter dryers and where indicated. Provide full line size sight glasses.

3.2.9 Discharge Line Oil Separator

Provide discharge line oil separator in the discharge line from each compressor. Connect the oil return line to the compressor as recommended by the compressor manufacturer.

3.2.10 Accumulator

Provide accumulators in the suction line to each compressor.

3.2.11 Flexible Pipe Connectors

Install connectors perpendicular to line of motion being isolated. Fit piping for equipment with bidirectional motion with two flexible connectors, in perpendicular planes. Install reinforced elastomer flexible connectors in accordance with manufacturer's instructions. Provide piping guides and restraints related to flexible connectors as required.

3.2.12 Temperature Gauges

Locate temperature gauges specifically on, but not limited to the following: [the sensing element of each automatic temperature control device where a thermometer is not an integral part thereof] [the liquid line leaving a receiver] [and] [the suction line at each evaporator or liquid cooler]. Thermowells for insertion thermometers and thermostats must extend beyond thermal insulation surface not less than 1 inch.

3.2.13 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports must conform to MSS SP-58, except as modified herein. Do not use pipe hanger types 5, 12, and 26. Fabricate hangers used to support piping 2 inches and larger to permit adequate adjustment after erection while still supporting the load. Support piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, by variable spring hangers and supports or by constant support hangers.

3.2.13.1 Hangers

Do not use Type 3 on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.2.13.2 Inserts

Secure Type 18 inserts 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.

3.2.13.3 C-Clamps

Torque Type 19 and 23 C-clamps in accordance with MSS SP-58 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.2.13.4 Angle Attachments

Furnish Type 20 attachments used on angles and channels with an added malleable-iron heel plate or adapter.

3.2.13.5 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, must be used on all pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Use Type 40 shields on all piping less than 4 inches and all piping 4 inches and larger carrying medium less than 60 degrees F. Use a high-density insulation insert of cellular glass under the Type 40 shield for piping 2 inches and larger.

3.2.13.6 Horizontal Pipe Supports

Space horizontal pipe supports as specified in MSS SP-58 and install a support no more than 1 foot from the pipe fitting joint at each change in direction of the piping. Space pipe supports no more than 5 feet apart at valves. [Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 50 pounds must have the excess hanger loads suspended from panel points.]

3.2.13.7 Vertical Pipe Supports

Support vertical pipe 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.

3.2.13.8 Pipe Guides

Provide Type 35 guides using, steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides where required to allow longitudinal pipe movement. Provide lateral restraints as required. Provide slide materials that are suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.2.13.9 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, usea Type 39 saddle. 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.

3.2.13.10 High Temperature Guides with Cradles

Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide must include a pipe cradle, welded to the guide structure and strapped securely to the pipe. Separate the pipe from the slide material by at least 4 inches, or by an amount adequate for the

insulation, whichever is greater.

3.2.13.11 Multiple Pipe Runs

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 must not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.2.13.12 Seismic Requirements

Support and brace piping and attached valves to resist seismic loads as specified under UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and [23 05 48.19 [SEISMIC] BRACING FOR HVAC] [22 05 48.00 20 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL] [as shown on the drawings]. Provide structural steel required for reinforcement to properly support piping, headers, and equipment but not shown under this section. Specify material used for support under Section 05 12 00 STRUCTURAL STEEL.

3.2.13.13 Structural Attachments

Attachment to building structure concrete and masonry must be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors must be applied with a safety factor not less than 5. Do not attach supports to metal decking. Construct masonry anchors for overhead applications of ferrous materials only. Provide structural steel brackets required to support piping, headers, and equipment, but not shown, under this section. Specify material used for support under Section 05 12 00 STRUCTURAL STEEL.

3.2.14 Pipe Alignment Guides

Provide pipe alignment guides 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.

3.2.15 Pipe Anchors

Provide anchors wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Provide anchors consisting of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Install anchor braces in the most effective manner to secure the desired results using turnbuckles where required. Do not attach supports, anchors, or stays 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, immediately anchor these items adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Submit detailed drawings of pipe anchors for approval before installation.

3.2.16 Building Surface Penetrations

Do not install sleeves in structural members except where indicated or approved. Provide galvanized sheet metal sleeves in non-load bearing surfaces conforming to ASTM A653/A653M, Coating Class G-90, 20 gauge. Provide uncoated carbon steel pipe sleeves in load bearing surfaces

conforming to ASTM A53/A53M, [Schedule 30] [Schedule 20] [Standard weight]. Apply sealants to moisture and oil-free surfaces and elastomers to not less than 1/2 inch depth. Do not install sleeves in structural members.

3.2.16.1 Refrigerated Space

Fit refrigerated space building surface penetrations with sleeves fabricated from hand-lay-up or helically wound, fibrous glass reinforced polyester or epoxy resin with a minimum thickness equal to equivalent size Schedule 40 steel pipe. Construct sleeves with integral collar or fit cold side with a bonded slip-on flange or extended collar. In the case of masonry penetrations where sleeve is not cast-in, fill voids with latex mixed mortar cast to shape of sleeve and assemble flange/external collar type sleeve with butyl elastomer vapor barrier sealant through penetration to cold side surface vapor barrier overlap and fastened to surface with masonry anchors. Flash integral cast-in collar type sleeve [as indicated.] [with not less than 4 inches of cold side vapor barrier overlap of sleeve surface.] Normally seal noninsulated penetrating round surfaces to sleeve bore with mechanically expandable seals in vapor tight manner and insulate remaining warm and cold side sleeve depth with not less than [4] [_____] inches of foamed-in-place rigid polyurethane or foamed-in-place silicone elastomer. Apply vapor barrier sealant to finish warm side insulation surface. Insulate warm side of penetrating surface beyond vapor barrier sealed sleeve insulation for a distance which prevents condensation. Seal wires in refrigerated space surface penetrating conduit with vapor barrier plugs or compound to prevent moisture migration through conduit and condensation therein.

3.2.16.2 General Service Areas

Extend each sleeve through its respective wall, floor, or roof, and cut flush with each surface. Provide pipes passing through concrete or masonry wall or concrete floors or roofs with pipe sleeves fitted into place at the time of construction. Provide sleeves that allow 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, seal the annular space between pipe and sleeve or between jacket over-insulation and sleeve in accordance with Section 07 92 00 JOINT SEALANTS.

3.2.16.3 Waterproof Penetrations

Install pipes passing through roof or floor waterproofing membrane through a 17 ounce copper sleeve, or a 0.032 inch thick aluminum sleeve, each within an integral skirt or flange. Form flashing sleeve, and extend skirt or flange greater than 8 inches from the pipe and set over the roof or floor membrane in a troweled coating of bituminous cement. Extend the flashing sleeve up the pipe a minimum of 2 inches above the roof or floor penetration. Seal the annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation as indicated. Seal penetrations by either one of the following methods.

3.2.16.3.1 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. Clamp waterproofing membrane into place and place sealant in the caulking recess.

3.2.16.3.2 Modular Mechanical Type Sealing Assembly

In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. Provide seals consisting 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. Loosely assemble links 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, tighten the bolt to cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Size each seal assembly as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals must provide sleeves of the proper diameters.

3.2.16.4 Fire-Rated Penetrations

Seal penetration of fire-rated walls, partitions, and floors as specified in Section 07 84 00 FIRESTOPPING.

3.2.16.5 Escutcheons

Provide escutcheons for finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Where sleeves project slightly from floors, use special deep-type escutcheons. Secure escutcheon to pipe or pipe covering.

3.2.17 Access Panels

Provide access panels for all concealed valves, vents, controls, and items requiring inspection or maintenance. Provide access panels of sufficient size and locate so that the concealed items may be serviced and maintained or completely removed and replaced. Provide access panels as specified in Section 08 31 00 ACCESS DOORS AND PANELS.

3.2.18 Field Applied Insulation

Field installed insulation is specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.2.19 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.

3.2.19.1 Color Coding

Color coding for piping identification is specified in Section 09 90 00 PAINTS AND COATINGS.

3.2.19.2 Color Coding Scheme

Provide a color coding scheme for locating hidden piping in accordance with [Section 22 00 00 PLUMBING, GENERAL PURPOSE][Section 22 00 70 PLUMBING, HEALTHCARE FACILITIES].

3.2.20 Identification Tags

Provide identification tags made of brass, engraved laminated plastic or engraved anodized aluminum indicating service and item number on all valves and dampers. Tags must be 1-3/8 inch minimum diameter and marking must be stamped or engraved. Indentations must be black for reading clarity. Attach tags to valves with No. 12 AWG copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.3 CLEANING AND ADJUSTING

Clean uncontaminated system(s) by evacuation and purging procedures currently recommended by refrigerant and refrigerant equipment manufacturers, and as specified herein, to remove small amounts of air and moisture. Systems containing moderate amounts of air, moisture, contaminated refrigerant, or any foreign matter are considered contaminated systems. Restore contaminated systems to clean condition including disassembly, component replacement, evacuation, flushing, purging, and re-charging, using currently approved refrigerant and refrigeration manufacturer's procedures. Restore contaminated systems at no additional cost to the Government as determined by the Contracting Officer. Do not use water in any procedure or test.

3.4 TRAINING COURSE

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. Conduct a training course for [_____] members of the operating staff as designated by the Contracting Officer. The training period must consist of a total [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests.

b. Cover all of the items contained in the approved operation and maintenance manuals as well as demonstrations of routine maintenance operations in the field posted instructions..

c. 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. Include the manufacturer's name, model number, and parts list in the booklets. Include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features in the manuals.

d. Submit [6] [_____] complete copies of maintenance manual in bound 8 1/2 x 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. Include piping layouts and simplified wiring and control diagrams of the system as installed in the manuals.

3.5 REFRIGERANT PIPING TESTS

After all components of the refrigerant system have been installed and connected, subject the entire refrigeration system to pneumatic, evacuation, and startup tests as described herein. Submit a schedule, at least [2] [_____] weeks prior to the start of related testing, for each test. Identify the proposed date, time, and location for each test. 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. Provide the services of a qualified technician, as required, to perform all tests and procedures indicated herein. Coordinate field tests with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Submit [6] [_____] copies of the tests report in bound 8 1/2 by 11 inch booklets documenting all phases of the tests performed. Include initial test summaries, all repairs/adjustments made, and the final test results in the report.

3.5.1 Preliminary Procedures

Prior to pneumatic testing, isolate equipment which has been factory tested and refrigerant charged as well as equipment which could be damaged or cause personnel injury by imposed test pressure, positive or negative, from the test pressure, or remove from the system. Remove safety relief valves and rupture discs that are not part of factory sealed systems, and cap or plug openings.

3.5.2 Pneumatic Test

Provide pressure control and excess pressure protection at the source of test pressure. Valves must be wide open, except those leading to the atmosphere. Test gas must be dry nitrogen, with minus 70 degree F dewpoint and less than 5 ppm oil. Apply test pressure in two stages before any refrigerant pipe is insulated or covered. In accordance with ASME B31.5, a preliminary test not to exceed 25 psi must be applied as a means of locating major leaks. Every joint being tested must be coated with a thick soap or color indicating solution. The second stage test pressure must be at least 110 percent of the design pressure, but cannot exceed 130 percent of the design pressure of any component in the system. For large systems that are not completely visible, the pressure in the system must be gradually increased to one-half of the test pressure after which the pressure must be increased in steps of one-tenth of the test pressure, until the required test pressure has been reached. The test pressure must be continuously maintained for at leas 24 hours, after which it can be reduced to the leak test pressure. A correction factor of 0.3 psi will be allowed for each degree F change between test space initial and final ambient temperature, plus for increase and minus for a decrease. The leak test pressure must be the design pressure, or a pressure specified in the engineering design. To repair leaks, the joint must be taken apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, re-melting, or back-welding/brazing are not acceptable. Following repair, the entire system must be retested using the pneumatic tests described above. Reassemble the entire system once the pneumatic tests are satisfactorily completed.

3.5.3 Evacuation Test

Following satisfactory completion of the pneumatic tests, relieve the pressure and evacuate the entire system to an absolute pressure of 300

micrometers. During evacuation of the system, the ambient temperature must be higher than 35 degrees F. Do not evacuate no more than one system at one time by one vacuum pump. Once the desired vacuum has been reached, close the vacuum line and allow the system to stand for 1 hour. If the pressure rises over 500 micrometers after the 1 hour period, evacuate the system again down to 300 micrometers and let set for another 1 hour period. Do not charge the system until a vacuum of at least 500 micrometers is maintained for a period of 1 hour without the assistance of a vacuum line. If during the testing the pressure rises above 500 micrometers, continue to repeat the evacuation procedures until all residual moisture has been removed. During evacuation, record pressures by a thermocouple-type, electronic-type, or a calibrated-micrometer type gauge.

3.5.4 System Charging and Startup Test

Following satisfactory completion of the evacuation tests, charge the system with the required amount of refrigerant by raising pressure to normal operating pressure and in accordance with manufacturer's procedures. Following charging, the system must operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. Test the entire system tested for leaks. Test fluorocarbon systems with halide torch or electronic leak detectors.

3.5.5 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system must be immediatelyisolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. The refrigerant must not be discharged into the atmosphere.

3.5.6 Contractor's Responsibility

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 will the allowable leak rate exceed the leak rates allowed in Section 608 of the Clean Air Act: 30 percent of the full charge per year for industrial refrigeration, 20 percent of the full charge per year for commercial refrigeration, and 10 percent of the full charge per year for comfort cooling. 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.

-- End of Section --

SECTION 23 25 00

CHEMICAL TREATMENT OF WATER FOR MECHANICAL SYSTEMS
05/21

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B40.100	(2013) Pressure Gauges and Gauge Attachments

ASTM INTERNATIONAL (ASTM)

ASTM D596	(2001; R 2018) Standard Guide for Reporting Results of Analysis of Water
ASTM D1384	(2005; R 2019) Corrosion Test for Engine Coolants in Glassware
ASTM D2688	(2015; E 2016) Standard Test Method for Corrosivity of Water in the Absence of Heat Transfer (Weight Loss Methods)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2018) Motors and Generators

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 200-1-13	(2016) Environmental Quality -- Minimizing the Risk of Legionellosis Associated with Building Water Systems on Army Installation
PWTB 420-49-5	(1998) Industrial Water Treatment Procedures

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-430-08N	(2004) Central Heating Plants

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00

SUBMITTAL PROCEDURES:

SD-03 Product Data

Water Treatment System; G, AE

Water Analysis; G, AE

Spare Parts

Field Instructions

Tests; G, AE

Training Course; G, AE

SD-06 Test Reports

SD-10 Operation and Maintenance Data

Water Treatment System

1.3 MAINTENANCE MATERIAL SUBMITTALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings, not later than [_____] months prior to the date of beneficial occupancy. Include a complete list of parts and supplies, with source of supply, with the data.

1.4 QUALITY CONTROL

1.4.1 Safety

Ensure 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 are insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired. Provide [catwalk,] [ladder,] [and guardrail] where indicated and in accordance with Section [05 50 13 MISCELLANEOUS METAL FABRICATIONS] [05 51 33 METAL LADDERS].

1.4.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. 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.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Summary

This section covers the provisions and installation procedures necessary for a complete and totally functional water system(s) chemical treatment. Provide and install the system with all necessary System Components, Accessories, Piping Components, and Supplemental Components/Services. Minimize to risk of Legionellosis by following the guidance in EM 200-1-13.

2.1.2 Standard Products

a. Provide materials and equipment which are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship and that have been in satisfactory commercial or industrial use for two years' prior to bid opening.

b. Include in the two-year use all applications of equipment and materials under similar circumstances and of similar size. Ensure the two years' experience has been 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 two-year field service record are 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.

c. All products are required to be supported by a service organization. Submit a certified list of qualified permanent service organizations for support of the equipment, including their addresses and qualifications. These service organizations are required to 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.

d. The selected service organization provides the chemicals required, the concentrations required, and the water treatment equipment sizes and flow rates required. The company provides all chemicals required for the [condenser] [condenser and chilled] water systems and fills the systems with chemicals to the levels specified. The chemical is required to meet the requirements of this specification as well as the recommendations from the manufacturers of the condenser and cooling tower. Acid treatment chemicals are not allowed to be used.

2.1.3 Water Analysis

Conditions of make-up water to be supplied to the boilers, cooling towers and chilled water systems reported in accordance with ASTM D596 are as follows:

Date of Sample	[_____]
Temperature	[_____] degrees C

Silica (SiO 2)	[_____] ppm (mg/L)
Insoluble	[_____] ppm (mg/L)
Iron, total (Fe)	[_____] ppm (mg/L)
Aluminum (Al)	[_____] ppm (mg/L)
Calcium (Ca)	[_____] ppm (mg/L)
Magnesium (Mg)	[_____] ppm (mg/L)
Carbonate (HCO 3)	[_____] ppm (mg/L)
Sulfate (SO 4)	[_____] ppm (mg/L)
Chloride (Cl)	[_____] ppm (mg/L)
Nitrate (NO 3)	[_____] ppm (mg/L)
Turbidity	[_____] ntu
pH	[_____]
Residual Chlorine	[_____] ppm (mg/L)
Total Alkalinity	[_____] ppm (mg/L)
Non-Carbonate Hardness	[_____] ppm (mg/L)
Total Hardness	[_____] ppm (mg/L)
Dissolved Solids	[_____] ppm (mg/L)
Conductivity	[_____] Micromho/cm

2.2 EQUIPMENT

2.2.1 Nameplates

Provide a nameplate for each major component of equipment that includes the manufacturer's name, address, type or style, and catalog or serial number securely attached to the item of equipment. Provide nameplates for:

a. Pump(s)

b. Pump Motor(s)

c. Water Treatment Controller(s)

2.2.2 Electrical Work

Ensure all electrical equipment, motors, motor efficiencies, and wiring complies with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical motor driven equipment specified complete with motors, motor starters, and controls. Provide electrical characteristics and enclosure

types as shown, and unless otherwise indicated, provide all motors of 1 horsepower and above with open, drip-proof, or totally enclosed fan cooled enclosures, high efficiency type. Perform field wiring in accordance with manufacturer's instructions. Each motor is required to conform to NEMA MG 1 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Provide continuous duty motors with the enclosure specified. Provide motor starters complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Furnish motors with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Furnish motor starters with [NEMA 1] [NEMA 3R] [NEMA [_____]] enclosures. Provide 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.

2.2.3 Gauges

Provide gauges that conform to ASME B40.100, Class 1, 2, or 3, Style X, Type I or III as required, 4-1/2 inches in diameter with phenolic or metal case.

2.3 COMPONENTS

2.3.1 Condenser Water Treatment Systems

The use of chemical-treatment products containing hexavalent chromium (Cr) is prohibited. Treat the water to be used in the condenser water systems to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Chemicals are required to meet all required federal, state, and local environmental regulations for the treatment of condenser-side heat exchangers, cooling towers and direct discharge to the sanitary sewer.

Provisions should be made to effectively dose, monitor and control a water treatment program to include (1) inhibitor and biocide injection (2) water sampling, (3) corrosion coupon sampling, and (4) effective bleed and control points.

2.3.1.1 Condenser Water Limits

Meet the following condenser water limits, unless dictated differently by the cooling tower or chiller manufacturer's recommendations:

Treatment type	Phosphonate/Polymer
Puckorius Index	4 minimum
Langelier Index	4 maximum
Total Dissolved Solids	5000 ppm maximum
Calcium Hardness	1200 ppm maximum
Silica	150 ppm maximum

pH	7.5 - 8.5

For treated condenser/cooling tower water, minimize blowdown until the first of one of the top 5 limits is reached. Specific requirements for treatment chemicals and levels are listed below in paragraphs dealing with small and large systems.

2.3.1.2 Glycol Solution

Coordinate minimum glycol concentration with manufacturer to avoid corrosion inhibitor degradation. Test the glycol in accordance with ASTM D1384 with less than 0.5 mils penetration per year for all system metals. Provide glycol that contains corrosion inhibitors. Silicate based inhibitors are not acceptable. Ensure the solution is compatible with pump seals, other elements of the system, and water treatment chemicals used within the system.

2.3.1.3 Chemical Treatment for Small Systems

For cooling systems with a capacity of 50 tons or less, provide the following chemical treatment. For corrosion control provide 15 to 20 pounds polyphosphate in nylon mesh bag in cooling tower sump. If biocide is needed, use either 1-bromo-3-chloro-5.5-dimethylhydantoin or gluteraldehyde as recommended by manufacturer.

2.3.1.4 Chemical Treatment for Large Systems

For cooling systems with capacities greater than 50 tons provide one of the three following chemical treatments with the limits indicated. The zinc and molybdate in the last two treatments help to meet the maximum corrosion requirements in waters that tend to be more corrosive. Maintain biocides to control bacteria below 10,000 colony forming units per milliliter.

a. Phosphonate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
TT	1-2 ppm
Biocides	as required

b. Zinc-Phosphonate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
Zinc	1-2 ppm

TT	1-2 ppm
Biocides	as required

c. Zinc-Molybdate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
Molybdate	10-15 ppm
Zinc	2-3 ppm
TT	1-2 ppm
Biocides	as required

2.3.1.4.1 General Requirements

Provide a water treatment system capable of automatically feeding chemicals and bleeding the system to prevent corrosion, scale, and biological formations. Submit [6] [_____] complete copies, at least 5 weeks prior to the purchase of the water treatment system, of the proposed water treatment plan including a layout; control scheme; a list of existing make-up water chemistry, including the items listed in paragraph Water Analysis; a list of treatment chemicals to be added; the proportion of chemicals to be added; the final treated water control levels; and a description of health, safety and environmental concerns for handling the chemicals plus any special ventilation requirements. Automatic chemical feed systems automatically feed chemicals into the condenser water based on makeup water rate. Use electrical signals from a water meter on the makeup water line to control the output of chemical feed pumps. Set the system initially manually based on the water analysis of the make-up water. Submit [6] [_____] complete copies of operating and maintenance manuals for the step-by-step water treatment procedures. Include in the manuals all testing procedures used in determining water quality.

2.3.1.4.2 Chemical Feed Pumps and Tanks

a. Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. Furnish chemical feed pumps of the positive displacement diaphragm type. Furnish all pump cylinders, plungers, ball check valves, and check valve bodies made of corrosion resistant materials suitable for the chemicals being pumped. Ensure the cylinders of the provided pumps are replaceable for increased or reduced pressure or capacity ranges.

b. Provide pumps with a flow rate adjustable from 0 to 100 percent while in operation. The volumetric accuracy of the pumps is required to be within one percent over the range indicated. Ensure pump capacities are adjustable by positioning crank pin with micrometer setscrews. Divide stroke length scale in percentage graduations engraved on scale. Ensure the discharge pressure of pumps is not less than 1.5

times the line pressure at the point of connection. Provide the pumps with a pressure relief valve and a check valve mounted in the pump discharge. Control the pump by an external controller/timer receiving signals from the makeup water meter.

c. Provide drive motors rated at 110 volt, single phase with drip-proof enclosures. Provide two chemical tanks constructed of [materials compatible with the chemicals to be stored in the tank] [high density polyethylene] [stainless steel] [fiber reinforced plastic] with a hinged cover and mounted on legs. Ensure tanks have filling and drain connections and gauge glasses. Furnish each tank with one pump, mounted and piped with pipe materials and fittings suitable for working pressure and compatible with the chemicals in the tank it is in contact with, with suction strainer and stainless steel screen, and with 1/2 inch relief valve with steel body and stainless steel trim. Provide a tank bottom that is dished concave to a radius equal to the diameter of the tank. Provide motor-driven agitator. Size the tanks to have sufficient capacity to require recharging only once per [7] [14] [21] [_____] days during normal operation.

2.3.1.4.3 Chemical Injection Assembly

Provide an injection assembly at each chemical feed point. Locate the injection assembly downstream of recirculating pumps and upstream of the condenser. Construct the injection assemblies of stainless steel. Locate the discharge of the assemblies in the condenser water piping as recommended by the manufacturer. Include with each assembly a shutoff valve and check valve at the point of entrance into the condenser water line.

2.3.1.4.4 Water Meter

Provide water meters with an electric contacting register and remote accumulative counter. Install the meter within the make-up water line, as indicated.

2.3.1.4.5 Timers

Provide timers which are of the automatic reset, adjustable type, and are electrically operated. Ensure the timers are designed to work with the contacting head water meters. Include the water meter cable with the timer. Ensure timers control operation of the chemical feed pumps and are suitable for a 120 volt current. Locate the timers within the water treatment control panel.

2.3.1.4.6 Bleed (Blowdown) Line

Control the flow through the bleed line by a conductivity meter and probe installed to measure the conductivity of the condenser water. Provide a high and low set point on the conductivity meter above which the meter opens a solenoid valve on the bleed line. Locate the bleed line attachment to the condenser water piping downstream of the recirculating pumps and upstream of the chemical injection point. Extend the bleed line to the nearest drain for continuous discharge.

2.3.1.4.7 Control Panel

Provide a NEMA 12 control panel enclosure suitable for surface mounting. Construct the panel of [stainless steel] [coated steel] with a hinged door

and lock. Include a laminated plastic nameplate identifying each of the following functions:

(1) Main power switch and indicating light
(2) MAN-OFF-AUTO selector switch
(3) Indicating lamp for bleed-off valve
(4) Indicating lamp for each chemical feed pump
(5) Set point reading for each timer

2.3.1.4.8 Chemical Piping

Construct the piping and fittings of [schedule 80 PVC] [stainless steel] suitable for the water treatment chemicals.

2.3.1.4.9 Sequence of Operation

Add chemicals based upon sensing the make-up water flow rate and activating appropriate timers. Provide a separate timer for each chemical. Control the blow down based upon the conductivity of the condenser water. Control the injection of the chemical required for biological control manually set for proper chemical feed. The water treatment company is required to determine and set a timer set points, blow down rates, and chemical pump flow rates.

2.3.1.4.10 Test Kits

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals.

2.3.2 Chilled Water System

Provide a [2] [5] [_____] gallon shot feeder on the chilled water piping as indicated. Furnish the feeder with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.3.2.1 Requirements for Glycol Solution

Coordinate minimum [ethylene][propylene] glycol concentration with manufacturer to avoid corrosion inhibitor degradation. Test the glycol in accordance with ASTM D1384 with less than 0.5 mils penetration per year for all system metals. Ensure the glycol contains corrosion inhibitors. Silicate based inhibitors are not acceptable. Ensure the solution is compatible with pump seals, other elements of the system, and water treatment chemicals used within the system.

2.3.2.2 Chilled Water Treatment

Treat chilled water with either a borax/nitrite type treatment or a molybdate type treatment. Both types of treatment are acceptable for use with glycol. Maintain borax/nitrite treatment at the limits of [ ] ppm nitrite, [ ] ppm copper corrosion inhibitor (TT or MBT), and pH of 8.5 to 9.5. Maintain molybdate treatment at the limits of [ ] ppm molybdate, [ ] ppm copper corrosion inhibitor (TT or MBT), and pH of 8.0 to 9.0.

2.3.2.3 Dual Temperature Systems

Dual hot/chilled water systems that are treated with borax/nitrite are also to be treated with a biocide.

2.3.2.4 Chilled Water Test Kits

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals (e.g. pH and nitrite or molybdate).

2.3.3 Low and Medium Temperature Hot Water Boilers and Heat Exchangers

Low and medium temperature hot water boilers are defined as those operating below 350 degrees F, (250 degrees F for Low Temperature).

2.3.3.1 Chemical Feeder

Provide a [2] [5] [_____] gallon shot feeder on the hot water piping as indicated. Base the size and capacity of feeder upon local requirements and water analysis. Furnish the feeder with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.3.3.2 Water Softening System

Provide a water softening system as specified in Section 22 31 00 WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE).

2.3.3.3 Low and Medium Temperature Hot Water Treatment

Treat hot water with either a borax/nitrite type treatment or a molybdate type treatment. Both types of treatment are acceptable to use with glycol. Maintain borax/nitrite treatment at the limits of 600 to 1000 ppm nitrite, 40 - 50 ppm copper corrosion inhibitor (TT or MBT) and pH of 8.5 to 9.5. Maintain molybdate treatment at the limits of 100 to 125 ppm molybdate, 40 - 50 ppm copper corrosion inhibitor (TT or MBT) and pH of 8.0 to 9.0.

2.3.3.4 Dual Temperature Systems

Dual hot/chilled water systems treated with borax/nitrite are required to also be treated with a biocide.

2.3.3.5 Test Kit Requirements

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals (e.g. pH and nitrite or molybdate).

2.3.4 High Temperature Hot Water Boilers

2.3.4.1 Chemical Feeder Unit

Provide a feeder unit for each boiler. Ensure chemical feeder provided is automatic proportioning, shot type, or pump type. Provide all appurtenances necessary to ensure the system performs in compliance with the requirements outlined herein. Base the size and capacity of feeder upon local requirements and water analysis.

2.3.4.2 Pumps and Tanks

a. Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. The chemical feed pumps

are required to be positive displacement diaphragm type. Furnish the pump cylinders, plungers, ball check valves, and check valve bodies fabricated from corrosion resistant materials suitable for the chemicals being pumped. Ensure cylinders used are replaceable for increased or reduced pressure or capacity ranges.

b. Provide for a flow rate of the pumps that is adjustable from 0 to 100 percent while in operation. Ensure volumetric accuracy of the pumps is within one percent over the range indicated. Ensure pump capacities are adjustable by positioning crank pin with micrometer setscrews. Divide stroke length scale in percentage graduations engraved on scale. Ensure the discharge pressure of pumps is not less than 1.5 times the line pressure at the point of connection. Design the pumps to feed the chemical solutions into the HTW return line to the system circulating pumps with a capacity to feed a maximum of [5] [_____] gph. Provide the pumps with a pressure relief valve and a check valve mounted in the pump discharge. Control the pumps by an external controller/timer receiving signals from the makeup water meter.

c. Provide drive motors that are 110 volt, single phase and have drip-proof enclosures. Provide the tanks constructed of [materials compatible with the chemicals to be stored in the tank] [high density polyethylene] [stainless steel] [fiber reinforced plastic] with a hinged cover and mounted on legs. Ensure tanks have both filling and drain connections and gauge glass. Furnish each tank with one pump, mounted and piped with black iron pipe and fittings suitable for working pressures and compatible with the chemicals in the tank it is in contact with, with suction strainer and stainless steel screen, and with 1/2 inch relief valve with steel body and stainless steel trim. Provide tank with a dished concave bottom to a radius equal to the diameter of the tank. Provide units suitable for phosphate, caustic feed and sulfite feeding. Provide sulfite tank with a floating cover to completely cover the surface of the solution. Include a motor-driven agitator. Size tanks to have sufficient capacity to require recharging only once per [7] [14] [21] [_____] days during normal operation.

d. For auto proportioning systems, provide controllers designed to be used with selected system specifically for the purpose of injecting chemicals into boiler systems.

e. Mount system components on metal buses or supports instead of mounting directly to the floor.

2.3.4.3 Water Softening System

Provide water softening system as specified in Section 22 31 00 WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE).

2.3.4.4 Treated Water Limits

Consult with the boiler manufacturer for the determination of the boiler water chemical composition limits. Provide for the following recirculating hot water chemical limits unless dictated differently by the boiler manufacturer's recommendations:

pH	9.3-9.9
Sulfite	30-60 ppm
Hardness	Less than 2.0 ppm

2.3.5 Test Kit

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals (e.g. pH, hardness and sulfite).

2.3.6 Steam Boiler Water Treatment

Provide a water treatment system capable of feeding chemicals and blowdown of the system to prevent corrosion and scale within the boiler and piping distribution system. Treat the water to maintain the conditions recommended by the boiler manufacturer or UFC 3-430-08N (Central Heating Plants) and PWTB 420-49-5 (Industrial Water Treatment Procedures). Provide chemicals that meet all required federal, state, and local environmental regulations for the treatment of boilers and discharge to the sanitary sewer. Engage the services of a company regularly engaged in the treatment of boilers to determine the correct concentrations required for water treatment. The company is required to maintain the chemical treatment and provide all chemicals required for a period of 1 year from the date of occupancy. Do not use filming amines, hydrazine and chelants. Ensure the water treatment chemicals remain stable throughout the operating temperature range of the system and are compatible with pump seals and other elements of the system.

2.3.6.1 Boiler Water Limits

Provide for boiler water limits as follows unless dictated differently by the boiler manufacturer's recommendations:

Causticity (OH)	20-200 ppm
Total Alkalinity (CaCO3)	200-800 ppm
Phosphate (PO4)	30-60 ppm
Polymer (dispersant) or Tannin	5-10 ppm or medium color, respectively
Dissolved Solids (water tube boilers)	3000-3500 ppm
Dissolved Solids (fire tube boilers)	3500-5000 ppm
Suspended Solids	15 ppm Maximum
Sodium Sulfite	20-40 ppm
Silica	Less than 200 ppm
Dissolved Oxygen	Less than 7 ppb

Iron	Less than 10 ppm
pH (Condensate)	7.5 - 8
Conductivity (Condensate)	Less than 35 micromhos
Hardness (Condensate and makeup)	Less than 2 ppm

The above limits apply to boilers operating above 15 psi up 300 psi. Above 300 psi these limits decrease. Use ABMA or chemical vendor recommended limits above 300 psi.

2.3.6.2 Water Softening System

Provide the water softening system as specified in Section 22 31 00 WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE).

2.3.6.3 Boiler Water Treatment System

Provide water treatment system capable of automatically feeding chemicals to prevent corrosion and scale within the boiler and condensate system. Ensure automatic chemical feed systems feed chemicals into the boiler based on makeup water rate. Use electrical signals from a water meter on the makeup water line to control the output of chemical feed pumps.

2.3.6.4 Steam Boiler Chemical Feed Pumps and Tanks

a. Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. Use chemical feed pumps that are positive displacement diaphragm type. Ensure the pump cylinders, plungers, ball check valves, and check valve bodies are fabricated of corrosion resistant materials suitable for the chemicals being pumped. Ensure cylinders are replaceable for increased or reduced pressure or capacity ranges. Ensure the flow rate of the pumps is adjustable from 0 to 100 percent while in operation. Ensure volumetric accuracy of the pumps is within one percent over the range indicated. Pump capacities are required to be adjustable by positioning crank pin with micrometer setscrews. Divide stroke length scale in percentage graduations engraved on scale.

b. Ensure the discharge pressure of pumps is not less than 1.5 times the line pressure at the point of connection. Provide pumps with a pressure relief valve and a check valve mounted in the pump discharge. Control the pumps by an external controller/timer receiving signals from the makeup water meter.

c. Provide drive motors rated for 110 volt, single phase and are equipped with drip-proof enclosures. Provide tanks constructed of [materials compatible with the chemicals to be stored in the tank] [high density polyethylene] [stainless steel] [fiber reinforced plastic] with a hinged cover and mounted on legs. Ensure tanks have filling and drain connections and gauge glass. Furnish each tank with one pump, mounted and piped with pipe and fittings suitable for working pressures and compatible with the chemicals in the tank it is in contact with, with suction strainer and stainless steel screen, and with 1/2 inch relief valve with steel body and stainless steel trim. Shape tank bottom to

be dished concave to a radius equal to the diameter of the tank. Ensure the tank for sodium sulfite is equipped with a floating cover to minimize contact with air. Provide a motor-driven agitator. Size the tanks to have sufficient capacity to require recharging only once per [7] [14] [21] [_____] days during normal operation.

2.3.6.5 Steam Boiler Chemical Injection Assemblies

Provide an injection assembly at each chemical injection point located along the boiler piping as indicated. Provide injection assemblies that are constructed of stainless steel. Extend the discharge of the assemblies to the centerline of the piping. Include a shutoff valve and check valve with each assembly at the point of entrance into the water line.

2.3.6.6 Steam Boiler Water Meter

Provide the water meter with an electric contacting register and remote accumulative counter. Install the meter within the makeup water line, as indicated.

2.3.6.7 Steam Boiler Timers

Provide timers that are automatic reset, adjustable type, and electrically operated. Design timers to work with the contacting head water meters. Include the water meter cable with the timer. Ensure timers control operation of the chemical feed pumps. Ensure timers are suitable for a 120 volt current. Use timers to control the electrical signals from the water meters to the chemical feed pumps.

2.3.6.8 Steam Boiler Control Panel

Provide control panel constructed of a NEMA 12, single door, wall-mounted box conforming with NEMA 250. Ensure the panel is constructed of [coated steel] [stainless steel] with a hinged door and lock. Ensure the panel contains, as a minimum, the following functions identified with a laminated plastic nameplate:

a. Main power switch and indicating light
b. MAN-OFF-AUTO selector switch
c. Indicating lamp for each chemical feed pump
d. Indicating lamp for the water softener

2.3.6.9 Boiler Blowdown

Provide the boiler with [continuous blowdown] [automatic blowdown based upon conductivity or boiler load]. Provide a bottom blowdown connection and valve to allow removal of solids and water from the bottom of the boiler.

2.3.6.10 Boiler Chemical Piping

Fabricate the piping and fittings of [steel] [stainless steel].

2.3.6.11 Boiler Test Kits

Provide one test kit of each type required to determine the water quality as outlined in paragraph Boiler Water Limits above and within the operation and maintenance manuals.

2.3.7 Supplemental Components/Services

Ensure drain and makeup water piping complies with the requirements of Section 22 00 00 PLUMBING, GENERAL PURPOSE. Connect drains to sanitary sewer systems by means of an indirect waste connection.

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 any work.

3.2 INSTALLATION

Provide all chemicals, equipment and labor necessary to bring all system waters in conformance with the specified requirements. Perform all work in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements.

3.2.1 Piping

Fabricate all connections between dissimilar metals using dielectric unions.

3.3 FIELD QUALITY CONTROL

3.3.1 Tests

If the waters of the mechanical systems are not in conformance with the specified requirements or in accordance with manufacturer's recommendations, the contractor is required to direct the water treatment company to take corrective action to achieve compliance. Perform daily operational tests in the directed frequencies to maintain required control to prevent corrosion, scaling and damage to equipment during operation. Submit test schedules, at least 2 weeks prior to the start of related testing, for the condenser/chilled/boiler/condensate/feedwater water quality tests. Identify the date, time, frequency and collection location for each test within the schedules.

3.3.2 Condenser Water Quality Tests

3.3.2.1 Small Systems (weekly)

Once a week, for cooling systems with a capacity of 50 tons or less, ensuring the following items are recorded.

pH	[_____]
Total Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm

3.3.2.2 Tests for Large Systems (daily)

Daily, for cooling systems with a capacity larger than 50 tons, ensuring

the following items are recorded.

pH	[_____]
Total Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Phosphate	[_____] ppm (mg/L)
Zinc, if used (Zn)	[_____] ppm (mg/L)
Molybdate, if used (Mo)	[_____] ppm (mg/L)

3.3.3 Chilled Water Testing (monthly)

Perform the following tests on chilled water on a monthly basis.

pH	[_____]
Nitrite or Molybdate	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm

3.3.4 Hot Water Boiler Water Quality Testing

3.3.4.1 Low and Medium Temperature Systems (monthly)

Complete and record monthly testing for the following parameters.

pH	[_____]
Nitrite or Molybdate	[_____] ppm (mg/L)

3.3.4.2 High Temperature Hot Water Systems (daily)

Complete and record daily testing for the following parameters.

pH	[_____]
Sulfite	[_____] ppm (mg/L)
Hardness	[_____] ppm (mg/L)

3.3.5 Steam Boiler Water Testing

3.3.5.1 Small Steam Systems

The type of treatment required for small steam systems (below 25 hp) varies greatly depending on local water and system conditions. Base the

determination of the type of treatment and frequency of testing on the recommendations of by the water treatment chemical vendor.

3.3.5.2 Medium Steam Systems (twice weekly)

Record the following items twice a week for steam boiler systems operating between 25 hp and 100 hp and utilize data for operation purposes.

pH	[_____]
P Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Total Dissolved Solids	[_____] ppm (mg/L)
Phosphate (PO4)	[_____] ppm (mg/L)
Sulfite (NaSO3)	[_____] ppm (mg/L)

3.3.5.3 Large Steam Systems (daily)

Record the following items daily for steam boiler systems operating above 15 psi and 100 hp and utilize data for operational purposes.

Sulfite (NaSO3)	[_____] ppm (mg/L)
P Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Neutralized Conductivity	[_____] micromho/cm
Total Dissolved Solids	[_____] ppm (mg/L)
Phosphate (PO4)	[_____] ppm (mg/L)
Condensate pH	[_____]
Condensate Conductivity	[_____] micromho/cm
Condensate Hardness (as CaCO3)	[_____] ppm (mg/L)
Makeup Water Hardness (as CaCO3)	[_____] ppm (mg/L)

3.3.6 Quality Assurance Testing

Conduct QA testing periodically by an independent water treatment lab/consultant to verify to managers that the mechanical and water treatment systems are being maintained properly. Provide the QA evaluation reports to the government COR.

3.3.6.1 Condenser Water QA Tests

Submit test reports in bound 8-1/2 by 11 inch booklets. Within the

reports, identify the chemical composition of the condenser water. Also include in the reports a comparison of the manufacturer's or chemical vendor's recommended operating conditions for the cooling tower and condenser in relation to the actual condition of the condenser water. Document any required corrective actions undertaken within the report.

a. For cooling systems with a capacity of 50 ton or less, the perform following tests

Presence of scale/corrosion	[_____]
Polyphosphate	[_____] ppm (mg/L)
Biocide	[_____] ppm (mg/L)
pH	[_____]
Total Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Calcium Hardness (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Written evaluation summary	

b. For cooling systems with capacities greater than 50 ton), analyze the condenser water a minimum of once a month for a period of one year by the water treatment company. Ensure the analysis includes the following information recorded in accordance with ASTM D596.

Date of Sample	[_____]
Temperatures (before & after condenser)	[_____] & [_____] degrees C
pH	[_____]
Silica (SiO2)	[_____] ppm (mg/L)
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Copper (Cu)	[_____] ppm (mg/L)
Calcium Hardness(CaCO3)	[_____] ppm (mg/L)
Total Hardness (as CaCO3)	[_____] ppm (mg/L)
Chloride (Cl)	[_____] ppm (mg/L)
Total Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Total Dissolved Solids	[_____] ppm (mg/L)
Phosphonate (as PO4)	[_____] ppm (mg/L)

Zinc (if used) (Zn)	[_____] ppm (mg/L)
Molybdate (if used) (Mo)	[_____] ppm (mg/L)
Tolyltriazole (TT)	[_____] ppm (mg/L)
Biocide	[_____] ppm (mg/L)
Bacteria colony count	[_____] colonies/mL
Makeup water pH	[_____] ppm (mg/L)
Makeup water Iron	[_____] ppm (mg/L)
Makeup water Silica	[_____] ppm (mg/L)
Makeup water Calcium Hardness	[_____] ppm (mg/L)
Makeup water Total Hardness	[_____] ppm (mg/L)
Makeup water Total Alkalinity	[_____] ppm (mg/L)
Makeup water Chloride (Cl)	[_____] ppm (mg/L)
Makeup water Conductivity	[_____] micromho/cm
Written evaluation summary	

3.3.6.2 Chilled Water Quality Assurance Testing (quarterly)

Perform the following tests quarterly on chilled water.

pH	[_____]
Nitrite or Molybdate	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Written evaluation summary	

3.3.6.3 Hot Water Boiler Water Quality Assurance Testing

a. Complete quarterly testing of Low and Medium Temperature Systems and record the following parameters.

pH	[_____]

Nitrite or Molybdate	[_____] ppm (mg/L)
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Written evaluation summary	

b. Have an independent consultant analyze the hot water boiler water once a month for a period of 1 year. Include the following information recorded in accordance with ASTM D596 in the monthly report.

pH	[_____]
Sulfite (Na2SO3)	[_____] ppm (mg/L)
Hardness(as CaCO3)	[_____] ppm (mg/L)
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Written evaluation summary	

3.3.6.4 Steam Boiler Water QA Tests

Submit the water quality test report identifying the chemical composition of the boiler, feedwater and condensate water. Include in the report a comparison of the condition of the boiler water with the manufacturer's or chemical vendor's recommended conditions. Document any required corrective action within the report.

a. Small and Medium Steam Boiler Systems (quarterly)are systems operating between 25 hp and 100 hp. Perform the following tests quarterly.

pH	[_____]
Sulfite, if used, (NaSO3)	[_____] ppm (mg/L)
P Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Total Dissolved Solids	[_____] ppm (mg/L)
Phosphate, if used, (PO4)	[_____] ppm (mg/L)
Polymer, if used	[_____] ppm (mg/L)
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Condensate pH	[_____]
Condensate Conductivity	[_____] micromho/cm
Condensate Hardness (as CaCO3)	[_____] ppm (mg/L)

Condensate Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Makeup Water Hardness (as CaCO3)	[_____] ppm (mg/L)
Written evaluation summary	

b. Large steam boilers are those operating above 15 psi and 100 hp. Retain an independent consultant to analyze the boiler water a minimum of once a month for a period of 1 year. Include the following information recorded in accordance with ASTM D596 in the monthly report.

Date of Sample	[_____]
pH	[_____]
Sulfite (NaSO3)	[_____] ppm (mg/L)
P Alkalinity (as CaCO3)	[_____] ppm (mg/L)
Conductivity	[_____] micromho/cm
Neutralized Conductivity	[_____] micromho/cm
Total Dissolved Solids	[_____] ppm (mg/L)
Phosphate (PO4)	[_____] ppm (mg/L)
Polymer, if used	[_____] ppm (mg/L)
Silica (SiO2)	[_____] ppm (mg/L)
Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Condensate pH	[_____]
Condensate Conductivity	[_____] micromho/cm
Condensate Hardness (as CaCO3)	[_____] ppm (mg/L)
Condensate Iron (total, as Fe(2)O(3))	[_____] ppm (mg/L)
Makeup Water Hardness (as CaCO3)	[_____] ppm (mg/L)
Written evaluation summary	

3.3.7 Corrosion Testers

Install corrosion coupon and rack systems to verify corrosion control in the systems. Install testers or coupons in flowing system water through a sidestream or rack system. Test both mild steel and copper metal samples

in the corrosion testers in accordance with ASTM D2688. Replace and analyze samples every 3 months. Rates of corrosion less than 3 mpy for steel and 0.2 mpy for copper are acceptable. Install corrosion testers on the piping systems of the following systems.

Condenser loop
Chilled water system
Hot water loop
Condensate

3.4 CLOSEOUT ACTIVITIES

3.4.1 Training Course

Submit a schedule, at least 2 weeks prior to the date of the proposed training course that identifies the date, time, and location for the training. Conduct a training course for the operating staff as designated by the Contracting Officer. Conduct the training to include a total of [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. Submit field 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. Include within the condensed operation instructions all preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. Frame the posted instructions under glass or laminated plastic and post where indicated by the Contracting Officer. Ensure the field instructions cover all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

3.5 INSPECTIONS

3.5.1 Inspection General Requirements

Thirty days after project completion, inspect the cooling tower and condenser for problems due to corrosion, scale, and biological growth. If the cooling tower and condenser are found not to conform to the manufacturer's recommended conditions, and the water treatment company recommendations have been followed; instruct the water treatment company to provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations.

3.5.2 Boiler/Piping Test

Thirty days after project completion, inspect the boiler and condensate piping for problems due to corrosion and scale. If the boiler is found not to conform to the manufacturer's recommendations, and the water treatment company recommendations have been followed, instruct the water treatment company to provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations. If corrosion is found within the condensate piping, proper repairs are required to be made by the water treatment company at no additional cost.

-- 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.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S12.51	(2012; R 2017) American National Standard Acoustics - Determination of Sound Power Levels and Sound Energy Levels of Noise Sources using Sound Pressure - Precision Methods for Reverberation Test Rooms

AIR CONDITIONING CONTRACTORS OF AMERICA (ACCA)

ACCA Manual 4	(2001) Installation Techniques for Perimeter Heating and Cooling; 11th Edition

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 220	(2005;R 2012) Test Methods for Air Curtain Units
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 350	(2015) Sound Rating of Non-Ducted Indoor Air-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 440	(2008) Performance Rating of Room Fan-Coils
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 DCAACP	(Online) Directory of Certified Applied Air-Conditioning Products
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 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	(2017) 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 2021) Method of Testing the Performance of Air Outlets and Inlets
ASHRAE 84	(2020; Errata 2021) Method of Testing Air-to-Air Heat/Energy Exchangers
ASHRAE 90.1 - IP	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (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 A924/A924M	(2020) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B75/B75M	(2020) Standard Specification for Seamless Copper Tube
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 B280	(2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
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 C916	(2020) Standard Specification for Adhesives for Duct Thermal Insulation
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 D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120

ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D2564	(2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2855	(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D3359	(2017) Standard Test Methods for Rating Adhesion by Tape Test
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
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

GERMAN INSTITUTE FOR STANDARDIZATION (DIN)

DIN EN 14037	(2016) Free Hanging Heating and Cooling Surfaces for Water with a Temperature Below 120 Degrees C - Part 1: Pre-Fabricated Ceiling Mounted Radiant Panels for Space Heating
DIN EN 14240	(2004) Ventilation for Buildings

INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY (IEST)

IEST RP-CC-001	(2016; Rev 6) HEPA and ULPA Filters

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
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 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 96	(2021) Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
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 1403	(2008) Accepted Industry Practice for Industrial Duct Construction, 2nd Edition
SMACNA 1819	(2002) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th Edition
SMACNA 1966	(2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition
SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT (SCAQMD)

SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders

U.S. DEPARTMENT OF ENERGY FEDERAL ENERGY MANAGEMENT PROGRAM (FEMP)

PL-109-58	(1992; R 2005) Energy Efiicient Procument Requirements

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 94	(2013; Reprint May 2021) UL Standard for

	Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
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 Aug 2021) UL Standard for Safety Power Ventilators
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 900	(2015) Standard for Air Filter Units
UL 1995	(2015) UL Standard for Safety Heating and Cooling Equipment
UL 2021	(2015; Reprint Dec 2016) UL Standard for Safety Fixed and Location-Dedicated Electric Room Heaters
UL Bld Mat Dir	(updated continuously online) Building Materials Directory
UL Electrical Construction	(2012) Electrical Construction Equipment 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 - [_____]
Control and instrument air	CONTROL AND INSTR.
Exhaust Fan Number	EF - [_____]
VAV Box Number	VAV - [_____]
Fan Coil Unit Number	FC - [_____]
Terminal Box Number	TB - [_____]
Unit Ventilator Number	UV - [_____]

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:

a. Each point of entry and exit of pipe passing through walls.

b. Each change in direction, i.e., elbows, tees.

c. In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard.

d. 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] [MIL-STD-101].

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. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings; G, AE

SD-03 Product Data

Metallic Flexible Duct

Insulated Nonmetallic Flexible Duct Runouts

Duct Connectors

Duct Access Doors; G, AE

Fire Dampers

Manual Balancing Dampers; G, AE

Sound Attenuation Equipment

Acoustical Duct Liner

Diffusers

Registers and Grilles

Louvers

Air Vents, Penthouses, and Goosenecks

Centrifugal Fans

In-Line Centrifugal Fans

Axial Flow Fans

Panel Type Power Wall Ventilators

Centrifugal Type Power Wall Ventilators

Centrifugal Type Power Roof Ventilators

Propeller Type Power Roof Ventilators

Air-Curtain Fans

Ceiling Exhaust Fans

PL-109-58 label for ceiling exhaust fan product; S

Air Handling Units; G, AE

Room Fan-Coil Units; G, AE

Coil Induction Units; G, AE

Constant Volume, Single Duct Terminal Units; G, AE

Variable Volume, Single Duct Terminal Units; G, AE

Variable Volume, Single Duct, Fan-Powered Terminal Units; G, AE

Dual Duct Terminal Units; G, AE

Ceiling Induction Terminal Units; G, AE

Reheat Units; G, AE

Unit Ventilators

Energy Recovery Devices; G, AE

Hydronic Modular Panels; G, AE

Prefabricated Radiant-Heating Electric Panels; G, AE

Test Procedures

Diagrams; G, AE

Indoor Air Quality for Duct Sealants; S

SD-06 Test Reports

Performance Tests; G, AE

Damper Acceptance Test; G, AE

SD-07 Certificates

Bolts

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; G, AE

Fire Dampers; G, AE

Manual Balancing Dampers; G, AE

Centrifugal Fans; G, AE]

In-Line Centrifugal Fans; G, AE

Axial Flow Fans; G, AE

Panel Type Power Wall Ventilators; G, AE

Centrifugal Type Power Wall Ventilators; G, AE

Centrifugal Type Power Roof Ventilators; G, AE

Propeller Type Power Roof Ventilators; G, AE

Air-Curtain Fans; G, AE

Ceiling Exhaust Fans; G, AE

Air Handling Units; G, AE

Room Fan-Coil Units; G, AE

Coil Induction Units; G, AE

Constant Volume, Single Duct Terminal Units; G, AE

Variable Volume, Single Duct Terminal Units; G, AE

Variable Volume, Single Duct, Fan-Powered Terminal Units; G, AE

Dual Duct Terminal Units; G, AE

Ceiling Induction Terminal Units; G, AE

Reheat Units; G, AE

Unit Ventilators; G, AE

Energy Recovery Devices; G, AE

Hydronic Modular Panels; G, AE

Prefabricated Radiant-Heating Electric Panels; G, AE

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.[Equipment having a lower efficiency may be specified if the designer determines such equipment to be more life-cycle cost effective.]

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.[Provide written certification from the bolt manufacturer that the bolts furnished comply with the requirements of this specification. Include illustrations of product markings, and the number

of each type of bolt to be furnished in the certification.]

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 Testing, Adjusting and Balancing for HVAC and Section 23 09 00 Instrumentation and Control 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

Provide components and equipment that are "standard products" of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. "Standard products" is defined as being in satisfactory commercial or industrial use for 2 years before bid opening, including applications of components and equipment under similar circumstances and of similar size, satisfactorily completed by a product that is sold on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record are 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. 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 00INTERIOR 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 SEISMIC ANCHORAGE

Anchor equipment in accordance with applicable seismic criteria for the area and as defined in SMACNA 1981

2.7 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-PEFORMANCE COATINGS.

2.8 INDOOR AIR QUALITY

Provide equipment and components that comply with the requirements of ASHRAE 62.1 unless more stringent requirements are specified herein.

2.9 DUCT SYSTEMS

2.9.1 Metal Ductwork

Provide metal ductwork construction, including all fittings and components, that complies with SMACNA 1966, as supplemented and modified by this specification .

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][C]. Provide ductwork in VAV systems upstream of the VAV boxes that meets the requirements of Seal Class A.

e. 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.

f. 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.

g. Fabricate outdoor air intake ducts and plenums with watertight soldered or brazed joints and seams.

2.9.1.1 Metallic Flexible Duct

a. Provide duct that conforms to UL 181 and NFPA 90A with factory-applied insulation, vapor barrier, and end connections. Provide duct assembly that does not exceed 25 for flame spread and 50 for smoke developed. Provide ducts designed for working pressures of 2 inches water gauge positive and 1.5 inches water gauge negative. Provide flexible round duct length that does not exceed 5 feet. Secure connections by applying adhesive for 2 inches over rigid duct, apply flexible duct 2 inches over rigid duct, apply metal clamp, and provide minimum of three No. 8 sheet metal screws through clamp and rigid duct.

b. Inner duct core: Provide interlocking spiral or helically corrugated flexible core constructed of zinc-coated steel, aluminum, or stainless steel; or constructed of inner liner of continuous galvanized spring steel wire helix fused to continuous, fire-retardant, flexible vapor barrier film, inner duct core.

c. Insulation: Provide inner duct core that is insulated with mineral fiber blanket type flexible insulation, minimum of 1 inch thick. Provide insulation covered on exterior with manufacturer's standard fire retardant vapor barrier jacket for flexible round duct.

2.9.1.2 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.

2.9.1.3 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.

2.9.1.4 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.

2.9.1.5 Aluminum Ducts

ASTM B209, alloy 3003-H14 for aluminum sheet and alloy 6061-T6 or equivalent strength for aluminum connectors and bar stock.

2.9.1.6 Copper Sheets

ASTM B152/B152M, light cold rolled temper.

2.9.1.7 Corrosion Resisting (Stainless) Steel Sheets

ASTM A167

2.9.2 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.

2.9.3 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 a pressure relief door upstream of the fire damper. If the ductwork connected to the fire damper is to be insulated then provide a factory installed pressure relief damper. 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] [in the air stream] [out of the air stream][or][single blade type][or][multi-blade type] 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.

2.9.4 Manual Balancing Dampers

Furnish manual balancing dampers with accessible operating mechanisms. Use chromium plated operators (with all exposed edges rounded) in finished portions of the building. Provide manual volume control dampers that are operated by locking-type quadrant operators. Install dampers that are 2 gauges heavier than the duct in which installed. Unless otherwise indicated, provide opposed blade type multileaf dampers with maximum blade width of 12 inches. Provide access doors or panels for all concealed damper operators and locking setscrews. Provide stand-off mounting brackets, bases, or adapters not less than the thickness of the insulation when the locking-type quadrant operators for dampers are installed on ducts to be thermally insulated, to provide clearance between the duct surface and the operator. Provide stand-off mounting items that are integral with the operator or standard accessory of the damper manufacturer.

2.9.5 Air Supply And Exhaust Air Dampers

Provide outdoor air supply and exhaust air dampers that have a maximum leakage rate when tested in accordance with AMCA 500-D as required by ASHRAE 90.1 - IP, including maximum Damper Leakage for:

a. Climate Zones 1,2,6,7,8 the maximum damper leakage at 1.0 inch w.g. for motorized dampers is 4 cfm per square foot of damper area and non-motorized dampers are not allowed.

b. All other Climate Zones the maximum damper leakage at 1.0 inch w.g. is 10 cfm per square foot and for non-motorized dampers is 20 cfm per square foot of damper area.

Dampers smaller than 24 inches in either direction may have leakage of 40 cfm per square foot.

2.9.6 Air Deflectors (Volume Extractors) and Branch Connections

Provide air deflectors (volume extractors) at all duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections are allowed in lieu of deflectors for branch connections. Furnish all air deflectors (volume extractors), except those installed in 90 degree elbows, with an approved means of adjustment. Provide easily accessible means for adjustment

inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, provide external adjustments with stand-off mounting brackets, integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Provide factory-fabricated air deflectors consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Provide factory or field assembled air deflectors (volume extractors). Make adjustment from the face of the diffuser or by position adjustment and lock external to the duct. Provide stand-off brackets on insulated ducts as described herein. Provide fixed air deflectors (volume extractors), also called turning vanes, in 90 degree elbows.

2.9.7 Plenums and Casings for Field-Fabricated Units

2.9.7.1 Plenum and Casings

Fabricate and erect plenums and casings as shown in SMACNA 1966, as applicable. Construct system casing of not less than 16 gauge galvanized sheet steel. Furnish cooling coil drain pans with 1 inch threaded outlet to collect condensation from the cooling coils. Fabricate drain pans from not lighter than 16 gauge steel, galvanized after fabrication or of 18 gauge corrosion-resisting sheet steel conforming to ASTM A167, Type 304, welded and stiffened. Thermally insulate drain pans exposed to the atmosphere to prevent condensation. Coat insulation with a flame resistant waterproofing material. Provide separate drain pans for each vertical coil section, and a separate drain line for each pan. Size pans to ensure capture of entrained moisture on the downstream-air side of the coil. Seal openings in the casing, such as for piping connections, to prevent air leakage. Size the water seal for the drain to maintain a pressure of at least 2 inch water gauge greater than the maximum negative pressure in the coil space.

2.9.7.2 Casing

Terminate casings at the curb line and bolt each to the curb using galvanized angle, as indicated in SMACNA 1966.

2.9.7.3 Access Doors

Provide access doors in each section of the casing. Weld doorframes in place, gasket each door with neoprene, hinge with minimum of two brass hinges, and fasten with a minimum of two brass tension fasteners operable from inside and outside of the casing. Where possible, make doors 36 by 18 inches and locate them 18 inches above the floor. Where the space available does not accommodate doors of this size, use doors as large as the space accommodates. Swing doors so that fan suction or pressure holds doors in closed position, airtight. Provide a push-button station, located inside the casing, to stop the supply.

2.9.7.4 Factory-Fabricated Insulated Sheet Metal Panels

Factory-fabricated components are allowed for field-assembled units, provided all requirements specified for field-fabricated plenums and casings are met. Provide panels of modular design, pretested for structural strength, thermal control, condensation control, and acoustical control. Seal and insulate panel joints. Provide and gasket access doors to prevent air leakage. Provide panel construction that is not less than

20 gauge galvanized sheet steel, assembled with fasteners treated against corrosion. Provide standard length panels that deflect not more than 1/2 inch under operation. Construct details, including joint sealing, not specifically covered, as indicated in SMACNA 1966. Construct the plenums and casings to withstand the specified internal pressure of the air systems.

2.9.7.5 Duct Liner

Unless otherwise specified, duct liner is not permitted.

2.9.8 Sound Attenuation Equipment

2.9.8.1 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.

2.9.8.2 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.

2.9.8.3 Acoustical Duct Liner

Use fibrous glass designed or flexible elastomeric duct liner for lining ductwork and conforming to the requirements of ASTM C1071, Type I and II. Provide uniform density, graduated density, or dual density liner composition, as standard with the manufacturer. Provide not less than 1 inch thick coated lining. Where acoustical duct liner is used, provide the thermal equivalent of the insulation specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS for liner or combination of liner and insulation applied to the exterior of the ductwork. Increase duct sizes shown to compensate for the thickness of the lining used. In lieu of sheet metal duct with field-applied acoustical lining, provide acoustically equivalent lengths of fibrous glass duct, elastomeric duct liner or factory fabricated double-walled internally insulated duct with perforated liner.

2.9.9 Diffusers, Registers, and Grilles

Provide factory-fabricated units of [steel][corrosion-resistant steel][or][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 sound power level as indicated. Provide diffusers and registers with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device is acceptable. Provide opposed blade type volume dampers for all diffusers and registers, except linear slot diffusers. 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.

2.9.9.1 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. Provide air handling troffers or combination light and ceiling diffusers conforming to the requirements of UL Electrical Construction for the interchangeable use as cooled or heated air supply diffusers or return air units. 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 that are similar to

supply diffusers.

2.9.9.2 Security Ceiling Diffusers

Provide diffusers that are steel with faceplate, fixed diffusion louvers, with flat surface margin, and an opposed blade damper. Provide faceplate that is 14 gage minimum with 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

2.9.9.3 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. Locate return and exhaust registers 6 inches above the floor 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. Provide grilles as specified for registers, without volume control damper.

2.9.9.4 Security Supply Air Registers Except in Cells

Provide supply air registers, except in prisoner cells and prisoner holding cells, that are steel with individually adjustable horizontal and vertical vanes, perforated faceplate, flat surface margin and opposed blade damper. Put vertical vanes in front; with 3/4 inch o.c. vane spacing. Provide a 14 gage (minimum) perforated faceplate with 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

2.9.9.5 Security Return and Other Air Registers Except in Cells

Provide return, exhaust, transfer and relief air registers, except in prisoner cells and prisoner holding cells, that are steel with perforated faceplate, flat surface margin, opposed blade damper, and duct mounting sleeve. Provide 14 gage (minimum) faceplate with 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent.

2.9.9.6 Security Supply Air Registers in Cells

Provide supply air registers in prisoner cells and prisoner holding cells that are steel with perforated faceplate, flat surface margin, extension sleeve, opposed blade damper, and back mounting flanges. Provide a 14 gage (minimum) faceplate with 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent. Provide a 14 gage (minimum) wall sleeve.

2.9.9.7 Security Return and Other Type Air Registers in Cells

Provide steel return, exhaust, transfer and relief air registers in prisoner cells and prisoner holding cells with perforated faceplate, flat surface margin, wall sleeve, opposed blade damper, and back mounting flanges. Provide 14 gage (minimum) faceplate with 1/2 by 1/2 inch holes on 3/16 inch spacing and a minimum free area of 45 percent. Provide a 14 gage (minimum)wall sleeve.

2.9.10 Louvers

Provide louvers for installation in exterior walls that are associated

with the air supply and distribution system as specified in Section [07 60 00 FLASHING AND SHEET METAL] [08 91 00 METAL [WALL][AND][DOOR] LOUVERS].

2.9.11 Air Vents, Penthouses, and Goosenecks

Fabricate air vents, penthouses, and goosenecks from galvanized steel [or aluminum] sheets with galvanized[or aluminum] structural shapes. Provide 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.

2.9.12 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.

2.9.13 Radon Exhaust Ductwork

Fabricate radon exhaust ductwork installed in or beneath slabs from Schedule 40 PVC pipe that conforms to ASTM D1785. Provide fittings that conform to ASTM D2466. Use solvent cement conforming to ASTM D2564 to make joints. Otherwise provide metal radon exhaust ductwork as specified herein.

2.10 AIR SYSTEMS EQUIPMENT

2.10.1 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] [140] [120] 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.

2.10.1.1 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 open-wheel radial type booster fans for exhaust dryer systems, and fans suitable for conveying lint and the temperatures encountered. Equip the fan shaft with a heat slinger to dissipate heat buildup along the shaft. Install an access (service) door to facilitate maintenance to these fans.] 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. Provide[[manually] [automatically] operated inlet vanes on suction inlets. Provide [manually] [automatically] operated outlet dampers.] Unless otherwise indicated, provide motors that do not exceed 1800 rpm and have [open] [dripproof] [totally enclosed] [explosion-proof] enclosures. [Provide [manual] [magnetic] [across-the-line] [reduced-voltage-start] type motor starters with [general-purpose] [weather-resistant] [watertight] enclosure.] [Provide remote manual switch with pilot indicating light where indicated.]

2.10.1.2 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 [open][dripproof][totally enclosed] [explosion-proof] enclosure.] [Provide [manual] [magnetic] motor starters across-the-line with [general-purpose] [weather-resistant] [explosion-proof] enclosures.][Provide remote manual switch with pilot indicating light where indicated.]

2.10.1.3 Axial Flow Fans

Provide axial flow fans complete with drive components and belt guard,

with steel housing, cast fan wheel, cast or welded steel diffusers, fan shaft, bearings, and mounting frame as a factory-assembled unit. Provide fan wheels that are dynamically balanced and keyed to the fan shaft, with radially projecting blades of airfoil cross-section. Enclose and isolate fan bearings and drive shafts from the air stream. Permanently lubricate fan bearings or provide them with accessible grease fittings. Provide precision self-aligning ball or roller type fan bearings that are sealed against dust and dirt. Provide fan bearings that have a L50 rated bearing life at not less than 200,000 hours of operation as defined by ABMA 9 and ABMA 11. Provide fan inlets with an aerodynamically shaped bell and an inlet cone. Install diffuser or straightening vanes at the fan discharge to minimize turbulence and provide smooth discharge air flow. Furnish fan unit with [inlet and outlet flanges,] [inlet screen,] [duct equalizer section,] and [manual] [automatic] operation adjustable inlet vanes. Unless otherwise indicated, provide motors that do not exceed 1800 rpm and have [open] [dripproof] [totally enclosed] [explosion-proof] enclosure. [Provide [manual] [magnetic] motor starters across-the-line with [general-purpose] [weather-resistant] [explosion-proof] enclosure.] [Provide remote manual switch with pilot indicating light where indicated.]

2.10.1.4 Panel Type Power Wall Ventilators

Provide propeller type fans, assembled on a reinforced metal panel with venturi opening spun into panel. Provide direct or V-belt driven fans with wheels less than 24 inches in diameter and provide V-belt driven fans with wheels 24 inches in diameter and larger. Provide fans with wall mounting collar. Provide lubricated bearings. Equip fans with wheel and motor side metal or wire guards which have a corrosion-resistant finish. Provide [dripproof][totally enclosed fan cooled][explosion-proof] type motor enclosure. Install [gravity][motor operated] backdraft dampers where indicated.

2.10.1.5 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,] [[anodized aluminum][stainless steel] wall grille,] [manufacturer's standard [gravity][motor-operated] damper,] an airtight and liquid-tight metallic wall sleeve. Provide [totally enclosed fan cooled] [dripproof] [explosion-proof] type motor enclosure. Use only lubricated bearings.

2.10.1.6 Centrifugal Type Power Roof Ventilators

Provide [direct][or][V-belt] driven centrifugal type fans with backward inclined, non-overloading wheel. Provide hinged or removable and weatherproof motor compartment housing, constructed of heavy gauge aluminum. Provide fans with [birdscreen,] [disconnect switch,] [[gravity] [motorized] dampers,] [sound curb,] [roof curb,] and [extended base]. Provide [dripproof] [explosion-proof] type motor enclosure. Provide centrifugal type kitchen exhaust fans according to UL 705, fitted with V-belt drive, round hood, and windband upblast discharge configuration, integral residue trough and collection device, with motor and power transmission components located in outside positively air ventilated compartment. Use only lubricated bearings.

2.10.1.7 Propeller Type Power Roof Ventilators

Provide [direct][or][V-belt] driven fans. Provide hinged or removable weathertight fan housing, fitted with framed rectangular base constructed of aluminum or galvanized steel. Provide [totally enclosed fan cooled] [explosion-proof] type motors. Furnish motors with nonfusible, horsepower rated, manual disconnect mount on unit. Furnish fans with [gravity] [motor operated] dampers, [birdscreen][sound curb][roof curb]. Use only lubricated bearings.

2.10.1.8 Air-Curtain Fans

Provide fans that conform to AMCA 220 with AMCA seal. Furnish air curtains with a weatherproof housing constructed of high impact plastic or minimum 18 gauge rigid welded steel. Provide backward curved, non-overloading, centrifugal type fan wheels, accurately balanced statically and dynamically. Provide motors with totally enclosed fan cooled enclosures. Provide remote manual type motor starters with weather-resistant enclosure actuated when the doorway served is open. Provide air curtains that attain the air velocities specified within 2 seconds following activation. Provide bird screens at air intake and discharge openings. Provide air curtain unit or a multiple unit installation that is at least as wide as the opening to be protected. Provide the air discharge openings to permit outward adjustment of the discharge air. Place installation and adjust according to the manufacturer's written recommendation. Furnish directional controls on air curtains for service windows for easy clean or convenient removal. Design air curtains to prevent the adjustment of the air velocities specified. Make the interior surfaces of the air curtain units accessible for cleaning. Provide certified test data indicating that the fan can provide the air velocities required when fan is mounted as indicated. Provide air curtains designed as fly fans unless otherwise indicated. [Provide air curtains designed for use in service entranceways that develop an air curtain not less than 3 inches thick at the discharge nozzle. Provide air velocity that is not less than 1600 fpm across the entire entryway when measured 3 feet above the floor.] [Provide air curtains designed for use on customer entranceways that develop an air curtain not less than 8 inches thick at the discharge opening. Provide velocity that is not less than 600 fpm across the entire entryway when measured 3 feet above the floor. Equip recirculating type air curtains with readily removable filters, or design the filters for in-position cleaning. Provide readily accessible and easily cleanable air capture compartment or design for in-position cleaning.] [Provide air curtains designed for use on service windows that develop an air curtain not less than 8 inches thick at the discharge opening. Provide air velocity that is not less than 600 fpm across the entire opening of the service window measured 3 feet below the air discharge opening.]

2.10.1.9 Ceiling Exhaust Fans

Provide centrifugal type, direct driven suspended cabinet-type ceiling exhaust fans. Provide fans with acoustically insulated housing. Provide chatter-proof backdraft damper. Provide egg-crate design or louver design integral face grille. Mount fan motors on vibration isolators. Furnish unit with mounting flange for hanging unit from above. Provide U.L. listed fans. Provide PL-109-58 labeled ceiling exhaust fan product. Provide proof of PL-109-58 label for ceiling exhaust fan product.

2.10.2 Coils

Provide fin-and-tube type coils constructed of seamless [copper][red brass] 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][0.020][0.024] inches].[Provide red brass tube wall thickness that is a minimum of [0.035] [0.049] inches]. [Provide aluminum fins that are [0.0055][0.0075] inch minimum thickness.][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.]

2.10.2.1 Direct-Expansion Coils

Provide suitable direct-expansion coils for the refrigerant involved. Provide refrigerant piping that conforms to ASTM B280 and clean, dehydrate and seal. Provide seamless copper tubing suction headers or seamless or resistance welded steel tube suction headers with copper connections. Provide supply headers that consist of a distributor which distributes the refrigerant through seamless copper tubing equally to all circuits in the coil. Provide circuited tubes to ensure minimum pressure drop and maximum heat transfer. Provide circuiting that permits refrigerant flow from inlet to suction outlet without causing oil slugging or restricting refrigerant flow in coil. Provide field installed coils which are completely dehydrated and sealed at the factory upon completion of pressure tests. Pressure test coils in accordance with UL 1995.

2.10.2.2 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.

2.10.2.3 Steam Heating Coils

Construct steam coils from cast semisteel, welded steel or copper headers, and [red brass][copper] tubes. Construct headers from cast iron, welded steel or copper. Provide fin tube and header section that float within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Provide each coil with a field or factory installed vacuum breaker. Provide single-tube type coils with tubes not less than 1/2 inch outside diameter, except for steam preheat coils. Provide supply headers that distribute steam evenly to all tubes at the indicated steam pressure. Factory test coils to ensure that, when supplied with a uniform face velocity, temperature across the leaving side is uniform with a maximum variation of no more than 5 percent. Pressure testcoils in accordance with UL 1995.

2.10.2.4 Steam Preheat (Nonfreeze) Coils

Provide steam-distribution-tube type steam (nonfreeze) coils with condensing tubes not less than 1 inch outside diameter for tube lengths 60 inches and over and 1/2 inch outside diameter for tube lengths under 60 inches. Construct headers from cast iron, welded steel, or copper.

Provide distribution tubes that are not less than 5/8 inch outside diameter for tube lengths 60 inches and over and 3/8 inch outside diameter for tube lengths under 60 inches with orifices to discharge steam to condensing tubes. Install distribution tubes concentric inside of condensing tubes and hold securely in alignment. Limit maximum length of a single coil to 144 inches. Factory test coils to ensure that, when supplied with a uniform face velocity, temperature across the leaving side is uniform with a maximum variation of no more than 5 percent. Pressure test coils in accordance with UL 1995.

2.10.3 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.

2.10.3.1 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.

2.10.3.2 Extended Surface Nonsupported Pocket Filters

Provide [30][_____] 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 [0.45][_____] inches water gauge. Provide UL Class 1 filters. Provide fibrous glass media, supported in the air stream by a wire or non-woven synthetic backing and secured to a galvanized steel metal header. Provide pockets that do not sag or flap at anticipated air flows. Install each filter [with an extended surface pleated panel filter as a prefilter] in a factory preassembled, side access housing or a factory-made sectional frame bank, as indicated.

2.10.3.3 Cartridge Type Filters

Provide 12 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 [0.56][_____] 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 an 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.

2.10.3.4 Sectional Cleanable Filters

Provide [1][2] inch thick cleanable filters. Provide viscous adhesive in 5 gallon containers in sufficient quantity for 12 cleaning operations and not less than one quart for each filter section. Provide one washing and charging tank for every 100 filter sections or fraction thereof; with each

washing and charging unit consisting of a tank and [single][double] drain rack mounted on legs and drain rack with dividers and partitions to properly support the filters in the draining position.

2.10.3.5 Replaceable Media Filters

Provide the [dry-media][viscous adhesive] type replaceable media filters, of the size required to suit the application. Provide filtering media that is not less than 2 inches thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Enclose pad in a holding frame of not less than 16 gauge galvanized steel, equipped with quick-opening mechanism for changing filter media. Base the air flow capacity of the filter on net filter face velocity not exceeding [300][_____] fpm, with initial resistance of [0.13][_____] inches water gauge. Provide MERV that is not less than [_____] when tested according to ASHRAE 52.2.

2.10.3.6 Automatic Renewable Media Filters

Provide the following:

a. Automatic, renewable media filters consisting of a horizontal or vertical traveling curtain of adhesive-coated bonded fibrous glass supplied in convenient roll form, and filter that does not require water supply, sewer connections, adhesive reservoir, or sprinkler equipment as part of the operation and maintenance requirements.

b. Basic frame that is fabricated of not less than 14 gauge galvanized steel, and sectional design filters with each section of each filter fully factory assembled, requiring no field assembly other than setting in place next to any adjacent sections and the installation of media in roll form.

c. Each filter complete with initial loading of filter media drive motor adequate to handle the number of sections involved, and [painted steel] [stainless steel] control box containing a warning light to indicate media runout, a runout switch, and a Hand-Off-Auto selector switch.

d. Media feed across the filter face in [full-face increments] [increments] automatically controlled as determined by [filter pressure differential] [time interval control] [time interval control with pressure override] [photo electric control] to provide substantially constant operating resistance to airflow and varying not more than plus or minus 10 percent. Roll or enclose media in such a way that collected particulates can not re-entrain.

e. Rolls of clean media, no less than 65 feet long, rerolled on disposable spools in the rewind section of the filter after the media has accumulated its design dirt load. Equip rewind section with a compression panel to tightly rewind used media for ease of handling. Provide media made of continuous, bonded fibrous glass material, UL Class 2, that does not compress more than 1/4 inch when subjected to air flow at 500 fpm. Factory charge media with an odorless and flame retardant adhesive which does not flow while in storage nor when subjected to temperatures up to 175 degrees F. Support media on both the leaving and entering air faces. Clean media must have initial resistance that does not exceed 0.18 inch water gauge at its rated velocity of 500 fpm. Set control so that the resistance to air flow is between 0.40-and 0.50 inch water gauge unless otherwise indicated.

f. Dust holding capacity, of 80 percent average arrestance under these operating conditions, when operating at a steady state with an upper operating resistance of 0.50 inch water gauge, that is at least 592 (55) grams of ASHRAE Standard Test Dust per square foot of media area, when tested according to the dynamic testing provisions of ASHRAE 52.2.

g. The horizontal type automatic renewable media filters, when used in conjunction with factory fabricated air handling units, that are dimensionally compatible with the connecting air handling units, and horizontal type filter housings with all exposed surfaces factory insulated internally with 1 inch, 1-1/2 pound density neoprene coated fibrous glass with thermal conductivity not greater than 0.27 Btu/hour/degree F/square foot/inch of thickness.

h. Access doors for horizontal filters with double wall construction as specified for plenums and casings for field-fabricated units in paragraph DUCT SYSTEMS.

2.10.3.7 Electrostatic Filters

Provide the following:

a. The combination dry agglomerator/extended surface, nonsupported pocket electrostatic filters or the combination dry agglomerator/automatic renewable, media (roll) type electrostatic filters, as indicated (except as modified). Supply each dry agglomerator electrostatic air filter with the correct quantity of fully housed power packs and equip with silicon rectifiers, manual reset circuit breakers, low voltage safety cutout, relays for field wiring to remote indication of primary and secondary voltages, with lamps mounted in the cover to indicate these functions locally. Equip power pack enclosure with external mounting brackets, and low and high voltage terminals fully exposed with access cover removed for ease of installation. Furnish interlock safety switches for each access door and access panel that permits access to either side of the filter, so that the filter is de-energized in the event that a door or panel is opened.

b. Ozone generation within the filter that does not exceed five parts per one hundred million parts of air. Locate high voltage insulators in a serviceable location outside the moving air stream or on the clean air side of the unit. Fully expose ionizer wire supports and furnish ionizer wires precut to size and with formed loops at each end to facilitate ionizer wire replacement.

c. Agglomerator cell plates that allow proper air stream entrainment of agglomerates and prevent excessive residual dust build-up, with cells that are open at the top and bottom to prevent accumulation of agglomerates which settle by gravity. Where the dry agglomerator electrostatic filter is indicated to be the automatic renewable media type, provide a storage section that utilizes a horizontal or vertical traveling curtain of adhesive-coated bonded fibrous glass for dry agglomerator storage section service supplied in 65 foot lengths in convenient roll form. Otherwise, provide section construction and roll media characteristics as specified for automatic renewable media filters. Also a dry agglomerator/renewable media combination with an initial air flow resistance, after installation of clean media, that does not exceed 0.25 inch water gauge at 500 fpm face velocity.

d. A MERV of the combination that is not less than 15 when tested according to ASHRAE 52.2 at an average operating resistance of 0.50 inch water gauge. Where the dry agglomerator electrostatic filter is indicated to be of the extended surface nonsupported pocket filter type, provide a storage section as specified for extended surface non-supported pocket filters, with sectional holding frames or side access housings as indicated.

e. A dry agglomerator/extended surface nonsupported pocket filter section combination with initial air flow resistance, after installation of clean filters, that does not exceed 0.65 inch water gauge at 500 fpm face velocity, with a MERV of the combination not less than 16 when tested according to ASHRAE 52.2. Furnish front access filters with full height air distribution baffles and upper and lower mounting tracks to permit the baffles to be moved for agglomerator cell inspection and service. When used in conjunction with factory fabricated air handling units, supply side access housings which have dimensional compatibility.

2.10.3.8 High-Efficiency Particulate Air (HEPA) Filters

Provide HEPA filters that meet the requirements of IEST RP-CC-001 and are individually tested and certified to have an efficiency of not less than [95] [99.97] percent, and an initial resistance at [_____] fpm that does not exceed [_____] inches water gauge. Provide filters that are constructed by pleating a continuous sheet of filter medium into closely spaced pleats separated by corrugated aluminum or mineral-fiber inserts, strips of filter medium, or by honeycomb construction of the pleated filter medium. Provide interlocking, dovetailed, molded neoprene rubber gaskets of 5-10 durometer that are cemented to the perimeter of the [upstream] [downstream] face of the filter cell sides. Provide self-extinguishing rubber-base type adhesive or other materials conforming to fire hazard classification specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Provide filter cell sides that are [3/4 inch thick exterior grade fire-retardant plywood] [cadmium plated steel] [galvanized steel] assembled in a rigid manner. Provide overall cell side dimensions that are correct to 1/16 inch, and squareness that is maintained to within 1/8 inch. Provide holding frames that use spring loaded fasteners or other devices to seal the filter tightly within it and that prevent any bypass leakage around the filter during its installed life. Provide air capacity and the nominal depth of the filter as indicated. Install each filter in a factory preassembled side access housing or a factory-made sectional supporting frame as indicated. Provide prefilters of the type, construction and efficiency indicated.

2.10.3.9 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.

2.10.3.10 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 [graduations] [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 tips with integral compression fittings, two molded plastic vent valves, two 5 foot minimum lengths of 1/4 inch diameter [aluminum] [vinyl] tubing, and all hardware and accessories for gauge mounting.

2.11 AIR HANDLING UNITS

2.11.1 Field-Fabricated Air Handling Units

Provide built-up units as specified in paragraph DUCT SYSTEMS. Provide fans, coils spray-coil dehumidifiers, and air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types indicated.

2.11.2 Factory-Fabricated Air Handling Units

Provide [single-zone draw-through type][or][single-zone blow-through type][or][multizone blow-through type][blow-through double-deck type][blow-through triple deck type] units as indicated. Units must include fans, coils, airtight insulated casing, [prefilters,] [secondary filter sections,][and][diffuser sections where indicated,] [air blender] adjustable V-belt drives, belt guards for externally mounted motors, access sections where indicated, [mixing box] [combination sectional filter-mixing box,] [[pan][drysteam][spray type] humidifier,] 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.

2.11.2.1 Casings

Provide the following:

a. [Casing sections [[single] [2 inch double] wall type] [as indicated], constructed of a minimum 18 gauge galvanized steel, or 18 gauge corrosion-resisting sheet steel conforming to ASTM A167, Type 304.][Inner casing of double-wall units that are a minimum 20 gauge solid galvanized steel or corrosion-resisting sheet steel conforming to ASTM A167, Type 304.] 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. [Install a minimum 8 by 8 inches sealed glass window suitable for the intended application, in all access doors.]

d. Double-wall insulated type drain pan (thickness equal to exterior casing) constructed of 16 gauge [galvanized steel] [corrosion resisting sheet steel conforming to ASTM A167, Type 304], conforming to ASHRAE 62.1. Construct 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 indicated].

2.11.2.2 Heating and Cooling Coils

Provide coils as specified in paragraph AIR SYSTEMS EQUIPMENT.

2.11.2.3 Air Filters

Provide air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

2.11.2.4 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 [open][splashproof][totally enclosed] enclosures.

e. Motor starters of [manual][magnetic][across-the-line][reduced-voltage-start] type with [general-purpose][weather-resistant][watertight] enclosure. 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.

2.11.2.5 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.

2.11.2.6 Diffuser Sections

Furnish diffuser sections between the discharge of all housed supply fans [and cooling coils of blow-through single zone units][and][filter sections of those units with high efficiency filters located immediately downstream of the air handling unit fan section]. Provide diffuser sections that are fabricated by the unit manufacturer in a manner identical to the remainder of the unit casing, designed to be airtight under positive static pressures up to [8][_____] inches water gauge and with an access door on each side for inspection purposes. Provide a diffuser section that contains a perforated diffusion plate, fabricated of galvanized steel, Type 316 stainless steel, aluminum, or steel treated for

corrosion with manufacturer's standard corrosion-resisting finish, and designed to accomplish uniform air flow across the down-stream [coil][filters] while reducing the higher fan outlet velocity to within plus or minus 5 percent of the required face velocity of the downstream component.

2.12 TERMINAL UNITS

2.12.1 Room Fan-Coil Units

Provide base units that include galvanized coil casing, coil assembly drain pan [valve and piping package,] [outside air damper,] [wall intake box,] air filter, fans, motor, fan drive, motor switch, an enclosure for cabinet models and casing for concealed models, leveling devices integral with the unit for vertical type units, and sound power levels as indicated. Obtain sound power level data or values for these units according to test procedures based on AHRI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles. Values obtained for the standard cabinet models are acceptable for concealed models without separate test provided there is no variation between models as to the coil configuration, blowers, motor speeds, or relative arrangement of parts. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Fasten each unit securely to the building structure. Provide units with capacity indicated. Provide room fan-coil units that are certified as complying with AHRI 440, and meet the requirements of UL 1995.

2.12.1.1 Enclosures

Fabricate enclosures from not lighter than 18 gauge steel, reinforced and braced. Provide enclosures with front panels that are removable and have 1/4 inch closed cell insulation or 1/2 inch thick dual density foil faced fibrous glass insulation. Make the exposed side of a high density, erosion-proof material suitable for use in air streams with velocities up to 4,500 fpm. Provide a discharge grille that is [adjustable] [fixed] and that is of such design as to properly distribute air throughout the conditioned space. Plastic discharge and return grilles are acceptable provided the plastic material is certified by the manufacturer to be classified as flame resistant according to UL 94 and the material complies with the heat deflection criteria specified in UL 1995. Provide galvanized or factory finished ferrous metal surfaces with corrosion resistant enamel, and access doors or removable panels for piping and control compartments, plus easy access for filter replacement. Provide duct discharge collar for concealed models.

2.12.1.2 Fans

Provide steel or aluminum, multiblade, centrifugal type fans. In lieu of metal, fans and scrolls could be of non-metallic materials of suitably reinforced compounds with smooth surfaces. Dynamically and statically balance the fans. Provide accessible assemblies for maintenance. Disassemble and re-assemble by means of mechanical fastening devices and not by epoxies or cements.

2.12.1.3 Coils

Fabricate coils from not less than 3/8 inch outside diameter seamless copper tubing, with copper or aluminum fins mechanically bonded or soldered to the tubes. Provide coils with not less than 1/2 inch outside

diameter flare or sweat connectors, accessory piping package with thermal connections suitable for connection to the type of control valve supplied, and manual air vent. Test coils hydrostatically at 300 psi or under water at 250 psi air pressure. Provide coils suitable for 200 psi working pressure. Make provisions for coil removal.

2.12.1.4 Drain Pans

Size and locate drain and drip pans to collect all water condensed on and dripping from any item within the unit enclosure or casing. Provide condensate drain pans designed for self-drainage to preclude the buildup of microbial slime and thermally insulated to prevent condensation and constructed of not lighter than 21 gauge type 304 stainless steel or noncorrosive ABS plastic. Provide insulation with a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and of a waterproof type or coated with a waterproofing material. Design drain pans so as to allow no standing water and pitch to drain. Provide minimum 3/4 inch NPT or 5/8 inch OD drain connection in drain pan. Provide plastic or metal auxiliary drain pans to catch drips from control and piping packages, eliminating insulation of the packages; if metal, provide auxiliary pans that comply with the requirements specified above. Extend insulation at control and piping connections 1 inch minimum over the auxiliary drain pan.

2.12.1.5 Manually Operated Outside Air Dampers

Provide manually operated outside air dampers according to the arrangement indicated, and parallel airfoil type dampers of galvanized construction. Provide blades that rotate on stainless steel or nylon sleeve bearings.

2.12.1.6 Filters

Provide disposable type filter that complies with ASHRAE 52.2. Provide filters in each unit that are removable without the use of tools.

2.12.1.7 Motors

Provide motors of the permanent split-capacitor type with built-in thermal overload protection, directly connected to unit fans. Provide motor switch with two or three speeds and off, manually operated, and mounted on an identified plate [inside the unit below or behind an access door][or][adjacent to the room thermostat][as indicated]. In lieu of the above fan speed control, a solid-state variable-speed controller having a minimum speed reduction of 50 percent is allowed. Provide motors with permanently-lubricated or oilable sleeve-type or combination ball and sleeve-type bearings with vibration isolating mountings suitable for continuous duty. Provide a motor power consumption, shown in watts, at the fan operating speed selected to meet the specified capacity that does not exceed the following values:

Free Discharge Motors			
Unit Capacity (cfm)	Maximum Power Consumption (Watts)		
	115V	230V	277V
200	70	110	90
300	100	110	110
400	170	150	150
600	180	210	220
800	240	240	230
1000	310	250	270
1200	440	400	440

High Static Motors	
Unit Capacity (cfm)	Maximum Power Consumption (Watts)
200	145
300	145
400	210
600	320
800	320
1000	530
1200	530

2.12.2 Coil Induction Units

Provide base unit that includes air plenums, air-discharge nozzles, air discharge grilles, recirculation grilles, water coil assembly, valve and piping package, condensate drain pan, and adjustable air-balancing dampers, plus an enclosure for cabinet models and casing for concealed models. Make each unit capable of producing not less than the capacity indicated without exceeding the indicated static pressure. Provide a sound power level as indicated with power level data or values for these units based on tests conducted according to ASA S12.51. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles. The values obtained for the standard cabinet models are acceptable for concealed models without separate tests, provided there is no variation between models as to coil configuration, air discharge

nozzles, air balancing dampers, or relative arrangement of parts. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Secure each unit to the building structure. Provide units with capacity indicated.

2.12.2.1 Enclosures

Fabricate enclosures from not lighter than 18 gauge steel, reinforced and braced. Provide a removable front panel of enclosure and insulate when required acoustically and to prevent condensation. Provide discharge grilles that are [adjustable][integrally stamped] and properly distribute air throughout the conditioned space. Plastic discharge and return grilles are not acceptable. Provide access doors for all piping and control compartments.

2.12.2.2 Air Plenums

Fabricate plenums from galvanized steel with interior acoustically baffled and lined with sound absorbing material to attenuate the sound power from the primary air supply to the room. Provide heat-resistant nozzles that are integral with or attached airtight to the plenum. Where coil induction units are supplied with vertical runouts, furnish a streamlined, vaned, mitered elbow transition piece for connection between the unit and ductwork. Provide an adjustable air-balancing damper in each unit.

2.12.2.3 Coils

Fabricate coils from not less than 3/8 inch outside diameter seamless copper tubing, with copper or aluminum fins, mechanically bonded or soldered to the tubes. Furnish coil connections with not less than 1/2 inch outside diameter flare or sweat connectors, accessory piping package with terminal connections suitable for connection to the type of control valve supplied, and manual air vent. Test coils hydrostatically at 300 psi or under water at 250 psi air pressure and provide coils suitable for 200 psi working pressure.

2.12.2.4 Screens

Provide easily accessible lint screens or throwaway filters for each unit.

2.12.2.5 Drain Pan

Size and locate drain and drip pans to collect condensed water dripping from any item within the unit enclosure. Provide drain pans constructed of not lighter than 21 gauge steel, galvanized after fabrication, and thermally insulated to prevent condensation. Provide insulation that has a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and that is a waterproof type or coated with a waterproofing material. In lieu of the above, drain pans constructed of die-formed 22 gauge steel are allowed, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 21 gauge steel material or of die-formed 21 gauge type 304 stainless steel insulated as specified above. Pitch drain pans to drain. Provide drain connection when a condensate drain system is indicated. Make connection a minimum 3/4 inch NPT or 5/8 inch OD.

2.12.3 Variable Air Volume (VAV) and Dual Duct 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.

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.

2.12.3.1 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.

2.12.3.2 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.

2.12.3.3 Variable Volume, Single Duct, Fan-Powered Terminal Units

Provide variable volume, single duct, fan-powered terminal units with a calibrated air volume sensing device, air valve or damper, actuator, fan and motor, and accessory relays. Provide units that control primary air volume to within plus or minus 5 percent of each air set point as determined by the thermostat with variations in inlet pressure from 3/4 to 6 inch water gauge. Provide unit fan that is centrifugal, direct-driven, double-inlet type with forward curved blades. Provide either single speed with speed controller or three-speed, permanently lubricated, permanent split-capacitor type fan motor. Isolate fan/motor assembly from the casing to minimize vibration transmission. Provide factory furnished fan control that is wired into the unit control system. Provide a factory-mounted pressure switch to operate the unit fan whenever pressure exists at the unit primary air inlet or when the control system fan operates.

2.12.3.4 Dual Duct Terminal Units

Provide dual duct terminal units with hot and cold inlet valve or dampers that are controlled in unison by single or dual actuators. Provide actuator as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Provide unit that controls delivered air volumes within plus or minus 5 percent with inlet air variations from 1 to 8 inch water gauge in either duct. Include mixing baffles with the unit casing. Provide cabinet and closed duct leakage that does not exceed 2 percent of maximum rated air volume. Provide units with an internal resistance that does not exceed [_____] inch water gauge at maximum flow range.

2.12.3.5 Ceiling Induction Terminal Units

Provide ceiling induction unit with a calibrated primary air volume sensing device, primary air valve, induced air damper, and insulated induction tube. Arrange unit to induce air from the ceiling plenum to maintain a maximum total flow circulated to the conditioned space. Vary primary air upon demand of the room thermostat. Upon a demand for maximum cooling, provide a unit that delivers 100 percent primary air and, at minimum cooling, delivers [50] [25] percent primary air. Provide a terminal unit capable of closing to full shut off without additional actuators or linkage changes. Provide terminals that reset primary air volume within plus or minus 5 percent determined by the thermostat regardless of upstream changes in the static pressure. Provide a minimum inlet static pressure that does not exceed 1 inch water gauge, including a maximum of 0.3 inch water gauge downstream static pressure. Provide external differential pressure taps separate from control pressure taps for primary air flow measurement with 0 to 1 inch water gauge range. Make each unit normally [open] [closed] upon loss of pneumatic pressure. Factory pipe actuator and accuracy controls requiring only field installation of 20 psi pneumatic main air and room thermostat.

2.12.3.6 Series Fan Powered Variable Air Volume (VAV) Terminals

Provide units factory assembled, designed, tested, rated in accordance with AHRI 880 I-P, that are AHRI certified, listed in the AHRI DCAACP and that produce a supply air discharge mix by modulation of conditioned primary air and recirculating of return air. Provide units that include casing, centrifugal fan and motor, primary VAV damper or valve, electronic volume regulator, discharge air damper, primary air inlet cone with high and low pressure flow sensors, recirculating air filter frames, filter, and electrical disconnect. [Provide hot water heating coils integral to the terminal, or provide insulated hot water coil section attached to the discharge of the terminal.]

2.12.3.6.1 Casing

Provide removable full bottom access panels for servicing internal components without disturbing duct connections. Insulate inside of casing with manufacturer's standard insulation. Provide units that have recirculating air inlet equipped with filter frame, round primary damper or valve, and unit mounting brackets.

2.12.3.6.2 Fans and Motors

Provide centrifugal, forward curved, multiblade, fan wheels with direct-drive motors. Provide motors that are the high efficiency permanent-split capacitor type with thermal overload protection,

permanently lubricated bearings, and have three speeds or are equipped with solid state speed controllers. Provide isolation between fan motor assembly and unit casing. Provide fan and motor that is removable through casing access panel.

2.12.3.6.3 Flow Sensor

Provide ring or cross type sensor with minimum of two pickup points which average the velocity across the inlet. Obtain flow measurement within plus or minus 5 percent of rated airflow with 1.5 diameters of straight duct upstream of unit and inlet static variation of 0.5 to 5.0 inches water gauge. Supply flow measuring taps and calibration flowchart with each unit for field balancing airflows.

2.12.3.6.4 Primary VAV Damper or Valve

Provide galvanized steel damper blade that closes against gasket inside unit. Connect damper to operating shaft with a positive mechanical connection. Provide nylon bearing for damper shaft. Cylindrical die cast aluminum valve inlet tapered to fit round flexible ducts with integral flow diffuser and beveled self-centering disc. Provide damper or valve leakage at shutoff that does not exceed 2 percent of capacity at 1 inch water gauge pressure.

2.12.3.6.5 Regulator

Provide electronic volume regulator. Electronic controls contained in NEMA ICS 6, Type 1 enclosure sealed from airflow. Provide unit with controls mounted on side or on air valve. System powered regulators are not permitted. Provide volume regulator that resets primary air volume as determined by thermostat, within upstream static pressure variation noted in paragraph titled "Flow Sensor." Provide volume regulators that are field adjustable, factory set and calibrated to indicated maximum and minimum primary airflows, direct acting and normally [open] [closed] upon loss of pneumatic pressure.

2.12.3.6.6 Electrical

Provide unit that incorporates single point electrical connection with electrical disconnect. Provide electrical components that are UL or ETL listed, installed in accordance with NFPA 70 and mounted in control box. Units UL or ETL listed as an assembly do not require airflow switch interlock with electric heating coil, when factory assembled.

2.12.3.6.7 Filters

Provide UL listed throwaway one inch thick fiberglass filters, standard dust-holding capacity.

2.12.3.7 Reheat Units

2.12.3.7.1 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.

2.12.3.7.2 Steam Coils

Provide steam coils constructed of cast semisteel, welded steel, or copper headers, red-brass or copper tubes, and copper or aluminum fins mechanically bonded or soldered to the tubes. Roll and bush, braze or weld tubes into headers. Provide coil casings and tube support sheets, with collars of ample width, that are not lighter than 16 gauge galvanized steel formed to provide structural strength. When required, furnish multiple tube supports to prevent tube sag. Float the fin tube and header section within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Provide coils that are factory pressure tested and capable of withstanding 250 psi hydrostatic test pressure or 250 psi air pressure, and are for [100] [200] psi steam working pressure. Provide steam-distribution tube type preheat coils with condensing tubes having not less than 5/8 inch outside diameters. Provide distribution tubes that have not less than 3/8 inch outside diameter, with orifices to discharge steam to condensing tubes. Install distribution tubes concentric inside of condensing tubes held securely in alignment. Limit the maximum length of a single coil to 120 times the diameter of the outside tube. Other heating coils must be single tube type with an outside diameter not less than 1/2 inch. Provide supply headers that distribute steam evenly to all tubes at the indicated steam pressure. Provide coils that conform to the provisions of AHRI 410.

2.12.3.7.3 Electric Resistance Heaters

Provide the duct-mounting type electric resistance heaters consisting of a nickel-chromium resistor mounted on refractory material and a steel or aluminum frame for attachment to ductwork. Provide electric duct heater that meets the requirement of Underwriters Laboratories and NFPA 70 and is provided with a built-in or surface-mounted high-limit thermostat. Interlock electric duct heaters electrically so that they cannot be energized unless the fan is running.

2.12.4 Unit Ventilators

Provide unit ventilators that include an enclosure, [galvanized casing,] [cold-rolled steel casing with corrosion resistant coating,] coil assembly, [resistance heating coil assembly,] [valve and piping package,] drain pan, air filters, fan assembly, fan drive, motor, motor controller, dampers, damper operators, and sound power level as indicated. Obtain sound power level data or values for these units according to test procedures based on AHRI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles, when handling standard flow for which the unit air capacity is rated. Secure each unit to the building structure. Provide the unit ventilators with capacity indicated. Provide the year-round classroom type unit ventilator with automatic controls arranged to properly heat, cool, and ventilate the room. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Make the sequence of control any one of the standard ANSI cycles specified in paragraph CONTROLS.

2.12.4.1 Enclosures

Fabricate enclosures from not lighter than 16 gauge galvanized steel, reinforced and braced, or all welded framework with panels to provide equivalent strength. Provide casing that is acoustically and thermally insulated internally with not less than 1/2 inch thick dual density fibrous glass insulation. Make the exposed side a high density, erosion-proof material suitable for use in air streams with velocities up to 4500 fpm. Fasten the insulation with waterproof, fire-resistant adhesive. Design front panel for easy removal by one person. Provide discharge grilles that [have adjustable grilles or grilles with adjustable vanes and] properly distribute air throughout the conditioned space. Provide return grilles that are removable where front panel does not provide access to interior components. Plastic discharge or return grilles are not acceptable. Furnish removable panels or access doors for all piping and control compartments. Provide fan switch that is key operated or accessible through a locked access panel. Install gaskets at the back and bottom of the unit for effective air seal, as required.

2.12.4.2 Electric Resistance Heating Elements

Provide electric resistance heating elements that are of the sheathed, finned, tubular type, or of the open resistance type designed for direct exposure to the air stream. Provide heating element electrical characteristics as indicated. Where fan motor or control voltage is lower than required for the electric-resistance heating element, install a fused factory mounted and wired transformer.

2.12.4.3 Fans

Provide fans that meet the requirements as specified in paragraph AIR SYSTEMS EQUIPMENT. Provide galvanized steel or aluminum, multiblade, centrifugal type fans, dynamically and statically balanced. Equip fan housings with resilient mounted, self-aligning permanently lubricated ball bearings, sleeve bearings, or combination ball and sleeve bearings, capable of not less than 2000 hours of operation on one oiling. Provide direct-connected fans.

2.12.4.4 Coils

Provide coils that are circuited for a maximum water velocity of 8 fps without excessive pressure drop and are otherwise as specified for hot water coils in paragraph TERMINAL UNITS.

2.12.4.5 Drain Pans

Size and locate drain and drip pans to collect all condensed water dripping from any item within the unit enclosure. Provide drain pans constructed of not lighter than 18 gauge steel, galvanized after fabrication, and thermally insulated to prevent condensation. Provide insulation that is coated with a fire-resistant waterproofing material. In lieu of the above, drain pans constructed of die-formed 20 gauge steel is allowed, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 18 gauge steel material, or of die-formed 18 gauge type 304 stainless steel insulated as specified above. Pitch drain pans to drain. Furnish drain connection unless otherwise indicated. Make the minimum connection 3/4 inch NDT or 5/8 inch OD.

2.12.4.6 Filters

Disposable type rated in accordance with ASHRAE 52.2, installed upstream of coil.

2.12.4.7 Dampers

Provide an outside air proportioning damper on each unit. In addition, provide a vane to prevent excessive outside air from entering unit and to prevent blow-through of outside air through the return air grille under high wind pressures. Where outside air and recirculated air proportioning dampers are provided on the unit, an additional vane is not required. Provide face and bypass dampers for each unit to ensure constant air volume at all positions of the dampers. Furnish each unit with a factory installed control cam assembly, pneumatic motor, or electric motor to operate the face and bypass dampers and outside air damper or outside air and recirculated air dampers in the sequence as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS.

2.12.4.8 Motors

Provide permanent split-capacitor type motors with built-in thermal overload protection and automatic reset. Mount motor on a resilient mounting, isolated from the casing and suitable for operation on electric service available. Provide a manually operated motor switch that provides for 2 or 3 speeds and off, mounted on an identified plate [inside the unit below or behind an access door][or][adjacent to the room thermostat][as indicated]. In lieu of speed control, provide a solid state variable speed controller having minimum speed reduction of 50 percent.

2.12.4.9 Outside Air Intakes

Provide the manufacturer's standard design outside air intakes furnished with 1/2 inch mesh bird screen or louvers on 1/2 inch centers.

2.13 ENERGY RECOVERY DEVICES

2.13.1 Rotary Wheel

Provide unit that is a factory fabricated and tested assembly for air-to-air energy recovery by transfer of sensible heat from exhaust air to supply air stream, with device performance according to ASHRAE 84 and that delivers an energy transfer effectiveness of not less than [70][85][_____] percent with cross-contamination not in excess of [0.1][1.0][_____] percent of exhaust airflow rate at system design differential pressure, including purging sector if provided with wheel. Provide exchange media that is chemically inert, moisture-resistant, fire-retardant, laminated, nonmetallic material which complies with NFPA 90A. Isolate exhaust and supply streams by seals which are static, field adjustable, and replaceable. Equip chain drive mechanisms with ratcheting torque limiter or slip-clutch protective device. Fabricate enclosure from galvanized steel and include provisions for maintenance access. Provide recovery control and rotation failure provisions as indicated.

2.13.2 Run-Around-Coil

Provide assembly that is factory fabricated and tested

air-to-liquid-to-air energy recovery system for transfer of sensible heat from exhaust air to supply air stream and that delivers an energy transfer effectiveness not less than that indicated without cross-contamination with maximum energy recovery at minimum life cycle cost. Computer optimize components for capacity, effectiveness, number of coil fins per inch, number of coil rows, flow rate, heat transfer rate of [_____] percent by volume of [ethylene][propylene] glycol solution, and frost control. Provide coils that conform to paragraph AIR HANDLING UNITS. Provide related pumps, and piping specialties that conform to requirements of [Section 23 63 00.00 10 COLD STORAGE REFRIGERATION SYSTEMS][Section 23 57 10.00 10 FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS][23 69 00.00 20 REFRIGERATION EQUIPMENT FOR COLD STORAGE] [_____].

2.13.3 Heat Pipe

Provide a device that is a factory fabricated, assembled and tested, counterflow arrangement, air-to-air heat exchanger for transfer of sensible heat between exhaust and supply streams and that delivers an energy transfer effectiveness not less than that indicated without cross-contamination. Provide heat exchanger tube core that is [1/2][5/8][1] inch nominal diameter, seamless aluminum or copper tube with extended surfaces, utilizing wrought aluminum Alloy 3003 or Alloy 5052, temper to suit. Provide maximum fins per unit length and number of tube rows as indicated. Provide tubes that are fitted with internal capillary wick, filled with a refrigerant complying with ASHRAE 15 & 34, selected for system design temperature range, and hermetically sealed. Refrigerants containing chlorofluorocarbons (CFC) are prohibited. Provide heat exchanger frame that is constructed of not less than 16 gauge galvanized steel and fitted with intermediate tube supports, and flange connections. Provide tube end-covers and a partition of galvanized steel to separate exhaust and supply air streams without cross-contamination and in required area ratio.[Provide a drain pan constructed of welded Type 300 series stainless steel.] Provide heat recovery regulation by [system face and bypass dampers and related control system as indicated][interfacing with manufacturer's standard tilt-control mechanism for summer/winter operation, regulating the supply air temperature and frost prevention on weather face of exhaust side at temperature indicated]. Coil must be fitted with pleated flexible connectors.

2.13.4 Desiccant Wheel

Provide counterflow supply, regeneration airstreams, a rotary type dehumidifier designed for continuous operation, and extended surface type wheel structure in the axial flow direction with a geometry that allows for laminar flow over the operating range for minimum air pressure differentials. Provide the dehumidifier complete with a drive system utilizing a fractional-horsepower electric motor and speed reducer assembly driving the rotor. Include a slack-side tensioner for automatic take-up for belt-driven wheels. Provide an adsorbing type desiccant material. Apply the desiccant material to the wheel such that the entire surface is active as a desiccant and the desiccant material does not degrade or detach from the surface of the wheel which is fitted with full-face, low-friction contact seals on both sides to prevent cross leakage. Provide rotary structure that has underheat, overheat and rotation fault circuitry. Provide wheel assembly with a warranty for a minimum of five years.

2.13.5 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.

2.14 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 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.

2.15 SUPPLEMENTAL COMPONENTS/SERVICES

2.15.1 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

2.15.2 Refrigerant Piping

The requirements for refrigerant piping are specified in Section 23 23 00 REFRIGERANT PIPING.

2.15.3 Water or Steam Heating System Accessories

The requirements for water or steam heating accessories such as expansion tanks and steam traps are specified in Section [23 52 00 HEATING BOILERS][23 21 13.00 20 LOW TEMPERATURE WATER (LTW) HEATING SYSTEM][23 22 26.00 20 STEAM SYSTEM AND TERMINAL UNITS].

2.15.4 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][23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS] except as modified herein.

2.15.5 Backflow Preventers

The requirements for backflow preventers are specified in Section 22 00 00

PLUMBING, GENERAL PURPOSE.

2.15.6 Insulation

The requirements for shop and field applied insulation are specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.15.7 Controls

The requirements for controls are specified in [Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS][and][Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][and][Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS].

2.16 RADIANT PANELS

2.16.1 Hydronic Modular Panels

2.16.1.1 Panels

Modular radiant panels will fit into a standard 24 inch x 24 inch or 24 inch x 48 inch suspended T-Bar ceiling grid or flush mounted on a drywall ceiling. For flush mounted ceiling applications, the manufacturer will provide a one piece extruded aluminum frame. Panels must be supported from the T-bar assembly. Panels must be [14 gauge] or [16 gauge] extruded aluminum or sheet steel.

2.16.1.2 Heat Sink

The modular panels must use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face.

2.16.1.3 Water Tubes

Tubes must consist of ASTM B75/B75M [1/2 inch] [5/8 inch] O.D. nominal copper tubing. Water connections will be suitable for solder or compression fittings. Heat pads will be used between the soldered fitting and the panel to protect the panel surface. The manufacturer will provide water pressure drop data as well as heating and cooling output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling). The panels will have the capacity to have multiple passes with connections either on the [same end] or [opposite ends], dependent on the number of passes.

2.16.1.4 Finish

All visible components must be powder coated with highly emissive powder coat polyester paint for optimal radiative properties as well as durability and easy cleaning. Standard finish color must be white.

2.16.1.5 Performance

Manufacturer will provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling).

2.16.1.6 Capacity

Modular radiant panel capacity will be tested and certified by manufacturer in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling) to meet the required performance. Should any performance rating, chilled or hot water supply temperature, water pressure drop, etc. deviate from the schedule, the manufacturer will submit the updated capacity. [The manufacturer will have factory testing facility available to perform performance test of units in accordance with said standard.]

2.16.1.7 Water Connections

Connections will be shipped sealed to limit the introduction of dust and dirt during shipping and construction.

2.16.1.8 Installation

Panels will be installed as recommended by the manufacturer.

2.16.1.9 Accessories

Stainless steel braded hoses, 12 inches or 18 inches long will be supplied with the panels.

The top of the heating and cooling panels must be covered with1-1/2 inches thick 1 lb/cu ft formaldehyde-free fiber glass insulation with a minimum R = 4.5 (hr ft2 deg F)/BTU. The insulation must be covered with a foil scrim kraft vapor barrier facing.

2.16.2 Hydronic Linear Panels

2.16.2.1 Panels

Linear radiant panels must use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face. The linear radiant panel is to radiate or absorb heat from or to the zone below. Panels must be [14 gauge] or [16 gauge] extruded aluminum.

2.16.2.2 Heat Sink

The modular panels must use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face.

2.16.2.3 Water Tubes

Tubes must consist of ASTM B75/B75M 1/2 inch or 5/8 inch O.D. nominal copper tubing. Water connections will be suitable for solder or compression fittings. The manufacturer will provide water pressure drop data as well as heating and cooling output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling).

2.16.2.4 Mounting

Units must be provided with mounting hardware as required for mounting in T-Bar applications or ceiling flush mounting. The manufacturer's standard hardware for mounting panels abutting each other must be submitted for approval.

2.16.2.5 Finish

All visible components must be powder coated with highly emissive powder coat polyester paint for optimal radiative properties as well as durability and easy cleaning. Standard finish color must be white.

2.16.2.6 Performance

Manufacturer must provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling).

2.16.2.7 Capacity

Modular radiant panel capacity must be tested and certified by manufacturer in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling) to meet the required performance. Should any performance rating, chilled or hot water supply temperature, water pressure drop, etc. deviate from the schedule, the manufacturer must submit the updated capacity. [The manufacturer must have factory testing facility available to perform performance test of units in accordance with said standard.]

2.16.2.8 Water Connections

Connections will be shipped sealed to limit the introduction of dust and dirt during shipping and construction.

2.16.2.9 Accessories

Stainless steel braded hoses, 12 inches or 18 inches long will be supplied with the panels.

The top of the heating and cooling panels must be covered with 1-1/2 inches thick 1 lb/cu ft formaldehyde-free fiber glass insulation with a minimum R = 4.5 (hr ft2 deg F)/BTU. The insulation must be covered with a foil scrim kraft vapor barrier facing.

2.16.3 Prefabricated Radiant-Heating Electric Panels

2.16.3.1 Description

Sheet metal enclosed panel with heating element suitable for [lay-in installation flush with T-bar ceiling grid] [surface mounting] [recessed mounting]. Comply with UL 2021

2.16.3.2 Panel

Minimum 0.027 inch thick, galvanized steel sheet back panel riveted to minimum 0.040 inch thick, galvanized steel sheet front panel with fused-on crystalline surface.

2.16.3.3 Heating Element

Powdered graphite sandwiched between sheets of electric insulation.

2.16.3.4 Electrical Connections

Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.

2.16.3.5 Exposed-Side Panel Finish

[Apply silk-screened finish to match appearance of Architect selected acoustical ceiling tiles.] [Baked-enamel finish in color as selected by Architect.]

2.16.3.6 Surface-Mounting Trim

Sheet metal with baked-enamel finish in color as selected by Architect.

2.16.3.7 Wall Thermostat

Bimetal, sensing elements; with contacts suitable for [low] [line]-voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.

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] [units except room [fan-coil units][and][coil-induction 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 30 00 CAST-IN-PLACE 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.

3.2.5.1 Underground Ductwork

Provide PVC plastisol coated galvanized steel underground ductwork with coating on interior and exterior surfaces and watertight joints. Install ductwork as indicated, according to ACCA Manual 4 and manufacturer's instructions. Maximum burial depth is 6 feet.

3.2.5.2 Radon Exhaust Ductwork

Perforate subslab suction piping where indicated. Install PVC joints as

specified in ASTM D2855.

3.2.5.3 Light Duty Corrosive Exhaust Ductwork

For light duty corrosive exhaust ductwork, use PVC plastisol coated galvanized steel with PVC coating on interior [surfaces][and exterior surfaces][and epoxy wash primer coating on exterior surfaces].

3.2.6 FRP Ductwork

Provide fibrous glass reinforced plastic ducting and related structures that conform to SMACNA 1403. Provide flanged joints where indicated. Crevice-free butt lay-up joints are acceptable where flanged joints are not indicated. When ambient temperatures are lower than 50 degrees F, heat cure joints by exothermic reaction heat packs.

3.2.7 Kitchen Exhaust Ductwork

3.2.7.1 Ducts Conveying Smoke and Grease Laden Vapors

Provide ducts conveying smoke and grease laden vapors that conform to requirements of NFPA 96. Make seams, joints, penetrations, and duct-to-hood collar connections with a liquid tight continuous external weld. Provide duct material that is a [minimum 18 gauge, Type 304L or 316L, stainless steel] [minimum 16 gauge carbon steel]. [Include with duct construction an external perimeter angle sized in accordance with SMACNA 1966, except place welded joint reinforcement on maximum of 24 inch centers; continuously welded companion angle bolted flanged joints with flexible ceramic cloth gaskets where indicated; pitched to drain at low points; welded pipe coupling-plug drains at low points; welded fire protection and detergent cleaning penetration; steel framed, stud bolted, and flexible ceramic cloth gasketed cleaning access provisions where indicated. Make angles, pipe couplings, frames, bolts, etc., the same material as that specified for the duct unless indicated otherwise.]

3.2.7.2 Exposed Ductwork

Provide exposed ductwork that is fabricated from minimum 18 gauge, Type 304L or 316L, stainless steel with continuously welded joints and seams. Pitch ducts to drain at hoods and low points indicated. Match surface finish to hoods.

3.2.7.3 Concealed Ducts Conveying Moisture Laden Air

Fabricate concealed ducts conveying moisture laden air from minimum [18 gauge, Type 300 series, stainless steel] [16 gauge, galvanized steel] [16 ounce, tempered copper sheet]. Continuously weld, braze, or solder joints to be liquid tight. Pitch ducts to drain at points indicated. Make transitions to other metals liquid tight, companion angle bolted and gasketed.

3.2.8 Acoustical Duct Lining

Apply lining in cut-to-size pieces attached to the interior of the duct with nonflammable fire resistant adhesive conforming to ASTM C916, Type I, NFPA 90A, UL 723, and ASTM E84. Provide top and bottom pieces that lap the side pieces and are secured with welded pins, adhered clips of metal, nylon, or high impact plastic, and speed washers or welding cup-head pins installed according to SMACNA 1966. Provide welded pins, cup-head pins,

or adhered clips that do not distort the duct, burn through, nor mar the finish or the surface of the duct. Make pins and washers flush with the surfaces of the duct liner and seal all breaks and punctures of the duct liner coating with the nonflammable, fire resistant adhesive. Coat exposed edges of the liner at the duct ends and at other joints where the lining is subject to erosion with a heavy brush coat of the nonflammable, fire resistant adhesive, to prevent delamination of glass fibers. Apply duct liner to flat sheet metal prior to forming duct through the sheet metal brake. Additionally secure lining at the top and bottom surfaces of the duct by welded pins or adhered clips as specified for cut-to-size pieces. Other methods indicated in SMACNA 1966 to obtain proper installation of duct liners in sheet metal ducts, including adhesives and fasteners, are acceptable.

3.2.9 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.

3.2.10 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][or][up to the point where the outdoor air mixes with the return air stream].

3.2.11 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.

3.2.12 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.

3.2.13 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 [28][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. When the work area is in an occupied space such as office, laboratory or warehouse [_____] protect all furniture and equipment from dirt and debris. 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.

3.7.4 Finish Painting

The requirements for finish painting of items only primed at the factory, and surfaces not specifically noted otherwise, are specified in Section 09 90 00 PAINTS AND COATINGS.

3.7.5 Color Coding Scheme for Locating Hidden Utility Components

Use scheme in buildings having suspended grid ceilings. Provide color coding scheme that identifies points of access for maintenance and operation of components and equipment that are not visible from the finished space and are accessible from the ceiling grid, consisting of a color code board and colored metal disks. Make each colored metal disk approximately 3/8 inch diameter and secure to removable ceiling panels with fasteners. Insert each fastener into the ceiling panel so as to be concealed from view. Provide fasteners that are manually removable without the use of tools and that do not separate from the ceiling panels when the panels are dropped from ceiling height. Make installation of colored metal disks follow completion of the finished surface on which the disks are to be fastened. Provide color code board that is approximately 3 foot wide, 30 inches high, and 1/2 inches thick. Make the board of wood fiberboard and frame under glass or 1/16 inch transparent plastic cover. Make the color code symbols approximately 3/4 inch in diameter and the related lettering in 1/2 inch high capital letters. Mount the color code board [where indicated] [in the mechanical or equipment room]. Make the color code system as indicated below:

Color	System	Item	Location
[_____]	[_____]	[_____]	[_____]

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 TEST

Perform ductwork leak test for the entire air distribution and exhaust system, including fans, coils, [filters, etc.][filters, etc. designated as static pressure Class 3 inch water gauge through Class 10 inch water gauge.] Provide test procedure, apparatus, and report that conform to SMACNA 1972 CD. The maximum allowable leakage rate is [_____] cfm. Complete ductwork leak test with satisfactory results prior to applying insulation to ductwork exterior or concealing ductwork.

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 TESTING, ADJUSTING AND BALANCING FOR HVAC. 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 Testing, Adjusting and Balancing for HVAC and Section 23 09 00 Instrumentation and Control 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][coil-induction units,] [air terminal units,] [unit ventilators,] 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 [_____] 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 --

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SECTION 23 31 13.00 40

METAL DUCTS
05/16

PART 1 GENERAL

[Section 23 30 00 HVAC AIR DISTRIBUTION apply to work specified in this section.

][Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT applies to work in this section.

][Section 40 17 30.00 40 WELDING GENERAL PIPING applies to work specified in this section.

]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 INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2017) Steel Construction Manual
AISC 360	(2016) Specification for Structural Steel Buildings

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

ASHRAE EQUIP IP HDBK	(2012) Handbook, HVAC Systems and Equipment (IP Edition)
ASHRAE FUN IP	(2017) Fundamentals Handbook, I-P Edition

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding

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 A924/A924M	(2020) Standard Specification for General Requirements for Steel Sheet,

	Metallic-Coated by the Hot-Dip Process
ASTM C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D257	(2014) Standard Test Methods for D-C Resistance or Conductance of Insulating Materials
ASTM E90	(2009; R2016) Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

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
SMACNA 1987	(2006) HVAC Duct Systems Inspection Guide, 3rd Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Painting Manual	(2002) Good Painting Practice, Steel Structures Painting Manual, Volume 1

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS 2480	(2009; Rev H) Phosphate Treatment, Paint, Base

UNDERWRITERS LABORATORIES (UL)

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

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists; G, AE

Records of Existing Conditions; G, AE

SD-02 Shop Drawings

Connection Diagrams; G, AE

Offset Fitting Configurations; G, AE

SD-03 Product Data

Equipment and Performance Data

Galvanized Steel Ductwork Materials; G, AE

Brazing Materials

Mill-Rolled Reinforcing and Supporting Materials

Round Sheet Metal Duct Fittings; G, AE

Round, High-Pressure, Double-Wall Sheet Metal Ducts; G, AE

Turning Vanes; G, AE

Sound Traps; G, AE

Flexible Connectors; G, AE

Flexible Duct Materials

Power Operated Dampers; G, AE

Fire Dampers and Wall Collars; G, AE

Gravity Backdraft and Relief Dampers; G, AE

Manual Volume Dampers; G, AE

SD-05 Design Data

Design Analysis and Calculations; G, AE

SD-06 Test Reports

Ductwork Leakage Tests; G, AE

Operational Tests; G, AE

SD-07 Certificates

Listing of Product Installations

Galvanized Steel Ductwork Materials

Brazing Materials

Mill-Rolled Reinforcing and Supporting Materials

Round Sheet Metal Duct Fittings

Round, High-Pressure, Double-Wall Sheet Metal Ducts

Turning Vanes

Dampers

Sound Traps

Flexible Connectors

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, AE

Power Operated Dampers; G, AE

Fire Dampers and Wall Collars; G, AE

SD-11 Closeout Submittals

Record Drawings; G, AE

1.3 QUALITY CONTROL

When furnishing the listing of product installations for medium and high pressure ductwork systems include identification of at least 5 units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. Include purchaser, address of installation, service organization, and date of installation.

PART 2 PRODUCTS

Include the manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information within material, equipment, and fixture lists.

2.1 SYSTEM DESCRIPTION

Provide low-pressure systems ductwork and plenums where maximum air velocity is 2,000-feet per minute(fpm) and maximum static pressure is 2-inches water gage (wg), positive or negative.

Submit connection diagrams for low pressure ductwork systems indicating the relation and connection of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

High velocity systems ductwork encompass systems where:

a. Minimum air velocity exceeds 2,000-feet per minute (fpm) or static pressure exceeds 2-inches water gage (wg).

[b. Medium static pressure ranges from over 2-inches wg through 3-inches wg, positive or negative, or over 3-inches wg through 6-inches wg positive.

][c. High static pressure ranges from over 6-inches wg through 10-inches wg, positive.

] d. Do not use rigid fibrous-glass ductwork.

2.1.1 Design Requirements

Submit records of existing conditions including the results of a survey consisting of work area conditions, and features of existing structures and facilities within and adjacent to the jobsite.

Submit equipment and performance data for medium and high pressure ductwork systems consisting of use life, system functional flows, safety features, and mechanical automated details. Submit test response and performance characteristics curves for certified equipment.

Submit design analysis and calculations for ductwork systems indicating the manufacturer's recommended air velocities, maximum static pressure, and temperature calculations.

2.2 COMPONENTS

2.2.1 Round Sheet Metal Duct Fittings

Submit offset fitting configurations for approval. Shop fabricate fittings.

2.2.1.1 Fittings Construction

Manufacture as separate fittings, not as tap collars welded or brazed into duct sections.

Provide two-piece type miter elbows for angles less than 31 degrees, three-piece type for angles 31 through 60 degrees, and five-piece type for angles 61 through 90 degrees. Ensure centerline radius of elbows is 1-1/2 times fitting cross section diameter.

Provide conical type crosses, increasers, reducers, reducing tees, and 90-degree tees.

Ensure cutouts in fitting body are equal to branch tap dimension or, where smaller, excess material is flared and rolled into smooth radius nozzle configuration.

2.2.2 Round, High-Pressure, Double-Wall Sheet Metal Ducts

Shop fabricate ducts and fittings.

Construction comprises of an airtight, vapor barrier, outer pressure shell, a 1 inch insulation layer, and a metal inner liner that completely covers the insulation throughout the system.

Provide insulation conforming to NFPA 90A and ASTM C1071 for thermal conductivity in accordance with ASTM D257.

2.2.3 Reinforcement

Support inner liners of both duct and fittings by metal spacers welded in position to maintain spacing and concentricity.

2.2.4 Fittings

Make divided flow fittings as separate fittings, not tap collars into duct sections, with the following construction requirements:

a. Sound, airtight, continuous welds at intersection of fitting body and tap

b. Tap liner securely welded to inner liner, with weld spacing not to exceed 3-inches.

c. Pack insulation around the branch tap area for complete cavity filling.

d. Carefully fit branch connection to cutout openings in inner liner without spaces for air erosion of insulation and without sharp projections that cause noise and airflow disturbance.

Continuously braze seams in the pressure shell of fittings. Protect galvanized areas that have been damaged by welding with manufacturer's standard corrosion-resistant coating.

Construct two-piece type elbows for angles through 35 degrees, three-piece type for angles 36 through 71 degrees, and five-piece type for angles 72 through 90 degrees.

[Provide conical type crosses, increasers, reducers, reducing tees, and 90-degree tees.

]2.2.5 Turning Vanes

Provide double-wall type turning vanes, commercially manufactured for high-velocity system service.

2.2.6 Dampers

Construct low pressure drop, high-velocity manual volume dampers, and high-velocity fire dampers in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

2.2.7 Sound Traps

[Provide sound traps.

] Ensure the pressure drop at the rated flow does not exceed ratings in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966 or design criteria.

Ensure the sound trap is airtight when operating under an internal pressure of 0.37 pounds per square inch. Provide an air-side surface capable of withstanding air velocities of 10,000-feet per minute without any particulate matter leaving the trap and being carried downstream.

2.2.7.1 Attenuation

Factory fabricate sound traps. Confirm cataloged acoustic attenuation made by an independent laboratory in accordance with ASTM E90. Confirm pressure drop measurements in accordance with ASHRAE EQUIP IP HDBK, Chapter 18. For noise-reduction data, include effects of flanking paths

and vibration transmission. Conduct tests with standard metal inlet and outlet connections under indicated capacity flow.

[Ensure attenuation is in accordance with ASHRAE FUN IP. Include a graphic system noise spectrum certification indicating proposed fan sound power level. Attenuation of ducting system proposed for installation is based on ASHRAE FUN IP for bends, branches, and other duct system construction noise criteria curve.
]

Reduce fan-rated sound-power level to not less than 65 decibels in the 250-hertz third octave band when measured at the sound trap discharge end.

2.2.7.2 Construction of Sound Traps

Provide double-metal walled, [round] [rectangular] sound traps. Provide mill-galvanized sheet metal steel with commercial weight of zinc, conforming to ASTM A653/A653M. Exterior metal acts as a vapor barrier. Metal thickness is not less than that required for the pressure service, in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966, but not less than 22-gage. Cover absorbing material, on the sound-impinging side, with formed perforated mill-galvanized steel of not less than 24-gage. Ensure all exterior sheet joints are continuously welded, or construct with locksets filled with chloroprene mastic prior to forming.

Spot weld interior surfaces not more than 3-inches on center. Ensure all connections to duct transitions are flanged with through-bolted 1/8-inch by 1-inch continuous rubber gasketing. Provide vibration isolated trapeze type supports.

Provide fibrous glass absorption material. [Ensure surfaces exposed to airstream are chloroprene coated or protected with woven fibrous-glass cloth conforming to ASTM C1071.]Ensure the total compressed thickness gives the required attenuation, and thermal insulation to preclude condensation on exterior surface under normal operating conditions. Compressed material density is approximately 4.5 pounds per cubic foot. Select materials conforming to fire hazard requirements of NFPA 90A.

2.2.8 Flexible Connectors for Sheet Metal

Use UL listed connectors, 30-ounce per square yard, waterproof, fire-retardant, airtight, woven fibrous-glass cloth, double coated with chloroprene. Clear width, not including clamping section, is 6 to 8-inches.

[Provide leaded vinyl sheets as a second layer for sound attenuation. Ensure leaded vinyl is not less than 0.055-inch thick, weighing not less than 0.87 pound per square foot, and capable of approximately 10-decibel attenuation in the 10- to 10,000-hertz range.

]2.2.9 Duct Hangers

For duct hangers in contact with galvanized duct surfaces, provide [galvanized] [black carbon] steel painted with inorganic zinc.

2.2.10 Mill-Rolled Reinforcing and Supporting Materials

Provide mill-rolled structural steel conforming to ASTM A36/A36M. Whenever in contact with sheet metal ducting, provide galvanized steel in accordance with ASTM A123/A123M.

In lieu of mill-rolled structural steel, submit equivalent strength, proprietary-design, rolled-steel structural support systems for approval.

2.2.11 Flexible Duct Materials

Ensure flexible duct connectors comply with NFPA 90A, and conform with UL 181, Class 1 material.

[Provide [aluminum] [carbon steel] zinc-coated ASTM A123/A123M metal duct; bendable through 180 degrees without damage, with an inside bend radius not greater than one-half the diameter of duct.

][Provide wire-reinforced cloth duct consisting of a [chloroprene] [vinyl-impregnated and coated] fibrous-glass cloth bonded to and supported by a corrosion-protected spring steel helix. Fabric may be a laminate of metallic film and fibrous glass. Ensure working pressure rating of ducting is not less than three times maximum system pressure, and the temperature range is minus 20 to plus 175 degrees F.

][Provide wire-reinforced fibrous-glass duct consisting of a minimum [1] [_____] 1 pound/cubic foot density fibrous glass, bonded to and supported by corrosion-protected spring helix. Vapor barriers are a minimum of [4] [_____] mil, pigmented polyvinylchloride film. Ensure duct is bendable without damage through 180 degrees with an inside bend radius not greater than two duct diameters. Minimum wall thickness is [1][_____]-inch. Thermal conductivity is not greater than [0.23 BTU per hour per square foot per degrees F] [_____] at 75 degrees F mean temperature. Ensure permeance is not greater than [0.10 perm] [_____]. Working pressure range is from minus [1/2][_____]-inch wg to plus [1-1/2][_____]-inches wg. Working temperature ranges from minus 20 to plus 250 degrees F. Minimum sustained velocity without delamination is [2,400] [_____] fpm. Use materials conforming to NFPA 90A.

]2.2.12 Manual Volume Dampers

Conform to SMACNA 1966 for volume damper construction.

Equip dampers with an indicating quadrant regulator with a locking feature externally located and easily accessible for adjustment and standoff brackets to allow mounting outside external insulation. Where damper rod lengths exceed [30][_____]-inches, provide a regulator at each end of damper shaft.

2.2.12.1 Damper Construction

Provide all damper shafts with two-end bearings.

Ensure splitter damper is[[22] [_____]-gage sheet metal][and is [2] [_____] gages heavier than duct in which installed]. Hinges are [full length piano-type][1/8-inch thick door type].

Provide a full length damper shaft and extend it beyond the damper blade. use a [3/8] [_____]-inch square shaft for damper lengths up to [20] [_____]-inches and a [1/2] [_____]-inch square shaft for damper lengths [20] [_____]-inches and larger. Where necessary to prevent damper vibration or slippage, provide adjustable support rods with locking provisions external to duct at damper blade end.

Provide dampers in ducts having a width perpendicular to the axis of the damper that is greater than [12] [_____]-inches of multiblade type having a substantial frame with blades fabricated of [16] [_____]-gage metal. Provide blades not exceeding [10] [_____]-inches in width and [48] [_____]-inches in length, [pinned] [welded] to [1/2] [_____]-inch diameter shafts. Ensure dampers greater than [48] [_____]-inches in width are made in two or more sections with intermediate mullions, each section being mechanically interlocked with the adjoining section or sections. Provide blades with [graphite-impregnated nylon] [oil-impregnated sintered bronze] bearings and connect so that adjoining blades rotate in opposite directions.

2.2.13 Gravity Backdraft and Relief Dampers

Construct frames of not less than [1-1/2- by 4-inch] [_____] reinforced [16-gage] [_____] galvanized carbon steel. Solidly secure frames and mullions in place and seal with elastomer caulking against air bypass.

Provide shaft bearings with [graphite-impregnated nylon] [oil-impregnated bronze].

Equip counterbalanced dampers with fixed or adjustable counterbalancing weights.

Gravity backdraft dampers may be equipment manufacturer's standard construction in sizes [18 by 18] [_____]-inch or smaller, when furnished integral with air moving equipment.

2.2.13.1 Blade Construction

Maximum blade width is [9] [_____] inches, and maximum blade length is [36] [_____]-inches. Blade material is[16-gage galvanized steel] [14-gage [6063] [5052] alloy aluminum][18-gage AISI 18-8 corrosion-resistant steel]. Provide blades with mechanically retained seals and 90-degree limit stops.

Blades linked together for relief service dampers are to open not less than 30 degrees on 0.05-inch wg differential pressure.

2.2.14 Power Operated Dampers

Ensure dampers conform to applicable requirements specified under Section 23 09 33.00 40 ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC.

2.2.15 Fire Dampers and Wall Collars

Ensure fire damper locations are in accordance with NFPA 90A.

Provide fire dampers in ductwork at firewall barriers.

Construct and label fire dampers in accordance with UL 555 to provide damper and mounting fire-resistance that equals or exceeds fire-resistance of the construction in which installed. For link loads in excess of [20] pounds [_____], provide UL-approved quartzoid links.

Construct wall collars in accordance with UL 555.

2.3 MATERIALS

2.3.1 Galvanized Steel Ductwork Materials

Provide hot-dip galvanized carbon steel ductwork sheet metal of lock-forming quality, with regular spangle-type zinc coating, conforming to ASTM A924/A924M and ASTM A653/A653M, Designation G90. Treat duct surfaces to be painted by annealing.

Conform to ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966 for sheet metal gages and reinforcement thickness.

Low pressure ductwork minimum thicknesses are:

MINIMUM SHEET METAL THICKNESS	
DUCT WIDTH INCHES	GAGE
0-12	26
13-30	24
31-60	22

2.3.2 Brazing Materials

Provide silicon bronze brazing materials conforming to AWS A5.8/A5.8M.

2.3.3 Mill-Rolled Reinforcing and Supporting Materials

Conform to ASTM A36/A36M for mill-rolled structural steel. Wherever in contact with sheet metal ducting, galvanize to conforming with ASTM A123/A123M [SSPC Painting Manual].

In lieu of mill-rolled structural steel, submit for approval, equivalent strength, proprietary design, rolled-steel structural support systems.

PART 3 EXECUTION

3.1 PREPARATION

For sheet metal surfaces to be painted, and surfaces to which adhesives are to be applied, clean surface of oil, grease, and deleterious substances.

Ensure strength is adequate to prevent failure under service pressure or vacuum created by fast closure of duct devices. Provide leaktight, automatic relief devices.

3.1.1 Construction Standards

Provide sheet metal construction in accordance with the recommendations for best practices in ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32, SMACNA 1966, and NFPA 90A.

Design and fabricate supplementary steel in accordance with AISC 360 and AISC 325.

Where construction methods for certain items are not described in the referenced standards or herein, perform the work in accordance with

recommendations for best practice defined in ASHRAE EQUIP IP HDBK.

3.2 INSTALLATION

Fabricate an airtight system. Include reinforcements, bracing, supports, framing, gasketing, sealing, and fastening to provide rigid construction and freedom from vibration, airflow-induced motion and noise, and excessive deflection at specified maximum system air pressure and velocity.

Provide offsets and transformations as required to avoid interference with the building construction, piping, or equipment.

Make plenum anchorage provisions, sheet metal joints, and other areas airtight and watertight by caulking, mating galvanized steel and concrete surfaces with a two-component elastomer.

3.2.1 Jointing

Enclose dampers located behind architectural intake or exhaust louvers by a rigid sheet metal collar and sealed to building construction with elastomers for complete air tightness.

Provide outside air-intake ducts and plenums made from sheet metal with soldered watertight joints.

3.2.2 Ducts

Wherever ducts pass through firewalls or through walls or floors dividing conditioned spaces from unconditioned spaces, provide a flanged segment in that surface during surface construction.

Where interiors of ducting may be viewed through air diffusion devices, construct the viewed interior with sheet metal and paint flat black.

3.2.2.1 Ductwork Cleaning Provisions

Protect open ducting from construction dust and debris in a manner approved by the Contracting Officer. Clean dirty assembled ducting by subjecting all main and branch interior surfaces to airstreams moving at velocities two times specified working velocities, at static pressures within maximum ratings. This may be accomplished by: filter-equipped portable blowers which remain the Contractor's property; wheel-mounted, compressed-air operated perimeter lances which direct the compressed air and which are pulled in the direction of normal airflow; or other means approved by the Contracting Officer. Use water- and oil- free compressed air for cleaning ducting. After construction is complete, and prior to acceptance of the work, remove construction dust and debris from exterior surfaces. [Clean in conformance with SMACNA 1987.]

3.3 APPLICATION

3.3.1 Low Pressure Sheet Metal Ducts

Weld angle iron frames at corners and ends, whenever possible. Rivet or weld angle iron reinforcements to ducts not more than [6]-inches [_____] on center, with not less than [two] [_____] points of attachment. Spot welding, where used, is 3-inches on center.

Seal standard seam joints with an elastomer compound to comply with

SMACNA 1966 Seal Class A, B or C as applicable.

Limit crossbreaking to [4][_____]-feet and provide on all ducts [8][_____]-inches wide and wider. Provide bead reinforcement in lieu of crossbreaking where panel popping may occur. Where rigid insulation is applied, crossbreaking is not required.

3.3.1.1 Longitudinal Duct Seams

Provide Pittsburgh lock [_____] corner seams.

3.3.1.2 Joints and Gaskets

Bolt companion angle flanges together with [1/4] [_____]-inch diameter bolts and nuts spaced [6] [_____]-inches on center. Gasket flanged joints with chloroprene full-face gaskets [1/8] [_____]-inch thick, with Shore A 40 durometer hardness. Use one piece gaskets, [vulcanized] [dovetailed] at joints.

3.3.1.3 Flexible Duct Joints

Between flexible duct without sheet metal collars and round metal ductwork connections make joints by trimming the ends, coating the inside of the flexible duct for a distance equal to depth of insertion with elastomer caulk, and by securing with sheet metal screws or binding with a strap clamp.

3.3.1.4 Square Elbows

[Provide single-vane duct turns in accordance with SMACNA 1966[, use on ducts 12 inches in width and narrower].

][Provide double-vane duct turns in accordance with SMACNA 1966.

]3.3.1.5 Radius Elbows

Conform to SMACNA 1966 for radius elbows. Provide an inside radius equal to the width of the duct. Where installation conditions preclude use of standard elbows, the inside radius may be reduced to a minimum of [0.25] [_____] times duct width. Install turning vanes in accordance with the following schedule.

	RADIUS OF TURNING VANES IN PERCENT OF DUCT WIDTH		
WIDTH OF ELBOWS INCHES	VANE NO. 1	VANE NO. 2	VANE NO. 3
Up to 16	56	--	--
17 to 48	43	73	--
49 and over	37	55	83

Where two elbows are placed together in the same plane for ducts 30-inches wide and larger, continue the guide vanes through both elbows rather than spaced in accordance with above schedule.

3.3.1.6 Outlets, Inlets, and Duct Branches

Install branches, inlets, and outlets so that air turbulence is reduced to

a minimum and air volume properly apportioned. Install adjustable splitter dampers at all supply junctions to permit adjustment of the amount of air entering the branch. Wherever an air-diffusion device is shown as being installed on the side, top, or bottom of a duct, and whenever a branch take-off is not of the splitter type; provide a commercially manufactured 45 degree side-take-off (STO) fitting with manual volume damper to allow adjustment of the air quantity and to provide an even flow of air across the device or duct it services.

Where a duct branch is to handle more than [25] [_____] percent of the air handled by the duct main, use a complete 90-degree increasing elbow with an inside radius of [0.75] [_____] times branch duct width. Size of the leading end of the increasing elbow within the main duct with the same ratio to the main duct size as the ratio of the related air quantities handled.

Where a duct branch is to handle [25] [_____] percent or less of the air handled by the duct main, construct the branch connection with a 45 degree side take-off entry in accordance with SMACNA 1966.

3.3.1.7 Duct Transitions

Where the shape of a duct changes, ensure the angle of the side of the transition piece does not exceed [15] [_____] degrees from the straight run of duct connected thereto.

Where equipment is installed in ductwork, ensure the angle of the side of the transition piece from the straight run of duct connected thereto does not exceed [15] [_____] degrees on the upstream side of the equipment and [22-1/2] [_____] degrees on the downstream side of the equipment.

3.3.1.8 Branch Connections

Construct radius tap-ins in accordance with SMACNA 1966.

3.3.1.9 Access Openings

Construct access door in accordance with SMACNA 1966, except that sliding doors may be used only for special conditions upon prior approval. Provide double-panel type doors.

Install access doors and panels in ductwork [upstream from coils] [upstream and downstream from coils] [adjacent to fire dampers] [at controls or at any item requiring periodic inspection, adjustment, maintenance, or cleaning] [where indicated], and every 20-feet for indoor air quality housekeeping purposes.

Minimum access opening size is [12 by 18] [_____]-inches, unless precluded by duct dimensions or otherwise indicated.

Make airtight access doors that leak by adding or replacing hinges and latches or by construction of new doors adequately reinforced, hinged, and latched.

[3.3.1.10 Duct Access for Cleaning

[Make duct access particularly suitable for commercial duct cleaning methods utilizing vacuum devices. Space access openings with a frequency and at points that permits ready access to duct internals with essentially

no duct or insulation cutting. Where access through an air-diffusion device or through access doors specified herein is not available at a specific point, provide [8] [_____]-inch diameter, [16] [_____]-gage access plates not more than [10] [_____]-feet on center. Where duct is insulated and vapor-sealed, provide mastic seals around circumference of access. When access plate is in place and insulated, externally identify the location.

]]3.3.1.11 Plenum Construction

Provide intake and discharge plenum companion angle joints with the following minimum thickness of materials:

LONGEST ANGLES SIDE INCHES	SHEET METAL USS GAGE ALL SIDES	COMPANION ANGLES INCHES	REINFORCEMENT 24 INCHES ON CENTER MAXIMUM
To 48	20	1-1/2 by 1-1/2 by 1/8	1-1/2 by 1-1/2 by 1/8
49 to 84	18	2 by 2 by 1/8	2 by 2 by 3/16
85 to 120	16	2 by 2 by 1/8	2 by 2 by 1/8
121 and larger	14	2 by 2 by 3/16	2 by 2 by 3/16

At the floor line and other points where plenums join masonry construction, bolt panels [12] [_____]-inches on center to [2- by 2- by 3/16] [_____]-inch thick hot-dip galvanized steel angle that has been secured to the masonry with masonry anchors and bolts [24][_____]-inches on center and caulked tight to the masonry.

Anchor panels to curbing with hot-dip galvanized steel angle iron of a size not less than [2- by 2- by 3/16] [_____]-inch thick. Concrete curbing includes angle iron nosing with welded studs for the anchoring of panels. Level nosing at curb height within plus or minus [1/16] [_____]-inch.

Weld and grind miter corners for angle iron and channel iron.

3.3.1.12 Plenum Door Construction

Construct plenum access doors in accordance with SMACNA 1966 except that access doors smaller than man-access doors have door openings framed with angle iron that is one commercial size smaller than the specified panel reinforcement.

Ensure man-access door size conforms to SMACNA 1966 and paragraph ACCESS OPENINGS. Insulated and uninsulated construction is per SMACNA 1966. Frame door openings with channel iron. Frame doors with angle iron. Size channel iron and angle iron approximately the same size as specified panel reinforcement. Provide exterior door skin [16] [_____] gage. Fabricate latches from steel with hinges at least [4] [_____]-inches long, and bolts at least [3/8] [_____]-inch diameter.

3.3.1.13 Manual Volume Dampers

Provide balancing dampers of the splitter, butterfly, or multilouver type,

to balance each respective main and branch duct.

For dampers regulated through ceilings provide a regulator concealed in a box mounted in the ceiling, with a cover finish aesthetically compatible with ceiling surface. Where ceiling is of removable construction, set regulators above the ceiling, and mark the location on ceiling in a manner acceptable to the Contracting Officer.

3.3.1.14 Flexible Connectors for Sheet Metal

Connect air handling equipment, ducts crossing building expansion joints, and fan inlets and outlets to upstream and downstream components by treated woven-cloth connectors.

Install connectors only after system fans are operative, and vibration isolation mountings have been adjusted. When system fans are operating, ensure connectors are free of wrinkles caused by misalignment or fan reaction. Width of surface is curvilinear.

3.3.2 Rectangular Sheet Metal Ducts

3.3.2.1 Medium-Pressure Gages, Joints, and Reinforcement

Ensure minimum sheet metal gages, joints, and reinforcements between joints are in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

Ensure sheet metal minimum thickness, transverse reinforcement between joints, and joints of ducts are in accordance with the following:

LONGEST SIDE (INCHES)	SHEET METAL GAGE ALL SIDES	COMPANION ANGLE (INCHES)	REINFORCEMENT ANGLES 24 INCHES ON CENTER MAXIMUM (BACK TO BACK)
97 to 108	16	2 by 2 by 1/8, two tie rods along angle	Two 2 by 2 by 1/8, two tie rods along angle
109 to 132	16	2 by 2 by 3/16, two tie rods along angle	Two 2 by 2 by 3/16, two tie rods along angle
133 and longer	14	2 by 2 by 3/16, with tie rods every 48 inches	Two 2 by 2 by 3/16, with tie rods every 48 inches

3.3.2.2 Medium- And High-Pressure Branches, Inlets, Outlets

Install branches, inlets, and outlets to minimize air turbulence and to ensure proper airflow.

Install dampers so that the amount of air entering duct mains is adjustable.

Provide commercially manufactured air extractors to allow adjustment of the air quantity and to provide an even flow of air across the device or duct served.

3.3.2.3 Duct Branch Transition

Where a duct branch handles over 25 percent of the air transported by the duct main, use a complete 90-degree increasing elbow, with an inside radius of 0.75 times duct branch width. Ensure the size of the trailing end of the increasing elbow within the main duct has the same ratio to the main duct size as the ratio of the relative air quantities handled.

Where a duct branch is to handle 25 percent or less of the air handled by the duct main, provide a branch connection with an inside radius of 0.75 times branch duct width, a minimum arc length of 45 degrees, and an outside radius of 1.75 times duct branch width. Place arc tangent to duct main.

3.3.2.4 High-Pressure Gages, Joints, and Reinforcement

Ensure sheet metal minimum thickness, joints, and reinforcement between joints are in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

Use the following types of ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966 joints and seams:

Transverse Joints:

a. Welded flange joint [with] [without] angle

b. Companion angle flanged joint

Longitudinal Seams:

a. Approved lock seams, back brazed, or continuously brazed seams for ducts with largest dimension up to 72-inches

b. Continuously welded or brazed seams for ducts with largest dimension greater than 72-inches

Sheet metal minimum thickness, transverse reinforcement between joints, and companion angle joints of ducts with longest side greater than 96 inches are in accordance with the following:

LONGEST SIDE (inches)	SHEET METAL GAGE ALL SIDES	COMPANION ANGLE (inches)	REINFORCEMENT ANGLES 24 INCHES ON CENTER MAXIMUM (BACK TO BACK)
97 to 108	16	2 by 2 by 1/8, two tie rods along angle	*Two 2 by 2 by 1/8, two tie rods along angle
109 to 132	16	2 by 2 by 3/16, two tie rods along angle	*Two 2 by 2 by 3/16, two tie rods along angle

LONGEST SIDE (inches)	SHEET METAL GAGE ALL SIDES	COMPANION ANGLE (inches)	REINFORCEMENT ANGLES 24 INCHES ON CENTER MAXIMUM (BACK TO BACK)
133 and longer	14	2-1/2 by 2-1/2 by 3/16, with tie rods every 24 inches	*Two 2-1/2 by 2-1/2 by 3/16, with tie rods every 24 inches

3.3.3 Round Sheet Metal Ducts

3.3.3.1 Duct Gages and Reinforcement

Sheet metal minimum thickness, joints, and reinforcement between joints shall be in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

Provide ducts with supplemental girth angle supports, riveted with [solid rivets 6 inches on center] [tack welded] [brazed] to duct. Locate girth angles as follows:

DIAMETER, INCHES	REINFORCEMENT-MAXIMUM SPACING INCHES
25 to 36	1-1/4 by 1-1/4, 1/8 thick, 72 inches on center
37 to 50	1-1/4 by 1-1/4, 1/8 thick, 60 inches on center
51 to 60	1-1/2 by 1-1/2, 1/8 thick, 48 inches on center

Use hex-shaped bolt heads and nuts, 5/16-inch diameter for ducts up to 50-inch diameter, and 3/8-inch diameter for 51-inch diameter ducts and larger.

[Continuously weld] [Braze] flanges to duct on outside of duct and intermittently welded with 1-inch welds every 4-inches on inside joint face. Remove excess filler metal from inside face. Protect galvanized areas that have been damaged by welding with manufacturer's standard corrosion-resistant coating.

3.3.3.2 Duct Joints

Provide duct joints manufactured by machine, with spiral locksets up to and including 60-inch diameters, and to dimensional tolerances compatible with fittings provided. Draw-band girth joints are not acceptable.

Prepare slip joints by coating the male fitting with elastomer sealing materials, exercising care to prevent mastic from entering fitting bore. Leave only a thin annular mastic line exposed internally. Use sheet metal screws to make assembly rigid, not less than four screws per joint, maximum spacing 6-inches. Do not use pop rivets. Tape and heat seal all joints.

3.3.3.3 Duct Transitions

[Where the shape of a duct changes, ensure the angle of the side of the transition piece does not exceed 15 degrees from the straight run of duct connected thereto.

] Where equipment is installed in ductwork, ensure the angle of the side of the transition piece from the straight run of duct connected thereto does not exceed 15 degrees on the upstream side of the equipment and 22-1/2 degrees on the downstream side of the equipment.

3.3.4 Round, High Pressure, Sheet Metal Duct Installation

3.3.4.1 Joints

Provide an inner coupling to align the inner lining to maintain good airflow conditions equivalent to standard round high-pressure duct joints. Butt joints are not suitable for the inner liner. Accomplish this alignment by [extending the liner of the fitting for slip joint into the pipe] [the use of a double concentric coupling with the two couplings held by spacers for rigidity and wall spacing]. For ducts over 34-inches inside diameter, provide a separate coupling for inner alignment, with the pressure shells joined by angle-ring flanged connections.

3.3.4.2 Insulation Ends

At the end of an uninsulated section or run where internally insulated duct connects to uninsulated spiral duct, fitting, fire damper or flexible duct, install an insulated end-fitting to bring the outer pressure shell down to nominal size.

3.3.5 Transverse Reinforcement Joints

Provide transverse reinforcements that are [riveted with solid rivets to duct sides 6 inches on center] [spot welded 4 inches on center]. Weld transverse reinforcement at [all corners] [ends] to form continuous frames.

3.3.6 Joint Gaskets

For flanged joints, use chloroprene full-face gaskets 1/8-inch thick, with Shore A 40 durometer hardness. Use one-piece gaskets, [vulcanized] [dovetailed] at joints.

3.3.7 Radius Elbows

Fabricate elbow proportions and radius elbows in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

3.3.8 Plenum Connections

Ensure round duct connections are welded joint bellmouth type.

Ensure rectangular duct connections are bellmouth type, constructed in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966.

3.3.9 Access Openings

Install access panels in ductwork adjacent to fire dampers.

Minimum size of access opening is 12 by 18 inches, unless precluded by duct dimension.

Frame access openings with welded and ground miter joints, 1/8-inch thick [strap steel] [angle iron], with [1/4] [3/8]-inch studs welded to frame. Ensure cover plates are not less than[16-gage, reinforced as necessary for larger sizes] [constructed of 12-gage metal].

In lieu of access doors, use readily accessible flanged duct sections upon approval. Provide stable hanger supports for disconnected duct terminal.

3.3.10 Duct Supports

Install duct support in accordance with ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966. Meet the minimum size for duct hangers as specified in ASHRAE EQUIP IP HDBK, Chapter 16, ASHRAE FUN IP, Chapter 32 and SMACNA 1966. Provide two hangers where necessary to eliminate sway. Support attachment to duct surfaces by [solid rivet] [bolt] [welding] 4-inches on center.

Take the following into account in selection of a hanging system:

a. Location and precedence of work under other sections

b. Interferences of various piping and electrical conduit

c. Equipment,and building configuration

d. Structural and safety factor requirements

e. Vibration, and imposed loads under normal and abnormal service conditions

Support sizes, configurations, and spacing are given to show the minimal type of supporting components required. If installed loads are excessive for the specified hanger spacing, hangers, and accessories [provide heavier-duty components] [reduce hanger spacing]. After system startup, replace any duct support device which due to length, configuration, or size, vibrates or causes possible failure of a member. Do not use a ductwork support system that allows a cascade-type failure to occur.

Do not hang ductwork and equipment from roof deck, piping, or other ducts or equipment. Maximum span between any two points is 10-feet, with lesser spans as required by duct assemblies, interferences, and permitted loads imposed.

[Where support from metal deck systems is involved, coordinate support requirements with installation of metal deck.

][3.3.10.1 Double-wall Ducts

Provide round, double-wall duct supports as recommended by the manufacturer except that minimum hanger ring and strap size is 1-1/2 inches by 1/8 inch.

]3.3.10.2 Hangars

Attach hanger rods, angles, and straps to beam clamps. Receive approval

from the Contracting Officer for concrete inserts, masonry anchors, and fasteners for the application.

Hardened high-carbon spring-steel fasteners fitted onto beams and miscellaneous structural steel are acceptable upon prior approval of each proposed application and upon field demonstration of conformance to specification requirements. Make fasteners from steel conforming to AISI Type [1055] [1070], treated and finished in conformance with SAE AMS 2480, Type Z (zinc phosphate base), Class 2 (supplementary treatment). Verify a 72-hour load-carrying capacity by a certified independent laboratory.

Where ductwork system contains heavy equipment, excluding air-diffusion devices and single-leaf dampers, hang such equipment independently of the ductwork by means of rods or angles of sizes adequate to support the load.

Cross-brace hangers to preclude swaying both vertically and laterally.

3.3.10.3 Installation

Ensure hanger spacing gives a 20-to-1 safety factor for supported load.

Maximum load supported by any two fasteners is 100 pounds.

Install hangers on both sides of all duct turns, branch fittings, and transitions.

Friction rod assemblies are not acceptable.

3.3.10.4 Strap-type Hangars

Support rectangular ducts up to 36-inches by strap-type hangers attached at not less than three places to not less than two duct surfaces in different planes.

Perforated strap hangers are not acceptable.

3.3.10.5 Trapeze Hangars

Support rectangular ducting, 36-inches and larger, by trapeze hangers. Support ducts situated in unconditioned areas and required to have insulation with a vapor-sealed facing on trapeze hangers. Space hangers far enough out from the side of the duct to permit the duct insulation to be placed on the duct inside the trapeze. Do not penetrate the vapor-sealed facing with duct hangers.

Where trapeze hangers are used, support the bottom of the duct on angles sized as follows:

WIDTH OF DUCT, INCHES	MINIMUM BOTTOM ANGLE SIZE, INCHES
30 and smaller	1-1/4 by 1-1/4 by 1/8
31 to 48	1-1/2 by 1-1/2 by 1/8
49 to 72	1-1/2 by 1-1/2 by 3/16
73 to 96	2 by 2 by 1/4

WIDTH OF DUCT, INCHES	MINIMUM BOTTOM ANGLE SIZE, INCHES
97 and wider	3 by 3 by 1/4

3.3.10.6 Purlins

Do not support ducting from roof purlins at points greater than one-sixth of the purlin span from the roof truss. Do not exceed 400 pounds load per hanger.

If the hanger load must exceed the above limit, provide reinforcing of purlin(s) or additional support beam(s). When an additional beam is used, have the beam bear on the top chord of the roof trusses, and also bear over the gusset plates of top chord. Stabilize the beam by connection to roof purlin along bottom flange.

Purlins used for supporting fire-protection sprinkler mains, electrical lighting fixtures, electrical power ducts, or cable trays are considered fully loaded. Provide supplemental reinforcing or auxiliary support steel for these purlins when used to support ductwork.

3.3.10.7 Vibration Isolation

[Isolate the structure from duct support vibration at points indicated. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

][Provide vibration isolators in discharge ducting system for a distance not less than 50-feet beyond the air handling unit. Coordinate deflection of duct and equipment mountings.

]3.3.11 Flexible Connectors for Steel Metal

Connect air-handling equipment, ducts crossing building expansion joints, and fan inlets and outlets to upstream and downstream components with treated woven-cloth connectors.

Install connectors only after system fans are operative and all vibration isolation mountings have been adjusted. When system fans are operating, ensure connectors are free of wrinkles caused by misalignment or fan reaction. Width of surface is curvilinear.

3.3.12 Insulation Protection Angles

Provide galvanized 20-gage sheet, formed into an angle with a 2-inch exposed long leg with a 3/8-inch stiffening break at outer edge, and with a variable concealed leg, depending upon insulation thickness.

Install angles over all insulation edges terminating by butting against a wall, floor foundation, frame, and similar construction. Fasten angles in place with blind rivets through the protection angle, insulation, and sheet metal duct or plenum. Install angles after final insulation covering has been applied.

3.3.13 Duct Probe Access

Provide holes with neat patches, threaded plugs, or threaded or twist-on

caps for air-balancing pitot tube access. Provide extended-neck fittings where probe access area is insulated.

3.3.14 Openings In Roofs and Walls

Existing building openings are fixed in size and can not be resized with out authorization. Provide equipment to suit existing opening size.

3.4 FIELD QUALITY CONTROL

[3.4.1 Fire Damper Tests

Perform operational tests on each fire damper in the presence of the Contracting Officer by enervating a fusible link with localized heat. Provide and install new links after successful testing.

]3.4.2 Ductwork Leakage Tests

Conduct complete leakage test of new ductwork in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Perform tests prior to installing ductwork insulation.

[3.4.3 Inspection

Inspect ductwork in accordance with SMACNA 1987.

]3.5 CLOSEOUT ACTIVITIES

3.5.1 Operation and Maintenance

Submit [6] [_____] copies of the operation and maintenance manuals 30 calendar days prior to testing the medium and high pressure ductwork systems. Update data and resubmit for final approval no later than 30 calendar days prior to contract completion.

Ensure operation and maintenance manuals are consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions.

3.5.2 Record Drawings

Provide record drawings with current factual information. Include deviations from, and amendments to, the drawings. Include concealed or visible changes in the work. Label drawings "As-Built".

-- End of Section --

SECTION 23 34 23.00 40

HVAC POWER VENTILATORS
02/17

PART 1 GENERAL

Provide a power roof ventilator[s] [system] complete with all components and accessory equipment as specified in this section.

[Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

][Section 26 60 13.00 40 LOW-VOLTAGE MOTORS applies to this section.

]1.1 REFERENCES

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

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

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

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B37	(2018) Standard Specification for Aluminum for Use in Iron and Steel Manufacture
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

UNDERWRITERS LABORATORIES (UL)

UL 705	(2017; Reprint Aug 2021) UL Standard for Safety Power Ventilators

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings; G, AE

Installation Drawings; G, AE

SD-03 Product Data

Housing; G, AE

Fan; G, AE

Motor; G, AE

Bases; G, AE

Roof Curbs; G, AE

Dampers; G, AE

Screens; G, AE

Sound Baffles; G, AE

SD-06 Test Reports

Final Test Reports; G, AE

SD-11 Closeout Submittals

Record Drawings; G, AE

1.3 QUALITY CONTROL

Rate and label ventilators in accordance with the applicable standards of the Air Movement Control Association (AMCA), and indicate if the license bears the AMCA seal for both air and sound.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Design Requirements

Submit the manufacturer's catalog data, including equipment and performance data, for power roof ventilator(s). As a minimum, include the following data:

a. Fan Type

b. Fan Specifications, including:

(1) Number of rotating fan blades/vanes

(2) Number of stationary fan blades/vanes

(3) Rotating speed(s)

(4) Number of belts (if belt-driven)

(5) Belt lengths- measured at the pitch line (if belt-driven)

(6) Diameter of the drive sheave at the drive pitch line (if

belt-driven)

(7) Diameter of the driven sheave at the drive pitch line (if belt-driven)

c. Location of Installation

d. [_____] Identification Number

e. Date of Installation (Required or Actual Acceptance Date)

f. Applicable [_____] reference drawing number(s)

Submit detailed shop drawings for power roof ventilator systems.

Provide roof ventilators that comply with UL 705 and are furnished complete with bases, curbs, flashing flanges, noise baffles, dampers, damper controls, louvers, and screens, as indicated.

Provide ventilators that are designed for windloads in accordance with ASCE 7-16 with the installed design not less than 130[_____] miles per hour windload. Ensure that the structural bracing is properly spaced to accommodate this loading and meets the design requirements of the covering material. Ensure that ventilators are adequately reinforced and well-braced with the joints properly formed. Ensure that the edges are wired or beaded where necessary to ensure rigidity. Prevent galvanic action between different metals in direct contact by providing nonconductive separators. Make all soldering even and smooth.

Provide corrosion-resistant steel bolts, rivets, and other fastenings used in connection with protected metal.

2.2 COMPONENTS

2.2.1 Housing Style

Provide [round-mushroom style] [louvered-penthouse style] [low-contour style] [vertical-discharge style] power roof ventilator as indicated.

2.2.2 Fan Type

Provide fans of the following types:

2.2.2.1 Type C-PRV Centrifugal, Direct Drive

For Type C-PRV ventilators, provide a centrifugal roof ventilator with direct drive, nonoverloading, backward-inclined wheel. Provide a vibration-isolated drive with an elastomer. Provide drive components that are mounted in a compartment isolated from the airstream.

2.2.2.2 Type CB-PRV Centrifugal, V-Belt Drive

For Type CB-PRV ventilators provide a centrifugal roof ventilator with V-belt drive, nonoverloading, backward-inclined wheel. Provide a vibration-isolated drive with an elastomer. Provide drive components that are mounted in a compartment isolated from the airstream.

2.2.2.3 Type P-PRV Propeller, Direct Drive

For Type P-PRV ventilators, provide a propeller roof ventilator with direct drive that is vibration-isolated with an elastomer. Provide drive components that are mounted in a compartment isolated from the airstream.

2.2.2.4 Type PB-PRV Propeller, V-Belt Drive

For Type PB-PRV ventilators, provide a propeller roof ventilator with V-belt drive that is vibration-isolated with an elastomer. Provide drive components that are mounted in a compartment isolated from the airstream.

2.2.2.5 Type VA-PRV Vane Axial, Direct Drive

For Type VA-PRV ventilators, provide a vane axial roof ventilator with direct drive that is vibration-isolated with an elastomer.

2.2.2.6 Type VAB-PRV Vane Axial, V-Belt Drive

For Type VAB-PRV ventilators, provide a vane axial roof ventilator with V-belt drive that is vibration-isolated with an elastomer.

2.2.2.7 Type TA-PRV Tube Axial, Direct Drive

For Type TA-PRV ventilators, provide a tube axial roof ventilator with direct drive that is vibration-isolated with an elastomer.

2.2.2.8 Type TAV-PRV Tube Axial, V-Belt Drive

For Type TAV-PRV ventilators, provide a tube axial roof ventilator with V-belt drive that is vibration-isolated with an elastomer.

2.2.3 Fan Motor

Provide single-phase, 120 V, 60 Hz, split-phase, belt-driven motors less than 1/2 horsepower, with permanently lubricated ball bearings.

Provide three-phase [_____], 460 [_____] V, 60 Hz motors 1/2 horsepower and larger.

Provide motors with local disconnects to allow for fan and motor maintenance. Provide all motors with thermal-overload protection. For motors located in airstreams, use a totally enclosed type.

Use energy efficient permanent split capacitor motors, single phase, 60 Hz direct-drive motors 1/2 horsepower or less.

2.2.4 Bases

When bases are provided with the ventilators, use factory-formed bases of the type indicated, constructed of the same material as the hoods, and of the thickness necessary to meet the design requirement for connection to the roof. Provide bases that are suitable for raised-curb mounting where indicated. Form curb flanges of the base as cap flashing, extending at least 2 inches over the roofing base. Where indicated or required, extend the shafts of ventilators a sufficient distance through the supporting construction to permit attachment of vent ducts.

2.2.5 Roof Curbs

Provide factory-formed metal ventilator curbs of the type and design required for the ventilator and suitable for the roof configuration and flashing.

Provide job-built curbs that conform to the recommendations of the ventilator manufacturer, that are sized correctly for the ventilator, and that are suitable for the type of supporting roof construction.

2.2.6 Back-Draft Dampers

Provide gravity-operated back-draft dampers with adjustable counterweights constructed of the same material as fan housing.

[Provide motor-operated back-draft dampers constructed of the same material as fan housing.

][Interlock damper-actuating motor with the fan motor.

]2.2.7 Screens

Provide [bird screens] [insert screens] with frames constructed of the same material as that used in the ventilators and ensure the screens are securely attached in a manner that permits easy removal for access and cleaning.

2.2.8 Sound Baffles

Provide permanently constructed sound baffles that are impervious to moisture. Provide removable baffles.

2.3 MATERIALS

Provide manufacturers' standard materials.

2.3.1 Aluminum Alloy

Provide aluminum alloy in accordance with ASTM B209 and ASTM B37.

2.3.2 Zinc-Coated Steel

Provide zinc-coated steel in accordance with ASTM A653/A653M.

2.3.3 Fibrous Glass

Provide fibrous glass ventilators that are molded from a glass-fiber-reinforced polyester resin with a pigmented polyester resin gel coat in the manufacturer's standard color, and that are between 0.02 inches and 0.06 inches thick. Provide a matrix material that is not less than 30 percent, by weight, of chopped-fiber and random-strand glass fibers, and that is thoroughly saturated and impregnated with not more than 70 percent high-solids polyester resin with not less than 5 percent antimony trioxide fire-retardant additive. Provide material that is smooth and uniform in texture, and color throughout the cross section and that is shatter-resistant. Ensure that the material is free from visual defects, foreign inclusions, cracks, crazing, die lines, pinholes, and striations. Ensure that the material has no areas that are unsaturated or lacking resin, and no areas with excessive resin.

PART 3 EXECUTION

3.1 INSTALLATION

Submit installation drawings for power roof ventilators.

Install power roof ventilators in accordance with the manufacturer's installation instructions. Coordinate installation of ventilators with other work. Coordinate anchors, attachments, and other items to be built for installation as the work progresses. Rigidly install ventilators in a weathertight and watertight manner that is free from vibration. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT for vibration isolation considerations.

[3.1.1 Lubrication

Ensure the movable parts of dampers and related operating hardware are lubricated in accordance with manufacturer's printed instructions and that they operate smoothly and quietly without binding.

]3.2 FIELD QUALITY CONTROL

3.2.1 Tests

[After installation, test each power roof ventilator to demonstrate proper operation at indicated and specified performance requirements, including the running, balance, noise, and proper direction of fan rotation.

][3.2.1.1 Vibration Analyzer

Use an fast Fourier transform (FFT) analyzer to measure vibration levels. Ensure that the ventilator meets the following characteristics: a dynamic range greater than 70 dB; a minimum of 400 line resolution; a frequency response range of 5 Hz to 10 KHz (300 600000 cpm); the capacity to perform ensemble averaging, the capability to use a Hanning window; auto-ranging frequency amplitude; a minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB.

Use either a stud-mounted accelerometer or mount the accelerometer using a rare earth, low-mass magnet and a sound disk (or finished surface) with the FFT analyzer to collect data. Provide the accelerometer with a mass and mounting that minimally influence the frequency response of the system over the selected measurement range.

][3.2.2 Acceptance

Prior to final acceptance, use precision alignment devices to demonstrate that the fan and motor are aligned as specified by the manufacturer.

Prior to final acceptance, verify conformance to specifications with vibration analysis. Ensure vibration levels are not more than .075 in/sec at 1 times the run speed and at the fan/blade frequency, and not more than 0.04 in/sec at other multiples of the run speed.

][3.2.3 Final Test Reports

Provide final test reports to the Contracting Officer. Provide reports

with a cover letter/sheet clearly marked with the system name, date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

]3.3 CLOSEOUT ACTIVITIES

Submit detailed record drawings upon completion of the installation.

-- End of Section --

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SECTION 23 36 00.00 40

AIR TERMINAL UNITS
05/16

PART 1 GENERAL

Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

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 DUCT COUNCIL (ADC)

ADC Standards Manual	(2008; 5th Edition) Flexible Duct Performance Installation Standards

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 880 I-P	(2011) Performance Rating of Air Terminals

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

ASHRAE 130	(2008) Method of Testing for Rating Ducted Air Terminal Units

ASTM INTERNATIONAL (ASTM)

ASTM C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

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 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 181	(2013; Reprint Apr 2017) UL Standard for

	Safety Factory-Made Air Ducts and Air Connectors
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors

1.2 ADMINISTRATIVE REQUIREMENTS

Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, communication and security systems,and partition assemblies.

1.2.1 Pre-Installation Meetings

Submit itemized lists for all materials, equipment, and fixtures to be incorporated in the work [30][_____] days prior to commencement of work. Ensure list includes manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information. Submit product data for each type of air terminal unit indicated, including rated capacities, furnished specialties, sound-power ratings, and accessories:

[a. Bypass Single-Duct Air Terminal Units

][b. Dual-Duct Air Terminal Units

][c. Fan-Powered Air Terminal Units

][d. Induction Air Terminal Units

][e. Shutoff Single-Duct Air Terminal Units

][f. Integral-Diffuser Air Terminal Units

][g. High-Pressure Dual-Duct Mixing Boxes

][h. Low-Pressure Dual-Duct Mixing Boxes

] Submit records of existing conditions consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work constitutes acceptance of existing conditions.

Submit shop drawings which detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished. Include wiring diagrams to show power, signal, and control wiring.

Provide units with the configuration, capacity, and static-pressure characteristics indicated.

Ensure dimensional data stated constitutes nominal sizing, which has been adjusted by the manufacturer when necessary to accommodate acoustic material thickness.

Ensure units proposed are identical to units having at least 2 years of

proven satisfactory field service.

Provide certification that units and the list of spare parts are ADC Standards Manual tested and rated.

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. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Records of Existing Conditions

SD-02 Shop Drawings

D
D
Fan-Powered Air Terminal Units; G, AE

D

D

D

D

D

SD-03 Product Data

D
Fan-Powered Air Terminal Units; G, AE

SD-06 Test Reports

Test Report

SD-07 Certificates

List of Spare Parts

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Record Drawings

1.4 QUALITY CONTROL

Indicate on drawings the size, profiles, and dimensional requirements of

air terminal units that are based on the specific system indicated.

Conform to NFPA 70, Article 100 for electrical components, devices, and accessories. List and label items as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

Ensure Air Terminals are certified under the AHRI 880 I-P Certification Program and carry the ARI Seal.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Verification of Performance

Rate air terminal units according to AHRI 880 I-P.

2.1.2 [Enter Appropriate Subpart Title Here]2.1.2.1 [Enter Appropriate Subpart Title Here]

2.1.3 Fan-Powered Air Terminal Units

2.1.3.1 Configuration

Provide volume-damper assembly and fan in [series] [parallel] arrangement inside unit casing with control components inside a protective metal shroud.

2.1.3.2 Casing

Provide[0.034-inch][0.032-inch] casing. Include with casing an integral mixing baffle to efficiently mix the hot and cold airstream.

a. Casing Lining

Provide[1/2-inch][3/4-inch][1-inch] thick with 1.5 pounds per cubic foot density, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

Provide a round stub connection for the air inlet duct attachment. For the air outlet provide s-slip and drive connections. Provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn gaskets.

2.1.3.3 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearings.

Perform a Maximum Damper Leakage Test (MDLT) in conformance to AHRI 880 I-P, for [2][3] percent of nominal airflow at[3-inch wg][6-inch wg] inlet static pressure, when tested in accordance with ASHRAE 130.

Select damper position: Normally [open][closed].

2.1.3.4 Fan Section

Provide a galvanized-steel plenum, with direct-drive, forward-curved fan with air filter and backdraft damper.

a. Lining

Provide[1/2-inch][3/4-inch][1-inch] thick, coated, fibrous-glass duct liner complying with ASTM C1071; secured with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

b. Motor

Comply with requirements in Section 26 60 13.00 40 LOW-VOLTAGE MOTORS for [Multi-speed] [_____] motors. Provide motor which includes a speed control feature that is infinitely adjustable with pneumatic-electric and electronic controls. Provide rubber isolators with fan-motor assembly.

c. Air Filter

Provide[2-inch][1-inch] thick, [fiberglass throwaway] [polyurethane] air-filter.

2.1.3.5 Attenuator Section

Provide[0.034-inch][0.03-inch aluminum] sheet metal. Provide 1/2-inch, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. [Cover liner with nonporous foil.][Cover liner with nonporous foil and perforated metal.]

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

[2.1.3.6 Hot-Water Heating Coil

Provide a copper tube mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.

][2.1.3.7 Electric Heating Coil

Provide a slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

a. Primary and secondary over-temperature protection

b. Nickel chrome 80/20 heating elements

c. Fan interlock contacts

d. Non-interlocking disconnect switch

e. Fuses (for coils more than 48 A)

f. Mercury contactors

g. Pneumatic-electric switches and relay

h. Magnetic contactor for each step of control (for three-phase coils)

]2.1.3.8 Factory-Mounted and -Wired Controls

Mount electrical components in control box with removable cover. Incorporate single-point electrical connection to power source.

Provide factory mounted control transformer for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.

Provide fan and controls to terminal strip, with terminal lugs which match quantities, sizes, and materials of branch-circuit conductors for wiring terminations. Enclose terminal lugs in terminal box that is sized according to NFPA 70.

Factory-mount a fused type disconnect switch.

2.1.3.9 Control Panel Enclosure

Provide control panel enclosure conforming to NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

2.1.3.10 Electric Controls

Provide a 24 V damper actuator with wall-mounting electric thermostat and appropriate mounting hardware.

2.1.3.11 Pneumatic Controls

a. Pneumatic Damper Operator

Provide a pneumatic damper operator with a[8 to 13 psig][3 to 13 psig] spring range.

b. Velocity Controllers

Provide a factory calibrated velocity controller, field adjustable to minimum and maximum air volumes. Ensure controllers maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg when tested in accordance with ASHRAE 130. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

2.1.3.12 Electronic Controls

Provide a bi-directional damper operator and microprocessor-based controller with integral airflow transducer and room sensor compatible with temperature controls, having the following features:

a. Proportional, plus integral control of room temperature

b. Time-proportional reheat-coil control

c. Occupied and unoccupied operating mode

d. Remote reset of airflow or temperature set points

e. Adjusting and monitoring with portable terminal

f. Communication with temperature-control system

2.1.4 [Enter Appropriate Subpart Title Here]2.1.4.1 [Enter Appropriate Subpart Title Here]
2.1.4.2 [Enter Appropriate Subpart Title Here]

]PART 3 EXECUTION

3.1 INSTALLATION

Install air terminal units level and plumb, and in accordance with NFPA 90A. Maintain sufficient clearance for normal service and maintenance.

3.1.1 Identification

Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

3.1.2 Connections

Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems.

Install piping adjacent to air terminal units to allow service and maintenance.

3.1.2.1 Hot-Water Piping

Connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

Connect ducts to air terminal units.

Ground units with electric heating coils.

Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

3.2 FIELD QUALITY CONTROL

[Engage a factory-authorized service representative to inspect[, test, and adjust] field-assembled components and equipment installation, including connections[, and to assist in field testing].

][Perform the following field tests and inspections and prepare a test report.

] After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.

3.2.1 Leak Test

After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

3.2.2 Operational Test

After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Remove and replace malfunctioning units and retest.

3.3 SYSTEM STARTUP

Engage a factory-authorized service representative to perform startup service.

Complete installation and startup checks according to manufacturer's written instructions and do the following:

a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.

b. Verify that controls and control enclosure are accessible.

c. Verify that control connections are complete.

d. Verify that nameplate and identification tag are visible.

e. Verify that controls respond to inputs as specified.

3.4 CLOSEOUT ACTIVITIES

3.4.1 Operation and Maintenance

Submit [6][_____] copies of the operation and maintenance manuals 30 calendar days prior to testing the following items. Update and re-submit data for final approval no later than 30 calendar days prior to contract completion. Concurrently, submit record drawings providing current factual information, including deviations and amendments to the drawings, and concealed and visible changes in the work.

3.4.2 Demonstration

Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

-- End of Section --

SECTION 23 37 13.00 40

DIFFUSERS, REGISTERS, AND GRILLES
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.

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

ASHRAE 113	(2013) Method of Testing for Room Air Diffusion
ASHRAE EQUIP IP HDBK	(2012) Handbook, HVAC Systems and Equipment (IP Edition)
ASHRAE FUN IP	(2017) Fundamentals Handbook, I-P Edition

1.2 ADMINISTRATIVE REQUIREMENTS

Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

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. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists; G, AE

Records of Existing Conditions; G, AE

SD-02 Shop Drawings

Fabrication Drawings; G, AE

Installation Drawings; G, AE

SD-03 Product Data

Equipment and Performance Data; G, AE

SD-04 Samples

Manufacturer's Standard Color Chart; G, AE

SD-10 Operation and Maintenance Data

Diffusers, Registers and Grilles; G, AE

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

Certify air diffusion devices having been tested and rated in accordance with Chapter 19-ASHRAE EQUIP IP HDBK, Chapter 16-ASHRAE FUN IP, and ASHRAE 113, where such certification is required.

Submit equipment and performance data for air-diffusion devices consisting of [sound data in terms of Noise Criteria (NC) index for the capacity range of the device.] [sound data in terms of sound-power level in octave bands second through eighth and Noise Criteria (NC) index for the capacity range of the device. Where room attenuation is not specified or indicated, assume 18 decibels. Where space or sound data are not specified or indicated, assume NC40.]

2.2 COMPONENTS

2.2.1 Air Diffusion Device Construction

Preclude flutter, rattle, or vibration on air-diffusion device construction and mounting. Refer to Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT for vibration isolation considerations. Modify devices and provide accessories necessary for mounting in indicated surface construction.

[Select color from manufacturer's standard color chart which indicates the manufacturer's standard color selections and finishes for air-diffusion devices.

][Match color with architectural background.

][Provide color as indicated on drawings.

] Provide supply diffusers with combination damper and equalizing grid. Ensure dampers are extracting-splitter type, except as otherwise indicated.

Ensure air-diffusion device volume and pattern adjustments can be made from the face of the device. Make volume adjustments by [removable key] [tamper-deterring device].

Provide gaskets for supply-terminal air devices mounted in finished surfaces.

Include within the material, equipment, and fixture lists the manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

Submit records of existing conditions consisting of the results of Contractor's survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite. Commencement of work constitutes acceptance of existing conditions.

Submit fabrication drawings for air-diffusion devices consisting of fabrication and assembly details to be performed in the factory.

2.2.2 Types of Air Diffusion Devices

2.2.2.1 Type DRA

Provide type DRA supply diffuser, round with five or more expanding cones with beaded edges to provide hemispherically diffused discharge air. Arrange cones to provide a minimum of [four] [_____] air paths which simultaneously diffuse air at 20 to 50 feet per minute (fpm) and aspirate room air at 25 to 35 percent of discharge volume.

Provide aluminum diffuser with baked enamel finish.

Provide antismudge rings and extended cones.

2.2.2.2 Type DRB

Provide type DRB supply diffuser, round with [four] [_____] more expanding cones to provide hemispherically diffused discharge air. Arrange cones to provide a minimum of [three] [_____] air paths which simultaneously diffuse air at 20 to 50 fpm. Provide a pattern adjustment range from horizontal to downward projection, and any intermediate point, when mounted on exposed ductwork.

Provide aluminum diffuser with baked enamel finish.

Provide [Integral] [Separate] antismudge rings and extended cones.

2.2.2.3 Type DRC

Provide type DRC combination supply and return diffuser, round with four expanding cones. Arrange cones to provide one return air path and two supply air paths. Provide a butterfly supply-air damper and an annular return-air damper. [Provide a baked enamel finish][Provide aluminum construction.]

[Provide antismudge rings.

]2.2.2.4 Type DRE

Provide type DRE supply diffuser, round with [three] [_____] expanding cones to provide discharge air paths, minimally, two-position adjustable for horizontal or vertical discharge. [Provide a baked enamel finish.]

[Provide antismudge rings.

]2.2.2.5 Type DRH

Provide type DRH supply diffuser, half-round with [four] [_____] semiconical expanding members to discharge diffused air in a 180-degree pattern. Arrange cones to provide a minimum of [three] [_____] air paths which simultaneously diffuse air at 20 to 50 fpm. Provide opposed-blade volume control.

[Provide a baked enamel finish.

][Provide antismudge rings.

]2.2.2.6 Type DP Series

Provide type DP series supply diffuser with a [square] [rectangular], perforated, hinged, face plate with [opposed blade] [splitter-damper] volume control, white baked enamel exterior finish, and black matte finish on exposed-to-view interior surface.

[Provide one-way deflection.

][Provide two-way opposed deflection.

][Provide two-way diagonal deflection.

][Provide three-way deflection.

][Provide four-way deflection.

]2.2.2.7 Type DLB

Provide type DLB supply diffuser, linear bar type, frame mounted, with extruded-aluminum bar and frame.

Ensure bars are [1/4] [_____] inch thick by [3/4] [_____] inch high, [1/2] [_____] inch on center, pencilproof spacing, with zero degree bar deflection angle.

For floor- and sill-mounted diffusers provide heavy-duty reinforced construction to carry loads of not less than [100] [_____] pounds per square foot.

Provide continuous length diffuser with hairline butt joints.

Provide mitered end caps where diffuser run terminates.

Provide opposed-blade type dampers.

Provide an integral, pivoted, bar-type access door where indicated.

Provide straightening grids where indicated.

2.2.2.8 Type DLS

Provide type DLS supply diffuser, linear slot type, extruded aluminum construction, with fully adjustable integral air pattern and volume control vanes that deflect air pattern from horizontal along ceiling to straight down. Ensure any intermediate setting and a pattern control element that permits complete blanking-off of slot.

Slot width: [3/4] [_____] inch.

Provide number of slots per unit run as indicated.

Align butts in continuous runs for hairline joints.

Butt ends of diffuser against walls without mitered end caps. Provide end caps where slot terminates.

Provide exposed-to-view part of frame with anodized aluminum, and all

interior exposed-to-view components with a black matte finish.

2.2.2.9 Type DSA

Provide type DSA supply diffuser, square with [four] [_____] expanding flared members to provide radially diffused discharge air. Arrange flared members to provide a minimum of four air paths which simultaneously diffuse air at 20 to 50 fpm. Include pattern adjustments horizontal, vertical projection, and an intermediate position or range.

[Provide a baked enamel finish.

][Provide aluminum construction.

][Provide antismudge rings.

][Provide integral extended surface to fit into module of lay-in ceiling.

]2.2.2.10 Type GS

Provide type GS supply grilles double deflection type with adjustable face bars parallel to short dimension and adjustable rear bars parallel to long dimension.

[Provide a baked enamel finish.

][Provide aluminum construction.

][Provide antismudge rings.

][Provide integral extended surface to fit into module of lay-in ceiling.

]2.2.2.11 Type GR

Provide type GR return grilles, single deflection type with fixed face bars.

Provide grilles installed in vertical surfaces with horizontal face bars set downward at 35 degrees from vertical.

Provide grilles installed in horizontal surfaces with face bars straight and parallel to short dimension.

[Provide a baked enamel finish.

][Provide aluminum construction.

][Provide antismudge rings.

][Provide integral extended surface to fit into module of lay-in ceiling.

]2.2.2.12 Type GCA

Provide type GCA with an individually adjustable, horizontal, curved-blade grilles and a one-way pattern.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.13 Type GCB

Provide type GCB with an individually adjustable, vertical, curved-blade grilles and a one-way pattern.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.14 Type GCD

Provide type GCD with an individually adjustable, vertical, curved-blade grilles and a two-way pattern.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.15 Type GCE

Provide type GCE with an individually adjustable, vertical and horizontal, curved-blade grilles and a three-way pattern.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.16 Type GCF

Provide type GCF with an individually adjustable, vertical and horizontal, curved-blade grilles and a four-way pattern.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.17 Type RS

Provide type RS supply register, double-deflection type, with adjustable face bars parallel to short dimension and adjustable rear bars parallel to long dimension with opposed-blade type dampers.

[Provide a baked enamel finish.

][Provide aluminum construction.

][Provide integral extended surface to fit into module of lay-in ceiling.

]2.2.2.18 Type RR

Provide type RR return register, single-deflection type with fixed face bars with opposed-blade dampers.

Provide registers installed in vertical surfaces with horizontal face bars set downward at approximately 35 degrees from vertical.

Provide registers installed in horizontal surfaces with face bars set straight and parallel to short dimension.

[Provide a baked enamel finish.

]2.2.2.19 Type RCA

Provide type RCA with an individually adjustable, horizontal, curved-blade register and a one-way pattern with opposed-blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.20 Type RCB

Provide type RCB with individually adjustable, vertical, curved-blade register and a one-way pattern with opposed blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.21 Type RCC

Provide type RCC with an individually adjustable, horizontal, curved-blade register and a two-way pattern with opposed blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.22 Type RCD

Provide type RCD with an individually adjustable, vertical, curved-blade register and a two-way pattern with opposed blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.23 Type RCE

Provide type RCE with an individually adjustable, vertical and horizontal, curved-blade register and a three-way pattern with opposed-blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.24 Type RCF

Provide type RCF with an individually adjustable, vertical and horizontal, curved-blade register and a four-way pattern with opposed-blade damper.

[Provide a baked enamel finish.

][Provide aluminum construction.

]2.2.2.25 Type TS

Provide type TS supply troffer complete assembly as specified in Section 26 51 00 INTERIOR LIGHTING and as indicated. Install air handling section of unit under this section.

2.2.2.26 Type TR

Provide type TR return troffer conforming to requirements for Type TS supply troffer.

2.2.2.27 Type TSR

Provide type TSR combination supply and return troffer assembly as specified in Section 26 51 00 INTERIOR LIGHTING and as indicated. Install air handling section of unit under this section.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment as indicated and specified and in accordance with manufacturer's recommendations.

[Mount wall-mounted supply registers 6 inches below ceiling.

][Mount wall-mounted return registers 6 inches above the finished floor.

] Submit installation drawings for air-diffusion devices. Indicate on drawings overall physical features, dimensions, ratings, service requirements, and equipment weights.

3.1.1 Operations and Maintenance Manuals

Provide operation and maintenance manuals consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures and safety precautions.

-- End of Section --

SECTION 23 41 13.00 40

PANEL FILTERS
02/16

PART 1 GENERAL

[Section 23 30 00 HVAC AIR DISTRIBUTION applies to work specified in this section.

] Provide panel filter[s] [system] complete with all components and accessory equipment as specified in this section.

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	(2017) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME AG-1	(2019) Code on Nuclear Air and Gas Treatment

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 14644-1	(2015) Cleanrooms and Associated Controlled Environments Part 1: Classification of Air Cleanliness

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST PS 1	(2009) DOC Voluntary Product Standard PS 1-07, Structural Plywood

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-282	(2015; Rev B; Notice 1 2020) Filter Units, Protective Clothing, Gas-Mask Components and Related Products: Performance Test Methods

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-50544	(Basic; Notice 2; Notice 3) Radiators, Heating, Steam and Hot Water, Cast Iron

UNDERWRITERS LABORATORIES (UL)

UL 586	(2009; Reprint Dec 2017) UL Standard for Safety High-Efficiency Particulate, Air Filter Units
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 900	(2015) Standard for Air Filter Units

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings

SD-03 Product Data

Air Filters; G, AE

Filter Gages; G, AE

Manometers; G, AE

SD-06 Test Reports

Test Reports

SD-07 Certificates

Air Filters

Filter Gages

Manometers

PART 2 PRODUCTS

2.1 FILTERS

Submit manufacturer's catalog data, including physical characteristics and performance data for panel filter[s] [system].

Submit physical characteristics information and performance data for air filters consisting of use life, system functional flows, safety features, and mechanical automated details. Also submit curves indicating tested and certified equipment responses and performance characteristics.

Provide air filters with a net effective filtering area and a face area to provide the required airflow at the indicated initial pressure-drop.

Provide sufficient clearance for maintenance and operation in and around filter assembly.

Construct filter-holding frames of [extruded aluminum] [type 300 corrosion-resistant steel] [corrosion-resistant coated 16-gage (minimum) steel] [not less than 16-gage galvanized carbon steel conforming to ASTM A653/A653M with not less than 1.25 ounces of zinc per square foot of two-sided surface] [wood-pulp products]. Provide frame assemblies and fasteners constructed of corrosion-resistant metal or carbon steel with a corrosion-resistant finish to preclude surface degradation.

[Make viscous-impingement framed panel filter gaskets from a material inert to filter impregnates, with a minimum thickness after compression of 1/8-inch.

][Provide dry filter gaskets of closed-cell foamed neoprene or urethane elastomer of sufficient hardness to compress to not more than 40 percent of original thickness when filter is in position.

]2.1.1 Filters, Disposable Type

Listed below is the minimum acceptable performance for the air filter:

DIMENSIONS (Inches)	INITIAL RESISTANCE (Inch WG)	ARRESTANCE (Percent)	DUST-HOLDING CAPACITY (Gram/Sq Ft)
14 by 20 by 1	0.04	65	145
16 by 20 by 1	0.04	65	145
16 by 25 by 1	0.04	65	145
20 by 20 by 1	0.04	65	145
20 by 25 by 1	0.04	65	145
16 by 20 by 2	0.08	75	190
16 by 25 by 2	0.08	75	190
20 by 20 by 2	0.08	75	190

DIMENSIONS (Inches)	INITIAL RESISTANCE (Inch WG)	ARRESTANCE (Percent)	DUST-HOLDING CAPACITY (Gram/Sq Ft)
20 by 25 by 2	0.08	75	190

For all sizes of filters, ensure the final resistance value is 0.50-inch, with air volume of 1,200 cubic feet per minute, and airflow velocity of 300-feet per minute.

2.1.2 Filters, Cleanable Type

Provide nonwoven synthetic-fabric-type filtering element, supported on rigid pleats of suitable grid material, with a nominal overall depth of [2-inches] [4-inches]. Seal filter element into an enclosing frame of rigid chipboard, providing a unit that will not rack. Verify initial pressure drop at a face velocity of 500 fpm is [0.25] [0.22]-inch wg, with average dust-spot efficiency of [10 percent] [18 percent] and arrestance of [85 percent] [87 percent] when filter is operated to a final pressure drop of 1-inch wg. Verify, under these circumstances, the dust-holding capacity is [45] [70] grams per square foot of face area.

Use test method in accordance with ASHRAE 52.2.

2.1.3 Filters, Replaceable Type

Provide filters conforming to CID A-A-50544, Type I or Type II. Base filter efficiency on ASHRAE 52.2. Efficiency, by definition, is dust-spot efficiency using atmospheric dust. Arrestance is weight efficiency using test dust.[Provide Type III filter arrestance efficiencies in accordance with MIL-STD-282 DOP test.]

Provide each air filter with a permanent corrosion-resistant holding frame and a replaceable factory-assembled filter element. Supply the permanent holding frame with suitable gaskets designed to maintain a positive pressure seal between the frame and the filter element(s).

Design and construct air filters to facilitate field maintenance. Make adjustments and ensure replaceable accessories are readily accessible. Conditions which may be hazardous to personnel or deleterious to equipment are not permitted.

Provide antiallergenic and nontoxic filter element, with no detectable odor, which have no adverse effect on the health of personnel handling or served by the filter element.

Use adhesive coatings on filters with a flashpoint of not less than 325 degrees F conforming to ASTM D92.

[Provide Type I, Grade A filters with 30 percent commercially rated efficiency conforming to UL 900, Class 2, and requirements specified herein. Provide filters, when operated at rated capacity of [_____] cfm, that have an initial pressure drop of not more than [_____]-inch wg, and a final pressure drop not exceeding [_____]-inch wg. Ensure filter initial efficiency is not less than 20 percent, and the average efficiency is not less than 25 percent. Verify dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute), is not less than [_____]

at [_____] [600 at 1,500] [1,000 at 2,000] [1,000 at 2,500].

][Provide Type I, Grade B filter with 40 percent commercially rated efficiency conforming to UL 900, Class 2, and requirements specified herein. Provide filters, when operated at rated capacity of [_____] cfm, that have an initial pressure drop of not more than [_____]-inch wg and a final pressure drop not exceeding [_____]-inch wg. Ensure filter initial efficiency is not less than 20 percent, and the average efficiency is not less than 35 percent, with dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute), of not less than [_____] at [_____] [500 at 1,500] [600 at 2,000] [700 at 2,500].

][Provide Type II, Grade C filter with 85 percent commercially rated efficiency [minimum of 58 percent per ASHRAE 52.2 using atmospheric dust] conforming to UL 900, [Class 2] [Class 1] and requirements specified herein. Provide filters, that when operated at rated capacity of [_____] cfm, having an initial pressure drop of not more than [_____]-inch wg, and final pressure drop not exceeding [_____]-inch wg, with an initial filter efficiency of not less than 58 percent, and an average efficiency not less than 76 percent. Verify the dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute) is not less than [_____] at [_____] [300 at 1,500] [400 at 2,000] [470 at 2,500].

][Provide Type II, Grade D filter with 95 percent commercially rated efficiency [minimum of 78 percent per ASHRAE 52.2 using atmospheric dust] conforming to UL 900, [Class 2] [Class 1] and requirements specified herein. Provide filters, that when operated at rated capacity of [_____] cfm, having an initial pressure drop of not more than [_____]-inch wg, and final pressure drop not exceeding [_____]-inch wg. Verify filter initial efficiency is not less than 80 percent, and the average efficiency is not less than 90 percent, a with dust-holding capacity (grams per square foot), at a rated air flow (cubic feet per minute) of not less than [_____] at [_____] [220 at 1,500] [300 at 2,000] [380 at 2,500].

][Provide Type III, Grade E filter 95 percent rated efficiency [DOP test using 0.2-micrometer particles] conforming to UL 900, [Class 2] [Class 1] and requirements specified herein. Provide filters with an initial pressure drop not exceeding [1.0-inch wg with a face velocity of 325 fpm on 6-inch deep filter] [1.0-inch wg with a face velocity of 500 fpm on 12-inch-deep filter] [[_____] inch wg with a face velocity of [_____] fpm on [_____] inch-deep filter], and a final pressure drop not exceeding [2.0-inches wg with a face velocity of 325 fpm on 6-inch-deep filter] [2.0-inches wg with a face velocity of 500 fpm on 12-inch-deep filter] [[_____] inches wg with a face velocity of [_____] fpm on [_____] inch deep filter].[Verify the filter efficiency is not less than 95 percent as determined in accordance with MIL-STD-282, using a 0.3-micrometer particle of thermally generated DOP smoke.]

][2.1.4 Filters, Automatic Type

Provide automatic renewable filtering element type filters in which a roll of the element is unwound across the airstream by a mechanism regulated by a timer or a differential-pressure control, or a combination of both.

Provide a unit suitable for 120-volt, single-phase, 60-hertz power.

Submit manufacturer established filter performance data established in accordance with ASHRAE 52.2 dynamic loading test procedures. Verify initial resistance does not exceed 0.20-inch wg at an airstream velocity of

500 fpm, and(when operating at its specified rate of airflow) has a dust-holding capacity of 65 grams per square foot when the resistance to airflow is maintained between 0.45 and 0.55-inch wg. Provide filtering element with an average dust-spot efficiency of not less than 20 percent and an arrestance of 85 percent.

Provide a viscous-impingement progressively graded density UL, Class 2, fibrous-glass type filter with a continuous material element. Filter to have a normal depth of 2-inches when clean and not compress more than 1/4-inch when subject to air velocity of 500 fpm. Reinforce element in both length and width. Support element so that no leakage of unfiltered air occurs. Wind dirty element with the dirty surface inward and ensure it re-rolls automatically under tension. Provide each spool of filtering element with guide keys to ensure correct installation, and possessing compressibility that will allow 65-feet to be wound to a maximum of 16-inches in diameter on the used roll. Ensure each roll of filtering element is not less than 65-feet long.

Wind the dirty filtering element and feed the clean element so that no blowoff of collected dirt can occur. Otherwise, contain clean and dirty elements in steel enclosures in reverse-flow units and in horizontal units where the element is wound outside of airstream.

Provide filter widths of uniform size for all project air-handling units.

Provide electrically driven type timer, readily adjustable in the field without special tools. Electrically interlock the timer with the fan motor to start and stop the filter element advancing mechanism, as required, when the fan is operating. Adjust initially such that the pressure-drop through the filter element will be maintained at approximately 0.45-inch wg. If used, the differential-pressure control can adjust to any cut-in and cutout with a differential of 0.05 to 0.10-inch wg. Initially adjust to 0.55-inch cut-in to 0.45-inch wg cutout. Install controls out of the airstream.

Equip master section with a runout switch to stop the feed movement and operate a signal light when the element from one of the sections runs out. Furnish a manual feed-advance switch with each drive unit to advance the element to the end of the roll as required. Locate signal light on the air-handling unit temperature-control panel.

Fabricate filter-supporting structural members of not less than 14-gage mill-galvanized carbon steel for the base and side panels and 16-gage mill-galvanized carbon steel for the top panel. Provide galvanized steel sheet in accordance with ASTM A653/A653M.

]2.1.5 Filters, High-Efficiency Particulate Air (HEPA)

Provide fire-resistant type HEPA filters capable of withstanding a minimum of 90-percent relative humidity determined dynamically at temperatures between 70 and 100 degrees F.

Provide filtering elements conforming to ASME AG-1. Individually certify that each filter has an efficiency of not less than 99.97 percent by a test method other than the DOP test specified in ISO 14644-1. An acceptable method for certification is to remove a filter from a production run prior to testing, then test the five filters before and after the removed filter in accordance with the DOP test (99.97 percent). Successful passing of the test by the five filters before and five filters

after the untested filter is the acceptance criteria for the untested filter. Verify the clean filter static pressure drop does not exceed 1.0 inch wg when the filter is tested at rated capacity.

Provide filtering elements containing no holes, cracks, slits, or other visual imperfections, with every splice required in the assembly of a filter pack joined with not less than 1-1/2 inches of fire-retardant adhesive for a continuous coating along the entire width of the element, with filter element made of glass paper with a minimum tensile strength of 3 pounds per inch of width and retain 50 percent of its tensile strength when folded flat upon itself. Verify elongation before rupture is a minimum of 1 percent, and element is water-proofed, retaining 50 percent of its original tensile strength after being immersed in water.

Register the results of test penetration on the frame of the filter unit, legibly and indelibly. Include the test resistance, test flow rate, together with direction of test airflow, manufacturer's name, model number, and serial number of the filter unit.

Provide elements with 3/4-inch plywood frames, Grade A-B EXT-DFPA or better, conforming to NIST PS 1. Treat plywood to exhibit a flame-spread of not more than 30 when tested according to UL 723 or ASTM E84. Countersink flathead wood screws after drilling lead holes. Create a positive seal at corner joints by coating adjoining surfaces with a suitable adhesive having the characteristics specified below. Particle board conforming to the flame-spread requirements specified for plywood may be used in lieu of plywood.

Coat entire inside face of frame members with an adhesive before assembly with filter pack. Following assembly, form a continuous bead of the same adhesive to seal between cut edges of filter pack and edges of abutting frame member on both faces of the filter unit. Ensure filter unit is square to a diagonal tolerance of 1/8-inch.

Provide a resilient and water-resistant adhesive able to withstand a temperature of 250 degrees F for 8 hours after curing. If capable of ignition, provide a self-extinguishing adhesive which meets general operating conditions without change in physical properties and without loss of seal. Ensure the cured adhesive contains no cracks, checks, alligatoring, or separation.

Provide HEPA filters conforming to UL 586.

[Provide with 14-gage [aluminum sheet] [zinc] [aluminum] [cadmium-coated 16-gage steel sheet] frames, with all corner joints given a positive seal by coating adjoining surfaces with a suitable adhesive having the characteristics indicated.

] Provide separators constructed of [aluminum] [_____] that do not contribute to fire, will remain structurally intact under fire exposure, and are not damaged by exposure to the humidity and temperature.

Provide 1/4-inch thick closed cellular construction neoprene gaskets, or gaskets with an elastomer of 20 to 40 Shore A durometer hardness. Attach gasketing firmly and continuously to the frame with rubber-based adhesive.

Assemble filter unit to provide uniformity of materials and construction, surface smoothness and finish, cleanliness, and freedom from protrusions and obvious flaws.

2.2 FILTER GAGES AND MANOMETERS

Provide air-filter gages or manometers for each type filter assembly.

Provide dial-indicator type gages, graduated to read 0 to 2-inches wg, except that gages for HEPA filters are to read0 to 3-inches wg. Provide manometers measuring from minus 0.5 to 3-inches wg, equipped with a built-in indicator bubble. Connect gage or manometer to static-pressure ports of approved design and located so that resistance to airflow will be correctly indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Coordinate filter supports and retention elements to provide a substantial, structurally sound, leakproof installation.

3.1.1 Holding Frame Installation

Provide installation drawings in accordance with referenced standards in this section.

Install gasket [to holding frames on perimeter][caulked to each other][to supplementary steel][to closures with elastomeric compounds recommended by the filter manufacturer]. Prepare substrate in accordance with the elastomer manufacturer's instructions, including the priming of surfaces in areas where the elastomer is not confined.

3.2 FIELD QUALITY CONTROL

Submit test reports in accordance with ASHRAE 52.2.

-- 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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (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
ASTM C592	(2016) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)

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

U.S. DEPARTMENT OF ENERGY (DOE)

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

UNDERWRITERS LABORATORIES (UL)

UL 296	(2017; Reprint Jan 2021) UL Standard for Safety Oil Burners
UL 726	(1995; Reprint Oct 2013) Oil-Fired Boiler Assemblies
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 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 have an output of [_____] BTU/hr. 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 [30 psig] [_____]. Boiler operating pressure must be [12 psig] [_____]. Boiler operating temperature must be [180 degrees F] [_____]. Boiler return water temperature must be [160 degrees C] [_____]. Provide a thermostatically controlled three-way mixing valve on boiler suitable for operating conditions of the boiler.

1.3.1 Boiler Installation Requirements

1.3.1.1 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.

1.3.1.2 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.

1.3.1.3 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.

1.3.2 Detail Drawings

1.3.2.1 Drawings

Show boiler hot water isolation valves, emergency disconnect switch, and complete boiler gas train on the contract drawings.

1.3.2.2 Fuel Train / Wiring Diagram

Submit fuel train and wiring diagram.

1.3.3 Water Analysis

Provide test reports of water analysis. UFC 3-240-13FN Industrial Water Treatment must be followed for all boiler installations.

1.4 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. Oil-Fired Units: UL 726, NFPA 31, NFPA 70, ASME CSD-1.

b. Gas-Fired Units: ASME CSD-1, NFPA 54, NFPA 70, ANSI Z21.13/CSA 4.9 or UL 795.

c. Combination Gas- and Oil-Fired Units: ASME CSD-1, NFPA 54, NFPA 31, NFPA 70, UL 726, ANSI Z21.13/CSA 4.9, UL 795 or UL 296.

d. 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.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 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

Stack, Breeching, and Supports

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

Feedwater Treatment Feeder

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.[Gas fired residential boilers less than 300,000 Btuh must have an Annual Fuel Utilization Efficiency (AFUE)of at least 90 percent, and be Energy Star labeled. Provide proof of Energy Star label for oil-fired residential boiler product.][Oil-fired residential boilers less than 300,000 Btuh must have an Annual Fuel Utilization Efficiency (AFUE) of at least 87 percent, and be Energy Star labeled. Provide proof of Energy Star label for gas fired residential boiler product.][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.][Oil-fired boilers greater than 300,000 Btuh output must have a thermal efficiency of at least 82 percent when fired at the maximum and minimum rated 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.

2.2 BURNERS AND CONTROL EQUIPMENT

[2.2.1 Atmospheric-Type Gas Burner

][2.2.2 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 [on/off] [high-low-off] [positioning] [metering] type. Locate flame scanner such that testing and cleaning of scanner can be accomplished without disassembly of burner. Provide fuel train as indicated. Gas pressure available: [[_____] inches of water gage] [[_____] psig].

2.2.3 [Enter Appropriate Subpart Title Here]
]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 [_____]-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] [to 6 inches above floor].

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] [to 6 inches above floor].

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 Feedwater Treatment Feeder

Provide floor mounted, Type II - Shot-Type Feeder (manual, intermittent feed), as indicated for use with pressures up to 200 psig maximum.

2.3.8 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.

2.3.9 Air Vent Valve

Provide with screwed connection, stainless steel disk, and stainless steel seats to vent entrapped air.

2.3.10 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 [, activating a red indicating light, and sounding an alarm] 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.

2.3.11 Low Water Level Cutoff Switch

Low water level cutoff must cause a safety shutdown by closing fuel valves[,] [and] shutting down burner equipment [, activating a red indicating light, and sounding an alarm] 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.

2.3.12 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.

2.3.13 Indicating Lights

Each safety interlock requiring a manual reset must have an individually labeled red indicating light. Non-recycling control interlocks must have the reset located on the control itself. Red indicating lights on the control panel may be omitted if the burner combustion control system has a Keyboard Display Module installed that will identify the lockout information required in Item c. below. Indicating lights must have colors as follows:

a. Amber: Ignition on

b. Green: Main fuel safety shut-off valves open

c. Red (One for Each): Safety lockout, flame failure, low water level, and high temperature

[d. Blue: Draft

]2.3.14 Alarm Bell

Provide alarm bell, electrically operated, with a manual disconnect switch. Disconnect switch must be type and wired so that switching off alarm following a safety shutdown will not prevent alarm from sounding again upon recurrence of a subsequent safety shutdown condition.

2.3.15 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.

2.3.16 Draft

Comply with boiler manufacturer's recommendations.

2.3.17 Stack, Breeching, and Supports

[Provide boiler stack constructed of sheet steel having a thickness of not less than 0.0972 inches with welded joints. Insulate stack located inside the building with 1 1/2 inches of mineral wool conforming to applicable requirements of ASTM C592, Class II - for use up to 1200 degrees F. Insulation must receive a finish coat of finishing cement not less than 3/4 inch thick, trowelled to a smooth finish. Provide stack supports, umbrella collar and cap, and flue transition piece. Stack diameter and height must be in accordance with manufacturer's recommendations and conform to NFPA 211.]

[NFPA 211, [Type B - gas] [Type L - oil and gas/oil], prefabricated multi-wall type, flashed to the roof, and complete with rain cap. Stack diameter and height must be in accordance with manufacturer's recommendations and conform to NFPA 211.]

2.3.18 Hot Water Coils

Provide coils capable of heating [_____] GPM of water with [_____] degree F rise conforming to ASME BPVC SEC IV.

2.3.19 Stack Thermometer

Provide flue gas dial type thermometer with scale calibrated from 150 to 750 degrees F and mounted in flue gas outlet.

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 NBBI 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 30 00 CAST-IN-PLACE 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 73 13.00 40

MODULAR OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS
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.

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

AMCA 99	(2016) Standards Handbook
AMCA 211	(2013; Rev 2017) Certified Ratings Program Product Rating Manual for Fan Air Performance
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 430 I-P	(2014) Performance Rating of Central Station Air-handling Unit Supply Fans
AHRI 880 I-P	(2011) Performance Rating of Air Terminals

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

ASHRAE 51	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
ASHRAE 52.2	(2017) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

ASTM INTERNATIONAL (ASTM)

ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 21940-11	(2016) Mechanical vibration -- Rotor balancing -- Part 11: Procedures and Tolerances for Rotors with Rigid Behavior

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A (2021) Standard for the Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 900 (2015) Standard for Air Filter Units

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G, AE

Fabrication and Connection Drawings; G, AE

SD-03 Product Data

Equipment and Performance Data; G, AE

Sample Warranty; G, AE

Air Filter Gauges; G, AE

SD-04 Samples

[Coating Specimen; G, AE

] SD-06 Test Reports

Final Test Reports; G, AE

SD-07 Certificates

List of Product Installations

Certificates of Conformance; G, AE

Unit Cabinet

Fan

Drain Pans

Insulation

Plenums

Multizone AHU

Blow-Through AHU

Spare Parts

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Warranty

1.3 QUALITY CONTROL

Submit a list of product installations for air-handling units showing a minimum of five installed units, similar to those proposed for use, that have been in successful service for at least 5 years. Provide a list that includes the purchaser, address of installation, service organization, and date of installation.

1.3.1 Certification of Conformance

Submit certificates of conformance for the following items, showing conformance with the referenced standards contained in this section:

a. Unit Cabinet

b. Fan

c. Drain Pans

d. Insulation

e. Plenums

h. Spare Parts

1.3.2 Sample Warranty

Submit samples of warranty language concurrently with Certificates for review and approval by the Contracting Officer.

Submit a sample warranty for the following items:

a. Unit Cabinet

b. Fan

c. Drain Pans

d. Insulation

e. Plenums

[h. Spare Parts

]1.4 DELIVERY, STORAGE, AND HANDLING

Deliver, handle, and store equipment and accessories in a manner that prevents damage or deformity. Provide temporary skids under units weighing more than [_____] pounds.

1.5 WARRANTY

Final acceptance is dependent upon providing the warranty, based on approved sample warranty, to the Contracting Officer, along with final test reports. Ensure that the warranty is valid for at least [2] [5] [_____] years from the date of project closeout, showing [Government] [_____] as the warranty recipient.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit equipment and performance data for air-handling units, including use life, total static pressure and coil face area classifications, and performance ratings.

Submit all required fabrication and connection drawings and obtain approval from the Contracting Officer before the start of work shown on these drawings.

Submit drawings and manuals that include a spare parts data sheet, with manufacture's recommended stock levels.

2.2 COMPONENTS

2.2.1 Air-Handling Unit (AHU)

Provide a central-station type, factory-fabricated, and [sectionally] [fully] assembled AHU. Provide AHU that includes components and auxiliaries in accordance with AHRI 430 I-P. Balance the AHU fan and motor according to ISO 21940-11.

Ensure that the total static pressure and coil face area classification conforms to AMCA 99.

Fans with enlarged outlets are not permitted.

[Provide a double-width, double-inlet, centrifugal scroll type AHU fan.

]2.2.2 Unit Cabinet

2.2.2.1 Class A and Class B Cabinets

Provide an AHU cabinet suitable for the pressure class shown and has leaktight joints, closures, penetrations, and access provisions. Provide a cabinet that does not expand or contract perceptibly when fans are starting or stopping and that does not pulsate during operation. Reinforce cabinet surfaces with deflections in excess of 0.004167 of unsupported span before acceptance. Stiffen pulsating panels, which

produce low-frequency noise due to diaphragming of unstable panel walls, to raise the natural frequency to an easily attenuated level. Fabricate the enclosure from continuous hot-dipped-galvanized steel no lighter than 20 gauge thickness, to match the industry standard. Provide mill-galvanized sheet-metal that conforms to ASTM A653/A653M and that is coated with not less than 1.25 ounces of zinc per square foot of a two-sided surface. Provide mill-rolled structural-steel that is hot-dip-galvanized or primed and painted. Corrosion-protect cut edges, burns, and scratches in galvanized surfaces. Provide primed and painted black carbon steel cabinet construction that complies with this specification.

Provide removable panels to access the interior of the unit cabinet. Provide seams that are welded, bolted, or gasketed and sealed with a rubber-based mastic. Make entire cabinet floor and ceiling hot-dipped-galvanized steel. Provide removable access doors on both sides of all access, filter, and fan sections for inspection and maintenance.

2.2.2.2 Class C Cabinets

Provide an AHU cabinet that is suitable for the pressure class shown and has leaktight joints, closures, penetrations, and access provisions. Provide a cabinet that does not expand or contract perceptibly when the fans are starting or stopping and that does not pulsate during operation. Reinforce cabinet surfaces with deflections in excess of 0.002778 of unsupported span before acceptance by the Contracting Officer. Stiffen pulsating panels, which produce low-frequency noise due to diaphragming of unstable panel walls, to raise the natural frequency to an easily attenuated level. Provide the enclosure that is fabricated from mill-galvanized or primed and painted carbon sheet steel. Provide mill-galvanized sheet metal that conforms to ASTM A653/A653M and that is coated with not less than 1.25 ounces of zinc per square foot of a two-sided surface. Provide mill-rolled structural steel that is hot-dip galvanized or primed and painted. Corrosion-protect edges, burns, and scratches in galvanized surfaces. Provide primed and painted black carbon steel cabinet construction that complies with this specification.

Provide removable panels to access the interior of the unit cabinet. Provide seams that are welded, bolted, or gasketed and sealed with a rubber-based mastic. Make the entire cabinet floor and ceiling hot-dipped galvanized steel. Provide removable access doors on both sides of all access, filter, and fan sections for inspection and maintenance.

2.2.2.3 Cabinet Construction

Where the cabinet size is such that personnel access is possible, strengthen the cabinet floor to permit entry without damaging any component. Hinge and latch the access doors and panels sufficiently close together to preclude leaks caused by distortion, and effectively gasket.

[Make all door handles operable from inside the casing.

] Black carbon steel cabinet construction is acceptable when the following conditions are met:

a. Coat all interior and exterior surfaces, including the lapped contacting surfaces, with a corrosion-protective coating.

b. Certify the coating as passing a 500-hour-exposure salt-spray fog test

in accordance with ASTM B117.

c. Immediately after completing the test, provide a coating specimen that shows no signs of wrinkling, cracking, or loss of adherence and no signs of rust creep beyond 1/8 inch on either side of the scratch mark.

d. Ensure that inspection of interior and exterior cabinet surfaces will pass examination for the same defects as the salt-spray fog test specimen, after 11 months of service and before the guarantee expires.

Interior surfaces of cabinets that are constructed of intact mill-galvanized steel require no further protection.

Provide cabinets with exterior surfaces constructed of mill-galvanized-steel that are [left unpainted] [painted] [prepared by a phosphatizing treatment, and painted with two coats of manufacturer's standard enamel finish in a color selected by the Contracting Officer].

Provide cabinets and casings that are double-walled with[1 inch][2 inch] [_____] insulation. Provide a [stainless steel] [galvanized] [non-absorbent coating] [_____] interior wall.

Weigh the fan and motor assembly at the AHU manufacturer's factory for isolator selection. Statically and dynamically balance fan section assemblies, including fan wheels, shafts, bearings, drives, belts, isolation bases, and isolators. Allow isolators to free-float when performing fan balance. Measure vibration at each fan shaft bearing in horizontal, vertical, and axial directions.

Factory install all motors on slide bases to permit adjustment of belt tension.

Provide heavy-duty, open drip-proof, three-phase fan motors, operable at 460 volts (V), 60 hertz (Hz). Provide high-efficiency motors. Refer to specification Section 26 05 70.00 40 HIGH VOLTAGE OVERCURRENT PROTECTIVE DEVICES and Section 26 05 71.00 40 LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES.

Provide a marine-type, vapor-proof service light in the fan segment. Provide a 100 watt (W) service light that is wired to an individual switch and operates on 115 V, single-phase, 60 Hz service that is separate from the main power to the AHU. Provide a single 115 V outlet at the light switch.

2.2.3 Fan

Ensure that fan wheels are dynamically and statically balanced at the factory. Provide a fan with RPM that is 25 percent less than the first critical speed. Provide a fan shaft that is solid, ground and polished steel and coated with a rust inhibitor. Provide V-belt-driven fans that are designed for 50 percent overload capacity. For variable air volume AHUs that are provided with variable-frequency drives, have their fans balanced over the entire range of operation (20 percent to 100 percent RPM). Balancing fans of only 100 percent design of RPM is not acceptable for AHUs to be used with variable-frequency drives.

Mount fans on isolation bases. Internally mount motors on the same isolation bases and internally isolate fans and motors. Install flexible canvas ducts or a vibration absorbent fan discharge seal between the fan

and casings to ensure complete isolation. Provide flexible canvas ducts that comply with NFPA 90A.

Provide an overall fan-section depth that is equal to or greater than the manufacturer's free-standing fan.

[Provide single-wheel fans.

] Locate the fan inlet where it provides not less than one-half fan-wheel diameter clearance from the cabinet wall or the adjacent fan inlet where double wheels are permitted.

Mount the AHU fan drive external to the casing.

Install the AHU fan motor and drive inside the fan cabinet. Provide a motor that conforms to NEMA MG 1 and is installed on an adjustable base. Provide an access door of adequate size for servicing the motor and drive. Provide a belt guard inside the cabinet or interlock the access door with the supply fan so that power to the fan is interrupted when the access door is opened.

2.2.4 Drain Pans

Provide intermediate-coil, 3 inch deep drip pans for each tiered coil bank.

Extend the top pan 12 inches beyond the face of the coil, and extend the bottom pan not less than 24 inches beyond the face of the coil. Where more than two pans are used, make the pan extension proportional. Make adequate supports from the same type of material as the pans or from hot-dip galvanized angle iron with isolation at the interface. Use 22-gauge, AISI Type 304, corrosion-resistant steel for pan material, with silver-soldered joints. Minimum size of the drain opening is 1-1/4 inches. Pipe the pan to the drain.

Extend the integral cabinet drain pan under all areas where condensate is collected and make it watertight with welded or brazed joints, piped to the drain. Provide corrosion protection in condensate collection areas, and insulate against sweating. Provide minimum 14-gauge sheet metal; however 16-gauge double-drain-pan construction is also acceptable.

Provide cooling coil ends that are enclosed by the cabinet and are factory insulated against sweating or drain to a drain pan.

Provide drain pans that are double-pan construction, thermally isolated from the exterior casing with 1 inch thick fiberglass insulation. Provide drain pans that slope to the drain and drain substantially dry by gravity alone when the drains are open.

Provide pans that have a double slope to the drain point.

][2.2.5 Insulation

Provide a unit that is internally fitted at the factory with a sound-attenuating, thermal-attenuating, fibrous-glass material not less than 2 inches thick. Ensure that the insulation precludes any condensation on any exterior cabinet surface under conditions that are normal to the unit's installed location. Provide acoustic treatment that

attenuates fan noise in compliance with specified noise criteria. Apply material to the entire cabinet with waterproof adhesives and permanent fasteners. Provide adhesive and insulating material in accordance with NFPA 90A.

[Provide insulated plenums and bypasses.

]][2.2.6 Plenums

Provide plenums in the following minimum widths:

a. 6 inches for mounting temperature controls and to separate two or more coils of different size that are mounted in series

b. 14 inches between face and bypass dampers and upstream accessories and at change in cross-section

c. 24 inches for access sections

2.2.7 [Enter Appropriate Subpart Title Here]
]2.2.8 Coils

2.2.8.1 Coil Section

Provide a coil section that encases cooling coils and drain pipes. Arrange coils for horizontal air flow. Provide intermediate drain pans for multiple-coils installation. Completely enclose coil headers with the insulated casing with only the connections extending through the cabinet.

2.2.8.2 Coil Pressure and Temperature Ratings

Ensure that the coils are designed for the following fluid operating pressures and temperatures:

SERVICE	PRESSURE	TEMPERATURE
Hot Water	200 PSI	250 degrees F

Provide coils that are air-pressure-tested under water at the following minimum pressures:

SERVICE	PRESSURE
Water (hot)	250 PSI

2.2.8.3 Coil Casings

Provide coils that are factory-tested, dehydrated, vacuum-tested, purged with inert gas, and sealed before shipped to the job site.

Provide stainless-steel casings. Provide cast iron, brass, or copper coil headers. Fit water coil headers with 0.25 inch ips spring-loaded plug drains and vent petcocks. Provide automatic air vents with ball-type isolation valves for each coil that is piped to the drain pan.

2.2.8.4 [Enter Appropriate Subpart Title Here]

2.2.8.5 Hot Water Coils

Provide heating coils that have copper tubing [aluminum] [copper] fins.

2.2.8.6 Drainable Coils

[Provide drainable coils that are capable of being purged free of water with compressed air.

][Provide self-draining coils that have a drain point at the end of every tube and are pitched to that point. Drain provisions include drained headers, U-bends with integral plugs, or nonferrous plugs in cast-iron headers. Provide tubes that drain substantially dry by gravity alone when the drains and vents are open.

]2.2.9 Eliminators

Provide eliminators that are SMACNA three-break, hooked-edge design, constructed of reinforced 16 gauge galvanized steel with assembled brazed joints. Provide easily removable eliminator sections for cleaning from the side of the AHU without requiring partial or complete disassembly of the AHU casing.

2.2.10 Filters

2.2.10.1 Filter Housing

Provide factory-fabricated filter sections of the same construction and finish as the unit casings. Provide filter sections that have filter guides and full height, double-wall, hinged, and removable access doors for filter removal. Provide air sealing gaskets to prevent air bypass around filters. Provide visible identification on media frames showing the model number and airflow direction. Where a filter bank is indicated or required, provide a means of sealing to prevent bypass of unfiltered air. Ensure that the filters perform in accordance with ASHRAE 52.2.

2.2.10.2 Replaceable Air Filters

Select filters conforming to UL 900, Class 1. Ensure that when clean filters are exposed to flame, the filters do not contribute fuel when attacked by flame and emit only negligible amount of smoke. Provide permanent frames with replaceable media, 1 inch thickness, size as indicated.

2.2.10.3 Disposable Cartridge Air Filters

Provide UL 900, Class 2, UL-classified, and factory-assembled filters. Provide media of ultra-fine glass fibers having 50 to 55 percent average dust spot efficiencies with a maximum final resistance 0.75-inch water gauge, and maximum face velocity of 500 feet per minute. Construct filter frames of 18 gauge galvanized steel or aluminum with welded or riveted joints. Caulk or gasket the entire assembly to prevent air leakage around the frames. Ensure that the minimum efficiency of the filter is 60 percent per ASHRAE 52.2.

2.2.10.4 Outside Air Filters

Provide an extended-surface, factory-assembled air filters with supported cartridges. Provide extended surface filter units fabricated for disposal when the dust-load limit is reached as indicated by maximum (final) pressure drop.

Filter Classification: UL-approved for Class 1 or 2 conforming to UL 900.

Filter Grades, Nominal Efficiency and Application:

a. Grade B: 80 to 85 percent nominal efficiency outfitter

b. Grade D: 25 to 30 percent nominal efficiency prefilter

Filter Media: Grade B Supported (Rigid Pleated) Type: Provide media that is composed of high-density glass fibers[or [_____] fibers]. Use fastening methods to maintain pleat shape, seal aluminum separators in a proper enclosing frame to ensure that there is no air leakage for the life of filter. Staples and stays are prohibited.

Grade D Type: Provide media that is composed of synthetic/natural fibers. Bond a metal grid backing to the air leaving side of the media to maintain uniform pleat shape and stability for proper airflow and maximum dust loading. Provide a media frame that is constructed of high-strength, moisture-resistant fiber or beverage board. Bond the pleated media pack on all four edges to ensure that there is no air leakage for the life of the filter. Staples and stays are prohibited.

Filter Efficiency and Arrestance: Determine the efficiency and arrestance of filters in accordance with ASHRAE 52.2 Standard Atmospheric dust spot efficiency and synthetic dust weight arrestance that is not less than the following:

	Initial Efficiency (Percent)	Average Efficiency (Percent)	Final Efficiency (Percent)
Grade B	58	79	98
Grade D	Less than 20	22	89

Maximum initial and final resistance and inches of water gauge for each filter cartridge when operated at a face velocity of 500-feet per minute are as follows:

	Initial Resistance	Final Resistance
Grade B, Rigid Pleated	0.60	1.00
Grade D, 2-inches deep	0.32	0.70

Dust-Holding Capacity: When tested to 1.00 inch w.g. at 500 feet per minute face velocity, provide a dust-holding capacity from each 24 inch by 24 inch (face area) filter that is at least equal to the values listed below. For other filter sizes, provide a dust-holding capacity that is proportionally higher or lower.

Grade B, Rigid Pleated	6.17 ounces
Grade D, 2 inches Deep	2.29 ounces
Grade D, 4 inches Deep	10.58 ounces

Minimum Media Area: Provide a minimum net effective area in square feet for each 24 inch by 24 inch (face area) filter at 500 feet per minute face velocity of at least the values listed below. For other filter sizes, provide a net effective media that is proportionally higher or lower.

Grade B, Rigid Pleated	57.0
Grade D, 2-inches Deep	14.8

2.2.10.5 Air Filter Gauges

Provide manometer air filter gauges of the inclined tube differential type that have solid acrylic plastic construction with a built-in level vial and with an adjustable mirror-polished scale. Equip gauges with vent valves for zeroing and over-pressure safety traps. Ensure that the gauge range is adequate for the particular installation.

Provide one air filter gauge at each filter bank.

PART 3 EXECUTION

3.1 PREPARATION

Coordinate the size and location of concrete equipment pads, variable frequency drives, control, and electrical requirements.

3.2 INSTALLATION

Install equipment in accordance with the manufacturer's recommendations.

Provide installation drawings in accordance with referenced standards in this section.

3.2.1 Temporary Construction Filters

Have temporary construction filters in place during normal building construction whenever the AHUs are run for general ventilation, building dehumidification, or other purposes during construction. Install two layers of blanket filter at a time. Replace temporary construction filters as required during construction and after duct system cleaning is completed.

After systems have been cleaned and temporary construction filters are removed, and before test and balance operations are started, install a set of final filters. Avoid loading the filter with construction dust; do not have final filters in place while general building construction is taking place. Clean the permanent filter bank before testing and balancing.

[Perform operation tests on each fire damper in the presence of the Contracting Officer by removing the fusible link and demonstrating the operation of the damper.

] The maximum number of coil rows is four. Maximum number of fins per inch is ten.

Provide variable air volume (VAV) terminal units that are certified by

AHRI 880 I-P and UL-listed.

3.3 FIELD QUALITY CONTROL

3.3.1 Vibration Analyzer

Use an Fast Fourier Transform (FFT) analyzer to measure vibration levels. The following characteristics are required: A dynamic range greater than 70 dB; a minimum of 400-line resolution; a frequency response range of 5 Hz to 10 KHz(300-600000 cpm); the capacity to perform ensemble averaging, the capability to use a Hanning window; auto-ranging frequency amplitude; a minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB.

Use an accelerometer, either stud-mounted or mounted using a rare earth, low-mass magnet and sound disk (or finished surface) with the FFT analyzer to collect data. Ensure that the mass of the accelerometer and its mounting have minimal influence on the frequency response of the system over the selected measurement range.

3.3.2 Acceptance

Before final acceptance, use dial-indicator gauges to demonstrate that the fan and motor are aligned as specified.

Before final acceptance, verify conformance to specifications using vibration analysis. Ensure that the maximum vibration levels are 0.075 inches per second at 1 times run speed and at fan/blade frequency, and 0.04 inches per second at other multiples of run speed.

3.3.3 AHU Testing

Conduct performance test and rate the AHU and components in accordance with AMCA 211, AMCA 300, and ASHRAE 51. Provide AHU ratings in accordance with AHRI 430 I-P.

Provide final test reports to the Contracting Officer. Provide reports with a cover letter/sheet clearly marked with the system name, date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

Perform AHU start-up in the presence of the Contracting Officer.

3.4 CLOSEOUT ACTIVITIES

3.4.1 Operation And Maintenance

Submit operation and maintenance manuals before testing the AHUs. Update and resubmit data for final approval no later than 30 calendar days before contract completion.

3.4.2 Acceptance

With the warranty, provide a cover letter/sheet clearly marked with the system name, date, and the words "Equipment Warranty" - "Forward to the

Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --

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SECTION 23 81 00

DECENTRALIZED UNITARY HVAC EQUIPMENT
05/18, CHG 1: 02/21

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 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils
AHRI 490 I-P	(2011) Performance Rating of Remote Mechanical-Draft Evaporatively-Cooled Refrigerant Condensers
AHRI 540	(2015) Performance Rating Of Positive Displacement Refrigerant Compressors And Compressor Units
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 270	(2008) Sound Rating of Outdoor Unitary Equipment
ANSI/AHRI 370	(2015; Addendum 1 2016) Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment
ANSI/AHRI 460	(2005) Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ANSI/AHRI 495	(2005) Performance Rating of Refrigerant

Liquid Receivers

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

ANSI/ASHRAE 15 & 34	(2013) 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	(2017) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 55	(2010) Thermal Environmental Conditions for Human Occupancy
ASHRAE 62.1	(2010) Ventilation for Acceptable Indoor Air Quality
ASHRAE 64	(2020) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers
ASHRAE 90.1 - IP	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (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 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 A307	(2021) 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 C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D520	(2000; R 2011) Zinc Dust Pigment
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E2129	(2018) Standard Practice for Data Collection for Sustainability Assessment of Building Products
ASTM F104	(2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
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

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

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-DTL-5541	(2006; Rev F) Chemical Conversion Coatings on Aluminum and Aluminum Alloys

UNDERWRITERS LABORATORIES (UL)

UL 207	(2009; Reprint Jan 2020) Refrigerant-Containing Components and Accessories, Nonelectrical
UL 586	(2009; Reprint Dec 2017) UL Standard for Safety High-Efficiency Particulate, Air Filter Units
UL 900	(2015) Standard for Air Filter Units
UL 1995	(2015) UL Standard for Safety Heating and

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. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Spare Parts

Posted Instructions

Coil Corrosion Protection

System Performance Tests

Training; G, AE

Inventory

Environmental Data

Supplied Products

Manufacturer's Standard Catalog Data

Humidifier

SD-06 Test Reports

Refrigerant Tests, Charging, and Start-Up; G, AE

System Performance Tests; G, AE

SD-07 Certificates

Service Organizations

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, AE

SD-11 Closeout Submittals

Ozone Depleting Substances; S, AE

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. Thermal comfort must meet or exceed [ASHRAE 55] [AFGM 2016-01].

1.7 WARRANTY

Provide equipment with the [Manufacturer's Standard Warranty.] [[1 year] [2 year] [5 year] [10 year] [____ year] manufacturer's warranty.]

PART 2 PRODUCTS

2.1 ENERGY EFFICIENCY REQUIREMENTS

42 USC 8259b requires the procurement of energy efficient products in product categories covered by the Energy Star program or the Federal Energy Management Program for designated products. A list of covered product categories is available from the Federal Energy Management Web site at http://energy.gov/eere/femp/covered-product-categories. A list of qualified light commercial products is available at http://www.energystar.gov/productfinder/product/certified-light-commercial-hvac/result

Submit Material, Equipment, and Fixtures List of all supplied products

within a covered product category, including manufacturer's catalog numbers, specification and drawing reference number, warranty information, fabrication site, and energy performance data. For product categories covered by the Energy Star program, submit documentation that the product is Energy Star-qualified. For product categories covered by the Federal Energy Management Program, submit documentation that the product meets or exceeds FEMP-designated efficiency requirements.

2.1.1 Room Air Conditioners

Selected room air conditioners are required to meet performance requirements specified by Energy Star. Information on the requirements can be found at ENERGY STAR Version 4.0 Room Air Conditioners Program Requirements.

2.1.2 Air-Source Heat Pumps

Selected air-source heat pumps are required to meet applicable performance requirements specified by Energy Star. Information on the requirements can be found for residential models (single-phase units of 65,000 BTU/h or less)at http://www.energystar.gov/products/specs/system/files/Central_ASHP_and_CAC_Program_Req v4_1.pdf and for light commercial models (three-phase units of less than 240,000 BTU/h) at http://www.energystar.gov/products/specs/system/files/lchvac_prog_req_v2_2_0.pdf.

2.2 MATERIALS

Provide Manufacturer's standard catalog data, at least [5 weeks] [_____] 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.

2.2.1 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 [bid opening] [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.

2.2.2 Product Sustainability Criteria

2.2.2.1 Energy Efficient Equipment

Provide equipment meeting the efficiency requirements as stated within this section and provide documentation in conformance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING paragraph ENERGY EFFICIENT EQUIPMENT.

2.2.2.2 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.

2.2.2.3 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 SUSTAINABILITY REQUIREMENTS AND REPORTING paragraph OZONE DEPLETING SUBSTANCES.

2.2.2.4 Local/Regional Materials

Use materials or products extracted, harvested, or recovered, as well as manufactured, within a [500][_____] mileradius from the project site, if available from a minimum of three sources.

2.2.2.5 Environmental Data

Submit Table 1 of ASTM E2129 for the following products: [_____].

2.2.3 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 [anodized aluminum] [stainless steel] [_____]. Fix plates in prominent locations with nonferrous screws or bolts.

2.2.4 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.

2.3 EQUIPMENT

2.3.1 [Enter Appropriate Subpart Title Here]
2.3.2 [Mini-]Split-System Air Conditioners [Heat Pumps]

2.3.2.1 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][ceiling mounted] indoor unit, and interconnecting refrigerant piping. Provide the [air conditioning][heat pump] type unit conforming to applicable Underwriters Laboratories (UL) standards including UL 1995. Unit must be rated in accordance with [ANSI/AHRI 210/240][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 [open][drip proof][totally enclosed][explosion proof] enclosures. Design unit to operate at outdoor ambient temperatures up to [115] [_____] degrees F.

2.3.2.1.1 Energy Efficiency

Provide unit with an Energy Star label. [Air Conditioners must have [a minimum [seasonal] energy efficiency ratio ([S]EER) of [_____],] [a minimum Heating Seasonal Performance Factor (HSPF) of [_____],] [a minimum Integrated Part Load Value (IPLV) of [_____],] and [a minimum COP of [_____].]][Provide unit with hot gas reheat.]

2.3.2.1.2 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 [condenser] [evaporator] [condenser and evaporator] coil with a uniformly applied [epoxy electrodeposition][phenolic][vinyl][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 [500][1,000][_____] hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

2.3.2.1.3 Compressor

Provide direct drive [hermetic reciprocating] [variable speed] [digital scroll] [scroll] type compressor.Provide compressor with internal over temperature and pressure protector; sump heater; oil pump; high pressure and low pressure controls; and liquid line dryer.

2.3.2.1.4 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.

2.3.2.1.5 Unit Controls

Provide unit internally prewired with a [24][120][_____] 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.] [Control unit by a [two stage heating /cooling thermostat] [one stage heating/cooling thermostat] with [manual] [automatic] changeover.] [Control unit by a programmable electronic thermostat with heating setback and cooling setup with 7-day programming capability.]

Controls must include a control system interface to a LonWorks control system. The control system interface, as well as any network between physically separate units, must meet the requirements of Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

[
Communication networks between physically separate units in a split system must be in accordance with either Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS or Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. and must match the protocol used by the control system interface.
]2.3.2.1.6 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 eacj coil after testing and prior to evaluation and charging. Provide separate

expansion devices for each compressor circuit.

2.3.2.1.7 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 [20][55][_____]degrees F. Provide fan and cabinet construction as specified in paragraph UNITARY EQUIPMENT ACCESSORIES. Fan and condenser motors must have [open][drip proof][totally enclosed][explosion proof] enclosures. [Condensing unit must have controls to initiate a refrigerant pump down cycle at system shut down on each refrigerant circuit.]

[2.3.2.1.7.1 Sound Rating

Provide units of capacities less than 135,000 Btu/h with a maximum AHRI sound rating of [85][_____] dB when rated in accordance with ANSI/AHRI 270.

]2.3.2.1.7.2 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.

2.3.2.1.8 Primary/Supplemental Heat

Provide heating unit with internal thermal insulation having a fire hazard rating not to exceed 25 for flame spread and 50 for smoke developed as determined by ASTM E84.

[2.3.2.1.8.1 Electric Heating

[Provide electric duct heater in accordance with UL 1995 and NFPA 70. Coil must be completely assembled, unit-mounted, and integral to the unit. Provide coil with nickel chromium elements and a maximum density of 40 watts per square inch. Provide coil with automatic reset high limit control operating through heater backup contactors. Provide coil casing and support brackets of [galvanized steel] [or] [aluminum]. Mount coil to eliminate noise from expansion and contraction and be completely accessible for service.][

Construct electric heater of heavy-duty nickel chromium elements. Achieve staging through the unit control processor. Each heater must have automatically reset high limit control. Heaters must be individually fused from the factory and comply with NEC requirements. Power assemblies must provide single point connection. Electric heat modules must be listed and labeled by a national recognized testing laboratory acceptable to authorities having jurisdiction. Electric heater controls must confirm the supply fan is operating before electric elements are energized. Operate electric heater in [2][3] stages when outdoor ambient is too low to maintain space thermostat setting with compressor operation.]

][2.3.2.1.8.2 Gas-Fired Heating Section

[Construct the gas-fired heat exchanger and burner of stainless steel

suitable for [natural gas][liquid propane gas] fuel supply. Burner must have [direct spark] [pilot ignition]. Heating section must be completely assembled and integral to unit, having modulation with a turn down ratio of at least [4] [3] to 1. Fire test all units prior to shipment. Valve must include a pressure regulator. Supply combustion air with a centrifugal combustion air blower with built-in thermal over load protection. Safety controls must include a flame sensor and air pressure switch. Mount heater section to eliminate noise from expansion and contraction, and allow accessibility for service. Gas equipment must bear the AGA label for the type of service involved. Provide burner in accordance with NFPA 54.][

Construct the gas-fired furnace and burner of materials suitable for [natural gas][liquid propane gas] fuel supply. Furnace must have [direct spark] [pilot ignition]. Heating section must be completely assembled and integral to unit, having modulation with a turn down ratio of at least [4] [3] to 1. Fire test all units prior to shipment. Gas valve must include a pressure regulator. Supply combustion air with a centrifugal combustion air blower with built-in thermal over load protection. Safety controls must include a flame sensor and air pressure switch. Mount burner to eliminate noise from expansion and contraction, and allow accessibility for service. Gas equipment must bear the AGA label for the type of service involved. Provide burner in accordance with NFPA 54. Gas furnaces must have the Energy Star Label and a minimum efficiency of [78][85][90][___] percent AFUE.]

][2.3.2.1.8.3 Hot Water Coils

Serpentine type constructed of seamless copper tubes with aluminum fins mechanically or hydraulically bonded to tubes. Provide factory-furnished tee and manual air vent on return connection. Factory test coils at twice maximum operating pressure.

][2.3.2.1.8.4 Steam Coils

Serpentine type constructed of red brass or seamless copper tubes with aluminum fins mechanically or hydraulically bonded to tubes. Factory test coils at twice the maximum operating pressure.

]2.3.2.1.9 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 [by hinged access panel(s)]. [1] [2] inch MERV [7][8][13], provide throwaway filter on all units below 6 Tons.

Provide filter rack that can be converted to 2.0 inch capability. Filters must have an average dust spot efficiency of [25-35][90-95] percent and an average arrestance of [90][_____] percent when tested in accordance with ASHRAE 52.2. Provide UL Class 1 filters.

2.3.2.1.10 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.

2.3.2.2 Large-Capacity Split-System Air Conditioners (Greater Than 65,000 Btu/h)

Provide an air-cooled, split system which employs a remote condensing unit, a separate [floor mounted][wall mounted][ceiling mounted] indoor unit, and interconnecting refrigerant piping. Provide the [air conditioning][heat pump] type unit conforming to applicable Underwriters Laboratories (UL) standards including UL 1995. Unit must be rated in accordance with [ANSI/AHRI 210/240][AHRI 340/360 I-P]. Provide unit with necessary fans, air filters, and cabinet construction as specified in paragraph UNITARY EQUIPMENT ACCESSORIES. Provide double-width, double inlet, [forward curved] [backward inclined] [airfoil blade] centrifugal scroll type evaporator or supply fans. Provide the manufacturer's standard for the unit specified and may be [either] [propeller] [or] [centrifugal scroll] type condenser or outdoor fans. Enclose fan condenser motors in [open][drip proof][totally enclosed][explosion proof] enclosures [and permanently lubricate ball bearings]. [Air Conditioners must have [a minimum [seasonal] energy efficiency ratio ([S]EER) of [_____],] [a minimum Heating Seasonal Performance Factor (HSPF) of [_____],] [a minimum Integrated Part Load Value (IPLV) of [_____],] and [a minimum COP of [_____].]][Provide unit with hot gas reheat.]

2.3.2.2.1 Air-To-Refrigerant Coil

Provide coils with [nonferrous][copper] [or] [aluminum] tubes tubes of 3/8 inch minimum diameter with [copper] [or] [aluminum] fins that are mechanically bonded or soldered to the tubes. Provide casing of [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. Provide each unit with [a factory operating charge of refrigerant and oil] [or] [a holding charge]. Field charge unit shipped with a holding charge with refrigerant and oil. Provide separate expansion devices for each compressor circuit. [Condenser coil must have an integral sub-cooler.] [Condenser coil must have special coating for corrosion resistance.] [Condenser coil must be copper finned.]

Coat [condenser] [evaporator] [condenser and evaporator] coil with a uniformly applied [epoxy electrodeposition][phenolic][vinyl][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 [500][1,000][____] hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

2.3.2.2.2 Compressor

Provide direct drive, semi-hermetic or hermetic reciprocating, or scroll type compressor capable of operating at partial load conditions. Compressor must be capable of continuous operation down to the lowest step of unloading as specified. Equip compressors of 10 tons and larger with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors operate in sequence, and each compressor has an independent refrigeration circuit through the condenser

and evaporator. Start compressors in the unloaded position. Provide each compressor with vibration isolators, crankcase heater, thermal overloads,[lubrication pump,] [high][high and low] pressure safety cutoffs and protection against short cycling.

2.3.2.2.3 Refrigeration Circuit

Refrigerant-containing components must comply with ASHRAE 15 & 34 and be factory tested, cleaned, dehydrated, charged, and sealed. Provide refrigerant charging valves and connections, and pumpdown valves for each circuit. Provide reversible-flow type filter-drier in each liquid line. Refrigerant flow control devices must be an adjustable superheat thermostatic expansion valve with external equalizer matched to coil, capillary or thermostatic control, and a pilot solenoid controlled, leak-tight, four-way refrigerant flow reversing valve. Provide a refrigerant suction line [thermostatic][thermostatic and water flow switch] control to prevent freeze-up in event of loss of water flow during heating cycle.

2.3.2.2.4 Primary/Supplemental Heat

Provide heating unit with internal thermal insulation having a fire hazard rating not to exceed 25 for flame spread and 50 for smoke developed as determined by ASTM E84.

[2.3.2.2.4.1 Electric Heating

[Provide electric duct heater in accordance with UL 1995 and NFPA 70. Coil must be completely assembled, unit-mounted, and integral to the unit. Provide coil with nickel chromium elements and a maximum density of 40 watts per square inch. Provide coil with automatic reset high limit control operating through heater backup contactors. Provide coil casing and support brackets of [galvanized steel] [or] [aluminum]. Mount coil to eliminate noise from expansion and contraction and be completely accessible for service.][

Construct electric heater of heavy-duty nickel chromium elements. Achieve staging through the unit control processor. Each heater must have automatically reset high limit control. Heaters must be individually fused from the factory and comply with NEC requirements. Power assemblies must provide single point connection. Electric heat modules must be listed and labeled by a national recognized testing laboratory acceptable to authorities having jurisdiction. Electric heater controls must confirm the supply fan is operating before electric elements are energized. Operate electric heater in [2][3] stages when outdoor ambient is too low to maintain space thermostat setting with compressor operation.]

][2.3.2.2.4.2 Gas-Fired Heating Section

[Construct the gas-fired heat exchanger and burner of stainless steel suitable for [natural gas][liquid propane gas] fuel supply. Burner must have [direct spark] [pilot ignition]. Heating section must be completely assembled and integral to unit, having modulation with a turn down ratio of at least [4] [3] to 1. Fire test all units prior to shipment. Valve must include a pressure regulator. Supply combustion air with a centrifugal combustion air blower with built-in thermal over load protection. Safety controls must include a flame sensor and air pressure switch. Mount heater section to eliminate noise from expansion and contraction, and allow accessibility for service. Gas equipment must bear

the AGA label for the type of service involved. Provide burner in accordance with NFPA 54.][

Construct the gas-fired furnace and burner of materials suitable for [natural gas][liquid propane gas] fuel supply. Furnace must have [direct spark] [pilot ignition]. Heating section must be completely assembled and integral to unit, having modulation with a turn down ratio of at least [4] [3] to 1. Fire test all units prior to shipment. Gas valve must include a pressure regulator. Supply combustion air with a centrifugal combustion air blower with built-in thermal over load protection. Safety controls must include a flame sensor and air pressure switch. Mount burner to eliminate noise from expansion and contraction, and allow accessibility for service. Gas equipment must bear the AGA label for the type of service involved. Provide burner in accordance with NFPA 54. Gas furnaces must have the Energy Star Label and a minimum efficiency of [78][85][90][___] percent AFUE.]

][2.3.2.2.4.3 Hot Water Coils

Serpentine type constructed of seamless copper tubes with aluminum fins mechanically or hydraulically bonded to tubes. Provide factory-furnished tee and manual air vent on return connection. Factory test coils at twice maximum operating pressure.

][2.3.2.2.4.4 Steam Coils

Serpentine type constructed of red brass or seamless copper tubes with aluminum fins mechanically or hydraulically bonded to tubes. Factory test coils at twice the maximum operating pressure.

]2.3.2.2.5 Unit Controls

Provide unit internally prewired with a [24][120][_____] volt control circuit powered by an internal transformer. Provide terminal blocks for power wiring and external control wiring. Unit must have cutoffs for [high][high and low] pressure,[and] low oil pressure for compressors with positive displacement oil pumps, [supply fan failure], [and safety interlocks on all service panels]. Head pressure controls must sustain unit operation with ambient temperature of [20][55][_____]degrees F. Adjustable-cycle timers must prevent short-cycling. Stage multiple compressors by means of a time delay. Internally protect unit by [fuses] [or] [a circuit breaker] in accordance with UL 1995. Make low cost cooling possible by means of a control circuit which will modulate dampers to provide 100 percent outside air while locking out compressors.

Controls must include a control system interface to a LonWorks control system. The control system interface, as well as any network between physically separate units, must meet the requirements of Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

[

Communication networks between physically separate units in a split system must be in accordance with either Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS or Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. and must match the protocol used by the control system interface.

]

2.3.2.2.6 Remote Condenser or Condensing Unit

Units with capacities 135,000 Btuh or greater must produce a maximum AHRI sound rating of [85][_____] dB when rated in accordance with ANSI/AHRI 370. Fit each remote condenser coil with a manual isolation valve and an access valve on the coil side. Saturated refrigerant condensing temperature must not exceed 120 degrees F at 95 degrees F ambient. Provide unit with low ambient condenser controls to ensure proper operation in an ambient temperature of [20] [55] [_____] degrees F. Provide fan and cabinet construction must be provided as specified in paragraph UNITARY EQUIPMENT COMPONENTS. Fan and condenser motors must have [open][dripproof][totally enclosed][explosion proof] enclosures. [Condensing unit must have controls to initiate a refrigerant pump down cycle at system shut down on each refrigerant circuit.]

2.3.2.2.6.1 Air-Cooled Condenser

Provide unit rated in accordance with ANSI/AHRI 460 and conform to the requirements of UL 1995. Provide factory fabricated, tested, packaged, and self-contained unit. Unit must be complete with casing, propeller or centrifugal type fans, heat rejection coils, connecting piping and wiring, and all necessary appurtenances.

a. Provide interconnecting refrigeration piping, electrical power, and control wiring between the condensing unit and the indoor unit as required and as indicated. Provide electrical and refrigeration piping terminal connections between [condenser][condensing unit] and evaporator units.

b. Low ambient control for multi-circuited units serving more than one evaporator coil must provide independent condenser pressure controls for each refrigerant circuit. Set controls to produce a minimum of 95 degrees F saturated refrigerant condensing temperature. Provide unit with a liquid subcooling circuit that ensures proper liquid refrigerant flow to the expansion device over the specified application range of the condenser. Unit must be provided with [manufacturer's standard] [not less than [8][_____] degrees F] liquid subcooling. Liquid seal the subcooling circuit.

c. Coils must have [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 COIL CORROSION PROTECTION.] 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 after testing and prior to evaluation and charging. 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 separate expansion devices for each compressor circuit.

d. Provide a complete control system with required accessories for regulating condenser pressure by fan cycling, solid-state variable fan speed, modulating condenser coil or fan dampers, flooding the condenser, or a combination of the above. Construct unit mounted control panels or enclosures in accordance with applicable requirements of NFPA 70 and house in NEMA ICS 6, Class 1 or 3A

enclosures. Controls must include [control transformer,] [fan motor [starters,]] [solid-state speed control,] [electric heat tracing controls,] [time delay start-up,] overload protective devices, interface with local and remote components, and intercomponent wiring to terminal block points.

2.3.2.2.6.2 Evaporative Condenser

[Provide a counter-flow blow-through design, with single-side air entry.]The unit must have fan assemblies built into the unit base, with all moving parts factory mounted and aligned. Primary construction of the pan section and the cabinet must not be lighter than 16-gauge steel, protected against corrosion by a zinc coating. Conform the zinc coating ASTM A153/A153M and ASTM A123/A123M, as applicable and have an extra heavy coating of not less than 2.5 ounces/square foot of surface. Give cut edges a protective coating of zinc-rich compound. After assembly, apply the manufacturer's standard zinc chromatized aluminum or epoxy paint finish to the exterior of the unit. Unit must be rated in accordance with AHRI 490 I-P and tested in accordance with the requirements of ASHRAE 64.

a. Provide a watertight pan complete with drain, overflow, and make-up water connections. Provide standard pan accessories to include circular access doors, a lift-out strainer of anti-vortexing design and a brass make-up valve with float ball.

b. Provide a direct driven, statically and dynamically balanced, [centrifugal][or][propeller] type fan. Do not locate fan and fan motor in the discharge airstream of the unit. Enclose motors in [open] [splashproof] [totally enclosed] enclosure that is suitable for the indicated service. Design the condensing unit design to prevent water from entering into the fan section.

c. Provide condensing coils with [nonferrous][copper] [or] [aluminum] tubes of 3/8 inch minimum diameter without fins. [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 each unit with [a factory operating charge of refrigerant and oil] [or] [a holding charge]. [Field charge unit shipped with a holding charge with refrigerant and oil.]

d. Provide a water distribution system that distributes water uniformly over the condensing coil to ensure complete wetting of the coil at all times. Provide [brass,] [stainless steel,] [or] [high-impact plastic] spray nozzles that are the cleanable, non-clogging, removable type. Design nozzles to permit easy disassembly and arrange for easy access.

e. Provide [a][two] bronze-fitted [centrifugal] [or] [turbine] type water pump[s] that may be mounted as an integral part of the evaporative condenser or remotely on a separate mounting pad. Pumps must have cast-iron casings. Impellers must be bronze, and shafts stainless steel with bronze casing wearing rings. Use mechanical type shaft seals. Factory coat the pump casing with epoxy paint. Pump motors must have [open][drip proof][totally enclosed][explosion proof] enclosures. Provide a bleed line with a flow valve or fixed orifice in the pump discharge line and extend to the nearest drain for

continuous discharge. Fully submerge pump suction and provide with a [galvanized steel] [or] [monel] screened inlet.

f. Provide drift eliminators to limit drift loss to not over 0.005 percent of the specified water flow. Construct eliminators of [zinc-coated steel] [or] [polyvinyl chloride (PVC)]. Eliminators must prevent carry over into the unit's fan section.

g. Provide the evaporative condenser unit with modulating capacity control dampers mounted in the discharge of the fan housing. On a decrease in refrigerant discharge pressure the dampers must modulate to reduce the airflow through the evaporative condenser. Controls must include a proportional acting pressure controller, a control transformer, motor actuator with linkages and end switches to cycle fan motor on and off. Cycle a fan motor on and off in accordance with the manufacturer's instructions.

2.3.2.2.6.3 Compressor

Provide compressor rated in accordance with AHRI 540. Provide direct drive, semi-hermetic or hermetic reciprocating, or scroll type compressor capable of operating at partial load conditions. Compressor must be capable of continuous operation down to the lowest step of unloading as specified. Provide units 120,000 Btuh and larger with capacity reduction devices to produce automatic capacity reduction of at least 50 percent. If standard with the manufacturer, two or more compressors may be used in lieu of a single compressor with unloading capabilities, in which case the compressors operate in sequence, and each compressor must have an independent refrigeration circuit through the condenser and evaporator. Each compressor must start in the unloaded position. Provide each compressor with vibration isolators, crankcase heater,[lubrication pump,] thermal overloads, and [high][high and low] pressure safety cutoffs and protection against short cycling.

2.3.2.2.6.4 Fans

Provide fan wheel shafts supported by either maintenance-accessible grease lubricated antifriction block-type bearings, or permanently lubricated ball bearings. Mount fan motor and fan assembly on a common base to allow consistent belt tension with no relative motion between fan and motor shafts. The entire fan motor and fan assembly must be completely vibrationally isolated from the unit. Select unit fans to produce the cfm required at the fan total pressure. Motor starters, if applicable, must be magnetic across-the-line type with a [open drip-proof][totally enclosed][explosion proof] enclosure. Provide [manual] [or] [automatic-reset] type thermal overload protection. Construct fan wheels of [aluminum] [or] [galvanized steel]. Provide centrifugal fan wheel housings of galvanized steel, and construct centrifugal fan casings of [aluminum] [or] [galvanized steel]. Steel elements of fans, except fan shafts, must be [hot-dipped galvanized after fabrication] [or] [fabricated of mill galvanized steel]. Recoat mill-galvanized steel surfaces and edges damaged or cut during fabrication by forming, punching, drilling, welding, or cutting with an approved zinc-rich compound. Statically and dynamically balance [fan wheels] [or] [propellers]. Provide double inlet [forward-curved] [air foil] type fan wheels. Fan must reach rated rpm before the fan shaft passes through the first critical speed. Fans must be belt-driven with adjustable sheaves. Select the sheave size so that the fan speed at the approximate midpoint of the sheave adjustment produces the specified air quantity. Provide centrifugal scroll-type fans

with streamlined orifice inlet and V-belt drive. Each drive must be independent of any other drive. Condenser fans must be propeller type, direct drive, statically balanced with galvanized steel blades and permanently lubricated ball bearings. Protect condenser fan motor drive bearings with water slingers or shields. Fit all belt drives with guards where exposed to contact by personnel.

2.3.2.2.7 Filters

Provide filters of the [sectional] [or] [panel] [cleanable] type, capable of filtering the entire air supply. Mount filter(s) integral within the unit and make accessible [by hinged access panel(s)]. Factory supply 2.0 inch, MERV [8][13], throwaway filters. Filters must have an average dust spot efficiency of [25-35][90-95] percent and an average arrestance of [90][__] percent when tested in accordance with ASHRAE 52.2. Provide UL Class 1 filters.

2.3.3 [Enter Appropriate Subpart Title Here]2.3.3.1 [Enter Appropriate Subpart Title Here]2.3.3.1.1 [Enter Appropriate Subpart Title Here]

2.4 COMPONENTS

2.4.1 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.

2.4.2 Fans

Fan wheel shafts must be supported by either maintenance-accessible lubricated antifriction block-type bearings, or permanently lubricated ball bearings. Unit fans must be selected to produce the cfm required at the fan total pressure. Motor starters, if applicable, must be magnetic across-the-line type with a [open][dripproof][totally enclosed][explosion proof] enclosure. Thermal overload protection must be of the manual or automatic-reset type. Fan wheels or propellers must be constructed of aluminum or galvanized steel. Centrifugal fan wheel housings must be of galvanized steel, and both centrifugal and propeller fan casings must be constructed of aluminum or galvanized steel. Steel elements of fans, except fan shafts, must be hot-dipped galvanized after fabrication or fabricated of mill galvanized steel. Mill-galvanized steel surfaces and edges damaged or cut during fabrication by forming, punching, drilling, welding, or cutting must be recoated with an approved zinc-rich compound. Fan wheels or propellers must be statically and dynamically balanced. Forward curved fan wheels must be limited to [_____] inches. Direct-drive fan motors must be of the multiple-speed variety. Belt-driven fans must have adjustable sheaves to provide not less than [_____] percent fan-speed adjustment. The sheave size must be selected so that the fan speed at the approximate midpoint of the sheave adjustment will produce the specified air quantity. Centrifugal scroll-type fans must be provided with streamlined orifice inlet and V-belt drive. Each drive will be independent of any other drive. Propeller fans must be [direct-drive][V-belt] drive type with [adjustable][fixed] pitch blades.

V-belt driven fans must be mounted on a corrosion protected drive shaft supported by either maintenance-accessible lubricated antifriction block-type bearings, or permanently lubricated ball bearings. Each drive will be independent of any other drive. Drive bearings must be protected with water slingers or shields. V-belt drives must be fitted with guards where exposed to contact by personnel and [fixed pitch] [adjustable pitch] sheaves.

2.4.3 Primary/Supplemental Heating

2.4.3.1 Water Coil

Coil must conform to the provisions of AHRI 410. Coil must be fin-and-tube type constructed of seamless copper tubes and [aluminum][or][copper] fins mechanically bonded or soldered to tubes. Headers must be constructed of cast iron, welded steel or copper. Coil must be constructed to float within the casing to allow free expansion and contraction of tubing. Casing and tube support sheets must not be lighter than 16 gauge galvanized steel formed to provide structural strength. When required, multiple tube supports must be provided to prevent tube sag. Coil must be circuited for suitable water velocity without excessive pressure drop and properly pitched for drainage where required or indicated. Each coil must be tested at the factory under water at not less than 300 psi air pressure, tested hydrostatically after assembly of the unit and proved tight under a gauge pressure of 200 psi. Coil must be suitable for use with water up to 250 degrees F. Coil must allow complete coil drainage with a pitch of not less than 1/8 inch/foot slope to drain.

2.4.3.2 Steam Coil

Coil must conform to the provisions of AHRI 410. Coil must be constructed of cast semi-steel, welded steel, or copper headers, red-brass or copper tubes, and copper or aluminum fins mechanically bonded or soldered. Tubes must be rolled and bushed and brazed or welded into headers. Coil casings and tube support sheets, with collars of ample width, must be not lighter than 16 gauge galvanized steel, formed to provide structural strength. When required, multiple tube supports must be provided to prevent tube sag. The fin tube and header section must float within the casing to allow free expansion of tubing for coils subject to high pressure-steam service. Coils must be factory pressure tested and capable of withstanding 250 psi hydrostatic test pressure or 250 psi air pressure, and be for [100][200] psi steam working pressure. Preheat coils must be steam-distributing tube type. Condensing tubes must be not less than 5/8 inch outside diameter. Distribution tubes must be not less than 3/8 inch outside diameter, and be equipped with orifices to discharge steam to condensing tubes. Distribution tubes must be installed concentrically inside of condenser tubes and be held securely in alignment. The maximum length of a single coil must be limited to 120 times the diameter of the outside tube. Other heating coils must be minimum 1/2 inch outside diameter single-tube type. Supply headers must distribute steam evenly to all tubes at the indicated steam pressure. Coil must allow complete coil drainage with a pitch of not less than 1/8 inch/foot slope to drain.

2.4.3.3 Electric Heating Coil

Coil must be an electric duct heater in accordance with UL 1995 and NFPA 70. Coil must be duct- or unit-mounted. Coil must be of the [nickel chromium resistor, single stage, strip][nickel chromium resistor, single stage, strip or stainless steel, fin tubular] type. Coil must be provided with a

built-in or surface-mounted high-limit thermostat interlocked electrically so that the coil cannot be energized unless the fan is energized. Coil casing and support brackets must be of galvanized steel or aluminum. Coil must be mounted to eliminate noise from expansion and contraction and be completely accessible for service. Supplemental Electric Resistance Heating controls must be provided to prevent operation when the heating load can be met by the primary source.

2.4.3.4 Gas-Fired Heating Section

Gas-fired heat exchanger must be constructed of aluminized steel, ceramic coated cold-rolled steel or stainless steel suitable for [natural gas][liquid propane gas] fuel supply. Burner must have direct spark or hot surface ignition. Valve must include a pressure regulator. Combustion air must be supplied with a centrifugal combustion air blower. Safety controls must include a flame sensor and air pressure switch. Heater section must be mounted to eliminate noise from expansion and contraction and must be completely accessible for service. Gas equipment must bear the AGA label for the type of service involved. Burner must be in accordance with NFPA 54.

2.4.4 Air Filters

Provide filters to filter outside air and return air and locate [as indicated] [inside air conditioners] [inside filter box] [inside combination air filter mixing box]. Provide [replaceable (throw-away)] [high efficiency] [cleanable (reusable)] type. Filters must conform to UL 900, [Class 1] [or] [Class 2]. Polyurethane filters cannot be used on units with multiframe filters.

Air filters must be listed in accordance with requirements of UL 900, except high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test Method must be as listed under the label service and must meet the requirements of UL 586.

2.4.4.1 Extended Surface Pleated Panel Filters

Filters must be 2 inch depth sectional type of the size indicated and must have an average efficiency of 25 to 30 percent when tested in accordance with ASHRAE 52.2. Initial resistance at 500 feet/minute must not exceed 0.36 inches water gauge. Filters must be UL Class 2. Media must be nonwoven cotton and synthetic fiber mat. A wire support grid bonded to the media must be attached to a moisture resistant fiberboard frame. Four edges of the filter media must be bonded to the inside of the frame to prevent air bypass and increase rigidity.

2.4.4.2 Replaceable Media Filters

Provide replaceable media filters of the [dry-media] [viscous adhesive] type, of the size required to suit the application. Filtering media must not be less than 2 inches thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Pad must be enclosed in a holding frame of not less than 16 gauge galvanized steel, and equipped with quick-opening mechanism for changing filter media. Base the air flow capacity of the filter on net filter face velocity not exceeding [300][_____] feet/minute, with initial resistance of [0.13][_____] inches water gauge. Average efficiency must be not less than [_____] percent when tested in accordance with ASHRAE 52.2.

2.4.4.3 Sectional Cleanable Filters

Provide sufficient oil to coat filters six times based on 1 pint of oil per each 10 square feet of filter area. Provide washing and charging tanks for cleaning and coating filters. Filters must have a MERV of [6] [8] [_____] when tested in accordance with ASHRAE 52.2.

Cleanable filters must be [1][2] inches thick. Viscous adhesive must be provided in 5 gallon containers in sufficient quantity for 12 cleaning operations and not less than one quart for each filter section. One washing and charging tank must be provided for every 100 filter sections or fraction thereof. Each washing and charging unit must consist of a tank and [single] [double] drain rack mounted on legs. Drain rack must be provided with dividers and partitions to properly support the filters in the draining position.

2.4.4.4 High Efficiency Filters

Filters must have a MERV of 17 when tested in accordance with ASHRAE 52.2. Filter assembly must include; holding frame and fastener assembly, filter cartridge, mounting frame, and retainer assembly. Reinforce filter media with glass fiber mat. Pressure drop across clean filter shall not exceed [_____] inches of water gage. Precede high efficiency filters with a UL Class 2 replaceable type filter.

2.4.4.5 Manometers

Provide inclined-type manometers for filter stations of 2,000 cfm capacity or larger including filters furnished as integral parts of air-handling units and filters installed separately. Provide sufficient length to read at least one inch of water column with 10 major graduations, and equipped with spirit level. Equip manometers with overpressure safety traps to prevent loss of fluid, and two three-way vent valves for checking zero setting. [Mercury cannot be used as the operating fluid.]

2.4.5 Coil Frost Protection

Provide each circuit with a manufacturer's standard coil frost protection system. The coil frost protection system must use a temperature sensor in the suction line of the compressor to shut the compressor off when coil frosting occurs. Use timers to prevent the compressor from rapid cycling.

2.4.6 Pressure Vessels

Pressure vessels must conform to ASME BPVC SEC VIII D1 or UL 207, as applicable for maximum and minimum pressure or temperature encountered. Where referenced publications do not apply, test pressure components at 1-1/2 times design working pressure. Refrigerant wetted carbon steel surfaces must be pickled or abrasive blasted free of mill scale, cleaned, dried, charged, and sealed.

2.4.6.1 Hot Gas Muffler

Unit must be selected by the manufacturer for maximum noise attenuation. Units rated for 30 tons capacity and under may be field tunable type.

2.4.6.2 Liquid Receiver

A liquid receiver must be provided when a system's condenser or compressor

does not contain a refrigerant storage capacity of at least 20 percent in excess of a fully charged system. Receiver must be designed, filled, and rated in accordance with the recommendations of ANSI/AHRI 495, except as modified herein. Receiver must be fitted to include an inlet connection; an outlet drop pipe with oil seal and oil drain where necessary; two bull's-eye liquid level sight glass in same vertical plane, 90 degrees apart and perpendicular to axis of receiver or external gauge glass with metal guard and automatic stop valves;[thermal well for thermostat;][float switch column;][external float switches;] and purge, charge, equalizing, pressurizing, plugged drain and service valves on the inlet and outlet connections. Receiver must be provided with a relief valve of capacity and setting in accordance with ASHRAE 15 & 34.

2.4.6.3 Oil Separator

Separator must be the high efficiency type and be provided with removable flanged head for ease in removing float assembly and removable screen cartridge assembly. Pressure drop through a separator must not exceed [10][_____] psi during the removal of hot gas entrained oil. Connections to compressor must be as recommended by the compressor manufacturer. Separator must be provided with an oil float valve assembly or needle valve and orifice assembly, drain line shutoff valve, sight glass, [filter for removal of all particulate sized 10 microns and larger,][thermometer and low temperature thermostat fitted to thermal well,] [immersion heater,][external float valve fitted with three-valve bypass,] and strainer.

2.4.6.4 Oil Reservoir

Reservoir capacity must equal one charge of all connected compressors. Reservoir must be provided with an external liquid gauge glass, plugged drain, and isolation valves. Vent piping between the reservoir and the suction header must be provided with a 5 psi pressure differential relief valve. Reservoir must be provided with the manufacturer's standard filter on the oil return line to the oil level regulators.

2.4.7 Internal Dampers

Dampers must be parallel blade type with renewable blade seals and be integral to the unitary unit. Damper provisions must be provided for each outside air intake, exhaust, economizer, and mixing boxes. Dampers must [have minimum position stops][be linked together][have [manual][automatic] modulation] and operate as specified.

2.4.8 Mixing Boxes

Mixing boxes must match the base unit in physical size and must include equally-sized[flanged] openings, each capable of full air flow. Arrangement must be as indicated.

2.4.9 Cabinet Construction

Casings for the specified unitary equipment must be constructed of galvanized steel or aluminum sheet metal and galvanized or aluminum structural members. Minimum thickness of single wall exterior surfaces must be 18 gauge galvanized steel or 0.071 inch thick aluminum on units with a capacity above 20 tons and 20 gauge galvanized steel or 0.064 inch thick aluminum on units with a capacity less than 20 tons. Casing must be fitted with lifting provisions, access panels or doors, fan vibration

isolators, electrical control panel, corrosion-resistant components, structural support members, insulated condensate drip pan and drain, and internal insulation in the cold section of the casing. Where double-wall insulated construction is proposed, minimum exterior galvanized sheet metal thickness must be 20 gauge. Provisions to permit replacement of major unit components must be incorporated. Penetrations of cabinet surfaces, including the floor, must be sealed. Unit must be fitted with a drain pan which extends under all areas where water may accumulate. Drain pan must be fabricated from Type 300 stainless steel, galvanized steel with protective coating as required, or an approved plastic material. Pan insulation must be water impervious. Extent and effectiveness of the insulation of unit air containment surfaces must prevent, within limits of the specified insulation, heat transfer between the unit exterior and ambient air, heat transfer between the two conditioned air streams, and condensation on surfaces. Insulation must conform to ASTM C1071. Paint and finishes must comply with the requirements specified in paragraph FACTORY COATING.

2.4.9.1 Indoor Cabinet

Indoor cabinets must be suitable for the specified indoor service and enclose all unit components.

2.4.9.2 Outdoor Cabinet

Outdoor cabinets must be suitable for outdoor service with a weathertight, insulated and corrosion-protected structure. Cabinets constructed exclusively for indoor service which have been modified for outdoor service are not acceptable.

2.4.10 Condenser Water Piping And Accessories

Provide condenser water piping and accessories in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.4.11 Refrigerant Piping

Provide refrigerant piping in accordance with Section 23 23 00 REFRIGERANT PIPING.

2.4.12 [Enter Appropriate Subpart Title Here]

2.4.13 Condensate Drain Piping

provide condensate drain piping in accordance with Section 23 05 15 COMMON PIPING FOR HVAC.

2.4.14 Ductwork

Provide ductwork in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.4.15 Temperature Controls

Temperature controls shall be [in accordance with [Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][Section 23 09 23.02 BACnet DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDNG CONTROL SYSTEMS]][fully coordinated with and integrated into the existing air-conditioning system].

2.5 UNITARY EQUIPMENT ACCESSORIES AND MISCELLANEOUS EQUIPMENT

2.5.1 Air Economizer

Provide [down flow][horizontal flow][field][factory] installed economizer with fully modulating 0-100 percent motor and dampers, barometric relief, minimum position setting and fixed dry bulb. [Field install solid state enthalpy and differential enthalpy control.]

2.5.2 [Enter Appropriate Subpart Title Here]2.5.2.1 [Enter Appropriate Subpart Title Here]

2.5.2.2 Refrigerant Leak Detector

Provide continuously-operating, halogen-specific type refrigerant leak detector. Detector must be appropriate for the refrigerant in use. Detector must be specifically designed for area monitoring and must include [a single sampling point][[_____] sampling points] installed where indicated. Detector design and construction must be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector must have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector must be supplied factory-calibrated for the appropriate refrigerant(s). Detector must be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant in use. The detector's relay must be capable of initiating corresponding alarms and ventilation system as indicated on the drawings. Detector must be provided with a failure relay output that energizes when the monitor detects a fault in its operation.[Detector must be compatible with the facility's energy or utility management and control system (EMCS/UMCS). The EMCS/UMCS must be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.]

2.5.2.3 Refrigerant Relief Valve/Rupture Disc Assembly

The assembly must be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly must be in accordance with ASME BPVC SEC VIII D1 and ASHRAE 15 & 34. The assembly must be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc must be the non-fragmenting type.

2.5.2.4 Refrigerant Signs

Refrigerant signs must be a medium-weight aluminum type with a baked enamel finish. Signs must be suitable for indoor or outdoor service. Signs must have a white background with red letters not less than 0.5 inches in height.

2.5.2.4.1 Installation Identification

Provide each new refrigeration system with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name.

b. Refrigerant number and amount of refrigerant.

c. The lubricant identity and amount.

d. Field test pressure applied.

2.5.2.4.2 Controls and Piping Identification

Provide refrigerant systems containing more than 110 lb of refrigerant with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow[, the ventilation system,] and the refrigerant compressor.

b. Pressure limiting device(s).

2.5.2.5 Heat Recovery Devices

2.5.2.5.1 Hot Air Reclaim

Provide a [built in] heat recovery unit, factory-fabricated in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.5.2.5.2 Hot Water Reclaim

Unit must be a double-wall, tube-within-tube heat exchanger type, complete with thermostatic control. Unit must be constructed and refrigerant pressure/temperature rated in accordance with ASHRAE 15 & 34. Heat exchanger coil must consist of an external refrigerant containing carbon steel tube and an internal, double-wall-in-metallic contact, convoluted, potable water containing copper tube. Cabinet must be fabricated of zinc-protected steel and be internally insulated in coil space. The recovery device must be provided with a refrigerant compressor head pressure control and a interlocked, potable water circulating pump. Pump and motor assembly must be close-coupled, manufacturer's standard type with indicated head and capacity characteristics, and with brass, bronze, copper or stainless steel wetted parts. Pump must be mounted [remotely][integral] to the exchanger and be rated for [115][208][230] volt ac power supply.

2.5.2.6 Gaskets

Provide gaskets conforming to ASTM F104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 700 degrees F service.

2.5.2.7 Bolts and Nuts

Bolts and nuts 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.

2.5.2.8 Bird Screen

Screen must be 0.063 inch diameter aluminum wire or 0.031 inch diameter stainless steel wire.

2.6 FINISHES

2.6.1 Coil Corrosion Protection

Provide coil with a uniformly applied [epoxy electrodeposition] [phenolic] [vinyl] [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 1,000 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution.

2.6.2 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 [125][500] 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.

2.6.2.1 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.

2.6.2.2 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.

2.6.2.3 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

2.6.3 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.

2.7 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 D1and 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. If mechanical vibration isolators are not provided, provide vibration absorbing foundations. 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. Isolators must limit vibration to [10] [10-20] [20-40] [_____] percent at lowest equipment rpm. Provide lines connected to pumps mounted on pedestal blocks with flexible connectors. Provide foundation drawings, bolt-setting information, and foundation bolts 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 30 00 CAST-IN-PLACE CONCRETE. Equipment must be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.2.2 Mechanical Room Ventilation

Provide mechanical ventilation systems in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.2.3 Field Applied Insulation

Apply field applied insulation as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.2.4 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 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 [8] [_____] 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 as specified in Section 23 23 00 REFRIGERANT PIPING. 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. [Submit [6] [_____] copies of each test containing the information described below in bound 8-1/2 by 11 inch booklets. Individual reports must be submitted for the refrigerant system tests.]

a. The date the tests were performed.
b. A list of equipment used, with calibration certifications.
c. Initial test summaries.
d. Repairs/adjustments performed.
e. Final test results.

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 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 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 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 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 B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
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 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(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

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. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Unit Heaters

SD-10 Operation and Maintenance Data

Unit 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 [Enter Appropriate Subpart Title Here]

2.1.1.1 [Enter Appropriate Subpart Title Here]

2.1.2 [Enter Appropriate Subpart Title Here]2.1.2.1 [Enter Appropriate Subpart Title Here]

2.1.3 Hot-Water Unit Heater

ASHRAE 33 tested for heating coils; UL listed for motor and controls.

2.1.3.1 Casing

Minimum [20] [_____] gage [steel] [or] [aluminum] with removable access panels or means to remove, service, and maintain major components.

2.1.3.2 Coil

Fin-and-tube coil constructed of [copper,] [red brass,] [90-10 copper nickel,] [or] [steel] tubes and [copper] [or] [aluminum] fins. Use maximum design pressure of [steam at [_____] pounds per square inch gage (psig)] [and] [hot water at [_____] psig and [_____] degrees F].

2.1.3.3 Controls

[Automatic controls of [modulating] [on-off-auto] [or] [combination of modulating and on-off-auto] system] [As indicated]. [Provide a three-position selector switch.]

2.2 [Enter Appropriate Subpart Title Here]2.2.1 [Enter Appropriate Subpart Title Here]2.2.1.1 [Enter Appropriate Subpart Title Here]

]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 NOISE, VIBRATION AND SEISMIC CONTROLS

Section 22 05 48.00 20 MECHANICAL SOUND VIBRATION AND SEISMIC CONTROL.

2.6 [Enter Appropriate Subpart Title Here]

][2.7 HOT WATER PIPING SYSTEM

Section 23 21 13.00 20 LOW TEMPERATURE WATER [LTW] HEATING SYSTEMS.

2.8 [Enter Appropriate Subpart Title Here]
]2.9 SOURCE QUALITY CONTROL

Special protection is not required for equipment that has a zinc coating conforming to [ASTM A123/A123M] [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 [Enter Appropriate Subpart Title Here]

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 [Enter Appropriate Subpart Title Here]

3.2.3.2 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.

3.2.3.3 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 --

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SECTION 23 82 16.00 40

AIR COILS
05/16

PART 1 GENERAL

Section 23 30 00 HVAC AIR DISTRIBUTIONapplies to work specified in this section.

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 410	(2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils

ASTM INTERNATIONAL (ASTM)

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

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Record of Existing Conditions

SD-02 Shop Drawings

Fabrication Drawings; G, AE

Connection Diagrams; G, AE

Controls Layout; G, AE

Internal Tubing and Wiring; G, AE

Installation Drawings; G, AE

SD-03 Product Data

Hot-Water Heating; G, AE

Volatile Refrigerant Cooling; G, AE

SD-05 Design Data

Design Analysis and Calculations

SD-06 Test Reports

Final Test Reports

SD-07 Certificates

Certificates of Conformance

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Record Drawings

1.3 QUALITY CONTROL

Submit a record of existing conditions consisting of the results of a survey of work area conditions and features of existing structures and facilities within and adjacent to the jobsite.

Provide coils that bear the ARI certification seal indicating compliance with AHRI 410. Submit Certificates of Conformance for following items showing conformance with AHRI 410:

a. Coil

b. Coil casings

c. Coil headers

d. Coil tubing

e. Coil circuiting

Indicate the general physical controls layout, and internal tubing and wiring details on the drawings. Submit design analysis and calculations for coils.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit manufacturer's catalog data for the following coil types indicating, when applicable, coil pressure and temperature ratings, coil casings, headers, tubing, circuiting, and drainable coils.

a. Steam heating

b. Hot-water heating

c. Chilled-water cooling

d. Volatile refrigerant cooling

Submit fabrication drawings for coil units consisting of fabrication and assembly details to be performed in the factory. Include connection diagrams indicating the relations and connections of the following items:

a. Coil

b. Coil casings

c. Coil headers

d. Coil tubing

e. Coil circuiting

2.1.1 Coil Pressure and Temperature Ratings

Provide coils designed for the following fluid operating pressures and temperatures:

Service	Pressure (psi)	Temperature (Degrees F)
Steam - low pressure	25	267
Steam - high pressure	150	366
Steam - superheated	350	500
Hot water	200	250
Chilled water	200	45
Volatile refrigerant	200	300

Air-pressure test coils under water at the following minimum pressures:

Service	Pressure (psi)
Steam	250
Hot water	250
Chilled water	250
Volatile refrigerant	400

2.2 COMPONENTS

2.2.1 Coil Casings

Provide coil casings that are mill-galvanized, 16-gage, minimum. Ensure sheet metal has not less than 1.25-ounces of zinc per square foot of two-sided metal surface conforming to ASTM A653/A653M. Provide a casing flanged on four sides for bolted assembly, except as otherwise specified.

Where coils are stacked, provide a double-bend construction casing.

Provide duct-mounted reheat coil casings not over 36-inches in length, fabricated from a minimum 20-gage galvanized steel conforming to above specified requirements. Provide casings that are flanged or suitable for drive-slip assembly.

Provide coil mounting within the housing that is either fixed or slide-out type, except as otherwise specified. Provide slide-out type coils for ceiling-suspended package units, and for other package units whose capacity exceeds 15,000 cubic-feet per minute.

2.2.2 Coil Headers

Provide coil headers of [cast iron] [brass] [copper] [aluminum casting].

Provide direct expansion, volatile refrigerant coils that have copper or brass headers with necessary control connections.

Fit steam and water coil headers with 1/4-inch iron pipe size(ips) spring-loaded plug drains and vent petcocks. Provide automatic vents where indicated.

2.2.3 Coil Tubing

Install coils constructed of copper tubing with aluminum or copper fins. Provide helical coil fins that are wound tight to the tubes and solder-coated. Provide plate fins that have spacer collars in metallic contact with the adjacent fin. Ensure fins are mechanically bonded to the tube. Ensure bare tube surface is not visible within the finned portion of the coil.

Provide solder-coated cooling coils of helical wound copper design.

For coil tubes in water or volatile refrigerant service, provide tubes that are parallel. Ensure coil tubes have sufficient intermediate full coil depth supports to prevent sagging of unsupported span due to: working fluid pressures, temperatures, and summer and winter coil-ambient conditions. Sagging is unacceptable if tube centerline is displaced by more than 3/16-inch from centerline of tube connection at outlet header when coils are more than two rows deep and when installed in accordance with the manufacturer's instructions. Make adequate provision for expansion and contraction that precludes sagging and distortion under thermal loads applied in indicated or specified service. Slope tubes to be free draining.

Provide maximum heating-coil face tube spacing of 3-inches on center for 1-inch outside-diameter (od) tubes, 2-inches for 3/4-inch od tubes, and 1-1/2-inches for 5/8-inch od tubes.

Provide coil face tube spacing for cooling coils and for helically wound heating coils immediately followed by water-cooling coils that do not exceed 1-1/2-inches on center.

Ensure tubes are straight, with turns made through headers or return U-bends, with brazed connections and joints, except as otherwise specified.

Ensure coil tube material is seamless deoxidized copper.

Ensure coil tube material is seamless 90-10 copper-nickel with 0.035-inch wall thickness for superheated-steam service to 350-pounds per square inch (psi) at 500 degrees F.

Provide raw coil tube stock wall with a minimum thickness of 0.025-inch.

Provide raw coil tube stock wall with a minimum thickness of 0.035-inch.

Where mechanical insert devices are used to increase liquid turbulence within tubes, increase the wall thickness of these tubes by 0.010-inch over the minimum raw coil tube stock specified for the service.

Provide minimum tube outside diameter of 1/2-inch.

2.2.4 Coil Circuiting

[Provide standard or full-circuited water coils that have as many full-length tubes in each circuit as the number of tubes in the depth of the coil face.][Provide double-circuit water coils that have twice as many tubes as standard coils.][Provide half-circuit water coils that have half as many tubes as standard coils and to the next larger whole number where odd numbers are involved.]

Provide counterflow type coils when more than two rows deep, except that in the case of double- or half-circuit coils, reasonable deviation from counterflow arrangement is permitted, provided the pressure drop and capacity requirements are met.

2.2.5 Drainable Coils

Provide drainable coils that are capable of being purged free of water with compressed air.

Provide self-draining coils with a drain point at the end of every tube and sloped to that point. Provide drain provisions that include: drained headers, U-bends with integral plugs; or nonferrous plugs in cast-iron headers. Provide tubes that drain substantially dry by gravity alone when drains and vents are open.

Where necessary, fill the coil with water to the end of the manufacturer's header connections and check drainage volume against the manufacturer's data.

2.2.6 Coil Types

2.2.6.1 Steam Heating

[For Type SA, provide steam distributing, tube-in-tube with multiple-orifice distributors. Provide a tube with a minimum outside-diameter of 1-inch wherever coil is exposed to airstream at freezing temperatures. For all other applications, provide a minimum outside-diameter of 5/8-inch. Provide tubes that are sloped 1/8-inch per foot, and coil casing that is level. Provide coil with inlet and outlet connections on the same side.

][For Type SB, provide tube-in-tube type, for reheat service, with modulating control. When located in ductwork over 6-feet in total width, provide either two separate coils or one coil with supply to both ends and

a single return. Provide coil with inlet and outlet connections on the same end and on opposite sides of the two-coil assembly.

][For Type SC, provide single row, single circuit, for reheat service with two-position control.

][For Type SD, provide integral damper face and bypass type. Provide coil that includes finned elements with headers. Ensure return bends are pitched within the casing; and bypasses with interlocked dampers are controlled by a damper motor and airstream thermostats.

] Provide a maximum fin spacing of 10 per linear inch. Provide tubes that are connected to supply and return headers by mechanical joints and are secured against vibration by a channel that permits expansion and contraction. Provide 16-gage cold-rolled steel damper blades. Provide graphite-impregnated nylon damper rod bearings. Provide oil-impregnated bronze linkage bearings. Proportion air such that the average temperature at any point in a plane parallel to the coil face, 3-feet downstream of the leaving side, does not vary more than 5 degrees F from the thermostat setting. Vary pressure-drop of air passing through the coil no more than plus or minus 5 percent, regardless of the position of the internal dampers.

2.2.6.2 Hot-Water Heating

[For Type HA, provide continuous circuit type, limited to two rows depth.

][For Type HB, provide drainable counterflow type, with more than two rows.

]2.2.6.3 Chilled-Water Cooling

[For Type CA, provide continuous circuit, drainable type, limited to two rows depth.

][For Type CB, provide self-draining, counterflow type.

][For Type CC, provide self-draining, cleanable, counterflow type. Provide straight-through type tubes, rolled or brazed into steel tube sheets. Enclose headers with gasketed and bolted removable cover plates to provide access to tube internals from either one end or both ends of coil.

]2.2.6.4 Volatile Refrigerant Cooling

[For Type DX, provide counterflow type, designed for use with refrigerant specified, with equal length circuiting arrangement. Provide the number of distributors that suit indicated refrigerant and that eliminate trapping of refrigerant and oil. Obtain coil capacity with an expansion valve set for not less than 8 degrees F of superheat. Provide a refrigerant distributor that is furnished and installed by the coil manufacturer. Provide a tube outside diameter that is either 5/8-inch or 3/4-inch.

][Provide refrigerant distributor that is suitable for the thermostatic expansion valve recommended by the manufacturer for the service and capacity specified or indicated. Ensure arrangement is capable of stable operation down to 40 percent or less of design capacity.

][Provide refrigerant distributor suitable for use with a balanced, double-ported thermostatic expansion valve or with a pilot-operated valve

where indicated. Ensure arrangement is capable of stable operation down to 15 percent of design capacity.

]PART 3 EXECUTION

3.1 INSTALLATION

Install coils in accordance with the manufacturer's recommendations.

Submit installation drawings for coil systems. Indicate overall physical features, dimensions, ratings, service requirements, equipment weights and layout and arrangement details of equipment room on drawings.

3.2 FIELD QUALITY CONTROL

For drainable coils:

a. Field check coil pitch and leveling for drainability in the presence of the Contracting Officer.

b. Perform pressure tests and dehydrate coils.

c. Perform vacuum tests, purge with inert gas, and seal coils.

Provide final test reports to the Contracting Officer. Provide reports with a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

3.3 CLOSEOUT ACTIVITIES

3.3.1 Operation and Maintenance

Submit [6] [_____] copies of the operation and maintenance manuals 30 calendar days prior to testing the coil systems. Update and resubmit data for final approval no later than 30 calendar days prior to contract completion.

3.3.2 Record Drawings

Submit record drawings for coil systems providing current factual information including deviations from, and amendments to, the drawings and concealed and visible changes in the work.

-- End of Section --

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SECTION 25 05 11

CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS
05/21

PART 1 GENERAL

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

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

[1.1 CONTROL SYSTEM APPLICABILITY

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

]1.2 RELATED REQUIREMENTS

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

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

project.

1.3 REFERENCES

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

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

ASHRAE 135	(2020; Errata 2021) 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

INTERNET ENGINEERING TASK FORCE (IETF)

IETF RFC 2819	(2000) Remote Network Monitoring (RMON) Management Information Base (MIB)

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

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

U.S. DEPARTMENT OF DEFENSE (DOD)

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

1.4 DEFINITIONS

1.4.1 Administrator Account

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

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

1.4.2 Computer

A computer is one of the following:

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

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

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

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

e. a device running a version of Apple iOS

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

1.4.3 Controller

A device other than a computer or Ethernet switch.

1.4.4 Mission Space

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

1.4.5 Network

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

1.4.6 Network Connected

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

1.4.6.1 Wireless Network Connected

Any device that supports wireless network communication is network

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

1.4.7 Network Media

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

1.4.8 User Account Support Levels

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

1.4.8.1 FULLY Supported

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

1.4.8.2 MINIMALLY Supported

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

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

1.4.8.3 NOT Supported

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

1.4.9 Manual Local Input

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

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

1.4.10 Card Reader

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

1.4.11 User Interface

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

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

1.4.11.1 Local User Interface

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

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

1.4.11.2 Remote User Interface

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

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

1.4.11.3 Types of User Interface (by capability)

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

1.4.11.3.1 Read-Only User Interface

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

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

1.4.11.3.2 Limited User Interface

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

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

1.4.11.3.3 Full User Interface

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

1.4.11.3.4 View-Only User Interface

See Read-Only User Interface

1.4.11.4 Other User Interface Terminology

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

1.4.11.4.1 Writable User Interface

Any User Interface that is not Read-Only is Writable. (Limited User Interfaces and Full User Interfaces are both writable user interfaces (as

they are capable of changing a value)).

1.4.11.4.2 Privileged User Interface

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

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

b. Full User Interfaces are privileged user interfaces.

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

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

f. Writeable User Interfaces in Electronic Security Systems (ESS) are privileged user interfaces.

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

1.4.12 Wireless Network

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

1.4.13 Wired Broadcast Network

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

1.5 ADMINISTRATIVE REQUIREMENTS

1.5.1 Points of Contact

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

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

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

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

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

e. Mobile Code Point of Contact: [The Contracting Office Representative (COR)][_____][

f. PKI Infrastructure Point of Contact: [The Contracting Office Representative (COR)][_____]]

1.5.2 Coordination

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

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

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

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

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

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

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

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

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

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

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

1.6 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Codes of "RO" for Resident Office approval, "DO" for Engineering approval, and "AE" for Architect/Engineer approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Wireless and Wired Broadcast Communication Request; G, AEDevice Account Lock Exception Request; G, AE

Multiple Ethernet Connection Device Request; G, AE

Contractor Computer Cybersecurity Compliance Statements; G, AE

Contractor Temporary Network Cybersecurity Compliance Statements; G, AE

Cybersecurity Interconnection Schedule; G, AE

Protection of Information At Rest Proposal; G, AE

Proposed STIG and SRG Applicability Report; G, AE

SD-02 Shop Drawings

Network Communication Report; G, AE

Cybersecurity Riser Diagram; G, AE

SD-03 Product Data

Control System Cybersecurity Documentation; G, AE

SD-06 Test Reports

Wireless Communication Test Report; G, AE

Control System Cybersecurity Testing Procedures; G, AE

Control System Cybersecurity Testing Report; G, AE

SD-07 Certificates

Software Licenses; G, AE

SD-11 Closeout Submittals

[Confidential Password Report; G, AE

][Password Change Summary Report; G, AE

] Enclosure Keys; G, AE

Software and Configuration Backups; G, AE

Auditing Front End Software; G, AE

Device Audit Record Upload Software; G, AE

System Maintenance Tool Software; G, AE

Control System Scanning Tools; G, AE

STIG, SRG and Vendor Guide Compliance Result Report; G, AE

Control System Inventory Report; G, AE

Integrity Verification Software; G, AE

1.7 QUALITY CONTROL

[1.7.1 Regulatory Requirements

For the [_____] control system: [_____].

][1.7.2 [Certifications][Qualifications]

For the [_____] control system: [_____].

][1.7.3 Pre-Construction Testing

For the [_____] control system: [_____].

][1.8 DELIVERY, STORAGE, AND HANDLING

[_____]

]1.9 CYBERSECURITY DOCUMENTATION

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

1.9.1 Proposed STIG and SRG Applicability Report

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

[1.9.2 Cybersecurity Interconnection Schedule

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

Provide a completed Cybersecurity Interconnection Schedule documenting

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

In addition to the requirements of Section 01 33 00 SUBMITTAL PROCEDURES, provide the Cybersecurity Interconnection Schedule as an editable Microsoft Excel file (a template Cybersecurity Interconnection Schedule in Excel format is available at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1

]1.9.3 Network Communication Report

{For Government Reference Only: This subpart (and its subparts) relates to CA-9, PL-8; CCI-003075; CCI-002102, CCI-002103, CCI-002104, CCI-002105, CCI-003072, CCI-003073, CCI-003075 and also the submittal requirements associated with CM-6, CM-7, SC-8 and SC-41 including CM-7(3), CCI-000388.}

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

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

1.9.4 Control System Inventory Report

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

Provide a Control System Inventory report using the Inventory Spreadsheet listed under this Section at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1 documenting all [networked devices, including network infrastructure devices][devices, including networked devices, network infrastructure devices, non-networked devices, input devices (e.g. sensors) and output devices (e.g. actuators)]. For each device provide all applicable information for which there is a field on the spreadsheet in accordance with the instructions on the spreadsheet.

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

file.

1.9.5 Software and Configuration Backups

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

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

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

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

1.9.6 Cybersecurity Riser Diagram

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

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

1.9.7 STIG, SRG and Vendor Guide Compliance Result Report

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

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

1.9.8 Control System Cybersecurity Documentation

{For Government Reference Only: 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.

1.9.8.1 Software Applications

For all software applications running on computers provide:

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

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

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

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

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

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

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

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

1.9.8.2 For HVAC Control System Devices

1.9.8.2.1 HVAC Control System Devices FULLY Supporting User Accounts

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

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

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

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

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

e. Documentation that describes user-accessible security functions or

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

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

1.9.8.2.2 All Other HVAC Control System Devices

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

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

b. Documentation that describes effective use and maintenance of security functions or mechanisms for the device; or a specific indication that there are no security functions or mechanisms in the device {For Government Reference Only: relates to CCI-003127}

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

[1.9.8.3 [_____] Control System Devices

[_____]

]1.9.8.4 Default Requirements for Control System Devices

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

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

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

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

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

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

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

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

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

1.10 SOFTWARE LICENSING

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

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

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

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

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

1.11 CYBERSECURITY DURING CONSTRUCTION

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

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

1.11.1 Contractor Computer Equipment

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

1.11.1.1 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.

1.11.1.2 Anti-Malware Software

The computer must run anti-malware software from a reputable software manufacturer. Anti-malware software must be a version currently supported by the software manufacturer, must be current on all patches and updates,

and must use the latest definitions file. Computers used on this project must be scanned using the installed software at least once per day.

1.11.1.3 Passwords and Passphrases

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

1.11.1.4 User-Based Authentication

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

1.11.1.5 Demonstration of Compliance

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

1.11.1.6 Contractor Computer Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Computer Cybersecurity Compliance Statements for each company using contractor owned computers. Contractor Computer Cybersecurity Compliance Statements must use the template published at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1 Each Statement must be signed by a cybersecurity representative for the relevant company.

1.11.2 Temporary IP Networks

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

1.11.2.1 Network Boundaries and Connections

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

1.11.3 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.

1.11.4 Temporary Wireless IP Networks

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

be changed from their default values.

1.11.5 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.

1.11.6 Contractor Temporary Network Cybersecurity Compliance Statements

Provide a single submittal containing completed Contractor Temporary Network Cybersecurity Compliance Statements for each company implementing a temporary IP network. Contractor Temporary Network Cybersecurity Compliance Statements must use the template published at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1 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.

1.12 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

All products used on this project must meet the indicated requirements, but not all products specified here will be required by every project.

2.1 ETHERNET SWITCH

Provide Open Systems Interconnection (OSI) Layer 2 Ethernet switches with the following capabilities, and with an interface to support switch configuration for these capabilities:

2.1.1 Required Functionality

Switches must:

a. Copper Ethernet ports must auto negotiate for 10, 100 and 1000 megabits-per-second links.

b. Be capable of implementing port level access control by MAC address and limit the number of MAC addresses to one MAC address per port.

c. For MODERATE Impact Systems, be capable of implementing per-port access control lists (ACLs) where the list can be filtered by source and destination IP addresses, and by source and destination UDP or TCP ports.[

c. For LOW Impact Systems, be capable of implementing per-port access control lists (ACLs) where the list can be filtered by source and destination IP addresses, and by source and destination UDP or TCP ports.][

d. Support Remote Network Monitoring (RMON) Port Analysis in accordance with IETF RFC 2819][

e. Configure target port and analysis port such that switch clones all target port traffic to analysis port.][

f. Support authentication via RADIUS server (for management and 802.1x)][

g. Support IEEE 802.1x network login.]

2.1.2 Configuration Requirements

Switches must:

a. Support configuration save and restore.

b. Support both manual IP address assignment and acquisition of a dynamic IP address via Dynamic Host Configuration Protocol (DHCP).

c. Be capable of limiting access for configuration to one or more of: a web interface using HTTPS, a command line interface using SSH, or an SNMP connection using SNMP version 3 or later.[

d. Support the ability to lock configuration capability to a dedicated management port.]

2.2 DAISY CHAIN IP CONTROLLERS

Controllers used as Daisy Chain IP Controllers must be IP controllers with exactly two Ethernet network connections and basic built-in switch capabilities to allow implementation of an Ethernet network in a daisy chain architecture. Switches incorporated by Daisy Chain IP Controllers are not required to meet the requirements for Ethernet Switches as defined in this Section.

2.3 DATABASE AND WEB SERVER SOFTWARE FOR MODERATE IMPACT SYSTEMS

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

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

PART 3 EXECUTION

3.1 CYBERSECURITY HARDENING AND CONFIGURATION GUIDES

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

3.2 NETWORK REQUIREMENTS

3.2.1 Information Flow Enforcement In MODERATE Impact Systems

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

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

3.2.2 Wireless and Wired Broadcast Communication

{For Government Reference Only: This subpart (and its subparts) relates to AC-18, AC-18(3); CCI-001438, CCI-001439, CCI-002323, CCI-001441, CCI-002252}

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

3.2.2.1 Wireless and Wired Broadcast IP Communications

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

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

3.2.2.2 Non-IP Wireless Communication

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

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

3.2.2.3 Wireless and Wired Broadcast Communication Request

Provide a report documenting the proposed use of wireless or wired broadcast communication prior to device selection using the Wireless and Wired Broadcast Communication Request Schedule at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1 If there is no proposed use of wireless or wired broadcast communication, provide a document indicating this instead of the Request Schedule.

For each device proposed to use wireless or wired broadcast communication show: the device identifier, a description of the device, the location of the device, the device identifiers of other devices communicating with the device, the protocol used for communication, encryption type and

strength. For wireless communication, also show: RF Frequency, Radiated Power in dBm (decibel with a milliwatt reference), free-space range, and the expected as-installed range.

3.2.2.4 Wireless Communication Testing

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

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

3.2.3 Non-IP Control Networks

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

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

3.2.4 IP Control Networks

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

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

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

3.2.4.1 IP Network Routers

Do not install any device that performs IP routing.

3.2.4.2 IP Devices With Multiple Ethernet Connection

Except for Ethernet Switches and Daisy Chain IP Controllers, devices must not have more than one Ethernet connection to IP networks unless doing so is required by the project specifications and the specific application is

approved. If a device with Multiple Ethernet Connections to IP networks is required, provide a Multiple Ethernet Connection Device Request using the Multiple Ethernet Connection Device Request Template at https://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-25-05-1 to request approval for each device. If a device with Multiple Ethernet Connections to IP networks is not required, instead provide a document stating that no approval is being requested.

3.2.5 Cryptographic Protection

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

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

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

3.2.6 Device Identification and Authentication

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

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

3.2.6.1 For HVAC Control System Devices

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

[3.2.6.2 [_____] Control System Devices

[_____]

]3.2.6.3 Default Requirements for Control System Devices

For control system devices where Device Identification and Authentication requirements are not otherwise indicated in this Section: [Devices using Ethernet must support IEEE 802.1x.]Devices using HTTP as a control protocol must use HTTPS instead.

3.2.7 Cryptographic Module Authentication

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

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

3.3 ACCESS CONTROL REQUIREMENTS

3.3.1 User Accounts

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

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

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

3.3.1.1 Computers

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

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

3.3.1.2 Controllers

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

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

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

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

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

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

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

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

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

3.3.1.2.1 HVAC Control Systems

User Interface Requirements for LOW Impact HVAC Control Systems	
User Interface Type	**Access Control Requirement**
Local Read Only (see note 1)	None Required
Local Limited, Non-privileged	[None Required][MINIMALLY]
Local Limited, Privileged	[MINIMALLY][Physical Security]
Local Full	MINIMALLY
Remote Read Only	None Required
Remote Limited, Non-Privileged	MINIMALLY
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged	

User Interface Requirements for MODERATE Impact HVAC Control Systems	
User Interface Type	**Access Control Requirement** (See note 3)
Local Read Only (see note 1)	None Required
Local Limited, Non-privileged	[None Required][MINIMALLY]
Local Limited, Privileged	[MINIMALLY and Physical Security][FULLY]
Local Full	MINIMALLY and Physical Security
Remote Read Only	[None Required][MINIMALLY]
Remote Limited, Non-Privileged	FULLY
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged 3)Devices outside mission space require physical security protections as indicated (in "PHYSICAL SECURITY IN MODERATE IMPACT SYSTEMS")	

3.3.1.2.2 Electronic Security Systems (ESS)

User Interface Requirements for LOW Impact Electronic Security Systems	
User Interface Type	**Access Control Requirement**
Local Read Only (see note 1)	[KEY][MINIMALLY]
Local Limited, Non-privileged	NA
Local Limited, Privileged	[MINIMALLY and KEY][FULLY]
Local Full	FULLY and Physical Security
Remote Read Only	[None Required][MINIMALLY]
Remote Limited, Non-Privileged	NA
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY

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

User Interface Requirements for MODERATE Impact Electronic Security Systems	
User Interface Type	**Access Control Requirement** (See note 3)
Local Read Only (see note 1)	[KEY][MINIMALLY]
Local Limited, Non-privileged	NA
Local Limited, Privileged	FULLY
Local Full	FULLY and Physical Security
Remote Read Only	[None Required][MINIMALLY]
Remote Limited, Non-Privileged	NA
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged 3)Devices outside mission space require physical security protections as indicated (in "PHYSICAL SECURITY IN MODERATE IMPACT SYSTEMS")	

[3.3.1.2.3 [_____] Control Systems

User Interface Requirements for LOW Impact [_____] Systems	
User Interface Type	**Access Control Requirement**
Local Read Only (see note 1)	[_____]
Local Limited, Non-privileged	[_____]
Local Limited, Privileged	[_____]
Local Full	[_____]
Remote Read Only	[_____]
Remote Limited, Non-Privileged	[_____]

User Interface Requirements for LOW Impact [_____] Systems	
User Interface Type	**Access Control Requirement**
Remote Limited, Privileged AND Remote Full (see note 2)	[_____]
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged	

User Interface Requirements for MODERATE Impact [_____] Systems	
User Interface Type	**Access Control Requirement** (See note 3)
Local Read Only	[_____]
Local Limited, Non-privileged	[_____]
Local Limited, Privileged	[_____]
Local Full	[_____]
Remote Read Only	[_____]
Remote Limited, Non-Privileged	[_____]
Remote Limited, Privileged AND Remote Full (see note 2)	[_____]
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged 3)Devices outside mission space require physical security protections as indicated (in "PHYSICAL SECURITY IN MODERATE IMPACT SYSTEMS")	

]3.3.1.2.4 Default Requirements for Other Control Systems

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

Default User Interface Requirements for LOW Impact Control Systems	
User Interface Type	**Access Control Requirement**
Local Read Only (see note 1)	[None Required][MINIMALLY]

Default User Interface Requirements for LOW Impact Control Systems	
User Interface Type	**Access Control Requirement**
Local Limited, Non-privileged	[None Required][MINIMALLY]
Local Limited, Privileged	[MINIMALLY][Physical Security]
Local Full	[MINIMALLY][FULLY]
Remote Read Only	[None Required][MINIMALLY]
Remote Limited, Non-Privileged	MINIMALLY
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged	

Default User Interface Requirements for MODERATE Impact Control Systems	
User Interface Type	**Access Control Requirement** (See note 3)
Local Read Only (see note 1)	[None Required][MINIMALLY]
Local Limited, Non-privileged	[None Required][MINIMALLY]
Local Limited, Privileged	[MINIMALLY and Physical Security][FULLY]
Local Full	[MINIMALLY and Physical Security][FULLY]
Remote Read Only	[None Required][MINIMALLY]
Remote Limited, Non-Privileged	FULLY
Remote Limited, Privileged AND Remote Full (see note 2)	FULLY
Notes: 1)Local Read Only User Interfaces are always Non-Privileged 2)Remote Full User Interfaces are always Privileged 3)Devices outside mission space require physical security protections as indicated (in "PHYSICAL SECURITY IN MODERATE IMPACT SYSTEMS")	

3.3.1.3 Additional User Account Expiration Requirements In MODERATE Impact Systems:

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

3.3.1.3.1 For Control System Applications Running on Computers

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

3.3.1.3.2 For Other Control System Devices FULLY Supporting Accounts

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

3.3.2 Unsuccessful Logon Attempts

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

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

3.3.2.1 Devices MINIMALLY Supporting Accounts

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

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

3.3.2.2 Devices FULLY Supporting Accounts

Devices which FULLY support accounts must meet the following requirements.

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

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

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

3.3.2.3 High Availability Interfaces Exempt from Unsuccessful Logon Attempts Requirements

[There are no high availability interfaces which are exempt from unsuccessful logon attempts requirements.][The following high availability interfaces are exempt from unsuccessful logon attempts requirements:

High Availability Interfaces Exempt from Unsuccessful Logon Attempts Requirements		
User Interface	**Location**	**Action to take in lieu of locking screen**
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]

]

3.3.3 System Use Notification

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

3.3.3.1 System Use Notification for Remote User Interfaces

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

3.3.3.2 System Use Notification for Local User Interfaces

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

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

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

{For Government Reference Only: This subpart (and its subparts) relates to AC-11(a), AC-11(b), AC-11(1), AC-12, SC-10; AC-10; CCI-000058, CCI-000059, CCI-000056, CCI-000057, CCI-000060, CCI-002360, CCI-002361, CCI-001133, CCI-001134, CCI-000054, CCI-000055, CCI-002252}

3.3.4.1 Session Termination

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

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

3.3.4.2 Session Lock

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

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

3.3.4.3 Session Lock and Termination for Computers

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

[Except as shown in the Session Lock and Session Termination Exception Table,]Other User Interface sessions running on computers (for local user interfaces) or hosted on a computer (for remote user interfaces) and supporting accounts must support user initiation of Session Termination[and session lock. Session lock may be initiated by user initiation or automatically after [15][___] minutes of inactivity]. In addition, remote User Interface sessions must also initiate Session Termination after [30][_____] minutes of inactivity [unless otherwise indicated in the Session Lock and Termination Exceptions table].

3.3.4.4 Session Lock and Termination for Controllers

[Except as shown in the Session Lock and Session Termination Exception Table,]Writable Remote User Interfaces must support requirements for Session Termination, and must both be capable of being initiated by the user and initiated by lack of activity. Session Termination must initiate after [30][___] minutes of inactivity.

[Except as shown in the Session Lock and Session Termination Exception Table,]Local User Interfaces supporting accounts must support manual initiation of Session Termination. Privileged Local User Interfaces must

also support timed initiation of Session Termination[, unless otherwise indicated in the Session Lock and Termination Exceptions table], with Session Termination initiated at [30][___] minutes of inactivity.[They must also support session lock, where session lock may be initiated by user initiation or automatically after [15][___] minutes of inactivity.]

[3.3.4.5 Session Lock and Termination Exceptions

Table: Session Lock and Termination Exceptions

Device	**Location**	**Session Lock and Termination Requirements for Device (or "none" to indicate session lock or session termination is not required)**
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]

]3.3.5 Permitted Actions Without Identification or Authentication

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

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

3.3.6 Pysical Security in MODERATE Impact Systems

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

3.3.6.1 Physical Security for Media

3.3.6.1.1 Physical Security for Media Inside Mission Space

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

3.3.6.1.2 Physical Security for Media Outside Mission Space

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

3.3.6.2 Physical Security for Devices

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

Install all controllers connected to an IP network in lockable enclosures

(both inside and outside of mission space).

3.3.6.3 Physical Security for User Interfaces

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

[3.3.6.4 Additional Physical Security for Confidentiality of User Interfaces and Printers

For each user interface or printer indicated in the "User Interfaces and Printers Requiring Additional Security Controls" table, implement the additional confidentiality controls indicated.

User Interfaces and Printers Requiring Additional Security Controls		
User Interface or Printer	Location	Additional Confidentially Control to be Implemented
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]
[_____]	[_____]	[_____]

]3.3.7 Enclosures

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

3.4 USER IDENTIFICATION AND AUTHENTICATION

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

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

3.4.1 User Identification and Authentication for All System Types

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

[For LOW Impact Systems: User interfaces provided by computer operating systems must implement multifactor authentication via PIV.]

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

3.4.2 User Identification and Authentication for Specific System Types

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

3.4.2.1 HVAC Control Systems Devices

[No additional system specific requirements apply.][User Interfaces which FULLY support accounts and which run on a computer must use multifactor authentication via PIV.]

3.4.2.2 Electronic Security System Devices

User interfaces which FULLY support accounts and which run on a computer must use multifactor authentication via PIV.[Other user interfaces which FULLY support accounts must use multifactor authentication via PIV.][User interfaces which MINIMALLY support accounts must use either passwords or multifactor authentication via PIV.]

[3.4.2.3 [_____] Control System Devices

[_____]

]3.4.3 User Identification and Authentication for Specific Devices

[There are no additional device specific user interface requirements][Additional user identification and authentication requirements are defined in the TABLE.

TABLE: Additional Device Specific User Identification and Authentication Requirements	
User Interface Device or Description	**Identification and Authorization Requirements**
[_____]	[_____]
[_____]	[_____]
[_____]	[_____]
[_____]	[_____]

]
[3.4.3.1 [_____]

[_____]

]

3.4.4 Implementation of Identification and Authorization Requirements

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

a. Direct implementation in the user interface.

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

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

3.4.5 Password-Based Authentication Requirements

3.4.5.1 Passwords for Software and Applications Running on Computers

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

a. Minimum password length of 12 characters

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

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

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

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

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

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

3.4.5.2 Passwords for Controllers FULLY Supporting Accounts

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

a. Minimum password length of twelve (12) characters

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

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

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

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

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

3.4.5.3 Passwords for Remote Interfaces

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

a. Minimum password length of twelve (12) characters

b. Password must contain at least one uppercase character.

c. Password must contain at least one lowercase character.

d. Password must contain at least one numeric character.

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

f. Password must have a maximum lifetime of 60 days. When passwords

expire, prompt users to change passwords. Do not lock accounts due to expired passwords.

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

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

3.4.5.4 Passwords for Devices Minimally Supporting Accounts

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

3.4.5.5 Password Configuration and Reporting

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

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

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

3.4.6 Authenticator Feedback

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

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

[3.4.7 Implementation of PKI Infrastructure in MODERATE Impact Systems

Coordinate with the PKI Infrastructure Point of Contact to configure the system to implement PKI such that the system validates certifications by constructing and verifying a certification path to an accepted trust anchor including checking certificate status information; the system

enforces authorized access to the corresponding private key; the system maps the authenticated identity to the account of the individual or group; and the system implements a local cache of revocation data to support path discovery and validation in case of inability to access revocation information via the network.

]3.5 CYBERSECURITY AUDITING

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

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

{For Government Reference Only: This subpart (and its subparts) relates to AU-2(a), AU-2(c), AU-2(d), AU-3, AU-10, AU-12, AU-13(3), AU-14(b), AU-14(1), AU-14(2), AU-14(3), CM-5(1), SC-7 (9); CCI-000123, CCI-001571, CCI-000125, CCI-001485, CCI-000130, CCI-000131, CCI-000132, CCI-00133, CCI-000134, CCI-001487, CCI-000166, CCI-001899, CCI-000169, CCI-001459, CCI-000171, CCI-000172, CCI-001910, CCI-001914, CCI-001919, CCI-001464, CCI-001462, CCI-001920, CCI-001814, CCI-002400. For MODERATE Impact systems, this subpart (and its subparts) also relates to AU-3 (1); CCI-000135, CCI-001488}

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

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

3.5.1.1 Computers

For each computer, provide the capability to select audited events and the content of audit logs. Configure computers to audit the indicated events, and to record the indicated information for each auditable event

3.5.1.1.1 Audited Events

Configure each computer to audit the following events:

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

b. Successful and unsuccessful logon attempts

c. Successful logouts

d. Privileged activities or other system level access

e. Concurrent logons from different workstations

f. Successful and unsuccessful accesses to objects

g. All program initiations

h. All direct access to the information system

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

j. All kernel module load, unload, and restart

3.5.1.1.2 Audit Event Information To Record

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

a. What type of event occurred

b. When the event occurred

c. Where the event occurred

d. The source of the event

e. The outcome of the event

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

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

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

3.5.1.2 For HVAC Control System Controllers

3.5.1.2.1 HVAC Control System Controllers FULLY Supporting User Accounts

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

3.5.1.2.1.1 Audited Events

Configure each controller to audit the following events:

a. Successful and unsuccessful logon attempts to the controller

b. Successful logouts

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

d. All controller shutdown and startup

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

commands.

3.5.1.2.1.2 Audit Event Information To Record

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

a. what type of event occurred

b. when the event occurred

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

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

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

3.5.1.2.2 Other HVAC Control System Controllers

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

[3.5.1.3 [_____] Control System Controllers

[_____]

]3.5.1.4 Default Requirements for Control System Controllers

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

3.5.1.4.1 Controllers Which FULLY Support Accounts

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

3.5.1.4.1.1 Audited Events

Configure each controller to audit the following events:

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

b. Successful and unsuccessful logon attempts

c. Successful logouts

d. Concurrent logons from different workstations

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

f. All kernel module load, unload, and restart

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

3.5.1.4.1.2 Audit Event Information To Record

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

a. what type of event occurred

b. when the event occurred

c. where the event occurred

d. the source of the event

e. the outcome of the event

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

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

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

3.5.1.4.2 Controllers Which Do Not FULLY Support Accounts

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

3.5.2 Audit Time Stamps

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

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

3.5.3 Auditing Front End Software

The project site currently has the following software to support control system auditing: [none][_____]. If there is no existing auditing front end software or the software is not compatible with the provided control systems, provide Auditing Front End Software with audit log import and upload, export, notification, and analysis functionality. The Auditing Front End Software may be provided as a component of the control system front end or as a separate software package, and a single package may

serve multiple control systems provided under the same projects if they are sharing a cybersecurity authorization.

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

3.5.3.1 Import and Upload Requirements

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

3.5.3.2 Export Requirements

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

3.5.3.3 Notification Of Audit Failure in Devices in MODERATE Impact Systems

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

3.5.3.4 Audit Reduction and Report Generation In MODERATE Impact Systems

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

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

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

3.5.4 Audit Storage Capacity and Audit Upload

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

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

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

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

c. For computers, provide storage for at least [_____] audit records.]

3.5.4.1 Audit Log Storage Notification In MODERATE Impact Systems

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

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

3.5.4.2 Device Audit Record Upload Software

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

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

3.5.5 Response to Audit Processing Failures

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

In the case of a failure in the auditing system, computers associated with auditing must provide email notification[and must [_____]]. For MODERATE Impact systems, the computer must also notify the associated auditing front end software. In case of an audit failure, if possible, continue to collect audit records by [overwriting existing audit records][_____].

For MODERATE Impact Systems: In the case of an audit failure at a controller performing auditing, the device must notify the associated auditing front end software of the audit failure if able, and must continue to collect audit records by [overwriting existing audit

records][_____] if able. The auditing front end software must provide notification as indicated, treating the notification of failure from the device as a failure in the auditing system.

3.6 REQUIREMENTS FOR LEAST FUNCTIONALITY

{For Government Reference Only: This subpart (and its subparts), along with the network communication report submittal specified elsewhere in this section, relates to CM-6(a), CM-6(c), CM-7, CM-7(1)(b), SC-41; CCI-000363, CCI-000364, CCI-000365, CCI-001588, CCI-001755, CCI-000381, CCI-000380, CCI-00382, CCI-001761, CCI-001762, CCI-002544, CCI-002545, CCI-002546. For MODERATE Impact systems, this subpart (and its subparts) also relates to CM-7(2), CM-7(5)(a), CM-7(5)(b); CCI-000381, CCI-000380, CCI-00382, CCI-001761, CCI-001762}

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

3.6.1 Device Capabilities

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

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

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

Unless specifically required by the government, do not provide a capability to update device firmware over the network.

3.6.2 Software

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

For MODERATE Impact Systems: Do not provide (install) software that is not specifically required to meet a contract requirement. Do not implement functionality within software
that is not specifically required to meet contract requirements.

3.7 SYSTEM AND COMMUNICATION PROTECTION

3.7.1 Collaborative Computing

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

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

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

{For Government Reference Only: This subpart relates to SC-5, SC-39, SC-7(a); CCI-001093, CCI-002385, CCI-002386, CCI-002430, CCI-001097. For MODERATE Impact systems, this subpart also relates to SC-2; CCI-001082.}

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

3.7.2.1 Network Reliance in MODERATE Impact HVAC Control Systems

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

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

[3.7.2.2 Network Reliance in MODERATE Impact [_____] Control Systems

[_____]

]3.7.2.3 Default Requirements for MODERATE Impact Control Systems

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

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

3.7.3 Mobile Code In MODERATE Impact Systems:

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

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

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

3.7.4 Protection of Information at Rest In MODERATE Impact Systems:

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

Computers must protect information at rest in accordance with applicable STIGs.

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

3.8 SAFE MODE AND FAIL SAFE OPERATION

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

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

3.9 SYSTEM MAINTENANCE TOOL SOFTWARE

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

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

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

3.10 DEVICE POWER

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

For LOW Impact Systems: [Provide emergency power in accordance with the control system and equipment specification Sections, [_____]]

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

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

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

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

3.11 VULNERABILITY SCANNING

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

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

3.11.1 Computers and Software Running on Computers

Computers and applications running on computers must meet relevant

vulnerability scanning STIGs/SRGs and respond to approved DoD vulnerability scanning tools.

3.11.2 Controllers

Controllers shall be scannable by standard control system discovery tools or control system browsers and return meaningful status information including the network inputs and outputs for the controller. This information shall contain sufficient detail to detect vulnerabilities or exploits of the controller.

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

3.12 FIPS 201-2 REQUIREMENT

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

Devices in the following systems which implement PIV must be on the NIST FIPS 201-2 approved product list (https://www.idmanagement.gov/approved-products-list/): [NONE][electronic security systems(ESS)][_____].

3.13 SYSTEM AND INTEGRATION INTEGRITY

3.13.1 Malicious Code Protection

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

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

a. [Provide malware protection software licenses.][Malware protection software licenses will be Government furnished.]

b. [Provide malware protection software media.][Malware protection software media will be Government furnished.]

c. [Install and configure malware protection software in accordance with the relevant STIGs.][Malware protection software will be Government installed.]

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

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

[3.13.3 Information System Monitoring

{For Government Reference Only: This subpart relates to SI-4 (a),(b); CCI-001253, CCI-002645}

[_____]

]3.14 CONTROL SYSTEM CYBERSECURITY TESTING

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

3.14.1 Control System Cybersecurity Testing Procedures

Prepare Control System Cybersecurity Testing Procedures explaining step-by-step, the actions and expected results that will demonstrate that the control system meets the requirements of this Section.

Submit [4] [_____] copies of the Control System Cybersecurity Testing Procedures. The Control System Cybersecurity Testing Procedures may be submitted as a Technical Data Package.

3.14.2 Control System Cybersecurity Testing Execution

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

3.14.3 Control System Cybersecurity Testing Report

Prepare and submit a Control System Cybersecurity Testing Report documenting all tests performed and their results. Include all tests in the Control System Cybersecurity Testing Procedures and any additional tests performed during testing. Document test failures and repairs conducted with the test results.

Submit [four][_____] copies of the Control System Cybersecurity Testing Report. The Control System Cybersecurity Testing Report may be submitted as a Technical Data Package.

3.15 FIELD QUALITY CONTROL, CYBERSECURITY VALIDATION SUPPORT

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

3.16 CYBERSECURITY TRAINING

Provide [eight][__] hours of classroom[and hands-on] training for [six][__] Government personnel on the cybersecurity operation and maintenance of the control system provided. This training is in addition

to and must be coordinated with control system training specified in other Sections.

The Government will provide the training location. Training must cover, at a minimum: (a) applying software and firmware updates, (b) user account creation, modification and deletion, (c) audit log upload procedures and (d) identification of privileged user interfaces and system impact of those interfaces. Training session must include a question and answer period during which government staff questions about cybersecurity aspects of the control system are answered. [See SECTION 01 11 01.00 28 SUPPLEMENTARY REQUIREMENTS for additional training requirements.]

-- End of Section --

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SECTION 26 05 00.00 40

COMMON WORK RESULTS FOR ELECTRICAL
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PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

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 D709	(2017) Standard Specification for Laminated Thermosetting Materials

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 480	(1981) Toggle Switches

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

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

INTERNATIONAL CODE COUNCIL (ICC)

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

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.7	(2014) Requirements for Watthour Meter Sockets
ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2020) American National Standard for Electrical Metallic Tubing (EMT)
ANSI Z535.1	(2017) Safety Colors
ANSI/NEMA OS 1	(2013; R 2020) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA PB 1	(2011) Panelboards
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices
NEMA WD 6	(2016) Wiring Devices Dimensions 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 70E	(2021) Standard for Electrical Safety in the Workplace

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 20	(2018; Reprint Jan 2021) UL Standard for Safety General-Use Snap Switches
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 Aug 2021) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 486A-486B	(2018; Reprint May 2021) UL Standard for Safety Wire Connectors
UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint Feb 2021) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017) UL Standard for Safety Specialty Transformers

UL 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 2021) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 870	(2016; Reprint Mar 2019) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1242	(2006; Reprint Aug 2020) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 4248-1	(2017) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2018) UL Standard for Safety Fuseholders - Part 12: Class R

1.2 DEFINITIONS

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

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

c. Vertical assembly: A vertical assembly is a pole, tower or other such support, mounting hardware, arms, brackets and the load. Load can be

a luminaire, siren, loudspeaker or other device. All components of a vertical assembly will be rated by the manufacturer to withstand 150 mph wind loading in accordance with ASCE 7-16.

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 information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Marking Strips; G

SD-03 Product Data

Conduits and Raceways; G

Wire and Cable; G

Splices and Connectors; G

Switches; G

Receptacles; G

Outlet Boxes, Pull Boxes and Junction Boxes; G

Circuit Breakers; G

Panelboards; G

Dry-Type Distribution Transformers; G

Device Plates; G

SD-06 Test Reports

Continuity Test; G

Phase-Rotation Tests; G

Insulation Resistance Test; G

600-Volt Wiring Test; G

Transformer Tests; G

Ground-Fault Receptacle Test; G

Insulation-Resistance Test; G

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.4.2 Standard Products

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

PART 2 PRODUCTS

2.1 EQUIPMENT

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

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

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

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

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

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

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

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

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

2.1.1 Conduits and Raceways

2.1.1.1 Rigid Steel Conduit

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

Use threaded fittings for rigid steel conduit.

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

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

2.1.1.2 Electrical Metallic Tubing (EMT)

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

2.1.1.3 Flexible Metallic Conduit

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

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

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

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

2.1.1.4 Intermediate Metal Conduit

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

2.1.1.5 Rigid Nonmetallic Conduit

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

2.1.1.6 Surface Metal Raceway

Ensure surface metal raceways and multi-outlet assemblies conform to NFPA 70, and have receptacles conforming to NEMA WD 1, Type 5-20R.

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.

2.1.1.7 Surface Nonmetallic Raceway

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

2.1.2 Wireways

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

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

2.1.3 Outlet Boxes, Pull Boxes and Junction Boxes

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

2.1.4 Panelboards

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

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

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

Provide copper buses of the rating indicated, with main lugs or main circuit breaker. Provide all panelboards for use on grounded ac systems

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

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

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping.

2.1.4.1 Circuit Breakers

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

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

Provide inverse-time-delay thermal-overload protection and instantaneous magnetic short-circuit protection. Provide an instantaneous thermal-magnetic tripping element that is adjustable and accessible from the front of the breaker on frame sizes larger than 100 ampere.

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

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

Provide a phenolic-composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required to meet lock-out/tag-out requirements of NFPA 70E.

2.1.5 Dry-Type Distribution Transformers

2.1.5.1 General Requirements

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

Provide transformers in NEMA 3R enclosure.

Transformer insulation system:

a. 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 150 degrees C under full-rated load in maximum ambient of 40 degrees C.

b. 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 150 degrees C under full-rated load in maximum ambient of 40 degrees C.

2.1.5.2 Transformer Factory Tests

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

2.2 MATERIALS

2.2.1 Wire And Cable

Provide wires and cables in accordance applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 12 months prior to date of delivery to site.

Provide minimum conductor size in accordance with the following:

a. Branch circuits: No. 12 AWG.

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

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

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

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

Ensure conductors installed in plenums are marked plenum rated.

2.2.1.1 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts, Type THWN/THHN conforming to UL 83, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83.

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

2.2.2 Device Plates

Provide the following:

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

b. For metal outlet boxes, plates on unfinished walls: zinc-coated sheet steel or cast metal having round or beveled edges.

c. For nonmetallic boxes and fittings, other suitable plates may be provided.

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

e. Plates on finished walls: satin finish stainless steel or brushed-finish aluminum, minimum 0.03 inch thick.

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

g. Sectional type device plates are not be permitted.

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

2.2.3 Switches

2.2.3.1 Safety Switches

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

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

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

2.2.3.2 Toggle Switches

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

Provide commercial grade toggle switches, single -pole, three -way two-position devices rated 20 amperes at 120/277 volts, 60 hertz

alternating current (ac) only.

Ensure all toggle switches are products of the same manufacturer.

2.2.4 Fuses

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

2.2.4.1 Fuseholders

Provide in accordance with UL 4248-1.

2.2.4.2 Cartridge, Current Limiting Type (Class R)

UL 198M, Class RK-1. Provide only Class R associated fuseholders in accordance with UL 4248-12.

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

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

2.2.4.4 Cartridge Fuses, Current Limiting Type (Class T)

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

2.2.5 Receptacles

Provide the following:

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

b. Ratings and configurations: as indicated.

c. Bodies: white as per NEMA WD 1.

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

e. Dimensional requirements: per NEMA WD 6.

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

g. Grounding pole connected to mounting strap.

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

2.2.5.1 Switched Duplex Receptacles

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

2.2.5.2 Weatherproof Receptacles

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

2.2.5.3 Ground-Fault Circuit Interrupter Receptacles

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

2.2.5.4 Special Purpose Receptacles

Receptacles serving [_____] are special purpose.[Provide in ratings indicated.][NEMA [_____] configuration, rated [_____] amperes, [_____] volts.][Furnish one matching plug with each receptacle.]

2.2.5.5 Plugs

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

2.2.5.6 Tamper-Resistant Receptacles

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

2.2.6 Manufacturer's Nameplate

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

2.2.7 Warning Signs

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. Enclosure integrity to conform with [IEEE C57.12.28][IEEE C57.12.29], such as for pad-mounted transformers. Provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Provide decal signs with nominal dimensions of 7 by 10 inches. Print the legend "DANGER HIGH VOLTAGE" in two lines of nominal 2 inch high letters. Show the word "DANGER" in white letters on a red background and the words "HIGH VOLTAGE" in black letters on a white background. Use Panduit decal No. PPSO710D72 or approved equal.

2.2.8 Firestopping Materials

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

2.2.9 Metering

ANSI C12.1. Provide a self-contained, socket-mounted, electronic programmable outdoor watthour meter. Meter: either programmed at the factory or programmed in the field. Turn field programming device over to the Contracting Officer at completion of project. Coordinate meter to system requirements.

a. Design: Provide watthour meter designed for use on a single-phase, three-wire, 240/120 volt system. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS).

b. Class: 200; Form: 2S, accuracy: plus or minus 1.0 percent; Finish: Class II.

c. Cover: Polycarbonate and lockable to prevent tampering and unauthorized removal.

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

e. Demand Register:

(1) Provide solid state.

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

(3) Demand interval length: programmed for 15 minutes with rolling demand up to six subintervals per interval.

f. Socket: ANSI C12.7. Provide NEMA Type 3R, box-mounted socket, ringless, having jaws compatible with requirements of the meter. Provide manufacturers standard enclosure color unless otherwise indicated.

2.2.10 Surge Protective Devices

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

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Phase to phase (L-L)
Each phase to neutral (L-N)
[Neutral to ground (N-G)]
[Phase to ground (L-G)]

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

] SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G)[and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G)].

[Provide SPDs per NFPA 780 for the lightning protection system.

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

[600V for 120V, single phase system]
[600V for 120/240V, single phase system]
[600V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

Maximum L-L Voltage Protection Rating:

[1,200V for 120V, single phase system]
[1,200V for 120/240V, single phase system]
[1,200V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

][Provide SPDs. Maximum L-N, L-G, and N-G Voltage Protection Rating:

[700V for 120V, single phase system]
[700V for 120/240V, single phase system]
[700V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

Maximum L-L Voltage Protection Rating:

[1,200V for 120V, single phase system]
[1,200V for 120/240V, single phase system]
[1,200V for 208Y/120V, three phase system]
[2,000V for 480Y/277V, three phase system]

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

[Provide EMI/RFI filtering per UL 1283 for each mode with the capability to attenuate high frequency noise. Minimum attenuation: 20db.

]PART 3 EXECUTION

3.1 PREPARATION

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

Clean and paint conduit, supports, fittings, cabinets, pull boxes, and racks as specified in [Section 09 90 00 PAINTS AND COATINGS][Section 09 96 00 HIGH-PERFORMANCE COATINGS].

Protect metallic materials against corrosion. Provide equipment enclosures with the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical and abrasive action), and all outdoor installations, refer to Section [09 96 00 HIGH-PERFORMANCE COATINGS][09 90 00 PAINTS AND COATINGS]. Do not use aluminum when in contact with earth or concrete and, where connected to dissimilar metal, protect by using approved fittings and treatment. Except where other equivalent protective treatment is specifically approved in writing, provide hot-dip galvanized ferrous metals for items such as, anchors, bolts, braces, boxes, bodies,

clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous items not made of corrosion-resistant steel.

3.2 INSTALLATION

3.2.1 Underground Service

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

3.2.2 Overhead Service

Overhead service conductors into buildings: terminate at service entrance fittings or weatherhead outside building. Overhead service conductors and support bracket for overhead conductors are included in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

3.2.3 Hazardous Locations

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

3.2.4 Service Entrance Identification

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

3.2.5 Labels

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

3.2.6 Wiring Methods

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

3.2.6.1 Pull Wire

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

[3.2.6.2 Metal Clad Cable

Install in accordance with NFPA 70, Type MC cable.

][3.2.6.3 Armored Cable

Install in accordance with NFPA 70, Type AC cable.

][3.2.6.4 Mineral Insulated, Metal Sheathed (Type MI) Cable Installation

Mineral-insulated, metal-sheathed cable system, Type MI, may be used in lieu of exposed conduit and wiring. Conductor sizes: not less than those indicated for the conduit installation. Fasten cables within 12 inches of each turn or offset and at 33 inches maximum intervals. Make cable terminations in accordance with NFPA 70 and cable manufacturer's recommendations. Terminate single-conductor cables of a circuit, having capacities of more than 50 amperes, in a single box or cabinet opening. Color code individual conductors in all outlets and cabinets.

]3.2.7 Conduits, Raceways and Fittings

Ensure that conduit runs between outlet and outlet, between fitting and fitting, or between outlet and fitting does not contain more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting.

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

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

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

]3.2.7.1 Rigid Steel Conduit

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

Provide a flush coupling for all conduit stubbed-up through concrete floors for connections to free-standing equipment with the exception of motor-control centers, cubicles, and other such items of equipment, when

the floor slab is of sufficient thickness. Otherwise, provide a floor box set flush with the finished floor. For conduits installed for future use, terminate with a coupling and plug; set flush with the floor.

3.2.7.2 Electrical Metallic Tubing (EMT)

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

3.2.7.3 Flexible Metallic Conduit

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

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

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

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

Provide flexible steel conduit between 3 and 6 feet in length for recessed and semirecessed lighting fixtures[; for equipment subject to vibration, noise transmission, or movement; and for motors]. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: 1/2 inch diameter. Provide liquidtight flexible[nonmetallic] conduit in wet and damp locations[and in fire pump rooms] for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.2.7.4 Intermediate Conduit

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

3.2.7.5 Rigid Nonmetallic Conduit

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

3.2.7.6 Underground Conduit

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

3.2.7.7 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.2.7.8 Conduit Installed Under Floor Slabs

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

barrier.

3.2.7.9 Conduit Installed Through Floor Slabs

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

3.2.7.10 Conduit Installed in Concrete Floor Slabs

[Rigid steel; steel IMC; fiberglass, or PVC, Type EPC-40.][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.][Do not stack conduits more than two diameters high with minimum vertical separation of [_____] inches.] Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends must not be visible above finish slab. Increase slab thickness as necessary to provide minimum one inch cover over conduit. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings must allow horizontal and vertical movement of raceway. Conduit larger than one inch trade size: installed parallel with or at right angles to main reinforcement; when at right angles to reinforcement, install conduit close to one of supports of slab.[Where nonmetallic conduit is used, convert raceway to plastic coated rigid steel or plastic coated steel IMC before rising above floor, unless specifically indicated.]

3.2.7.11 Stub Ups

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

3.2.7.12 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners. Provide vibration resistant and shock-resistant fasteners attached to concrete ceiling. Do not cut main reinforcing bars for any holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems: supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Do not share supporting means between electrical raceways and mechanical piping or ducts. Coordinate installation with above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations.[Support exposed risers in wire shafts of

multistory buildings by U-clamp hangers at each floor level and at 10 foot maximum intervals.] Where conduit crosses building expansion joints, provide suitable[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.

3.2.7.13 Directional Changes in Conduit Runs

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

3.2.7.14 Wireway and Auxiliary Gutter

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

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

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

3.2.7.15 Surface Raceways and Assemblies

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

3.2.7.16 Cable Trays

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

3.2.8 Wiring

Color code feeder and branch circuit conductors as follows:

CONDUCTOR	COLOR AC
Phase A	Black (208VAC); Brown (480VAC)
Phase B	Red (208VAC); Orange (480VAC)

CONDUCTOR	COLOR AC
Phase C	Blue (208VAC); Yellow (480VAC)
Neutral	White (208VAC); Natural Gray (480VAC)
Equipment Grounds	[Green] [Green with Yellow Stripe] [Bare]

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

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

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

3.2.9 Wiring Devices

3.2.9.1 Wall Switches and Receptacles

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

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

3.2.9.2 Device Plates

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

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

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

3.2.10 Splices and Connectors

Make all splices in AWG No. 8 and smaller with approved [insulated electrical type] [indentor crimp-type connectors and compression tools].

Make all splices in AWG No. 6 and larger with [indentor crimp-type connectors and compression tools][insulated electrical lugs type] . Wrap joints with an insulating tape that has an insulation and temperature rating equivalent to that of the conductor.

3.2.11 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 [_____], [_____]][Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][manufacturer's recommendations].[Provide telecommunications system conductor identification as specified in Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEMS.]

3.2.11.1 Marking Strips

Provide marking strips in accordance with the following:

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

b. Use permanent ink for the wire numbers

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

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

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

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

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

3.2.12 Safety Switches

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

3.2.13 Boxes and Fittings

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

convenient intermediate location.

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

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

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

3.2.14 Covers and Device Plates

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

3.2.15 Electrical Penetrations

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

3.2.16 Panelboards

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

3.2.17 Dry-Type Distribution Transformers

Connect dry-type transformers with flexible metallic conduit.

[Mount all dry-type transformers on vibration isolators in accordance with Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

]3.2.18 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet.

3.2.19 Field Fabricated Nameplates

Ensure nameplates conform to ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device, as specified or as indicated on the drawings. Each nameplate inscription identifies the function and, when applicable, the position. Provide nameplates that are melamine plastic, 0.125-inch thick, white with [black] [_____] center core and a matte finish surface [with square corners]. Accurately align lettering and engrave into the core. Minimum size of nameplates is 1 by 2.5 inches. Lettering is a minimum of 0.25-inch high normal block style.

3.2.20 Identification Plates and Warnings

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

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

3.3 FIELD FABRICATED NAMEPLATE MOUNTING

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

3.4 WARNING SIGN MOUNTING

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

3.5 FIELD APPLIED MOUNTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. [Painting: as specified in Section 09 90 00 PAINTS AND COATINGS.][Where field painting of enclosures for panelboards, load centers or the like is specified to match adjacent surfaces, to correct damage to the manufacturer's factory applied coatings, or to meet the indicated or specified safety criteria, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions.]

3.6 FIELD QUALITY CONTROL

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

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

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

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

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

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

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

Perform 600-volt wiring test on wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance: 250,000 ohms.

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

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

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

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

-- End of Section --

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SECTION 26 05 19.10 10

INSULATED WIRE AND CABLE
05/16

PART 1 GENERAL

1.1 REFERENCES

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1202	(2006; R 2012; CORR 1 2012) Flame-Propagation Testing of Wire and Cable

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-58-679	(2014) Control, Instrumentation and Thermocouple Extension Conductor Identification
ICEA T-30-520	(1986) Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input Rate of 70,000 B.T.U./Hour

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 71/ICEA S-96-659	(2014) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA WC 26	(2008) Binational Wire and Cable Packaging Standard
NEMA WC 57	(2014) Standard for Control, Thermocouple Extension, and Instrumentation Cables
NEMA WC 70	(2009) Power Cable Rated 2000 V or Less for the Distribution of Electrical Energy--S95-658
NEMA WC 74/ICEA S-93-639	(2012) 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

UNDERWRITERS LABORATORIES (UL)

UL 44	(2018; Reprint May 2021) UL Standard for

	Safety Thermoset-Insulated Wires and Cables
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 1685	(2015) UL Standard for Safety Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables
UL 2556	(2015) UL Standard for Safety Wire and Cable Test Methods

1.2 SUBMITTALS

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

SD-03 Product Data

Wire and Cable; G[, [____]]

Conductors; G[, [____]]

Cable Manufacturing Data

SD-06 Test Reports

Test Report(s), Inspection Report(s), and Verification Report(s); G[, [_____]]

1.3 DELIVERY, STORAGE, AND HANDLING

Furnish cables on reels or coils. Each cable and the outside of each reel or coil, must be plainly marked or tagged to indicate the cable length, voltage rating, conductor size, and manufacturer's lot number and reel number. Each coil or reel of cable must contain only one continuous cable without splices. Cables for exclusively dc applications, as specified in paragraph "High-Voltage Test Source," must be identified as such. Shielded cables rated 2,001 volts and above must be reeled and marked in accordance with NEMA WC 26, as applicable. Reels must remain the property of the [Contractor] [Government].

1.4 PROJECT/SITE CONDITIONS

[_____]

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Wire Table

Furnish wire and cable in accordance with the requirements of the [wire

table below] [wire table appended to these specifications], conforming to the detailed requirements specified herein.

2.1.2 Rated Circuit Voltages

All power wire and cable must have minimum rated circuit voltages in accordance with NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Power wire and cable for circuit voltages rated 0-600 volts must be rated not less than 600 volts. Control wire and cable must have minimum rated circuit voltages in accordance with NEMA WC 57, but must be rated 600 volts if routed in raceway with other conductors that are rated 600 volts.

2.1.3 Conductors

2.1.3.1 Material for Conductors

Conductors must conform to all the applicable requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Copper conductors must be annealed copper material and they may be bare, or tin- or lead-alloy-coated, if required by the type of insulation used. [Aluminum conductors must be Type AA-8000 aluminum conductors. Type 1350 is not acceptable. Intermixing of copper and aluminum conductors in the same raceway is not permitted.]"

2.1.3.2 Size

Minimum wire size must be No. 12 AWG for power and lighting circuits; No. 10 AWG for current transformer secondary circuits; No. 14 AWG for potential transformer, relaying, and control circuits; No. 16 AWG for annunciator circuits; and No. 19 AWG for alarm circuits. Minimum wire sizes for rated circuit voltages of 2,001 volts and above must not be less than those listed for the applicable voltage in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable.

2.1.3.3 Stranding

Conductor stranding classes cited herein must be as defined for control conductors in NEMA WC 57 or as defined for 0-2,000 volts power conductors in NEMA WC 70, as applicable. Lighting conductors No. 10 AWG and smaller must be solid or have Class B stranding. Any conductors used between stationary and moving devices, such as hinged doors or panels, must have Class H or K stranding. All other conductors must have Class B or C stranding, except that conductors as shown, or in the schedule, as No. 12 AWG may be 19 strands of No. 25 AWG, and conductors shown as No. 10 AWG may be 19 strands of No. 22 AWG. Conductor stranding classes for circuit voltages 2,001 volts and above must be as defined in ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639, as applicable.

2.1.3.4 Conductor Shielding

Use conductor shielding conforming to NEMA WC 57 for control wire and cable as applicable. Use conductor shielding conforming to ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable, on power cables having a rated circuit voltage above 2,000 volts.

2.1.3.5 Separator Tape

Where conductor shielding, strand filling, or other special conductor

treatment is not required, a separator tape between conductor and insulation is permitted.

2.1.4 Insulation

2.1.4.1 Insulation Material

Unless specified otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, [Type THWN/THHN conforming to UL 83] [or] [Type [XHHW] [or] [RHW] conforming to UL 44]. Insulation for control wire and cable must meet the requirements of NEMA WC 57. Insulation requirements for wire and cable rated less than 2,000 volts must meet the requirements of NEMA WC 70. Insulation requirements for wire and cable rated 2,001-5,000 volts must meet the requirements of ANSI/NEMA WC 71/ICEA S-96-659. Insulation requirements for wire and cable rated 5,001 volts and greater must meet the requirements of NEMA WC 74/ICEA S-93-639.

For shielded cables of rated circuit voltages above 2,000 volts, the following provisions must also apply:

a. XLPE, if used, must be tree-retardant.

b. Insulation must be chemically bonded to conductor shielding.

c. The insulation material and its manufacturing, handling, extrusion and vulcanizing processes must all be subject to strict procedures to prevent the inclusion of voids, contamination, or other irregularities on or in the insulation. Insulation material must be inspected for voids and contaminants.

d. Cables with repaired insulation defects discovered during factory testing, or with splices or insulation joints, are prohibited [unless specifically approved].

2.1.4.2 Insulation Thickness

The insulation thickness for each conductor must be based on its rated circuit voltage.

2.1.4.2.1 Power Cables, 2,000 Volts and Below

The insulation thickness for single-conductor and multiple-conductor power cables rated 2,000 volts and below must be as required by NEMA WC 70, as applicable. Some thicknesses of NEMA WC 70 will be permitted only for single-conductor cross-linked thermosetting polyethylene insulated cables without a jacket. NEMA WC 70 ethylene-propylene rubber-insulated conductors must have a jacket.

2.1.4.2.2 Power Cables, Rated 2,001 Volts and Above

Thickness of insulation for power cables rated 2,001 volts and above must be in accordance with the following

a. Non-shielded cables, 2,001 to 5,000 volts, must comply with ANSI/NEMA WC 71/ICEA S-96-659, as applicable.

b. Shielded cables rated 5,000 volts to 46,000 volts must comply with NEMA WC 74/ICEA S-93-639, as applicable.

2.1.4.2.3 Single-Conductor and Multiple-Conductor Control Cables

The insulation thickness of control conductor sizes 22 AWG to 10 AWG used for control and related purposes must be as required by NEMA WC 57, as applicable. Control conductors larger than 10 AWG must be as required by NEMA WC 70.

2.1.4.3 Insulation Shielding

Unless otherwise specified, provide insulation shielding for conductors having rated circuit voltages of 2,001 volts and above. The voltage limits above which insulation shielding is required, and the material requirements, are given in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The material, if thermosetting, must meet the wafer boil test requirements as described in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The method of shielding must be in accordance with the current practice of the industry; however, the application process must include strict precautions to prevent voids or contamination between the insulation and the nonmetallic component. Voids, protrusions, and indentations of the shield must not exceed the maximum allowances specified in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The cable must be capable of operating without damage or excessive temperature when the shield is grounded at both ends of each conductor. All components of the shielding system must remain tightly applied to the components they enclose after handling and installation in accordance with the manufacturer's recommendations. Shielding systems which require heat to remove are prohibited unless specifically approved.

2.1.5 Jackets

All cables must have jackets meeting the requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, and NEMA WC 74/ICEA S-93-639, as applicable, and as specified herein. Individual conductors of multiple-conductor cables must be required to have jackets only if they are necessary for the conductor to meet other specifications herein. Jackets of single-conductor cables and of individual conductors of multiple-conductor cables, except for shielded cables, must be in direct contact and adhere or be vulcanized to the conductor insulation. Multiple-conductor cables and shielded single-conductor cables must be provided with a common overall jacket, which must be tightly and concentrically formed around the core. Repaired jacket defects found and corrected during manufacturing are permitted if the cable, including jacket, afterward fully meets these specifications and the requirements of the applicable standards.

2.1.5.1 Jacket Material

The jacket must be one of the materials listed below. [Polyvinyl chloride compounds will not be permitted.] [Variations from the materials required below will be permitted only if approved for each specific use, upon submittal of sufficient data to prove that they exceed all specified requirements for the particular application.]

2.1.5.1.1 General Use

Heavy-duty black neoprene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Heavy-duty chlorosulfonated polyethylene	NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Heavy-duty cross-linked (thermoset) chlorinated polyethylene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639

2.1.5.1.2 Accessible Use Only, 2,000 Volts or Less

Cables installed where they are entirely accessible, such as cable trays and raceways with removable covers, or where they pass through less than 10 feet of exposed conduit only, must have jackets of one of the materials in item "a. General Use" or one of the following:

General-purpose neoprene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Black polyethylene (MDPE)	NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Thermoplastic chlorinated polyethylene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639

2.1.5.2 Jacket Thickness

The minimum thickness of the jackets must be not less than 80 percent of the respective nominal thicknesses specified below.

2.1.5.2.1 Multiple-Conductor Cables

Thickness of the jackets of the individual conductors of multiple-conductor cables must be as required by NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable and must be in addition to the conductor insulation thickness required by the applicable respective NEMA publication for the insulation used. Thickness of the outer jackets and associated coverings of the assembled multiple-conductor cables must be as required by NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable.

2.1.5.2.2 Single-Conductor Cables

Single-conductor cables must have a jacket thickness as specified in

NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable.

2.1.6 Metal-Clad Cable

2.1.6.1 General

The metallic covering or sheath must be [interlocked metal tape] [continuous corrugated metal], conforming to the applicable requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639. The type of metal for the metallic covering must be [galvanized steel] [aluminum] [copper] [copper alloy]. If the covering is of ferrous metal, it must be galvanized. Grounding conductor(s) conforming to NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable must be furnished for each multiple-conductor metal-clad cable. Assembly and cabling must be as specified in paragraph "Cabling." The metallic covering must be applied over an inner jacket or filler tape. The cable must be assembled so that the metallic covering will be tightly bound over a firm core.

2.1.6.2 Jackets

Metal-clad cables may have a jacket under the armor, and must have a jacket over the armor. Jackets must comply with the requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. The outer jacket for the metal-clad cable may be of polyvinyl chloride (PVC) only if specifically approved.

2.1.7 Multiple-Conductor Cables

Grounding conductor(s) conforming to NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable must be furnished for each multiple-conductor cable. Assembly and cabling must be as specified in paragraph CABLING.

2.2 CABLE IDENTIFICATION

2.2.1 Color-Coding

Insulation of individual conductors of multiple-conductor cables must be color-coded in accordance with ICEA S-58-679, except that colored braids will not be permitted. Only one color-code method must be used for each cable construction type. Control cable color-coding must be [in accordance with ICEA S-58-679, Method [_____]] [as indicated] [as follows: - [_____]]. Power cable color-coding must be black for Phase A, red for Phase B, blue for Phase C, white for grounded neutral, and green for an insulated grounding conductor, if included. [Other individual conductors must be color-coded as indicated, but such color-coding may be accomplished by applying colored plastic tapes or colored sleeves at terminations.]

2.2.2 Shielded Cables Rated 2,001 Volts and Above

Marking must be in accordance with ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable.

2.2.3 Cabling

Individual conductors of multiple-conductor cables must be assembled with flame-and moisture-resistant fillers, binders, and a lay conforming to NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639. Flat twin cables are prohibited. Fillers must be used in the interstices of multiple-conductor round cables with a common covering where necessary to give the completed cable a substantially circular cross section. Fillers must be non-hygroscopic material, compatible with the cable insulation, jacket, and other components of the cable. The rubber-filled or other approved type of binding tape must consist of a material that is compatible with the other components of the cable and must be lapped at least 10 percent of its width.

2.2.4 Dimensional Tolerance

The outside diameters of single-conductor cables and of multiple-conductor cables must not vary more than 5 percent and 10 percent, respectively, from the manufacturer's published catalog data.

PART 3 EXECUTION

3.1 INSTALLATION INSTRUCTIONS

Submit cable manufacturing data [as requested]. The following information must be provided by the cable manufacturer for each size, conductor quantity, and type of cable furnished:

a. Minimum bending radius, in inches - For multiple-conductor cables, this information must be provided for both the individual conductors and the multiple-conductor cable.

b. Pulling tension and sidewall pressure limits, in pounds.

c. Instructions for stripping semiconducting insulation shields, if furnished, with minimum effort without damaging the insulation.

d. Upon request, compatibility of cable materials and construction with specific materials and hardware manufactured by others must be stated. Also, if requested, recommendations must be provided for various cable operations, including installing, splicing, terminating, etc.

3.2 TEST REPORT(S), INSPECTION REPORT(S), AND VERIFICATION REPORT(S)

3.2.1 Cable Data

Do not begin any wire and cable fabrication until materials are submitted and approved by the Contracting Officer. Submit cable data for approval including, but not limited to, dimensioned sketches showing cable construction and sufficient additional data to show that wire and cable meet the requirements of this Section.

3.2.2 Inspection and Tests

Inspection and tests of wire and cable furnished under these specifications must be made by and at the plant of the manufacturer, [and must be witnessed by the Contracting Officer, unless waived in writing.]

[and the manufacturer must provide certification and certification reports of completed inspections and completed tests.] The Government may require or perform further tests before or after installation. Testing in general must comply with NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Specific tests required for particular materials, components, and completed cables must be as specified in the sections of the above standards applicable to those materials, components, and cable types. Tests must also be performed in accordance with the additional requirements specified below. Submit [_____] certified copies of test reports.

3.2.2.1 High-Voltage Test Source

Where the applicable standards allow a choice, high-voltage tests for cables to be used exclusively on dc circuits must be made with dc test voltages. Cables to be used exclusively on ac circuits must be tested with ac test voltages. If both ac and dc will be present, on either the same or separate conductors of the cable, ac test voltages must be used.

3.2.2.2 Shielded Cables Rated 2,001 Volts or Greater

The following test(s) must be performed in addition to those specified above:

a. If high-voltage testing is done with an AC test voltage as specified in paragraph "High-Voltage Test Source," an additional test must be made using a DC test voltage rated at 75 percent of the specified full DC test voltage, for 5 consecutive minutes.

b. If voltage tests after installation are required for 5-65kV shielded power cables then testing must be done in accordance with NEMA WC 74/ICEA S-93-639, Appendix F.

3.2.2.3 Flame Tests

All [multiple-conductor and single-conductor] cable assemblies must pass either the vertical cable tray flame tests required by ICEA T-30-520 (stated in, but not required by NEMA WC 70), the vertical tray flame propagation test requirements of UL 1685 and IEEE 1202, the wire and cable burning characteristics test of the UL 2556 VW-1 Test, or (for control cables only) the flame test as required by NEMA WC 57. If such tests, however, have previously been made on identical cables, these tests need not be repeated. Instead, certified reports of the original qualifying tests must be submitted. In this case the reports furnished under paragraph "Reports," must include information, identify critical information, and verify that all of each cable's materials, construction, and dimensions are the same as those in the qualifying tests.

3.2.2.4 Independent Tests

The Government may make visual inspections, continuity or resistance checks, insulation resistance readings, power factor tests, or dc high potential tests at field test values. A cable's failure to pass these tests and inspections, or failure to produce readings consistent with acceptable values for the application, will be grounds for rejection of the cable.

3.2.2.5 Reports

Furnish results of tests. No wire or cable must be shipped until authorized. Lot number and reel or coil number of wire and cable tested must be indicated on the test reports.

WIRE TABLE						
Item No.	Size, AWG or kcmil	No. of Conds.	Rated Circuit Voltage	Stranding	Comments	Quantity, lin ft
Class [_____] stranding may be substituted for [_____] where indicated by "*".						

-- End of Section --

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SECTION 26 05 26.00 40

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
08/19

PART 1 GENERAL

[Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to work specified in this section.

][Section 26 41 00 LIGHTNING PROTECTION SYSTEMS applies to work specified in this section.

]1.1 REFERENCES

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

AMERICAN WELDING SOCIETY (AWS)

AWS A3.0M/A3.0	(2020) Standard Welding Terms and Definitions
AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.1/B2.1M	(2014; Errata 2015) Specification for Welding Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

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 B187/B187M	(2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA GR 1	(2007) Grounding Rod Electrodes and Grounding Rod Electorode Couplings

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	(2020) Standard for the Installation of Lightning Protection Systems

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-889	(2021; Rev D) Galvanic Compatibility of Electrically Conductive Materials

UNDERWRITERS LABORATORIES (UL)

UL 467	(2013; Reprint Jun 2017) UL Standard for Safety Grounding and Bonding Equipment
UL 546	(2008) UL Outline of Investigation for Conductor Termination Compounds

1.2 SUBMITTALS

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

SD-03 Product Data

Ground Rods; G[, [____]]

Ground Wires; G[, [____]]

Connectors and Fasteners; G[, [____]]

Test Wells; G[, [____]]

Conductive Corrosion Inhibiting Compounds; G[, [____]]

Ground Buses; G[, [____]]

SD-06 Test Reports

Bond Resistance Test; G[, [____]]

Ground Resistance Tests; G[, [_____]]

Ground Isolation Test; G[, [_____]]

Equipment Continuity Test; G[, [_____]]

SD-07 Certificates

Ground Resistance Test Equipment; G[, [_____]]

Micro-Ohmmeter Test Equipment; G[, [_____]]

SD-11 Closeout Submittals

Record Drawings

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

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

1.3.3 Ground Resistance Test Equipment

Provide combination 3-point and 4-point type ground resistance test equipment specifically designed for grounding electrode resistance and soil resistivity tests. Submit proof of current equipment calibration with test equipment product data.

1.3.4 Micro-Ohmmeter Test Equipment

Perform [circuit and]bond resistance tests using a micro-ohmmeter with the following characteristics:

a. Resistance range selectable and capable of measuring to 10 micro-Ohms using a minimum of 1 ampere of test current.

b. Positive and negative test leads of the 2-wire balanced type.

Provide both clamp and probe type connections to allow measurements across all bonded surfaces. Provide long length balanced test lead to allow measurements from a bonding location to the nearest test well.

Submit proof of current equipment calibration with test equipment product data.

1.4 PREDICTIVE TESTING AND INSPECTION TECHNOLOGY REQUIREMENTS

This section contains systems and equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with RCBEA GUIDE to ensure building equipment and systems have been installed properly and contain no identifiable defects that shorten the design life of a system and its components. Satisfactory completion of all acceptance requirements is required to obtain Government approval and acceptance of the work.

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

PART 2 PRODUCTS

Submit material, equipment, and fixture lists for grounding systems, including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

2.1 MATERIALS

2.1.1 Ground Rods

Provide ground rods of [copper][copper-clad steel] conforming to UL 467 and ANSI/NEMA GR 1. Ensure ground rods are not less than[3/4 inch in diameter and 10 feet in length][as indicated].

Where ground rod length is greater than 10 feet, provide sectional type ground rods with each section 10 feet in length. Join sectional type ground rods using [threaded brass couplings][exothermic welding completely around both rod/coupling joints][threaded couplings that are welded at the threaded joints]. Ensure ground rods have cone-shaped point on the end of the first section driven into the ground.

Provide ground rods and ground rod sections die-stamped near the top with the name or trademark of the manufacturer and the length of the segment in feet.

2.1.2 Ground Wires

2.1.2.1 Bare

Provide annealed bare copper, Class "B" stranded ground and bond wires in accordance with ASTM B8 for wires #4 AWG and larger and solid in accordance with ASTM B3 for wires #6 AWG and smaller. Provide conductors with 98 percent conductivity and sized wires in accordance with the requirements of NFPA 70 and NFPA 780.

2.1.2.2 Insulated

Ensure insulated conductors conform to the requirements of Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL.

Where installed in conduit as part of a complete circuit provide conductors with green insulation for sizes #8 AWG and smaller and with green phase tape at each end and in each junction box for sizes #6 AWG and larger.

2.1.2.3 Straps/Jumpers

Provide copper bonding straps and jumpers with a cross-sectional area of not less than [No. 6 AWG][as indicated]. Ensure bonding straps and jumpers for shock-mounted devices with [pivot] [hinged] [swivel] joints are made of [flat] [tinned-copper] [woven-wire braid] [flexible stranded] wire.

2.1.3 Connectors and Fasteners

2.1.3.1 Exothermic Welds

Ensure the molds, materials and powder charges used to make exothermic welds are the standard product of a single manufacturer and listed by the manufacturer for use on the specific type, size, quantity and configuration of conductors to which the weld is applied.

2.1.3.2 Irreversible Compression Lugs

Provide irreversible compression lug type connectors manufactured from tin-plated copper and installed using a hydraulic compression tool and die to apply correct, uniformly distributed, circumferential pressure. Ensure tools and dies are as recommended by the irreversible compression lug type connector manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed onto the conductor. Apply irreversible compression lug type connectors in strict accordance with the manufacturer's written instructions and published installation instructions. Use 2-hole lug type connectors for connections to NEMA cable pads and bus bars, and single-hole connectors otherwise.

2.1.3.3 Mechanical

Provide split bolt and clamp style mechanical type connectors manufactured from [copper,][copper alloy,][or][bronze,] listed by the manufacturer as suitable for direct burial use. Ensure mechanical type connectors are applied in strict accordance with the manufacturer's published installation instructions.

2.1.3.4 Fasteners

Provide bolts, nuts, washers, lock washers, and associated fasteners used for grounding and bonding connections manufactured of [copper][bronze][tin plated tempered brass][stainless steel]. Where fasteners contact dissimilar metals, apply conductive oxide-inhibiting compound.

[2.1.4 Test Wells

Provide test wells that are H2O rated, precast reinforced concrete,

[circular][rectangular], with open bottom and concrete or cast iron lid/frame. Ensure test wells have inside dimensions of not less than [15 inches wide by 22 inches long][12 inches in diameter] by 24 inches deep. Provide test well lid with cast "GROUND" legend.

]2.1.5 Conductive Corrosion Inhibiting Compounds

Provide conductive corrosion inhibiting compounds UL Listed in accordance with UL 546, listed by the manufacturer as suitable for the application, and suitable for all aluminum and copper conductor/connector applications. Ensure conductive corrosion inhibiting compounds inhibit oxidation at the conductor/connector interface and have no deleterious effect on the conductor/connector metal or EPDM, natural rubber, or polyethylene insulating materials.[

Provide gritted conductive corrosion inhibiting compound that are non-petroleum based and non-toxic, and contain conductive grit. Ensure gritted conductive corrosion inhibiting compound is specified by the manufacturer for application to the conductor/connector interface of compression connectors.][

Provide non-gritted conductive corrosion inhibiting compound that are non-petroleum based and non-toxic and contain no grit filler. Ensure non-gritted conductive corrosion inhibiting compound is specified by the manufacturer for application to the conductor/connector interface of mechanical connectors such as bolted joints, flat-to-flat contact surfaces, terminal and lug tongues, and grooves of bolted parallel connectors or clamps.]

2.1.6 Ground Buses

Provide [electro-tin plated,]solid copper ground buses conforming to ASTM B187/B187M with minimum dimensions of 0.25 inches thick, 4 inches wide, and 12 inches in length or as indicated. Ensure ground buses are equipped with two UL Recognized red 1000V rated insulated standoffs and stainless steel mounting brackets.

Provide Telecommunications Main Ground Buses and Telecommunications Ground Buses in meeting the standards of TIA-607.

Provide grounding buses with predrilled NEMA hole configuration as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Install grounding systems in accordance with NFPA 70, NFPA 780 and IEEE C2, and as indicated.

Bond exposed non-current-carrying metallic parts of electrical equipment and metallic raceway systems to ground.

Bond grounding conductors in metallic and non-metallic raceways to ground. Make ground connections at equipment and to ground rods as indicated. 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.

Bond wiring system neutrals to ground in accordance with the requirements of NFPA 70. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection. [

Counterpoise ground systems consist of a series of ground rods with a direct buried grounding conductor loop, configured to minimize the number of dead-ends, interconnecting the individual ground rods. Provide ground rods in the locations indicated.]

3.1.1 Ground Rods

[Install ground rods using a water jetting procedure.]

[Install ground rods so that the top of the rod is [4] [_____] inches above grade.

][Install ground rods so that the top of the rod is not less than [18] [_____] inches below finished grade.

]### 3.1.2 Conductors

Install bare or insulated conductors as indicated. Install bare conductors where not specifically identified as bare or insulated except where installed in conduit with associated phase conductors. Install insulated conductors in conduit with insulation of the same material as the associated phase conductors with which it is installed.

Provide straps/jumpers across joints subject to vibration. Install strap/jumper such that vibration will not change its electrical characteristics. Apply strap/jumper to the metallic structure on each side of the joint; do not penetrate any adjacent parts. Install straps/jumpers in areas that are accessible for maintenance. Install strap/jumper such that it does not restrict the movement of the metallic structures to which it is connected. Install strap/jumper such that it does not weaken the metallic structures to which it is attached. Do not connect two or more straps/jumpers in series.

3.1.3 Counterpoise

Install No. [4/0] [_____] AWG bare copper counterpoise grounding conductor direct buried outside of the structure drip line, within 24 to 72 inches of the structure foundation, with a minimum of 18 inches of earth cover. Install counterpoise grounding conductor 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 conductor.

Install ground rods vertically into the earth not less 10 feet with top of ground rod not less than [18] [_____] inches below finished grade. Bond ground rods to counterpoise grounding conductor at intervals no less than 20 linear feet nor greater than 40 linear feet of ground counterpoise cable.

3.1.4 Ground Buses

Install ground busses in accordance with manufacturer's instructions.

3.1.5 Building Grounds

Install No. [4/0] [_____] AWG bare copper ground conductor from [concrete encased foundation rebar][and][every corner column and intermediate exterior column] to counterpoise. [Connect conductors to rebar using [mechanical connectors manufactured for such purpose][exothermic welds]. Install one conductor a minimum of every [60] [_____] feet of concrete foundation perimeter.]Connect ground conductors to [columns and]counterpoise using [mechanical connectors manufactured for such purpose][exothermic welds].

3.1.6 Equipment Grounding

Install ground systems for power, telecommunications, and instrumentation. Independently connect each system to the building counterpoise.

3.1.6.1 Equipment and Enclosure Bonding

Bond each metallic enclosure and all electrical equipment to ground. Make at least one copper connection from the system ground point to one or more enclosures in the area such that all enclosures and equipment provide a low-impedance path to ground when properly bonded together.

[In addition to the green colored equipment grounding conductor required in each raceway and sized in accordance with Table 250.122 of NFPA 70, bond each panelboard, switchboard enclosure, transformer housing, motor housing, disconnect, starter, and other electrical equipment, to the grounding system with a stranded copper conductor, routed external to the feeder raceway.

] Individually and directly connect indoor substations, transformers, switchboard frames, switchgear assemblies, motors, motor control centers, air compressors, air handlers, refrigerated air dryers, generators, frames and tracks of cranes, and [_____] to the building ground. Ensure the current-carrying capacity of the grounding conductor is the same as the current-carrying capacity of the power conductors for circuits utilizing power lines size No. [2] [_____] AWG and smaller. For circuits with power wiring larger than No. [2] [_____] AWG, ensure the grounding conductor is in accordance with NFPA 70.

3.1.6.2 Bonding of Conduit and Raceway Systems

Bond all metal conduit, fittings, junction boxes, outlet boxes, armored and metal sheathed cable, and other raceways. Ensure adequate electrical contact at the joints and terminations. Ensure metallic raceway systems have electrical continuity with equipment. Individually and directly connect equipment to the building ground, independent of the raceway system.

For rigid metal conduit and terminations, ensure threaded connections are wrench-tight with no exposed threads. Ream all ends of the conduit to remove burrs and rough edges. Bond conduits entering boxes and enclosures to the box with [bonding-type locknuts, one outside and one inside.] [locknuts and grounding-type bushings.] Locknuts that gouge into the metal box when tightened are not acceptable.

Conduit systems that are interrupted by PVC dielectric links are bonded separately on either side of the link. Do not jumper the dielectric link.

Install flexible metal conduit with an integral grounding conductor.

3.1.6.3 Cable Tray Bonding

Bond cable tray sections together. Cable tray sections in tandem assembly are considered as having electrical continuity when these sections are bonded with the appropriate bolts. Install bond straps across expansion joints. Bond cable trays to the building ground system.

3.1.7 Bonding Materials And Methods

Accomplish bonding of metal surfaces by [brazing] [welding] [clamping] [structural joining methods].

3.1.7.1 Brazing

Ensure brazing solder conforms to AWS A5.8/A5.8M [_____].

3.1.7.2 Welding

Weld using the exothermic process with procedures conforming to AWS A3.0M/A3.0, AWS B2.1/B2.1M, and manufacturer's recommendation. Where dissimilar metals are to be joined via exothermic weld, follow the weld kit manufacturer's recommendations and published instructions. Ensure connections between dissimilar metals do not produce galvanic action in accordance with MIL-STD-889.

Use welding processes of the exothermic fusion type that makes a connection without corroding or loosening. Ensure process joins all strands and does not cause the parts to be damaged or weakened. Completed connection or joint is equal or larger in size than the conductors joined and has the same current-carrying capacity as the largest conductor. Paint the buried ground connections with a bitumastic paint.

3.1.7.3 Clamping

In external locations, use clamping only where a disconnect type of connection is required. Connection device may utilize [spring-loaded jaws] [threaded fasteners]. Construct device such that positive contact pressure is maintained at all times. Use machine bolts with [tooth-type] [spring-type] lockwashers.

3.1.7.4 Cleaning of Bonding Surfaces

Thoroughly clean surfaces that comprise the bond before joining. Apply an appropriate abrasive with gentle and uniform pressure to ensure a smooth and uniform surface. Do not remove excessive metal from the surface. Clean clad metals in such a manner that the cladding material is not penetrated by the cleaning process. Then clean bare metal with an appropriate solvent to remove any grease, oil, dirt, corrosion preventives, and other contaminants. Bond to the cleaned area within one hour after cleaning. Seal joint and refinish the exposed surfaces within two hours of exposure to prevent oxidation. When additional time is required, apply a corrosion preventive compound until the area can be refinished.

3.1.7.5 Protection of Finished Bonds

Protect finished bonds by painting to match the original finish after the bond is made.

3.2 FIELD QUALITY CONTROL

Perform PT&I tests and provide submittals as specified in Section 01 86 26.07 40 RELIABILITY CENTERED ACCEPTANCE FOR ELECTRICAL SYSTEMS.

[The requirements of Section 26 08 00 APPARATUS COORDINATION, INSPECTION AND TESTING apply to this section.

] Perform the following tests in the presence of the Contracting Officer. Furnish test equipment and personnel and submit written results of each test. Notify the Contracting Officer at least 14 calendar working days prior to each test.

Submit written results of each test to Contracting Officer for review and approval. Document each location where test is performed, the field conditions at the time of the test, the measured results of the test, and whether the measured results "PASSED" or "FAILED" relative to specified pass/fail performance criteria.

Perform rework to correct FAILED conditions at no additional cost to the Government.

3.2.1 Bond Resistance Test

Resistance of any bond connection cannot exceed [0.5] [_____] milliohm. Rework bonds that exceed this resistance at no additional cost to the Government.

3.2.2 Ground Resistance Tests

Test grounding systems for ground resistance. Total resistance from any point on the ground network to the building counterpoise cannot exceed [50] [_____] milliohms.

Make ground resistance and counterpoise tests during dry weather, and no sooner than [48] [_____] hours after rainfall. Conduct tests using the ratio method that measures the ratio of the resistance to earth of an auxiliary test electrode to the series resistance of the electrode under test and a second auxiliary electrode. Perform measurements in accordance with IEEE 81.

3.2.3 Ground Isolation Test

Test ground systems for isolation from other ground systems.

3.2.4 Equipment Continuity Test

Test connection from electrical distribution equipment including panelboards, switchboards, transformers, substations, and motor control centers to counterpoise. Measure and record the circuit resistance between electrical equipment ground connections and the counterpoise. The circuit resistance shall not exceed [5][ ] Ohms.

3.3 CLOSEOUT ACTIVITIES

Submit record drawings indicating the location of ground rods, mats, grids, building ground bus, supplementary grounding electrodes, steel building columns, and other metal structures connected to the grounding system.

-- End of Section --

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SECTION 26 05 48.00 10

SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT
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.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2017) Steel Construction Manual

ASTM INTERNATIONAL (ASTM)

ASTM E580/E580M	(2020) Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019) Structural Engineering

UNDERWRITERS LABORATORIES (UL)

UL 1598	(2021; Reprint Jun 2021) Luminaires

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

The requirements for seismic protection measures described in this section shall be applied to the electrical equipment and systems listed below. Structural requirements shall be in accordance with Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

1.2.2 Electrical Equipment

Electrical equipment shall include the following items to the extent required on the drawings or in other sections of these specifications:

Control Panels	Air Handling Units
Pumps with Motors	Switchgear
Light Fixtures	Unit Substations
Motor Control Centers	Transformers

Switchboards (Floor Mounted)	Storage Racks
Solar Heating Units	[_____]

1.2.3 Electrical Systems

The following electrical systems shall be installed as required on the drawings and other sections of these specifications and shall be seismically protected in accordance with this specification: [_____]

1.2.4 Contractor Designed Bracing

Submit copies of the Design Calculations with the Drawings. Calculations shall be approved, certified, stamped and signed by a Registered Professional Engineer. Calculations shall verify the capability of structural members to which bracing is attached for carrying the load from the brace. Design the bracing in accordance with UFC 3-301-01 and additional data furnished by the Contracting Officer. Resistance to lateral forces induced by earthquakes shall be accomplished without consideration of friction resulting from gravity loads. UFC 3-301-01 uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas shall be required. Loadings determined using UFC 3-301-01 are based on strength design; therefore, AISC 325 shall be used for the design. Develop the bracing for the following electrical equipment and systems: [_____].

1.2.5 Conduits Requiring No Special Seismic Restraints

Seismic restraints may be omitted from electrical conduit less than 2-1/2 inches trade size and [_____]. All other interior conduit, shall be seismically protected as specified.

1.3 EQUIPMENT REQUIREMENTS

Submit detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall be complete in detail, indicating thickness, type, grade, class of metal, and dimensions; and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction. Submit copies of the design calculations with the detail drawings. Calculations shall be stamped by a registered engineer and shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

1.3.1 Rigidly Mounted Equipment

The following specific items of equipment: [_____] to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in UFC 3-301-01. Each item of rigid electrical equipment shall be entirely located and rigidly attached on one side only of a building expansion joint. Piping, electrical conduit, etc., which cross the expansion joint shall be provided with flexible joints that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

Engine-Generators
Substations

Transformers
Switch Boards and Switch Gears
Motor Control Centers
Free Standing Electric Motors
[_____]

1.3.2 Nonrigid or Flexibly-Mounted Equipment

The following specific items of equipment to be furnished: [_____] shall be constructed and assembled to resist a horizontal lateral force of [_____] times the operating weight of the equipment at the vertical center of gravity of the equipment.

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.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting Fixtures in Buildings
Equipment Requirements

SD-03 Product Data

Lighting Fixtures in Buildings; G[, [_____]]
Equipment Requirements; G[, [_____]]
Contractor Designed Bracing; G[, [_____]]

PART 2 PRODUCTS

2.1 LIGHTING FIXTURE SUPPORTS

Lighting fixtures and supports shall conform to UL 1598.

2.2 SWAY BRACING MATERIALS

Sway bracing materials (e.g. rods, plates, rope, angles, etc.) shall be as specified in Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

PART 3 EXECUTION

3.1 SWAY BRACES FOR CONDUIT

Conduit shall be braced as for an equivalent weight pipe in accordance with Section 23 05 48.19 [SEISMIC] BRACING FOR HVAC.

3.2 LIGHTING FIXTURES IN BUILDINGS

Lighting fixtures and supports shall conform to the following:

3.2.1 Pendant Fixtures

Pendant fixtures shall conform to the requirements of UFC 3-301-01.

3.2.2 Ceiling Attached Fixtures

3.2.2.1 Recessed Fluorescent Fixtures

Recessed fluorescent individual or continuous-row mounted fixtures shall be supported by a seismic-resistant suspended ceiling support system built in accordance with [ASTM E580/E580M][Section 09 51 00 ACOUSTICAL CEILINGS]. Seismic protection for the fixtures shall conform to the requirements of UFC 3-301-01. Recessed lighting fixtures not over 56 pounds in weight may be supported by and attached directly to the ceiling system runners using screws or bolts, number and size as required by the seismic design. Fixture accessories, including louvers, diffusers, and lenses shall have lock or screw attachments.

3.2.2.2 Surface-Mounted Fluorescent Fixtures

Surface-mounted fluorescent individual or continuous-row fixtures shall be attached to a seismic-resistant ceiling support system built in accordance with [ASTM E580/E580M][Section 09 51 00 ACOUSTICAL CEILINGS]. Seismic protection for the fixtures shall conform to the requirements of UFC 3-301-01.

3.2.3 Assembly Mounted on Outlet Box

A supporting assembly, that is intended to be mounted on an outlet box, shall be designed to accommodate mounting features on [4] [3] inch boxes, plaster rings, and fixture studs.

3.2.4 Wall-Mounted Emergency Light Unit

Attachments for wall-mounted emergency light units shall be designed and secured for the worst expected seismic disturbance at the site.

3.2.5 Lateral Force

Structural requirements for light fixture bracing shall be in accordance with Section 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT.

-- End of Section --

SECTION 26 05 71.00 40

LOW VOLTAGE OVERCURRENT PROTECTIVE DEVICES
02/17

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to work specified in this section.

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
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 D877/D877M	(2019) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 443	(1979) NARM Standard for Solid State Relays Service

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.17	(2012) Standard for Trip Devices for AC and General-Purpose DC Low-Voltage Power Circuit Breakers
IEEE C37.90	(2005; R 2011) Standard for Relays and Relay Systems Associated With Electric Power Apparatus
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
IEEE C63.2	(2009) Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz - Specifications
IEEE C63.4	(2014) American National Standard for

	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

IPC - ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES (IPC)

IPC D330	(1992) Design Guide Manual

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C78.23	(1995; R 2003) American National Standard for Incandescent Lamps - Miscellaneous Types
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 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

UNDERWRITERS LABORATORIES (UL)

UL 20	(2018; Reprint Jan 2021) UL Standard for Safety General-Use Snap Switches
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are

[for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Connection Diagrams; G[, [____]]

Fabrication Drawings; G[, [____]]

Control Devices; G[, [____]]

Protective Devices; G[, [____]]

SD-03 Product Data

Fuses; G[, [____]]

Motor Controllers; G[, [____]]

Instrument Transformers; G[, [____]]

Enclosures; G[, [____]]

Circuit Breakers; G[, [____]]

Control Devices; G[, [____]]

Time Switches; G[, [____]]

Protective Relays; G[, [____]]

Indicating Instruments; G[, [____]]

Indicating Lights; G[, [____]]

SD-06 Test Reports

Dielectric Tests; G[, [____]]

Final Test Reports; G[, [____]]

SD-07 Certificates

Insulating Oil; G[, [____]]

SD-08 Manufacturer's Instructions

Control Devices; G[, [____]]

Protective Devices; G[, [____]]

SD-10 Operation and Maintenance Data

Manual Motor Controllers; G[, [____]]

Magnetic Motor Controllers; G[, [____]]

Combination Motor Controllers; G[, [_____]]

Circuit Breakers; G[, [_____]]

Time Switches; G[, [_____]]

Protective Relays; G[, [_____]]

Indicating Instruments; G[, [_____]]

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit connection diagrams showing the relations and connections of control devices and protective devices by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

Submit fabrication drawings for control devices and protective devices consisting of fabrication and assembly details performed in the factory.

2.2 EQUIPMENT

2.2.1 Motor Controllers

Conform to NEMA ICS 1, NEMA ICS 2, and UL 508 for motor controllers. Ensure controllers have thermal overload protection in each phase.

2.2.1.1 Manual Motor Controllers

Provide full-voltage, manually operated manual motor controllers for the control and protection of single-phase 60-Hz ac fractional-horsepower squirrel-cage induction motors.

Provide single-throw, single- or double-pole, three-position controllers rated at not more than 1 horsepower at 115 V and 230 V single-phase. Include a supporting base or body of electrical insulating material with enclosed switching mechanism, yoke, thermal-overload relay, and terminal connectors. Provide controllers that clearly indicate operating condition: on, off, or tripped.

Provide toggle- or key-operated-type manual motor controllers as indicated and arrange them so that they are lockable with a padlock in the "OFF" position.

Provide recessed manual motor controllers for single-speed, fractional-horsepower, squirrel-cage induction motors. Include a single controller and indicating light in a 4-inch-square wall outlet box; for flush-wiring devices, include matching corrosion-resistant steel flush cover plates. Provide surface-mounted manual motor controllers for single-speed, fractional-horsepower squirrel-cage induction motors that include a single controller and indicating light in a NEMA 250, Type [1] [_____], general-purpose enclosure.

Provide recessed and surface-mounted manual motor controllers for two-speed, fractional-horsepower, squirrel-cage induction motors; include two controllers, two indicating lights, and a selector switch in a multiple-gang wall outlet box for flush-wiring devices, with matching

corrosion-resistant steel flush cover plates. Provide surface-mounted manual motor controllers for two-speed, fractional-horsepower, squirrel-cage induction motors; include two controllers, two indicating lights, and a selector switch in a NEMA 250, Type [1] [_____], general-purpose enclosure.

2.2.1.2 Magnetic Motor Controllers

a. Full-Voltage Controllers

Provide full-voltage, full-magnetic devices for the control and protection of single- and three-phase, 60 Hz, squirrel-cage induction motors in accordance with NEMA ICS 1, NEMA ICS 2, and UL 508 for magnetic motor controllers.

Ensure that the operating coil assembly operates satisfactorily between 85 percent and 110 percent of rated coil voltage. Provide 120 V, 60 Hz motor control circuits.

Provide the controllers with two normally open and two normally closed auxiliary contacts rated according to NEMA ICS 1 and NEMA ICS 2, in addition to the sealing-in contact for the control circuits.

Provide solderless pressure wire terminal connectors for line and load connections to the controllers.

Include three manual-reset thermal-overload devices for overcurrent protection, one in each pole of the controller. Provide thermal-overload relays of the [melting-alloy] [bimetallic nonadjustable] type with continuous-current ratings and service-limit current ratings. Ensure that ratings have a plus or minus 15 percent adjustment to compensate for ambient operating conditions.

Provide an externally operable manual-reset button to reestablish control power to the holding coil of the electromagnet. After the controller has tripped from overload, ensure that resetting the motor-overload device does not restart the motor.

Provide an enclosure in accordance with NEMA 250, Type [_____].

b. Reduced-Voltage Starters

Conform to the requirements for full-voltage controllers for reduced-voltage starters, except for voltage, and to the following additional requirements:

(1) Fully protect the motor during all phases of motor starting with an overload device in each motor leg. Rate the starter contacts to withstand the switching surges during selector to full voltage. Provide a starter that contains the sensing and timing devices necessary to monitor motor operation and select the correct time for selector to full voltage.

(2) Ensure adequate ventilation of resistors and autotransformers used for starting. Ventilate solid-state starters for starting cycles as well as any follow-on restart-run cycles. Operate external control circuits or solid-state starters at a maximum of 120 V ac.

(3) For solid-state starters, provide adjustable starting torque from

0 percent to 50 percent of applied voltage, minimum. Provide autotransformer starters with a minimum of three taps above 50 percent reduced voltage.

2.2.1.3 Combination Motor Controllers

The following requirements are in addition to the requirements specified for magnetic motor controller:

a. Provide combination motor controllers for the control and protection of single- and three-phase, 60 Hz ac squirrel-cage induction motors with branch-circuit disconnecting and protective devices in accordance with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6.

b. For combination motor controllers, include magnetic motor controllers and molded-case circuit breakers or motor circuit protectors (MCPs) in metal enclosures in accordance with NEMA 250 or motor control center draw-out assemblies with control-power transformers, selector switches, pushbuttons, and indicating lights as follows:

(1) Provide full-voltage, full-magnetic devices as specified in this section under paragraph REMOTE-CONTROL STATION ENCLOSURES for magnetic motor controllers and enclosures.

(2) Provide thermal-magnetic breakers as specified in paragraph MANUAL MOTOR CONTROLLERS for molded-case circuit breakers. Manufacturer's standard MCPs may be used in lieu of molded-case circuit breakers.

(3) Provide control-power transformers 120 V ac maximum, selector switches, pushbuttons, and pilot lights as required.

(4) Identify combination motor controllers with identification plates affixed to the front cover of the controller.

a. Nonreversing Combination Motor Controllers

The following requirements are in addition to the requirements for magnetic motor controllers:

(1) For the control and protection of single-speed squirrel-cage induction motors, include a magnetic controller with molded-case circuit breaker or MCPs with selector switch or start/stop pushbutton and indicating light in the cover of the enclosure.

(2) Provide rating of [single] [and] [three]-phase, single-speed, full-voltage magnetic controllers for nonplugging and nonjogging duty in accordance with NEMA ICS 1 and NEMA ICS 2.

(3) Provide wiring and connections for full-voltage, single-speed magnetic controllers in accordance with NEMA ICS 1 and NEMA ICS 2.

b. Reversing Combination Motor Controllers

The following requirements are in addition to the requirements for magnetic motor controllers:

(1) For the control and protection of single-speed squirrel-cage induction motors, include two interlocked magnetic controllers

with molded-case circuit breaker or MCPs, with selector switch or forward/reverse/stop pushbutton and two indicating lights in the cover of the enclosure. Provide indicating lights to identify the forward and reverse running connection of the motor controller.

(2) Provide rating of [single] [and] [three]-phase, single-speed, full-voltage magnetic controllers for plug-stop, plug-reverse, or jogging duty in accordance with NEMA ICS 1 and NEMA ICS 2.

(3) Provide wiring and connections for full-voltage, single-speed magnetic controllers in accordance with NEMA ICS 1 and NEMA ICS 2.

c. Two-Speed Combination Motor Controllers

The following requirements are in addition to the requirements for magnetic motor controllers:

(1) For the control and protection of single- and two-winding, two-speed, three-phase, squirrel-cage induction motors, include two magnetic controllers with molded-case circuit breaker or MCPs, with selector switch or fast/slow/stop pushbutton and two indicating lights in the cover of the enclosure. Provide indicating lights to identify the high- and low-speed running connection of the motor controller.

(2) Provide rating of three-phase, two-speed, full-voltage magnetic controllers for nonplugging and nonjogging duty for constant- and variable-torque motors in accordance with NEMA ICS 1 and NEMA ICS 2.

(3) Provide rating of three-phase, two-speed, full-voltage magnetic controllers for nonplugging and nonjogging duty for constant-horsepower motors in accordance with NEMA ICS 1 and NEMA ICS 2.

(4) Provide rating of three-phase, two-speed, full-voltage magnetic controllers for plug-stop, plug-reverse, or jogging duty for constant-torque, variable-torque, and constant-horsepower motors in accordance with NEMA ICS 1 and NEMA ICS 2.

2.2.2 Circuit Breakers

Provide circuit breakers that conform to UL 489 and NEMA AB 3.

2.2.2.1 Molded-Case Circuit Breakers

Provide molded-case, manually operated, trip-free circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection as required. Completely enclose circuit breakers in a molded case, with a factory-sealed, calibrated sensing element to prevent tampering.

Locate thermal-magnetic tripping elements in each pole of the circuit breaker, and provide inverse-time-delay thermal-overload protection and instantaneous magnetic short-circuit protection. Provide an instantaneous magnetic tripping element that is adjustable and accessible from the front of the breaker on frame sizes larger than 100 A.

Size the breaker as required for the continuous-current rating of the circuit. Provide the breaker class as required.

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 A and that conform to NEMA AB 3.

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

Provide a phenolic-composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required.

For meter circuit disconnects, provide circuit breakers of the motor-circuit-protector type that meet the applicable requirements of NFPA 70.

For service disconnection, provide enclosed circuit-breakers with external handles for manual operation. Provide sheet-metal enclosures with hinged covers suitable for surface mounting.

2.2.2.2 Enclosed Molded-Case Circuit Breakers

For enclosed circuit breakers, provide thermal-magnetic, molded-case circuit breakers in surface-mounted, nonventilated enclosures conforming to NEMA 250 and UL 489.

Provide enclosed circuit breakers in nonhazardous locations as follows:

[a. Contain circuit breakers installed inside clean, dry locations in NEMA Type 1, general purpose, sheet-steel enclosures.

][b. Contain circuit breakers installed in unprotected outdoor locations, in NEMA Type 3R, weather-resistant sheet-steel enclosures that are splashproof, weatherproof, sleetproof, and moisture-resistant.

][c. Contain circuit breakers installed in wet locations, in NEMA Type 4, watertight corrosion-resistant, sheet-steel enclosures constructed to prevent entrance of water.

][d. Contain circuit breakers installed in wet locations in NEMA Type 4, watertight, cast-iron enclosures, constructed to prevent entrance of water when tested in accordance with NEMA ICS 1 for Type 4 enclosures.

][e. Contain circuit breakers installed in dry, noncombustible, dust-laden atmospheres in NEMA Type 5, dusttight, corrosion-resistant sheet steel enclosures, with gaskets or their equivalent to prevent the entrance of dust.

][f. Contain circuit breakers installed in dry, noncombustible, dust-laden atmospheres in NEMA Type 5, dusttight, cast-iron enclosures, with gaskets or their equivalent to prevent the entrance of dust.

][g. Contain circuit breakers installed in industrial locations in NEMA

Type 12, industrial-use, sheet-steel enclosures, constructed to prevent the entrance of dust, lint, fibers, and flyings and the seepage of oil and coolant.

][h. Fabricate steel enclosures from corrosion-resistant sheet-steel, conforming to ASTM A240/A240M, 300-series, corrosion-resistant steel. Ensure that the box dimensions and thickness of the sheet steel conform to UL 50.

][i. Provide cast-iron enclosures of gray-iron castings conforming to ASTM A48/A48M with tensile-strength classification suitable for this application. Provide cast-metal enclosures that are not less than 1/8 inch thick at every point, of greater thickness at reinforcing ribs and door edges, and not less than 1/4 inch thick at tapped holes for conduits.

]2.2.3 Fuses

Provide a complete set of fuses for all switches and switchgear. Ensure that fuses have a voltage rating of not less than the circuit voltage.

Make no change in continuous-current rating, interrupting rating, or clearing or melting time of fuses unless written permission is first obtained from the Contracting Officer.

Provide nonrenewable-cartridge-type fuses for ratings 30 A, 125 V or less. Provide renewable-cartridge-type fuses for ratings above 30 A 600 V or less with time-delay dual elements, except where otherwise indicated. Ensure that fuses conform to NEMA FU 1.

Install special fuses such as extra-high interrupting-capacity fuses, fuses for welding machines, and capacitor fuses where required. Do not use plug fuses.

Label fuses showing UL class, interrupting rating, and time-delay characteristics, when applicable.

Provide porcelain fuse holders when field-mounted in a cabinet or box. Do not use fuse holders made of such materials as ebony asbestos, Bakelite, or pressed fiber for field installation.

2.2.4 Control Devices

2.2.4.1 Magnetic Contactors

Provide magnetic contactors in accordance with NEMA ICS 1 and NEMA ICS 2 as required for the control of low-voltage, 60-Hz, tungsten-lamp loads, fluorescent-lamp loads, resistance-heating loads, and the primary windings of low-voltage transformers.

Provide core-and-coil assembly that operates satisfactorily with coil voltage between 85 percent and 110 percent of its voltage rating.

Provide contactors that are designed with a normally open holding-circuit auxiliary contact for control circuits, with a rating in accordance with NEMA ICS 1 and NEMA ICS 2.

Furnish solderless pressure wire terminal connectors, or make available for line and load connections to contactors in accordance with NEMA ICS 1

and NEMA ICS 2.

Provide magnetic contactors with a rating in accordance with NEMA ICS 1 and NEMA ICS 2.

2.2.4.2 Control-Circuit Transformers

Provide control-circuit transformers within the enclosure of magnetic contactors and motor controllers when the line voltage exceeds 120 V. Provide an encapsulated dry-type, single-phase, 60-Hz transformer, with a 120 V (or 24 V) isolated secondary winding.

Do not provide a transformer with a rated primary voltage less than the rated voltage of the controller, or a rated secondary current less than the continuous-duty current of the control circuit.

Provide voltage regulation of the transformer such that, with rated primary voltage and frequency, the secondary voltage is not less than 95 percent nor more than 105 percent of rated secondary voltage.

Provide a source of supply for control-circuit transformers at the load side of the main disconnecting device. Protect the secondary winding of the transformer and control-circuit wiring against overloads and short circuits, with fuses selected in accordance with NEMA ICS 6. Ground the secondary winding of the control-circuit transformer in accordance with NEMA ICS 6.

2.2.4.3 Magnetic Control Relays

Provide magnetic control relays for energizing and de-energizing the coils of magnetic contactors or other magnetically operated devices, in response to variations in the conditions of electric control devices in accordance with NEMA ICS 1, and NEMA ICS 2.

Ensure that the core-and-coil assembly operates satisfactorily with coil voltages between 85 percent and 110 percent of their voltage rating.

Provide relays that are designed to accommodate normally open and normally closed contacts.

Provide [120] [_____] V, 60-Hz, Class [AIB] [_____] magnetic control relays with a continuous--contact rating of 10 A, and with current-making and -breaking ability in accordance with NEMA ICS 1 and NEMA ICS 2, two normally open and two normally closed.

2.2.4.4 Pushbuttons and Switches

a. Pushbuttons

For low-voltage ac full-voltage magnetic pushbutton controllers, provide heavy-duty, oiltight NEMA 250, Type [12] [_____], momentary-contact devices rated 600 V, with pilot light, and with the number of buttons and the marking of identification plates as shown. Furnish pushbutton color code in accordance with NEMA ICS 6.

Provide pushbuttons that are designed with normally open, circuit-closing contacts; normally closed circuit-opening contacts; and two-circuit normally open and normally closed circuit-closing and -opening contacts. Ensure that pushbutton-contact ratings are in accordance with NEMA ICS 1

and NEMA ICS 2, with contact designation A600.

Identify pushbuttons in remote-control stations with identification plates affixed to the front cover in a prominent location. Identify the system being controlled on the identification plate.

b. Selector Switches

Provide heavy-duty, oiltight, maintained-contact selector switches for low-voltage control circuits, with the number of positions and the marking of identification plates in accordance with NEMA ICS 1 and NEMA ICS 2.

Identify selector switches in remote-control stations with engraved identification plates affixed to the front cover in a prominent location. Identify the system being controlled on the identification plate.

c. Ammeter Selector Switches

Provide rotary, multistage, snap-action-type ammeter selector switches for switchgear in accordance with UL 20. Use silver-plated contacts rated for 600 V, ac or dc. Provide a manually operated, four-position selector switch rated for 600 V, 20 A, minimum. Ensure that the switch is designed to select the display of current readings on each bus of the main bus from a single indicating instrument. Mount the ammeter switch on the hinged front panel of the switchgear compartment, with engraved escutcheon plate. Completely isolate the switch from high-voltage circuits.

Provide a [pistol-grip] [oval]-type selector switch handle.

d. Voltmeter Selector Switches

Provide rotary, snap-action-type voltmeter selector switches for switchgear in accordance with UL 20. Use silver-plated contacts rated for 600 V ac or dc. Provide manually operated, four-position switches designed to select the display of voltage readings on each phase of the main bus from a single indicating instrument. Mount the voltmeter switch on the hinged front panel of the switchgear compartment, with engraved escutcheon plate. Completely isolate the switch from high-voltage circuits.

Provide a [pistol-grip] [oval]-type selector switch handle.

e. Miscellaneous Switches

Provide float, limit, door, pressure, proximity, and other types of switches in accordance with IPC D330 and of the types and classes indicated.

2.2.5 Finish

Protect metallic materials against corrosion. Provide equipment with the standard finish by the manufacturer when used for most indoor installations. For harsh indoor environments (any area subjected to chemical or abrasive action) and all outdoor installations, refer to Section 09 96 00 HIGH-PERFORMANCE COATINGS.

2.3 COMPONENTS

2.3.1 Instrument Transformers

Comply with the interference requirements listed below, measured in accordance with IEEE C63.2, and IEEE C63.4 for Instrument transformers.

Insulation Class kV	Basic Insulation Level kV	Nominal System Voltage kV	Preferred Test Voltage for Potential Transformers kV	Test Voltage for Current Transformers kV	Radio Influence Voltage Level, Microvolts	
					Dry Type	Oil Filled
0.6	10	----	----	0.76	250	250
1.2	30	0.208 0.416 0.832 1.04	0.132 0.264 0.528 0.66	0.76	250	250
2.5	45	2.40	1.52	1.67	250	250
5.0	60	4.16 4.80	2.64 3.04	3.34	250	250
8.7	75	7.20 8.32	4.57 5.28	5.77	250	250
15L or 15H	95 - 110	12.00 12.47 14.40	7.62 7.92 9.14	9.41	1000	250
25	150	23.00	14.60	15.70	2500	650
34.5	200	34.50	21.90	23.0	----	650
46	250	46.00	29.20	29.30	----	1250
69	350	69.00	43.80	44.00	----	1250
92	450	92.00	58.40	58.40	----	2500
115	550	115.00	73.40	73.40	----	2500
138	650	138.00	88.00	88.00	----	2500

2.3.1.1 Current Transformers

Ensure that current transformers conform to IEEE C57.13 for installation in metal-clad switchgear. Use a standard 3-A secondary transformer.

Provide [wound] [bushing] [bar] [window]-type transformers.

Provide transformers that have [single] [double] secondary winding.

Provide transformers that are complete with a secondary short-circuiting device.

For window-type current transformers, provide indoor, dry-type construction, with secondary current ratings as indicated with the specified burden, frequency, and accuracy.

2.3.1.2 Potential Transformers

For potential transformers, conform to IEEE C57.13 for installation in metal-clad switchgear. Use standard 120-volt secondary transformers.

Provide transformers that have [single] [tapped] [double] secondary winding.

Provide burden, frequency, and accuracy as required.

For disconnecting potential transformers with integral fuse mountings and current-limiting fuses, provide indoor, dry-type two-winding construction with primary and secondary voltage ratings as required.

2.3.2 Enclosures

2.3.2.1 Equipment Enclosures

Provide enclosures for equipment in accordance with NEMA 250.

[Contain equipment that is installed inside clean, dry locations in a NEMA Type 1, general-purpose sheet-steel enclosure.

][Contain equipment that is installed in wet locations in a NEMA Type 4, watertight, corrosion-resistant, sheet-steel enclosure. Construct the enclosure to prevent entrance of water when tested in accordance with NEMA ICS 6 for Type 4 enclosures.

][Contain equipment that is installed in industrial locations in a NEMA Type 12, industrial-use, sheet-steel enclosure. Construct the enclosure to prevent the entrance of dust, lint, fibers, and flyings and the seepage of oil and coolant.

][Contain equipment that is installed in Class I, Division 1, Group A, B, C, and D, hazardous locations, in NEMA Type 7 enclosures approved for the specific flammable gas or vapor that is possibly present under normal operating conditions.

][Contain equipment that is installed in Class II, Division 1, Group E, F and G, hazardous locations, in NEMA Type 9 enclosures approved for use where combustible dust is possibly present under normal operating conditions.

][Fabricate sheet-steel enclosures from uncoated carbon sheet-steel of commercial quality. Ensure that the box dimensions and thickness of sheet-steel conform to UL 50.

][Fabricate steel enclosures from corrosion-resistant, chromium-nickel sheet-steel conforming to ASTM A240/A240M Type 300 series with ASM No. 4, general-purpose, polished finish. Ensure that the box dimensions and

thickness of sheet steel conform to UL 50.

][Provide cast-iron enclosures from gray-iron castings conforming to ASTM A48/A48M with a tensile-strength classification recognized as suitable for the application. Provide cast-metal enclosures that are not less than 1/8 inch thick at every point, of greater thickness at reinforcing ribs and door edges, and not less than 1/4 inch thick at tapped holes for conduits.

]2.3.2.2 Remote-Control Station Enclosures

Provide remote-control station enclosures for pushbuttons, selector switches, and indicating lights in accordance with NEMA ICS 6 and NEMA 250.

[Contain remote-control stations installed in indoor, clean, dry locations in NEMA Type 1 general-purpose, sheet-steel enclosures. Contain recessed remote-control stations in standard wall outlet boxes with matching corrosion-resistant-steel flush cover plates.

][Contain remote-control stations installed in wet locations in NEMA Type 4, watertight, corrosion-resistant, sheet-steel enclosures. Construct enclosures to prevent entrance of water when tested in accordance with NEMA ICS 6 and NEMA 250 for Type 4 enclosures.

][Contain remote-control stations installed in wet locations in NEMA Type 4, watertight, cast-iron enclosures. Construct enclosures to prevent entrance of water when tested in accordance with NEMA ICS 6 and NEMA 250 for Type 4 enclosures.

][Contain remote-control stations installed in dry, noncombustible, dust-laden atmospheres in NEMA Type 12, dusttight, cast-iron enclosures, with gaskets or their equivalent to prevent the entrance of dust.

][Contain remote-control stations installed in industrial locations in NEMA Type 12, industrial-use, sheet-steel enclosures. Construct enclosures to prevent the entrance of dust, lint, fibers, and flyings and the seepage of oil and coolant.

][Contain remote-control stations installed in industrial locations in NEMA Type 12, industrial-use, cast-iron enclosures. Construct enclosures to prevent the entrance of dust, lint, fibers, and flyings and the seepage of oil and coolant.

][Contain remote-control stations installed in Class I, Division 1, Group A, B, C, and D, hazardous locations in NEMA Type 7 enclosures, approved for the specific flammable gas or vapor that is possibly present under normal operating conditions.

][Contain remote-control stations installed in Class II, Division 1, Group E, F and G, hazardous locations in NEMA Type 9 enclosures, approved for use where combustible dust is possibly present under normal operating conditions.

][Fabricate sheet-steel enclosures from uncoated carbon steel sheets of commercial quality, with box dimensions and thickness of sheet steel conforming to UL 50.

][Fabricate steel enclosures from corrosion-resistant, chromium-nickel sheet-steel, conforming to ASTM A240/A240M, Type 300 series with ASM No.

4, general-purpose, polished finish. Ensure that the box dimensions and thickness of the sheet steel conform to UL 50.

][Provide cast-iron enclosures of gray-iron castings, conforming to ASTM A48/A48M, with tensile-strength classification recognized as suitable for this application. Provide cast metal enclosures that are not less than 1/8 inch thick at every point, of greater thickness at reinforcing ribs and door edges, and not less than 1/4 inch thick at tapped holes for conduit.

] Install remote-control stations with the centerline 66 inches above the finished floor.

2.3.3 Time Switches

Provide time switches for the control of tungsten-lamp loads, fluorescent-lamp loads, resistive-heating loads, motors, and magnetically operated devices, consisting of a motor-driven time dial and switch assembly in a NEMA 250, Type 1, general-purpose enclosure.

Provide motor drives consisting of 120-V, single-phase, 60-Hz, heavy-duty, self-starting synchronous motors directly connected to the time dial through a geartrain operating mechanism. Provide a spring-wound stored-energy source of reserve power that automatically operates the mechanism for a period of at least 12 hours in case of electric power failure. Ensure that the spring automatically rewinds electrically in not more than 3 hours after electric power is restored.

Include a heavy-duty, general-purpose, precision snap-action switch conforming to UL 20 for the switch mechanism, with provisions for manual "OFF" and "ON" operation of the switch.

Provide time switches for the control of 120/240-V, two- and three-wire, single-phase, 60-Hz circuits and 120/208-V, three-phase, four-wire, 60-Hz circuits, with a continuous-current tungsten-lamp load rating of 35 A.

[Provide 24-hour time dials with adjustable on and off trippers for repetitive switching operations at the same time each day. Calibrate the dials in 15-minute intervals over a 24-hour period around its circumference. Provide dials that make one revolution in the 24-hour period. Make provision to defeat the switching operation over weekends or up to 6 preselected calendar days each week. Provide time dials that have a minimum "ON" time setting of not more than 20 minutes, and are fully adjustable upward in 15-minute intervals throughout each day.

][Provide 7-day-type time dials with adjustable on and off trippers for programmed switching operations for each day in the week. Provide a dial that makes one revolution in not more than 2 1/2 hours, and is fully adjustable upward in 2-hour intervals throughout each day. Calibrate the dial in 2-hour intervals for each day and for each day in the week around its circumference.

][Provide astronomic-type time dials that automatically change settings each day, in accordance with the seasonal time changes in sunrise and sunset. Provide astronomic-type dials that have adjustable on and off trippers, for repetitive switching operations at solar time each day and at each day in the year and that make one revolution in a 24-hour period. Provide time dials that are designed to operate in the "ON" position at sunset and be fully adjustable upward in 15-minute intervals throughout each day, and

that indicate the day and month of the year. Calibrate the dials in 15-minute intervals over a 24-hour period around its circumference. Provide a method to defeat the switching operation over weekends or up to 6 preselected calendar days each week.

]2.3.4 Protective Relays

2.3.4.1 Overcurrent Relays

Provide a trip unit that employs a combination of discrete components and integrated circuits to ensure the time-current protection functions as required in a modern, selectively coordinated distribution system.

Conform relays to IEEE C37.90 for overcurrent relays.

For protection against phase and ground faults, provide single-phase nondirectional, removable, induction-type overcurrent relays with built-in testing facilities designed for operation on the dc or ac control circuit indicated.

Provide ground-fault overcurrent relays with short-time inverse-time characteristics with adjustable current tap range as required.

Provide phase-fault overcurrent relays with varied inverse-time characteristics with adjustable current tap range as required. Provide attachments that indicate instantaneous trip with adjustable current range as required.

Provide solid-state, static-type trips for low-voltage power circuit breakers in accordance with EIA 443 and IEEE C37.17.

Provide complete system-selective coordination by using a combination of the following time-current curve-shaping adjustments: ampere setting; long-time delay; short-time pickup; short-time delay; instantaneous pickup; and ground fault.

Provide switchable or easily defeatable instantaneous and ground fault trips.

Make all adjustments using nonremovable, discrete-step, highly reliable switching plugs for precise settings. Provide a sealable, transparent cover over the adjustments to prevent tampering.

Furnish trip devices with three visual indicators to denote the automatic tripping mode of the breaker, including overload, short circuit, and ground fault.

Wire the trip unit to the appropriate terminals so that an optional, remote, automatic trip accessory can be used to provide the same indication.

Make available for use a series of optional, automatic trip relays for use with the trip unit to provide remote alarm and lockout circuits.

Provide all trip units with test jacks for in-service functional testing of the long-time instantaneous and ground-fault circuits using a small handheld test kit.

2.3.4.2 Directional Overcurrent Relays

Provide directional overcurrent relays in accordance with IEEE C37.90.

For protection against reverse-power faults, provide single-phase induction relays with adjustable time-delay and instantaneous trip attachments. Provide removable-type relays with inverse-time directional and overcurrent units with built-in testing facilities.

2.3.4.3 Reclosing Relays

Ensure that reclosing relays conform to IEEE C37.90.

Provide reclosing relays that reclose circuit breakers that have tripped from overcurrent. Provide a device that automatically recloses the breaker at adjustable time intervals between reclosures and then locks out the breaker in the open position if the fault persists. Ensure that if the fault disappears after any reclosure, the circuit breaker remains closed and the reclosing relay resets automatically and is ready to start a new sequence of operation.

Provide removable reclosing relays that have built-in testing facilities and that consist of a timing unit rated at 120/240 V, single-phase, ac and solenoid and contactor units with dc rating as indicated. Arrange contacts for one instantaneous reclosure and two subsequent reclosures at 15 and 45 seconds, respectively. Set the time dial for 60-second drum speed.

2.3.4.4 Undervoltage Relays

Ensure that undervoltage relays conform to IEEE C37.90.

Provide three-phase, induction-type undervoltage relays, including inverse timing with adjustable high- and low-voltage contacts and calibrated scale. Equip relays with indicating contactor and voltage switches to provide electrically separate contact circuits. Provide relays that are removable with built-in testing facilities and that are suitable for operation on 120 V ac circuits, with contacts that are suitable for operation on dc or ac control circuits.

2.3.5 Indicating Instruments

2.3.5.1 Ammeters

[Provide switchboard indicating ammeters of approximately 4 1/2 inches square with 250-degree scale and recessed cases suitable for flush mounting. Furnish white dials with black figures and black pointers. Mount instruments on the hinged front panel of the switchgear compartment, completely isolated from high-voltage circuits. Provide a standard 5-ampere-type meter for a zero-to-full-scale normal movement, 60 Hz.

]2.3.5.2 Voltmeters

[Provide switchboard indicating voltmeters that are approximately 4 1/2 inches square with 250-degree scale and recessed cases suitable for flush mounting. Furnish white dials with black figures and black pointers. Mount instruments on the hinged front panel of the switchgear compartment, completely isolated from high-voltage circuits. Provide a standard 120-volt-type voltmeters for zero-to-full-scale normal movement, 60 Hz.

]2.3.5.3 Watt-Hour Meters/Wattmeters

Provide watt-hour meters, wattmeters, and pulse initiation meters conforming to ANSI C12.1.

Provide three-phase induction-type switchboard wattmeters for use with instrument transformers with two stators, each equipped with a current and potential coil. Provide a meter rated for 5 A at 120 V and suitable for connection to three-phase, three- and four-wire circuits. Provide the instrument complete with potential-indicating lamps, light-load and full-load adjustments, phase balance, power-factor adjustments, four-dial clock register, ratchets to prevent reverse rotation, and built-in testing facilities.

For use with demand meters or pulse recorders, provide pulse-initiating meters that are suitable for use with either mechanical or electrical pulse initiators. Ensure that the mechanical load imposed on the meter by the pulse initiator is within the limits of the pulse meter. Provide a load as constant as practical throughout the entire cycle of operation to ensure accurate meter readings. Provide a pulse-initiating meter that is capable of measuring the maximum number of pulses at which the pulse device is nominally rated. Consider the pulse-initiating meter to be operating properly when a kilowatt-hour check indicates that the demand meter kilowatt-hours are within limits of the watt-hour meter kilowatt-hours.

Locate pulse-initiating meters such that components sensitive to moisture and temperature conditions are minimized. Take precautions to protect sensitive electronic metering circuitry from electromagnetic and electrostatic induction.

Furnish removable meters with draw-out test plugs and furnish contact devices to operate remote impulse-totalizing graphic demand meters.

2.3.5.4 Graphic Demand Meters

Provide impulse-totalizing graphic demand meters conforming to ANSI C12.1.

Provide impulse-totalizing graphic demand meters that are suitable for use with switchboard watt-hour meters and include the following: a two-circuit totalizing relay, cyclometer for cumulative record of impulses, four-dial totalizing kilowatt-hour register, synchronous motor for timing mechanism, torque motor, and chart drive. Provide a positive chart-drive mechanism, consisting of chart spindles and drive sprockets, that maintains the correct chart speed for roll strip charts. Provide an instrument that records, as well as indicates, on clearly legible graph paper, the 15-minute integrated kilowatt demand of the totalized system.

Furnish the motive power for advancing the register and pen-movement mechanism with a torque motor. Provide a capillary pen containing a 1-month ink supply. Provide roll charts with a 31-day continuous record of operation capacity.

2.3.5.5 Specialty-Type Meters

Specialty-type meters are panel meters applicable to specific situations, such as pyrometers and dc parameter meters that conform to the panel layout specified. Provide meter scales that are at least 180 degrees. Do

not use edgewise meters for circuit current and voltage measurements.

2.3.6 Indicating Lights

2.3.6.1 General-Purpose Type

For indicating lights, provide oiltight instrument devices with threaded base and collar for flush mounting; translucent convex lens; candelabra screw-base lampholder; and 120 V, 6 W, Type S-6 incandescent lamp in accordance with ANSI C78.23. Provide indicating lights that are color-coded in accordance with NEMA ICS 6.

Provide indicating lights in remote-control stations when pushbuttons and selector switches are out of sight of the controller.

2.3.6.2 Switchboard Indicating Lights

For switchboard indicating lights, provide the manufacturer's standard transformer-type units [120 V input] [_____] using low-voltage lamps and convex lenses of the colors indicated. Provide indicating lights that are capable of being relamped from the switchboard front. Do not use indicating lights that use resistors in series with the lamps, except in dc control circuits. Provide lights that have a press-to-test feature.

[2.4 TESTS, INSPECTIONS, AND VERIFICATIONS

2.4.1 Factory Testing

Obtain factory test results on [_____] control and low-voltage protective devices.

]PART 3 EXECUTION

3.1 INSTALLATION

Clearly list fuse information on equipment drawings.

Install control devices and protective devices that are not factory-installed in equipment, in accordance with the manufacturer's recommendations. Field-adjust the devices. Perform operation tests on the control and protective devices. Conform requirements for installation of control and protective devices to NFPA 70, NEMA ICS 1, and NEMA ICS 2.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

Demonstrate the operation and controls of protective devices of non-factory-installed equipment.

Verify tap settings of instrumentation, potential, and current transformers.

Perform dielectric tests on insulating oil in oil circuit breakers before the breakers are energized. Test oil in accordance with ASTM D877/D877M, and provide breakdown voltage that is not less than 25,000 V. Provide manufacturer certification that the oil contains no PCB's, and affix a label to that effect on each breaker tank and on each oil drum containing the insulating oil.

Field-adjust reduced-voltage starting devices to obtain optimum operating conditions. Provide test meters and instrument transformers that conform to ANSI C12.1 and IEEE C57.13.

Do not energize control and protective devices until the results of the recorded test data have been approved by the Contracting Officer. Provide final test reports with a cover letter/sheet clearly marked with the system name, date, and the words final test reports to the Contracting Officer for approval.

-- End of Section --

SECTION 26 08 00

APPARATUS INSPECTION AND TESTING
11/21

PART 1 GENERAL

1.1 REFERENCES

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

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

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

1.2 RELATED REQUIREMENTS

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

1.3 SUBMITTALS

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

SD-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 (Level III) or the National Institute for Certification in Engineering Technologies (NICET) with a minimum of 5 years' experience inspecting, testing, and calibrating electrical distribution and generation equipment, systems, and devices.

1.4.2 Acceptance Tests and Inspections Reports

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

1.4.3 Acceptance Test and Inspections Procedure

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

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 ACCEPTANCE TESTS AND INSPECTIONS

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

[a. Section 26 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

][c. Section 26 12 21 SINGLE-PHASE 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.

][f. Section 26 13 00 SF6/HIGH-FIREPOINT FLUID INSULATED PAD-MOUNTED SWITCHGEAR

][g. Section 26 11 16 SECONDARY UNIT SUBSTATIONS

][h. Section 26 11 13.00 20 PRIMARY UNIT SUBSTATION

][i. Section 26 36 23 AUTOMATIC TRANSFER SWITCHES AND BY-PASS/ISOLATION SWITCH

][j. Section 26 23 00 LOW VOLTAGE SWITCHGEAR

][k. Section 26 24 13 SWITCHBOARDS

][l. Section 26 35 43 400 HERTZ ((HZ) SOLID STATE FREQUENCY CONVERTER. The NETA ATS representative must coordinate with the Contractor and the Converter Manufacturers' representative to witness, document, and validate the Converter Field Quality Control, Inspection and Testing. These tests will be performed by the converter manufacturers' representative, however include the documentation in the overall NETA report as well.

][m. Section 26 35 44 270 VDC SOLID STATE CONVERTER. The NETA ATS representative must coordinate with the Contractor and the Converter Manufacturers' representative to witness, document, and validate the Converter Field Quality Control, Inspection and Testing. These tests will be performed by the converter manufacturers' representative, however include the documentation in the overall NETA report as well.

]3.2 SYSTEM ACCEPTANCE

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

3.3 PLACING EQUIPMENT IN SERVICE

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

-- End of Section --

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SECTION 26 24 16.00 40

PANELBOARDS
08/19

PART 1 GENERAL

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to work specified in this section.

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 D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA RS-416	(1974; R 1981) Filters for Radio Interference
ECIA/IS 46	(1987) Test Procedure for Resistance to Soldering (Vapor Phase Technique) for Surface Mount Devices

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA PB 1	(2011) Panelboards

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

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-HDBK 232	(1987; Rev A; Notice 1 1988; Notice 2 2000; Notice 3 2014) Red/Black Engineering - Installation Guidelines

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595	(Rev C; Notice 1) Colors Used in Government Procurement

UNDERWRITERS LABORATORIES (UL)

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 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
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 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021) UL Standard for Safety Surge Protective Devices
UL 1699	(2017; Reprint Nov 2020) UL Standard for Safety Arc-Fault Circuit-Interrupters

1.2 SUBMITTALS

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

SD-03 Product Data

Panelboards; G, MECH-1, MECH-2

Filtered Panelboards; G, MECH-1, MECH-2

SD-06 Test Reports

Acceptance Tests; G, MECH-1, MECH-2

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

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

Products manufactured more than 3 years prior to date of delivery to site are not to be used, unless specified otherwise.

PART 2 PRODUCTS

2.1 PANELBOARDS

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

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

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

layout, overall physical features, dimensions, ratings, service requirements, and weights of equipment.

2.2 COMPONENTS

2.2.1 Enclosure

Ensure panelboard enclosures are NEMA 250, Type 3R as indicated and in accordance with UL 50 and NEMA PB 1.

Provide flush-mountedor surface mounted panelboard cabinets as indicated. Ensure cabinets are constructed of 12 gauge sheet steel and hot-dipped galvanized after fabrication. Ensure front of cabinet is form-flanged or fitted with structural shapes welded or riveted to the sheet steel for supporting the panelboard front. Provide panelboard cabinets fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than 1/8 inch. Provide holes 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.

Provide door-in-door style cover where entire front is hinged on one side with a piano hinge for the full height and has keyed latch mechanism opposite the hinged side. Provide side gutters in enclosure measuring minimum 5.75 inches for routing of wiring. Where panelboards are installed flush with the walls, ensure that the hinged front can be opened without damage to the adjacent wall surfaces. Ensure circuit breaker access doors are equipped with pin-tumbler cylinder locks. Ensure all locks provided, including locks for hinged covers, are identically keyed and properly tagged. Provide two keys for each enclosure.

Finish panelboards with baked enamel. Finish color is ASTM D1535 No. 61 gray conforming to FED-STD-595.

2.2.2 Panelboard Buses

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

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

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping.

[2.2.2.1 Panelboard Neutrals for Non-Linear Loads

Where indicated, provide panelboard specifically listed for use on non-linear loads. Ensure panelboards are 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. [Provide verification of testing procedure.]Two neutral assemblies paralleled together with cable is not acceptable. Ensure panel is marked "SUITABLE FOR NON-LINEAR LOADS" with field fabricated nameplate and provide a neutral label with instructions for wiring of panelboard.

]2.2.3 Circuit Breakers

Provide circuit breakers that conform to UL 489 and NEMA AB 3 and as specified in Section 26 05 71.00 40 LOW VOLTAGE OVERCORRECT PROTECTIVE DEVICES with frame a trip ratings as indicated.

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

Provide inverse-time-delay thermal-overload protection and instantaneous magnetic short-circuit protection. Provide an instantaneous thermal-magnetic tripping element that is adjustable and accessible from the front of the breaker on frame sizes larger than 100 ampere.

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

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

Provide a phenolic-composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required to meet lock-out/tag-out requirements of NFPA 70E.

Provide shunt trips where indicated.

Ensure branch circuit breakers supplying convenience receptacle circuits have sensitive instantaneous trip settings of not more than 10 times the trip rating of the breaker to prevent repeated arcing shorts resulting from frayed appliance cords. Provide UL listed single-pole 15- and 20-ampere circuit breakers as "Switching Breakers" at 120 volts ac .

When multiple wires per phase are specified, furnish the circuit breakers with connectors made to accommodate multiple wires.

Ensure circuit breaker spaces called out on the drawings are complete with mounting hardware to permit ready installation of the circuit breakers.

2.2.3.1 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.

2.2.3.2 Circuit Breaker With Ground-Fault Circuit Interrupter

UL 943 and NFPA 70. Provide with "push-to-test" button, visible indication of tripped condition, and ability to detect and trip on current imbalance of 6 milliamperes or greater per requirements of UL 943 for Class A ground-fault circuit interrupter. Tripping of a branch circuit breaker containing ground fault circuit interruption is not to disturb the feeder circuit to the panelboard.

2.2.3.3 Circuit Breakers for HVAC Equipment

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

2.2.3.4 Arc-Fault Circuit Interrupters

UL 489, UL 1699 and NFPA 70. Molded case circuit breakers: rated as indicated. Two pole arc-fault circuit-interrupters: rated 120/240 volts. The provision of (two) one pole circuit breakers for shared neutral circuits in lieu of (one) two pole circuit breaker is unacceptable. Provide with "push-to-test" button.

2.2.4 Directory Card and Holder

Provide a directory card on the inside of hinged fronts and doors under non-flammable plastic, with spaces for circuit numbers and load supplied. Where hinged fronts or doors are not required, provide the directory card under plastic mounted on the left-hand side of the front trim. Ensure the directory card includes type written designations identifying each branch circuit with its respective and numbered circuit breaker.

2.2.5 Filtered Panelboards

2.2.5.1 General

Design panelboards for the distribution, control, and protection of electrical circuits, providing filtering and shielding performance and, when specified, conforming to MIL-HDBK 232.

Provide panelboard cabinet with 12-gauge steel minimum, corrosion-resistant finish and four external mounting brackets welded to the case. Provide code-gauge steel front door and trim, with ASTM D1535 No. 61 gray finish, equipped with directory, holder, adjustable trim clamps, hinges, self-latching catch, tumbler lock and key and bears the UL label. Provide a red diagonal strip across the outside surface of door and trim.

2.2.5.2 RF Shielding

Ensure circuit breaker and filter compartments are completely radio-frequency (RF) shielded and in compliance with specified shielding requirements with front door open. Ensure case seams are continuous inert gas welded. Fit removable circuit breaker actuator faceplate and the filter compartment cover with corrosion-resistant RF gasketing material. Install in place with suitable fasteners having a maximum spacing of 3 inches on center. Mount RF filter units to the internal shield wall with similar RF gasketing to ensure RF shielding integrity.

2.2.5.3 Circuit Breaker Actuators

Design circuit breaker operating mechanisms to maintain RF shielding effectiveness without limit to time or number of operations.

2.2.5.4 Terminals

Ensure filter terminals are high-temperature alumina ceramic, continuously brazed to filter case. Do not use soft solder. Provide ceramic terminals that incorporate a permanently attached flexible lead, with a suitable electric lug. Make incoming service connections to the filter lead at a UL-approved, flame-retardant standoff insulator, mounted in the filter compartment.

2.2.5.5 Attenuation

Ensure each filter provides a minimum insertion loss of 100 dB over the frequency range of 14 kilohertz (kHz) to 10 gigahertz (GHz) . Ensure each filter provides a full rated load insertion loss of 100 dB in the frequency range 14 kHz to 20 megahertz (MHz), to 14 kHz as measured by a Government-approved laboratory.

2.2.5.6 Current

Ensure each filter unit is capable of carrying its full rated current continuously without heat rise exceeding 122 degrees F above ambient temperature. Ensure each filter is capable of withstanding a 100 -percent overload for 30 seconds without damage.

2.2.5.7 Voltage

Ensure each filter unit is capable of continuous operation at its full rated voltage and withstanding an initial voltage test of twice its rated voltage without damage.

2.2.5.8 Circuit Breakers

Ensure circuit breakers are rated a minimum 10,000 amperes asymmetrical ac interrupting capacity, 5,000 amperes dc, and are in accordance with UL 489.

2.2.5.9 RF Filters

Design RF filter units to suppress and reduce the amplitude of undesired RF energy conducted by power service lines. Design RF filter units in compliance with the applicable requirements of ECIA RS-416.

Provide filter cases made of steel, 16-gaugeminimum, corrosion-resistant finish with a blue lacquer over zinc chromate primer. Use conductive

grounding surfaces that are either plated or made of corrosion-resistant steel. Use continuous inert gas welds for hermetic seams; do not use soft solder. Firmly mount internal components to withstand applicable shock and vibration test requirements without damage.

Ensure internal components are fully impregnated and immersed in the fluid to obtain the full benefit of cooling by convection flow through the liquid medium to filter case. Completely fill filter case with the fluid. Ensure fluid conforms to UL nonflammable classification.

2.2.5.10 Filter Discharge Unit

Provide a filter discharge unit for three-filtered circuits on the panelboard. Install in accordance with NFPA 70. Ensure unit meets applicable requirements of ECIA/IS 46

2.2.6 Surge Protective Devices

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the , panelboards . Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker. Ensure SPDs are of the Metal Oxide Varistor (MOV) type and rated have fault current rating equal to or greater than the rating of the device to be protected. Where internal fuses are used, ensure fuses will allow maximum rated surge to pass without operating fuse.

Provide SPDs that are factory installed and integrated with the equipment to be protected. Ensure factory installed SPDs are supplied through a dedicated circuit breaker or are directly connected to the bus with no wire between bus bare and SPD.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Phase to phase (L-L)
Each phase to neutral (L-N)
[Neutral to ground (N-G)]
[Phase to ground (L-G)]

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

] SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G)[and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G)].

Provide SPDs per NFPA 780 for the lightning protection system.

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

600V for 208Y/120V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 208Y/120V, three phase system

Provide SPDs. Maximum L-N, L-G, and N-G Voltage Protection Rating:

700V for 208Y/120V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 208Y/120V, three phase system

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

Provide EMI/RFI filtering per UL 1283 for each mode with the capability to attenuate high frequency noise. Minimum attenuation: 20db.

2.2.7 Precautionary Label

To ensure persons are aware of immediate or potential hazard in the application, installation, use, or maintenance of panelboards, conspicuously mark each panelboard on the trim or dead front shield with the text (or equivalent) **DANGER** symbol. If the panel is supplied with a door, ensure the label is visible when the door is in the open position.

2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

Provide panelboards in compliance with UL 67.

PART 3 EXECUTION

3.1 INSTALLATION

Install panelboards in accordance with the manufacturer's instructions. Fully align and mount panels so that the height of the top operating handle does not exceed 72inches above the finished floor.

Ensure directory-card information is typewritten in capital letters to indicate loads served by each circuit and is mounted in holders behind protective covering.

3.2 FIELD QUALITY CONTROL

Do not energize panelboards until the recorded test data has been submitted to and approved by the Contracting Officer.

Provide test equipment, labor, and personnel as required to perform the acceptance tests as specified. Record and submit test data. Include the location and identification of panelboards and megohm readings versus time.

Conduct continuity tests using a dc device with bell . Document results as pass-fail.

Conduct continuity and insulation tests on the panelboards after the installation has been completed and before the panelboard is energized. Document results as pass-fail.

Conduct insulation tests on 480-volt panelboards using a 1,000-volt insulation-resistance test set. Record readings every minute until three equal and consecutive readings have been obtained. Ensure resistance between phase conductors and between phase conductors and ground is not less than 50 megohms.

Conduct insulation tests on panelboards rated 300 volts or less using a 500-volt minimum insulation-resistance test set. Record readings after 1 minute and until the reading is constant for 15 seconds. Ensure resistance between phase conductors and between phase conductors and ground is not less than 25 megohms.

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

3.3 CLOSEOUT ACTIVITIES

Submit manufacturer's instructions for panelboards including special provisions required to install equipment components and system packages. Provide special notices details impedances, hazards and safety precautions.

-- End of Section --

SECTION 26 28 01.00 10

COORDINATED POWER SYSTEM PROTECTION
08/21

PART 1 GENERAL

1.1 REFERENCES

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

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

1.2 SYSTEM DESCRIPTION

The power system covered by this specification consists of: [_____].

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.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fault Current Analysis

Protective Device Coordination Study

System Coordinator

1.4 QUALITY ASSURANCE

1.4.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis must 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. Provide experience data consisting of at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers.

PART 2 PRODUCTS

2.1 COORDINATED POWER SYSTEM PROTECTION

Prepare analyses to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. Include a load flow analysis, a fault current analysis, and a protective device coordination study. Submit the study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government is not 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 must 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.

2.1.1 Scope of Analyses

The fault current analysis and protective device coordination study must 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.] [the source bus and extended through the secondary side of transformers for medium voltage distribution feeders.] [the source bus and extend through [outgoing breakers] [outgoing medium voltage feeders, down to the individual protective devices for medium voltage radial taps] [outgoing medium voltage feeders, through the secondary side of transformers] [as indicated] for main electric supply substations.] [the nearest upstream device in the existing source system and extend through the downstream devices at the load end.]

2.1.2 Determination of Facts

Determine and document the time-current characteristics, features, and nameplate data for each existing protective device. [Coordinate with the [commercial power company] [_____] for fault current availability at the site.] [Utilize the fault current availability indicated as a basis for fault current studies.]

2.1.3 Single Line Diagram

Prepare a single line diagram 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 must have a unique identifier. If a fault-impedance diagram is provided, show impedance data. Show location of switches, breakers, and circuit interrupting devices on the diagram together with available fault data, and the device interrupting rating.

2.1.4 Fault Current Analysis

2.1.4.1 Method

Perform the fault current analysis in accordance with methods described in

IEEE 242, and IEEE 399.

2.1.4.2 Data

Utilize actual data in fault calculations. Bus characteristics and transformer impedance must be those proposed. Document data in the report.

2.1.4.3 Fault Current Availability

Provide balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values at each voltage transformation point and at each power distribution bus. Show the maximum and minimum values of fault available at each location in tabular form on the diagram or in the report.

2.1.5 Coordination Study

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. Include a description of the coordination of the protective devices in this project. Provide a written narrative describing: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Provide recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction). Provide composite coordination plots on log-log graph paper.

2.1.6 Study report

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

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

c. Document [utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings;] [and] [existing power system data including time-current characteristic curves and protective device ratings and settings].

d. The report must 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. Include recommended ratings and settings of all protective devices in tabulated form.

e. Provide the calculation performed for the analyses, including computer analysis programs utilized. Provide the name of the software package, developer, and version number.

PART 3 EXECUTION

Not Used

-- End of Section --

SECTION 26 29 23

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

PART 1 GENERAL

1.1 REFERENCES

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

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519	(2014) Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 3.1	(2019) Guide for the Application, Handling, Storage, Installation and Maintenance of Medium-Voltage AC Contactors, Controllers and Control Centers
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA ICS 7	(2020) Adjustable-Speed Drives

NEMA ICS 7.2	(2015) Application Guide for AC Adjustable Speed Drive Systems
NEMA ICS 61800-2	(2005) Adjustable Speed Electrical Power Drive Systems Part 2: General Requirements - Rating Specifications for Low Voltage Adjustable Frequency A.C. Power Drive Systems
NEMA MG 1	(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; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 61800-5-1	(2016) Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy

1.2 RELATED REQUIREMENTS

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

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements

1.3.1.1 Electromagnetic Interference Suppression

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

1.3.1.2 Electromechanical and Electrical Components

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

1.3.2 Electrical Requirements

1.3.2.1 Power Line Surge Protection

IEEE C62.41.1 and IEEE C62.41.2, IEEE 519, IEC 61000-3-12 Control panel

must have surge protection, included within the panel to protect the unit from damaging transient voltage surges. Surge protective device must be mounted near the incoming power source and properly wired to all three phases and ground. Fuses must not be used for surge protection.

1.3.2.2 Sensor and Control Wiring Surge Protection

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

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

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

1.4 SUBMITTALS

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

SD-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-07 Certificates

Testing Agency's Field Supervisor NETA Certificate; G[, [_____]]

] SD-08 Manufacturer's Instructions

Installation instructions

SD-09 Manufacturer's Field Reports

ASD Test Plan; G[, [_____]]

Standard Products

SD-10 Operation and Maintenance Data

Adjustable Speed Drives, Data Package 4

1.5 QUALITY ASSURANCE

1.5.1 Schematic Diagrams

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

1.5.2 Interconnecting Diagrams

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

1.5.3 Installation Drawings

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

1.5.4 Equipment Schedule

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

1.5.5 Installation Instructions

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

1.5.6 Standard Products

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

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

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

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

1.6 DELIVERY AND STORAGE

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

1.7 WARRANTY

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

1.8 MAINTENANCE

1.8.1 Spare Parts

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

[Provide one [_____] spare ASD of each model provided for HVAC equipment, fully programmed and ready for back-up operation when connected.

]### 1.8.2 Operation and Maintenance Data

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

1.8.3 Maintenance Support

During the warranty period, provide on-site, on-call maintenance services by drive manufacturer's personnel on the following basis: The service must be on a per-call basis with 36 hour response. Contractor is responsible for the maintenance of all hardware and software of the system during the warranty period. Various personnel of different expertise must be sent on-site depending on the nature of the maintenance service required. Costs must include travel, local transportation, living

expenses, and labor rates of the service personnel while responding to the service request. The provisions of this Section are not in lieu of, nor relieve the Contractor of, warranty responsibilities covered in this specification. Should the result of the service request be the uncovering of a system defect covered under the warranty provisions, all costs for the call, including the labor necessary to identify the defect, must be borne by the Contractor.

1.8.4 Technical Support

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

PART 2 PRODUCTS

2.1 ADJUSTABLE SPEED DRIVES (ASD)

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

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

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

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

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

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

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

[Adjust decelerating time by[providing an external dynamic braking resistor designed to meet NEMA ICS 61800-2 to be capable of decelerating six times the motor inertia with no more than 150 percent of rated current with the motor at its base speed.][providing an ASD with a regenerative braking designed to return some of braking energy from the motor to the AC power distribution system.][providing each of several ASD used in a process with a common DC bus tie designed to share the regenerative energy between tied in parallel controls.]]Required deceleration time may be achieved using not only dynamic braking resistor but with other methods described in NEMA ICS 7.2-2015 paragraph 5.2.5.

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

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

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

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

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

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

    (1) Short circuit at controller output

    (2) Ground fault at controller output

    (3) Open circuit at controller output

    (4) Input undervoltage

    (5) Input overvoltage

    (6) Loss of input phase

    (7) AC line switching transients

    (8) Instantaneous overload

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

    (10) Over temperature

    (11) Phase reversal

m. Solid state motor overload protection must [be included such that current exceeding an adjustable threshold must activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.][have [sensor in each phase,][[Class 10] [Class 20] [Class 10/20 selectable] tripping characteristic selected to protect motor

against voltage and current unbalance and single phasing,] [Class II ground-fault protection, with start and run delays to prevent nuisance trip on staring,] [analog communication module,][[NC] [NO] isolated overload alarm contact,] [external overload, reset push button].]

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

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

p. The ASD must include external fault reset capability. All the necessary logic to accept an external fault reset contact must be included.

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

r. Provide preperly sized [NEMA][IEC] rated by-pass and isolation contactors to enable operation of motor in the event of ASD failure[and for safety transfers motor between power converter output and bypass circuit using a field-selectable automatic and manual bypass mode]. Install mechanical and electrical interlocks between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer. Motor overload and short circuit protective features must remain in use during the bypass mode.

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

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

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

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

(4) These tests should be performed at the Manufacturers Laboratory facilities and submitted as part of the Product Data Submittals, in order to prevent the necessity of adding mitigation equipment

in the field. If the requirements listed above are met, IEEE 519 will also be met.

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

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

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

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

][2.1.1 ASD for Industrial Application

Provide the following operator control and monitoring devices mounted on the front panel of the ASD:

a. Manual speed potentiometer.

b. Hand-Off-Auto (HOA) switch.

c. Power on light.

d. Drive run power light.

e. Local display[capable of including ASD status, frequency, motor RPM, phase current, fault diagnostic in descriptive text, and all programmed parameters].

][2.1.2 ASD for HVAC Application

ASDs must have the following features:

a. A local operator control providing the following functions:

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

(2) Run/Stop and manual speed commands.

(3) All programming functions.

(4) Scrolling through all display functions.

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

(1) ASD status.

(2) Frequency.

(3) Motor RPM.

(4) Phase current.

(5) Scrolling through all display functions.

(6) Fault diagnostics in descriptive text.

(7) All programmed parameters.

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

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

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

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

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

h. Historical logging information and displays:

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

] (2) Running log of total power versus time.

(3) Total run time.

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

] (5) [_____].

[i. The ASD must be capable of automatic control by a remote [4-20 mA][0 to 10 VDC][_____] signal, by [BACnet][LONworks][_____] 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. An HMCP device shall provide the disconnecting means. The operating handle shall protrude through the door, but the disconnect shall not be mounted on the door. The handle shall indicate ON, OFF, and tripped conditions. The handle shall have provisions to accommodate a minimum of three padlocks in the OFF position. Interlocks shall prevent unauthorized opening or closing of the ASD door with the disconnect handle in the ON position. The door handle interlock should have provisions to be defeated by qualified maintenance personnel.

2.3 WIRES AND CABLES

All wires and cables must conform to NEMA 250, NEMA ICS 7, NFPA 70.

2.4 NAMEPLATES

Nameplates external to NEMA enclosures must conform with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide manufacturer's standard, permanent nameplates for internal areas of enclosures.

2.5 SOURCE QUALITY CONTROL

2.5.1 ASD Test Plan

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans.

2.5.2 ASD Test Report

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test reports.

PART 3 EXECUTION

3.1 INSTALLATION

Per NEMA ICS 3.1, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer must supervise the installation of all equipment, and wiring.

3.2 GROUNDING

Per NEMA ICS 7.2, ASD must be solidly grounded to the main distribution.

3.3 FIELD QUALITY CONTROL

Specified products must be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Conduct performance verification tests in the presence of Government representative, observing and documenting complete compliance of the system to the specifications. Submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.3.1 ASD Test

A proposed test plan must be submitted to the contracting officer at least 28 calendar days prior to proposed testing for approval. The tests must conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Government reserves the right to witness all tests and review any documentation. Inform the Government at least 14 working days prior to the dates of testing. Perform the ASD test [with the assistance of a factory-authorized service representative][engaging a qualified testing agency's field supervisor currently certified by NETA to supervise on-site testing].

3.3.2 Performance Verification Tests

"Performance Verification Test" plan must provide the step by step procedure required to establish formal verification of the performance of the ASD. Compliance with the specification requirements must be verified by inspections, review of critical data, demonstrations, and tests. The Government reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. Inform the Government 14 calendar days prior to the date the test is to be conducted.

3.3.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test must commence. The system must be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of 0.9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. The contractor is not allowed in the building during the endurance test. The system must respond as designed.

3.4 DEMONSTRATION

3.4.1 Training

Coordinate training requirements with the Contracting Officer. Provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. Provide all training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the contracting officer.

3.4.1.1 Instructions to Government Personnel

Provide the services of competent instructors with minimum two-year field experience with the operation and maintenance of similar ASDs who will give full instruction to designated personnel in operation, maintenance, calibration, configuration, and programming of the complete control system. Orient the training specifically to the system installed. Instructors must be thoroughly familiar with the subject matter they are to teach. The number of training days of instruction furnished must be as specified. A training day is defined as eight hours of instruction, including two 15-minute breaks and excluding lunch time; Monday through Friday. Provide a training manual for each student at each training phase which describes in detail the material included in each training program. Provide one additional copy for archiving. Provide equipment and materials required for classroom training. Provide a list of additional related courses, and offers, noting any courses recommended. List each training course individually by name, including duration, approximate cost per person, and location of course. Unused copies of training manuals must be turned over to the Government at the end of last training session.

3.4.1.2 Operating Personnel Training Program

Provide one 2-hour training session at the site at a time and place mutually agreeable between the Contractor and the Government. Provide session to train 4 operation personnel in the functional operations of the system and the procedures that personnel will follow in system operation.

This training shall include:

a. System overview

b. General theory of operation

c. System operation

d. Alarm formats

e. Failure recovery procedures

f. Troubleshooting

3.4.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training must be conducted on site at a location designated by the Government. Provide a one-day training session to train four [_____] engineering personnel in the functional operations of the system. This training must include:

a. System overview

b. General theory of operation

c. System operation

d. System configuration

e. Alarm formats

f. Failure recovery procedures

g. Troubleshooting and repair

h. Maintenance and calibration

i. System programming and configuration

-- End of Section --

SECTION 28 31 60

INTERIOR FIRE ALARM SYSTEM, NON-ADDRESSABLE
08/20

PART 1 GENERAL

1.1 REFERENCES

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

FM GLOBAL (FM)

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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 4	(2018) Standard for Integrated Fire Protection and Life Safety System Testing
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; TIA 21-1; ERTA 1 2021) National Fire Alarm and Signaling Code
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 170	(2021) 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
UFC 4-010-06	(2016; with Change 1, 2017) Cybersecurity of Facility-Related Control 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 521	(1999; Reprint Mar 2021) UL Standard for Safety Heat Detectors for Fire Protective Signaling Systems
UL 864	(2014; Reprint May 2020) UL Standard for Safety Control Units and Accessories for Fire Alarm Systems
UL 1638	(2016; Reprint Sep 2017) UL Standard for Safety Visible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories
UL 1971	(2002; Reprint Oct 2008) Signaling Devices for the Hearing Impaired
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 Fire Prot Dir	(2012) Fire Protection Equipment Directory

1.2 RELATED SECTIONS

Section 25 05 11Cybersecurity for Facility-Related Control Systems, applies to this section, with the additions and modifications specified herein. In addition, refer to the following sections for related work and coordination:

Section 21 13 13 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION
Section 07 84 00 FIRESTOPPING for additional work related to firestopping.

1.3 SUMMARY

1.3.1 Scope

a. This work includes designing and modifying the existing fire alarm system as described herein and on the contract drawings for the West Point Fire Station. Include system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, initiating devices, notification appliances, supervising station fire alarm transmitters, and other accessories and miscellaneous items required for a complete operational system even though each item is not specifically mentioned or described. Provide system complete and ready for operation. Existing interior fire alarm system was manufactured by Monaco Enterprises. Design and installation must comply with UFGS 25 05 11, UFC 4-010-06 and AFGM 2019-320-02.

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.

f. The fire alarm system must be independent of the building security, building management, and energy/utility monitoring systems other than for control functions.

1.3.2 Qualified Fire Protection Engineer (QFPE)

Services of the QFPE must include:

a. Reviewing SD-02, SD-03, and SD-05 submittal packages for completeness and compliance with the provisions of this specification. Construction (shop) drawings and calculations must be prepared by, or prepared under the immediate supervision of, the QFPE. The QFPE must affix their professional engineering stamp with signature to the shop drawings, calculations, and material data sheets, indicating approval prior to submitting the shop drawings to the DFPE.

b. Providing a letter documenting that the SD-02, SD-03, and SD-05 submittal package has been reviewed and noting any outstanding comments.

c. Performing in-progress construction surveillance prior to installation of ceilings (rough-in inspection).

d. Witnessing pre-Government and final Government functional performance testing and performing a final installation review.

e. Signing applicable certificates under SD-07.

1.4 DEFINITIONS

Wherever mentioned in this specification or on the drawings, the equipment, devices, and functions must be defined as follows:

1.4.1 Terminal Cabinet

A steel cabinet with locking, hinge-mounted door where terminal strips are securely mounted inside the cabinet.

1.4.2 Designated Fire Protection Engineer (DFPE)

The DoD fire protection engineer that oversees that Area of Responsibility for that project. This is sometimes referred to as the "cognizant" fire protection engineer. Interpret reference to "authority having jurisdiction" and/or AHJ in referenced standards to mean the Designated Fire Protection Engineer (DFPE). The DFPE may be responsible for review of the contractor submittals having a "G" designation, and for witnessing final inspection and testing.

1.4.3 Qualified Fire Protection Engineer (QFPE)

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

1.5 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.

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

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualified Fire Protection Engineer (QFPE); G, AE

Fire alarm system designer; G, AE

Supervisor; G, AETechnician; G, AE

Installer; G, AE

Test Technician; G, AE

SD-02 Shop Drawings

Nameplates; G, AE

Wiring Diagrams; G, AE

System Layout; G, AE

Notification Appliances; G, AE

Initiating devices; G, AE

Battery Power; G, AE

Voltage Drop Calculations; G, AE

SD-03 Product Data

Manual Stations; G, AE

Smoke Detectors; G, AE

Duct Smoke Detectors; G, AE

Heat Detectors; G, AE

Carbon monoxide detector; G, AE

Notification Appliances; G, AE

Batteries; G, AE

Battery Chargers; G, AE

Supplemental Notification Appliance Circuit Panels; G, AE

Back Boxes and Conduit; G, AE

Ceiling Bridges for Ceiling-Mounted Appliances; G, AE

Terminal Cabinets; G, AE

SD-06 Test Reports

Test Procedures; G, AE

SD-07 Certificates

Verification of Compliant Installation; G, AE

Request for Government Final Test; G, AE

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G, AE

SD-11 Closeout Submittals

As-Built Drawings

1.6 SYSTEM OPERATION

Fire alarm system components requiring power, except for the FACU(s) power supply, must operate on 24 volts DC unless noted otherwise in this section.

Provide a fire alarm system that is a complete, supervised fire alarm reporting system. Activate the system into the alarm mode by actuation of any alarm initiating device. Remain in the alarm mode until the initiating device is reset and the fire alarm control unit is reset and restored to normal. Audible and visual appliances and systems must comply with NFPA 72. Operate fire alarm system components requiring power, except for the control unit power supply, on 24 Volts dc.

1.6.1 Alarm Initiating Devices and Notification Appliances (Visual, Audible)

a. Connect alarm initiating devices to initiating device circuits (IDC) Class "B" and installed in accordance with NFPA 72.

b. Connect notification appliances to notification appliance circuits (NAC) Class "B".

1.6.2 Functions and Operating Features

The system must provide the following functions and operating features:

a. Power, annunciation, supervision, and control for the system.

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.

e. A trouble signal silence feature that must silence the audible trouble signal, without affecting the visual indicator.

f. Alarm functions must override trouble or supervisory functions. Supervisory functions must override trouble functions.

g. There must be no limit, other than maximum system capacity, as to the number of zones that may be in alarm simultaneously.

h. Where the fire alarm system is responsible for initiating an action in another emergency control device or system, such as HVAC, the fire alarm relay must be located in the vicinity of the emergency control device.

i. An alarm signal must automatically initiate the following functions:

(1) Transmission of an alarm signal to the fire department.

(2) Visual indication of the device operated on the FACU, . Indication on the graphic annunciator must be by floor, zone or circuit, and type of device.

(3) Actuation of alarm notification appliances.

j. A supervisory signal must automatically initiate the following functions:

(1) Visual indication of the device operated on the FACU, and on the remote annunciator.

(2) Record the event on the system printer.

(3) Transmission of a supervisory signal to the fire department.

(4) 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.

k. A trouble condition must automatically initiate the following functions:

(1) Visual indication of the device operated on the FACU, and on the remote annunciator.

(2) Transmission of a trouble signal to the fire department.

l. Activation of a carbon monoxide alarm initiating device must automatically initiate the following functions:

(1) Visual indication of the device operated on the , LED Display unit (VDU.) Indication on the graphic annunciator must be by floor and room number, device address, and device type.

(2) Transmission of a carbon monoxide alarm signal to the fire department.

m. System control equipment must be programmed to provide a 60-minute to 180-minute delay in transmission of trouble signals resulting from primary power failure.

1.7 EXISTING EQUIPMENT

a. Equipment and devices must be compatible and operable with the existing fire alarmmass notification system and must not impair reliability or operational functions of existing supervising station fire alarm system..

b. Equipment and devices must be compatible and operable with the existing building fire alarm system. Equipment must not impair reliability or operational functions of the existing system. The existing building system control unit is Monaco Model M2.

1.8 QUALITY ASSURANCE

1.8.1 Submittal Documents

1.8.1.1 Preconstruction Submittals

Within 36 days of contract award but not less than 14 days prior to commencing any work on site, the Contractor must submit the following for review and approval. SD-02, SD-03 and SD-05 submittals received prior to the review and approval of the qualifications of the fire alarm subcontractor and QFPE must be returned disapproved without review. All resultant delays must be the sole responsibility of the Contractor.

1.8.1.2 Shop Drawings

Shop drawings must not be smaller than the Contract Drawings. Drawings must comply with the requirements of NFPA 72 and NFPA 170. Minimum scale for floor plans must be 1/8"=1'.

1.8.1.3 Nameplates

Nameplate illustrations and data to obtain approval by the Contracting Officer before installation.

1.8.1.4 Wiring Diagrams

Six copies of point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the

system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams must show connections from field devices to the FACU and remote FACU, initiating circuits, switches, relays and terminals, including pathway diagrams between the control unit and shared communications equipment within the protected premises. Point-to-point wiring diagrams must be job specific and must not indicate connections or circuits not being utilized. Provide complete riser diagrams indicating the wiring sequence of all devices and their connections to the control equipment. Include a color-code schedule for the wiring.

1.8.1.5 System Layout

Six copies of plan view drawing showing device locations, terminal cabinet locations, junction boxes, other related equipment, conduit routing, conduit sizes, wire counts, conduit fill calculations, wire color-coding, circuit identification in each conduit, and circuit layouts for all floors. Indicate candela rating of each visual notification appliance. Indicate the addresses of all devices, modules, relays, and similar. Indicate if the environment for the FACU is within its environmental listing (e.g. temperature/humidity).

Provide a complete description of the system operation in matrix format similar to the "Typical Input/Output Matrix" included in the Annex of NFPA 72.

1.8.1.6 Notification Appliances

Calculations and supporting data on each circuit to indicate that there is at least 25 percent spare capacity for notification appliances. Annotate data for each circuit on the drawings.

1.8.1.7 Initiating Devices

Calculations and supporting data on each circuit to indicate that there is at least 25 percent spare capacity for initiating devices. Annotate data for each circuit on the drawings.

1.8.1.8 Battery Power

Calculations and supporting data as required in paragraph Battery Power Calculations for alarm, alert, and supervisory power requirements. Calculations including ampere-hour requirements for each system component and each control unit component, and the battery recharging period, must be included on the drawings.

1.8.1.9 Voltage Drop Calculations

Voltage drop calculations for each notification circuit indicating that sufficient voltage is available for proper operation of the system and all components, at a minimum rated voltage of the system operating on batteries. Include the calculations on the system layout drawings.

1.8.1.10 Product Data

Six copies of annotated descriptive data to show the specific model, type, and size of each item. Catalog cuts must also indicate the NRTL listing.

The data must be highlighted to show model, size, and options that are intended for consideration. Data must be adequate to demonstrate compliance with all contract requirements. Product data for all equipment must be combined into a single submittal.

Provide an equipment list identifying the type, quantity, make, and model number of each piece of equipment to be provided under this submittal. The equipment list must include the type, quantity, make and model of spare equipment. Types and quantities of equipment submitted must coincide with the types and quantities of equipment used in the battery calculations and those shown on the shop drawings.

1.8.1.11 Operation and Maintenance (O&M) Instructions

Six copies of the Operation and Maintenance Instructions. The O&M Instructions must be prepared in a single volume or in multiple volumes, with each volume indexed, and may be submitted as a Technical Data Package. Manuals must be approved prior to training. The Interior Fire Alarm 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.

e. Routine maintenance checklist. The routine maintenance checklist must be arranged in a columnar format. The first column must list all installed devices, the second column must state the maintenance activity or state no maintenance required, the third column must state the frequency of the maintenance activity, and the fourth column provided for additional comments or reference. All data (devices, testing frequencies, and similar) must comply with UFC 3-601-02.

f. A final Equipment List must be submitted with the Operating and Maintenance (O&M) manual.

1.8.1.12 As-Built Drawings

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

1.8.2 Qualifications

1.8.2.1 Fire Alarm System Designer

The fire alarm system designer must be certified as a Level IIIIV (minimum) Technician by National Institute for Certification in Engineering Technologies (NICET) in the Fire Alarm Systems subfield of Fire Protection Engineering Technology or meet the qualifications for a QFPE.

1.8.2.2 Supervisor

A NICET Level III or IV fire alarm technician must supervise the installation of the fire alarm system. The fire alarm technicians supervising the installation of equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.2.3 Technician

Fire alarm technicians with a minimum of four years of experience must be utilized to install and terminate fire alarm devices, cabinets and control units. The fire alarm technicians installing the equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.2.4 Installer

NICET Level II technician to assist in the installation of fire alarm devices, cabinets and control units. A licensed electrician must be allowed to install wire, cable, conduit and backboxes for the fire alarm system system. The fire alarm installer must be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.8.2.5 Test Technician

Fire alarm technicians with a minimum of eight years of experience and NICET Level III or IVutilized in testing and certification of the installation of the fire alarm devices, cabinets and control units. The fire alarm technicians testing the equipment must be factory trained in the installation, adjustment, testing, and operation of the equipment installed as part of this project.

1.8.2.6 Manufacturer

Components must be of current design and must be in regular and recurrent production at the time of installation. Provide design, materials, and devices for a protected premises fire alarm system, complete, conforming to NFPA 72, except as specified herein.

1.8.3 Regulatory Requirements

Equipment and material must be listed or approved. Listed or approved, as used in this Section, means listed, labeled or approved by a Nationally Recognized Testing Laboratory (NRTL) such as UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of any item of equipment described must not be construed as waiving this requirement. All listings or approvals by testing laboratories must be

from an existing ANSI or UL published standard. The recommended practices stated in the manufacturer's literature or documentation must be considered as mandatory requirements.

1.9 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity, and temperature variation, dirt and dust, and other contaminants.

1.10 MAINTENANCE

1.10.1 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 equipment must be listed for use under the applicable reference standards.

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.

2.3 FIRE ALARM CONTROL UNIT

Existing to remain.

2.4 MANUAL STATIONS

Provide metal or plastic, surface mounted, -action, 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.

2.5 SMOKE DETECTORS

2.5.1 Spot Type Detectors

Provide photoelectric smoke detectors as follows:

a. Provide photoelectric smoke detectors utilizing the photoelectric

light scattering principle for operation in accordance with UL 268. Smoke detectors must be listed for use with the FACU .

b. Provide self-restoring type detectors that do not require any readjustment after actuation at the FACU to restore them to normal operation. The detector must have a visual indicator to show actuation.

c. Vibration must have no effect on the detector's operation. Protect the detection chamber with a fine mesh metallic screen that prevents the entrance of insects or airborne materials. The screen must not inhibit the movement of smoke particles into the chamber.

d. Provide twist lock bases with screw terminals for each conductor. The detectors must maintain contact with their bases without the use of springs.

2.5.2 Duct Smoke Detectors

Duct-mounted photoelectric smoke detectors must consist of a smoke detector, as specified in paragraph Spot Type Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry must be mounted in a metallic or plastic enclosure exterior to the duct. It is not permitted to cut the duct insulation to install the duct detector directly on the duct. Detectors must be listed for operation over the complete range of air velocities, temperature and humidity expected at the detector when the air-handling system is operating. Detectors must be powered from the FACU.

a. Sampling tubes must run the full width of the duct. The duct detector package must conform to the requirements of NFPA 90A, UL 268A, and must be listed for use in air-handling systems. The control functions, operation, reset, and bypass must be controlled from the FACU.

b. Lights to indicate the operation and alarm condition must be visible and accessible with the unit installed and the cover in place. Remote indicators must be provided where required by NFPA 72. Remote indicators as well as the affected fan units must be properly identified in etched plastic placards.

c. Detectors must provide for control of auxiliary contacts that provide control, interlock, and shutdown functions specified in Section 23 09 00 to INSTRUMENTATION AND CONTROL FOR HVAC. Auxiliary contacts provide for this function must be located within 3 feet of the controlled circuit or appliance. The auxiliary contacts must be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

2.6 HEAT DETECTORS

2.6.1 Heat Detectors

Heat detectors must be designed for detection of fire by fixed temperature in accordance with UL 521. The alarm condition must be determined by comparing detector value with the stored values.. Detectors located in areas subject to moisture, exterior atmospheric conditions, or hazardous locations as defined by NFPA 70, must be types approved for such locations.

2.6.1.1 Fixed Temperature Detectors

Detectors must be surface mounted in the horizontal orientation and supported independently of wiring connections. Detectors must be self-restoring. The detectors must have a specific temperature setting of 135 degrees F. The detector assembly must be weatherproof.

2.7 CARBON MONOXIDE DETECTOR

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. Detectors must be surface mounted in the horizontal orientation and supported independently of wiring connections. Detectors must be self-restoring. For FACU with no listed compatible addressable CO detectors, provide listed 4-wire detectors. Detector must be provided with an LED status indicator.

a. 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). Power circuits for 4-wire CO detectors must be dedicated to powering the CO detectors only. Battery powered and 120 VAC powered detectors are prohibited.

b. 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.

c. A trouble condition at an individual CO detector must not affect any other CO detectors. CO detectors must be powered by the FACU.

d. Detectors must be provided with a means to test CO gas entry into the CO sensing cell.

2.8 NOTIFICATION APPLIANCES

2.8.1 Audible Notification Appliances

Audible appliances must conform to the applicable requirements of UL 464. Appliances must be connected into notification appliance circuits. Surface mounted audible appliances must be painted red. Recessed audible appliances must be installed with a grill that is painted red.

2.8.1.1 Horns

Horns must be surface-mounted, with the matching mounting backbox surface mounted vibrating type suitable for use in an electrically supervised circuit. Horns must produce a sound rating of at least 85 dBA at 10 feet. Horns used in exterior locations must be specifically listed or approved for outdoor use and be provided with metal housing and protective grilles. Horns must be weatherproof.

2.8.2 Visual Notification Appliances

Visual notification appliances must conform to the applicable requirements of UL 1638, UL 1971 and conform to the Architectural Barriers Act (ABA). Visual Notification Appliances must have clear high intensity optic lens, xenon flash tubes, or light emitting diode (LED) and be marked "Alert" in letters of contrasting color. The light pattern must be 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 based on the UL 1971 test. Strobe must be surface mounted.

2.9 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.

2.9.1 Batteries

Provide sealed, maintenance-free, sealed lead acid batteries as the source for emergency power to the FACU. 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.

2.9.1.1 Capacity

Battery size must be the following capacity. This capacity applies to every control unit associated with this system, including supplemental notification appliance circuit panels, and fire alarm transmitters.

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.

2.9.1.2 Battery Power Calculations

a. Verify that battery capacity exceeds supervisory and alarm power requirements for the criteria noted in the paragraph "Capacity" above.

   (1) Substantiate the battery calculations for alarm and supervisory power requirements. Include ampere-hour requirements for each system component and each control unit component, and compliance with UL 864.

   (2) Provide complete battery calculations for both the alarm and supervisory power requirements. Submit ampere-hour requirements for each system component with the calculations.

   (3) Provide voltage drop calculations to indicate that sufficient voltage is available for proper operation of the system and all components. Calculations must be performed using the minimum rated voltage of each component.

b. For battery calculations assume a starting voltage of 24 VDC for starting the calculations to size the batteries. Calculate the required Amp-Hours for the specified standby time, and then calculate the required Amp-Hours for the specified alarm time. Using 20.4 VDC as starting voltage, perform a voltage drop calculation for circuits containing device and/or appliances remote from the power sources.

2.9.2 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.

2.10 WIRING

Provide wiring materials under this section as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM with the additions and modifications specified herein.

2.10.1 Alarm Wiring

IDC wiring must be solid copper cable in accordance with the manufacturers requirements. Copper initiating device circuit field wiring must be No. 16 AWG size conductors at a minimum. Visual notification appliance circuit conductors, that contain audible alarm appliances, must be copper No. 14 AWG size 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.

2.11 SYSTEM MONITORING

2.11.1 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 zone.

PART 3 EXECUTION

3.1 VERIFYING ACTUAL FIELD CONDITIONS

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

3.2 INSTALLATION

3.2.1 Battery Cabinets

When batteries will not fit in the FACU, locate battery cabinets below or adjacent to the FACU. Battery cabinets must be installed at an accessible location when standing at floor level. Battery cabinets must not be installed lower than 12 inches above finished floor, measured to the bottom of the cabinet, nor higher than 36 inches above the floor, measured to the top of the cabinet. Installing batteries above drop ceilings or in inaccessible locations is prohibited. Battery cabinets must be large enough to accommodate batteries and also to allow ample gutter space for interconnection of control units as well as field wiring. The cabinet must be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and surface mounting provisions.The cabinet must be identified by an engraved phenolic resin nameplate. Lettering on the nameplate must indicate the control unit(s) the batteries power and must not be less than 1-inch high.

3.2.2 Manual Stations

Locate manual stations as required by NFPA 72. 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.

3.2.3 Notification Appliances

a. Locate notification appliance devices as required by NFPA 72 Where more than two visual notification appliances are located in the same room or corridor or field of view, provide synchronized operation. Devices must use screw terminals for all field wiring. Audible and visual notification appliances mounted in acoustical ceiling tiles must be centered in the tiles plus or minus 2 inches..

b. Audible and visual notification appliances mounted on the exterior of the building, within unconditioned spaces, or in the vicinity of showers must be listed weatherproof appliances installed on weatherproof backboxes.

c. Speakers must not be located in close proximity to the FACU or LOC so as to cause feedback when the microphone is in use.

3.2.4 Smoke and Heat Detectors

Locate detectors as required by NFPA 72 and their listing on a 4-inch mounting box. Install heat detectors not less than 4 inches from a side wall to the near edge. Heat detectors located on the wall must have the top of the detector at least 4 inches below the ceiling, but not more than 12 inches below the ceiling. Smoke detectors are permitted to be on the wall no lower than 12 inches from the ceiling with no minimum distance from the ceiling. Install smoke detectors no closer than 3 feet from air handling supply diffusers. Detectors installed in acoustical ceiling tiles must be centered in the tiles plus or minus 2 inches.

3.2.5 Carbon Monoxide Detectors

Locate detectors as required by NFPA 72 and their listings on a 4-inch mounting box.

3.2.6 Ceiling Bridges

Provide ceiling bridges for ceiling-mounted appliances. Ceiling bridges must be as recommended/required by the manufacturer of the ceiling-mounted notification appliance.

3.3 SYSTEM FIELD WIRING

3.3.1 Wiring within Cabinets, Enclosures, and Boxes

Provide wiring installed in a neat and workmanlike manner and installed parallel with or at right angles to the sides and back of any box, enclosure, or cabinet. Conductors that are terminated, spliced, or otherwise interrupted in any enclosure, cabinet, mounting, or junction box must be connected to screw-type terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. The use of wire nuts or similar devices is prohibited. Wiring to conform with NFPA 70.

Indicate the following in the wiring diagrams:

a. Point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams must show connections from field devices to the FACU and remote fire alarm control units, initiating circuits, switches, relays and terminals.

b. Complete riser diagrams indicating the wiring sequence of devices and their connections to the control equipment. Include a color code schedule for the wiring. Include floor plans showing the locations of devices and equipment.

3.3.2 Terminal Cabinets

Provide a terminal cabinet at the base of any circuit riser, on each floor at each riser, and where indicated on the drawings. Terminal size must be appropriate for the size of the wiring to be connected. Conductor terminations must be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection must be permanently mounted in the terminal cabinet. Minimum size is 8 inches by 8 inches. Only screw-type terminals are permitted. Provide an identification label, that displays "FIRE ALARM TERMINAL CABINET" with 2-inch lettering, on the front of the terminal cabinet.

3.3.3 Alarm Wiring

a. Voltages must not be mixed in any junction box, housing or device, except those containing power supplies and control relays.

b. Utilize shielded wiring where recommended by the manufacturer. For shielded wiring, ground the shield at only one point, in or adjacent to the FACU.

c. T-tapping using screw terminal blocks is allowed for Class "B" initiating device circuits.

d. Color coding is required for circuits and must be maintained throughout the circuit. Conductors used for the same functions must

be similarly color coded. Conform wiring to NFPA 70.

e. Pull all conductors splice free. The use of wire nuts, crimped connectors, or twisting of conductors is prohibited. Where splices are unavoidable, the location of the junction box or pull box where they occur must be identified on the as-built drawings. The number and location of splices must be subject to approval by the Designated Fire Protection Engineer (DFPE).

3.3.4 Back Boxes and Conduit

In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide all wiring in rigid metal conduit or intermediate metal conduit unless specifically indicated otherwise. Minimum conduit size must be 3/4-inch in diameter. Do not use electrical non-metallic tubing (ENT) or flexible non-metallic tubing and associated fittings.

a. Galvanized rigid steel (GRS) conduit must be utilized where exposed to weather, where subject to physical damage, and where exposed on exterior of buildings. Intermediate metal conduit (IMC) may be used in lieu of GRS as allowed by NFPA 70.

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.

3.3.5 Conductor Terminations

Labeling of conductors at terminal blocks in terminal cabinets, FACU, and remote FACU must be provided at each conductor connection. Each conductor or cable must have a shrink-wrap label to provide a unique and specific designation. Each terminal cabinet, FACU, and remote FACU must contain a laminated drawing that indicates each conductor, its label, circuit, and terminal. The laminated drawing must be neat, using 12 point lettering minimum size, and mounted within each cabinet, control unit, or unit so that it does not interfere with the wiring or terminals. Maintain existing color code scheme where connecting to existing equipment.

3.4 FIRESTOPPING

Provide firestopping for holes at conduit penetrations through floor slabs, fire-rated walls, partitions with fire-rated doors, corridor walls, and vertical service shafts in accordance with Section 07 84 00 FIRESTOPPING.

3.5 FIELD QUALITY CONTROL

3.5.1 Test Procedures

Submit detailed test procedures, prepared and signed by the NICET Level III or IV Fire Alarm Technician, and the representative of the installing company, and reviewed by the QFPE 60 days prior to performing system tests. Detailed test procedures must list all components of the installed system such as initiating devices and circuits, notification appliances and circuits, 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 forma 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).

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.

3.5.2 Pre-Government Testing

3.5.2.1 Verification of Compliant Installation

Conduct inspections and tests to ensure that devices and circuits are functioning properly. Tests must meet the requirements of paragraph entitled "Minimum System Tests" as required by NFPA 72. The contractor and an authorized representative from each supplier of equipment must be in attendance at the pre-Government testing to make necessary adjustments. After inspection and testing is complete, provide a signed Verification of Compliant Installation letter by the QFPE that the installation is complete, compliant with the specification and fully

operable. The letter must include the names and titles of the witnesses to the pre-Government tests. Provide all completion documentation as required by NFPA 72 including all referenced annex sections and the test reports noted below.

a. NFPA 72 Record of Completion.

b. NFPA 72 Record of Inspection and Testing.

c. Fire Alarm and Emergency Communication System Inspection and Testing Form.

d. Audibility test results with marked-up test floor plans.

e. Documentation that all tests identified in the paragraph "Minimum System Tests" are complete.

3.5.2.2 Request for Government Final Test

When the verification of compliant installation has been completed, submit a formal request for Government final test to the Designated Fire Protection Engineer (DFPE). Government final testing will not be scheduled until the DFPE has received copies of the request for Government final testing and Verification of Compliant Installation letter with all required reports. Government final testing will not be performed until after the connections to the installation-wide fire reporting system has 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.

3.5.3 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.

3.5.4 Government Final Tests

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

a. The manufacturer's technical representative.

b. The contractor's Qualified Fire Protection Engineer (QFPE).

c. Marked-up red line drawings of the system as actually installed.

d. Loop resistance test results

e. Copy of pre-Government Test Certificate, test procedures and completed test data forms.

f. Audibility test results with marked-up floor plans.

Government Final Tests will be witnessed by the , Designated Fire

Protection EngineerContracting Officer's Representative (COR). At this time, any and all required tests noted in the paragraph "Minimum System Tests" must be repeated at their discretion.

3.6 MINIMUM SYSTEM TESTS

3.6.1 System Tests

Test the system in accordance with the procedures outlined in NFPA 72. The required tests are as follows:

a. Loop Resistance Tests: Measure and record the resistance of each circuit with each pair of conductors in the circuit short-circuited at the farthest point from the circuit origin. The tests must be witnessed by the Contracting Officer and test results recorded for use at the final Government test.

b. Verify the absence of unwanted voltages between circuit conductors and ground. The tests must be accomplished at the pre-Government test with results available at the final system test.

c. Verify that the control unit is in the normal condition as detailed in the manufacturer's O&M manual.

d. Test each initiating device and notification appliance and circuit for proper operation and response at the control unit. Smoke detectors must be tested in accordance with manufacturer's recommended calibrated test method. Use of magnets is prohibited. Testing of duct smoke detectors must comply with the requirements of NFPA 72 except disconnect at least 20 percent of devices. If there is a failure at these devices, then supervision must be tested at each device.

e. 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 red-line drawings are accurate.

l. Measure the current in circuits to ensure there is the calculated spare capacity for the circuits.

m. Measure voltage readings for circuits to ensure that voltage drop is not excessive.

n. Measure the voltage drop at the most remote appliance (based on wire

length) on each notification appliance circuit.

o. 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".

3.6.2 Audibility Tests

Sound pressure levels from audible notification appliances must be a minimum of 15 dBa over ambient with a maximum of 110 dBa in any occupiable area. The provisions for audible notification (audibility and intelligibility) must be met with doors, fire shutters, movable partitions, and similar devices closed.

3.7 SYSTEM ACCEPTANCE

Following acceptance of the system, as-built drawings and O&M manuals must be delivered to the Contracting Officer for review and acceptance. The drawings must show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings must be submitted within two weeks after the final Government test of the system. At least one set of as-built (marked-up) drawings must be provided at the time of, or prior to the Final Government Test.

a. The drawings must be prepared electronically and sized no less than the contract drawings.

b. Include complete wiring diagrams showing connections between devices and equipment, both factory and field wired.

c. Include a riser diagram and drawings showing the as-built location of devices and equipment.

d. Provide Operation and Maintenance (O&M) Instructions.

3.8 EXTRA MATERIALS

3.8.1 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 manufacturer. 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 --