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	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
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.

-- End of Section --

SECTION 23 05 15

COMMON PIPING FOR HVAC
05/22

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	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2021) Gray Iron Threaded Fittings; Classes 125 and 250
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 B16.22	(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 B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron

	Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.3	(2020) Process Piping
ASME B36.10M	(2015; Errata 2016) Welded and Seamless Wrought Steel Pipe
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	(2021) 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 A105/A105M	(2021) Standard Specification for Carbon Steel Forgings for Piping Applications
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 D2308	(2007; R 2013) Standard Specification for Thermoplastic Polyethylene Jacket for Electrical Wire and Cable
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 515	(2017) Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications
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-110	(2010) Ball Valves Threaded,

	Socket-Welding, Solder Joint, Grooved and Flared Ends
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	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
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.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists[; G[, [____]]]

SD-02 Shop Drawings

Record Drawings[; G[, [____]]]

Connection Diagrams[; G[, [____]]]

Coordination Drawings[; G[, [____]]]

Fabrication Drawings[; G[, [____]]]

Installation Drawings[; G[, [____]]]

SD-03 Product Data

Pipe and Fittings[; G[, [____]]]

Piping Specialties[; G[, [____]]]

Valves[; G[, [____]]]

Miscellaneous Materials[; G[, [____]]]

Supporting Elements[; G[, [____]]]

Equipment Foundation Data[; G[, [____]]]

SD-04 Samples

Manufacturer's Standard Color Charts[; G[, [____]]]

SD-05 Design Data

Pipe and Fittings[; G[, [____]]]

Piping Specialties[; G[, [____]]]

Valves[; G[, [____]]]

SD-06 Test Reports

Hydrostatic Tests[; G[, [____]]]

Air Tests[; G[, [____]]]

Valve-Operating Tests[; G[, [____]]]

Drainage Tests[; G[, [____]]]

Pneumatic Tests[; G[, [____]]]

Non-Destructive Electric Tests[; G[, [____]]]

System Operation Tests[; G[, [____]]]

SD-07 Certificates

Record of Satisfactory Field Operation[; G[, [____]]]

List of Qualified Permanent Service Organizations[; G[, [____]]]

Listing of Product Installations[; G[, [____]]]

Records of Existing Conditions[; G[, [____]]]

Surface Resistance[; G[, [____]]]

Shear and Tensile Strengths[; G[, [____]]]

Temperature Ratings[; G[, [____]]]

Bending Tests[; G[, [____]]]

Flattening Tests[; G[, [____]]]

Transverse Guided Weld Bend Tests[; G[, [____]]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals[; G[, [____]]]

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 ELECTRICAL HEAT TRACING

Provide heat trace systems for pipes, valves, and fittings that are in accordance with IEEE 515 and be UL listed. System include all necessary components, including heaters and controls to prevent freezing.

Provide self-regulating heaters consisting of two 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature along its length. Ensure heater is able to be crossed over itself without overheating. Obtain approval before used directly on plastic pipe. Cover heater with a radiation cross-linked modified polyolefin dielectric jacket in accordance with ASTM D2308.

[For installation on plastic piping, apply the heater using aluminum tape. Provide heater with an outer braid of tinned-copper and an outer jacket of modified polyolefin in accordance with ASTM D2308, to provide a good ground path and to enhance the heater's ruggedness.

] Provide heater with self-regulating factor of at least [90] [_____] percent, in order to provide energy conservation and to prevent overheating.

Operate heater on line voltages of [120] [208] [220] [240] [277] volts without the use of transformers.

Size Heater according to the following table:

Pipe Size

(Inch, Diameter)	Minus 10 degrees F	Minus 20 degrees F
3 inches or less	5 watts per foot (wpf)	5 wpf
4 inch	5 wpf	8 wpf
6 inch	8 wpf	8 wpf
8 inch	2 strips/5 wpf	2 strips/8 wpf
12 inch	2 strips/8 wpf	2 strips/8 wpf

Control systems by an ambient sensing thermostat set at 40 degrees F either directly or through an appropriate contactor.

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 Type BCS-125, 125-psi Service

Ensure pipe 1/8 through 1-1/2 inches is Schedule 40 steam, Schedule 80 condensate, furnace butt weld, black carbon steel, conforming to ASTM A53/A53M, Type F (furnace butt welded, continuous welded) and ASME B36.10M.

Ensure pipe 2 through 10 inches is Schedule 40 steam, Schedule 80 condensate, seamless or electric-resistance welded black carbon steel, conforming to ASTM A53/A53M [Type E, Grade B (electric-resistance welded)] [Type S (seamless)] and ASME B36.10M.

Ensure pipe 12 through 24 inches is 0.375-inch wall, [seamless] [electric-resistance] welded black carbon steel, conforming to ASTM A53/A53M [Type E, Grade B (electric-resistance welded)] [Type S (seamless) and ASME B36.10M].

[Ensure fittings 2 inches and under are 125-psig wsp, cast iron, screwed end, conforming to ASTM A126 Class A and ASME B16.4.

][Ensure fittings 2 inches and under are 150-psig wsp banded black malleable iron screwed, conforming to ASTM A197/A197M and ASME B16.3.

][Ensure fittings 1 through 2 inches are 2,000-or 3,000-psi water, oil, or gas (wog) to match pipe wall, forged carbon steel socket weld, conforming to ASTM A105/A105M and ASME B16.11.

][Ensure fittings 2 inches and under are 125-psig wsp, cast iron, screwed end, conforming to ASTM A126 Class A and ASME B16.4.

][Ensure fittings 2-1/2 inches and over are wall thickness to match pipe, long radius butt weld, black carbon steel, conforming to ASTM A234/A234M, Grade WPB and ASME B16.9.

][Ensure couplings 2 inches and under are commercial standard weight for Schedule 40 pipe and commercial extra heavy weight for Schedule 80 pipe, black carbon steel where threaded, and 2,000-or 3,000-psi wog forged carbon steel, conforming to ASTM A105/A105M and ASME B16.11, where welded.

][Ensure flanges 2-1/2 inches and over are 150-pound, forged carbon-steel welding neck, with raised face or flat face and concentric serrated finish, conforming to ASTM A105/A105M and ASME B16.5.

][Conform grooved pipe couplings and fittings in accordance with paragraph GROOVED PIPE COUPLINGS AND FITTINGS.

]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 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 isolate dissimilar 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 chlorosulphonated 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 chlorosulphonated 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 [four][_____] 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 psig and 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

Provide Y-type strainers with removable basket. Ensure strainers in sizes 2-inch ips and smaller have screwed ends; in sizes 2-1/2-inch ips and 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].

2.4 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. Valves shall conform to ASME B16.34.

2.4.1 Ball and Butterfly Valves

Ensure ball valves conform to MSS SP-72 for flanged valves and MSS SP-110 for screwed-end valves 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-67 and 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. Dielectric pipe unions shall be installed to prevent galvanic corrosion. The dielectric unions shall have metal connections on both ends. The ends shall be threaded, flanged, or brazed to match adjacent piping. The metal parts of the union shall be separated so that the electrical current is below 1 percent of the galvanic current which would exist upon metal-to-metal contact. Gaskets, flanges, and unions shall be installed in accordance with manufacturer's recommendations.

][Provide dielectric nipples between steel piping and copper piping to reduce galvanic corrosion. Dielectric nipples shall be Schedule 40 galvanized steel conforming to ASTM A53/A53M with inert, non-corrosive thermoplastic lining. For pipe sizes 2 inches ips smaller, a bronze ball valve can be used between dissimilar metals.

] Make final connections to equipment with [unions][flanges] installed every 100 feet of straight run. Install 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.

Install 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 polypropylene 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

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

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

Install 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.

Install 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

Install 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

Install 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, install 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

Install 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

Install 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. Install 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

Install escutcheons at all penetrations of piping into finished areas. Where finished areas are separated by partitions through which piping passes, install escutcheons on both sides of the partition. Where suspended ceilings are installed, install 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

[Install 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.

Install 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, install 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 HEAT TRACE CABLE INSTALLATION

Field apply heater tape and cut to fit as necessary, linearly along the length of pipe after piping has been pressure tested and approved by the Contracting Officer. Secure the heater to piping with [cable ties] [fiberglass tape]. Label thermal insulation on the outside, "Electrical Heat Trace."

Install power connection, end seals, splice kits and tee kit components in accordance with IEEE 515 to provide a complete workable system. Terminate connection to the thermostat and ends of the heat tape in a junction box. Ensure cable and conduit connections are raintight.

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 HEAT TRACE CABLE TESTS

Test heat trace cable system in accordance with IEEE 515 after installation and before and after installation of the thermal insulation. Test heater cable using a [1000] [_____] vdc megger. Minimum insulation resistance is [20 to 1000] [_____] megohms regardless of cable length.

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 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 AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

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

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

40 CFR 82	Protection of Stratospheric Ozone

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.""a leakage rate measured during DALT field acceptance testing which exceeds the leakage rate allowed by Appendix D REQUIREMENTS FOR DUCT AIR LEAK TESTING." When applied to TAB work this 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

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.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

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

Specific requirements relating to Reliability Centered Maintenance (RCM) principals and Predictive Testing and Inspection (PTI), by the construction contractor to detect latent manufacturing and installation defects must be followed as part of the Contractor's Quality Control program. Refer to the paragraph SUSTAINABILITY for detailed requirements. Requirements for price breakdown of HVAC TAB work are specified in Section 01 20 00 PRICE AND PAYMENT PROCEDURES.

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

1.4 SUBMITTALS

Government approval is required for submittals with a "G" 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-01 Preconstruction Submittals

Records of Existing Conditions; G[, [_____]]

Independent TAB Agency and Personnel Qualifications; G[, [_____]]

TAB Design Review Report; G[, [_____]]

TAB Firm; G[, [_____]]

Designation of TAB Team Assistants; G[, [_____]]

Designation of TAB Team Engineer; G[, [_____]] or TAB Specialist; G[, [_____]]

Designation of TAB Team Field Leader; G[, [_____]]

SD-02 Shop Drawings

TAB Schematic Drawings and Report Forms; G[, [_____]]

SD-03 Product Data

Equipment and Performance Data; G[, [_____]]

TAB Related HVAC Submittals; G[, [_____]]

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

TAB Procedures; G[, [_____]]

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

Calibration; G[, [_____]]

Systems Readiness Check; G[, [_____]]

TAB Execution; G[, [_____]]

TAB Verification; G[, [_____]]

SD-06 Test Reports

Completed Pre-Final DALT Report; G[, [_____]]

Certified Final DALT Report; G[, [_____]]

Prerequisite HVAC Work Checkout List For Proportional Balancing; G[, [_____]]

Certified Final TAB Report for Proportional Balancing; G[, [_____]]

Prerequisite HVAC Work Checkout List For Season 1; G[, [_____]]

Certified Final TAB Report for Season 1; G[, [_____]]

Prerequisite HVAC Work Checkout List For Season 2; G[, [_____]]

Certified Final TAB Report for Season 2; G[, [_____]]
TAB Design Review Report; G[, [_____]]

TAB Report for Season 1; G[, [_____]]

TAB Report for Season 2; G[, [_____]]

SD-07 Certificates

Independent TAB Agency and Personnel Qualifications; G[, [_____]]

DALT and TAB Submittal and Work Schedule; G[, [_____]]

TAB Pre-Field Engineering Report; G[, [_____]]

Instrument Calibration Certificates; G[, [_____]]

DALT and TAB Procedures Summary; G[, [_____]]

Completed Pre-Final DALT Work Checklist; G[, [_____]]

Advance Notice of Pre-Final DALT Field Work; G[, [_____]]

Advance Notice of TAB Field Work for Proportional Balancing; G[, [_____]]

Advance Notice of TAB Field Work for Season 1; G[, [_____]]

Advance Notice of TAB Field Work for Season 2 G[, [_____]]

TAB Firm; G[, [_____]]

Design Review Report; G[, [_____]]

[Pre-field DALT Preliminary Notification; G[, [_____]]

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

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

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

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

1.5 QUALITY ASSURANCE

1.5.1 Independent TAB Agency and Personnel Qualifications

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

1.5.1.1 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.

1.5.1.2 Qualifications

a. 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.

b. 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.

c. TAB Specialist Responsiblities

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.

1.5.1.3 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.

1.5.2 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.

1.5.2.1 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.

1.5.2.2 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.

1.5.2.3 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.

1.5.2.4 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.

[1.5.3 Project/Site Conditions

1.5.3.1 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.

]1.5.4 Sequencing and Scheduling

[1.5.4.1 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.

a. 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.

]1.5.4.2 DALT and TAB Submittal and Work Schedule

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

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.

] a. 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.

b. 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.

1.5.4.3 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.

1.5.5 Subcontractor Special Requirements

Perform all work in this section in accordance with the paragraph SUBCONTRACTOR SPECIAL REQUIREMENTS in Section 01 30 00 ADMINISTRATIVE REQUIREMENTS, stating that all contract requirements of this section must be accomplished directly by a first tier subcontractor. No work may be performed by a second tier subcontractor.

1.5.6 Instrument Calibration Certificates

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

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

1.5.7 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.

1.5.8 Sustainability

Contractor must submit the following as part of the Quality Control Plan for acceptance testing:

a. List all test equipment to be used, including its manufacturer,model number, calibration date, and serial number.

b. Certificates of test personnel qualifications and certifications. Provide certification of compliance with 40 CFR 82.

c. Proof of equivalency if the contractor desires to substitute a test requirement.

Perform the following PTI as an integral part of the TAB process per the most recent edition of the NASA RCBEA GUIDE:

[Compressors:
a. Vibration Analysis
b. Balance Test and Measurement
c. Alignment (laser preferred)
d. Lubricating Oil Test
e. Thermodynamic Performance Test
][f. Hydraulic Oil Test (optional)
]
[Fans:
a. Vibration Analysis
b. Balance Test and Measurement
c. Alignment (laser preferred)
d. Lubricating Oil Test
e. Thermodynamic Performance Test
]
[Heat Exchangers (General):
a. Hydrostatic Test
b. Airborne Ultrasonic Test
c. Thermodynamic Performance Test
][d. Infrared Thermography (optional)
]
[Heat Exchangers (Condenser Air Cooled):
a. Hydrostatic Test
b. Thermodynamic Performance Test
][c. Airborne Ultrasonic Test (optional)
][d. Pulse Ultrasonic Test (optional)
][e. Infrared Thermography (optional)
]
[Heat Exchangers (Condenser Water Cooled):
a. Hydrostatic Test
b. Thermodynamic Performance Test

][c. Airborne Ultrasonic Test (optional)
][d. Pulse Ultrasonic Test (optional)
][e. Infrared Thermography (optional)
]
[Heat Exchange Cooling Tower:
a. Vibration Analysis
b. Balance Test and Measurement
c. Alignment (laser preferred)
d. Lubricating Oil Test
e. Performance Test
]
[HVAC Ducts:
a. Operational Test
b. Ductwork Leak Testing (DALT); Pre-Final DALT report, Final DALT report
]
[Piping Systems:
a. Vibration Analysis
b. Infrared Thermography
]
[Steam Coils:
a. Warranty Test
b. Vibration Analysis
c. Performance Test
d. Infrared Thermography
]
[Valves:
a. Hydrostatic Test
b. Airborne Ultrasonic Test (optional)
c. Thermodynamic Performance Test (optional)
][d. Infrared Thermography (optional)
]

1.5.9 Qualifications

1.5.9.1 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.

1.5.9.2 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.

1.5.9.3 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].

1.5.9.4 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.

1.5.10 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.

1.5.10.1 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.

1.5.10.2 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.

1.5.10.3 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.

1.5.10.4 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.

1.5.11 Test Reports

1.5.11.1 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.

1.5.11.2 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

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

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 as specified in Appendix A WORK DESCRIPTIONS OF PARTICIPANTS.

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

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

3.3.9 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 [and AABC MN-4,][NEBB PROCEDURAL STANDARDS, NEBB MASV,] 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.

][3.4.3.9 Cabinet Heaters

][3.4.3.10 Cooling Units

][3.4.3.11 Door Heaters

Door heater systems, including fans, coils, and diffusers.

][3.4.3.12 Unit Heaters

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

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

[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.

3.7 APPENDICES

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

Appendix A

WORK DESCRIPTIONS OF PARTICIPANTS

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

1. Contractor

a. HVAC documentation: Provide pertinent contract documentation to the TAB Firm, to include the following: the contract drawings and specifications; copies of the approved submittal data for all HVAC equipment, air distribution devices, and air/water measuring/balancing devices; the construction work schedule; and other applicable documents requested by the TAB Firm. Provide the TAB Firm copies of contract revisions and modifications as they occur.

b. Schedules: Ensure the requirements specified under the paragraph "DALT and TAB Schedule" are met.

c. Pre-DALT and TAB meeting: Arrange and conduct the Pre-DALT and TAB meeting. Ensure that a representative is present for the sheet metal contractor, the mechanical contractor, the electrical contractor, and the automatic temperature controls contractor.

d. Coordinate Support: Provide and coordinate support personnel required by the TAB Firm in order to accomplish the DALT and TAB field work. Support personnel may include factory representatives, HVAC controls installers, HVAC equipment mechanics, sheet metal workers, pipe fitters, and insulators. Ensure support personnel are present at the work site at the times required.

e. Correct Deficiencies: Ensure the notifications of Construction Deficiencies are provided as specified herein. Refer to the paragraph CONSTRUCTION DEFICIENCIES. Correct each deficiency as soon as practical with the Contracting Officer, and submit revised schedules and other required documentation.

f. Pre-TAB Work Checklists: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as pre-TAB work checklist items, the deficiencies pointed out by the TAB team supervisor in the design review report.

Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's DALT and TAB Work Procedures Summary. Do not allow the TAB team to commence TAB field work until all of the following are completed.

g. Give Notice of Testing: Submit advance notice of proportional balancing, Season 1, and Season 2 TAB field work accompanied by completed prerequisite HVAC Work List

h. Insulation work: Ensure that no insulation is shall not be installed on ducts to be DALT'd until DALT work on the subject ducts is complete.

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

2. TAB Team Supervisor

a. Overall management: Supervise and manage the overall TAB team work effort, including preliminary and technical DALT and TAB procedures and TAB team field work.

b. Schedule: Ensure the requirements specified under the paragraph "DALT and TAB Schedule" are met.

c. Submittals: Provide the submittals specified herein.

d. Pre-DALT/TAB meeting: Attend meeting with Contractor. Ensure TAB personnel that will be involved in the TAB work under this contract attend the meeting.

e. 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.

f. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency; such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the DALT and TAB Procedures Summary, the during the DALT or TAB field work.

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

Ensure all inspections and verifications for the Pre-Final DALT and Pre-TAB Checklists are completely and successfully conducted before DALT and TAB field work is performed.

g. Advance Notice: Monitor the completion of the duct system installations and provide the Advance Notice for Pre-Final DALT field work as specified herein.

h. Technical Assistance: Provide technical assistance to the DALT and TAB field work.

i. Deficiencies Notification: Ensure the notifications of Construction Deficiencies are provided as specified herein. Comply with requirements of the paragraph CONSTRUCTION DEFICIENCIES. Resolve each deficiency as soon as practical and submit revised schedules and other required documentation.

j. Procedures: Develop the required TAB procedures for systems or system components not covered in the TAB Standard.

3. TAB Team Field Leader

a. Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, EXECUTION.

b. Full time: Be present at the contract site when DALT field work or TAB field work is being performed by the TAB team; ensure day-to-day TAB team work accomplishments are in compliance with this section.

c. Prerequisite HVAC work: Do not bring the TAB team to the contract site until a copy of the prerequisite HVAC work list, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.

Appendix B

REPORTS - DALT and TAB

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

1. DALT and TAB Work Execution Schedule

Submit a detailed schedule indicating the anticipated calendar date for each submittal and each portion of work required under this section. For each work entry, indicate the support personnel (such as controls provider, HVAC mechanic, etc.) that are needed to accomplish the work. Arrange schedule entries chronologically.

2. DALT and TAB Procedures Summary

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

a. A list of the intended procedural steps for the DALT and TAB field work from start to finish. Indicate how each type of data measurement will be obtained. Include what Contractor support personnel are required for each step, and the tasks they need to perform.

b. A list of the project's submittals that are needed by the TAB Firm in order to meet this Contract's requirements.

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

d. The data presentation forms to be used in the report, with the preliminary information and initial design values filled in.

e. A list of DALT and TAB instruments to be used, edited for this project, to include the instrument name and description, manufacturer, model number, scale range, published accuracy, most recent calibration date, and what the instrument will be used for on this project.

f. A thorough checklist of the work items and inspections that need to be accomplished before DALT field work can be performed. The Contractor must complete, submit, and receive approval of the Completed Pre-Final DALT Work Checklist before DALT field work can be accomplished.

g. A thorough checklist of the work items and inspections that need to be accomplished before the [Season 1]TAB field work can be performed. The Contractor must complete, submit, and receive approval of the Completed [Season 1]Pre-TAB Work Checklist before the [Season 1]TAB field work can be accomplished.

[h. A thorough checklist of the work items and inspections that need to be accomplished before the Season 2 TAB field work can be performed. The Contractor must complete, submit, and receive approval of the Completed Season 2 Pre-TAB Work Checklist before the Season 2 TAB field work can be accomplished.

] i. The checklists specified above shall be individually developed and tailored specifically for the work under this contract. Refer to NEBB PROCEDURAL STANDARDS, Section III, "Preliminary TAB Procedures" under the paragraphs titled, "Air Distribution System Inspection" and "Hydronic Distribution System Inspection" for examples of items to include in the checklists.

3. Design Review Report

Submit report containing the following information:

a. Review the contract specifications and drawings to verify that the TAB work can be successfully accomplished in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.

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

4. Completed Pre-Final DALT Work Checklist

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

a. Submit a copy of the approved DALT and TAB Procedures Summary: Provide notations describing how actual field procedures differed from the procedures listed.

b. Report format: Submit a comprehensive report for the DALT field work data using data presentation forms equivalent to the "Air Duct Leakage Test Summary Report Forms" located in the SMACNA 1972 CD. In addition, submit in the report, a marked duct shop drawing which identifies each section of duct tested with assigned node numbers for each section. Node numbers shall be included in the completed report forms to identify each duct section.

c. Calculations: Include a copy of all calculations prepared in determining the duct surface area of each duct test section. Include in the DALT reports copy(s) of the calibration curve for each of the DALT test orifices used for testing.

d. 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 are to be calibrated within one year of the date of use in the field; instrument calibration is to be traceable to the measuring standards of the National Institute of Standards and Technology.

e. TAB Supervisor Approval: Include on the submitted report the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

5. Final DALT Report

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

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

a. Procedure Summary: Submit a copy of the approved DALT and TAB Procedures Summary. When applicable, provide notations describing how actual field procedures differed from the procedures listed.

b. Report format: Submit the completed data forms approved in the pre-field TAB Engineering Report completed by TAB field team, reviewed, approved and signed 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 shall be typewritten. Handwritten report forms or report data are not acceptable.

c. 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) Data shall be measured and compiled on a continuous basis for the period in which TAB work affecting those rooms is being done.

(2) Data shall be measured/recorded only after the HVAC systems installations are complete, the systems fully balanced and the HVAC systems controls operating in fully automatic mode. Provide a detailed explanation wherever a final measurement did not achieve the required value.

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

d. Air System Diagrams: Provided updated diagrams with final installed locations of all terminals and devices, any numbering changes, and actual test locations.

e. Air Static Pressure Profiles: Report static pressure profiles for air duct systems including: [AHU-1][RTAC-1][MUA-1][_____]. Report static pressure data for all supply, return, relief, exhaust and outside air ducts for the systems listed. The static pressure report data shall include, in addition to AABC or NEBB or TABB required data, the following:

(1) Report supply fan, return fan, relief fan, and exhaust fan inlet and discharge static pressures.

(2) Report static pressure drop across chilled water coils, DX coils, hot water coils, steam coils, electric resistance heating coils and heat reclaim devices installed in unit cabinetry or the system ductwork.

(3) Report static pressure drop across outside air, return air, and supply air automatic control dampers, both proportional and two-position, installed in unit cabinetry.

(4) Report static pressure drop across air filters, acoustic silencers, moisture eliminators, air flow straighteners, air flow measuring stations or other pressure drop producing specialty items installed in unit cabinetry, or in the system ductwork. Examples of these specialty items are smoke detectors, white sound generators, RF shielding, wave guides, security bars, blast valves, small pipes passing through ductwork, and duct mounted humidifiers.

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

(5) Report static pressure drop across outside air and relief/exhaust air louvers.

(6) Report static pressure readings of supply air, return air, exhaust/relief air, and outside air in duct at the point where these ducts connect to each air moving unit.

[f. Duct Transverses: Report duct traverses for main [and branch main] supply, return[, exhaust, relief and outside air] ducts. [This shall include all ducts, including those which lack 7 1/2 duct diameters upstream and 2 1/2 duct diameters downstream of straight duct unobstructed by duct fittings/offsets/elbows.] The TAB Agency shall evaluate and report findings on the duct traverses taken. Evaluate the suitability of the duct traverse measurement based on satisfying the qualifications for a pitot traverse plane as defined by AMCA 203, "Field Measurements", Section 8, paragraph 8.3, "Location of Traverse Plane".

] g. Instruments: List the types of instruments actually used to measure the tab data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.

Instrumentation, used for taking wet bulb temperature readings shall provide accuracy of plus or minus 5 percent at the measured face velocities. Submit instrument manufacturer's literature to document instrument accuracy performance is in compliance with that specified.

h. Performance Curves: The TAB Supervisor shall 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 shall include, in the TAB Reports, a factory calibration curve for installed flow control balancing valves, flow venturis and flow orifices TAB'd on the job.

j. Data From TAB Field Work: After completion of the TAB field work, prepare the TAB field data for TAB supervisor's review and approval signature, using the reporting forms approved in the pre-field engineering report. Data required by those approved data report forms shall be furnished by the TAB team. Except as approved otherwise in writing by the Contracting Officer, the TAB work and thereby the TAB report shall be considered incomplete until the TAB work is accomplished to within the accuracy range specified in the paragraph WORKMANSHIP.

Appendix C

DALT AND TAB SUBMITTAL AND WORK SCHEDULE

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

Submit TAB Agency and TAB Personnel Qualifications: Within [42] [_____] calendar days after date of contract award.

Submit the DALT and TAB Work Execution Schedule: within [14] [_____] days after receipt of the TAB agency and TAB personnel qualifications approval. Revise and re-submit this schedule 28 days prior to commencement of DALT work and 28 days prior to the commencement of TAB Season 1 work and TAB Season 2 work.

Submit the DALT and TAB Work Procedures Summary: within [14] [_____] days after receipt of the initial approved DALT and TAB Work Execution Schedule.

Meet with the COTR at the Pre-DALT/TAB Meeting: Within [28] [_____] calendar days after receipt of the approved initial DALT/TAB Execution Schedule.

Submit Design Review Report: Within [56] [_____] calendar days after the receipt of the approved initial DALT and TAB Work Execution Schedule.

[Conduct measurements and submit the Record of Existing Facility Conditions: within [28] [_____] days after receipt of approved DALT and TAB Work Procedures Summary.

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

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

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

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

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

Submit Final DALT Report: Within [14] [_____] calendar days after completion of successful DALT Work Field Check, submit [Season 1]TAB report.

Advance Notice of [Season 1]TAB Field Work: At a minimum of [14][_____] calendar days prior to [Season 1]TAB Field Work, submit advance notice of TAB field work accompanied by completed [Season 1]Pre-TAB Work Checklist.

[Season 1]TAB Field Work: At a minimum of [84][_____] 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 [14] [_____] calendar days after completion of [Season 1]TAB field work, submit initial [Season 1]TAB report.

[Season 1]Quality Assurance - COTR TAB Field Check: [30] [_____] calendar days after initial [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] and submit final.

Receive the approved TAB report: Within 21 calendar days, receive the report from Contracting Officer approved TAB report.

Advance Notice of Season 2 TAB Field Work: At a minimum of [126] [_____]calendar days after CCD, submit advance notice of Season 2 TAB field work accompanied by completed Season 2 Pre-TAB Work Checklist.

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

Submit Season 2 TAB Report: Within [14] [_____] calendar days after completion of Season 2 TAB field work, submit Season 2 TAB report.

Season 2 Quality Assurance - COTR TAB Field Checks: [28] [_____] 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 [14] [_____] calendar days after the completion of Season 2 TAB field data check, complete all TAB work.]

Receive the approved TAB report: Within calendar 21 days, receive the report from Contracting Officer.

Appendix D					
REQUIREMENTS FOR DUCT AIR LEAK TESTING					
		SYSTEMS			
		[Package Rooftop w/VAV Unit No. [1] [_____]]	[Package Rooftop w/VAV Unit No. [2] [_____]]	[Package Rooftop w/CV Unit No. [1] [_____]]	[Package Rooftop w/CV Unit No. [2] [_____]]
Duct System Static Pressure, in inches W.C.	for Supply	[4] [_____]	[4] [_____]	[2] [_____]	[2] [_____]
	for Return	[2] [_____]	[2] [_____]	[1] [_____]	[1] [_____]
	for Exhaust	[_____]	[_____]	[_____]	[_____]
	for Outside Air	[2] [_____]	[2] [_____]	[1] [_____]	[1] [_____]
System Oval/Round Duct and Rectangular Duct SMACNA Seal Class	for Supply	A	A	A	A
	for Return	A	A	A	A
	for Exhaust	A	A	A	A
	for Outside Air	A	A	A	A
System Oval/Round Duct SMACNA Leak Class	for Supply	[3] [_____]	[3] [_____]	[6] [_____]	[6] [_____]
	for Return	[6] [_____]	[6] [_____]	[12] [_____]	[12] [_____]
	for Exhaust	[_____]	[_____]	[_____]	[_____]
	for Outside Air	[6] [_____]	[6] [_____]	[12] [_____]	[12] [_____]

Appendix D					
REQUIREMENTS FOR DUCT AIR LEAK TESTING					
		SYSTEMS			
		[Package Rooftop w/VAV Unit No. [1] [_____]]	[Package Rooftop w/VAV Unit No. [2] [_____]]	[Package Rooftop w/CV Unit No. [1] [_____]]	[Package Rooftop w/CV Unit No. [2] [_____]]
System Rectangular Duct SMACNA Leak Class	for Supply	[6] [_____]	[6] [_____]	[12] [_____]	[12] [_____]
	for Return	[12] [_____]	[12] [_____]	[24][_____]	[24][_____]
	for Exhaust	[_____]	[_____]	[_____]	[_____]
	for Outside Air	[12] [_____]	[12] [_____]	[24] [_____]	[24] [_____]
Duct Test Pressure, in inches W.C.	for Supply	[4] [_____]	[2] [_____]	[50] [_____]	[2] [_____]
	for Return	[2] [_____]	[2] [_____]	[1] [_____]	[1] [_____]
	for Exhaust	[_____]	[_____]	[_____]	[_____]
	for Outside Air	[2] [_____]	[2] [_____]	[1] [_____]	[1] [_____]

Appendix D					
REQUIREMENTS FOR DUCT AIR LEAK TESTING					
		SYSTEMS			
		[AHU w/ Economizer & CV Unit No. [1] [______]]	[AHU w/ Economizer & CV Unit No. [2] [______]]	[Series VAV Terminal Boxes Unit No. [1] [______]]	[Exhaust Systems Unit No. [1] [______]]
Duct System Static Pressure, in millimeters W.C.	for Supply	[2] [______]	[2] [______]	[0.5] [______]	n/a
	for Return	[1] [______]	[1] [______]	[0.5] [______]	n/a
	for Exhaust	[0.5] [______]	[0.5] [______]	n/a	[1] [______]
	for Outside Air	[1] [______]	[1] [______]	n/a	n/a
System Oval/Round Duct and Rectangular Duct SMACNA Seal Class	for Supply	A	A	A	A
	for Return	A	A	A	A
	for Exhaust	A	A	A	A
	for Outside Air	A	A	A	A
System Oval/Round Duct SMACNA Leak Class	for Supply	[6] [______]	[6] [______]	12	n/a
	for Return	[12] [______]	[12] [______]	12	n/a
	for Exhaust	[12] [______]	[12] [______]	n/a	[12] [______]
	for Outside Air	[12] [______]	[12] [______]	n/a	n/a

Appendix D					
REQUIREMENTS FOR DUCT AIR LEAK TESTING					
		SYSTEMS			
		[AHU w/ Economizer & CV Unit No. [1] [_____]]	[AHU w/ Economizer & CV Unit No. [2] [_____]]	[Series VAV Terminal Boxes Unit No. [1] [_____]]	[Exhaust Systems Unit No. [1] [_____]]
System Rectangular Duct SMACNA Leak Class	for Supply	[12] [_____]	[12] [_____]	24	n/a
	for Return	[24] [_____]	[24] [_____]	24	n/a
	for Exhaust	[24] [_____]	[24] [_____]	n/a	[24] [_____]
	for Outside Air	[24] [_____]	[24] [_____]	n/a	n/a
Duct Test Pressure, in inches W.C.	for Supply	[2] [_____]	[2] [_____]	[0.5] [_____]	n/a
	for Return	[1] [_____]	[1] [_____]	[0.5] [_____]	n/a
	for Exhaust	[0.5] [_____]	[0.5] [_____]	n/a	[1] [_____]
	for Outside Air	[1] [_____]	[1] [_____]	n/a	n/a

-- End of Section --

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	(2019; Errata 1-4 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-AB 2021; Errata 5-7 2021; Interpretation 1-4 2020; Interpretation 5-8 2021) 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	(2021a) 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; R 2015) 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	(2021) Standard Test Methods for Gravimetric Determination ofWater Vapor Transmission Rate of Materials
ASTM E2231	(2021) 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 Mar 2022) 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.][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:

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

SD-02 Shop Drawings

MICA Plates; G[, [_____]]

Pipe Insulation Systems and Associated Accessories

Duct Insulation Systems and Associated Accessories

Equipment Insulation Systems and Associated Accessories

Recycled content for insulation materials; S

SD-03 Product Data

Pipe Insulation Systems; G[, [_____]]

Duct Insulation Systems; G[, [_____]]

Equipment Insulation Systems; G[, [_____]]

SD-04 Samples

Thermal Insulation; G[, [_____]]

Display Samples; G[, [_____]]

SD-07 Certificates

Indoor air quality for adhesives; S

SD-08 Manufacturer's Instructions

Pipe Insulation Systems; G[, [_____]]

Duct Insulation Systems; G[, [_____]]

Equipment Insulation Systems; G[, [_____]]

1.4 CERTIFICATIONS

1.4.1 Adhesives and Sealants

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

1.5 QUALITY ASSURANCE

1.5.1 Installer Qualification

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

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

2.1.1 Insulation System

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

2.1.2 Surface Burning Characteristics

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

2.2 MATERIALS

Provide insulation that meets or exceed the requirements of [][ASHRAE 90.2]. 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 Cellular Glass

ASTM C552, Type II, and Type III. Supply the insulation from the fabricator with (paragraph WHITE VAPOR RETARDER ALL SERVICE JACKET (ASJ)) ASJ vapor retarder and installed with all longitudinal overlaps sealed and all circumferential joints ASJ taped or supply the insulation unfaced from the fabricator and install with all longitudinal and circumferential joints sealed with vapor barrier mastic.

2.3.2.2 Flexible Elastomeric Cellular Insulation

Closed-cell, foam- or expanded-rubber materials containing anti-microbial additive, complying with ASTM C534/C534M, Grade 1, Type I or II. Type I, Grade 1 for tubular materials. Type II, Grade 1, for sheet materials. Type I and II shall have vapor retarder/vapor barrier skin on one or both sides of the insulation, and require an additional exterior vapor retarder covering for high relative humidity and below ambient temperature applications.

2.3.2.3 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 Calcium Silicate

ASTM C533, Type I indoor only, or outdoors above 250 degrees F pipe temperature. Supply insulation with the manufacturer's recommended factory-applied jacket/vapor barrier.

2.3.3.3 Cellular Glass

ASTM C552, Type II and Type III. Supply the insulation with manufacturer's recommended factory-applied jacket.

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 Perlite Insulation

ASTM C610

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 Aboveground Dual Temperature Pipeline

Selection of insulation for use over a dual temperature pipeline system (Outdoor, Indoor - Exposed or Concealed) shall be in accordance with the most limiting/restrictive case. Find an allowable material from paragraph PIPE INSULATION MATERIALS and determine the required thickness from the most restrictive case. Use the thickness listed in paragraphs INSULATION THICKNESS for cold & hot pipe applications.

2.3.5 Below-ground Pipeline Insulation

For below-ground pipeline insulation, use cellular glass, ASTM C552, type II.

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

Apply insulation to unheated and uncooled piping and equipment. Do not compress flexible elastomeric cellular insulation at joists, studs, columns, ducts, and hangers. The insulation must not pull apart after a one hour period; replace any insulation found to pull apart after one hour.

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

TABLE 1					
Insulation Material for Piping					
Service					
	Material	Specification	Type	Class	VR/VB Req'd
	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
	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					

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
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)					
	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
	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

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
	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
	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						

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
	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
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

Table 4 - Minimum Duct Insulation (inches)	
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 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
	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)		
Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (inches)
15 psig or 250 degrees F		
	Rigid Mineral Fiber	2
	Flexible Mineral Fiber	2
	Calcium Silicate/Perlite	4
	Cellular Glass	3
	Faced Phenolic Foam	1.5
	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

TABLE 6		
Insulation Thickness for Hot Equipment (inches)		
Equipment handling steam or media at indicated pressure or temperature limit		
	Material	Thickness (inches)
	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)						

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
	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:					
	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)						

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
	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
	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.

-- End of Section --

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.

Government Acceptance Testing Representatives - Government Acceptance Testing Representatives perform the inherently Governmental function of technical oversight and quality assurance for critical systems, and is distinctly separate from the commissioning process. Government Acceptance Testing Representatives witness final testing of critical systems and report systems' acceptance to the COR. Submittals to be surveilled and approved by Government Acceptance Testing Representatives are identified in Section 01 33 00 SUBMITTAL PROCEDURES. Testing required to be witnessed by Government Acceptance Testing Representatives are indentified in system level sections.

1.2 SEQUENCING AND SCHEDULING

Complete functional performance testing prior to performance verification testing required by Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. 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 01 91 00.15 20 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.][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

Test Equipment; G[, [_____]]

SD-06 Test Reports

Pipe Flushing, Testing, And Water Treatment Reports; G[, [____]]

[Seasonal Test Report; G[, [_____]]

][Full-Load Test Report; G

]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 01 91 00.15 20 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 01 91 00.15 20 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 01 91 00.15 20 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
01 91 00.15 20 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 01 91 00.15 20 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 01 91 00.15 20 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 Mechanical System Technical Commissioning Specialist must review the pre-final TAB Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC. Identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. 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 Mechanical System Technical Commissioning Specialist must witness the DALT Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. 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 Mechanical System Technical Commissioning Specialist must review the pre-final TAB Report required by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. 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 Mechanical System Technical Commissioning Specialist must witness the TAB Field Acceptance Testing specified by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. 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 Mechanical System Technical Commissioning Specialist must review the Start-Up Testing Report, PVT Procedures and PVT Reports including endurance testing trend submittals 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]. The Mechanical System Technical Commissioning Specialist must review each submittal and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel and include in the issues log. 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 Mechanical Systems Technical Commissioning Specialist must review the training plan required by Section 01 78 00 OPERATION AND MAINTENANCE DATA and identify any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel.

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.

-- End of Section --

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 Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet or Niagara BACnet systems, and other referenced Sections.

[1.1.1 Control System Vendor Requirement

The control system provided under this Section must be [_____]. Configure the equipment as indicated in [attached configuration setting requirements][the configuration settings drawings][_____].

]1.1.2 Proprietary Systems

1.1.2.1 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 Section 23 09 23.02 BACNET 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)

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.

1.1.2.2 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 Section 23 09 23.02 BACNET 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 Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

1.1.2.3 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.

1.1.3 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, unless otherwise pre-approved by the Contracting Officer.

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="*"
```

1.1.4 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.

1.1.5 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.

1.1.6 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 or Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet systems with or without 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 135	(2016) BACnet—A Data Communication Protocol for Building Automation and Control Networks
ASHRAE FUN IP	(2021) 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 Jan 2022) UL Standard for Safety 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 Building Automation and Control Network (BACnet) (BACnet)

The term BACnet is used in two ways. First meaning the BACnet Protocol Standard - the communication requirements as defined by ASHRAE 135 including all annexes and addenda. The second to refer to the overall technology related to the ASHRAE 135 protocol.

1.4.5 BACnet Advanced Application Controller (B-AAC) (BACnet)

A hardware device BTL Listed as a B-AAC, which is required to support BACnet Interoperability Building Blocks (BIBBs) for scheduling and alarming, but is not required to support as many BIBBs as a B-BC.

1.4.6 BACnet Application Specific Controller (B-ASC) (BACnet)

A hardware device BTL Listed as a B-ASC, with fewer BIBB requirements than a B-AAC. It is intended for use in a specific application.

1.4.7 BACnet Building Controller (B-BC) (BACnet)

A hardware device BTL Listed as a B-BC. A general-purpose, field-programmable device capable of carrying out a variety of building automation and control tasks including control and monitoring via direct digital control (DDC) of specific systems and data storage for trend information, time schedules, and alarm data. Like the other BTL Listed controller types (B-AAC, B-ASC etc.) a B-BC device is required to support the server ("B") side of the ReadProperty and WriteProperty services, but unlike the other controller types it is also required to support the client ("A") side of these services. Communication between controllers requires that one of them support the client side and the other support the server side, so a B-BC is often used when communication between controllers is needed.

1.4.8 BACnet Broadcast Management Device (BBMD) (BACnet)

A communications device, typically combined with a BACnet router. A BBMD forwards BACnet broadcast messages to BACnet/IP devices and other BBMDs connected to the same BACnet/IP network. Each IP subnet that is part of a BACnet/IP network must have at least one BBMD. Note there are additional restrictions when multiple BBMDs share an IP subnet.

1.4.9 BACnet/IP (BACnet)

An extension of BACnet, Annex J, defines the use of a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnets that share the same BACnet network number. See also paragraph BACNET BROADCAST MANAGEMENT DEVICE.

1.4.10 BACnet Internetwork (BACnet)

Two or more BACnet networks, connected with BACnet routers. In a BACnet Internetwork, there exists only one message path between devices.

1.4.11 BACnet Interoperability Building Blocks (BIBBs) (BACnet)

A BIBB is a collection of one or more ASHRAE 135 Services intended to define a higher level of interoperability. BIBBs are combined to build the BACnet functional requirements for a device in a specification. Some BIBBs define additional requirements (beyond requiring support for specific services) in order to achieve a level of interoperability. For example, the BIBB DS-V-A (Data Sharing-View-A), which would typically be used by a front-end, not only requires the client to support the ReadProperty Service, but also provides a list of data types (Object / Properties) which the client must be able to interpret and display for the user.

In the BIBB shorthand notation, -A is the client side and -B is the server side.

The following is a list of some BIBBs used by this or referenced Sections:	
DS-COV-A	Data Sharing-Change of Value (A side)
DS-COV-B	Data Sharing-Change of Value (B side)
NM-RC-B	Network Management-Router Configuration (B side)
DS-RP-A	Data Sharing-Read Property (A side)
DS-RP-B	Data Sharing-Read Property (B side)
DS-RPM-A	Data Sharing-Read Property Multiple (A Side)
DS-RPM-B	Data Sharing-Read Property Multiple (B Side)
DS-WP-A	Data Sharing-Write Property (A Side)
DM-TS-B	Device Management-Time Synchronization (B Side)
DM-UTC-B	Device Management-UTC Time Synchronization (B Side)
DS-WP-B	Data Sharing-Write Property (B side)
SCHED-E-B	Scheduling-External (B side)
DM-OCD-B	Device Management-Object Creation and Deletion (B side)
AE-N-I-B	Alarm and Event-Notification Internal (B Side)
AE-N-E-B	Alarm and Event-Notification External (B Side)
T-VMT-I-B	Trending-Viewing and Modifying Trends Internal (B Side)

The following is a list of some BIBBs used by this or referenced Sections:	
T-VMT-E-B	Trending-Viewing and Modifying Trends External (B Side)

1.4.12 BACnet Network (BACnet)

In BACnet, a portion of the control Internetwork consisting of one or more segments connected by repeaters. Networks are separated by routers.

1.4.13 BACnet Operator Display (B-OD) (BACnet)

A basic operator interface with limited capabilities relative to a B-OWS. It is not intended to perform direct digital control. A B-OD profile could be used for LCD devices, displays affixed to BACnet devices, handheld terminals or other very simple user interfaces.

1.4.14 BACnet Segment (BACnet)

One or more physical segments interconnected by repeaters (ASHRAE 135).

1.4.15 BACnet Smart Actuator (B-SA) (BACnet)

A simple actuator device with limited resources intended for specific applications.

1.4.16 BACnet Smart Sensor (B-SS) (BACnet)

A simple sensing device with limited resources.

1.4.17 BACnet Testing Laboratories (BTL) (BACnet)

Established by BACnet International to support compliance testing and interoperability testing activities and consists of BTL Manager and the BTL Working Group (BTL-WG). BTL also publishes Implementation Guidelines.

1.4.18 BACnet Testing Laboratories (BTL) Listed (BACnet)

A device that has been listed by BACnet Testing Laboratory. Devices may be certified to a specific device profile, in which case the listing indicates that the device supports the required capabilities for that profile, or may be listed as "other".

1.4.19 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'.

1.4.20 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.

1.4.21 Broadcast (BACnet)

Unlike most messages, which are intended for a specific recipient device, a broadcast message is intended for all devices on the network.

1.4.22 Building Control Network (BCN) (All protocols)

The network connecting all DDC Hardware within a building (or specific group of buildings).

1.4.23 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.)

1.4.24 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.

1.4.25 Commandable (All protocols)

See Overridable.

1.4.26 Commandable Objects (BACnet)

Commandable Objects have a Commandable Property, Priority_Array, and Relinquish_Default Property as defined in ASHRAE 135, Clause 19.2, Command Prioritization.

1.4.27 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.

In a non-Niagara Framework BACnet system, a property, setting, or value is configurable if it can be changed via one or more of:

1) via BACnet services (including proprietary BACnet services)
2) via hardware settings on the device

In a Niagara Framework BACnet system, a property, setting, or value is configurable if it can be changed via one or more of:

1) via BACnet services (including proprietary BACnet services)
2) via hardware settings on the device
3) via the Niagara Framework

Note this is more stringent than the ASHRAE 135 definition.

1.4.28 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).

1.4.29 Control Logic Diagram (All protocols)

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

1.4.30 Device (BACnet)

A Digital Controller that contains a BACnet Device Object and uses BACnet to communicate with other devices.

1.4.31 Device Object (BACnet)

Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet Internetwork. This number is often referred to as the device instance or device ID.

1.4.32 Device Profile (BACnet)

A collection of BIBBs determining minimum BACnet capabilities of a device, defined in ASHRAE 135. Standard device profiles include BACnet Advanced Workstations (B-AWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS).

1.4.33 Digital Controller (All protocols)

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

1.4.34 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.

1.4.35 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.

1.4.36 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.

1.4.37 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.

1.4.38 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.

1.4.39 Fox Protocol (Niagara Framework)

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

1.4.40 Functional Profile (LonWorks)

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

1.4.41 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.

1.4.42 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.

1.4.43 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.

1.4.44 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.

1.4.45 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".

1.4.46 I/O Expansion Unit (All protocols)

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

1.4.47 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.

1.4.48 JACE (Niagara Framework)

Java Application Control Engine. See paragraph NIAGARA FRAMEWORK SUPERVISORY GATEWAY

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

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

1.4.50 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.

1.4.51 LonMark (LonWorks)

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

1.4.52 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.

1.4.53 LonMark Interoperability Association (LonWorks)

See paragraph LONMARK INTERNATIONAL.

1.4.54 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).

1.4.55 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.

1.4.56 LonWorks Network Services (LNS) (LonWorks)

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

1.4.57 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.

1.4.58 MAC Address (All protocols)

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

1.4.59 Master-Slave/Token-Passing (MS/TP) (BACnet)

Data link protocol as defined by the BACnet standard. Multiple speeds (data rates) are permitted by the BACnet MS/TP standard.

1.4.60 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.

1.4.61 Network Number (BACnet)

A site-specific number assigned to each network. This network number must be unique throughout the BACnet Internetwork.

1.4.62 Network Variable (LonWorks)

See paragraph STANDARD NETWORK VARIABLE TYPE (SNVT).

1.4.63 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).

1.4.64 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.

1.4.65 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".

1.4.66 Node (LonWorks)

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

1.4.67 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).

1.4.68 Node ID (LonWorks)

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

1.4.69 Object (BACnet)

An ASHRAE 135 Object. The concept of organizing BACnet information into standard components with various associated Properties. Examples include Analog Input objects and Binary Output objects.

1.4.70 Object Identifier (BACnet)

A grouping of two Object properties: Object Type (e.g. Analog Value, Schedule, etc.) and Object Instance (in this case, a number). Object Identifiers must be unique within a device.

1.4.71 Object Instance (BACnet)

See paragraph OBJECT IDENTIFIER

1.4.72 Object Properties (BACnet)

Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.

1.4.73 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.

For non Niagara-based BACnet systems, a property, setting, or value in a device is Operator Configurable when it is Configurable and is either:

a. a Writable Property of a Standard BACnet Object; or

b. a Property of a Standard BACnet Object that is Writable when Out_Of_Service is TRUE and Out_Of_Service is Writable.

1.4.74 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).

1.4.75 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.

1.4.76 Packaged Unit (All protocols)

See packaged equipment.

1.4.77 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.

1.4.78 Physical Segment (BACnet)

A single contiguous medium to which BACnet devices are attached (ASHRAE 135).

1.4.79 Polling (All protocols)

A device periodically requesting data from another device.

1.4.80 Points (All protocols)

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

1.4.81 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.

1.4.82 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).

1.4.83 Proprietary (BACnet)

Within the context of BACnet, any extension of or addition to object types, properties, PrivateTransfer services, or enumerations specified in ASHRAE 135. Objects with Object_Type values of 128 and above are Proprietary Objects. Properties with Property_Identifier of 512 and above are proprietary Properties.

1.4.84 Protocol Implementation Conformance Statement (PICS) (BACnet)

A document, created by the manufacturer of a device, which describes which portions of the BACnet standard may be implemented by a given device. ASHRAE 135 requires that all ASHRAE 135 devices have a PICS, and also defines a minimum set of information that must be in it. A device as installed for a specific project may not implement everything in its PICS.

1.4.85 Repeater (All protocols)

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

1.4.86 Router (All protocols)

A device that connects two CEA-709.1-D channels (in a LonWorks system) or two ASHRAE 135 networks (in a BACnet system) 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 or a BACnet internetwork and to limit network traffic.

1.4.87 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.

1.4.88 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.

1.4.89 Standard BACnet Objects (BACnet)

Objects with Object_Type values below 128 and specifically enumerated in Clause 21 of ASHRAE 135. Objects which are not proprietary. See paragraph PROPRIETARY.

1.4.90 Standard BACnet Properties (BACnet)

Properties with Property_Identifier values below 512 and specifically enumerated in Clause 21 of ASHRAE 135. Properties which are not proprietary. See Proprietary.

1.4.91 Standard BACnet Services (BACnet)

ASHRAE 135 services other than ConfirmedPrivateTransfer or UnconfirmedPrivateTransfer. See paragraph PROPRIETARY.

1.4.92 Standard Configuration Property Type (SCPT) (LonWorks)

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

1.4.93 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.

1.4.94 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.

1.4.95 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.

1.4.96 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.

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

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

1.4.98 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.

1.4.99 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.

1.4.100 UMCS Network (All protocols)

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

1.4.101 Writable Property (BACnet)

A Property is Writable when it can be changed through the use of one or more of the WriteProperty services defined in ASHRAE 135, Clause 15 regardless of the value of any other Property. Note that in the ASHRAE 135 standard, some Properties may be writable when the Out of Service Property is TRUE; for purposes of this Section, Properties that are only writable when the Out of Service Property is TRUE are not considered to be Writable.

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	
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

TABLE II. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE FOR SUBMITTAL)
12	S,E	Execute PVT PVT Testing Activities	AAO #9 and #11As indicated in PART 3 of this Section
13	S	PVT Report	[[_____] days]ACO #12 As indicated in PART 3 of this Section
14	S	Controller Application Programs Controller Configuration Settings Niagara Framework Supervisory Gateway Backups Final LNS Database	[[_____] days]AAO #13
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.][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

DDC Contractor Design Drawings; G[, [_____]]

Draft As-Built Drawings; G[, [_____]]

Final As-Built Drawings; G[, [_____]]

SD-03 Product Data

Programming Software; G[, [_____]]

Controller Application Programs; G[, [_____]]

Configuration Software; G[, [_____]]

Controller Configuration Settings; G[, [_____]]

Proprietary Multi-Split Engineering Tool Software; G[, [_____]]

Manufacturer's Product Data; G[, [_____]]

XIF files; G[, [_____]]

Draft LNS Database; G[, [_____]]

Final LNS Database; G[, [_____]]

LNS Plug-ins; G[, [_____]]

Niagara Framework Supervisory Gateway Backups; G[, [_____]]

[Niagara Framework Engineering Tool; G[, [_____]]]

Niagara Framework Wizards; G[, [_____]]

SD-05 Design Data

Boiler Or Chiller Plant Gateway Request

SD-06 Test Reports

Existing Conditions Report

Pre-Construction Quality Control (QC) Checklist; G[, [_____]]

Post-Construction Quality Control (QC) Checklist; G[, [_____]]

Start-Up Testing Report; G[, [_____]]

PVT Procedures; G[, [_____]]

PVT Report; G[, [_____]]

Control Contractor’s Performance Verification Testing Plan; G

Equipment Supplier’s Performance Verification Testing Plan; G

Endurance Testing Results; G

Performance Verification Test Report; G

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G[, [_____]]

Training Documentation; G[, [_____]]

SD-11 Closeout Submittals

Enclosure Keys; G[, [_____]]

Password Summary Report; G[, [_____]]

Closeout Quality Control (QC) Checklist; G[, [_____]]

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 Configuration Software

For each type of controller, provide the configuration tool software in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copies of the software user manuals for each software with the software submittal.

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

1.8.4 Controller Configuration Settings

For each controller, provide copies of the installed configuration settings as source code compatible with the configuration tool software for that controller in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

Submit Controller Configuration Settings 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 [2][_____] copies of the Controller Configuration Settings CD-ROM.

1.8.5 Programming Software

For each type of programmable controller, provide the programming software in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS. Submit hard copies of software 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.

1.8.6 Controller Application Programs

For each programmable controller, provide copies of the application program as source code compatible with the programming software for that controller in accordance with Section 23 09 23.02 BACNET 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.

1.8.7 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.

1.8.8 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.

1.8.9 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.

[1.8.10 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 SYSTEMS and Section 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 non-BACnet 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 Checklist for BACnet 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 BACnet 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, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for

BACnet or Niagara BACnet 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

For all BACnet hardware: for each manufacturer, model and version (revision) of DDC Hardware provide the Protocol Implementation Conformance Statement (PICS) in accordance with Section 23 09 23.02 BACNET 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, Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS for BACnet or Niagara BACnet 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 BACnet Device Information

3.3.9.4.1 Device Object Identifier

The Device Object Identifier: The Object_Identifier of the Device Object

3.3.9.4.2 Network Number

The Network Number for the device.

3.3.9.4.3 MAC Address

The MAC Address for the device

3.3.9.4.4 BTL Listing

The BTL Listing of the device. If the device is listed under multiple BTL Profiles, indicate the profile that matches the use and configuration of the device as installed.

3.3.9.4.5 Proprietary Services Information

If the device uses non-standard ASHRAE 135 services as defined and permitted in Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS, indicate that the device uses non-standard services and include a description of all non-standard services used. Describe usage and content such that a device from another vendor can interoperate with the device using the non-standard service. Provide descriptions with sufficient detail to allow a device from a different manufacturer to be programmed to both read and write the non-standard service request:

a. read: interpret the data contained in the non-standard service and;

b. write: given similar data, generate the appropriate non-standard service request.

3.3.9.4.6 Alarming Information

Indicate whether the device is used for alarm generation, and which types of alarm generation the device implements: intrinsic, local algorithmic, remote algorithmic.

3.3.9.4.7 Scheduling Information

Indicate whether the device is used for scheduling.

3.3.9.4.8 Trending Information

Indicate whether the device is used for trending, and indicate if the device is used to trend local values, remote values, or both.

3.3.9.5 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 Object and Property Information

The Object Type and Instance Number for the Object associated with the point. If the value of the point is not in the Present_Value Property, then also provide the Property ID for the Property containing the value of 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 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.

3.3.10.9 Primary Point Information: SNVT Type

The SNVT type used by the point. Provide this information whenever SNVT Name is required.

3.3.10.10 Niagara Station ID

The Niagara Station ID of the Niagara Framework Supervisory Gateway the point is mapped into.

3.3.10.11 Network Data Exchange Information (Gets Data From, Sends Data To)

Provide the DDC Hardware Identifier of other DDC Hardware the point is shared with.

3.3.10.12 Override Information (Object Type and Instance Number)

For each point requiring an Override and not residing in a Niagara Framework Supervisory Gateway, indicate if the Object for the point is Commandable or, if the use of a separate Object was specifically approved by the Contracting Officer, provide the Object Type and Instance Number of the Object to be used in overriding the point.

3.3.10.13 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.

3.3.10.14 Trend Object Information

For each point requiring a trend, indicate if the trend is Local or Remote, the trend Object type and the trend Object instance number. For remote trends provide the DDC Hardware Identifier for the device containing the trend Object in the Points Schedule notes.

3.3.10.15 Alarm Information

Indicate the Alarm Generation Type, Event Enrollment Object Instance Number, and Notification Class Object Instance Number for each point requiring an alarm. (Note that not all alarms will have Event Enrollment Objects.)

For Niagara BACnet systems: Indicate the Alarm Generation Type and Notification Class Object Instance Number for each point requiring an alarm. (Note that not all alarms will have a Notification Class Object.)

3.3.10.16 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. For Operator Configurable Points indicate BACnet Object and Property information (Name, Type, Identifiers) containing the configurable value. Indicate whether the property is writable always, or only when Out_Of_Service is TRUE.

b. For Configurable Points indicate the BACnet Object and Property information as for Operator Configurable points, or identification of the configurable settings from within the engineering software for the device or identification of the hardware settings on the device.

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 BACnet Trend Log or Trend Log Multiple 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.

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 PERFORMANCE VERIFICATION TESTING

3.7.1 General

PVT testing must demonstrate compliance of controls work with contract document requirements and must be performed by the Controls Contractor and Equipment Suppliers. No less than [14][__] calendar days prior to start of controls system installation, meet with the Contracting Office's technical representative (COTR) [and the designing engineer of the HVAC systems], the Contractor's QA representative, the Contractor's Controls Contractor representative,[and the control system Owner] to develop a mutual understanding relate to the details of the PVT work requirements, including required submittals, work schedule, and field quality control.

3.7.2 Performance Verification Testing and Commissioning

PVT testing is a Government quality assurance function that includes systems trending and field tests. Commissioning is a quality control function that is the Commissioning Team’s responsibility to the extent required by this contract.

3.7.3 Performance Verification Testing of Equipment with Packaged Controls

Controls Contractor and Equipment Supplier(s) must share and coordinate PVT testing responsibilities for equipment provided with on-board factory packaged controls such as boiler controllers, dedicated outside air systems (DOAS’s), and packaged pumping systems.

3.7.3.1 Controls Contractor Responsibilities

The Controls Contractor must provide a PVT Plan separate from Equipment Supplier’s performance verification testing plan, perform endurance testing, and perform PVT testing concurrent with Equipment Suppliers’ testing for equipment provided with on-board factory packaged controls to demonstrate the following:

a. Equipment enabling and disabling.

b. Equipment standard and optional control points necessary to accomplish functionality regardless if specified in contract documents or not.

c. Equipment standard and optional alarms critical to safe operation regardless if specified in contract documents or not.

d. All control points added by Controls Contractor in addition to onboard factory packaged controls regardless if specified in contract documents or not.

Refer to paragraphs titled “Performance Verification Test Plan” and “Endurance Testing” for additional information.

3.7.3.2 Equipment Supplier Responsibilities

Each Equipment Supplier must provide PVT Plans separate from Controls Contractor’s plans and perform PVT testing concurrent with Controls Contractor’s testing for their equipment provided with on-board factory packaged controls to demonstrate the following:

a. Equipment standard and optional control features necessary to accomplish functionality regardless if specified in contract documents or not.

b. Equipment standard and optional operation modes necessary to accomplish functionality regardless if specified in contract documents or not.

c. Equipment standard and optional alarm conditions for safe operation regardless if specified in contract documents or not.

Refer to all paragraphs under paragraph titled “Performance Verification Testing” except for section titled “Endurance Testing” for additional information.

3.7.4 Sequencing of Performance Verification Testing Activities

PVT activities must be sequenced with major activities listed below for Test and Balance (TAB) Contractor, Equipment Suppliers, Commissioning Specialists, and others to demonstrate fully functioning systems. Refer to Section 01 32 17.00 20 COST-LOADED NETWORK ANALYSIS SCHEDULES (NAS). Complete the items in TABLE III: SEQUENCING OF PVT TESTING ACTIVITIES as schedule activities or milestones.

TABLE III: SEQUENCING OF PVT TESTING ACTIVITIES

SEQUENCE	ITEM
1	Submission, review, and approval of Control Contractors PVT Plans.
2	Submission, review, and approval of Equipment Suppliers PVT Plans.
3	Submission, review, and approval of certified final Test and Balance Report.
4	Conduct commissioning functional performance tests.
5	Submission, review, and approval of all of the Commissioning Specialists completed functional performance tests.
6	Request Contracting Officer to allow beginning of Government-witnessed PVT testing.
7	Contracting Officers approval to begin PVT testing.
8	Conduct PVT field work.
9	Governments verbal approval of PVT field work for all systems.
10	Conduct Test and Balance verification field work.
11	Governments written approval of Test and Balance verification field work.
12	Submission, review, and approval of endurance testing.

TABLE III: SEQUENCING OF PVT TESTING ACTIVITIES	
SEQUENCE	ITEM
13	Governments written approval of PVT field work for all systems.
14	Facility acceptance recommendation.
15	Submission, review, and approval of Control Contractors PVT Report.
16	Submission, review, and approval of Equipment Suppliers PVT Report.
17	Conduct applicable re-testing and seasonal testing within 10 months of beneficial occupancy.

3.7.4.1 PVT Testing for Multi-Phase Construction

For air moving systems except outside air systems serving multiple phases, all major activities listed in TABLE III through Government’s verbal approval of Test and Balance verification field work can be completed by phase if all ductwork construction is completed for that phase.

For primary systems such as chilled water systems, HVAC heating hot water systems, and outside air systems serving multiple phases, all major activities listed listed in TABLE III through Government’s verbal approval of Test and Balance verification field work for all air moving systems served by that primary system for that phase must be completed prior to conducting PVT field work for that primary system.

3.7.5 Control Contractor's Performance Verification Testing Plan

Submit a detailed PVT Plan of the proposed control systems testing in this contract for approval prior to its use. Develop and use a single PVT Plan for each system with a unique control sequence. Systems sharing an identical control sequence can be tested using copies of the PVT Plan intended for these systems.

PVT Plans must include system-based, step-by-step test methods demonstrating system performs in accordance with contract document requirements. The Government may provide sample PVT Plans upon request. PVT Plans must include the following:

a. Control sequences from contract documents segmented such that each control algorithm, operation mode, and alarm condition is immediately followed by numbered test methods required to initiate a response, expected response, space for comments, and “pass" or "fail” indication for each expected response.

b. PVT Plans with control sequences from contract documents that are not segmented into parts will not be accepted.

c. Indication where assisting personnel are required such as Mechanical Contractor.

d. Signature and date lines for the Contractor's PVT administrator, Contractor's quality assurance representative, and Contracting Officer's representative acknowledging completion of testing.

3.7.6 Performance Verification Testing Sample Size

PVT testing sample sizes will be as follows:

a. 100-Percent of the following systems:

(1) primary systems including, but not limited to, chilled water and HVAC heating hot water systems

(2) air handling unit systems including all associated fans except for remote exhaust air fans

(3) DOAS’s including all associated fans except for remote exhaust air fans

b. 20-Percent of each set of systems with a shared identical control sequence for systems such as:

(1) air terminal units

(2) exhaust air fans

(3) terminal equipment such as fan coil units and unit heaters

3.7.6.1 Selection of Systems to Test

For sample sets less than 100-percent, the Government will choose which systems will be tested. The Government may require additional testing if previous testing results are inconsistent or demonstrate improper system control as follows:

a. An additional 25-percent after five-percent failure rate of first sample set.

b. 100-percent after any failures occurring in additional sample set.

3.7.7 Conducting Performance Verification Testing

At least 15 days prior to preferred test date, request the Contracting Officer to allow the beginning of Government-witnessed PVT testing. Provide an estimated time table required to perform testing of each system. Furnish personnel, equipment, instrumentation, and supplies necessary to perform all aspects of testing. Testing personnel must be regularly employed in the testing and calibration of control systems. After receipt of Contracting Officer’s approval to begin testing, perform PVT testing using project's as-built (shop) control system drawings, project's design drawings, and approved PVT Plans.

During testing, identify deficiencies that do not meet contract document requirements. Deficiencies must be investigated, corrected with corrections documented, and re-tested at a later date following procedures for the initial PVT testing. The Government may require re-testing of any control system components affected by the original failed test.

3.7.8 Endurance Testing

3.7.8.1 General

Conduct endurance testing in conjunction with the PVT to demonstrate control loop stability and accuracy. For all control loops tested, record trend data of the control variables over time, demonstrating that the control loop responds to a sudden change of the control variable set point without excessive overshoot or undershoot. Conduct endurance testing for each system subject to PVT testing. Systems must be operating as normally anticipated during occupancy throughout endurance testing.

Endurance testing results must clearly demonstrate control loop stability and accuracy. Controlled loop outputs must be stable and accurately maintain each setpoint.

3.7.8.2 Hardware

[Use hardware provided in this contract for testing.] [Use Government furnished hardware for testing if available when endurance testing begins. If unavailable, the Contractor must provide suitable hardware for required testing.]

If insufficient buffer capacity exists to trend the entire endurance test, upload trend data during the course of endurance testing to ensure all trend data is retained. Lost trend data will require retesting of all control points for affected system(s).

3.7.8.3 Endurance Testing Results Format

Submit endurance testing results for each tested system in a graphical format complete with clear indication of value(s) for y-axis, value for x-axis, and legend identifying each trended control point. The number of control points contained on a single graph must be such that all control points can be clearly visible. Control points must be logically grouped such that related points appear on a single graph. In addition, submit a separate comma separated value (CSV) file of raw trend data for each trended system. Each trended control point in CSV file must be clearly identified.

For control points recorded based on change of value, change of value for recording data must be clearly identified for each control point.

3.7.8.4 Endurance Testing Start, Duration, and Frequency

Trending of all control points for a given system must start at an identical date and time regardless of the basis of data collection. Duration of all endurance tests must be at least [one-week][_____].

Unless specified otherwise for control points recorded based on time, frequency of data collection must be [15-minutes] [_____]. Frequency of data collection for specific types of control points is as follows:

3.7.8.4.1 Points Trended at One Minute Intervals

a. Temperature for supply air, return air, mixed air, supply water, and return water

b. Temperature for outside air, supply air, return air and exhaust air entering and leaving energy recovery device

c. Flow for supply air, return air, outside air, chilled water, and HVAC heating hot water

d. Flow for exhaust air associated with energy recovery

e. Relative humidity for outside air and return air

f. Relative humidity for outside air, supply air, return air and exhaust air entering and leaving energy recovery device

g. Command and status for control dampers and control valves

h. Speed for fans and pumps

i. Pressure for fans and pumps

3.7.8.4.2 Points Trended at 15 Minute Intervals

a. Temperature and relative humidity for zones

b. Temperature and relative humidity for outside air not associated with energy recovery

c. Command and status for equipment

d. Pressure relative to the outside for facility

3.7.8.5 Trended Control Points

Trended control points for each system must demonstrate each system performs in accordance with contract document requirements. Trended control points must include, but not be limited to, control points listed in contract document points list.

Minimum control points that are required to be trended for selected systems are listed below. These control points must be trended as applicable to this contract in addition to control points necessary to demonstrate systems perform in accordance with contract document requirements and those listed in contract document’s points list.

[3.7.8.5.1 Air-Cooled Chiller Chilled Water System.

a. Chiller(s) command and status

b. Chiller isolation valve(s) command and status

c. Chilled water pump(s) actual speed

d. Chilled water pump(s) setpoint and actual differential pressure

e. Minimum flow bypass control valve command

f. Minimum system flow setpoint and actual flow

g. Chilled water supply setpoint and actual temperature

h. Chilled water return actual temperature

i. Chilled water actual flow

j. Outside air actual dry-bulb temperature

][3.7.8.5.2 HVAC Heating Hot Water System with Boiler.

a. Boiler(s) command and status

b. Boiler(s) isolation valve command and status

c. HVAC heating hot water pump(s) actual speed

d. HVAC heating hot water pump(s) setpoint and actual differential pressure

e. Minimum flow bypass control valve command

f. Minimum system setpoint and actual flow

g. HVAC heating hot water supply setpoint and actual temperature

h. HVAC heating hot water return actual temperature

i. HVAC heating hot water actual flow

j. Outside air actual dry-bulb temperature

][3.7.8.5.3 HVAC Heating Hot Water System with Steam-to-Hot Water Heat Exchanger.

a. Steam control valve(s) command

b. Heat exchanger isolation valve(s) command and status

c. HVAC heating hot water pump(s) actual speed

d. HVAC heating hot water pump(s) setpoint and actual differential pressure

e. Minimum flow bypass control valve command

f. Minimum system setpoint and actual flow

g. HVAC heating hot water supply setpoint and actual temperature

h. HVAC heating hot water return actual temperature

i. HVAC heating hot water actual flow

j. Outside air actual dry-bulb temperature

][3.7.8.5.4 Air Handling Unit with Relief Air Fan

a. Outside air actual dry-bulb temperature

b. Outside air actual relative humidity

c. Outside air setpoint and actual airflow

d. Minimum outside air control damper command

e. Economizer outside air control damper command

f. Facility setpoint and actual relative pressure

g. Return air actual dry-bulb temperature

h. Return air actual relative humidity

i. Return air control damper command

j. Relief air control damper command

h. Relief air fan actual speed

i. Mixed air setpoint and setpoint and actual temperature

j. Preheat coil leaving air setpoint and actual temperature

k. Preheat coil control actuator command

l. Cooling coil leaving air setpoint and actual temperature

m. Cooling coil control valve command

n. Supply air fan actual speed

o. Discharge air actual temperature

p. Supply air fan setpoint and actual static pressure

][3.7.8.5.5 Dedicated Outside Air System (DOAS)

a. Outside air actual dry-bulb temperature

b. Outside air actual relative humidity

c. Outside air isolation damper command and status

d. Outside air setpoint and actual airflow

e. Energy recovery wheel command, status, and actual speed

f. Energy recovery wheel’s OA bypass control damper command and status

g. Energy recovery wheel’s defrost cycle command and status

h. Energy recovery wheel’s OA discharge air actual dry-bulb temperature

i. Energy recovery wheel’s OA discharge air actual relative humidity

j. Preheat coil leaving air setpoint and actual temperature

h. Preheat coil control actuator command

i. Cooling coil leaving air setpoint and actual temperature

j. Cooling coil control valve command

k. Supply air fan actual speed

l. Reheat coil control valve command

m. Discharge air setpoint and actual temperature

n. Supply air fan setpoint and actual static pressure

o. Facility setpoint and actual relative pressure

p. Return air actual dry-bulb temperature

q. Return air actual relative humidity

r. Energy recovery wheel’s EA bypass control damper command and status

s. Energy recovery wheel’s EA discharge air actual dry-bulb temperature

t. Energy recovery wheel’s EA discharge air actual relative humidity

u. Exhaust air fan actual speed

v. Exhaust air isolation damper command and status

][3.7.8.5.6 Series Fan-Powered Supply Air Terminal Units

a. Zone setpoint and actual dry-bulb temperature

b. Zone actual relative humidity

c. Control damper command

d. Fan command and status

e. Heating coil valve command

f. Airflow actual value

g. Leaving air actual temperature

]3.7.8.6 Endurance Testing Sample Size

Endurance Testing sample sizes ware as follows:

a. 100-Percent of the following systems:

(1) primary systems including, but not limited to, chilled water and HVAC heating hot water systems

(2) air handling unit systems including all associated fans except for remote exhaust air fans

(3) DOAS’s including all associated fans except for remote exhaust air fans

b. 20-Percent of each set of systems with a shared identical control sequence for systems such as:

(1) air terminal units

(2) exhaust air fans

(3) terminal equipment such as fan coil units and unit heaters

3.7.8.6.1 Selection of Systems to Test

For sample sets less than 100-percent, the Government will choose which systems will be tested. The Government may require additional testing if previous testing results are inconsistent or demonstrate improper system control as follows:

a. An additional 25-percent after five-percent failure rate of first sample set.

b. 100-percent after any failures occurring in additional sample set.

3.7.9 Performance Verification Test Report

Submit a PVT Report after receiving Government's written approval of PVT field work that is intended to document test results and final control system sequences and settings prior to turnover. The PVT Report must contain the following:

a. Executive summary that briefly discusses results of each system's endurance testing and PVT testing and conclusions for each system.

b. Endurance testing for each system.

c. Completed PVT Plan for each system used during testing that includes hand written field notes and participant signatures.

d. Blank PVT Plan for each system approved prior to testing that is edited to reflect changes occurring during testing. Edits must be typed and must reflect changes to control sequences from contract documents, must reflect changes to numbered test methods required to initiate a response, and must reflect changes to expected response. Only one blank PVT Plan is required for each set of systems sharing an identical control sequence, such as air terminal units, exhaust air fans, fan coil units and unit heaters.

e. Written certification that the installation and testing of all systems are complete and meet all contract document requirements.

3.8 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.

3.9 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.

[3.10 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.

3.10.1 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.

3.10.2 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.

3.10.3 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.

3.10.4 Scheduled Work

This work must be performed [during regular working hours, Monday through Friday, excluding Federal holidays][_____].

3.10.5 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.

3.10.6 Operation

After performing scheduled adjustments and repairs, verify control system operation as demonstrated by the applicable tests of the performance verification test.

3.10.7 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.

3.10.8 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.

3.10.9 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.

]3.11 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.

3.11.1 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.

3.11.2 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.

3.11.3 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).	|____|

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED LONWORKS SYSTEMS		
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 BACNET 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.	|____|
Items verified for Closeout QC Checklist Submittal:		

QC CHECKLIST FOR BACNET SYSTEMS

6	Final As-built Drawings, including all Points Schedule drawings, accurately represent the final installed system.		|____|
7	Programming software has been submitted for all programmable controllers.		|____|
8	All software has been licensed to the Government.		
9	O&M Instructions have been completed and submitted.		|____|
10	Training course has been completed.		|____|
11	All DDC Hardware is installed on a BACnet ASHRAE 135 network using either MS/TP in accordance with Clause 9 or IP in accordance with Annex J.		|____|
12	All DDC Hardware is BTL listed.		|____|
13	Communication between DDC Hardware is only via BACnet using standard services, except as specifically permitted by the specification. Non-standard services have been fully documented in the DDC Hardware Schedule.		|____|
14	Scheduling, Alarming, and Trending have been implemented using the standard BACnet Objects for these functions.		|____|
15	All Properties indicated as required to be Writable are Writable and Overrides have been provided as indicated		|____|

____ ___________________

(QC Representative Signature) (Date)

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED BACNET 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

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED BACNET SYSTEMS		
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.	|____|
Items verified for Closeout QC Checklist Submittal:		
6	Final As-built Drawings, including all Points Schedule drawings, accurately represent the final installed system.	|____|
7	Programming software has been submitted for all programmable controllers.	|____|
8	All software has been licensed to the Government.	
9	O&M Instructions have been completed and submitted.	|____|
10	Training course has been completed.	|____|
11	All DDC Hardware is installed on a BACnet ASHRAE 135 network using either MS/TP in accordance with Clause 9 or IP in accordance with Annex J.	|____|
12	All DDC Hardware is BTL listed.	|____|
13	Communication between DDC Hardware is only via BACnet using standard services, except as specifically permitted by the specification. Non-standard services have been fully documented in the DDC Hardware Schedule.	|____|
14	Scheduling, Alarming, and Trending have been implemented using Niagara Framework objects and services, and BACnet Instrinsic Alarming as indicated.	|____|
15	All Properties indicated as required to be Writable are Writable and Overrides have been provided as indicated	|____|
____ ___________________		

QC CHECKLIST FOR NIAGARA FRAMEWORK BASED BACNET SYSTEMS		
	(QC Representative Signature)	(Date)

-- 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	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
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

NSF INTERNATIONAL (NSF)

NSF 372	(2016) Drinking Water System Components - Lead Content

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.][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

System Coordination; G[, [_____]]

SD-03 Product Data

Instructions; G[, [_____]]

Equipment Data; G[, [____]]

Training Period; G[, [_____]]

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[, [_____]]

Training; G[, [____]]

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.
Circulator	[_____]
Small In-Line	[_____]
Large In-Line	[_____]
Base-Mounted, Flexible Coupled, End Suction	[_____]
Base-Mounted, Close Coupled, End Suction	[_____]
Base-Mounted, Flexible Coupled, Double Suction, [Horizontally] [and] [Vertically] Split	[_____]
Vertical Lineshaft Turbine	[_____]
Automatic Cooling Coil Condensate Pump Units	[_____]

2.3.1 Circulator

Provide pumps with capacities as indicated of a horizontal, [in-line, three piece oil lubricated] [wet rotor] circulator type specifically designed for quiet operation. Suitable for 225 degrees F operation at [125][_____] psig working pressure. The pump must be single stage with [flanged] [union] piping connections. The pump internals must be capable of being serviced without disturbing piping connections.

[a. The three piece pump must be composed of three separable components a motor, bearing assembly, and [cast iron] [lead free bronze certified in accordance with NSF 372 pump end (wet end). The motor shaft must be connected to the pump shaft via a replaceable flexible coupler.]
]
[b. Wet rotor circulator for potable water service must be lead content certified in accordance with NSF 372.
]

2.3.1.1 Seal Assembly

Pump must be equipped with an internally flushed mechanical seal assembly. Seal assembly must have a brass housing, 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.

2.3.1.2 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.

2.3.1.3 Motors

Motors must meet scheduled horsepower, speed, voltage, and enclosure design. Motors must be drip proof, maintenance free, premium efficiency and meet NEMA MG 1 specifications.

[Pump must be driven by an electrically commutated electrical motor (ECM) with permanent magnet rotor. The rotor magnets must be time stable, non-toxic ceramic magnets. Drive the electrically commuted electrical motor by a frequency converter with an integrated PFC filter.
]

2.3.2 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.

2.3.2.1 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.

2.3.2.2 Bearing

The bearing assembly must house maintenance-free permanently lubricated bearings.

2.3.2.3 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.

2.3.2.4 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.

2.3.2.5 Volute

Pump volute must be of cast iron. The connection style on cast iron pumps must be flanged.

2.3.2.6 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.

2.3.2.7 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.

2.3.3 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.

2.3.3.1 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.

2.3.3.2 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.

2.3.3.3 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.

2.3.3.4 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.

2.3.3.5 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.

2.3.3.6 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.

2.3.4 Base-Mounted, Flexible Coupled, End suction

Provide pumps with capacities as indicated; base mounted, separately-coupled, end suction designed with volute housing mounted to the frame to allow for pump service without relocating the motor or disturbing piping connections. Bearings and seals must be serviceable without disturbing piping. Pump must be factory hydrostatically tested in accordance with Hydraulic Institute standards and thoroughly cleaned.

2.3.4.1 Casing

Provide radially split pump casing ASTM A48/A48M Class 30 cast iron suitable for [175][250][_____] psig working pressure with integral cast iron flanges drilled for ASME B16.1 [ANSI Class 125] [ANSI Class 250] flanges, with an integrally-cast pedestal support foot. The pump volute must include gauge tappings at suction and discharge nozzles along with vent and drain tappings at top and bottom.

2.3.4.2 Pump Shaft

Carbon steel pump shaft with a replaceable [bronze][stainless steel] shaft sleeve completely covering the wetted area of the shaft under the seal.

2.3.4.3 Bearing

Incorporate maintenance free, permanently lubricated and sealed bearings in the pump bearing frame. [Regreasable ball bearing type with provision for purging or flushing through the bearing surface and greased while running after start-up.]

2.3.4.4 Seal Assembly

Equip with an integrally flushed mechanical seal assembly or a positive pressure external seal flushing line. Provide a mechanical seal with ceramic seal seat and carbon seal ring. Seal assembly must be rated up to 225 degrees F.

2.3.4.5 Baseplate

Baseplate must be of steel construction fully enclosed at sides and ends with welded cross members and fully open grouting area for field grouting. Minimum base plate stiffness must conform to HI 1.3 for horizontal baseplate design standards.

2.3.4.6 Coupler

Provide a flexible-type coupler between the pump and motor, capable of absorbing torsional vibration and variable speed operation between the pump and motor. The coupler must allow replacement with no need to move the hubs. Coupler must have natural rubber or neoprene type element materials with a maximum misalignment capability of 4 degrees angular and 0.125 inches parallel. Provide donut shaped elastomer element with preassembled flanges mechanically clamped to reinforced element and preassembled spacer center assembly. Secure flexible donut shaped element of coupler in place with radial clamp ring screws. Couplers must be rated for required maximum rpm, horsepower and torque. The coupler must be shielded by a coupler guard securely fastened to the base. Provide coupler guard in compliance with current national safety standards including 29 CFR 1910.219 and NEMA Z535.4. Guards cannot have gaps greater than 0.250 inches, must be safety orange in color, and have an NEMA Z535.4 compliant warning label.

2.3.4.7 Impeller
Hydraulically and dynamically balance to HI 9.6.4 balance grade G6.3, closed, overhung, single suction, fabricate from cast bronze, key to shaft and secured by a locking capscrew.

2.3.4.8 Motor

Electric Motors must meet NEMA MG 1 and be the horsepower, speed, and voltage indicated. Motor enclosure must be open drip proof [totally enclosed fan cooled]. Motor must have 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 comply with NEMA MG 1.]

2.3.5 Base-Mounted, Close Coupled, End Suction

Provide pumps with capacities as indicated. Pump must be base mounted, close coupled, single stage, end suction design capable of being serviced without disturbing piping connections.

2.3.5.1 Casing

Provide pump volute of Class 30 cast iron suitable for [175][_____] psig working pressure. Include vent, drain and gauge tappings.

2.3.5.2 Seal Assembly

Seal off the liquid cavity at the motor shaft by an internally flushed mechanical seal or a positive pressure external seal flushing line with ceramic seal seat and carbon seal ring, suitable for continuous operation at 225 degrees F. A replaceable shaft sleeve of bronze alloy must completely cover the wetted area under the seal.

2.3.5.3 Impeller

Provide cast bronze or 304 stainless steel impeller, enclosed type, hydraulically and dynamically balanced to HI 9.6.4 balance grade G6.3, keyed to shaft and secured by a locking capscrew.

2.3.5.4 Motor

Electric Motors must comply with NEMA MG 1 and be the horsepower, and voltage indicated. Motor enclosure must be [open drip proof] [totally enclosed fan cooled]. provide with heavy duty grease lubricated ball bearings completely adequate for the maximum load for which the motor and pump impeller 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.

2.3.6 Cooling Coil Condensate Pump Units

Provide pumps with capacities as indicated. Cooling Coil Condensate Pump Unit must be a packaged unit including a corrosion-resistant pump, plastic tank with cover, and automatic controls. Include [factory] [field] installed check valve and a 72 inch minimum, electrical power cord with plug for 120V/1PH/60HZ electrical service.

2.3.6.1 Motor

Electric motor must comply with NEMA MG 1 and be the size, voltage and enclosure indicated. Provide heavy duty grease lubricated ball bearings completely adequate for the maximum load for which the motor is designed.

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	(2019; Errata 1 2019; Errata 2-6 2020; Addenda BY-CP 2020; Addenda AF-DB 2020; Addenda A-G 2020; Addenda F-Y 2021; Errata 7-8 2021; Interpretation 1-4 2020; Interpretation 5-8 2021; Addenda AS-CB 2022) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

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 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; Errata 1 2021) Structural Welding Code - Steel
AWS Z49.1	(2021) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM 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, with Change 1, 2022) 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.][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

Refrigerant Piping System; G[, [_____]]

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[, [_____]]

Operation and Maintenance Manuals; G[, [_____]]

Demonstrations; G[, [_____]]

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 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.

2.4.2 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.

2.4.3 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.

2.4.4 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.

2.4.5 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 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	(2021) Fundamentals Handbook, I-P Edition

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

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	(2020) HVAC Duct Construction Standards Metal and Flexible, 4th 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 Dec 2021) 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.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists; G[, [____]]

Records of Existing Conditions; G[, [____]]

SD-02 Shop Drawings

Connection Diagrams; G[, [____]]

Offset Fitting Configurations; G[, [____]]

SD-03 Product Data

Equipment and Performance Data

Galvanized Steel Ductwork Materials; G[, [____]]

Brazing Materials

Mill-Rolled Reinforcing and Supporting Materials

Round Sheet Metal Duct Fittings; G[, [____]]

Round, High-Pressure, Double-Wall Sheet Metal Ducts; G[, [____]]

Turning Vanes; G[, [____]]

Sound Traps; G[, [____]]

Flexible Connectors; G[, [____]]

Flexible Duct Materials

Power Operated Dampers; G[, [____]]

Fire Dampers and Wall Collars; G[, [____]]

Gravity Backdraft and Relief Dampers; G[, [____]]

Manual Volume Dampers; G[, [____]]

SD-05 Design Data

Design Analysis and Calculations; G[, [____]]

SD-06 Test Reports

Ductwork Leakage Tests; G[, [____]]

Operational Tests; G[, [____]]

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[, [____]]

Power Operated Dampers; G[, [____]]

Fire Dampers and Wall Collars; G[, [____]]

SD-11 Closeout Submittals

Record Drawings; G[, [____]]

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 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.

]2.2.8 Duct Hangers

For duct hangers in contact with galvanized duct surfaces, provide [galvanized] [black carbon] steel painted with inorganic zinc.

2.2.9 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.

2.2.10 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.

]2.2.11 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.

2.2.11.1 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.

2.2.12 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.

2.2.12.1 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.

2.2.13 Power Operated Dampers

Ensure dampers conform to applicable requirements specified under Section 23 09 33.00 40 ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC.

2.2.14 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 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
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
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 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	(2021) 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.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Material, Equipment, and Fixture Lists[; G[, [____]]]

Records of Existing Conditions[; G[, [____]]]

SD-02 Shop Drawings

Fabrication Drawings[; G[, [____]]]

Installation Drawings[; G[, [____]]]

SD-03 Product Data

Equipment and Performance Data[; G[, [____]]]

SD-04 Samples

Manufacturer's Standard Color Chart[; G[, [____]]]

SD-10 Operation and Maintenance Data

Type TS Supply Troffer[; G[, [____]]]

Type TSR Combination Supply and Return Troffer[; G[, [____]]]

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 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.

]2.2.2.8 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.

]2.2.2.9 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.

]2.2.2.10 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.

]2.2.2.11 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.

]2.2.2.12 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.

]2.2.2.13 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.

]2.2.2.14 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.

]2.2.2.15 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.

]2.2.2.16 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.

]2.2.2.17 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.

]2.2.2.18 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.

]2.2.2.19 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.

]2.2.2.20 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.

]2.2.2.21 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.

]2.2.2.22 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.

]2.2.2.23 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.

2.2.2.24 Type TR

Provide type TR return troffer conforming to requirements for Type TS supply troffer.

2.2.2.25 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 52 33.03 20

WATER-TUBE BOILERS, OIL/GAS OR OIL
11/08, CHG 4: 02/22

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 118	(1979) Coal-Tar Bitumen Used in Roofing, Damp-Proofing, and Waterproofing

AMERICAN BOILER MANUFACTURERS ASSOCIATION (ABMA/BOIL)

ABMA Boiler 103	(2001) Selected Codes and Standards of the Boiler Industry

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN LADDER INSTITUTE (ALI)

ALI A14.3	(2008; R 2018) Ladders - Fixed - Safety Requirements

AMERICAN PETROLEUM INSTITUTE (API)

API Std 607	(2016) Fire Test for Quarter-turn Valves and Valves Equipped with Non-metallic Seats
API Std 650	(2013; Errata 1 2013; Addendum 1 2014; Errata 2 2014; Addendum 2 2016; Addendum 3 2018) Welded Tanks for Oil Storage

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A13.1	(2020) Scheme for the Identification of Piping Systems
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and

	Threaded
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2020) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC I	(2017) BPVC Section I-Rules for Construction of Power Boilers
ASME BPVC SEC II-C	(2017) BPVC Section II-Materials Part C-Specifications for Welding Rods Electrodes and Filler Metals
ASME BPVC SEC VII	(2017) BPVC Section VII-Recommended Guidelines for the Care of Power Boilers
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 4	(2013) Fired Steam Generators

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C511	(2017) Reduced-Pressure Principle Backflow Prevention Assembly
AWWA C651	(2014) Standard for Disinfecting Water Mains

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel
AWS D1.3/D1.3M	(2018) Structural Welding Code - Sheet Steel

ASTM INTERNATIONAL (ASTM)

ASTM A48/A48M	(2003; R 2021) Standard Specification for Gray Iron Castings
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 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 A242/A242M	(2013; R 2018) Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A312/A312M	(2021) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B111/B111M	(2018) Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM D1047	(2016) Poly(Vinyl Chloride) Jacket for Wire and Cable
ASTM D1220	(1965; R 1990) Measurement and Calibration of Upright Cylindrical Tanks
ASTM D5864	(2011) Standard Test Method for Determining Aerobic Aquatic Biodegradation of Lubricants or Their Components
ASTM D6081	(1998; R 2014) Aquatic Toxicity Testing of Lubricants: Sample Preparation and Results Interpretation
ASTM F1007	(2018) Standard Specification for Pipeline Expansion Joints of the Packed Slip Type for Marine Application
ASTM F1120	(1987; R 2019) Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications

ASTM F1508	(1996; R 2021) Standard Specification for Angle Style, Pressure Relief Valves for Steam, Gas, and Liquid Services

FM GLOBAL (FM)

FM DS 12-17	(2001) Watertube Boilers

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

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS (NBBI)

NBBI NB-27	(1991) National Board Rules and Recommendations for the Design and Construction of Boiler Blowoff Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021) National Fuel Gas Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 10/NACE No. 2	(2015) Near-White Blast Cleaning

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1424	(2016) Engineering and Design -- Lubricants and Hydraulic Fluids

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-101	(2014; Rev C) Color Code for Pipelines and for Compressed Gas Cylinders
MIL-T-19646	(1990; Rev A; Notice 1 2021) Thermometer,

	Gas Actuated, Remote Reading

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-50494	(Basic; Notice 1) Exhaust Head, Steam
CID A-A-50555	(Basic) Pumping Units, Sewage, Duplex, Centrifugal, Automatic Wet-Pit Type
CID A-A-50558	(Basic; Notice 1) Valves, Pressure Regulating, Steam
CID A-A-50562	(Basic) Pump Units, Centrifugal, Water, Horizontal; General Service and Boiler-Feed: Electric-Motor or Steam-Turbine-Driven
CID A-A-59222	(Basic; Notice 1; CANC Notice 1 2021) Fans, Centrifugal, Draft, Forced and Induced
CID A-A-59224	(Basic; Notice 2) Meters, Fluid Quantity Volumetric
CID A-A-60001	(Rev A) Traps, Steam
FS F-B-2902	(Basic; Notice 1) Boilers, Steam Watertube (Bent Tube, Multi-Drum and Cross Drum) Packaged Type (10,000,000 to 125,000,000 BTU/HR Thermal Output Capacity)
FS W-H-2904	(Basic; Notice 1) Heaters, Fluid, Deaerating (For Water Only) 1,000 to 1,600,000 Pounds Per Hour Capacity
FS WW-S-2739	(Basic; Notice 1; Notice 2) Strainers, Sediment: Pipeline, Water, Air, Gas, Oil, or Steam

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

29 CFR 1910-SUBPART D	Walking - Working Surfaces
29 CFR 1910-SUBPART Q	Welding, Cutting, and Brazing
40 CFR 82	Protection of Stratospheric Ozone

U.S. NAVAL FACILITIES ENGINEERING COMMAND (NAVFAC)

NAVFAC MO 324	(1992) Inspection and Certification of Boilers and Unfired Pressure Vessels

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

WATER QUALITY ASSOCIATION (WQA)

WQA S-100	(2000) Household, Commercial, and Portable Exchange Cation Exchange Water Softeners

1.2 RELATED REQUIREMENTS

The following UFGS sections apply to this section, with the additions and modifications specified herein:

a. 01 78 23 OPERATION AND MAINTENANCE DATA

b. 03 30 00 CAST-IN-PLACE CONCRETE

c. 09 90 00 PAINTS AND COATINGS

d. 09 97 13.17 THREE COAT EPOXY INTERIOR COATING OF WELDED STEEL PETROLEUM FUEL TANKS

e. 09 97 13.28 PROTECTION OF BURIED STEEL PIPING AND STEEL BULKHEAD TIE RODS

f. 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS

g. 21 13 13 WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION

h. 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS

i. 22 05 48.00 20 MECHANICAL SOUND VIBRATION AND SEISMIC CONTROL

j. 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS

k. 33 52 10 FUEL SYSTEMS PIPING (SERVICE STATION)

l. 40 17 26.00 20 WELDING PRESSURE PIPING

m. 22 00 00 PLUMBING, GENERAL PURPOSE

n. 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS

1.3 SYSTEM DESCRIPTION

1.3.1 Design Requirements

1.3.1.1 Boiler Design and Service Conditions

a. Design pressure: [_____] psig

b. Operating pressure: [_____] psig

c. Steam temperature: [_____] degrees F

d. Feedwater temperature: [_____] degrees F

e. Site elevation: [_____] feet

f. Ambient air temperature:

Minimum: [_____] degrees F

Maximum: [_____] degrees F

g. Maximum continuous output (steam): [_____] lb/hr

h. Excess air leaving the boiler: [_____] percent

i. Gas temperature leaving boiler: [_____] degrees F

j. Total forced draft fan static pressure: [_____] inches WC

k. Gas draft at boiler outlet: [_____] inches WC

l. Oxygen (O2) concentration in flue gas: [_____] percent

m. Carbon monoxide (CO) flue gas concentration: [_____] ppm

n. Nitrogen oxide (NOx) conc. in flue gas: [_____] ppm

o. Boiler thermal efficiency: [_____][_____] percent

1.3.1.2 Economizer

a. Design pressure: [_____] psig

b. Operating pressure: [_____] psig

c. Fuel [Natural Gas] [No.: [_____] Fuel Oil]

d. Specific heat of the flue gas: [_____] Btu/lb-degree F

e. Feedwater flow: [_____] gpm

f. Flue gas temperature entering economizer: [_____] degrees F

g. Flue gas temperature leaving economizer: [_____] degrees F

h. Feedwater temperature entering economizer: [_____] degrees F

i. Feedwater temperature leaving economizer: [_____] degrees F

j. Maximum pressure drop, economizer gas side: [_____] in. WC

k. Maximum pressure drop, economizer water side: [_____] psi

l. Fouling factor on feedwater side: [_____]

m. Fouling factor on gas side: [_____].

1.3.1.3 Fans

Design fan to handle air at temperatures from [_____] to [_____] degrees F. Fan shall be [single] [double] width inlet, [single] [double] width outlet, with [clockwise] [counter clockwise] rotation when viewed from the motor end.

1.3.1.4 Expansion Joints and Stacks

a. Temperature:

(1) Maximum ambient: [_____] degrees F

(2) Minimum ambient: [_____] degrees F

(3) Inlet gas at maximum gas flow (gas): [_____] degrees F

(4) Inlet gas at maximum gas flow (oil): [_____] degrees F

(5) Inlet gas at minimum gas flow (gas): [_____] degrees F

(6) Inlet gas at minimum gas flow (oil): [_____] degrees F.

b. Gas Flow at Inlet

(1) Maximum: [_____] lb/hr

(2) Minimum: [_____] lb/hr

c. Required Net Available Draft at Stack Inlet At maximum gas flow: [_____] inches water

d. Gas Exit Velocity (Cone Exit) Maximum at maximum conditions: [_____] ft/sec

e. Flue Gas Acid Dew Point Fuel oil: [_____] degrees F

f. Test Pressures Shop Test: [_____] inches water

g. Thermal Efficiency of Stack: 96 to 98 percent

h. Stack Friction Maximum at design conditions: [_____] inches water

i. Stack Height

(1) Ground elevation: [_____] ft

(2) Roof elevation: [_____] ft

(3) Stack height: [_____] ft

(4) Foundation or footing elevation: [_____] ft

j. Wind pressure: [_____] psf

k. Wind velocity, gusting: [_____] mph

l. Stack Diameter Minimum (below exit cone): [_____] inches

m. Stack deflection Maximum (from vertical center line): [_____] inches

n. Soil bearing stress, maximum: [_____] psf

o. Seismic zone: [_____].

1.3.1.5 Vertical Fuel Oil Storage Tanks

Design the tank to resist the following loads and forces:

Wind: [_____] pounds per square foot

Seismic zone: [_____]

Roof live load: [_____] pounds per square foot

Density of liquid: [_____] pounds per cubic foot.

Allow the following combinations of loads, with corresponding percentages of basic stresses to be used in design:

Load Combination	Percent of Basic Stress
Dead load plus live load	100
Dead load plus live load plus wind load	133
Dead load plus live load plus seismic load	133

1.3.1.6 Fuel Oil Pump and Heater Set

a. Pump/Heater Set

(1) Capacity each pump and each steam heater: [_____] gpm

(2) Suction lift: [_____] ft of water

(3) Discharge pressure at outlet of heater: [_____] psig

(4) Maximum pump speed: 1750 rpm

(5) Specific gravity range: [.92 to .99] [_____to_____]

(6) Viscosity at BHP selection point: 5000 ssu

(7) Viscosity range: [500 to 5000] ssu [_____to_____] ssu

(8) Oil temperature at inlet of heater: [_____] degrees F

(9) Oil temperature at outlet of heater: [_____] degrees F

(10) Maximum oil pressure drop through heater: [_____] psi

(11) Heating medium: Steam

(12) Steam pressure available: [_____] psig

(13) Steam temperature: [_____] degrees F

(14) Heater type: [Bare Tube] [Extended Surface]

b. Fuel Oil Heater Set With Electric Startup Heater

(1) Oil temperature at inlet of heater: [_____] degrees F

(2) Oil temperature at outlet of heater: [_____] degrees F

(3) Maximum oil pressure drop through heater: [_____] psi

(4) Capacity of heater: [_____] gpm

(5) Heating power supply at three phase, 60 Hz: [_____] volts

(6) Control power supply 120 volts, single phase, 60 Hz.

1.3.1.7 Deaerating Heater

a. Design pressure: 30 psig

b. Normal steam operating pressure: [_____] psig

c. Maximum steam operating pressure: [_____] psig

d. Capacity (minimum): [_____] lb/hr of feedwater

e. Inlet Conditions at Heater:

	Pressure psig	Temperature Range Degrees F	Maximum Flow Rate lb/hr
(1) Condensate return	[_____]	[_____] to [_____]	[_____]
(2) High pressure trap returns	[_____]	[_____] to [_____]	[_____]
(3) Makeup water (softened)	[_____]	[_____] to [_____]	[_____]

f. Outlet temperature of feedwater from heater at design capacity: [_____] degrees F

g. Heating steam pressure: [_____] psig

h. Heating steam enthalpy: [_____] Btu/lb

i. Storage capacity to overflow of tank: [_____] gallons storage.

1.3.2 Detail Drawings

1.3.2.1 Boiler

Show arrangement and details of foundations, plans, elevations, wall sections, insulation, tubing details, expansion joints, external piping details and schematics, wiring schematics, [economizer and economizer structural details]. Submit descriptive information with the drawings on each item of the drawings.

1.3.2.2 Boiler Room Auxiliary Equipment

Drawings shall show equipment arrangements, wiring and piping diagrams. Include descriptive information for each item shown. Submit drawings showing the following:

a. Water softening equipment

b. Brine storage tank

c. Condensate receiver

d. Condensate transfer pumps including certified performance curves

e. Deaerator

f. Boiler feed pumps including certified performance curves

g. Steam turbines

h. Continuous blowdown system

i. Chemical feed units

j. Air compressors

k. Air dryers

l. Cranes and hoists

m. Plant heating and ventilating equipment and related ductwork

1.3.2.3 Burners

Submit drawings showing the following:

a. General arrangement

b. Piping details

c. Burner control schematics

d. Flame safety schematics

e. Component details

f. Throat tile details

1.3.2.4 Dampers, Stacks, and Breechings

Submit drawings showing the following:

a. General arrangement

b. Breeching and reinforcing details

c. Breeching hangers and support details

d. Dampers and operators

e. Access doors and frames

f. Expansion joints

g. Stack details

For stack details, include anchor bolt and foundation details, stack sampling ports, platforms, and accessories.

1.3.2.5 Fuel Oil Equipment

Drawings may be manufacturer's standard size for pumps, pump curves, valves, strainers manufacturer's standard size for pumps, pump curves, valves, strainers and pump wiring. Submit drawings showing the following:

a. Certified outline and general arrangement

b. Certified pump curves

c. Equipment detail sheets including viscosity controller, heater, valves

d. Electrical wiring diagrams

e. Oil tanks, foundations, tank heaters, appurtenances, water drawoff, level indication

1.3.2.6 Piping and Specialty Items

Drawings may be manufacturer's standard size. Submit drawings showing the following:

a. Details of special valves and fittings

b. Feedwater regulator details and schematics

c. Details and schematics of feedwater automatic recirculation

1.3.2.7 Ball Joint Installation Details

Include allowable angular flex and minimum offset dimensions for approval.

1.3.2.8 Reproducible Drawings

Submit one reproducible mylar shop drawing of each approved drawing sheet to the Contracting Officer for the following items:

a. Boiler layout, construction and details

b. Breeching layout and details

c. Burner control schematics and burner details

d. Wiring diagrams

e. Fuel oil tanks, foundations and appurtenances

f. Automatic feedwater recirculation system

g. Piping schematics

1.3.3 Design Data

1.3.3.1 Engineering Calculations

Furnish the following calculations from the manufacturer:

a. Foundation (including bearing and moment forces) and anchor bolts.

b. Stack

(1) Stresses due to various loading conditions including wind and seismic loads.

(2) Vibration and damping.

(3) Heat transfer at various design and ambient conditions.

(4) Expansion profiles.

(5) Shipping and erection stress analysis.

1.3.4 Test Reports

Submit the predicted economizer performance along with and as part of the boiler predicted performance report.

1.3.5 Performance Requirements

1.3.5.1 Boiler

Base performance requirements, including furnace heat release rates, on the following ultimate analysis and high heating values.

a. Fuel Oil Analysis

(1) Grade of fuel oil: [_____]

(2) Ultimate analysis (percent by weight, as fired)

Carbon	[_____]
Hydrogen	[_____]
Nitrogen	[_____]
Sulfur	[_____]
Oxygen (O2)	[_____]
TOTAL	[_____]

(3) Heating valve: [_____] Btu/lb

(4) Specific gravity: [_____] degrees API

(5) Viscosity at burner: [_____] SSF at 122 degrees F

(6) Water and sediment: [_____] percent by volume

(7) Flash point: [_____] degrees F.

b. Natural gas analysis

(1) Proximate Analysis (percent by volume, as fired)

Methane:	[_____] percent
Ethane:	[_____] percent
Propane:	[_____] percent
Butane:	[_____] percent
Carbon Dioxide:	[_____] percent
Nitrogen:	[_____] percent
Miscellaneous:	[_____] percent
TOTAL	[_____] percent

(2) Ultimate analysis (percent by weight, as fired)

Hydrogen:	[_____] percent
Carbon:	[_____] percent
Nitrogen:	[_____] percent
Oxygen:	[_____] percent
Miscellaneous:	[_____] percent
TOTAL	[_____] percent

(3) Heating value: [_____] Btu/cu ft

(4) Heating value: [_____] Btu/lb

(5) Density: [_____] lb/cu ft

(6) Specific gravity: [_____].

1.3.5.2 Economizer

The increase in efficiency due to the economizer shall be not less than [_____] percent at full load. Fully coordinate the economizer with the boiler to which it is to be applied.

1.3.5.3 Oil Burner/Windbox Package

Burner turndown ratio on specified fuel oil shall be not less than eight to one, with excess air not over 15 percent at full steam load, and excess air not over 22 percent at 20 percent steam load. [Air flow shall be modulated through a single set of register louvers.]

1.3.5.4 Oil and Gas Burner/Windbox Package

Burner turndown ratio shall not be less than eight to one, when firing fuel oil only and ten to one when firing natural gas only with excess air not over 15 percent at full steam load, and excess air not over 22 percent at 20 percent steam load. [Air flow shall be modulated through a single set of register louvers.]

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:

Submittals required by this section require the approval of the Contracting Officer. Within [60] [75] [90] days after award of the contract, shop drawings accompanied with complete manufacturer's descriptive information shall be submitted for approval as specified in Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS. Drawing size shall be 34 by 22 inches.

SD-02 Shop Drawings

Boiler; G[, [_____]]

Boiler Room Auxiliary Equipment; G[, [_____]]

Burners; G[, [_____]]

Dampers, Stacks, and Breechings; G[, [_____]]

Fuel Oil Equipment; G[, [_____]]

Piping and Specialty Items; G[, [_____]]

Ball Joint Installation Details; G[, [_____]]

Reproducible Drawings; G[, [_____]]

SD-03 Product Data

Insulation Types and Installation Procedures; G[, [_____]]

Boiler

[Refrigerant (compressed air refrigerated air dryers) - Provide SDS sheets for all refrigerants

] SD-05 Design Data

Engineering Calculations; G[, [_____]]

SD-06 Test Reports

Boiler Predicted Performance

Economizer Performance

Variable Speed Motor Controller; G[, [_____]]

Submit certified copies of design, production and conformance tests for approval before delivery of the equipment.

Hydrostatic and Leak Tightness Tests; G[, [_____]]

Preliminary Operation; G[, [_____]]

General Startup Requirements; G[, [_____]]

Fuel Oil Tanks; G[, [_____]]

Boilers and Auxiliaries Tests and Inspections; G[, [_____]]

Submit for tests and inspections as specified in the paragraph FIELD QUALITY CONTROL. Submit a detailed written record of test conditions, test procedures, field data, and startup and operational performance of entire heating plant to the Contracting Officer before the Contractor's operational and test personnel leave the site.

Aquatic Toxicity

SD-07 Certificates

Compatibility of Boiler Components and Equipment; G[, [_____]]

System and Equipment Installation; G[, [_____]]

Tank Calibration; G[, [_____]]

Backflow Preventer; G[, [_____]]

Submit the required information and experience certificates as specified under the paragraph EXPERIENCE REQUIREMENTS, within 30 days after award and prior to commencing work on the site.

Identical Equipment; G[, [_____]]

Ozone Depleting Substances Technician Certification

SD-10 Operation and Maintenance Data

Boiler, Data Package 3; G[, [_____]]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Include the following supplemental information in addition to the requirements of Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS.

a. Illustrations, catalog information, shop drawings, and certified drawings of each item of equipment and control components

b. Tests and Test Results

c. Adjustments

d. Fan and Blower Characteristics Curves

e. Pump Characteristic Curves

f. Boiler Predicted Performance Data

g. List of Special Tools Required

h. Posted Operating Instructions

i. Controls Drawings, Setup and Calibration Data

1.5 QUALITY ASSURANCE

1.5.1 Experience

1.5.1.1 Experience Requirements

The boiler(s), with auxiliary equipment installed, within, or as a part of the heating plant, shall be of a proven design; the manufacturer shall be regularly employed in designing, fabricating, erecting, testing and startup of the equipment.

1.5.2 Responsibility of the Boiler Manufacturer

Contractor shall ensure that the manufacturers of boiler components and auxiliaries provide equipment compatible with the boiler. Equipment includes but is not limited to the following: Blowdown valves, burner/windbox package, combustion control system, emission control components, fans, economizer, refractories, insulation, sootblowers, steam separator, scanner, [air preheater,] dust collector, breeching between boiler outlet and stack inlet, boiler trim, safety valves and drains.

1.5.3 Standard Commercial Product

Boilers and equipment shall be manufactured in accordance with the requirements of this specification and shall be the manufacturer's standard commercial product. Additional or higher quality features which are not specifically prohibited by this specification, but which are a part of the manufacturers' standard commercial product, shall be included in the boilers and equipment being provided. A standard commercial product is a product which has been sold or is being currently offered for sale on the commercial market through advertisements or manufacturer's catalogs, or brochures, and represents the latest production model.

1.5.4 Modification of References

In API Std 650, the advisory provisions shall be considered mandatory, as though the word "shall" had been substituted for "should" and "suggested" wherever they appear.

1.5.5 Assembly of Components

The equipment shall be factory assembled except for steam generators which may utilize factory assembled components to the maximum extent to facilitate erection and minimize field labor.

1.5.6 Certificates

1.5.6.1 Backflow Preventer

Certificates of Approval for each backflow preventer from the Foundation for Cross-Connection Control Research, University of Southern California, and shall attest that this design, size, and make of backflow preventer has satisfactorily passed the complete sequence of performance testing and evaluation for the respective level of approval. A Certificate of Provisional Approval will not be acceptable in lieu of the above.

1.5.6.2 Compatibility of Boiler Components and Equipment

Contractor shall submit certifications from the boiler manufacturer stating that boiler components, including auxiliary equipment, are compatible with the boiler. Certificates of compatibility for boiler components and auxiliary equipment not directly produced by the boiler manufacturer may be submitted through the boiler manufacturer.

1.5.6.3 System and Equipment Installation

Contractor shall submit written certification from each system supplier and each manufacturer of the equipment that the system and equipment installation is in accordance with the system supplier's and equipment manufacturer's instructions and recommendations, that the unit or system has been run, rotating parts have been dynamically balanced, fluid (including air) flows have been balanced, instrumentation and controls are properly functioning, adjusted and have been calibrated, and the equipment or system is ready for final testing. Certificates shall be submitted before the entire boiler plant may be given an acceptance test.

1.5.6.4 Tank Calibration

Submit four copies of a certified record of the vertical fuel oil tank calibration.

1.5.6.5 Backflow Preventer

Submit a Certificate of Full Approval or a current Certificate of Approval for each design, size, and make of backflow preventer being provided for the project.

1.5.6.6 Identical Equipment

Contractor shall submit evidence from the equipment manufacturer to show that substantially identical equipment produced by the manufacturer and of comparable operating parameters (within plus or minus 20 percent) has been successfully installed and operated in not less than [one] [two] [three] installations under comparable operating conditions for a period of not less than two years.

1.5.6.7 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.

1.6 DELIVERY, STORAGE, AND HANDLING

Each assembly of components packaged as a unit shall be of a size that can be transported by common carrier without disassembly insofar as shipping clearances are concerned.

1.7 ENVIRONMENTAL REQUIREMENTS

1.7.1 Burner Emission Requirements

The emission requirements shall be met at the maximum required continuous output. The burner shall meet environmental rules and regulations. Emission requirements to be considered are oxides of nitrogen (NOx), opacity, particulate, sulfur dioxide, and carbon monoxide. Other emission requirements may be imposed.

1.7.1.1 NOx Emission Regulations

Compliance shall be met using [one] [a combination] of the following:

a. Low NOx burners

b. Flue gas recirculation equipment which conforms to UL 795

c. Other NOx reduction techniques. See Nitrogen oxide control for stationary combustion sources.

1.7.1.2 Aquatic Toxicity

Assess potential effects of all lubricants on aquatic organisms in accordance with ASTM D6081 and submit aquatic toxicity reports. Assess biodegradation in accordance with ASTM D5864. In accordance with EM 1110-2-1424 Chapter 8, aquatic toxicity shall exceed 1,000 ppm at LL50 and biodegradation shall exceed 60 percent conversion of carbon to carbon dioxide in 28 days.

PART 2 PRODUCTS

2.1 MATERIALS

Provide materials free of defects which could adversely affect the performance or maintainability of individual components or of the overall assembly. Materials not specified herein shall be of the same quality used for the intended purpose in commercial practice. Unless specified otherwise herein, equipment, material, and articles incorporated in the work covered by this specification shall be new.

2.1.1 Identical Equipment

Provide physically and mechanically identical boilers and equipment of the same classification size or capacity to permit the interchangeability of replacement parts. This requirement includes parts, assemblies, components, and accessories. Parts provided on the same type unit regardless of unit size and identifiable by identical part number shall be functionally and dimensionally interchangeable. No deviation is acceptable without prior written approval of the Contracting Officer.

2.2 BOILERS

2.2.1 Packaged Watertube Boiler

FS F-B-2902, Type [_____] except as modified below. Provide lifting attachments.

2.2.2 Tubes

Boiler and furnace tubes shall be at least [_____] inches in outside diameter.

2.2.3 Furnace

Furnaces for D-type boilers shall be on the [_____] hand side of the drums when viewed from the front of the boiler.

2.2.4 Transition

Provide a transition piece to permit adapting the [boiler] [economizer] outlet to the [stack] [breeching]. Design transition pieces for [vertical] [horizontal] discharge.

2.2.5 Combustion Controls

As specified in Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

2.2.6 Access and Observation Doors

Provide boiler with sufficient number of access doors and observation doors, to give free and easy access and observation to <u>all</u> parts of the interior of the boiler.

2.3 ECONOMIZERS

Provide a modular unit constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section 1, of one of the following types:

a. Internal Tubular Type: Boiler feedwater flows through the outer shell and flue gases circulate up through internal tubes provided with removable flue gas spinners.

b. Finned or Spiral Wound Tube Type: Feedwater circulates through finned tubes and flue gas flows through outer shell.

2.3.1 Construction

Provide manufacturer's standard economizer design for the operating conditions and the fuel(s) specified. Coordinate the amount of heating surface with the flue gas conditions exiting the boiler or boilers on which the economizer is to be applied to preclude reaching the "acid dew point" for the fuels specified. When necessary (if there is sulfur in the specified fuel, and the designed inlet temperature could fall below the acid dew point), provide a feedwater temperature control system to maintain temperatures above the acid dew point. Provide casing of not less than 12 gage steel plate reinforced as required with support lugs and breeching flanges. Provide building framing steel to support the economizer. [Provide built-in soot blower for each economizer to thoroughly clean the surfaces exposed to the flue gas.] Design the economizer so that internal construction can be easily cleaned and inspected.

2.3.2 Equipment

Provide the following equipment for each unit:

a. Relief valve.

b. Shutoff gate valve on feedwater outlet and shutoff globe valve on inlet with globe valve bypass. Size valves as shown in economizer piping detail.

c. Temperature indicator on feedwater outlet.

d. Temperature indicator on feedwater inlet.

e. Temperature indicator on flue gas outlet.

f. Temperature indicator on flue gas inlet.

g. Temperature alarm switches for high and low flue gas temperatures.

h. Alarm with trouble light and silencing switch.

i. Panel with annunciator and temperature indicators for feedwater inlet, feedwater outlet, flue gas inlet and flue gas outlet for each economizer.

j. A drain valve downstream of the economizer before the shutoff valve.

k. A stack flue gas temperature control system to control and limit flue gas temperature to not less than 300 degrees F by modulating motorized feedwater control valves in a bypass around the economizer. Provide shutoff valve on each side of the control valves with a strainer upstream of each valve. Provide this system in parallel to the manual shutoff and bypass described above.

l. Differential pressure indicator on water side.

m. Differential pressure indicator on gas side.

n. Pressure gages on feedwater inlet and outlet.

2.3.3 Insulation

Insulate the economizer with not less than the equivalent of 2 inches of mineral wool insulation and lag with not less than 27 gage galvanized, weatherproof lagging.

2.4 FANS

2.4.1 Forced Draft Fan

CID A-A-59222, Type [_____], Class 1, except as specified otherwise.

2.4.1.1 Fan Size

Size fans for complete combustion of fuel at maximum firing rate taking into account design allowances, corrections for burner pressure drop, furnace pressure, combustion air temperature, plant elevation, and other design factors [including allowance for economizer]. After fans have been sized in accordance with the above, add the following allowances for momentary overloads and normal deterioration of fans, firing equipment and boilers:

a. Excess volume: 10 percent

b. Excess pressure: 20 percent

2.4.1.2 Fan Construction

Construct fan wheel of steel. Direction of fan discharge shall be easily changed at angles of 45 degrees. Provide fan with roller bearings mounted in pillow blocks.

2.4.1.3 Electric Motor

Motor for driving the forced draft fan shall be [variable speed], [two speed], [_____] volt, three phase, 60 Hz, [open drip-proof] [totally enclosed, fan cooled] not less than [_____] hp, as specified under MOTORS AND DRIVES in this section, and shall not overload at the specified capacity with unheated cold air. [Provide [_____] inch thick steel soleplate for motor. Soleplate must be common for all four motor mounting bolts. Separate parallel soleplate bars are not acceptable.]

2.4.1.4 Noise Level

Noise level shall not exceed 85 dBA sound pressure level at 5 feet above the floor and 5 feet from the fan in any direction. [Provide heavy duty sound attenuator with screen on fan inlet, if required, to meet the sound pressure level requirements.]

2.5 BREECHING, EXPANSION JOINTS, STACKS, AND DAMPERS:

2.5.1 Breeching

Provide with rectangular cross section and fabricate of not less than 3/16 inch thick black steel plate unless otherwise noted. Stiffeners shall be not less than 2 1/2 by 2 by 1/4 inch steel angles welded to exterior with 2 inch leg outstanding. Stiffeners shall not exceed 3 feet on centers. Breeching shall connect to [each boiler flue gas outlet,] [intermediate heat recovery equipment,] [air pollution control equipment,] [and to stack as required].

2.5.1.1 Breeching Connections and Joints

Weld or bolt breeching joints unless indicated otherwise. Welding shall conform to AWS D1.1/D1.1M and AWS D1.3/D1.3M. Bolts for bolted connections shall be not less than 1/2 inch diameter and spaced not more than 3 inches apart, with bolts, lockwashers and nuts being hot-dipped galvanized. Provide bolted joints with a minimum of 1/8 inch thick gaskets. Bolt breeching connections to boilers, equipment items, dampers, expansion joints, and breeching accessories. Flanged breeching connections to equipment shall be drilled to match flanges on equipment. Flanged joints shall be seal welded to make connection gas-tight.

2.5.1.2 Uninsulated Breeching

Thoroughly wire brush breeching which is not to be insulated and clean by degreasing with nonflammable solvent such as trichloroethylene prior to painting.

2.5.1.3 Breeching Access Doors

Provide breeching access doors where indicated. Construct access doors with frame and hinged door of cast iron or reinforced steel plate. Frame shall be not less than 25 by 37 inches with access opening of 18 by 30 inches. Connection to breeching shall be gasketed and made with minimum 1/2 inch diameter hot-dipped galvanized bolts, lockwashers, and nuts spaced not less than 5 inches on center. Each side of the access door shall have not less than two quick-clamp positive closing latches, with the long side opposite the hinges containing three clamps to give a gastight seal. Side of access door opposite hinges shall contain a minimum 3 by 5 inch size handle. Provide a gasket consisting of 3/8 inch diameter fire resistant resilient rope seal and mastic compound between the access door and the access door frame.

2.5.1.4 Breeching Cleanout Doors

Provide breeching cleanout doors where indicated. Construct cleanout doors of not less than 3/16 inch thick steel plate. Secure cleanout doors to a 1 1/4 by 1 1/4 by 3/16 inch thick angle frame with 3/8 inch hot-dipped galvanized mounting bolts welded to the angle frame and spaced not more than 6 incheso.c. Weld frame to breeching and provide a 1/16 inch gasket between frame and cleanout door. Cleanout doors shall be not less than 24 inches square except where breeching dimensions are smaller, in which case the cleanout door shall be full height of the breeching and not less than 12 inches in length.

2.5.1.5 Breeching Structural Materials

Structural and support materials shall be steel and shall comply with the applicable sections of AISC 360. [Support and stiffen breeching as indicated.]

2.5.2 Expansion Joints

2.5.2.1 Metallic Breeching Expansion Joints

Provide factory fabricated metallic breeching expansion joints [where indicated]. Expansion joints shall be guided metal bellows type capable of a minimum of [_____] inches of axial travel. Form metal bellows from not less than 1/16 inch thick type 321 stainless steel plate. Cover plates shall be not less than 1/8 inch thick steel plate.

2.5.2.2 Non-Metallic Expansion Joints

Provide factory fabricated non-metallic breeching expansion joints 1/8 inch minimum thickness [where indicated]. Expansion joints shall be constructed of fluoroelastomer vulcanized to two plies of knitted wire mesh capable of a minimum of [_____] inches of axial compression, [_____] inches of axial extension and [_____] inches of lateral offset [unless indicated otherwise]. Joints shall have a continuous operating temperature rating of 400 degrees F, with excursion design standards up to 750 degrees F. Operating pressure range shall be minus 5 psig to plus 5 psig. Expansion joints shall be preformed with integrally molded corners, suitable for mounting against a 6 inch flange. Provide carbon steel backup bars with slotted holes, bolts, and nuts.

2.5.3 Stacks (For Installation Without Flue Gas Scrubbers)

Stacks shall be free standing, dual wall with insulated annular space, self supporting, steel construction. Contractor shall assure that the design of the stack and supporting steel or concrete foundations meets or exceeds the design conditions listed below. Provide each stack complete with accessories and appurtenances, including test ports, sampling platforms, caged safety ladders, anchors, sleeves, insulation, base and chair rings, and cleanout door.

2.5.3.1 Construction

a. Air Space: Provide in the annular air space between the two steel shells insulation with sealing means to accommodate thermal expansion differentials and lateral deflections or sway of the inner and outer shells.

b. Opening Reinforcement: Provide openings with adequate reinforcement to minimize stress concentrations.

c. Inner Shell: Design wall thickness of the inner shell to be 1/16 inch thicker than that required by dynamic and static structural design but not less than 3/16 inch.

d. Outer Shell: Construct of ASTM A242/A242M steel with a plate thickness not less than [_____] inch.

e. Expansion Devices: Construct of corrosion resistant stainless steel suitable for the temperatures and flue gas combinations to be experienced by the stacks.

f. Base construction of the stack shall transmit forces and moments in the shell to the [foundation] [supporting steel] without local stresses of appreciable magnitude being induced in the shell or exceeding the allowable stresses of the supporting [concrete] [steel].

g. Provide openings in breeching and stack for test equipment for sampling flue gas and for metering devices. Openings shall be properly reinforced and designed for differential expansion. Breeching opening shall be of double wall construction. All penetrations through inside shell of stack shall be completely welded to provide proper sealing between the stack and the opening.

h. Provide top 4 feet cone section of the stack of corrosion resistant steel.

i. Anchor Bolts: provide suitable anchor bolts.

2.5.3.2 Construction Accessories

Accessories to be provided:

a. Cleanout Door: Provide double wall insulated steel plate door complete with one inch round hinge pin, gasket and not less than 18 swing bolts.

b. Inspection Trolley: Provide a ring of Type 304 Corrosion Resistant Steel (CRES) to support an inspection or painter's trolley. Weld ring and support from the stack plates with not less that three brackets 3/8 by 2 1/2 by 15 inches. Space brackets at not more than 2 feet on centers around the circumference of the stack.

   Provide a three wheel CRES flat rail trolley of 500 pound capacity. The trolley shall have guides to prevent it from leaving the track and a hole shall be provided in the hinge plate for the attachment of [_____] feet of 1/4 inch CRES plow steel cable.

c. Ladder: Provide each stack with an external ladder with cage for the full height of the stack. Construct ladder and cage of corrosion resistant steel in accordance with ALI A14.3.

d. Thermocouples: Provide a flue gas sensing thermocouple well with thermocouple 3 feet above the breeching opening and 5 feet below the top of the stack. The wells shall be CRES and shall extend about halfway into the stack.

2.5.3.3 Finish

Stacks shall be shop coated prior to shipping from the factory.

2.5.3.4 Stack Sampling Platform

Provide stack sampling platform conforming to the requirements of 29 CFR 1910-SUBPART D.

2.5.4 Dampers

2.5.4.1 Multilouver Dampers

Provide factory fabricated multilouver dampers with [parallel] [or] [opposed] blade type operation. Construct damper frame of distortion resistant welded steel channels with raised seat to ensure free nonbinding operation of blades and to keep blades square in the frame. Construct blades of 1/4 inch thick steel plate in a stressed skin airfoil-shape with fully welded seams containing no external ribs. Blade shafts shall be stainless steel. Blades shall be pinned to blade shafts. Louver shaft bearings shall be outboard type and shall be self-lubricating and self-cleaning. Bearing seals shall be gas-tight.

a. Multilouver Damper Linkage: Damper linkage shall be adjustable and of pinned construction for easy removal and shall be designed to handle full operation torque. Linkage on dampers in clean flue gas areas shall operate from a single connection point. Design linkage on dampers in dirty flue gas areas, between boiler outlet and inlet to air pollution equipment, so that the bottom blade linkage arm is not connected to the above linkage, to allow this blade to operate separately. The remaining linkage for this damper shall be constructed to operate from a single operating point.

b. Control Damper Operators: Provide control damper operators as noted. Operators may be either electrically or pneumatically operated with positive positioning, manual override, and hydraulic or oil immersed gear trains. Each operator shall be full-proportioning type, with spring return to position indicated in case of loss of power. Damper operating speeds shall be selected or adjusted so that the operators will remain in step with the controller. Operators acting in sequence with other operators shall have adjustment of control sequence as required by the operating characteristics of the system.

c. Two-Position Damper Operators shall be pneumatically operated with air cylinder, four way valve, and solenoid valve arrangement.

2.5.4.2 Guillotine Dampers

Provide factory fabricated guillotine dampers with heavy structural frame rigid enough to support the extended blade and external loads through the breeching flange. Damper shall be capable of operating without precleaning or manual assistance under normal operating conditions. Enclosed bonnets will only be required where indicated. Provide three inch diameter cleanout ports on both sides for cleaning bottom sections.

a. Guillotine Damper Blades: Provide stress-relieved flat plate guillotine damper blades. Damper blade shall be nonwarping. Intermediate blade supports are acceptable to limit blade deflection. The leading edge of the damper blade shall be beveled and capable of guiding damper blade into frame seat. Blade guides shall be continuous and self cleaning and capable of preventing binding from deposits and damage from misalignment. Bonnet guides shall be removable. Design damper so that a damper blade can be replaced without opening the frame.

b. Guillotine Damper Bonnet Seal: Provide bonnet seal to effectively seal against atmospheric leakage under normal operating conditions.

c. Guillotine damper drive shall be a positive dual endless chain drive capable of driving damper in both directions. Chain drive headshaft shall have sufficient torsional rigidity to prevent binding of blade if the blade is stalled. Damper shall be motor operated with manual override. Design drive mechanism to prevent back driving of motor. Entire drive mechanism shall be of a simple design and require no routine maintenance other than inspection. Chain shall be capable of operating up to the stall torque of the damper drive motor.

d. Electric Motor: Shall be [_____] volt, [_____] phase, 60 Hz, [totally enclosed, fan cooled] [open drip-proof], not less than [_____] hp, as specified under MOTORS AND DRIVES in this section. Provide removable, totally enclosed chain guard.

2.5.5 Sampling Ports

Weld two sampling ports to [breeching] [stack] at 90 degrees apart. Each port shall consist of a section of 4 inch diameter steel pipe with threaded cap.

2.6 FUEL OIL SYSTEM

Provide fuel oil system as specified in Section 33 52 10 FUEL SYSTEMS PIPING (SERVICE STATION), for tanks located above grade, and Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS, for tanks below grade.

2.7 MISCELLANEOUS EQUIPMENT

2.7.1 Condensate Receiver

Provide a [horizontal] [vertical] type tank not less than [_____] feet [_____] inches in diameter by [_____] feet [_____] inches [long] [high] overall with a storage capacity of not less than [_____] gallons. Tank shall be constructed of welded steel plate not less than 3/8 inch thick. Provide condensate tank with a 24 inch diameter manway, dual gage glasses with protective guards, saddles, and other connections as indicated.

2.7.1.1 Coating

Surface blast interior of tank to bare metal and coat with a baked-on phenolic lining or corrosion resistant liner consisting of a resin and hardener suitable for immersion in water at not less than 250 degrees F. Coat tank exterior with one shop coat of manufacturer's standard primer rated for service of not less than 250 degrees F.

2.7.1.2 Accessories

Provide the condensate receiver with the following:

a. Connections for condensate pumped return, vent, water outlet, drain, sampling outlet, level transmitter and controls.

b. [_____] inch vent.

c. Reflex type water gage glasses with shutoff valves and guards.

d. One, 5 inch dial, thermometer, 50 to 300 degree F range, with lagging extension type wells, for steam and water space.

e. [_____] inch overflow trap.

f. One high water alarm switch with stainless steel float and trim. Circuit shall close as liquid level rises. Locate switch to close circuit when water level rises to one inch below overflow level of receiver.

g. One low water alarm switch with stainless steel float and trim. Close circuit as liquid level falls. Locate switch to close circuit when water level drops to 25 percent of the storage capacity of the storage tank.

h. Install switches on a single column with valved connections to tank. Provide unions in pipe on each side of each float switch.

i. Furnish pipe, fittings, controls, specialties, bolts, gaskets, drains, valves, necessary for a complete unit. Install at the jobsite.

j. Provide automatic control system to control level in condensate tank by modulating discharge from condensate pumps.

2.7.2 Deaerating Heater

2.7.2.1 General

Provide a deaerating feedwater heater with storage tank conforming to FS W-H-2904 and to ASME BPVC SEC VIII D1, except as modified below. Tank shall be ASME Code stamped. Provide stainless steel trays. No test model will be required.

Model A - Pressurized operation.

Type I - Tray-type heating and deaerating element.

Class 3 - 10 minute water storage capacity (minimum).

Grade A - Guaranteed removal from water of dissolved oxygen in excess of 0.0012 in3/gal, over a ten to one load swing.

2.7.2.2 Heater Capacity

Provide deaerating heater capable of heating and deaerating makeup water consisting of [_____] pounds per hour of softened makeup water from [_____] degrees F to [_____] degrees F (outlet temperature).

2.7.2.3 Inlet Water Characteristics

Softened makeup water:

Ph: [_____]
Total hardness (as CaC03): [_____]

2.7.2.4 Storage Tank

Horizontal design with steel supports [drilled for bolting] of approved design. Provide storage tank with not less than a 16 by 20 inch minimum size manhole and cover and provide heater section with not less than a 12 by 18 inch minimum size tray access handhole and door.

2.7.2.5 Vent Condensing Arrangement

Provide the deaerating heater with a vent condenser which shall condense the vented steam when the heater is operating at full capacity with the inlet water mixture at a temperature not exceeding 180 degrees F. Construct the vent condenser, when of the direct contact type, with stainless steel baffling.

2.7.2.6 Materials

Construct trays, tray supports, water distributors, and other parts coming in contact with underaerated water or air laden steam of 430 stainless steel.

2.7.2.7 Accessories

Provide deaerating heater with the following accessories:

a. Pressure Relief Valve: Sized in accordance with FS W-H-2904.

b. Thermometers: Two, 5 inch dial thermometers, 50 to 300 degrees F, with lagging extension type wells for the storage tank and the heater section. Provide a thermometer similar to above but with range of minus [_____] degrees F to plus [_____] degrees F for the makeup water connection.

c. Lifting attachments for the tray section and the storage tank.

d. Water Gage Glasses: Reflex type with shutoff valve and guards.

e. Pressure Gages: One 6 inch dial compound pressure gage for the heater section with range from [_____] inches of mercury (vacuum) to [_____] psig.

f. Float Controllers:

(1) Inlet condensate controller

(2) Makeup water controller

(3) Overflow controller

g. Overflow Control Valve: With pneumatic controller arranged for local automatic operation.

h. Storage Tank Gage Glass: Full height, shielded, for storage tank including shutoff valve and drain cocks.

i. Makeup Water Inlet Control Valve: With pneumatic controller.

j. Switches: For low water level alarm in the storage tank, high water level alarm, condensate pump shutdown in the storage tank, and low steam pressure alarm. Install switches on a single column with connections valved and unions provided in pipe on each side of each float switch.

k. Special tools: One set for maintenance.

l. Condensate Pump Reset: With stainless steel float and trim to reset pump shutdown switch on fall of liquid level in tank to [_____] inches below level of overflow level of storage tank.

m. Furnish pipe, fittings, controls, specialties, bolts, gaskets, drains, and valves, necessary for proper attachment of accessories and trimmings and install.

[n. Oil separator

]2.7.2.8 Connections

Provide necessary connections for condensate, steam, makeup water, removal of vented gases, vacuum breakers, discharge of deaerated water, and instruments and controls.

a. Provide heater connections as follows:

(1) [_____] inch steam inlet

(2) [_____] inch makeup water inlet

(3) [_____] inch condensate

(4) [_____] inch high pressure trap return

(5) [_____] relief valves sized as required

(6) [_____] inch vent

(7) [_____] inch for thermometer well

(8) [_____] inch for pressure gage

(9) Vacuum breakers as required

(10) [_____] inch heater drain

(11) [_____] inch spare [capped] [flanged]

(12) [_____] inch spare [capped] [flanged]

(13) Handholes and manhole with covers

b. Tank connections shall include:

(1) [_____] inch drain

(2) [_____] inch boiler feed recirculation ([_____] required)

(3) One inch sampling

(4) One inch chemical feed

(5) [_____] inch for sight glass ([_____] sets required)

(6) [_____] inch for high and low level alarm switches

(7) [_____] inch thermometer well

(8) Vacuum breakers as required

(9) [_____] inch spare (capped)

(10) [_____] inch spare (flanged)

(11) [_____] inch level transmitter and controller ([_____] sets required)

(12) Downcomer and equalizer as required

(13) [_____] inch feedwater outlet

(14) [_____] inch overflow outlet with internal water seal

2.7.2.9 Level Control

Provide an automatic control system to control water level in the storage tank, by modulating valves in makeup water lines. Condensate pump output shall be controlled by level in condensate storage tank.

a. Controllers: Provide external cage type air operated level controllers for both the condensate and makeup water lines complete with 1 1/2 inch screwed connections, external cage, and controller. Cage body shall be Class 125 cast iron construction. Internal components including displacer, torque tube, displacer rod, displacer rod driver and bearings shall be 316 stainless steel. Displacer shall be 14 inches long. Controller shall be direct acting with 3 to 15 psig range with proportional band adjustment. Locate controller to maintain an operating level at 2/3-full point of storage tank. Provide level controller with air pressure reducing valve, filter, gages and isolating valves for float cage. Provide unions on each side of float cage.

b. Air Operated Regulating Valves: Provide air operated control valves for both the condensate and makeup water lines. Valves shall have Class 125 or Class 150 rating with iron or semi-steel bodies and 316 stainless steel internals. Provide condensate valve which fails open on loss of air and makeup water valve with an air lock mounted on valve diaphragm to hold valve in last position on loss of air. Design valves for the following conditions:

	Condensate	Makeup Water
Valve size	[_____] inch	[_____] inch
Capacity	[_____] gpm	[_____] gpm
Maximum pressure drop at above capacity	[_____] psig	[_____] psig
Available pressure	[_____] psig	[_____] psig
Minimum Cv at 100 percent open	[_____]	[_____]

2.7.2.10 Low Pressure Steam Control

Provide an automatic control system to control the steam to the deaerating heater. Maintain steam pressure in the heater by modulating a pressure reducing valve in the steam supply line. Control shall be local and remote from the control panel.

a. Controller: Adjustable proportional band, 0 to 15 psig brass bellows for input signal, and 3 to 15 psig output air pressure range, pilot controller complete with air set (valve, filter, drier and pressure regulator) mounted on control valve yoke.

b. Pressure Reducing Station Control Valve: Provide a [_____] inch air operated pressure reducing valve with proper internals to pass a flow of [_____] pounds per hour of steam. Steam at the valve inlet shall be [_____] psig saturated, and the outlet shall be controlled at [_____] psig. Minimum steam flow shall be approximately [_____] pounds per hour. Minimum valve Cv shall be [_____] at 100 percent open. Valve shall be Class 250 or Class 300 flanged, iron or semi-steel body with stainless steel internals equal percentage flow characteristics and a full size port. Provide valve actuator including travel indicator, hand jack, valve positioner, and air supply filter-reducer set. Valve shall move to open position in case of failure.

2.7.2.11 Gage Glasses

Provide gage glasses to cover the entire range of water level in the storage section. Gage glasses shall not be greater than 24 inches center-to-center. Provide gage glasses complete with [chain operated] ball check shutoff and drain cock valves and safety shield.

2.7.2.12 Alarms

Provide high and low water level alarms for storage tank as follows:

a. High Water Level Alarm: Switch with stainless steel float and trim. Locate switch to close circuit when water level rises to one inch below overflow level of storage tank.

b. Low Water Level Alarm: Switch with stainless steel float and trim. Locate switch to close circuit when water level falls to [_____] feet [_____] inches above bottom of storage tank.

c. Coordination: Coordinate alarms with annunciator panel as indicated.

2.7.2.13 Multiport Back Pressure Relief Valve

Provide valve capable of relieving not less than [_____] pounds per hour of steam with not more than a [_____] psig pressure rise when set at [_____] psig initial operating pressure. Set pressure shall be fully adjustable by means of an external handwheel or chain operator for a range of zero to 25 psig. Locate on low pressure steam header manifold for the deaerating heater. Valve shall be multiport vapor cushion type rated for operating temperatures up to but not greater than 300 degrees F with Class 125 cast iron body, bronze trim and carbon steel springs.

2.7.2.14 Exhaust Head

CID A-A-50494, Type [I (cast iron)] [II (fabricated steel plate)] of [_____] inch size with [_____] inch diameter drain, and a capacity of [_____] pounds per hour of steam at [_____] psig.

2.7.3 Boiler Feed Pumps

CID A-A-50562, Type II (boiler feed pump), Style 1 (horizontally split case), Class 2 (multi-stage) except as modified below. Each pump shall be two stage with horizontal split casing, enclosed single suction opposed type impellers, renewable casing and impeller wearing rings, stuffing box with quenching gland and flooded oil lubricated, water cooled bearings.

2.7.3.1 Pump Service Requirements

a. Capacity: [_____] gpm

b. Pumping temperature: [_____] degrees F

c. Liquid pH: [_____]

d. Discharge head: [_____] feet

e. Available NPSH: [_____] feet

f. In addition to the operating point established above, the pump curve shall also run through the following points:

Capacity	Discharge Head
[_____] gpm	[_____] feet
[_____] gpm	[_____] feet

2.7.3.2 Construction

Boiler feed pumps shall be bronze fitted including bronze impeller and impeller wear rings, and ASTM A48/A48M, Class 30, cast iron casing. Provide casing with suction and discharge gages in tapped openings. Mount each pump and prime mover on a fabricated steel bed plate having a drip collection chamber with tapped drain openings. Provide lifting attachments to enable equipment to be set into its normal position and to enable pumps to be easily dismantled in place.

2.7.3.3 Electric Motors

[Variable speed], [open dripproof], [totally enclosed], [fan cooled], [_____] volt, three phase, 60 Hz of not less than [_____] hp, as specified under MOTORS AND DRIVES [and VARIABLE SPEED CONTROL FOR MOTORS] in this section. [Variable speed] electric motors [or turbines] direct connected to respective pumps with a gear type, forged steel, flexible coupling. Provide a shaft and coupling guard.

2.7.3.4 Steam Turbines

Single stage, rated at not less than [_____] hp, with inlet steam pressure of [_____] psig and [_____] degrees F and normal exhaust back pressure of 5 psig or a maximum back pressure of 15 psig. Water rate at full load and normal steam conditions shall not exceed [_____] pounds per BHP per hour. Provide a stainless steel steam strainer, sentinel relief valve, sight oil level indicator and one hand valve. [Variable speed] turbines direct connected to respective pumps with a gear type, forged steel, flexible coupling. Provide a shaft and coupling guard.

a. Turbine Construction: Turbine casing split on the horizontal centerline constructed of ASTM A48/A48Mcast iron, with a design pressure rating of 250 psig at 450 degrees F at inlet, and 55 psig at 450 degrees F at the outlet.

b. Turbine Bearings and Shaft: Horizontal split, ring oiled, sleeve type, water cooled. The shaft shall be stainless steel or chrome plated under the packing glands. The shaft seals shall be segmented carbon rings with springs and stops.

c. Speed Governor: Variable speed oil relay, NEMA Class D governor for speed control and pneumatic operator to maintain an adjustable, preset pump discharge header pressure by variation of turbine speed. Input to the operator shall be a 3 to 15 psig pneumatic signal. Provide an electro-pneumatic transducer to accept the 4 to 20 mA signal from the control system controller specified in Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

d. Emergency Overspeed Governor: Completely independent of the speed governor and shall operate trip valve.

e. Insulation: Turbine shall be insulated and lagged by the manufacturer as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.7.3.5 Minimum Flow Protection for Boiler Feed Water Pumps

a. Automatic Flow Control Valve: Provide with each pump an automatic bypass valve. Valve shall automatically program the recirculation flow, the detection of low flow, the cycling of control valve and pressure letdown for high pressure boiler feedwater return to the feedwater heater. Bypass valve shall be cast steel with stainless steel internals, and shall have a rating of not less than 300 psig at 400 degrees F. Valve shall have a line size body with a one inch recirculation connection.

b. Boiler Feedwater Automatic Recirculation System: (Option to Automatic Valve). Provide a boiler feedwater automatic recirculation system to protect the feedwater pumps at low flow conditions. System shall be capable of recirculating the minimum flow recommended by the pump manufacturer. The system shall be an engineered system consisting of the various functional components specified or shall be a self-contained and self-powered mechanical system. Components of the engineered system shall include a flow transmitter with orifice in feedwater line, bypass flow controller with bypass flow control valve, and a bypass pressure reducing orifice.

   (1) System Bypass Flow Controller: Include detection of low flow and modulation of a control valve in a bypass line returning to a low pressure sink. Incorporate a pressure let-down feature or device to reduce the pressure from the boiler feedwater pump discharge pressure to that of the low pressure sink.

   (2) System Bypass Control Valve: Modulate to provide minimum flow recommended by the pump manufacturer and to provide shutoff or recirculation flow when feedwater flow to the boilers exceeds the minimum flow required for pump protection.

c. Feedwater Stop and Check Valves: Provide a Class 300, flanged, cast steel feedwater stop gate valve and check valve on the feedwater outlet of each pump. Provide piping from the valves to the economizer inlet, and from the economizer to the flanged connection on the boiler drum. Provide connection on pipe at economizer outlet for remote recording thermometer.

2.7.4 Condensate Pumps

CID A-A-50562, Type I, Style [1 (horizontally split case)] [2 (end suction)], Class 1 (single stage) unless modified below.

2.7.4.1 Condensate Pump Service Requirements

a. Capacity: [_____] gpm

b. Pumping temperature range: [_____] to [_____] degrees F

c. Liquid pH: [_____]

d. Discharge head: [_____] feet

e. Available NPSH: [_____] feet

f. In addition to the operating point established above, the pump curve shall also run through the following points:

Capacity	Discharge Head
[_____] gpm	[_____] feet
[_____] gpm	[_____] feet

2.7.4.2 Construction

Condensate pumps shall have bronze impellers and impeller wear rings. Pump casings shall be [cast iron] [ductile iron], and shall be designed for the specified conditions. Bearings shall be oil lubricated. Casings shall have tapped openings for suction and discharge pressure gages. Provide suction and discharge pressure gages in openings. Mount pump and driver on a fabricated steel bed plate having a drip collection chamber with tapped drain openings. Provide lifting attachments for installation and maintenance.

2.7.4.3 Electric Motors

[Variable speed], [open dripproof], [totally enclosed], [fan cooled], [_____] volt, three phase, 60 Hz of not less than [_____] hp, as specified under the paragraph MOTORS AND DRIVES [and VARIABLE SPEED CONTROL FOR MOTORS] in this section. [Variable speed] electric motors direct connected to the respective pumps with a gear type flexible coupling. Provide shaft and coupling guards.

2.7.4.4 Steam Turbines

Single stage, rated at not less than [_____] hp, with inlet steam pressure of [_____] psig and [_____] degrees F, normal exhaust back pressure of 5 psig and a maximum back pressure of 15 psig. Water rate at full load and normal steam conditions shall not exceed [_____] pounds per BHP per hour. Provide a stainless steel steam strainer, sentinel relief valve, sight oil level indicator and one hand valve. [Variable speed] turbines direct connected to the respective pumps with a gear type flexible coupling. Provide shaft and coupling guards.

a. Turbine Construction: Turbine casing split on the horizontal or vertical centerline constructed of ASTM A48/A48M cast iron, with a design pressure rating of 250 psig at 450 degrees F at inlet, and 55 psig at 450 degrees F at the outlet.

b. Turbine Bearings Shaft: Ring oiled, anti-friction type. Shaft shall be stainless steel or chrome plated under the packing glands. Shaft seals shall be segmented carbon rings with springs and stops.

c. Speed Governor: Variable speed governor for speed limiting and pneumatic operator to maintain an adjustable preset level in [deaerator tank] [condensate receiver] by variation of turbine speed. Input to the operator shall be a 3 to 15 psig pneumatic signal and vary the turbine speed from minimum to full speed in a linear response. Maximum and minimum speed shall be adjustable. Provide an electro-pneumatic transducer to accept the 4 to 20 mA signal from the controller specified in Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

d. Emergency Overspeed Governor: Completely independent of the speed governor and shall operate a separate trip valve.

e. Insulation: Turbine shall insulated and lagged as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.7.5 Variable Speed Motor Controller

Remotely installed cabinet housed units with solid state rectification and inverter equipment to vary frequency of electrical power to the drive motors.

2.7.5.1 Housing

House the controller in a [wall] [floor] mounted, NEMA [_____] enclosure finished with manufacturers standard painted finish. Provide control panel complete with fused disconnect switches, magnetic [across the line] [part winding] starters with thermal overload protection, transformer, hand-off-automatic selector switches, hand potentiometer for manual speed control, fuses and running lights.

Manual Switch: Locate the manual switch within the control panel so that in the event failure of any of the components the motor can be put across the line at full voltage to maintain air or pump pressure. Provide a mechanical door interlock that allows the panel to open only when the fused disconnect is in the off position.

2.7.5.2 Variable Frequency Controllers

Variable frequency controllers shall use solid-state semiconductor power conversion equipment. Provide controllers as integrated and assembled products. Controllers shall be furnished by the same manufacturer.

2.7.5.3 Ratings

Each controller shall be rated for a supply of [_____] volts, three phase, 60 Hz. The output shall be [_____] volts, three phase with frequency variable between zero and 60 Hz. Controllers shall be rated to operate the motors continuously at their rated horsepower and frequency. Speed regulation shall be within (plus or minus) three percent of set point without tachometer feedback. Electrical supply system shall have an available short circuit rating of [_____] amperes symmetrical.

2.7.5.4 Minimum Speed

Each controller shall be capable of driving the motor continuously at a lower speed no greater than 20 percent of full rated motor speed with stable operation and without overheating the motor under rated ambient conditions. Provide estimate of minimum speed at which motor can be operated continuously without overheating or problems of instability due to overhauling of the load.

2.7.5.5 Fault Protection

Provide controller fault protection so that a single or three phase short circuit at the controller terminals or inverter commutation failure will not result in damage to power circuit components. Provide overload protection so that motor and controller are protected against operating overloads.

2.7.5.6 Time Delay

Provide adjustable time delay under voltage protection so that motors will continue to operate during momentary voltage fluctuation or loss of voltage. Time adjustment shall be zero to 5 seconds. Provide for orderly shutdown on undervoltage conditions exceeding the time delay interval.

2.7.5.7 Acceleration/Deceleration

Provide adjustable timed linear acceleration and deceleration.

2.7.5.8 Voltage/Frequency Control

Provide volts/Hz control to prevent motor overheating throughout the speed range.

2.7.5.9 Door Interlocks

Provide door interlocks to prevent opening of enclosure doors unless power is disconnected.

2.7.5.10 Shutdown Conditions

Controllers shall be self protecting and shall provide orderly shutdown for, but not limited to, the following conditions:

a. Loss of input power

b. Undervoltage

c. Sustained gradual overload

d. Fault or large instantaneous overload

e. Overtemperature

f. Failure of ventilating system

g. Overvoltage

h. Control circuit failure

Provide contacts for remote annunciation of shutdown or abnormal condition.

2.7.5.11 Electrical Bypass

Provide each controller with manual isolation and bypass switching. Switch shall be manually operated with controller deenergized. Switch shall be two position with provisions for locking the switch in either position.

a. Normal Position: Bypass shall be open and connect controller to the supply circuit and the load.

b. Bypass Position: Bypass shall be closed and the controller shall be electronically isolated from the supply and the load. Isolating contacts shall be located so that it is possible to verify by visual inspection that the contacts are open and the controller is electrically isolated. In the bypass position the motor shall be operated at constant speed and controlled from the air circuit breaker. Provide auxiliary contacts that close in the bypass position. Auxiliary contacts shall be used to activate the damper control to provide fan load control in the bypass position.

2.7.5.12 Controller Environmental Protection

a. Ventilation: Design controllers enclosed and ventilated for installation in a moderately dusty area. Provide forced filtered ventilation including fans, filters, controls and accessories required for operation. Enclosures shall be operated under positive pressure at all times. Provide filtered ventilating openings and gasketed doors to prevent infiltration of dust.

b. Heating: Provide electric heaters to prevent condensation in the enclosure and to prevent low ingoing air temperatures that exceed the equipment rating. Provide a low temperature alarm to sound when enclosure temperature falls below required minimum temperature. Provide contacts for remote annunciation of alarm condition.

2.7.5.13 Method of Control

Supply each controller from an electrically operated air circuit breaker or motor starter. Controller ventilation and heating shall be from another circuit.

a. Start Signal: Closes the electrically operated air circuit breaker or motor starter to energize the controller. The controller shall accelerate the fan to operating speed. Fan speed shall be controlled from the load control signal.

b. Stop Signal: Opens the electrically operated air circuit breaker or motor starter to deenergize the controller. Upon deenergization, the controller control system shall revert to the stop condition.

c. Boiler Feedwater Pump Speed Control System: Matches pump discharge to system demand and maintains a system header pressure controlled to the set point values. Provide Manual/Automatic control stations for master pressure and for each boiler feed pump. Provide indicators for feedwater header pressure and individual boiler feedwater pump flow. See Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS.

2.7.6 Valve Actuators

[Electrically] [or] [pneumatically] operated and designed so that valve may be manually operated by removing the drive pins. Actuators shall be operated by push button control. Locate one push button at a position adjacent to the valve. Locate a second push button within the boiler control room. Provide a valve position indicator utilizing indicating lights. A green light shall indicate the valve is fully open and an amber light shall indicate the valve is fully closed. Both lights on shall indicate when the valve is partially open. [Provide torque limit controls to protect the valve during opening and closing for electrically operated valves.] Actuator electric motor shall be totally enclosed, [_____] volts, [_____] phase, 60 Hz as specified under the paragraph MOTORS AND DRIVES in this section. Provide NEMA 4 control enclosures.

2.7.7 Sump Pumps

CID A-A-50555 with automatic float switch and disconnect switch in NEMA 6 enclosure.

2.7.8 Water Softening System

Ion exchange resin type conforming to WQA S-100 except as modified below. [Manual] [Push button automatic] [Fully automatic] in operation with operating controls housed in a NEMA 12 enclosure having a total capacity between regenerations of not less than [_____] gallons of water of [_____] grains hardness when operated at a sustained softening rate of [_____] gpm. The maximum effluent water temperature shall be [_____] degrees F.

2.7.8.1 Raw Water Analysis

The source of the raw water is [_____]. It is available at pressures of [_____] to [_____] psig. The analysis of the water available for makeup is approximately as follows:

TABLE 1: MAKEUP WATER ANALYSIS

	Constituent	Analysis	Parts Per Million (PPM)
Cations	Calcium (Ca++)	as CaCO3	[_____]
	Magnesium (Mg++)	as CaCO3	[_____]
	Sodium (Na+)	as CaCO3	[_____]
	Hydrogen (H+)	as CaCO3	[_____]
TOTAL CATIONS		as CaCO3	[_____]
Anions	Bicarbonate (HCO3 -)	as CaCO3	[_____]
	Carbonate (CO3 --)	as CaCO3	[_____]
	Hydroxide (OH -)	as CaCO3	[_____]
	Sulfate (SO4 --)	as CaCO3	[_____]
	Chloride (Cl -)	as CaCO3	[_____]
	Phosphate PO4 ---)	as CaCO3	[_____]
	Nitrate (NO3 -)	as CaCO3	[_____]

TABLE 1: MAKEUP WATER ANALYSIS			
TOTAL ANIONS		as CaCO3	[_____]
	Total hardness	as CaCO3	[_____]
	Methyl orange alkalinity	as CaCO3	[_____]
	Phenolphthalein alkalinity	as CaCO3	[_____]
	Iron, total	as Fe	[_____]
	Carbon dioxide	as Free CO2	[_____]
	Silica	as SiO2	[_____]
	Suspended solids (Turbidity)		[_____]
	Total dissolved solids (TDS)		[_____]
	Free acids		[_____]
	Color		[_____]
	pH		[_____]
	Specific Conductance Microhms/cm		[_____]

2.7.8.2 Softener Effluent Analysis

a. Hardness: Maintain hardness of the softened feedwater near zero and in no case allow it to exceed 1.0 ppm (parts per million) as CaCO3.

b. Total Solids: Maintain total solids in the softened feedwater at a level to ensure a total solids concentration in the boiler water of less than 3,500 parts per million (ppm) without excessive blowdown.

2.7.8.3 Softener Equipment

Including but not limited to the following:

a. Water Hardness Monitor: Provide a water hardness monitor with an alarm point at 1.0 ppm to ensure compliance for boilers rated above 25,000 lb/hr.

b. Total Solids Monitor/Controller: Provide a continuous monitor and controller (when required) to control the concentration of dissolved solids and treatment chemicals in the water for boilers rated above 25,000 lb/hr.

c. Water Meter: Provide a [_____] inch cold water meter on each softener unit.

d. Ion Exchange Resin: High capacity, polystyrene base, sulfonated synthetic type except that the exchange capacity shall be not less than 30 kilograins per cubic foot at a salt dosage of 15 pounds per cubic foot.

e. Tank Sizing: Minimum acceptable bed depth of 30 inches; maximum acceptable bed depth of 72 inches. Base reactor tank sizes on allowing a freeboard above the resin bed of not less than 75 percent of the resin bed depth, and flow rate between 0.5 and 3.2 gpm per cubic foot of resin.

2.7.8.4 Brine Storage System

Provide a complete brine storage system including fiberglass storage tank, sight level gage, bulk salt delivery tube, internal distribution system, level control system, tank vent with dust collection system, top and side manholes, access ladder, and other required appurtenances.

2.7.8.5 Brine Storage System Accessories

Provide the following accessories:

a. Steel holddown lugs securely bonded to the tank in adequate number to properly anchor tank to concrete base;

b. Side bottom flanged drain not less than 4 inches in diameter;

c. Side and top manholes not less than 22 inches in diameter;

d. Flanged top connections for delivery pipe and vent;

e. Ladder for access to top manhole;

f. Water inlet connection;

g. Brine outlet connection;

h. Level control system; and

i. Sight level gage.

2.7.8.6 Storage Tank

Filament wound fiberglass with flat bottom and domed top as recommended by the manufacturer for brine storage. Tank shall be [_____] feet [_____] inch in diameter by [_____] feet[_____] inch wall height with a nominal capacity of [_____] gallons and a dry salt storage capacity of [_____] tons. Design the water distribution system, internal piping distributors, and brine collection system so that the system shall be capable of dissolving [_____] pounds of rock salt per minute to produce [_____] gallons per minute of brine. System shall be able to dissolve [_____] tons of salt before cleanout.

a. Pneumatic Delivery Pipe: Not less than 4 inches in diameter.

b. Dust Collection Vent System and Safety Relief Valve: Provide storage tank with dust collection vent system and safety relief valve.

c. Access Ladder: Of steel construction to be bolted to tank by means of fiberglass reinforced plastic mounting lugs complete with safety cage. Platform shall connect the ladder to the tank for safe access to the manhole. Safety requirements shall be in accordance with ALI A14.3.

d. Tank Internals: Construct tank internals including water distribution piping and brine collectors of fiberglass reinforced plastic (FRP) or polyvinyl chloride (PVC).

e. Tank Nozzles: ASME B16.5, Class 150, reinforced FRP or PVC flanges.

f. Level Control System: Electrode holder and electrodes mounted in a standpipe exterior to the tank. Position electrodes so that a solenoid operated water makeup valve will be opened or closed to maintain the liquid level to within plus or minus one inch of the set level. Provide tank with a high water alarm. Electrodes shall be easily removable for cleaning and constructed of materials, that will allow continual immersion in brine.

2.7.9 Chemical Feed Systems

Provide systems complete with storage tank, supporting framework, hinged cover, mixer, strainers, level indicators, proportioning pumps, relief valves and interconnecting piping for a complete chemical feed packaged unit.

2.7.9.1 Storage Tank

50 gallon capacity constructed of fiberglass reinforced plastic. Provide removable, hinged cover.

2.7.9.2 Exterior Gage Glass

Protected, full height of the tank complete with gage cocks.

2.7.9.3 Low Level Alarm

Provide tank with a low level switch to sound alarm and shut down pumps should level drop to preset minimum.

2.7.9.4 Dissolving Baskets

Construct baskets of a corrosion resistant material suitable for continuous immersion in a [_____] solution.

2.7.9.5 Tank Strainer

Install tank strainer in suction line to pump.

2.7.9.6 Supporting Steelwork

Provide supporting steelwork to adequately support tank, mixer, and the number of proportioning pumps specified.

2.7.9.7 Agitator

Provide an agitator with mounting bracket to mount to storage tank.

Agitator shaft and propeller shall be of stainless steel.

2.7.9.8 Proportioning Pumps

Provide [two] [three] [_____] proportioning pump[s] of the [simplex] [duplex] type. Each pump shall have a minimum capacity of [_____] gallons per hour at a [_____] psig discharge pressure. Capacity shall be adjustable from zero to 100 percent by a convenient screw adjustment of stroke length. Provide pump with integral check valves. Electric motors shall be [totally enclosed], [fan cooled], [_____] volts, [_____] phase, 60 Hz as specified under the paragraph MOTORS AND DRIVES in this section.

2.7.9.9 Safety Relief Valve

Provide safety relief valve for each pump to discharge back into the tank in event of excessive line pressure.

2.7.10 Blowdown Tank

Provide a welded blowdown tank in accordance with NBBI NB-27, (supplemental to the National Board Inspection Code) latest edition published by the National Board of Boiler and Pressure Vessel Inspectors, Columbus, Ohio.

2.7.10.1 Construction

Construct equipment and accessories in accordance with the requirements of the ASME BPVC SEC VIII D1 for a working pressure of at least the maximum allowable working pressure of the boiler but in no case shall the plate thickness be less than 3/8 inch. Provide corrosion allowance of [0.1 inch] [_____]. Tank dimensions shall be [_____] feet [_____] inches O.D. by [_____] feet [_____] inches long over the heads (overall). Provide tank with wear plate not less than 3/8 inch thick and [11 by 15 inch] [18 by 20 inch] manhole.

2.7.10.2 Tank Connections

Provide the following connections:

a. Blowdown inlet for bottom blowdown [3/4] [1] inch;

b. Tangential blowdown inlet [_____] inch;

c. Steam vent, flanged [_____] inch;

d. Discharge water outlet, flanged [_____] inch with internal water seal and 3/4 inch siphon breaker;

e. Two inch drain;

f. Thermometer connection 3/4 inch;

g. Pressure gage connection 1/4 inch;

h. Cold water inlet [_____] inch with temperature regulating valve and backflow preventer; and

i. Two gage glass connections 1/2 inch.

2.7.10.3 Angle Supports and Coating

Provide tank with steel angle support legs extending [_____] feet below bottom of the tank. Coat tank with one coat of manufacturer's standard high temperature primer.

2.7.10.4 Accessories

a. Gage Glass: 12 inch reflex type with shutoff valves and guard;

b. Thermometer: Bi-metal dial type with separable socket, 5 inch dial, 50 to 300 degrees Frange;

c. Pressure Gage: Zero to 25 psig range; and

d. Internal Baffles and Pipes: As detailed.

2.7.10.5 Controls

Provide a self operating regulator to control the flow of cooling water to the tank. Regulator shall include a 3/4 inch screwed bronze body with stainless steel trim, reverse acting actuator (for cooling), capillary tubing and a union connection bulb with a stainless steel well. Control setting shall be 140 degrees F with a minimum Cv of [_____].

2.7.11 Continuous Blowdown System

Provide a complete automatic continuous boiler blowdown system which shall include a controller/programmer unit and flow assembly for each boiler, plus a continuous blowoff heat exchanger, flash tank and boiler water sample cooler.

2.7.11.1 Automatic Blowdown Controller

Intermittent type boiler blowdown system rated for not less than 250 psig steam pressure.

2.7.11.2 Flow Assembly

Include a one inch ball valve with 316 stainless steel ball and stem and stainless steel electrode assembly.

2.7.11.3 Controller/Programmer

Include a conductivity meter with zero to 6000 microhms range, valve open/closed indicators and manual/auto control switch. Cycle interval and sample duration shall both be adjustable over a wide range. Mount units at operating floor near boiler front.

2.7.11.4 Accessories and Connections

a. Continuous Blowdown Connection: At each boiler, provide a gate valve and extend piping to header at flash tank.

b. Header Connections: Provide with a tee with valved sampling connection. Provide a 3/4 inch, three globe valve bypass around each flow assembly.

c. Common Header: Provide from valved outlet connections on flow assembly units to connection on flash tank.

2.7.11.5 Flash Tank

Designed for [_____] psig and constructed in accordance with the ASME BPVC SEC VIII D1. Tank shall be [_____] inches in diameter by [_____] inches long including heads and shall be ASME Code stamped.

2.7.11.6 Blowdown Inlet

Provide tank with blowdown inlet, steam outlet, gage glass, float operated outlet valve, relief valve, and inspection openings. Tank shall have steel angle legs with plate feet for bolting to floor and legs shall be of sufficient length so that bottom of lower head of tank will be not less than 18 inches above floor.

2.7.11.7 Automatic Control System

Control level in the flash tank, by modulating a valve in the water outlet line.

a. Level Controller: External cage type air operated level controller, complete with 1 1/2 inch screwed connection, 14 inch stainless steel float and Class 125 cast iron body. Controller shall be direct acting with 3 to 15 psig range with proportional band. Locate controller to maintain an operating level at center line of storage tank. Provide level controller with air pressure reducing valve, filter, gages and isolating valves for float cage. Provide unions on each side of float cage.

b. Outlet Water Valve: [_____] inch air operated control valve with a capacity to pass [_____] gpm at a pressure drop of [_____] psig. Cv shall not be less than [_____] at 100 percent open. Valve shall be Class [_____], flanged, iron or semi-steel body with stainless steel internals. Valve shall have equal percentage flow characteristics with a full size port. Provide an air lock mounted on valve diaphragm and piped to hold valve in last position on air failure.

2.7.11.8 Sample Cooler

Water cooled shell and tube type with valves and accessories required to safely withdraw a water sample from the boiler drum. Provide drain under sampling valve terminating with a 3/4 inch splash proof funnel, 9 inches below outlet of valve.

2.7.11.9 Heat Exchanger

Provide an ASME code stamped continuous blowoff heat exchanger designed and constructed in accordance with ASME BPVC SEC VIII D1 to transfer heat from the continuous blowoff water leaving the continuous blowoff flash tank to the treated makeup water entering the feedwater heater. Heat exchanger shall be a bare tube, helical coiled bundle, installed in a one piece casing with removable front plate. Bundle shall be removable. Tube diameter shall be not less than 3/4 inch. Tubes shall be ASTM B111/B111M copper alloy with cast iron shell. Design tube side for not less than [_____] psig pressure at [_____] degrees F. Design shell side for not less than [_____] psig pressure at [_____] degrees F.

2.8 PIPING

Piping work shall include the provision of piping systems, including valving and specialty items, for the steam plant and related external auxiliary equipment. Piping materials, design, and fabrication shall be in accordance with ASME B31.1 except as modified below or indicated otherwise. The requirements of ASME B31.1 apply to the building steam heating and steam distribution piping designed for 15 psig or lower and hot water heating systems 30 psig or lower. Provide piping materials suitable for the maximum pressure at the maximum temperature at which the equipment must operate. Compute expansion of pipe with operating temperatures above zero degrees F with zero degrees F in lieu of 70 degrees F specified in ASME B31.1.

2.8.1 Piping Materials

a. Steam Pipe, Boiler Feedwater Pipe, Relief Pipe and Steam Tracer: Pipe Black, ASTM A53/A53M or ASTM A106/A106M seamless steel pipe, Grade A or B. Wall thickness not less than Schedule 40. Steam tracer pipe, with steam up to 15 psig, may be ASTM B88, Type K copper tubing.

b. Condensate Pipe and Boiler Blowdown Pipe: Black, welded or seamless ASTM A53/A53M or ASTM A106/A106M, steel pipe, Grade A or B. Wall thickness not less than extra strong (XS or Schedule 80).

c. Chemical Feed Pipe: ASTM A312/A312M austenitic stainless steel.

d. Fuel Oil Pipe: ASTM A53/A53M or ASTM A106/A106M, seamless black steel pipe, Grade A or B.

e. Treated Water, Hot Water Heating, High Temperature Water, Drains (Other Than Sanitary), and Overflow Pipe: ASTM A53/A53M, black, welded or seamless steel up to a maximum pressure of 250 psig or ASTM A106/A106M, Grade A or B.

f. Gas Pipe and Compressed Air Pipe: ASTM A53/A53M welded or seamless pipe up to a maximum pressure of 250 psig or ASTM A106/A106M, Grade A or B.

g. Instrument Air Pipe: ASTM B88 hard copper tubing, Type K or L; except in a corrosive atmosphere or outside pipe shall be copper tubing, Type K or L, with ASTM D1047 PVC jacketing.

h. Steam Tracer Pipe: As an option, the, contractor may provide ASTM B88, Type K, copper tubing for steam up 15 psig.

2.8.2 Chlorinated Polyvinyl Chloride (CPVC)

Chlorinated polyvinyl chloride (CPVC) and other plastic tubing and fittings shall not be used in the steam heating plant, unless otherwise specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Systems for potable water, sanitary drains and storm drains are also covered in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.8.3 Fittings

2.8.3.1 Fittings for Steel Pipe

a. Sizes 1/8 to 2 inches: ASME B16.3 malleable iron, screwed end fittings, for working pressures not greater than 300 psig at temperatures not greater than 450 degrees F or ASME B16.11forged steel.

b. Sizes 1/8 to 2 inches: ASME B16.11 steel, socket welded end fittings.

c. Sizes 1/8 to 2 1/2 inches: ASME B16.9 steel, butt welding fittings.

d. Sizes 2 1/2 to 24 inches: ASME B16.5 forged steel, flanged fittings.

2.8.3.2 Welded Outlets and Welding Saddles

Make branch connections of 45 and 90 degrees either with ASME B16.9 forged steel welded outlet fittings or welding saddles. Welding outlets and saddles shall not be smaller than two pipe sizes less than the main pipe sizes.

2.8.3.3 Fittings For Copper Tubing

ASME B16.18 cast bronze solder joint or ASME B16.22 wrought copper solder joint. For instrument air, fittings may be ASME B16.26 compression joint type.

2.8.3.4 Unions

a. Unions For Steel Pipe: ASME B16.11, ASME B16.39threaded. Unions for zinc coated pipe shall be zinc coated.

b. Unions For Copper Tubing: ASME B16.22. For instrument air, unions may be compression joint type.

2.8.4 Flanges

ASME B16.5, forged steel, welding type. Remove the raised faces on flanges when used with flanges having a flat face. Except as specified otherwise, pressure and temperature limitations shall be as specified in ASME B16.5 for the proper class and service, and the type face specified.

2.8.5 Valves

2.8.5.1 Low Pressure

Valves for maximum working pressure of 150 psig saturated steam or 225 psig W.O.G. (Water, Oil, Gas) at 200 degrees F, non-shock service. For working pressures not exceeding 125 psig saturated steam or 200 psig water at 200 degrees F non-shock service, Class 125 may be used in lieu of Class 150 or Class 250.

a. Valve Sizes 2 Inches and Smaller:

(1) Non-Throttling Valves: Gate valves, bronze, wedge disc, rising stem, Class 150, MSS SP-80 or ball valves, bronze, double stem seals, stainless steel ball and shaft, tight shutoff.

(2) Globe Valves and Angle Valves: Bronze, Class 150, MSS SP-80.

(3) Check Valves: Bronze, Type [IV, swing check] [III, lift check], Class 150, MSS SP-80.

b. Valve sizes 2 1/2 inches and larger.

(1) Gate Valves: Flanged, cast iron, Class 250, MSS SP-70 or steel, Class 150, ASME B16.34. Valves shall have wedge disc, outside screw and yoke (OS&Y), rising stem; valves 8 inches and larger shall have globe valved bypass.

(2) Globe Valves and Angle Valves: Flanged, cast iron, Class 250, MSS SP-85 or steel, Class 150, ASME B16.34.

(3) Check Valves: Flanged, cast iron, Class 250 or steel, Class 150, Type [_____], [lift] [swing] check, style [_____], ASME B16.34.

2.8.5.2 Medium Pressure

Valves for maximum working pressure of 250 psig steam at a maximum temperature of 450 degrees F or 500 psig W.O.G. at 200 degrees F (non-shock).

Valve sizes 2 1/2 inches and larger:

a. Gate Valves: Flanged or butt welded, cast iron, Class 250, MSS SP-70 (maximum size 12 inches) or steel, Class 300, ASME B16.34. Valves shall have wedge disc, OS&Y, rising stem; each valve 8 inches and larger shall have globe valved bypass.

b. Globe Valves and Angle Valves: Flanged or butt welded, cast iron, Class 250, MSS SP-85 or steel, Class 300, ASME B16.34.

c. Check Valves: Flanged or butt welded, iron body, Class 250 or steel, Class 300, Type [_____] [lift] [swing] check, style [_____], ASME B16.34.

2.8.5.3 High Pressure

Valves for maximum working pressure of 300 psigsteam at a maximum temperature of 850 degrees F or a maximum W.O.G. pressure of 675 psig at 300 degrees F (non-shock).

Valve sizes 2 1/2 inches and larger:

a. Gate Valves, Globe Valves, and Angle Valves: Flanged or butt welded, ASME B16.34, steel, Class 300, rising stem, OS&Y. Gate valves 8 inches and larger shall have globe valved bypass.

b. Check Valves: Flanged or butt welded, steel, Class 300, Type [_____], [lift] [swing] check, style [_____], ASME B16.34.

2.8.5.4 Ball Valves

ASME B16.5 and API Std 607 double stem seal type for bubble tight shutoff. Seats and seals shall be TFE material. Ball and shaft shall be stainless steel. Provide mechanical stops to prevent cycling valve in wrong direction and self-aligning stem seal.

2.8.5.5 Valve Accessories

ASME B16.34 valve operating mechanisms including chain wheels, gear operators, floor stands, electric motors, air motors and cylinder-type actuating devices. Provide accessories as follows and as indicated.

a. Provide power operators with remote position indicators on the following valves: soot blowers, [_____], [_____].

b. Provide floor stands and valve extensions on platforms and floors for the following valves: deaerator drain valves, [_____].

c. Provide motorized actuators or chain wheels with chain and guides on valves with handwheel centerline higher than 7 feet above the floor or platform except where specified otherwise. Chains shall extend from valve to within 3 feet above floor. Provide impact chain wheels on steam headers and other locations where valve has a tendency to stick. When a valve is motorized, provide hand operation for emergency.

d. Provide gear operators on ball valves larger than 3 inches and on gate valves 8 inches and larger.

2.8.5.6 Steam Pressure Regulating Valves

CID A-A-50558, minimum of Class [125] [150] [250] [300], except as specified otherwise. [Cast iron], [cast steel] valve body with valve seats and disc of replaceable heat treated stainless steel. Valves shall be single seated, shall seat tight under dead end conditions, and shall go to the closed position in the event of pressure failure of the operating medium. Valves shall be spring loaded diaphragm operated type, except valves exposed to ambient temperature of less than 35 degrees F or exposed to the weather shall be piston operated type. Capacity of valves shall be not less than that indicated. Pilot valves shall have strainer at inlet from external feeder piping.

a. Spring Loaded Diaphragm Operated Valves: Fabricate main spring of stainless steel, which shall not be in the path of steam flow through the valve. Control valve by pilot valve through external feeder piping.

b. Piston Operated Valves: Control valve by integral pilot valve through external feeder piping.

2.8.5.7 Safety Relief Valves

ASME BPVC SEC I ASTM F1508, Style D or E, with Class [150] [300] inlet flange, with test lever, designed for the intended service.

2.8.6 Bolts and Nuts

a. Bolts: ASTM A193/A193M, Grade B8. Lengths of bolts shall be such that not less than two full threads will extend beyond the nut with the bolts tightened to required tensions and washers seated.

b. Nuts: ASTM A194/A194M, Grade 8.

2.8.7 Gaskets

ASME B31.1 and as specified below, except provide spiral wound metal covered non-asbestos gaskets in lieu of compressed sheet non-asbestos. Gaskets shall be as thin as the finish of surfaces will permit. Do not use paper, vegetable fiber, rubber, or rubber inserted gaskets for temperatures greater than 250 degrees F. Provide metal or metal jacketed non-asbestos gaskets with small male and female and small tongue-and-groove flanges and flanged fittings; they may be used with steel flanges with lapped, large male and female, large tongue-and-groove, and raised facings. Provide fullface gaskets with flat-faced flanges. Raised face cast iron flanges, lapped steel flanges, and raised faced steel flanges shall have ring gaskets with an outside diameter extending to the inside of the bolt holes. Widths of gaskets for small male and female and for tongue-and-groove joints shall be equal to the widths of the male face and tongue. Gaskets shall have an inside diameter equal to or larger than the port opening. Dimensions for nonmetallic gaskets shall be in accordance with ASME B16.21. Materials for flanged gaskets shall be as listed below for service specified:

a. Steam, Boiler Blowdown, Exhaust Steam: Spiral wound metal composition or copper.

b. Boiler Feed Water: Metal jacketed non-asbestos, copper or monel.

c. Hot Water, (above 100 degrees F): Spiral wound metal non-asbestos.

d. Cold Water: Red rubber or neoprene rubber.

e. Heavy Fuel Oil (No. 6): Spiral wound metal non-asbestos, soft steel, or monel.

f. Diesel Fuel (No. 2): ASME B16.21 metallic.

g. Compressed Air: Spiral wound metal non-asbestos.

2.8.8 Expansion Joints

2.8.8.1 Slip Tube Expansion Joints

ASTM F1007, single or double slip tube as indicated, designed for [150] [300] psig saturated steam working pressure. Expansion joints shall be of the type which permits the injection of semi plastic type packing while the joint is in service under full line pressure. Slip tube shall be of chromium plated, wrought steel construction, guided by internal and external guides integral with joint body. Fit slip tube ends with forged steel pipe flanges or bevel for welding into pipe line where indicated. Deliver joints complete with packing and ready for installation.

2.8.8.2 Flexible Ball Expansion Joints in Piping

Capable of 360 degrees rotation plus 15 degrees angular flex movement. Ball joints shall have steel bodies and polished steel balls. Provide end connections to suit class of piping here in before specified. Seals shall be of pressure molded composition designed for the working pressure. Provide joints for [150] [300] psig saturated steam working pressure. Cold set the joints as necessary to compensate for temperature at time of installation. Do not use ball joints on superheated steam or on joints subject to frequent flexure. Install ball joints in strict accordance with manufacturer's recommendations.

2.8.8.3 Bellows Expansion Joints

ASTM F1120 flexible guided type with stainless steel expansion element, internal sleeves and external covers. Joints shall be designed for a working pressure of [_____] psig and a temperature of [_____] degrees F.

2.8.9 Pipe Hangers and Supports

MSS SP-58 and MSS SP-69, Type [_____] or Type [_____] of the adjustable type, except as specified or indicated otherwise. Suspended steam and condensate piping shall have pipe hangers Type [_____] with insulation protection saddles Type [_____]. Provide insulated piping, except steam and condensate piping, with insulation protection shields Type 40. Provide bronze or copper plated collars on uninsulated copper piping. Support rods shall be steel. Rods, hangers and supports shall be zinc plated, except for uninsulated copper piping which shall be copper plated; cast iron rollers, bases and saddles may be painted with two coats of heat resisting aluminum paint in lieu of zinc plating. Axles for cast iron rollers shall be stainless steel. Size hanger rods with a 150 percent safety factor for a seismic design.

2.8.10 Instrumentation

2.8.10.1 Pressure and Vacuum Gages

Conform to the applicable requirements of ASME B40.100.

2.8.10.2 Indicating Thermometers

MIL-T-19646 dial type. Thermometer shall include a separable immersion well.

2.8.11 Miscellaneous Pipeline Components

2.8.11.1 Cold and Hot Water Meters

CID A-A-59224 for maximum flow of [_____] gpm at 100 degrees F and reduced flow of up to [_____] gpm at 250 degrees F.

2.8.11.2 Air Traps

Float controlled valves arranged to close properly when water enters the traps. Air traps shall conform to the requirements for float operated steam traps (non-thermostatic), CID A-A-60001, except that the valve mechanism shall be inverted so as to be closed, not opened, by rising water.

2.8.11.3 Steam Traps

CID A-A-60001. Inverted bucket high pressure steam traps designed for use at [_____] psig at [_____] degrees F. Low pressure steam traps shall be float and thermostatic type for pressures up to 15 psig. Provide traps with separate strainers unless specified otherwise.

2.8.11.4 Strainers

FS WW-S-2739, Style Y for Class [125] [250] with blow off outlet. Construct strainers for Class 300 of cast carbon steel in accordance with ASME B16.5 for minimum of 300 psigsaturated steam pressure. Provide blow off outlet with pipe nipple and gate valve.

2.8.12 Backflow Preventers

Provide reduced pressure principle type conforming to applicable requirements of AWWA C511, and as specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.8.13 Insulation Types and Installation Procedures

Materials and application shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.8.14 Pipe Sleeves

2.8.14.1 Floor Slabs, Roof Slabs, and Outside Walls Above and Below Grade

Galvanized steel pipe having an i.d. at least 1/2 inch larger than the o.d. of the pipe passing through it. Provide sufficient sleeve length to extend completely through floors, roofs, and walls, so that sleeve ends are flush with finished surfaces except that ends of sleeves for floor slabs shall extend 1/2 inch above finished floor surface. Sleeves located in waterproofed construction shall include flange and clamping ring.

2.8.14.2 Partitions

Galvanized sheet steel, 26 gage or heavier, of sufficient length to completely extend through partition thickness with sleeve ends flush with partition finished surface.

2.8.15 Piping Identification

Conform to MIL-STD-101 and place in clearly visible locations; except that piping in the boiler room shall be painted the primary color of the color code. Labels and tapes conforming to ASME A13.1 shall be used in lieu of band painting or stenciling. Labels shall be outdoor grade acrylic plastic. Markings on the labels shall indicate the direction of flow, flowing media, and media design pressure and temperature. Spacing of identification marking shall not exceed 10 feet. Provide two copies of the complete color and stencil codes used. Frame codes under glass and install where directed.

2.9 FIRE PROTECTION SYSTEM

Provide the fuel oil [and gas metering] room[s] with a wet sprinkler system as specified in Section 21 13 13 WET PIPE SPRINKLER SYSTEMS, FIRE PROTECTION.

2.10 MARKING

Identify equipment, valves, switches, motor controllers, and controls or indicating elements by printed, stamped or manufactured identification plates or tags of rigid plastic or non-ferrous material. Lettering for identification plates or tags shall be not less than 3/16 inchhigh. Nomenclature and identification symbols used on identification plates or tags shall correspond to those used in the maintenance manuals, operating instructions, and schematic diagrams. Rigidly affix identification plates or tags to equipment or devices without impairing functions or, when this is not possible, attach using a non-ferrous wire or chain. In addition to the identification plate or tag, each major component of equipment shall have a nameplate listing the manufacturer's name, model number, and when applicable, electrical rating and other information required by pertinent standards or codes.

2.11 TOOLS AND TESTING EQUIPMENT

Provide special tools and wrenches required for the installation, maintenance, and operation of the equipment. Provide testing equipment necessary to perform routine tests:

a. On lubricating oil for acidity (pH-potentiometer), viscosity (saybolt test), and dirt (gravimetric).

b. On softened water for hardness (soap test or colorimetric test), and boiler blowdown water for pH (colorimetric) and conductivity (potentiometer).

c. For water (distillation) and sediment (gravimetric) in fuel oil.

2.12 WELDING MATERIALS

Comply with ASME BPVC SEC II-C. Welding equipment, electrodes, welding wire, and fluxes shall be capable of producing satisfactory welds when used by a qualified welder or welding operator using qualified welding procedures.

2.13 MOTORS AND DRIVES

Alternating current electric motors shall meet requirements of NEMA MG 1. Motors shall be designed for continuous operation at rated load under usual service conditions as defined by NEMA. Motors less than 1 hp shall meet NEMA High Efficiency requirements. Motors 1 hp and larger shall meet NEMA Premium Efficiency requirements. Unless specifically noted otherwise, motors less than 1/2 hp shall be 115 volt, 60 Hz, single phase, capacitor-start, or permanent split capacitor, with Class B insulation for 104 degrees F ambient. Unless specifically noted otherwise, motors 1/2 hp and larger shall be 460 volt, 60 Hz, three phase, Design B, squirrel cage induction with a minimum insulation of Class F for 104 degrees F ambient. Size motors to meet the power requirements of the driven unit at design conditions, including drive and coupling losses which are incurred, without loading the motor beyond its nameplate power rating. Minimum service factor for open drip-proof motors shall be 1.15 and for totally enclosed, fan cooled motors 1.0. Motor shall be quiet operating. Bearings shall be heavy duty, grease lubricated, anti-friction, single shielded, regreasable type and shall have approved lubricating fittings extended to an easily accessible location for field servicing. Provide sole plates for motors installed on concrete pads. Motors shall have copper windings.

2.14 SOURCE QUALITY CONTROL

2.14.1 Plant Equipment Tests

Tests specified below shall be conducted at factory prior to delivering equipment to job site.

2.14.1.1 Plant Air Compressors

Test plant air compressors in service to determine compliance with contract requirements and warranty. During the tests, test equipment under every condition of operation. Test safety controls to demonstrate performance of their required function. Completely test system for compliance with specifications.

2.14.1.2 Instrument Air Compressors

Factory test air compressor package at full load for not less than 2 hours. Check capacity, smoothness of operation, alternation of units, and proper operation of the air unloaders during the test.

2.14.1.3 Variable Speed Motor Controller Factory Test

Burn-in tests shall be conducted for at least 50 hours at rated conditions. If a component fails during the burn-in test it shall be replaced, and the entire test shall be run again on the complete assembly for another 50 hours. The burn-in test shall not be complete until the entire assembly has operated for 50 hours without failure.

PART 3 EXECUTION

3.1 INSTALLATION

Install materials and equipment as indicated and in accordance with manufacturer's recommendations.

3.1.1 Equipment Installation

Install equipment in accordance with this specification, and the installation instructions of the manufacturers. Equipment mounted on concrete foundations shall be grouted before installing piping. Install piping in such a manner that it will not impart a stress on equipment. Flanged joints shall not be bolted tight unless they match adequately. Expansion bends shall be adequately extended before installation. Support, grade, anchor, and guide all piping so that there are no low pockets, which could accumulate fluids, along the piping run.

3.1.1.1 Equipment Foundations

Equipment foundations shall be of sufficient size and weight, and proper design to prevent shifting of equipment under operating conditions, or under abnormal conditions which could be imposed upon equipment. Equipment vibration shall be limited within acceptable limits, and isolated. Foundations shall be adequate for soil conditions of the site and shall meet requirements of the equipment manufacturer. Trowel exposed foundation surfaces smooth except when properly roughened surfaces are necessary to receive grout.

3.1.1.2 Forced Draft Fan

Fan assembly shall be set, shimmed level, anchored and grouted in place prior to setting driver. Driver shall be properly shimmed on base plate using steel shim stock. Shims shall be full size of feet and shall have a slotted hole for installation. After the drive has been properly aligned and shimmed, by an approved millwright, the millwright shall drill and ream the foot and base plates and, install taper pins with nut on top for pullout removal. One front foot and diagonally opposite rear foot shall be pinned to base plate. Bolt equipment into place in an approved manner. Level and grout the fan and bearing pedestal sole plates into place.

3.1.1.3 Stack

Install, level and plumb. Erected stack shall be no more than one inch out of plumb (out of vertical) per 50 feet. Remove roughness, marks, and lifting lugs, from stack and grind surfaces smooth and flush with surrounding surfaces.

3.1.1.4 Fuel Oil Tanks

[a. Horizontal Fuel Oil Tanks (Below Ground): Provide concrete ballast slabs for tanks and concrete protective ground level slabs for FRP tanks. The ballast slabs shall be full length and width of the tanks and the protective slabs shall extend 2 feet beyond the tanks. Concrete work shall be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

(1) Installation: Install and backfill fiberglass reinforced tanks as recommended by the manufacturer; backfill adjacent to the tanks shall be pea gravel unless otherwise recommended by the manufacturer. Backfill for steel tanks shall be sand.

(2) Placement: Set steel tanks on a bed of sand not less than 6 inches deep over the concrete slab and strap in place with stainless steel hold-down straps with stainless steel turnbuckles. Set FRP tanks on a bed of pea gravel not less than 12 inches thick and pre-shape for the tank contours for FRP tanks. Fabricate straps for FRP tanks from FRP resins reinforced with stainless steel to prevent breaking of straps and floating of empty tanks.

(3) Slope tank toward sump not less thanone inch in each 5 feet.

][b. Horizontal Fuel Oil Tanks (Above Ground): Continuously support steel tank saddles along the full length of the base and level and grout to ensure full bearing.

][c. Vertical Fuel Oil Tank: Provide [sand, crushed stone or fine gravel cushion] [concrete base].

][(1) Sand, Crushed Stone or Fine Gravel Cushion: Cover area beneath tank with a minimum 20 mil thick fuel resistant plastic membrane. Carefully fuse or cement plastic membrane seams. Lay plastic over a thoroughly compacted select subgrade free from rocks that could puncture the plastic. Over plastic, provide a bed of sand, crushed stone or fine gravel not less than 6 inches thick. Stabilize bed with an approved material and shape to the tank bottom. Slope bed down to center sump approximately 6 inches for each 10 feet of tank radius. When in place, tank shell shall be plumb.

][(2) Concrete base shall be as indicated and in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.

][(3) Mastic Seal: Place the mastic seal between the tank and the concrete ring to the cross section indicated. Compact the mastic thoroughly. Immediately before placing the mastic, coat the tank surfaces to be in contact with the concrete ring with a coat of AASHTO M 118 bituminous material.

]3.1.2 Piping

Unless specified otherwise, erection, welding, brazing, testing and inspection of piping shall be in accordance with ASME B31.1 and Section

40 17 26.00 20 WELDING PRESSURE PIPING. Piping shall follow the general arrangement shown. Cut piping accurately to measurements established for the work. Work piping into place without springing or forcing, except where cold-springing is specified. Piping and equipment within buildings shall be entirely out of the way of lighting fixtures and doors, windows, and other openings. Locate overhead piping in buildings in the most inconspicuous positions. Do not bury or conceal piping until it has been inspected, tested, and approved. Where pipe passes through building structure, pipe joints shall not be concealed, but shall be located where they may be readily inspected and building structure shall not be weakened. Avoid interference with other piping, conduit, or equipment. Except where specifically shown otherwise, vertical piping shall run plumb and straight and parallel to walls. Install piping connected to equipment to provide flexibility for vibration. Support and anchor piping so that strain from weight of piping is not imposed on equipment.

3.1.2.1 Fittings

Provide long radius elbows on welded piping to reduce pressure drops. Do not miter pipe to form elbows, notch straight runs to form full sized tees, or use similar construction. Make branch connections with welding tees, except factory made forged welding branch outlets or nozzles having integral reinforcements conforming to ASME B31.1 may be used.

3.1.2.2 Grading of Pipe Lines

Unless indicated otherwise, install horizontal lines of steam and return piping to grade down in the direction of flow with a pitch of not less than one inch in 30 feet, except in loop mains and main headers where flow may be either direction. Pitch air lines to the source of supply, and make provisions for draining off condensate. Install water lines to drain to a shutoff valve.

3.1.2.3 Anchoring, Guiding, and Supporting Piping

Anchor and support piping in a manner such that expansion and contraction will take place in the direction desired, prevent vibration by use of vibration dampeners, and prevent undue strains on boilers and equipment served. Fabricate hangers used for support of piping of 2 inch nominal pipe size and larger to permit adequate adjustment after erection while still supporting the load. Provide wall brackets where pipes are adjacent to walls or other vertical surfaces which may be used for supports. Provide supports to carry weight of lines and maintain proper alignment. Provide inserts and sleeves for supports in concrete where necessary and place in new construction before pouring concrete. Provide insulated piping with a pipe covering protection saddle at each support. Provide pipe guides and anchors of approved type at points where necessary to keep pipes in accurate alignment, to direct expansion movement, and to prevent buckling and swaying and undue strain. Provide pipe guides for alignment of pipe connected to free unanchored end of each expansion joint. Support pipe rollers in concrete conduits and trenches by extra strong steel pipe with ends inserted in slots provided in concrete walls. Set pipe supports for rollers at correct elevations either by metal shims or by cutting away of concrete and after placing pipe lines in alignment, grout ends of pipe supports and fix in place. Space pipe supports to provide adequate support for pipes. Pipe shall not have pockets formed in the span due to sagging of pipe between supports, caused by weight of pipe, medium in pipe, insulation, valves, and fittings. Maximum spacing for pipe supports for steel pipe shall be in accordance with ASME B31.1; maximum spacing for supports for copper tubing shall be in accordance with MSS SP-69.

3.1.2.4 Copper Tubing

Copper tubing shall have solder joints with solder suitable for the pressure-temperature ratings of the piping system. Tubing 3/4 inch and smaller for instrument air may be compression joint in lieu of soldered joint. Tin-antimony (95/5) solder is suitable for saturated steam up to 15 psig but tin-lead (50/50) solder is not acceptable for steam service. Flux shall be non-corrosive. Wipe excess solder from the joints.

3.1.2.5 Sleeves

Provide pipe sleeves where pipes and tubing pass through masonry and concrete walls, floors, and partitions. Space between pipe, tubing, or insulation and the sleeve shall be not less than 1/4 inch. Hold sleeves securely in proper position and location before and during construction. Sleeves shall be of sufficient length to pass through entire thickness of walls, partitions, and slabs. Sleeves in floor slabs shall extend 1/2 inch above the finished floor. Firmly pack space between pipe or tubing and the sleeve with oakum and caulk on both ends of the sleeve with elastic cement.

3.1.2.6 Flashing for Buildings

Where pipes pass through building roofs and outside walls, provide proper flashing and counter flashing and make tight and waterproof.

3.1.2.7 Outlets for Future Connections

Locate as directed capped or plugged outlets for connections to future equipment, when not located exactly by the project drawings.

3.1.2.8 Screwed Joints in Piping

Provide teflon tape or suitable pipe joint compound applied to male threads only for making up screwed joints. Piping shall be free from fins and burrs. Ream or file out pipe ends to size of bore, and remove chips.

3.1.2.9 Welds and Welded Joints

Weld joints in piping by the metal-arc or gas welding processes in accordance with ASME B31.1. Number or mark each weld to identify the work done by each welder on welds which stress relieving or radiographic inspection is required.

a. Recertification: The Contracting Officer reserves the right to require the Contractor to provide re-examination and recertification of welders.

b. Radiographic testing of circumferential butt welded joints of pipe with operating temperature of 350 degrees F and above shall be required on ten percent of the joints, the location of which will be determined by the Contracting Officer; when more than ten percent of the radiographically tested joints show unacceptable defects radiographically test joints of this type piping.

c. Equipment and Protection: Items of equipment for welding shall be so designed and manufactured, and be in such condition as to enable qualified operators to follow procedures and to attain the results specified. Protect welders and gas cutters from the light of the arc and flame by approved goggles, shields, helmets, and gloves. Replace cover glasses in helmets and shields when they become sufficiently marred to impair the operator's vision. Take care to avoid risk of explosion and fire when welding and gas cutting near explosive or flammable materials. Ventilate welding and gas cutting operations in accordance with paragraph 29 CFR 1910-SUBPART Q.

d. Surface Conditions: Do not weld when atmospheric temperature is less than zero degrees F, when surfaces are wet, when rain or snow is falling or moisture is condensing on surfaces to be welded, nor during periods of high wind, unless the welder and work are protected properly. At temperatures between 32 degrees F and zero degrees F heat with a torch the surface for an area within 3 inches of the joint to be welded to a temperature warm to the hand before welding. Free surfaces to be welded from loose scale, slag, rust, paint, oil, and other foreign material. Joint surfaces shall be smooth, uniform and free from fins, tears, and other defects which might affect proper welding. Remove slag from flame-cut edges to be welded by grinding, but temper color need not be removed. Thoroughly clean each layer of weld metal by wire brushing prior to inspection or deposition of additional weld metal.

3.1.2.10 Cleaning of Piping

Before installing pipe, thoroughly clean it of sand, mill scale and other foreign material. After erection but before final connections are made to apparatus thoroughly clean the interior of piping. Flush with water piping except air and fuel lines, in addition, blow out steam lines with intermittent high pressure steam blows to promote shedding of internal scale. Blow compressed air and fuel oil lines clean with 80 to 100 psig air dried to a 35 degree F dew point at 80 psig. Sterilize potable water piping by means of liquid chlorine or hypochlorite in accordance with AWWA C651 before placing water system in service. Take care during fabrication and installation, to keep piping, valves, fittings and specialties free of loose welding metal chips of metal or slag, welding rods and other foreign matter. Blowing or flushing shall in no case be channeled through equipment, pump, control valve, regulating valve, instrument gage or specialty in the system. Provide temporary screens, strainers, connections, spool pieces and bypasses consisting of piping or hoses, pumps and other required equipment temporarily installed for the purpose of cleaning and flushing piping. Drain flushing water and test water to the sanitary sewer system.

3.1.2.11 Reduction in Pipe Size

Provide reducing fittings for changes in pipe size; the use of bushings will not be permitted. In horizontal steam lines, reducing fittings shall be the eccentric type to maintain the bottom of the lines in the same plane. In horizontal water mains, reducers shall be set to maintain the top of the lines in the same plane.

3.1.2.12 Expansion Control

Provide bends, loops, and offsets wherever practical to relieve overstressed piping systems due to thermal expansion and to provide adequate flexibility. Cold spring piping system as indicated but not more than 50 percent of the total linear expansion.

3.1.2.13 Connection to Equipment

Provide unions or flanges where necessary to permit easy disconnection of piping and apparatus. Provide unions and gate valves at each connection to threaded end control valves, strainers and equipment.

3.1.2.14 Valve Installation

Install valves in positions accessible for operation and repair. Install stems in a vertical position with handwheels or operators on top or in a horizontal position. Do not install handwheels on stop valves below the valve. When centerline of valve is more than 7 feet above floor or platform, provide valve with a chain-operated handwheel. When valve is motorized, provide hand operation for emergency use.

a. Gate Valves: Arrange back outlet gate valves for turbine exhaust for hand operation and provide with a floor stand.

b. Globe Valves: Pressure shall be below the disc. Install globe valves with the stems horizontal on steam and exhaust lines, when better drainage is required or desired.

c. Steam Pressure-Reducing Valves: Provide the steam line entering each pressure-reducing valve with a strainer. Provide each pressure-reducing valve unit with two shutoff valves and with a globe or angle bypass valve and bypass pipe. A bypass around a reducing valve shall be of reduced size to restrict its capacity to approximately that of the reducing valve. Provide each pressure-reducing valve unit with indicating steam gages to show the reduced pressure and the upstream pressure and an adequately sized safety valve on the low pressure side.

d. Valve Tags and Charts: Permanently tag each valve with a black and white engraved laminated plastic tag showing valve number, valve function and piping system and whether another valve must be opened or closed in conjunction with this valve. Provide a typed chart which will show the required valve tagging plus the location of each valve. Frame valve charts under glass and install as directed.

3.1.2.15 Traps and Connections

Traps shall be of the type and capacity for the service required, and shall be properly supported and connected. Except for thermostatic traps in pipe coils, radiators, and convectors, install traps with a dirt pocket and strainer between it and the piping or apparatus it drains. When it is necessary to maintain in continuous service apparatus or piping which is to be drained, provide a three valve bypass so that trap may be removed and repaired and condensate drained through the throttled bypass valve. Provide a check valve on discharge side of trap whenever trap is installed for lift or operating against a back pressure, or it discharges into a common return line. Provide test connections on discharge side of high and medium pressure traps when they are specifically required. Test connection shall include a 1/2 inch globe valve with open blow.

3.1.2.16 Pressure Gage Installation

Provide with a shutoff valve or petcock between the gage and the line, and gage on steam lines shall have a siphon installed ahead of the gage.

3.1.2.17 Thermometer and Sensing Element Installation

Provide thermometers and thermal sensing elements of control valves, with a separable socket. Install separable sockets in pipe lines in such a manner to sense flowing fluid temperature and minimize obstruction to flow.

3.1.2.18 Strainer Locations

Provide strainers with meshes suitable for the services upstream of each control valve and where dirt might interfere with the proper operation of valve parts, orifices, or moving parts of equipment.

3.1.2.19 Dissimilar Piping Materials

Provide dielectric unions or flanges between ferrous and nonferrous piping, equipment, and fittings, except that bronze valves and fittings may be used without dielectric couplings for ferrous-to-ferrous or nonferrous-to-nonferrous connections. Dielectric fittings shall utilize a nonmetallic filler which will prevent current flow from exceeding one percent of the short circuit current. Spacer shall be suitable for the pressure and temperature of the service. Fittings shall otherwise be as specified in this section.

3.1.2.20 Surface Treating, and Pipe Wrapping

Uninsulated steel piping buried in the ground shall have exterior surfaces protected with a tape wrapping system or a continuously extruded polyethylene coating system as specified in Section 09 97 13.28 PROTECTION OF BURIED STEEL PIPING AND STEEL BULKHEAD TIE RODS.

3.1.3 Painting

3.1.3.1 Piping, Fittings, and Mechanical and Electrical Equipment

Equipment shall be factory finished to withstand the intended end use environment in accordance with the specifications for particular end item. Factory finished equipment on which the finish has been damaged shall have damaged areas retouched and then be given a complete finish coat to restore the finish to its original condition. Finish coat shall be suitable for exposure in the intended end use environment.

3.1.3.2 Other Items

Unless specified otherwise, pipe hangers, structural supports, pipe and pipe fittings, conduit and conduit fittings, air grilles, pipe coverings, insulation, and metal surfaces associated with mechanical and electrical equipment including zinc-coated steel ducts shall be painted utilizing the painting systems as specified in Section 09 90 00 PAINTS AND COATINGS. Zinc-coated steel duct in unpainted areas shall not be painted. Except zinc-coated and copper pipe, give piping to be insulated, a protective coating prior to installing insulation.

3.1.3.3 Boilers

After erecting and testing boilers, clean exposed surfaces of the boiler normally painted in commercial practice to remove grease, coal dust, flyash and other foreign matter and finish with one coat of aluminum heat resisting paint applied to minimum dry film thickness of one mil.

3.1.3.4 Vertical Fuel Oil Tank

Clean interior surfaces to bare metal in accordance with SSPC SP 10/NACE No. 2. Clean to bare metal by powered wire brushing or other mechanical means surfaces that cannot be cleaned satisfactorily by blasting. Wash members which become contaminated with rust, dirt, oil, grease, or other contaminants with solvents until thoroughly clean. Remove weld backing plates prior to blast cleaning; when left in place, round off the corners prior to blast cleaning and coating. Tanks shall be internally coated in accordance with Section 09 97 13.17 THREE COAT EPOXY INTERIOR COATING OF WELDED STEEL PETROLEUM FUEL TANKS.

3.1.3.5 Surfaces Not to be Painted

Unless specified otherwise, do not paint equipment having factory applied permanent finish, switchplates and nameplates, motor starters, and concrete foundations.

3.1.4 Insulation

Insulate mechanical equipment, systems and piping as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2 FIELD QUALITY CONTROL

Provide labor, equipment, test apparatus and materials required for preparation and performance of tests and inspections specified to demonstrate that the boilers and auxiliary equipment as installed are in compliance with contract requirements. During startup and during tests, factory trained engineers or technicians employed by the boiler manufacturer and system suppliers or manufacturers of such components as the boiler, burner, forced draft fan, feedwater treatment equipment, and other auxiliary equipment shall be present, to ensure the proper functioning, adjustment, and testing of the individual components and systems. The Government will furnish, when available, water, electricity and fuel for the tests, except fuel required for retesting. The Contractor shall rectify defects disclosed by the tests and retest the equipment. The Contractor's boiler plant personnel shall be experienced in starting up and operating boiler plants.

3.2.1 Tests and Inspections (Piping)

3.2.1.1 General Requirements

Examine, inspect, and test piping in accordance with ASME B31.1except as modified below. The Contractor shall rectify defects disclosed by the tests. Necessary subsequent tests required to prove system tight after additional work by the Contractor shall be provided by the Contractor. Make tests under the direction of and subject to the prior approval of the Contracting Officer.

3.2.1.2 Hydrostatic and Leak Tightness Tests

a. Test piping systems attached to the boilers and included under the jurisdiction of the ASME BPVC SEC I in accordance with the requirement of that Code. Piping bearing ASME Code symbol stamp will be accepted only as indicating compliance with the design and material requirements of the code.

b. Test piping which is a part of the steam generation or auxiliary systems, including piping within the boiler room and external to the boiler room, by the following methods:

(1) Perform hydrostatic test at 150 percent of design pressure for welded and screwed steel piping systems except those for air, oil, and gas. Hold hydrostatic tests for a period of one hour with no pressure loss. Temperature of the testing fluid shall not exceed 100 degrees F.

(2) Test air and oil lines in accordance with the requirements of ASME B31.1 for pneumatic tests with the exception that the test pressure must be held for one hour. Examination for leaks by a soap or other foaming agent test.

(3) Inspection and test of gas piping shall conform to the requirements of NFPA 54.

c. For tests install a calibrated test pressure gage in the system to observe loss in pressure.

3.2.2 Preliminary Operation

The Contractor under the direction of the respective manufacturer's representative shall perform the work of placing into operation equipment provided except as specifically noted otherwise. Make adjustments to equipment that are necessary to ensure proper operation as instructed by the manufacturer of the equipment.

a. Lubricate equipment prior to operation in accordance with the manufacturer's instructions. Lubricants shall be provided by the Contractor. Contractor shall furnish lubrication gun with spare cartridges of lubricant to operating personnel.

b. Dry out motors before operation as required to develop and maintain proper and constant insulation resistance.

c. Check drive equipment couplings for proper alignment at both ambient and operating temperature conditions.

3.2.3 General Startup Requirements

Prior to initial operation of any complete system, check each component as follows:

a. Inspect bearings for cleanliness and alignment and remove foreign materials found. Lubricate as necessary and in accordance with manufacturer's recommendations. Replace bearings that run roughly or noisily.

b. Adjust direct drives for proper alignment of flexible couplings. Provide lubrication when a particular coupling so requires. Check security of couplings to driver shafts. Set drive components to ensure free rotation with no undesirable stresses present on the coupling of attached equipment.

c. Check motors for amperage comparison to nameplate value. Correct conditions that produce excessive current flow and that exist due to equipment malfunction.

d. Check speeds of each motor and driven apparatus to ensure that they are operating at the desired point.

e. Check actual suction and discharge pressure of each pump against desired performance curves.

f. Check pump packing glands or seals for cleanliness and adjustment before running each pump. Inspect shaft sleeves for scoring and proper placement of packing; replace when necessary. Ensure piping system is free of dirt and scale before circulating liquid through pumps.

g. Inspect both hand and automatic control valves. Clean bonnets and stems, tighten glands to ensure no leakage, but permit valve stems to operate without galling. Replace packing in valves that require same to retain maximum adjustment after system is judged complete. Replace entire packing in valves that continues to leak after adjustment. Remove and repair bonnets that leak. Coat packing gland threads and valve stems with a suitable surface preparation after cleaning.

h. Inspect and make certain that control valve seats are free from foreign material and are properly positioned for the intended service.

i. Check flanges and packing glands after the system has been placed in operation. Replace gaskets in flanges that show signs of leakage after tightening.

j. Inspect screwed joints for leakage and remake each joint that appears to be faulty. Do not wait for rust to form. Clean threads on both parts, apply compound and remake joint.

k. Strainers installed shall be thoroughly blown out through individual valved blow-off connection on each strainer prior to placing in operation.

l. Thoroughly blow out or dismantle and clean strainers after systems have been in operation one week. Thoroughly clean, repair, and place back in service traps or other specialties in which foreign matter has accumulated, causing malfunction or damage.

m. Adjust pipe hangers and supports for correct pitch and alignment.

n. Remove rust, scale and foreign materials from equipment and renew defaced surfaces. When equipment is badly marred, the Contracting Officer shall have the authority to request that new materials be provided.

o. Adjust and calibrate temperature, pressure and other automatic control systems.

p. Inspect each pressure gage and thermometer for calibration, and replace those that are defaced, broken or read incorrectly.

[q. Vertical Fuel Oil Tank Calibration: After completing installation of tank, prepare a calibration table for tank showing the volume of fuel in gallons in the tank to height of liquid in feet and inches, when measured by a steel tape lowered through the roof. Calibrate tank in accordance with ASTM D1220 for "critical measurement" "operating control." Calibration of the tank shall be done by a qualified organization that can certify to at least 2 years of prior successful and accurate experience in calibrating tanks of comparable type and size. Correct the data obtained for use with the product to be stored.

]3.2.4 Fuel Oil Tanks

[a. Horizontal Fuel Oil Tanks (Below Ground):

(1) Test tanks before placing in service, in accordance with the applicable paragraphs of the code under which they were built. An UL label, ASME Code Stamp, or API monogram on a tank shall be evidence of compliance with code requirements.

(2) Holiday Detection Test: Inspect coal tar epoxy coating system for film imperfections using a low voltage (75 volt) holiday tester. Inspect FRP coated tanks with a 10,000 volt spark test for imperfections or holidays (voids). Repair holidays or pinholes in the coatings.

][b. Vertical Fuel Oil Tank: Inspect and test as specified in API Std 650. Use the radiographic method of inspection of butt welds as required by API Std 650; sectioning method will not be acceptable as an alternative to radiographic inspection.

]3.2.4.1 Blowdown Valves and Try Cocks

Test blowdown valves and try cocks for proper operation.

3.2.4.2 Fans, Heaters, Pumps, and Motors

Test draft fans, fuel oil heaters, fuel pumps, and electric motors to determine compliance with the referenced standards. Standard symbols and certifications from the referenced organization may be accepted at the discretion of the Contracting Officer. Closely observe the operation of fans, fuel oil heaters, fuel pumps, and electric motors for possible defects or nonconformance.

3.2.5 Boilers and Auxiliaries Tests and Inspections

The Contractor, with qualified personnel provided by the Contractor, shall make tests and inspections at the site under direction of and subject to approval of the Contracting Officer. The respective manufacturer's representatives and consultants shall direct the Contractor's boiler plant personnel in the operation of each boiler and appurtenances through the entire testing period and shall ensure that necessary adjustments have been made. The Contractor shall notify the Contracting Officer in writing, at least 7 days in advance, indicating that equipment is ready for testing. The Contractor shall provide testing equipment, including gages, thermometers, calorimeter, flue gas analyzers, thermocouple pyrometers, fuel flow meters, water meters and other test apparatus and calibrate instruments prior to the test. Draft, fuel pressure and steam flow may be measured by permanent gages and meters installed under the contract. The Contractor is responsible for providing an analysis of the fuel being used for the tests. Control of noise levels developed by exhaust steam shall be as directed by the Contracting Officer to satisfy environmental conditions of the surrounding area. The Contractor shall perform the following tests in the sequence as listed when feasible:

a. Strength and tightness tests

b. Standards compliance tests

c. Preliminary operational tests (steady state combustion test and variable load combustion test)

d. Tests of auxiliary equipment

e. Feedwater equipment test

f. Capacity and efficiency tests

3.2.5.1 Strength and Leak Tightness Tests

Subject boiler[s] to the following strength and tightness tests:

a. Watersides Including Fitting and Accessories: Hydrostatically test watersides in accordance with the requirements of the ASME BPVC SEC I. Since damage to the boiler components may have occurred during shipping, the factory ASME label will not be accepted as evidence of this test. Therefore, the final hydrostatic test must be performed after the installation of the boiler and its auxiliary components have been installed.

b. Boiler Casing, Air Casing, and Ducts: Test air casing and ducts exterior to the furnace pneumatically at the maximum working pressure. Use the soap bubble method to verify tightness. Test gas sides of boilers normally operated under pressure for tightness at one and one half times the predicted operating pressure in the furnace at maximum continuous output. For this test, tightly seal the boiler with a suitable means to blank off openings. Admit air to the boiler until the test pressure is reached, and then hold. If in a 10 minute period the pressure drop does not exceed 5 inches water gage, the casing shall be regarded as tight and accepted.

3.2.5.2 Boiler Inspection

The Boiler Inspector shall be on hand to witness the appropriate tests which need to be observed in order to certify the safety of the boiler. The inspection shall include the requirements of NAVFAC MO 324Inspection and Certification of Boilers and Unfired Pressure Vessels. The Boiler Inspector shall complete NAVFAC form 9-11014/40, Data Record Sheet; NAVFAC form 9-11014/41, Inspection Report; NAVFAC 9-11014/32 Inspection Certificate for each boiler after boiler has been inspected and found to be safe. No boiler may be fired until it has passed the inspection of the Boiler Inspector. Boiler inspection forms shall be submitted through the Contractor to the Contracting Officer. Place Inspection Certificate under framed glass, mounted on or near the boiler in a conspicuous location.

3.2.5.3 Boiler Cleaning and Startup

Dry out, boil out, and operate firing rate of new boiler(s) under direct responsibility and supervision of the manufacturer, [and in the presence of boiler room operating personnel]. Provide required chemicals. Allow sufficient time for boiling out process to ensure interior surfaces are clean. This time shall be at least 24 continuous hours and generally not more than 36 hours; boil out shall continue until water is clear. Boil out, cleaning and starting procedures shall be in accordance with requirements of ASME BPVC SEC VII and FM DS 12-17.

3.2.5.4 Boiler Preliminary Operational Tests

Conduct a boiler operational test on each unit continuously for two weeks. Operate one boiler at a time to demonstrate control and operational conformance to specified requirements including ability to respond to load swings from the specified capacity to minimum turndown. Conduct operational test under the supervision of a registered professional engineer or a licensed power plant operator and demonstrate operation of safeties, controls, maintenance of stable combustion at low loads, proper flame lengths and patterns to avoid flame impingement on the tubes for oil firing [or gas firing], and proper mechanical and electrical functioning of systems. This test shall include items mentioned in this specification as well as items mentioned in the specification of the particular pieces of equipment. Conduct tests with factory trained combustion equipment engineers as previously specified. Test and record steam quality, steam flowrates, flue gas temperature, percentages of carbon dioxide, carbon monoxide, oxygen and nitrogen in the flue gas and percent excess air for each boiler at tested load and graphically present test data.

3.2.5.5 General Controls Operational Tests

Conduct operational tests, performance tests, and demonstration tests with boiler controls functional and on line. No bypassing, use of jumpers, or other disablement of control systems will be allowed unless specified elsewhere.

3.2.5.6 Steady State Combustion Tests

Test fuel burning and combustion control equipment with each of the specific fuels at the minimum limit of the turndown range and at increments of 50, 75 and 100 percent of full rated load. Each test run shall be at least two hours on each fuel and until stack temperatures are constant and capacity and efficiency requirements of this specification have been verified and recorded. Verify proper operation of instrumentation and gages during the tests.

3.2.5.7 Varying Load Combustion Tests

Test boilers continuously under varying load conditions to demonstrate proper operability of the combustion control, flame safeguard control, programming control and safety interlocks. Conduct these tests after the adjustment of the combustion controls has been completed under the steady state combustion tests. Continue the variable load operational tests for a period of at least 8 hours.

a. Sequencing: Boiler shall start, operate and stop in strict accordance with the specified operating sequence.

b. Flame Safeguard: Verify operation of flame safeguard controls by simulated flame and ignition failures. Verify the trial-for-pilot ignition, trial-for-main flame ignition, combustion control reaction and valve closing times by stop watch.

c. Immunity to Hot Refractory: Operate burner at high fire until combustion chamber refractory reaches maximum temperature. Main fuel valve shall then be closed manually. Combustion safeguard shall drop out immediately causing safety shutoff valves to close within the specified control reaction and valve closing times.

[d. Pilot Intensity Required: Gradually reduce fuel supply to the pilot flame to the point where the combustion safeguard begins to drop out (sense "no flame") but holds in until the main fuel valve opens. At this point of reduced pilot fuel supply, the pilot flame shall be capable of safely igniting the main burner. When the main fuel valve can be opened on a pilot flame of insufficient intensity to safely light the main flame, the boiler shall be rejected.

] e. Boiler Limit and Fuel Safety Interlocks: Safety shutdown shall be caused by simulating interlock actuating conditions for each boiler limit and fuel safety interlock. Safety shutdowns shall occur in the specified manner.

f. Combustion Controls: Demonstrate accuracy, range and smoothness of operation of the combustion controls by varying the steam demand through the entire firing range required by the turndown ratio specified for the burner. Control accuracy shall be as specified.

g. Safety Valves: High pressure limit switch shall be locked out or otherwise made inoperative and the boiler safety valves shall be lifted by steam. Determine the relieving capacity, popping pressure, blowdown and reseating pressure by observation and measurement in accordance with the ASME BPVC SEC I. The ASME standard symbol will be accepted only as indicating compliance with the design and material requirements of the code.

3.2.5.8 Auxiliary Equipment and Accessory Tests

Observe and test blowdown valves, stop valves, try cocks, fans, fuel oil heaters, pumps, electric motors, and other accessories and appurtenant equipment during operational and capacity tests for leakage, malfunctions, defects, and for compliance with referenced standards.

3.2.5.9 Feedwater Equipment Tests

Perform tests of feedwater treatment equipment in two steps. Conduct one test concurrently with the combustion tests. The Government will perform a second test during the first period of heavy loading after plant has been accepted and put in service. Correct deficiencies revealed during the Government tests under the guarantee provisions of the contract. Both the first and second series of tests shall determine compliance with limits for chemical concentrations of this specification. Supply equipment for taking samples and test kit for analyzing samples. Sampling equipment and test kit shall become the property of the Government when tests are completed.

3.2.5.10 Capacity and Efficiency Tests

Perform capacity and efficiency tests after satisfactorily completing operating tests and after operating boiler continuously for at least 14 days with no nuisance shutdowns and without the necessity for frequent or difficult adjustments. Perform these tests on each boiler. Conduct tests using [the] [each] specified fuel. Test procedures shall be in accordance with the heat loss method [and the input-output method] of ASME PTC 4. Before tests are performed, the Contracting Officer and the Contractor shall reach agreement on those items identified in ASME PTC 4, Section 3, paragraph 3.0l "Items on Which Agreement Shall be Reached." A test run shall not start until boiler and accessories have reached an equilibrium and stabilization condition for at least one hour in duration. Duration of tests shall be sufficient to record necessary data but in no case shall each run be less than [4] [10] [24] hours.

3.2.5.11 Test Runs

Accomplish maximum output testing by means of a single 2 hour run at 110 percent load on the boiler under test. Calculate boiler efficiency, using [the][both input-output and] heat loss method[s], from the consistent readings taken during the runs. Make runs at four different loads 30, 50, 70, and 100 percent of boiler rating during which take both heat loss and input-output data. Predict unmeasured losses used in conjunction with heat loss calculations and include with equipment data when submitted for approval. Subsequent tests required because of failure of equipment to perform adequately during specified capacity and efficiency tests shall be financial responsibility of the Contractor, including fuel cost.

3.2.5.12 Fuel Analysis

When analysis of fuel being burned during performance tests vary from that specified as the performance fuel the guarantees shall be adjusted in accordance with accepted engineering practice to determine compliance. Carbon loss shall be determined in accordance with ABMA Boiler 103, American Boiler Manufacturers Association curves for carbon loss.

3.2.5.13 Temporary Waste Steam Connection

When necessary to obtain sufficient load for these tests, provide a temporary steam line at a point outside of the building. Provide necessary pipe, fittings, supports, anchors and appurtenances including a field fabricated silencer as directed by the Contracting Officer. Remove temporary piping and silencer after tests have been satisfactorily completed.

3.2.5.14 Fire Safety for Oil-fired Boilers

Conduct tests as necessary to determine compliance with the applicable UL Safety Standards. The presence of the applicable Underwriters' label will be accepted as evidence of compliance in this respect.

a. Oil-Fired Boilers: Oil fired boilers shall meet test requirements of UL 726.

b. Oil Burners: Oil burners shall meet test requirements of UL 296.

3.2.5.15 Plant Acceptance Operation

After satisfactory completion of tests specified, operate the complete plant including each boiler, [its related flue gas cleaning equipment] and subsystems for a period of 30 continuous 24 hour operational days prior to final acceptance by the Government. Furnish labor, chemicals, test equipment and apparatus; the Government will furnish fuel, electricity and water. During this 30 day period, furnish readily available, the services of qualified representatives from manufacturers of plant components and systems for the purpose of additional operational assistance, component and system adjustment and repairs. Government personnel will observe

Contractor's operational procedures. The Contractor's representatives shall be prepared to answer pertinent questions from the Government, about the plant operation.

3.2.6 Manufacturer's Field Services

3.2.6.1 Erection/Installation Supervisors and Service Engineers

a. Boiler: Furnish the services of a competent supervisor who is in the direct employ of the boiler manufacturer. This supervisor shall remain on the construction site the full 8 hours per day, 5 days per week, or the same hours, that the boiler installation takes place. This supervisor shall be responsible for the complete steam generating unit, including the steam generator, forced draft fan, burner and other related work, such as refractory, or insulation regardless of whether the forced draft fan, burner or the other related items of work are furnished by manufacturers other than the boiler manufacturer.

b. Forced Draft Fans: The Contractor shall furnish a company service engineer to advise on the erection or installation of fans and related equipment.

c. Service Engineers: Services of the manufacturing companies' service engineers and the system suppliers' service engineers shall be provided by the Contractor to advise during erection and installation of other systems and equipment such as air compressors, air dryers, boiler feedwater pumps, fuel oil pumps, condensate pumps, water treatment equipment, chemical feed pumps, deaerating feedwater heater and stacks.

3.2.6.2 Boiler and System Representatives

a. Furnish factory trained engineers or technicians who are representatives of the boiler manufacturer and system suppliers to supervise testing of the boilers and auxiliary equipment.

b. Furnish the services of a Boiler Inspector who is qualified and certified as such by the National Board of Boiler and Pressure Vessel Inspectors and who is presently employed full time by a firm, such as Hartford Steam Boiler Inspection and Insurance Company, which has a business of inspecting boilers.

3.2.6.3 Instruction to Government Personnel

In accordance with the provisions of Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, supervisors and service engineers shall provide instruction for the Government's operators in the operation and maintenance of the equipment furnished under this section. The minimum number of hours of instruction provided shall be as follows:

Equipment	Operation Instruction	Maintenance Instruction
Boiler and auxiliaries	40 hours	16 hours
Forced draft fans	16 hours	16 hours

Equipment	Operation Instruction	Maintenance Instruction
Fuel handling system	16 hours	32 hours
Air compressors and dryers	8 hours	16 hours
Boiler feedwater pumps	8 hours	8 hours
Miscellaneous equipment	16 hours	16 hours

-- End of Section --

SECTION 23 65 00

COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS
11/16, 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 SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 64	(2020) Methods of Testing Remote Mechanical-Draft Evaporative Refrigerant Condensers

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1	(2021) 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 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 D520	(2000; R 2011) Zinc Dust Pigment
ASTM D1784	(2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials

COOLING TECHNOLOGY INSTITUTE (CTI)

CTI ATC-105	(2000) Acceptance Test Code

CTI Std-137	(2017) Fiberglass Pultruded Structural Products for Use in Cooling Towers
CTI Std-201	(2011) Standard for the Certification of Water Cooling Tower Thermal Performance

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
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 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

Cooling Towers; G[, [_____]]

Posted Instructions; G[, [_____]]

Demonstrations; G[, [_____]]

Verification of Dimensions; G[, [_____]]

Remote Evaporatively-Cooled Condensers

SD-06 Test Reports

[Packaged Cooling Tower - Installation Instructions; G[, [_____]]

][Field-Erected Cooling Tower - Installation Instructions; G[, [_____]]

][Packaged Cooling Tower - Field Acceptance Test Plan; G[, [_____]]

][Field-Erected Cooling Tower - Field Acceptance Test Plan; G[, [_____]]

][Packaged Cooling Tower - Field Acceptance Test Report; G[, [_____]]

][Field-Erected Cooling Tower - Field Acceptance Test Report; G[, [_____]]

] SD-07 Certificates

Service Organization

Cooling Tower

Remote Evaporatively-Cooled Condensers

SD-08 Manufacturer's Instructions

[Packaged Cooling Tower - Installation Instructions

][Field-Erected Cooling Tower - Installation Instructions

] Remote Evaporatively-Cooled Condensers

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

Remote Evaporatively-Cooled Condensers

1.3 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.[[Catwalk,] [ladder,] [and guardrail] must be provided where indicated and in accordance with[Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS][Section 05 51 33 METAL LADDERS][Section 05 52 00 METAL RAILINGS][Section 05 51 00 METAL STAIRS].]

1.4 DELIVERY, STORAGE, AND HANDLING

Stored items must be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings must be capped to keep out dirt and other foreign matter.

1.5 PROJECT/SITE CONDITIONS

1.5.1 Verification of Dimensions

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

1.5.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor must carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and must arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment must be standard commercial catalogued 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 in field service for two years prior to bid opening. The two year use must include applications of equipment and materials under similar circumstances and of similar size. 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 tests, can be shown. This 6000 hour record must not include any manufacturer's prototype or factory testing. Records of satisfactory field use must be completed by a product that had been, and presently is, sold, or offered for sale on a commercial market through the following copyrighted means: advertisements, manufacturer's catalogs, or brochures. Products must be supported by a service organization. System components must be environmentally suitable for the indicated locations.

2.2 MANUFACTURER'S STANDARD NAMEPLATES

Major equipment including cooling towers, cooling tower gear drive assemblies, 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. Plates must be fixed in prominent locations.

2.3 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.

b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.

c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.

d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors must be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. [Motor bearings must be fitted with grease supply fittings and grease relief to outside of the enclosure.] Motor enclosure type may be either TEAO or TEFC.

e. [Where two-speed motors are indicated, variable-speed controllers may be provided to accomplish the same function.][Use adjustable frequency drives for all variable-speed motor applications.] Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

f. Provide inverter duty premium efficiency motors for use with variable frequency drives.

2.4 COOLING TOWER MATERIALS

2.4.1 Fiberglass Reinforced Plastic (FRP)

FRP components must be inert, corrosion resistant, and fire-retardant with a thickness of 12 ounces per square foot. FRP components must contain an ultraviolet (UV) ray inhibitor as per CTI Std-137, Grade 1 or 3. Components manufactured of polystyrene will not be permitted.

2.4.2 Zinc-Coated Steel

Components fabricated of zinc-coated steel must be not lighter than 16 gauge 0.0635 inch steel, protected against corrosion by a zinc coating. The zinc coating must conform to ASTM A653/A653M, as applicable and have an extra heavy coating of not less than 2.35 ounces per square foot of surface. Galvanized surfaces damaged due to welding must be coated with zinc rich coating conforming to ASTM D520, Type 1.

2.4.3 Polyvinyl Chloride (PVC) Formed Sheets

ASTM D1784, Type I, Grade 1 with a flame spread rating in accordance with ASTM E84, Class A.

2.4.4 High Density Polyethylene (HDPE)

Components manufactured from HDPE must be seamless with a minimum thickness of 0.375 inch. The material must have the appropriate inhibitors to protect the component from any UV degradation. Tanks and cooling tower shells must be seamlessly molded to minimize water loss/consumption.

2.4.5 Stainless Steel Sheets

Type [304][316].

2.4.6 Concrete

Concrete must conform to Section 03 30 00 CAST-IN-PLACE CONCRETE. Exposed concrete must be rub-finished for smooth and uniform surfaces free of form marks and defects. Honeycomb concrete will not be permitted.

2.4.7 Hardware

Bolts must be cadmium-plated, zinc-coated steel, or Type 304 stainless steel. Each bolt must be provided with neoprene and cadmium-plated steel washers under the heads. Nails must be silicon bronze, commercial bronze, or stainless steel. Hardware must meet the salt-spray fog test as defined by ASTM B117. Angle brackets and similar parts must be zinc-coated steel. Zinc coatings must conform to ASTM A153/A153M and [ASTM A123/A123M], as applicable, and must have an extra heavy coating of not less than 2.35 ounces per square foot of surface. Nails must be silicon bronze, commercial bronze, or stainless steel. Subject hardware to a salt-spray fog test in accordance with ASTM B117. No signs of corrosion must be evident after 1,000 hours continuous exposure to a 5 percent salt spray.

2.5 REMOTE EVAPORATIVELY-COOLED CONDENSERS

Condenser must be rated and tested in accordance with the requirements of ASHRAE 64. Condenser must include fans, water pump with suction strainer, electric motor and drive equipment, water eliminators if required, condensing coil, liquid receiver if required, water pan or sump, spray nozzles or water-distribution pan, water strainer, water make-up assembly, bleeder with flow valve of the needle valve type sized for the flow required or a fixed orifice, enclosure with suitable access doors, and air-inlet and outlet openings. No water may carry over into the unit discharge outlet.

2.5.1 Condenser Casing

Enclosure must be constructed of not lighter than 18 gauge 0.516 inch[hot-dip galvanized steel][304 stainless steel], reinforced and braced. Access doors or panels suitably sized and located must be provided for access to water nozzles or distribution pan, coils, and valves for cleaning, repair, or removal of the item. Access doors or panels must be gasketed with synthetic rubber, or equivalent gasket material, and locked in place with thumb screws or catches. One-half inch mesh hot-dip galvanized steel or copper air-inlet screens must be provided on each air inlet.

2.5.2 Fans

Fans must be centrifugal or propeller type as best suited for the application. Fans must be direct or V-belt driven. Belt drives must be completely enclosed within the unit casing or equipped with a guard. When belt drive is provided, an adjustable sheave to furnish not less than 20 percent fan-speed adjustment must be provided. Sheave set must be matched and selected to provide the capacity indicated at the approximate midpoint of the adjustment. Fans must be statically and dynamically balanced. Fan motor must be totally enclosed type or open drip-proof and located within an enclosure to be fully protected from the weather.

2.5.3 Water Section

Water eliminators must be constructed of nonferrous metal, of an approved nonmetallic material, or of not lighter than 24 gauge 0.0276 inch steel, hot-dip galvanized after fabrication. Spray nozzles must be brass non-clogging type designed to permit easy disassembly, and must be arranged for easy access. Water pump must be bronze-fitted centrifugal or turbine type, and may be mounted as an integral part of the evaporative condenser or remotely on a separate mounting pad. Pump suction must be fully submerged and provided with screened inlet. Water pan or sump must be constructed of not lighter than 14 gauge 0.0785 inch steel, hot-dip galvanized after fabrication, or molded acid-resistant glass-fiber-reinforced polyester. Water distribution pan must be constructed of not lighter than 16 gauge 0.0635 inch steel, hot-dip galvanized after fabrication. Joints must be watertight. Water pan or sump must be provided with drain, overflow, and make-up water connection with stop valve and float valve. A bleed line with a flow valve of the needle type sized for the flow required or fixed orifice must be provided in the pump discharge line and must be extended to the nearest drain for continuous discharge.

2.6 FABRICATION

Equipment and component items, must have been proven to withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Equipment located in a sea coast environment must withstand 3,000 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117. 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 SUPPLEMENTAL COMPONENTS/SERVICES

2.7.1 Condenser Water Piping and Accessories

Condenser water piping and accessories must be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.

2.7.2 Cooling Tower Water Treatment Systems

Cooling tower water treatment systems must be provided and installed in accordance with Section 23 64 26 CHILLED, CHILLED-HOT AND CONDENSER WATER PIPING SYSTEMS.

2.7.3 Temperature Controls

Cooling towers must be fully coordinated with and integrated [into the temperature control system specified in [Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] [or] [Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS]] [into the existing air-conditioning system].

PART 3 EXECUTION

3.1 DEMONSTRATIONS

Contractor must conduct a training course for the operating staff as designated by the Contracting Officer. The training period must consist of a total [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. The training course must cover all of the items contained in the approved Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

Provide a schedule, at least [2] [_____] weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

3.2 INSTALLATION

Installation of cooling tower systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing must be in accordance with NFPA 70, and in compliance with the manufacturer's written installation instructions, including the following:

[(1) Packaged cooling tower - installation instructions

][(2) Field-erected cooling tower - installation instructions

]

3.2.1 Installation Instructions

Provide manufacturer's standard catalog data, at least [5] [_____] weeks prior to the purchase or installation of a particular component, highlighted to show features such as materials of construction, dimensions, options, performance and efficiency. Data must include manufacturer's recommended installation instructions and procedures. Data must be adequate to demonstrate compliance with contract requirements.

3.2.2 Vibration Isolation

If vibration isolation is specified for a unit, vibration isolator literature must be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

3.2.3 Posted Instructions

Provide posted instructions, 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.

3.2.4 Verification of Dimensions

Provide a letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

3.2.5 Demonstrations

Provide a schedule, at least [2] [_____] weeks prior to the date of the proposed training course, which identifies the date, time, and location for the training.

3.2.6 Certificates

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, proof of such compliance must be provided. The label or listing of the specified agency must be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above must be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

3.2.7 Operation and Maintenance Manuals

Provide [Six] [_____] complete copies of an operation manual in bound 8 1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least [4] [_____] weeks prior to the first training course. The booklets must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. [Six] [_____] complete copies of maintenance manual in bound 8 1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.2.8 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

[3.3 RELATED FIELD TESTING

3.3.1 Test Plans

a. Manufacturer's Test Plans: Within [120] [_____] calendar days after contract award, submit the following plans:

[(1) Packaged cooling tower - field acceptance test plan

][(2) Field-erected cooling tower - field acceptance test plan

] Field acceptance test plans must developed by the cooling tower manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance test plans must be the plan and procedures followed for the field acceptance tests of the cooling towers and subsequent test reporting.

b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls for the equipment provided under [Section 23 09 53.00 20, SPACE TEMPERATURE CONTROL SYSTEMS] [Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC][Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] [or] [Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS].

c. Prerequisite testing: Cooling towers for which performance testing is dependent upon the completion of the work covered by Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC must have that work completed as a prerequisite to testing work under this section. Indicate in each field acceptance test plan when such prerequisite work is required.

d. Test procedure: Indicate in each field acceptance test plan each equipment manufacturers published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer.

   Each test plan must include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures must be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

   Controllers must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan must list performance variables that are required to be measured or tested as part of the field test.

   Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Tower manufacturer must furnish with each test procedure a description of acceptable results that have been verified.

   Tower manufacturer must identify the acceptable limits or tolerances within which each tested performance variable must acceptably operate.

f. Job specific: Each test plan must be job specific and must address the particular cooling towers and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized components: Each test plan must include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

]3.4 TESTING

a. Each cooling tower system must be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:

[(1) Packaged cooling tower - field acceptance test report

][(2) Field-erected cooling tower - field acceptance test report

] b. Manufacturer's recommended testing: Conduct the manufacturer's recommend field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.

c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed must result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.

d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment must be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative must review, approve, and sign the report of the manufacturer's recommended test. Signatures must be accompanied by the person's name typed.

f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

g. Towers with thermal performance not CTI certified to CTI Std-201 must have their thermal performance verified by field testing that meets the requirements of CTI ATC-105

-- End of Section --

SECTION 23 74 33.00 40

PACKAGED, OUTDOOR, HEATING AND COOLING MAKEUP AIR-CONDITIONERS
05/17

PART 1 GENERAL

[Section 23 30 00 HVAC AIR DISTRIBUTIONapplies 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.
]

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 340/360 I-P	(2015) Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
AHRI 450	(2007) Water-Cooled Refrigerant Condensers, Remote Type
ANSI/AHRI 210/240	(2008; Add 1 2011; Add 2 2012) Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

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

ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

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

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

Packaged Unit; G[, [____]]

Compressor; G[, [____]]

Cooling Coil; G[, [____]]

Controls; G[, [____]]

Casing; G[, [____]]

Condenser; G[, [____]]

Installation Drawings; G[, [____]]

SD-03 Product Data

Equipment and Performance Data; G[, [____]]

Air-Conditioning Systems; G[, [____]]

Compressor; G[, [____]]

Cooling Coil; G[, [____]]

Fans; G[, [____]]

Controls; G[, [____]]

Casing; G[, [____]]

Filters; G[, [____]]

Condenser; G[, [____]]

Vibration Isolation; G[, [____]]

SD-07 Certificates

List of Product Installations

Manufacturer's Warranty; G[, [____]]

Coil Coating Warranty; G[, [____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

1.3 QUALITY CONTROL

Submit a list of product installations of packaged air-conditioning units showing a minimum of five installed units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. Provide a list that includes the purchaser, address of installation, service organization, and date of installation.

1.4 WARRANTY

Submit the manufacturer's warranty for the unit.

[Submit the coil coating warranty.

]PART 2 PRODUCTS

Submit equipment and performance data for packaged air-conditioning units, consisting of use life, power ratings, capacity ranges, face area classifications, and rotational velocities.

[2.1 FABRICATION

2.1.1 Coil Coating

Apply a [polyurethane][epoxy][silane][_____] coating to the coils for corrosion protection. Ensure that the coating thickness is [1][2][_____] mils. Ensure that the coating protects against ultraviolet radiation.

Ensure that the coating meets the requirements of ASTM B117.

]2.2 EQUIPMENT

2.2.1 Remote-Split, Packaged, Self-Contained (RSAC)

Provide an air-conditioner that consists of matched assemblies. Provide a packaged unit complete with a frame and enclosure, interconnecting piping and wiring, necessary controls and safety devices, and an operating charge of oil. Ensure that the unit is ready for full-capacity operation after removal of the shipping protection, connection to the remote compressor/condenser or condenser, charging, and connection to utilities. Completely charge the system in the field. Have units shipped with a refrigerant holding-charge.

[Provide an AHRI Classification RCU-A-CB, ANSI/AHRI 210/240 evaporator/blower unit and a remote air-cooled condenser and compressor, with capacities ranging from 20,000 to 120,000 Btu per hour.

][Provide an AHRI Classification RCU-W-CB, ANSI/AHRI 210/240 AHRI 340/360 I-P evaporator/blower unit and a remote water-cooled condenser and compressor, with capacities ranging from 35,000 to 180,000 Btu per hour.

][Provide an AHRI Classification RC-A, AHRI 340/360 I-P evaporator/blower, a compressor unit, and a remote air-cooled condenser unit, with capacities ranging from 31,000 to 240,000 Btu per hour.

][Provide a floor-mounted console evaporator/blower unit with plenum.

][Provide a floor-mounted evaporator/blower unit with connections for ductwork.

]2.2.1.1 Compressor

Provide one,750-revolution-per-minute (rpm) [semihermetic] [hermetic] compressor with an internal crankcase sight glass and a protected motor. A 3,500 rpm compressor is acceptable in units of 20 tons and less. Provide a unit that is capable of continuous operation under AHRI "Maximum Operating Conditions" and "Load Temperature Operations."

Provide a compressor with capacity reduction devices to automatically reduce capacity by at least 66 percent in two equal steps. Ensure that the compressors start with the capacity reduction devices in the unloaded position.

If standard with the manufacturer, provide two equal-sized compressors that operate in independent refrigerant circuits. Actuate the compressors by capacity control relays interlocked with a time sequence switch that starts unloaded or with gas pressures equalized across the compressor.

[Provide compressors with a high/low pressure safety cutoff. Equip each compressor with a reversible oil pump for lubrication, an oil-pressure-failure switch and gage, crankcase heaters, suction and discharge flanged valves, head pressure, and suction pressure gages with shutoff valves. Select a system that limits the compressor power input to 1.2 kilowatts per ton of refrigeration at standard AHRI conditions. Mount the compressor on spring vibration isolators.

]2.2.1.2 Cooling Coil

[Provide separate cooling-coil circuits for each compressor in the unit.] [Furnish pilot expansion valves.] For compressors with capacity reduction, provide the associated coil with a separate circuit, a liquid solenoid valve, and an expansion device for each two stages of capacity reduction. For each compressor of a dual-compressor unit, provide the associated coil with a protected, insulated drain pan. Provide seamless copper tubes, with [copper] [aluminum] fins mechanically bonded to the tubes at maximum intervals of 12 fins per inch. Provide [vertical] [angled] coils equipped with liquid-feed distributors to ensure equal feed to each refrigerant circuit. Ensure that coils are tested at 400 pounds per square inch (psi) at the factory and are completely dehydrated. Limit air flow to 500 feet per minute (fpm). Provide a design that precludes carryover of water.

2.2.1.3 Fans

Provide centrifugal fans with [_____] blades in each fan section. Provide fans that are mounted [on a common shaft] [on two shafts if each shaft is driven by double belts and a single double-end motor]. Provide antifriction bearings, manufactured from vacuum-processed alloys. Provide bearings that have an [ABMA 9] [ABMA 11], L-10 life expectancy rating of 40,000 hours under service load conditions. Statically and dynamically balance fans. Provide fans that are V-belt-driven by a constant-speed motor powerful enough that the brake power rating does not exceed the nominal motor rating. Ensure that an adjustable sheave provides fan speed adjustment of at least 20 percent. Size the sheave to ensure that the fan speed at the approximate midpoint of the sheave adjustment produces the specified air quantity.

2.2.1.4 Casing

Construct the outer casing of insulated 18-gage metal panels adequately reinforced with [angles] [a formed metal frame] and provided with easily removable panels located for access to all parts of the equipment. Round the corners to provide a neat appearance. Provide metal surfaces that are Bonderite-treated, are phosphatized, and have a baked enamel finish. Integrate the return air inlet grilles located on the front face of the unit as part of the unit casing. Ensure that the casing and insulation are designed to limit noise and vibration within acceptable levels.

Ensure that outlet grilles permit adjustable directional flow in both horizontal and vertical planes.

2.2.1.5 Controls

Mount a switch with fan/off/cool positions, [in the unit] [with the remote thermostat]. Remotely mount the thermostat where shown on the drawing. Mount other controls, including motor starter or contactors and safety controls, inside the enclosure. Provide magnetic across-the-line motor starters. Provide general-purpose enclosures for motor starters. Where two or more compressors are used, provide time-delay relays for sequence starting.

2.2.1.6 Filters

Locate filters in the filter return air fixture [in the rear of the casing] [on the inside of the front casing]. Select filters that limit air velocities to 500 fpm. Ensure that filters have an average efficiency of at least 20 percent based on ASHRAE 52.2.

[Provide a [_____] inch thick panel, with permanent, cleanable, impingement, all-metal construction filters. Provide a galvanized steel frame not less than 20-gage with mitered, reinforced corners. Provide a galvanized, corrugated-metal. filter medium. Use aluminum filters if the medium is the herringbone type. Do not use expanded aluminum metal.

] [Provide a [_____] inch thick panel, with glass-fiber filters, housed in a fiberboard casing between metal grids. Provide a stiffener bar for additional support. Provide a filtering medium that is formed of continuous interlaced glass filaments. Provide a fiber coated with a nonflammable fluid gel that forms an adhesive film to hold collected dust. Provide a fluid gel that does not drip at temperatures below 150 degrees F.]

2.2.1.7 Air-Cooled Condenser

Provide a condenser enclosure constructed of [sheet steel not less than 18-gage] [aluminum adequately reinforced and braced], with access panels and with a rust-inhibitive baked enamel or galvanized finish.

Provide an air-cooled condenser with vertical discharge, in a weather-protected casing, that is suitable for installation remote from the air-conditioning unit. Provide air inlet and discharge grilles with galvanized wire-mesh birdscreens.

Provide an extended-surface condenser coil, constructed with [copper] [aluminum] tubes with [_____] [copper] [aluminum] fins per inch, mechanically bonded to the coil. Ensure that the entire refrigerant circuit is dehydrated and sealed at the factory. Provide a coil that is designed for the refrigerant used in the air conditioner. Ensure that the condensers are designed for the working pressure of the system.

Provide [centrifugal] [propeller] fans that are [belt-driven] [directly connected to low-speed (1,200 rpm maximum) electric motors]. For belt-driven fans, provide a guard and adjustable sheaves that permit the fan speed to be adjusted at least 20 percent. Select sheaves that provide the capacity indicated at the approximate midpoint of the adjustment.

Provide an electric motor that is totally enclosed. Provide a magnetic across-the-line-type motor starter within a weather-resistant housing.

[Control the condensing pressure by an electronic solid-state control system that modulates the speed of the condenser's fan motor from 0 to 100 percent by fan cycling.

][Control the condensing pressure by an electric thermostat that cycles the condenser's fan motor.

][Control the condensing pressure by a head pressure switch that cycles the condenser's fan motor.

][Control the condensing pressure by [fan cycling] [modulation of dampers located in the airstream].

][Control the condensing pressure by [a condenser-coil flooding system] [modulation of dampers located in the airstream].

]2.2.1.8 Water-Cooled Condenser

Provide water-cooled condensers that include all necessary openings, water and refrigerant connections, purge valves, relief devices, refrigerant valves, a liquid-level indicating device, and support provisions.

Ensure that the condenser conforms to AHRI 450, ASME BPVC SEC VIII D1 [and is so stamped].

[When a condenser is being used as a combination receiver, provide a pump-down capacity equal to 80 percent of the available condenser volume.

][Select a unit for water velocities not in excess of 7 feet per second and a fouling factor of 0.0010.

][Provide a [copper][brass] condensing surface between the halogen refrigerant and the cooling water.

][Provide a copper condensing surface between the halogen refrigerant and the cooling water; provide nonferrous tube sheets.

][Provide condensers that are [shell and coil] [shell and U-tube] [shell and tube] construction, with a refrigeration capacity of 10 tons and under. Provide [brazed] [silver] soldered coil joints.

][Provide a condenser that is [shell and coil] [shell and U-tube] [shell and tube] construction.

][Provide condensers that are shell and tube, cleanable construction, with tubes that are [rolled] [brazed] into tube sheet, with a refrigeration capacity of at least 10 tons.

][Provide condensers that are shell and tube, cleanable construction, and with tubes that are [rolled] [brazed] into tube sheet.

] Provide intermediate tube supports so that the distance between the straight-tube supports does not exceed [3] [_____] feet for copper tubes and [4] [_____] feet for brass tubes. Fit supports to the tubes in a manner that precludes corrosion, vibration, and abrasion.

2.3 COMPONENTS

2.3.1 Vibration Isolators

Ensure that vibration isolation provisions conform to the requirements in Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment in accordance with the manufacturer's recommendations.

Submit installation drawings for packaged air-conditioning units in accordance with referenced standards in this section.

3.2 FIELD QUALITY CONTROL

3.2.1 Quality Control

Test and rate components of the air-conditioning systems as a system in accordance with ANSI/AHRI 210/240.

3.3 CLOSEOUT ACTIVITIES

Submit [6] [_____] copies of the operation and maintenance manuals at least 30 calendar days before testing the packaged air-conditioning units. Update and resubmit data for final approval at least 30 calendar days before contract completion.

-- End of Section --

SECTION 23 81 47

WATER-LOOP AND GROUND-LOOP HEAT PUMP SYSTEMS
08/08, CHG 4: 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 52.1	(1992; Interpretation 1 2007) Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
ASHRAE 62.1	(2010) Ventilation for Acceptable Indoor Air Quality
ASHRAE FUN IP	(2021) Fundamentals Handbook, I-P Edition
ASHRAE Item 90376	(1997) Ground-Source Heat Pumps, Design of Geothermal Systems for Commercial and Institutional Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.5	(2020) Refrigeration Piping and Heat Transfer Components
ASME B31.9	(2020) Building Services Piping

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A126	(2004; R 2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B62	(2017) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM B265	(2020a) Standard Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate
ASTM B333	(2003; R 2018) Standard Specification for Nickel-Molybdenum Alloy Plate, Sheet, and Strip
ASTM B424	(2019; E 2020) Standard Specification for Ni-Fe-Cr-Mo-Cu Alloy (UNS N08825 and UNS N08221, and UNS N06845) Plate, Sheet, and Strip
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D1177	(2017) Standard Test Method for Freezing Point of Aqueous Engine Coolants
ASTM D2657	(2007; R 2015) Heat Fusion Joining Polyolefin Pipe and Fittings
ASTM D3892	(2015) Standard Practice for Packaging/Packing of Plastics
ASTM F402	(2005; R 2012) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F1105	(2009; R 2014) Preparing Aircraft Cleaning Compounds, Liquid-Type, Temperature-Sensitive, or Solvent-Based, for Storage Stability Testing
ASTM F1290	(2019) Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings

INTERNATIONAL GROUND SOURCE HEAT PUMP ASSOCIATION (IGSHPA)

IGSHPA 21010	(1991) Grouting Procedures for Ground-Source Heat Pump Systems
IGSHPA 21015	(2000) Grouting for Vertical GHP Systems
IGSHPA 21020	(1988) Closed-Loop/Ground-Source Heat Pump System/Installation Guide
IGSHPA 21035	(2017) Design and Installation Standards
IGSHPA 21060	(1989) Soil and Rock Classification Field Manual

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 13256-1	(2021) Water-Source Heat Pumps - Testing and Rating for Performance - Part 1: Water-to-Air and Brine-to-Air Heat Pumps
ISO 13256-2	(2021) Water-Source Heat Pumps - Testing

	and Rating for Performance - Part 2: Water-to-Water and Brine-to-Water Heat Pumps

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

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2016) Motors and Generators - Revision 1: 2018; Includes 2021 Updates to Parts 0, 1, 7, 12, 30, and 31
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 704	(2022) Standard System for the Identification of the Hazards of Materials for Emergency Response

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 135	(1995; Annual Suppl 2010) Life Cycle Costing Manual for the Federal Energy Management Program

NSF INTERNATIONAL (NSF)

NSF/ANSI 60	(2020) Drinking Water Treatment Chemicals - Health Effects

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

SMACNA 1966	(2020) HVAC Duct Construction Standards Metal and Flexible, 4th Edition

U.S. DEPARTMENT OF ENERGY (DOE)

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

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

29 CFR 1910	Occupational Safety and Health Standards

40 CFR 82	Protection of Stratospheric Ozone

UNDERWRITERS LABORATORIES (UL)

UL 10B	(2008; Reprint May 2020) Fire Tests of Door Assemblies
UL 94	(2013; Reprint Mar 2022) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 SYSTEM DESCRIPTION

[Design and] Provide [new] [and modify existing] [ground-loop][water-loop] heat pump systems complete and ready for operation. Systems include heat pumps, system equipment, piping, pumps, electrical equipment, controls, [wells,] and [ground heat exchanger][condenser]. [Design and] Installation of [ground-loop][water-loop] heat pump systems including equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with ASME B31.9, ASME B31.5, ASHRAE FUN IP, IGSHPA 21010, IGSHPA 21015, IGSHPA 21020, IGSHPA 21035, IGSHPA 21060, NFPA 70, ASHRAE Item 90376, [ISO 13256-2][ISO 13256-1]and [ISO 13256-2] as supplemented and modified by this section. [Provide water-loop heat pump condenser piping under Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.] [Provide ground coupled condenser loop piping by the requirements of this section.]

1.3 GROUND-LOOP HEAT PUMP SYSTEM DESIGN

[Design ground-loop heat pump systems in accordance with the required and advisory provisions of NFPA 70, ASHRAE Item 90376, IGSHPA 21020 and IGSHPA 21035 except as modified herein. Provide calculations. Each system shall include materials, accessories, and equipment inside and outside the building to provide each system complete and ready for use. Design and provide each system to give full consideration to optimum well spacing and location, piping, electrical equipment, pumps, ground heat exchanger, and other construction and equipment in accordance with detailed working drawings to be submitted for approval. Locate ground-loop wells in a consistent pattern that would give the proper spacing between wells and the optimum performance. Provide well and piping system layout drawings.

]1.3.1 Calculations

1.3.1.1 Methodology

[Calculations shall be submitted as part of the design documentation. Provide calculations to determine the system design of the ground-loop heat pump system. Provide calculations for the HVAC loads and load profiles. Calculations shall include computer aided design programs that include the effects of thermal interaction between adjacent boreholes. Calculations shall include submission of the software name and version, and design parameters. Design parameters shall include but not limited to soil conditions, ground water level, soil heat transfer coefficients, heat transfer coefficient for grout materials, etc. Heat transfer and other calculations shall be prepared by the System Designer using computer software specifically intended for ground-loop heat pump systems. The design shall be based on calculations that will provide the most life cycle cost effective ground-loop heat pump system using an expected life of 25 years and shall be sized based upon the loads shown on the drawings. Life cycle cost analysis shall be performed as required by the NIST HB 135 using the current discount rates, factors, and energy cost rates.

]1.3.1.2 Design

[The diameter, length, flow, velocity, [friction loss], [number and type fittings], [total friction loss], and the [maximum expected expansion and contraction] of the pipe shall be indicated in the program output. An accompanying schematic drawing showing reference points used in the calculations shall be included with the calculations. The maximum entering water temperature to the heat pumps under the peak air conditioning load design condition should not exceed [90 degrees F][95 degrees F]. The minimum entering water temperature to the heat pumps under the peak heating load design condition should be no lower than 30 degrees F.][The entering water temperature to the heat pumps under peak heating load design shall be [45 degrees F][50 degrees F] for ground-loop heat pump systems with limited heating requirements.][Adjacent wells/system will not be spaced closer than 15 feet.]

1.3.2 Detail Drawings

[Prepare and provide 24 by 36 inch detail working drawings showing the ground-loop heat pump system, layout, assembly and installation details, electrical connection diagrams and wiring diagrams, installation and details of pumps, distribution manifolds, heat pumps, piping, and well field layout. Show well grouting details in accordance to IGSHPA 21010 and IGSHPA 21015. Show data essential for proper installation of each system. Show details, plan view, elevations, and sections of the systems supply and piping. Drawings shall be scaled, show the North arrow, show the graphic scales, equipment schedules, legends, abbreviation definitions, notes, symbol lists, and any key plans. Equipment schedules shall show the pump motor horsepower and power consumption. Show piping schematic of systems supply, devices, valves, pipe, and fittings. Show the well field arrangement. Show point to point Electrical Wiring Diagrams. The design and drawings shall show the piping lay out, piping sizes to transfer the heat required, including any boring, trenching, installation of piping, and connection to the piping in applicable HVAC System. Drawings shall include any information required to demonstrate that the system has been coordinated and will properly function within the HVAC system and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance and the test point locations where the ground-loop heat pump system will be monitored during testing. Submit drawings signed by a registered professional engineer.

]1.3.3 System Diagrams

[After completion, but before final acceptance, submit System diagrams that show the layout of equipment, piping, and circulation pumps, 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 shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed by the Contracting Officer. System diagrams may be submitted with operation and maintenance manuals.

]1.3.4 Soil Thermal Conductivity Testing

[For projects where the total heating design load for the ground-loop heat pump system exceeds 480,000 btu/hr or the total cooling design load exceeds 40 tons, insitu thermal properties testing will be conducted to determine soil thermal properties prior to the design. These tests must be conducted in accordance with the procedures outlined in ASHRAE Item 90376 and Part 3.0 herein.
]

1.3.5 System Designer

[The ground-loop heat pump system(s) shall be designed by an individual who is a [registered professional engineer][Certified GeoExchange Designer] and is regularly engaged in the design of the type and capacity of system(s) specified in this project for the immediate three years prior to the submittal of the System Designer's Statement of Qualifications. [Certification as a certified GeoExchange Designer shall be kept up to date and maintained with the Association of Energy Engineers]. The System Designer's Statement of Qualifications shall include design experience in ground-loop heat pump systems, geothermal heat pump design, data identifying the location, ground-loop heat pump system type, and capacity of at least three systems designed by the proposed System Designer during that period. The Contractor shall furnish documentation from the owner of each of these three systems verifying that each system has performed in the manner intended for the 6 months prior to submission of the Statement of Qualifications.

]1.4 GROUND SOURCE HEAT PUMP INSTALLER

[Work specified in this section shall be performed by accredited ground source heat pump (GSHP) installers. The GSHP installer shall be an "Accredited Installer." Accreditation as an Accredited Installer shall be kept up to date and maintained with the International Ground Source Heat Pump Association (IGSHPA). The Accredited Installer shall be engaged in the installation of the type and capacity of the system(s) specified in this project for the immediate three years prior to the submittal of the GSHP installer's Statement of Qualifications. The GSHP installer's Statement of Qualifications shall include a copy of IGSHPA Installer Certification and data identifying the location, GSHP system type, and capacity of at least three systems installed under the guidance of the proposed GSHP Installer during that period. The Contractor shall furnish documentation from the owner of these three GSHP systems verifying that each system has performed in the manner intended for the 6 months prior to submission of the Statement of Qualifications.

]1.5 RELATED REQUIREMENTS

[Requirements for cooling towers are specified in Section 23 65 00COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS.] [Requirements for water heating boilers are specified in Section 23 52 00 HEATING BOILERS.]

[Requirements for cooling towers are specified in Section 23 64 00PACKAGED WATER CHILLERS, ABSORPTION TYPE, 23 64 10WATER CHILLERS, VAPOR COMPRESSION TYPE, and 23 65 00 COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS.]

[Requirements for water heating boilers are specified in Section 23 52 46.00 20 LOW PRESSURE WATER HEATING BOILERS (OVER 800,000 BTU/HR OUTPUT).]

[Requirements for metal duct systems are specified in Section 23 30 00 HVAC AIR DISTRIBUTION.][Requirements for above ground piping are specified in Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.]

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.][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

[Detail Drawings; G[, [_____]]

][Calculations; G[, [_____]]

][Electrical Wiring Diagrams; G[, [_____]]]

[System Diagrams; G[, [_____]]

][Soil Thermal Conductivity Testing; G[, [_____]]

][Well and Piping System Layout Drawings; G[, [_____]]

] SD-03 Product Data

Product data for integral or appurtenant space temperature controls (STC) supplied with the listed equipment shall include shall include point-to-point electrical wiring diagrams for each STC.

[Water-Source Water-to-Air Heat Pumps; G[, [_____]]

[including STC data]

][Energy Star Label for Residential WAHP Product; S

][Water-Source Water-to-Water Heat Pumps; G[, [_____]]

[including STC data]

][Energy Star Label for Residential WWHP Product; S

] Refrigerants

[

][Thermally-Enhanced Bentonite Grout; G[, [_____]]

][High Grade Bentonite Grout; G[, [_____]]

][Cementitious Thermally Enhanced Grout; G[, [_____]]

][Closed Circuit Coolers; G[, [_____]]

][Plate Heat Exchangers; G[, [_____]]

][Heat Tape; G[, [_____]]

][Antifreeze; G[, [_____]]

][Pumps; G[, [_____]]

][Pipe, Fittings, and Piping Components; G[, [_____]]

][Expansion Tanks; G[, [_____]]

][Air Separators; G[, [_____]]

][U-Bend Assemblies; G[, [_____]]
]

For the pipe and piping components submittal, include recommendations for the connection of joints, including the preparation of joints for the electrofusion process.

SD-06 Test Reports

[Water-Source Water-To-Air Heat Pumps - Field Acceptance Test Plan; G[, [_____]]

][Water-Source Water-To-Water Heat Pumps - Field Acceptance Test Plan; G[, [_____]]

][Closed Circuit Coolers - Field Acceptance Test Plan; G[, [_____]]

][Plate Heat Exchangers - Field Acceptance Test Plan; G[, [_____]]

][Water-Source Water-To-Air Heat Pumps - Field Acceptance Test Report; G[, [_____]]

][Water-Source Water-To-Water Heat Pumps - Field Acceptance Test Report; G[, [_____]]

][Closed Circuit Coolers - Field Acceptance Test Report; G[, [_____]]

][Plate Heat Exchangers - Field Acceptance Test Report; G[, [_____]]

] SD-07 Certificates

[Employer's record documents

][ARI/ISO Performance Data For Water Source Heat Pumps; G[, [_____]]

][Qualifications Of Ground Heat Exchanger Fabricators; G[, [_____]]

][Qualifications Of Ground Heat Exchanger Installers; G[, [_____]]

][Qualifications of Ground Source Heat Pump Installer; G[, [_____]]

] A letter not later than 14 days [_____] after the Notice to Proceed, providing the name and Statement of Qualifications of the individual(s) who will serve as Ground Source Heat Pump (GSHP) Installer.

[Hydrostatic Test; G[, [_____]]
]
[System Designer; G[, [_____]]

] A letter no later than [14 days][_____] after the Notice to Proceed providing the name and Statement of Qualifications of the individual who will prepare the Design and Calculations.

[System Designer Design Certification; G[, [_____]]

][Concurrent with submittal of the Detail Drawings, submit certification by the System Designer that the design and calculations conform to all contract requirements, including signed approval of the Test Reports.
]
[Work Coordination and Performance Certificate; G[, [_____]]

][Ground Source Heat Pump Installation Certificate; G[, [_____]]

][Well Driller License; G[, [_____]]

][Pump Installer License; G[, [_____]]

][Well Construction Permit; G[, [_____]]

][Approved Well Permit; G[, [_____]]

][Well Construction Log Record; G[, [_____]]

][Ground Source Heat Pump Installation Certificate; G[, [_____]]

] Ozone Depleting Substances Technician Certification

SD-08 Manufacturer's Instructions

[Water-Source Water-to-Air Heat Pumps - Installation Instructions

][Water-Source Water-to-Water Heat Pumps - Installation Instructions

][Closed Circuit Coolers - Installation Instructions

][Plate Heat Exchangers - Installation Instructions

][Heat Tape - Installation Instructions

][On-Site Training; G[, [_____]]

] SD-10 Operation and Maintenance Data

[Water-Source Water-to-Air Heat Pumps, Data Package 2; ; G[, [_____]]

][Water-Source Water-to-Water Heat Pumps, Data Package 2; ; G[, [_____]]

][Closed Circuit Coolers, Data Package 2; ; G[, [_____]]

][Plate Heat Exchangers, Data Package 2; ; G[, [_____]]

][Heat Tape, Data Package 2; ; G[, [_____]]

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

SD-11 Closeout Submittals

[As-Built Drawings; G[, [_____]]

][Ground Heat Exchanger Piping System As-Built Drawings; G[, [_____]]

] Indoor Air Quality During Construction; S

1.7 QUALITY ASSURANCE

1.7.1 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 shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period.

1.7.2 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.

1.7.3 Service Support

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

1.7.4 Manufacturer's Nameplate

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

1.7.5 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.

1.7.5.1 Definitions

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

1.7.5.2 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, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.7.6 Ground heat exchanger piping system As-Built Drawings

Provide dimensioned as-built drawings of each complete ground heat exchanger piping system, depicting its relationship to other utilities and buildings in its proximity before burying, covering, or concealing. Drawings shall be of a quality equivalent to the contract design drawings. The as-built drawings of the installed ground heat exchanger piping system shall be laminated or stored in a clear plastic envelope and affixed visibly to the heat pump unit or on the wall in the mechanical room if serving a system of multiple heat pumps. As-built drawings shall be submitted with operation and maintenance data. A permanent label shall be affixed to each heat pump unit indicating basic information for that unit. The information shall include: nominal flow rate [_____] gpm, pressure [_____] drop feet, temperature drop/rise [_____] degree F, and capacity [_____] Btu/hr.

1.7.7 System Diagrams

After completion, but before final acceptance, submit System diagrams that show the layout of equipment, piping, and circulation pumps, 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 shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

1.7.8 Plastic Piping Heat Fusion Requirements

All plastic pipe shall be cut, made up, and installed in accordance with the pipe manufacturer's recommendations. Heat joining shall be performed in accordance with ASTM D2657. Electrofusion joining shall be performed in accordance with ASTM F1290. Qualifications for plastic pipe fabricators are given in this section under paragraph QUALIFICATIONS OF GROUND HEAT EXCHANGER FABRICATORS. Heat fusion tests shall be conducted to verify the quality of the joints.

1.7.9 Qualifications of Ground Heat Exchanger Fabricators

The only acceptable method for joining buried pipe systems is by a heat fusion process. Submit documentation substantiating the following qualifications: ground heat exchanger fabricators shall have completed a heat fusion school in which each participant has performed a heat fusion procedure under direct supervision of an approved manufacturing certification program, or a DOT certified heat fusion technician.

1.7.10 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.

1.7.11 Qualifications of Ground Heat Exchanger Installers

Submit documentation substantiating the following qualifications: installers shall have completed an approved manufacturer's certification program and shall have successfully completed at least two projects with ground heat exchanger work similar in size and complexity to that required for this project within the last 4 years. In documentation submit licensing requirements as regulated by local and state regulations for well drillers and pump installers. Submit for each well driller, the Well Driller license. For each pump installer, submit the Pump Installer License. Certification and licenses for each well driller and pump installer shall be in the state where the work occurs. All required certification and licenses shall be kept current. Out of date licenses and certification will not be accepted. Submit to contracting officer for approval the licenses and certification.

1.8 DELIVERY, STORAGE, AND HANDLING

Materials delivered and placed in storage shall be stored with protection from the weather, excessive humidity variation, excessive temperature variation, dirt, dust and/or other contaminants. Proper protection and care of material before, during and after installation is the Contractor's responsibility. Any material found to be damaged shall be replaced at the Contractor's expense. During installation, piping shall be capped to keep out dirt and other foreign matter. A material Safety Data Sheet (SDS) in conformance with 29 CFR 1910 Section 1200(g) shall accompany each chemical delivered for use in pipe installation. At a minimum, this includes all solvents, solvent cements, glues and other materials that may contain hazardous compounds. Handling shall be in accordance with ASTM F402. Storage facilities shall be classified and marked in accordance with NFPA 704. Materials shall be stored with protection from puncture, dirt, grease, moisture, mechanical abrasions, excessive heat, ultraviolet (UV) radiation damage, or other damage. Pipe and fittings shall be handled and stored in accordance with the manufacturer's recommendation. Plastic pipe shall be packed, packaged and marked in accordance with ASTM D3892. Upon delivery of piping, fitting, components, and equipment to the site, inspect items for damage and verify items meet project requirements.

1.9 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices shall be installed so that proper operation of equipment is not impaired.

1.10 PROJECT/SITE CONDITIONS

1.10.1 Verification of Dimensions

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

1.10.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and shall arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.10.3 Accessibility

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

1.11 COORDINATION OF WORK AND SYSTEM PERFORMANCE

a. Pump supports, piping offsets, fittings, and any other accessories required shall be furnished as required to provide a complete installation and to eliminate interference with other construction.

b. Submit a Work Coordination and Performance Certificate. Concurrent with submittal of the Detail Drawings and the Calculations, submit a Certificate by [both] the [System Designer] [and the] [Ground Source Heat Pump Installer] stating that the drawings and calculations have been coordinated with all related work and the Ground Source Heat Pump System will perform as [specified] [and indicated].

c. Submit a Ground Source heat Pump Installation Certificate. Concurrent with submittal of the Test Reports, submit certification by the Ground Source Heat Pump Installer stating that the Ground Source Heat Pump System and related work is installed in accordance with the contract requirements, including signed approval of the test reports.

PART 2 PRODUCTS

2.1 EQUIPMENT

Refrigerants containing chlorofluorocarbons (CFC) are prohibited. Provide refrigerants, or refrigerants with ozone depleting potential (ODP) of 0.0. Provide SDS Sheets for all refrigerants.

2.1.1 Water-Source Water-to-Air Heat Pumps (WAHP)

[Provide water-source water-to-air heat pump units factory assembled, designed, tested, and rated in accordance with ISO 13256-1.] [Provide ground-coupled closed-loop water-to-air heat pump (extended range) units factory assembled, designed, tested, and rated in accordance with ISO 13256-1.] Units shall be ISO 13256-1 certified, or listed in ISO 13256-1 directory. Units shall include fans, refrigerant-to-air heat exchangers, filters, [dampers], compressor, reversing valve, expansion valve, refrigerant-to-water heat exchangers, [desuperheater], [hose kits], bypass for flushing and purging, and controls. A permanent label shall be affixed to each heat pump unit indicating basic information for that unit. The information shall include: nominal flow rate gpm, pressure drop feet, temperature drop/rise degree F, and capacity Btu/hr. [For housing or residential applications, provide heat pump units with factory installed [energy management relay], [factory installed internal heat recovery kit], and a [factory installed ground loop pump kit]]. Provide certificates of ARI/ISO Performance Data For Water Source Heat Pumps.[Provide residential ground-coupled closed-loop water-to-air heat pumps that are Energy Star labeled. Provide proof of Energy Star label for residential WAHP product.]

a. Cabinet: Provide manufacturer's standard [galvanized steel] [stainless steel] cabinet [finished with corrosion resistant epoxy coating or lacquer acrylic]. Provide access panels for inspection and access to internal parts. Insulate cabinet with minimum 1/2 inch multi-density, fiberglass insulation with exposed edges sealed or tucked under flanges to prevent introduction of fibers into the airstream. Female threaded pipe condensate drain connections, supply water connections, and return water connections shall be copper threaded fittings mechanically fastened to the cabinet. Water piping shall be insulated. Construct cabinet with compartments and locate the compressor, reversing valve, and water coil out of the airstream. Insulate the divider between the compressor and fan sections. The control box shall be located within the unit.

b. Fans: Provide centrifugal type, direct drive fans with permanently lubricated motors. [Motors shall be permanent split capacitor (PSC) type with thermal overload protection.] [Motors shall be an Electronically Commutated Motor (ECM) microprocessor controlled DC type motor with internal programming factory set for the specific unit and featuring soft start/stop and a delay off feature for maximum efficiency and quiet operation. There will further be provisions for adjusting the air delivery of the motor and blower by plus or minus 15 percent from rated air flow.]

c. Refrigerant-to-Air Heat Exchanger: Provide coil constructed of rifled copper tubes with plate aluminum fins designed for refrigerant working pressure of 450 psi. Fins shall be mechanically bonded to tubes. The condensate drain pan shall be epoxy coated and insulated. Provide internal traps on vertical units. Provide drain pan with overflow protection. Drain pan shall be [corrosion-resistant plastic][galvanized steel] [stainless steel].

d. Filter Section: Provide [replaceable] [(throwaway)] [one inch] [2 inch] thick UL listed [fiberglass] [permanent washable] type filters with [standard dust-holding capacity] [a mean efficiency of [35] [65] percent when tested in accordance with ASHRAE 52.1]. Mount filters in filter frames and provide access panels or doors for removal and replacement of filters.

e. Compressor: Provide hermetically sealed type compressor, installed on vibration isolators enclosed in an acoustically treated enclosure. Provide high and low pressure switches, low suction temperature cut-out, motor thermal overload protection, 5 minute anti-recycle timer, and start capacitor kit. Provide capability to reset compressor lockout circuit at the remote thermostat and at the disconnect. [Provide units with factory installed sound attenuation package.]

f. Reversing Valve: Provide solenoid activated refrigerant reversing valves energized only during the cooling mode and designed to fail in the heating position.

g. Refrigerant-to-Water Heat Exchangers: Provide two-position automatic valve interlocked to shut off water flow when the compressor is off. Provide refrigerant-to-water heat exchangers of coaxial type (tube-in-tube), with inner [cupronickel] [copper] water tube and outer steel refrigerant tube. The refrigerant side of the heat exchanger shall be tested and rated for 450 psig refrigerant working pressure. The water side of the heat exchanger shall be tested and rated for 400 psig working pressure. A parallel capillary tube/thermal expansion valve assembly shall provide superheat over the entire liquid temperature range. Refrigerant-to-water heat exchangers and refrigerant piping shall be insulated to prevent condensation on the piping containing low temperature water.

[h. Factory-Installed Domestic Hot Water Desuperheater: Provide desuperheater of vented double-wall construction and factory installed within indoor heat pump cabinet. Desuperheater units shall be factory assembled, designed, tested, and rated.

Provide with the desuperheater, factory-installed water pump powered by a sealed magnetic drive motor, water line thermostat, secondary safety thermostat to prevent scalding, internal fuse, internally mounted disconnect switch, outside air thermostat, manual on-off switch, low refrigerant gas temperature limit switch, air bleed port, and refrigerant ports. Units shall be UL listed. Desuperheater units shall be UL listed. Units shall be provided by the [ground source] [water source] closed loop heat pump manufacturer.

Controls: The manual on- off switch shall be a push button type with a cover. An indicating light shall be provided next to the switch to indicate the desuperheater pump energized mode. [Provide an outside air thermostat with sun shield set for 40 degree F. The outside air thermostat de-energizes the desuperheater pump.] Provide in the water return to the desuperheater unit, a high water temperature limit with adjustable settings, which de-energizes the desuperheater pump at 140 degree F Also provide low refrigerant gas temperature limit which de-energizes the desuperheater pump and is set to open at 100 degree F
]

[i. Emergency Heater: Provide UL or ETL listed, electric resistance heater with internal fusing integral with heat pump unit; fan shall run until heater cools. Locate downstream of indoor coil. The emergency heater coil shall be provided as a supplementary electric heater. The heater shall be provided with a rack, control box with hinged cover, safety limits, and relay. Control voltage of the heater shall be compatible with the heat pump. The electric heater shall be provided by the heat pump manufacturer. The control of the electric heater shall be utilized as second stage heating. The first stage heating shall be normal heat pump operations.

]

[j. Hose Kits: Kits shall include two 2 foot long metal (stainless steel) braided hoses with swivel connectors on one end, an manual flow control valve with test ports, two shutoff ball valves with memory stops (one with test port), blow down ball valve, and Y-strainer. Hoses shall be fire rated to meet UL 94. Hoses shall have a maximum working pressure of 300 psi. [For residential or housing applications, provide flexible hose kits using heavy-duty radiator rubber hose kits. Provide a bypass around the heat pump unit condenser coil.]

]

k. Bypass for Purging and Flushing: Provide a bypass around the heat pump unit condenser coil. The bypass includes isolation valves and piping that allows for purging and flushing of the system piping. Provide the necessary flushing pump, hoses, and isolation valves.

l. Hanger Kits: Provide horizontal units with hanger kits consisting of galvanized steel brackets, bolts, washers, and vibration isolators. The hanger kit shall be designed to support the unit from below and suspend from threaded rods.

m. Controls: Controls and safety devices shall be factory wired and mounted within the control box of the unit cabinet.

(1) Provide a microprocessor based controller that communicates with an electronic multi-stage space thermostat. The microprocessor shall control sequencing, high and low pressure switch monitoring, freeze protection, lockout control, night setback, emergency shutdown, short cycle protection, random start, LED mode and fault indicators, fault memory, input and output diagnostics, and a communications port. Provide a factory-installed low voltage terminal block for field control wiring and a low voltage transformer. [Provide communications capability for remote direct digital control (DDC). Use standard communication protocol such as [LonWorks], [BACnet], or other [_____] protocol.] [Provide a hand held, remote service terminal from the heat pump manufacturer capable of interfacing with heat pump unit microprocessor controller to perform diagnostics, data retrieval, and calibration functions. When in the heating mode, where there is a continued drop in room temperature, the controller shall energize the second stage of heating, which would be the emergency heater. Provide night setback. The controller shall raise the night setback temperature gradually. Provide seven day schedule capability.]

[(2) Provide 24 volt electromechanical controls supplied with a low voltage transformer, controls for compressor, reversing valve, and fan motor operation. Controls shall include a random start relay, a night setback relay, a compressor cycling relay for demand load shedding, and a condensate overflow switch. Provide a low voltage terminal block for field control wiring.

] (3) [The ECM interface board shall include a screw type terminal board for a thermostat connection, LED's to indicate thermostat status and air delivery]. [Provide an energy management relay to allow unit control by an external source shall be factory installed.]

n. Space Temperature Controls: Provide electronic multi-stage, auto-changeover, adjustable thermostats with OFF-HEAT-AUTO-COOL-EMERGENCY system switch and AUTO-ON fan switch. Thermostats shall be the programmable type and shall be furnished by the unit manufacturer. [Thermostats shall have the energy star rating.] Provide seven day schedule capability. Provide with battery back-up. The thermostat shall have night setback and shall raise the night setback temperature gradually. When in the heating mode, where there is a continued drop in room temperature, the thermostat shall energize the second stage of heating, which would be the emergency heater. Provide relays, transformers, contractors, and control wiring between thermostats and unit. Thermostats shall read out in degrees C and degrees F.

2.1.2 Water-Source Water-to-Water Heat Pumps (WWHP)

[Provide water-source water-to-water heat pump units factory assembled, designed, tested, and rated in accordance with ISO 13256-2.] [Provide ground-coupled closed-loop water-to-water heat pump (extended range) units factory assembled, designed, tested, and rated in accordance with ISO 13256-2.] Units shall be listed by ETL, or listed in ISO 13256-2. Units shall include compressor, reversing valve, expansion valve, refrigerant-to-water condensing coil, refrigerant-to-water evaporator coil, [desuperheater], [hose kits], [dampers], bypass for flushing and purging, and controls. A permanent label shall be affixed to each heat pump unit indicating basic information for that unit. The information shall include: nominal flow rate gpm, pressure drop feet, temperature drop/rise degree F, and capacity Btu/hr. [For housing or residential applications, provide heat pump units with factory installed [energy management relay], [factory installed internal heat recovery kit], and a [factory installed ground loop pump kit]]. Provide certificates of ARI/ISO Performance Data For Water Source Heat Pumps.[Provide residential water-source water-to-water heat pumps that are Energy Star labeled. Provide proof of Energy Star label for residential WWHP product.]

a. Cabinet: Provide manufacturer's standard [galvanized steel][stainless steel] cabinet [finished with corrosion resistant epoxy coating or lacquer acrylic]. Provide access panels for inspection and access to internal parts. Insulate cabinet with minimum 1/2 inch multi-density, fiberglass insulation. Provide copper or stainless steel female threaded pipe connections for supply water and return water connections; these connections shall be mechanically fastened to the cabinet. Water piping shall be insulated.

b. Compressor: Provide hermetically sealed type compressor, installed on vibration isolators enclosed in an acoustically treated enclosure. Provide high and low pressure switches, low suction temperature cut-out, motor thermal overload protection, 5 minute anti-recycle timer, and start capacitor kit. Provide capability to reset compressor lockout circuit at the remote thermostat and at the disconnect. [Provide units with factory installed sound attenuation package.]

c. Reversing Valve: Provide solenoid activated refrigerant reversing valves energized only during the cooling mode and designed to fail in the heating position.

d. Refrigerant-to-Water Heat Exchangers: Provide refrigerant-to-water heat exchangers of coaxial type (tube-in-tube), with inner [cupronickel][copper] water tube and outer steel refrigerant tube.

The refrigerant side of the heat exchanger shall be tested and rated for 450 psig refrigerant working pressure. The water side of the heat exchanger shall be tested and rated for 400 psig working pressure. A parallel capillary tube/thermal expansion valve assembly shall provide superheat over the entire liquid temperature range. Refrigerant-to-water heat exchangers and refrigerant piping shall be insulated to prevent condensation on the piping containing low temperature water.

[e. Factory-Installed Domestic Hot Water Desuperheater: Provide desuperheater of vented double-wall construction and factory installed within indoor heat pump cabinet. Desuperheater units shall be factory assembled, designed, tested, and rated.

Provide with the desuperheater, factory-installed water pump powered by a sealed magnetic drive motor, water line thermostat, secondary safety thermostat to prevent scalding, internal fuse, internally mounted disconnect switch, outside air thermostat, manual on-off switch, low refrigerant gas temperature limit switch, air bleed port, and refrigerant ports. Units shall be UL listed. Desuperheater units shall be UL listed. Units shall be provided by the [ground source] [water source] closed loop heat pump manufacturer.

Controls: The manual on- off switch shall be a push button type with a cover. An indicating light shall be provided next to the switch to indicate the desuperheater pump energized mode. [Provide an outside air thermostat with sun shield set for 40 degree F. The outside air thermostat de-energizes the desuperheater pump.] Provide in the water return to the desuperheater unit, a high water temperature limit with adjustable settings, which de-energizes the desuperheater pump at 140 degree F. Also provide low refrigerant gas temperature limit which de-energizes the desuperheater pump and is set to open at 100 degree F
]

f. Hose Kits: Kits shall include two 2 foot long metal (stainless steel) braided hoses with swivel connectors on one end, [an flow control valve with test ports,] two shutoff ball valves with memory stops (one with test port), blow down ball valve, and Y-strainer. Hoses shall be fire rated to meet UL 94. Hoses shall have a maximum working pressure of 300 psi. [For residential applications, provide flexible hose kits using heavy-duty radiator rubber hose kits. Provide a bypass around the heat pump unit condenser coil.]

g. Bypass for Purging and Flushing: Provide a bypass around the heat pump unit condenser coil. The bypass includes isolation valves and piping that allows for purging and flushing of the system piping. Provide the necessary flushing pump, hoses, and isolation valves.

h. Hanger Kits: Provide units with hanger kits consisting of galvanized steel brackets, bolts, washers, and vibration isolators. The hanger kit shall be designed to support the unit from below and suspend from threaded rods.

i. Controls: Controls and safety devices shall be factory wired and mounted within the control box of the unit cabinet.

(1) Provide a microprocessor based controller. The microprocessor shall control sequencing, high and low pressure switch monitoring, freeze protection, lockout control, night setback, emergency shutdown, short cycle protection, random start, LED mode and fault

indicators, fault memory, input and output diagnostics, and a communications port. Provide a factory-installed low voltage terminal block for field control wiring and a low voltage transformer. [Provide communications capability for remote direct digital control (DDC). Use standard communication protocol such as [LonWorks], [BACnet], or other [_____] protocol.] [Provide a hand held, remote service terminal from the heat pump manufacturer capable of interfacing with heat pump unit microprocessor controller to perform diagnostics, data retrieval, and calibration functions.]

[(2) Provide 24 volt electromechanical controls supplied with a low voltage transformer, pump relay, controls for compressor, reversing valve coil, and lock out relay. Controls shall include a random start relay, a night setback relay, and a compressor cycling relay for demand load shedding, and a condensate overflow switch. Provide a low voltage terminal block for field control wiring.

] j. Space Temperature Controls: Provide electronic multi-stage, auto-changeover, adjustable thermostats with OFF-HEAT-AUTO-COOL-EMERGENCY system switch and AUTO-ON fan switch. Thermostats shall be furnished by the unit manufacturer. Provide relays, transformers, contractors, and control wiring between thermostats and unit. Thermostats shall read out in degrees C and degrees F.

2.1.3 Closed Circuit Coolers

a. Fan and Casing: Construct the fan section (up to top of intake louvers) of heavy gage stainless steel and construct casing of hot-dip galvanized steel. Standard pan accessories shall include louver access, overflow, drain, Type 304 stainless steel strainers, and brass make-up valve with plastic float.

b. Axial Propeller Fans: Fans shall be heavy duty axial propeller type statically balanced. Construct fans with aluminum alloy blades, and install in a closed fitted cowl with venturi air inlet.

c. Fan Motors: Motors shall be totally enclosed, ball bearing type, and suitable for outdoor service. Motors 1 Hp and greater shall be the premium efficiency type in accordance with NEMA MG 1. Fan motor speed control shall be provided for motors 7.5 hp or larger.

d. Drive: Fan drive shall be multi-groove, solid V-belt type with taper lock sheaves designed for 150 percent of nameplate HP. Fan and motor sheave shall be aluminum alloy construction. Belt adjustment shall be accomplished from exterior of unit.

e. Heat Transfer Coil: The coil shall be steel, encased in steel framework with the entire assembly hot-dip galvanized after fabrication. Arrange tubes in a self-spacing, staggered pattern in the direction of airflow for maximum heat transfer efficiency and minimum pressure drop, without the use of additional spacers between the coil tubes. Design coil with sloping tubes for free drainage of liquid and test to 350 psi air pressure under water.

f. Water Distribution System: The system shall provide a water flow rate of not less than 6 gpm over each square foot of unit face area to ensure proper flooding of the coil. Construct spray header of Schedule 40 polyvinyl chloride (PVC) pipe for corrosion resistance. Spray branches shall be removable for cleaning. Distribute water over the entire coil surface by spray nozzles(15 by 5/16 inch orifice) with internal sludge ring to eliminate clogging. Thread nozzles into spray header to provide easy removal for maintenance.

g. Water Recirculation Pump: The pump shall be close-coupled, centrifugal type with mechanical seal, installed vertically at the factory to allow free drainage at shutdown.

h. Eliminators: Construct eliminators of inert PVC in easily handled sections. The eliminator design shall incorporate three changes in air direction to ensure complete removal of entrained moisture from the discharge airstream. Maximum drift rate shall be less than 0.001 percent of the circulating water rate.

i. Construct Louvers From PVC: Mount louvers in removable frames for maintenance access to the pan. Louvers shall have a minimum of two changes in air direction to prevent splash out and block direct sunlight.

j. Finish: Apply corrosion protection system to the outside of galvanized surfaces. Construct non-stainless metal components of mill hot-dip galvanized steel. Coat component edges and welds with a 95 percent pure zinc-rich compound. Preparation for coating shall include degreasing, cleaning, and a light surface burnishing. The coating shall be suitable for field repair with the same original coating material applied in the same manner.

k. Electric Pan Heater Package: Electric pan heater package consists of electric immersion heaters, heater thermostat, and low water cutout, all installed in pan. Size heaters to maintain plus 40 degrees F pan water temperature with the fans off at design conditions indicated on drawings. Control the heaters with a thermostat, and provide water cutout to prevent heaters from cycling on unless they are completely submerged. Provide heater contactor and wiring under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

[l. Discharge Hood With Positive Closure Dampers: Provide unit with discharge hood, positive closure dampers, and 120-volt actuator for reduction of heat loss during idle periods of winter time operation. Construct the discharge hood and dampers of hot dipped galvanized steel. Equip hoods with access panels to facilitate maintenance on the eliminators and water distribution system. Factory assemble the dampers, damper actuator, and linkage.]

2.1.4 Plate Heat Exchangers

Plates, frames, and gaskets shall be designed for a working pressure of 300 psi and factory tested at 450 psi. Medium temperature water, low temperature water, and pressure relief valve connections shall be located in accordance with the manufacturer's standard practice. Connections larger than 3 inches shall be ASME 300 pound flanged. Plates shall be corrugated [Type 304 stainless steel] [Type 316 stainless steel] [nickel-iron-chromium alloy conforming to ASTM B424] [nickel-molybdenum alloy conforming to ASTM B333] [titanium alloy conforming to ASTM B265].

2.1.5 Pumps

2.1.5.1 In-Line Pumps

Provide pumps constructed of manufacturer's standard materials suitable for chilled water and hot water heating systems. Pumps shall have mechanical seals and drip-proof electric motors. Motors one Hp and greater shall be the premium efficiency type in accordance with NEMA MG 1.

2.1.5.2 End Suction Water Pumps

Pumps shall be single stage centrifugal, with mechanical seals and drip-proof electric motors. Motors one Hp and greater shall be the premium efficiency type in accordance with NEMA MG 1. Impeller shall be bronze. Other pump parts shall be manufacturer's standard materials provided with bronze impeller pump. Provide threaded suction and discharge pressure gage tapping with square-head plugs. Provide flexible coupling with steel cover guard on base-mounted pumps. Base-mounted pump, coupling guard, and motor shall each be bolted to a fabricated steel base which shall have bolt holes for securing base to supporting surface. Close-coupled pump shall be provided with integrally cast or fabricated steel feet with bolt holes for securing feet to supporting surface.

[Provide pump suction diffuser. Casing of the pump suction diffuser shall include an angle type body of cast iron. Unit shall have internal straightening vanes, strainer with minimum 0.25 inch openings, and auxiliary disposable fine mesh strainer which shall be removed 30 days after start-up. Provide warning tag for operator indicating scheduled date for removal. Casing shall have connection sizes to match pump suction and pipe sizes, and be provided with adjustable support foot or support foot boss to relieve piping strains at pump suction. Blowdown port and plug shall be provided on unit casing. Provide a magnetic insert to remove debris from system.

]2.1.5.3 [Pump [field assembled] [factory assembled]M[nodules]

[Provide pump module package with all necessary fittings and valves.][Provide field assembled pump units/components]Provide pump [module] units factory designed, assembled, and pressure tested. Units shall include flanged pumps, brass fill and purge valves, quick release fill and purge ports, pressure/temperature (Pete's) plug, wiring, and fuse protection. Pumps shall be the wet rotor and single stage types, with pump casings thermally insulated. Provide manufacturer's standard galvanized steel cabinet, finished with corrosion resistant epoxy paint. Pump [module] units shall be provided by the ground source, closed loop heat pump manufacturer.

]2.2 ELECTRICAL WORK

Provide electrical motor driven equipment specified complete with motors, motor starters, and controls as specified herein and in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11. In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide polyphase, squirrel-cage medium induction motors, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

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

Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

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

[Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Use solid-state variable -speed controllers for motors rated 7.45 kW (10 hp) or less and adjustable frequency drives for larger motors.] [Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.]

[2.3 ABOVEGROUND PIPING SYSTEMS

Provide above ground piping as specified in Section 23 64 26 CHILLED, CHILLED-HOT, CONDENSER WATER PIPING SYSTEMS.

]2.4 PIPING ACCESSORIES

2.4.1 Pipe Hangers and Supports

Provide MSS SP-58 and MSS SP-69. Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor. Provide Type 40 insulation protection shields for insulated piping.

2.4.2 Strainers

ASTM A126, Class B, flanged iron body, for 2.5 inches and larger. ASTM B62, cast iron or bronze for 2 inches and smaller. Provide basket or Y type. Tee type is acceptable for water service. Provide screens constructed of bronze, monel metal, or 18-8 stainless steel, free area not less than 2.5 times pipe area, with perforations as follows:

a. 3 inches and smaller: 0.045 inches diameter perforations for liquids.

b. 4 inches and larger: 0.125 inches diameter perforations for liquids.

2.4.3 [Pressure Gages

Provide single style pressure gage with 4.5 inch dial, brass or aluminum case, bronze tube, gage cock, pressure snubber, and syphon. Provide scale range for intended service. Gages shall have an accuracy of 0.5 percent [_____]of the span. Provide gages that have a dial layout with major ticks with numbers every 10[_____] pressure units and minor ticks every one[_____] pressure unit. [Provide gages with dials showing psi units.] [Provide pressure gages with dual range dials, kpa and psi].]

2.4.4 Pressure/Temperature Test Provisions

2.4.4.1 Pete's Plug

Provide 0.5 inch MPT by 3 inches long, brass body and cap, with retained safety cap, nordel self-closing valve cores, permanently installed in piping where shown, or in lieu of pressure gage test connections shown on the drawings.

2.4.4.2 Testing Accessories

Provide one each of the following test items to the Contracting Officer:

a. 0.25 inch FPT by 0.125 inch diameter stainless steel pressure gage adapter probe for extra long test plug.

b. 3.5 inch diameter, one percent accuracy, compound pressure gage, 0 to 200 psi range.

c. minus 20 to 120 degree F pocket thermometer one-half degree accuracy, one inch dial, 5 inch long stainless steel stem, stainless steel wetted materials, and stainless steel external materials.

[2.4.5 Thermometers

Provide bi-metal dial type thermometers with stainless steel case, stem, and fixed thread connection; 3 inch diameter dial with glass face gasketed within the case; and accuracy within 2 percent of scale range. Provide scale range for intended service.

]2.4.6 Flexible Pipe Connectors

Provide flexible bronze or stainless steel piping connectors with single braid where indicated. Connectors shall be suitable for the intended service.

2.4.7 Expansion Tanks

Construct of steel for minimum working pressure of 125 psi. Tank shall have polypropylene or butyl lined diaphragm which keeps the air charge separated from the water.

2.4.8 Air Separators

[Provide tangential inlet and outlet connections, blowdown connections, and internal perforated stainless steel air collector tube to direct released air to automatic air vent. Construct of steel for minimum working pressure of 125 psi.] [Design to separate air from water and to direct released air to automatic air vent. Unit shall be of one piece cast-iron construction with internal baffles and two air chambers at top of unit; one air chamber shall have outlet to expansion tank and other air chamber shall be provided with automatic air release device. Unit shall be for minimum working pressure of 125 psi.]

2.4.9 Tracer Wire for Nonmetallic Piping

Provide bare copper or aluminum wire not less than 0.10 inch in diameter in sufficient length to be continuous over each separate run of nonmetallic pipe.

2.4.10 U-Bend Assemblies

Provide factory-assembled and fused injection-molded 180 degree U-bend assemblies equipped with anti-buoyancy devices. U-bend assemblies shall be used for the vertical well field vertical loop heat exchangers. U bend assemblies shall be prefabricated assemblies with u-bends and continuous pipe. The assemblies shall be pre-marked [by the manufacturer] with depth graduations. Each assembly shall be the indicated length of the vertical loop heat exchanger as indicated. Each assembly shall be factory pressure tested to 100 psig. Each assembly shall be provided with a factory pressure test report. Each U-bend assembly shall be temporarily capped to prevent the entry of dirt during storage and installation.

2.4.11 Pipe Casings

Provide rigid nonmetallic conduit and fittings (PVC) as pipe casings at floor penetrations and underground building entries for the entry of ground heat exchanger piping. The conduit shall serve as a casing for ease of installation and removal of the piping into the building. The pipe casing diameter shall be at least 4 times the diameter of the carrier pipe to allow "pulling the pipe through the casing. Provide rigid nonmetallic conduit and fittings specified complete with fittings and necessary hardware as specified herein and in [Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM].

Carrier Pipe Size		Casing Size	
(mm)	(Inches)	(mm)	(Inches)
19	3/4	100	4
25	1	100	4
32	1-1/4	100	4
38	1-1/2	150	6
50	2	200	8

2.4.12 Building Surface Penetrations

Except as indicated otherwise, provide pipe sleeves as specified in this section. Provide where piping passes entirely through walls, ceilings, roofs, and floors. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors. Provide one inch minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole.

Sleeves shall not be installed in structural members except where indicated or approved. Except as indicated otherwise piping sleeves shall comply with requirements specified. Sleeves in non-load bearing surfaces shall be galvanized sheet metal, conforming to ASTM A653/A653M, Coating Class G-90, 20 gauge. Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A53/A53M, [Schedule 30][Schedule 20][Standard weight]. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 1/2 inch depth. Sleeves shall not be installed in structural members.

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Sleeves shall be of such size as to provide a minimum of 1/4 inch all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07 92 00 JOINT SEALANTS.

2.4.12.1 Sleeves in Masonry and Concrete

Provide [steel standard weight] [PVC standard weight] pipe sleeves. [Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction.] [Sleeves are not required where piping passes through concrete floor slabs located on grade.] [Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth.]

2.4.12.2 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a 17 ounce copper sleeve, or a 0.032 inch thick aluminum sleeve, each within an integral skirt or flange.

Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 8 inches from the pipe and be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 2 inches above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproofing Clamping Flange: Pipes up to and including 10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproofing clamping flange, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut.

After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal rubber sealing elements to expand and provide a watertight seal between the pipe/conduit seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

2.4.12.3 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07 84 00 FIRESTOPPING.

2.4.13 Escutcheon Plates

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

2.5 HEAT TAPE

Provide UL listed parallel conduction type heat tape, with electrical characteristics indicated, and adjustable thermostat for outdoor aboveground winterized piping. The heat trace system shall meet requirements of the NFPA 70, Section 427. The tape shall not be affected by direct sunlight, ambient temperature, operating temperature, rain, or salt laden atmosphere.

2.5.1 Heat Tape Construction

Provide flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed for cut-to-length at the job site and for wrapping around valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.

a. Provide end seals for ends of circuits. Wire at the ends of circuits are not to be tied together.

b. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 34 degrees F minimum during winter outdoor design temperature as indicated, but not less than the following:

   (1) 3 inch pipe and smaller with one inch thick insulation, 4 watts/feet.

   (2) 4 inch pipe and larger 1.5 inch thick insulation, 8 watts/feet of pipe.

2.5.2 Electrical Accessories

a. Power supply connection fitting and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.

b. 0.5 inch wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 12 inch intervals.

c. Pipe surface temperature control thermostat shall be cast aluminum, NEMA 4 (watertight) enclosure, 0.5 inch NPT conduit hub, SPST switch rated 20 amperes at 480 volts ac, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 34 degrees F.

d. Signs shall be manufacturer's standard (NEC), stamped "ELECTRIC TRACED" located on the insulation jacket at 10 feet intervals along the pipe on alternating sides.

2.6 ACCESS DOORS FOR VALVES

Provide factory fabricated and primed flush face steel access doors including steel door frame equipped with continuous hinges and turn-screw-operated latch. Provide door frame installation in plaster and masonry walls. Provide access door size as indicated. [Provide [insulated] [non-insulated] fire rated access doors as indicated. Fire rated doors shall meet UL 10B. Doors shall be rated for [1-1/2 hours] [2 hours]]

2.7 AUXILIARY DRAIN PAN, DRAIN CONNECTIONS, AND DRAIN LINES

Provide galvanized steel auxiliary drain pans under units where indicated. Provide separate drain lines for the unit drain and auxiliary drain pans. Drain pans shall be fully and freely draining in compliance with ASHRAE 62.1. Trap drain pans to ensure complete pan drainage. Provide drain lines full size of drain opening. Traps and piping to drainage disposal points shall conform to Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.8 ANTIFREEZE PROTECTION

Provide [ethylene glycol] [propylene glycol] antifreeze fluid in a water based solution which meets local, State, and Federal requirements and is acceptable to heat pump component manufacturers. The antifreeze and water-based heat transfer fluid shall be used in closed-loop ground source heat pump systems for the transfer of energy to provide heating and cooling. The heat transfer fluid shall contain the necessary corrosion inhibitors to protect pipe and equipment from attack by the antifreeze solution utilized. The mixture of antifreeze and corrosion inhibitors in a water based solution is defined as a heat transfer fluid.

2.8.1 Biodegradability

The heat transfer fluid shall not be less than 90 percent biodegradable.

2.8.2 Properties of the heat transfer fluid

The heat transfer fluid shall conform to the following requirements, and tests shall be performed in accordance with specified test methods on the fluid.

2.8.2.1 Flash Point

The flash point of the heat transfer fluid shall not be lower than 194 degrees F, determined in accordance with ASTM D92.

2.8.2.2 Biological Oxygen Demand (BOD)

For 5 days the BOD, at 50 degrees F, shall not exceed 0.007 ounce oxygen per gram nor be less than 0.0035 ounce oxygen per gram.

2.8.2.3 Freezing Point

The freezing point shall not exceed[15 degrees F], determined in accordance with ASTM D1177.

2.8.2.4 Toxicity

The toxicity shall not be less than LD 50 (oral-rats) of 0.175 ounce per kilogram. The NFPA hazardous material rating for health shall not be more than 1 (slight).

2.8.2.5 Storage Stability

The heat transfer fluid, tested in accordance with ASTM F1105, shall neither show separation from exposure to heat or cold nor show an increase in turbidity.

2.8.3 Quality

The heat transfer fluid, shall be homogeneous, uniform in color, and free from skins, lumps, and foreign materials detrimental to usage of the fluid.

2.9 CHEMICAL FEED PROVISIONS

[Provide chemical feed provisions as specified in Section 23 64 26 CHILLED, CHILLED-HOT, CONDENSER WATER PIPING SYSTEMS.

][2.9.1 Aboveground Condenser Water Piping System

Add borate-nitrite corrosion inhibitors, acceptable to heat pump component manufacturers, to initial fill water for heating and cooling water systems in concentrations of[0.5 ounce/gal] of system water if corrosion inhibitors are not contained in freeze protection solution in the ground heat exchanger loop.

][2.9.2 Chilled/Hot Water Piping System

Add borate-nitrite corrosion inhibitors, acceptable to heat pump component manufacturers, to initial fill water for heating and cooling water systems in concentrations of[0.5 ounce/gal] of system water if corrosion inhibitors are not contained in freeze protection solution in the ground heat exchanger loop.

][2.9.3 Ground Heat Exchanger Piping

Provide corrosion inhibitors acceptable to heat pump manufacturers with concentrations suitable for each system[and appropriate for the antifreeze used].

]2.10 PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein. New equipment surfaces constructed of non-ferrous surfaces and materials do not have to be factory or shop painted.

2.10.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand [125][500][3000] hours in a salt-spray fog test. Field applied coatings are not acceptable. Provide a factory coating system on the fins of exterior heat transfer equipment that meets ASTM B117.85 salt-fog test duration for [125][500][3000] hr. Salt-spray fog test shall be in accordance with ASTM B117, and for that test the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark.

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

2.10.2 Shop Painting Systems for Metal Surfaces

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

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

a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.

b. Temperatures Between 120 and 400 Degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.

c. Temperatures Greater Than 400 Degrees F: Metal surfaces subject to temperatures greater than 400 degrees F shall receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

2.11 BENTONITE GROUT

Provide bentonite grout mixture for pressure grouting and sealing the bore hole of the vertical well. Provide grouting of wells in accordance with IGSHPA 21015. The grout selected shall meet NSF/ANSI 60. The grout shall meet all local and state rules and regulations. The bentonite will be a slurry that will be tremie grouted from the bottom of the boring to the surface in accordance with the IGSHPA installation manual. The contractor will work quickly to assure that there are no air voids forming as a result of the bentonite placing.

2.11.1 High Grade Bentonite Grout

[Provide high grade bentonite grout mixture. The grout shall be mixed with potable water. The grout shall be mixed per manufacturer instructions. The thermoconductivity of the grout shall be 0.43 Btu/hr-ft-F or greater. The minimum solids content shall be 23 percent. The target grout weight shall be 9.5 lb/gallons to 9.8 lb/gallon.
]

2.11.2 Thermally-Enhanced Bentonite Grout

[Provide thermally enhanced bentonite grout mixture. Thermally enhanced bentonite grout mixture shall be a high solids bentonite grout. The grout shall be mixed per the manufacturer instructions. Potable water shall be used for mixing the grout. Grout shall have a minimum solids content of 65 to 70 percent. The thermal conductivity of the grout mixture compound shall be a minimum of 1.0 Btu/hr-ft-F or greater. The target grout weight shall be 13.3 lb/gallons to 14.4 lb/gallon. The thermally-enhanced bentonite grout shall have a thermal enhancement compound consisting of a high-grade silica compound that constitutes a minimum of 50 percent by weight of the aqueous slurry.
]

2.11.3 Cementitious Thermally Enhanced Grout

[Provide Cementitious Thermally Enhanced Grout mixture. The cementitious thermally enhanced grout mixture shall be a high solids sodium bentonite grout with portland cement, potable water, silica sand compound, and a super plasticizer compound. The grout shall be mixed per the manufacturer instructions. Potable water shall be used for mixing the grout. The thermal conductivity of the grout mixture compound shall be a minimum of 1.4 Btu/hr-ft-F or greater. The target grout weight shall be 16 lb/gallon.
]

2.12 CONTROLS

Controls for the [ground-loop][water-loop]heat pump systems complete and ready for operation shall be integrated with the HVAC system controls package specified in Section [23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS,] 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Systems include heat pumps, system equipment, piping, pumps, electrical equipment, controls, [wells,] and condenser Controls shall be designed in accordance with the manufacturer's recommendations and to comply with the sequence of controls shown on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Heat Pump System

Maintenance access to each piece of equipment shall not be compromised by any type of piping, electrical conduit, or any other utility. Further, install equipment in accordance with NFPA 70 and with the manufacturer's written installation instructions, including the following:

[Water-source water-to-air heat pumps - installation instructions

][Water-source water-to-water heat pumps - installation instructions

][Closed Circuit Coolers - installation instructions

][Plate Heat Exchangers - installation instructions

][Heat Tape - installation instructions

][As-Built Drawings of the installed systems. As-built drawings shall also show and document the as-constructed locations of the well field with dimensions, including all wells and loop fields.

]3.1.2 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems. Flush existing systems in accordance with paragraph FLUSHING THE GROUND HEAT EXCHANGER prior to making connections.

3.2 ABOVEGROUND PIPING

Provide above ground piping as specified in Section 23 64 26 CHILLED, CHILLED-HOT, CONDENSER WATER PIPING SYSTEMS.

a. Cleaning of Piping: Keep interior and ends of new piping and existing piping, affected by Contractor's operations, cleaned of water and foreign matter during installation by using plugs or other approved methods. When work is not in progress, securely close open ends of pipe and fittings to prevent entry of water and foreign matter. Inspect piping before placing into position.

b. Flushing and Purging of Piping: Before connection of the header to the polyethylene ground heat exchanger loops, flush and purge the entire aboveground piping system thoroughly in accordance with IGSHPA 21020 recommendations and leave filled with clean water. If the header is not immediately joined to the ground heat exchanger loop, the open ends shall be taped or capped. Purge and vent the above ground system piping of all air.

3.3 FIELD PAINTING AND FINISHING

Requirements for field painting and finishing are specified in Section

09 90 00 PAINTS AND COATINGS.

3.4 FLUSHING AND PURGING GROUND HEAT EXCHANGER

Before connection of the plastic ground heat exchanger loops to the header, flush and purge each loop thoroughly in accordance with IGSHPA 21020 recommendations and leave filled with clean water. If the loop is not immediately joined to the header, it shall be taped or capped. Purge and vent the ground heat exchanger system piping of all air.

3.5 ADJUSTMENTS

Adjust controls and equipment so as to give satisfactory operation. Adjust entire water temperature control system and place in operation so that water quantities circulated are as indicated. Adjust and balance air duct systems so that air quantities at outlets are as indicated and so that distribution from supply outlets is free from drafts and has uniform velocity over the face of each outlet.

3.6 INSTRUCTING OPERATING PERSONNEL

Upon completion of work and at time designated by Contracting Officer, provide services of water source heat pump manufacturer's technical representative for period of not less than one 8-hour working day for instruction of Government operating personnel in proper operation and maintenance of equipment.

3.7 FIELD QUALITY CONTROL

Upon completion and before final acceptance of work, test each system in service to demonstrate compliance with the contract requirements. Adjust controls and balance systems prior to final acceptance of completed systems. Test controls through every cycle of operation. Test safety controls to demonstrate performance of required function. Correct defects in work provided by Contractor and repeat tests. Furnish fuel, water, electricity, instruments, connecting devices, and personnel for tests. Flush and clean piping before placing in operation. Clean equipment, piping, strainers, ducts, and filters. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new replaceable filters were provided and installed and permanent filters were cleaned.

3.7.1 Piping Systems Except for Ground Heat Exchanger and Refrigerant

For above ground piping systems, and steel or copper piping systems: Before insulating, hydrostatically test each new piping system at not less than [1.5 times the system working pressure][188 psi based on 1.5 times a system pressure of 125 psig]. Maintain pressure for 2 hours with no leakage or reduction in gage pressure. Obtain approval before applying insulation.

3.7.2 Flow Test of Ground Heat Exchanger Piping

Before backfilling the trenches, flush, purge, and vent systems of air and flow test to ensure all portions of the heat exchanger are properly flowing using the procedures recommended by IGSHPA 21020. Utilize a portable temporary purging unit consisting of the following:

a. High volume, high head purge pump

b. Open reservoir

c. Filter assembly with bypass

d. Flow meter

e. Pressure gage

f. Connecting piping

g. Connecting hoses

Using a purge pump and the procedures recommended by IGSHPA 21020, flush and purge each ground heat exchanger system until free of air, dirt, and debris. A velocity of 2 feet/sec is required in pipe sections to remove the air. Purge and vent all air from the piping.

Perform the flushing and purging operation with the water source heat pumps isolated by shutoff valves from the ground heat exchanger system. Allow purge pump to run 15 minutes after the last air bubbles have been removed. After the ground heat exchanger is completely flushed of air and debris, open the isolation valves and permit circulation through the heat pumps until the entire system is flushed and purged.

Utilizing the purging unit and the procedures recommended by IGSHPA 21020, conduct a pressure and flow test on the ground heat exchanger to ensure the system is free of blockage. If the flow test indicates blockage, locate the blockage using the manufacturer's recommendation, remove the blockage, then repeat the purge procedure and conduct the pressure and flow test again until all portions of the system are free flowing. The flow test shall be observed and approved by the Contracting Officer.

After purging has been completed, add the required amount of antifreeze to the system to achieve the required solution concentration. [Fill the open reservoir with the quantity of antifreeze required for 15 degree F freeze protection and run the purge pump 15 minutes to deliver the antifreeze to the system. Test the solution with a hydrometer to determine the actual freezing point.]

Form 1, "Ground Heat Exchanger Inspection and Test Report" located below, shall be completed for each system by the [Contractor] [or QC Manager] after completion of the flow [and injection of required antifreeze to the system and] before the systems can be backfilled.

FORM 1

GROUND HEAT EXCHANGER (GHX) INSPECTION AND TEST REPORT

NOTE: Use separate form for each GHX loop system.

Building:_________________________ Inspection Date:_______________________

Ground Heat Exchanger No. or Description:_________________________________

Does the ground heat exchanger have a Well Construction Permit? Permit No.?

Does the ground heat exchanger have an approved well permit? Permit No.

List the WSHP Unit No.'s served by this GHX: _____________________________

Ground Heat Exchanger Design Water Flow - _____ gpm

Calculated purging flow and press to achieve 2 feet/sec

Purging: Flow _____ gpm Head _____ psi, Duration of test _____ min.

Hydrostatic test pressure _____ psi; Duration _____ min.

Did the system pass the pressure test? ___________________________________

Is antifreeze required in system?____ If yes, was antifreeze measured?____

Has a dimensioned drawing been prepared, completely and accurately showing the layout of the ground heat exchanger? _________________________________

Does the layout differ substantially from the contract documents? ________
If so is the deviation approved? _______________

Depth of installed vertical loops is _____ feet. (Design is ____ feet.)

Depth of horizontal piping is _____ feet. (Design is _____ feet.)

Are the trenches clear of sharp bends, rocks, or other sharp objects that could restrict flow?___________________

Are all joints heat fused (butt-, socket-, or saddle-fusion)?_____________
Do the joints have the proper amount of roll-out?_________________________

Has the piping material been cut-out and properly removed from saddle-fusion tees?_______________

Grout Manufacturer? ______________; Percent of solids used in grout?________Grout Type?_________Grout Thermal conductivity, k? (give units)______

Was the system backfilled properly with good clean backfill material?_____

Attach the soil boring and water well log sheet for the bore hole?__For each well submit a Well Construction Log Record

Comments:____
____
____

Inspected and approved this __________ date by ________________________________

Title: ____

3.7.3 Pressure Test of Ground Heat Exchanger Piping

Prior to any cover or backfill of bore holes or trenches and after flow testing, flushing, and purging, the ground heat exchanger piping and headers shall be pressure tested by hydrostatic test. The system shall be isolated from all connections to piping. Ensure that the piping system has been flushed of all dirt and debris. The piping shall then be plugged or capped as necessary in preparation for the hydrostatic test(s).

3.7.3.1 Hydrostatic Test

The piping shall be hydrostatically pressurized to 150 percent of system pressure [or [150] [_____]psi] and monitor piping. If there is any pressure loss or visible leakage during the testing, the leak shall be identified and repaired in accordance with the piping components manufacturer's recommendations. Test shall be repeated until there is no loss in pressure during the test period. Provide results of test in test report. During testing, do not exceed the pipe/pipe fitting manufacturer test pressure rating [or 150 percent of the pipe pressure rating]. Do not pneumatic test the pipe. Prior to testing, remove all air from the system. Provide test in accordance to IGSHPA standards.

3.7.4 Refrigerant Piping Pressure Test and Evacuation

Perform the following when field piping connections are provided.

a. Pressure Test: Test refrigerant piping using dry, oil-free nitrogen, and prove tight at 300 psi on the high side and 150 psi on the low side. Maintain pressure for 2 hours with no leakage or reduction in gage pressure.

b. Evacuation: Use a high vacuum pump and certified micron gage to reduce the absolute pressure on both sides of system simultaneously to 300 microns. After reaching this point charge system with proper refrigerant until pressure of 0 psi is obtained. Repeat evacuation-charging procedure for two more cycles, totaling to three evacuation-charging cycles. On final evacuation, secure pump and maintain 300 microns for 2 hours before charging with required final refrigerant.

3.7.5 Equipment Tests

3.7.5.1 Field Testing

Test each item of equipment in operation,[for continuous period of not more than 24 hours]under every condition of operation in accordance with each equipment manufacturer's recommendation. Verify that each item of equipment operating parameters are within limits recommended by the manufacturer.

3.7.5.2 Field Test Plans

Furnish water-source heat pump [and closed circuit cooler] field test plans developed by each equipment manufacturer detailing recommended field test procedures for each item of equipment. Field test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment will not be acceptable. The Contracting Officer will review and approve the field test plan for each item of equipment listed below prior to commencement of field testing of the equipment.

a. Equipment Items to Test:

[Water-source water-to-air heat pumps - field acceptance test plan

][Water-source water-to-water heat pumps - field acceptance test plan

][Closed Circuit Coolers - field acceptance test plan

][Plate Heat Exchangers - field acceptance test plan

] b. Coordinated Testing: Indicate in each field test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of equipment controls which interlock and interface with controls factory prewired or external controls for the equipment provided under [Section 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS] [23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC]

c. Prerequisite Testing: Equipment for which performance testing is dependent upon the completion of the work covered by 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC shall have that work completed as a prerequisite to testing work under this section. Indicate in each field test plan when such prerequisite work is required.

d. Test Procedure: Indicate in each field test plan each equipment manufacturer's published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer. Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Structure procedures to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control. Controllers shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance Variables: Each test plan shall list performance variables that are required to be measured or tested as part of the field test. Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Furnish with each test procedure a description of acceptable results that have been verified. Identify the acceptable limits or tolerances within which each tested performance variable shall acceptably operate.

f. Job Specific: Each test plan shall be job specific and shall address the particular item of equipment and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.

g. Specialized Components: Each test plan shall include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.7.5.3 Field Test Reports

a. Equipment Items to Test:

[Water-source water-to-air heat pumps - field acceptance test report

][Water-source water-to-water heat pumps - field acceptance test report

][Closed Circuit Coolers - field acceptance test report

][Plate Heat Exchangers - field acceptance test report

] b. Manufacturer's Recommended Test: Conduct the manufacturer's recommended field testing in compliance with the approved test plan specified above. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field testing.

c. Operational Test: Conduct a standard [continuous 24 hour] operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every 2 hours. Use the test report forms for logging the operational variables.

d. Notice of Tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.

e. Report Forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment shall be reviewed, approved, and signed by the Contractor's test director and the QC Manager. The manufacturer's field test representative shall review, approve, and sign the report of the manufacturer's recommended test. Signatures shall be accompanied by the person's name typed.

f. Deficiency Resolution: The test requirements acceptably met; deficiencies identified during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections retested to verify compliance.

3.7.6 Additional Field Testing

[Requirements for testing, adjusting, and balancing (TAB) of ducts, piping, and equipment are specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.][Testing, adjusting, and balancing shall begin only when the entire HVAC system, including controls, has been completed with the exception of performance tests. Where required the heat pump systems shall be charged with premixed antifreeze solution (type and concentration as indicated prior to testing, adjusting, and balancing.]

[Balance air flows to that indicated in accordance with SMACNA 1966, as supplemented and modified by this section. Testing, adjusting, and balancing shall begin only when the entire HVAC system, including controls, has been completed with the exception of performance tests. Where required the heat pump systems shall be charged with premixed antifreeze solution (type and concentration as indicated prior to testing, adjusting, and balancing). Submit written certificate to report the following:

a. Water source heat pump unit nameplate data, and actual voltage and ampere consumption.

b. Supply and return terminal airflow, and equipment used to measure airflow.

c. Water source heat pump cfm and entering and leaving air temperatures.

d. Water source heat pump unit condenser water gpm and entering and leaving temperatures.

e. Ambient outside air temperature, date, and person testing, balancing, and reporting.

][Design and]3.7.7 Soil Thermal Conductivity Testing

Perform soil thermal conductivity testing of the well system project location. The test will establish the thermal properties for design of the well field and the subsurface conditions at the site. The test will be performed by performed under the supervision of and certified by the ground source heat pump (GSHP) specialist. The test will be performed at [multiple] locations as [indicated] [determined by the designer]. Each test will contain a minimum of 48 hours of recorded data. [The test shall be used for verification of the design and installation.]

3.7.7.1 Soil Thermal Conductivity Testing Set-up

Conduct and perform tests in accordance with the procedures outlined in ASHRAE Item 90376.

3.7.7.2 Data Recording and sensor accuracy

Record data by means of automatic data logging equipment intended for such purposes and suitable for service of local ambient outside conditions. Protect compensated thermocouple reference junctions, if used, either from separate from the data logging equipment or integral to it, from rapid changes in environmental conditions. Record data at uniform [5 minute] time intervals during the 48 hour test period. Data recorded will include a minimum time, inlet and outlet temperatures, heater power input, circulating pump power input, and ambient temperatures.

Temperature Measurements: Measure inlet and outlet temperatures with immersion temperature sensors. The temperatures sensors shall be calibrated every six months and have a valid calibrated stamp. Include the date and results from the most recent calibration in the test report. Any change-out of the temperature sensor in the system or data logger will require re-calibration.

[Temperature Sensor calibration and accuracy: The combined rated sensor and data logger accuracy will be [as indicated] plus or minus 1 degree F or better. Verify temperature sensor and data logger accuracy and calibration at first use of the testing device during the test. The testing equipment shall have been calibrated semi-annually by immersion in ice and water bath. A calibration certificate stamp with date shall be on the test device. The result from the verification test using ice water bath shall not differ from 32 degrees F by more than the required data accuracy. Additional readings will not differ from one another by more than plus or minus 0.5 degrees F when simultaneously immersed in the ice bath.

] Power Measurements: Measure heater and circulating pump power input. [Power measurements shall be independently determined by using power transducers with the manufacturer stated accuracy of plus or minus two percent or better at the level of power consumption for the test.]

Flow Rate Measurements: Measure the flow rate. [Flow rate shall be measured using a variable flow meter calibrated by the flow meter manufacturer having a rated accuracy of plus or minus two percent of full scale. Full scale or maximum rated flow for the flow meter shall not exceed actual flow rate by more than 70 percent.]

3.7.7.3 Test Borehole Construction

Prepare the bore hole in a manner in which the heat exchangers will be ultimately installed to the extent possible with respect to the bore hole size, pipe diameter grouting method, and grout types as indicated. The installation of the test bore hole shall be as indicated for the vertical well field. The bore hole depth shall not vary more than 5 percent from the indicated design depth. Materials of the test borehole and heat exchanger shall be as indicated.

a. At least 6 feet of excess pipe shall be left protruding above grade upon completion of the test borehole construction. Temporarily cap the ends of the protruding pipes until the actual testing begins. All local and state codes and regulations will be adhered to during the construction of the test bore hole. Where any discrepancy exists between local codes and regulations and this specification, the more stringent requirement applies. The U-tube assembly shall be factory assembled and pressure tested to 100 psig prior to insertion into the vertical bore. All connections shall be by heat fusion.

b. During the completion of the test borehole, maintain a water well and soils property log. For each well submit a Well Construction Log Record

[3.7.8 ON-SITE TRAINING

The [System Designer] [Ground Source Heat Pump Specialist] shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of [16] [_____] hours of normal working time and shall start after the system is functionally complete but prior to the performance tests. The on-site training shall cover all of the items contained in the approved Operation and Maintenance Data packages.

] -- End of Section --

SECTION 23 82 46.00 40

ELECTRIC UNIT HEATERS
05/17

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.

UNDERWRITERS LABORATORIES (UL)

UL 1996	(2009; Reprint Sep 2021) UL Standard for Safety Electric Duct Heaters

1.2 ADMINISTRATIVE REQUIREMENTS

1.2.1 Preinstallation Meetings

The Contracting Officer will schedule a preinstallation meeting within [30] [_____] days of Contract Award. Provide the following for review and approval:

a. Submit fabrication drawings for electric heaters, indicating the fabrication and assembly details to be performed in the factory.

b. Submit manufacturer's instructions for electric heaters, stating the special provisions necessary to install equipment components and system packages. Detail the impedances, hazards and safety precautions within the special notices.

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-02 Shop Drawings

Fabrication Drawings

SD-03 Product Data

Performance Data; G[, [____]]

Electric Unit Heaters; G[, [____]]

Heating Element; G[, [____]]

Controls; G[, [____]]

Casings; G[, [____]]

Propellers and Motors; G[, [____]]

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide suspended electric unit heaters, and arrange for the discharge of air as indicated.

Provide electric unit heaters with at least the indicated capacity and ensure that they conform to the requirements specified herein. Ensure that the electric unit heaters are factory-prewired and ready for field terminal connections.

Ensure products conform to the requirements of UL 1996 for electric unit heaters.

Submit performance data for electric heaters, including use life, test, system functional flows, safety features, and mechanical automated details.

2.2 COMPONENTS

2.2.1 Heating Element

Provide a heating element constructed of a resistance wire insulated by highly compacted refractory insulation protected by a sealed metallic-finned sheath. Provide component materials as follows:

a. Provide a resistance wire of not less than 20-helix wound alloy of approximately 80-percent nickel and 20-percent chromium.

b. Provide a refractory insulation of magnesium oxide with a resistance of not less than 50,000 ohms after exposure to an ambient temperature and humidity of 90 degrees F and 85 plus or minus 5-percent relative humidity, respectively, for not less than 24 hours.

c. Provide a sheathing consisting of aluminum fins cast around an internal steel sheath containing refractory insulation and resistance wire or carbon-steel fins permanently attached to a tubular carbon-steel sheath containing refractory insulation and resistance wire and with external surfaces porcelainized.

[Ensure that the maximum surface temperature of porcelain-protected steel sheathing is [700] [_____] degrees F.

][Ensure that the maximum surface temperature of cast-aluminum sheathing is [500] [_____] degrees F.

]2.2.2 Controls

[Fit units up to and including 5 kilowatts with integral controls, including thermal overload cutout switches, necessary transformers, a liquid-vapor system, and low-mass bimetal thermostat as required. Provide a cutout switch that can be automatically reset.

][Provide the unit with a remote unfused disconnect switch that opens ungrounded conductors in the OFF position and a thermostat with integral controls, including thermal overload cutout switches, magnetic contactors, necessary transformers, and thermostat protection as required. Provide cutout switches that can be automatically reset.

] Provide wall-mounted thermostats complete with thermometer, mechanical high-limit stop, calibrated operator, and an adjustable heater to prevent override of space temperature with a range between 55 and 105 degrees F and a differential not exceeding 1.5 degrees F. Provide a thermostat rated for operation at 24 volts, 60 hertz. Provide transformers, wiring, and devices necessary to meet this requirement. Provide a casing finish in [brushed chrome] [satin chrome] [_____].

2.2.3 Propellers and Motors

Provide propellers with[mill-aluminized][galvanized-steel][all-aluminum] blades statically and dynamically balanced to within 0.5 percent. Provide units with fan-inlet safety guards.

Ensure that propellers and motors are AMCA-certified for air performance and noise level.

Protect motors against damage by the heating element and resilient mount.

Ensure that propellers and motors conform to Section 26 60 13.00 40 LOW-VOLTAGE MOTORS for motors, except that load-matched and custom-designed motors may be used and be so identified on the shop drawings. For motors not so identified, conform to the requirements specified.

Subfractional and fractional custom-designed or applied motors may deviate from the preceding motor requirements as follows:

a. Shaded-pole motors rated less than 1/6 horsepower may be used for direct-drive service.

b. Permanent split-capacitor, split-phase, and capacitor-start motors rated 1/4 horsepower or less may be used for direct-drive service.

c. Split-phase and capacitor-start motors, rated 1/4 horsepower or less, may be used for belt-drive service.

d. Motor bearings may be the manufacturer's standard prelubricated sleeve type but provide the motor with antifriction thrust bearings, when specified. Ensure that the lubricant provisions are for extended service, requiring replenishment not more than twice per year of continuous operation.

Provide the manufacturer's standard motor identification plate.

Provide the manufacturer's standard motor speed and control.

PART 3 EXECUTION

3.1 INSTALLATION

Install unit heaters in accordance with the manufacturer's instructions at the mounting heights indicated.

3.1.1 Casings

Provide casings with smoothly contoured propeller orifice rings of at least 20-gage cold-rolled carbon steel. Provide a casing surface finish with phosphate pretreatment, prime coating, and baked-enamel finish.

3.1.2 Air Distribution

[Fit vertical discharge units with louver-cone diffusers.

][Provide horizontal units with adjustable single- or double-deflection louvers.

]3.2 FIELD QUALITY CONTROL

Demonstrate in the presence of the Contracting Officer that the unit heaters operate satisfactorily.

Cycle unit heaters five times, from start to operating thermal conditions to off, to verify adequacy of construction, system controls, and component performance.

Conduct an operational test for a minimum of 6 hours.

-- End of Section --