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PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2017)	Steel	Construction	Manual

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME A112.18.1/CSA B125.1	(2018) Plumbing Supply Fittings
ASME A112.19.2/CSA B45.1	(2018; ERTA 2018) Standard for Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals
ASME B1.20.7	(1991; R 2013) Standard for Hose Coupling Screw Threads (Inch)
ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2016) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME B16.22	(2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.25	(2017) Buttwelding Ends
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300

ASME	B31.3	3	(2016)	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	(2017a) Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A74	(2020) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM A105/A105M	(2018) 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 A216/A216M	(2016) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
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	A307	(2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM	A312/A312M	(2019) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
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	(2020) Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile
ASTM	C109/C109M	(2020b) 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	C564	(2020a) Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
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 E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
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	(2019) Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems
FLUID SEALING ASSOCIATIO	DN (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 STANDARDIZ INDUSTRY (MSS)	ATION SOCIETY OF THE VALVE AND FITTINGS
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

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MSS SP-125 (2010) Gray Iron and Ductile Iron In-Line, Spring-Loaded, Center-Guided Check Valves NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA) (2018) Motors and Generators NEMA MG 1 NEMA MG 10 (2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors (1977; R 2012) Energy Management Guide for NEMA MG 11 Selection and Use of Single Phase Motors NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA NFPA 70 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code NSF INTERNATIONAL (NSF) NSF/ANSI 14 (2019) Plastics Piping System Components and Related Materials U.S. DEPARTMENT OF DEFENSE (DOD) MIL-C-18480 (1982; Rev B; Notice 2 2009) Coating Compound, Bituminous, Solvent, Coal-Tar Base (2009; Rev H; Supp 1 2009; Notice 1 2013) MIL-DTL-17813 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) (Rev A; Notice 3) Shield, Expansion (Lag, CID A-A-1923 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) Fire Tests of Through-Penetration Firestops

1.2 GENERAL REQUIREMENTS

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

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

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

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

Submit Material, Equipment, and Fixture Lists for pipes, valves and specialties including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information. Provide a complete list of construction equipment to be used.

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

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

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

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

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

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval When used, a code following the "G" classification identifies the office that will review the submittal for the Government. 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

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, 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, 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 208volts 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). 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).

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) and ASME B36.10M.

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

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 GCS, Galvanized Carbon Steel

Ensure pipe 1/2 through 10 inches, and where indicated is Schedule 40 seamless or electric-resistance welded galvanized steel conforming to ASTM A53/A53M, Type E, Grade B (electric-resistance welded) or Type S (seamless).

Ensure pipe 12 inches and over is 0.375-inchwall, seamless, galvanized steel, conforming to ASTM A53/A53M, Grade B.

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

Ensure unions 2 inches and under are 150-psig wsp female, screwed, galvanized malleable iron with brass-to-iron seat and ground joint.

Ensure fittings 2-1/2 inches and over are 125-psig wsp cast-iron flanges

and flanged fittings, conforming to ASTM A126, Class A and ASME B16.1.

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

As an option, use 150-psig wsp banded galvanized malleable iron screwed fittings, conforming to ASTM A197/A197M and ASME B16.3.

2.2.4 Type GCS-DWV, Galvanized Steel Drain, Waste and Vent

Ensure pipe (all sizes) is Schedule 40 galvanized carbon steel, conforming to ASTM A53/A53M, Grade A.

Furnace butt weld pipe is acceptable for sizes less than 2 inches.

Provide risers 3 inches and larger are Type CISP-DWV.

Ensure fittings are galvanized, , screwed, cast iron, recessed pattern drainage fittings, conforming to ASTM A126.

Use long radius fittings wherever space permits. Short-turn tees, branches, and ells may be used for vent piping and connections of branch lines to battery fixtures, except wall-hung water closets.

2.2.5 Type CISP-DWV, Cast-Iron Drain, Waste and Vent

Provide soil pipe drain, waste, and vent bell-and-spigot type pipe cast iron, conforming to ASTM A74. Caulk and lead all joints in lines where necessary to provide proper leaktight support and alignment; other-wise joints may be two-gasket system type chloroprene, conforming to ASTM C564. Select the extra heavy (CISP-DWV-XH) pipe class.

2.2.6 Type CPR, Copper

2.2.6.1 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.

2.2.6.2 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.

2.2.6.3 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.

2.2.7 Polypropylene Pipe

Pipe is manufactured from a PP-R resin meeting the short-term properties and long-term strength requirements of ASTM F2389 Pipe is made in a three layer extrusion process. Piping contains a fiber layer (faser) to restrict thermal expansion. Pipe complies with the rated pressure requirements of ASTM F 2389 Ensure layers are incorporated in the pipe wall to limit thermal expansion to 2 1/4-inches per 100 F per 100-ft. If the hydronic system includes ferrous components, an oxygen barrier is required in pipe wall.

Ensure pipe is certified by NSF International as complying with $\ensuremath{\mathsf{NSF}}/\ensuremath{\mathsf{ANSI}}$ 14, and $\ensuremath{\mathsf{ASTM}}$ F2389

Ensure pipe wrap or insulation meets the requirements of ASTM E84. Ensure the system has a Flame Spread Classification of less than 25 and Smoke Development rating of less than 50.

Where pipe is exposed to direct UV light for more than 30 days, provide a Factory applied, UV-resistant coating or alternative UV protection.

2.2.8 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. Fit vent with try-cock. Ensure vent discharges air at any pressure up to 150 psi. Ensure outlet is copper tube routed.

2.3.3 Compression Tank

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

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

2.3.4 Dielectric Connections

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

2.3.5 Expansion Vibration Isolation Joints

Construct single or multiple arch-flanged expansion vibration isolation joints of steel-ring reinforced chloroprene-impregnated cloth materials. Design joint to absorb the movement of the pipe sections in which installed with no detrimental effect on the pipe or connected equipment. Back flanges with ferrous-metal backing rings. Provide control rod assemblies to restrict joint movement. Coat all nonmetallic exterior surfaces of the joint with chlorosulphinated polyethylene. Provide grommets in limit bolt hole to absorb noise transmitted through the bolts. Ensure joints are suitable for continuous-duty working temperature of at least 250 degrees F.

Fill arches with soft chloroprene.

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

2.3.6 Flexible Pipe

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

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

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

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

2.3.7 Flexible Metallic Pipe

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

Minimum working pressure rating is 50 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.

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

Ensure flanged end connection rating and materials conform to

specifications for system primary-pressure rating.

2.3.8 Flexible Metal Steam Hose

Provide a bellows type hose with wire braid cover and designed, constructed, and rated in accordance with the applicable requirements of ASME B31.3.

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

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

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

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

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).

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

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

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

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

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

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

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

End connections require no field preparation other than cleaning.

Butt weld end preparation of expansion joints conform to the same codes and standards requirements as applicable to the piping system materials at the indicated joint location. Flanges of flanged-end expansion joints conforms to the same codes and standard requirements as are applicable to companion flanges specified for the given piping system at the indicated joint location.

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

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

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

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

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

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

2.3.10 Hose Faucets

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

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

2.3.11 Pressure Gages

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

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

2.3.12 Sight-Flow Indicators

Construct sight-flow indicators for pressure service on 3-inch ips and smaller of bronze with specially treated single- or double-glass sight windows and have a bronze, nylon, or tetrafluoroethylene rotating flow indicator mounted on an AISI Type 304 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. . 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 fitted with a two-way brass cock across the strainer.

Provide manual air vent cocks in cap of each strainer.

2.3.16 Line Strainers, Water Service

Install Y-type strainers with removable basket. Ensure strainers in sizes 2-inch ips and smaller have screwed ends; in sizes 2-1/2-inch ipsand larger, strainers have flanged ends. Ensure body working-pressure rating exceeds maximum service pressure of installed system by at least 50 percent. Ensure body has cast-in arrows to indicate direction of flow. Ensure all strainer bodies fitted with screwed screen retainers have straight threads and gasketed with nonferrous metal. For strainer bodies

2-1/2-inches and larger, fitted with bolted-on screen retainers, provide offset blowdown holes. Fit all strainers larger than 2-1/2-inches with manufacturer's standard ball-type blowdown valve. Ensure body material is cast bronze conforming to ASTM B62. 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 corrosion-resistant steel.

2.3.17 Line Strainers, Steam Service

Install Type Y strainers with removable strainer element.

Use flanged body end connections for all valves larger than 2 inches, unless butt weld ends are specified. Use screwed weld for sizes 2 inches and under to suit specified piping system end connection and maintenance requirements .

For strainers located in tunnels, trenches, manholes, and valve pits, use welded end connections.

Body working steam pressure rating is the same as the primary valve rating for system in which strainer is installed, except where welded end materials requirements result in higher pressure ratings. Ensure body has integral cast or forged arrows to indicate direction of flow. Provide strainer bodies with blowdown valves that have discharge end plugged with a solid metal plug. Make closure assembly with tetrafluoroethylene tape. Ensure bodies fitted with bolted-on screen retainers have offset blowdown holes.

Body materials are cast steel conforming to ASTM A216/A216M, Grade WCB .

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 0.020 inch or equivalent wire mesh. Strainer screens have finished ends fitted to machined screen chamber surfaces to preclude bypass flow. Strainer element material is AISI Type 304 corrosion-resistant steel and fitted with backup screens where necessary to prevent collapse.

2.4 VALVES

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

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

2.4.1 Ball and Butterfly Valves

Ensure ball valves conform to MSS SP-72 for Figure 1A, 1 piece body 1B,

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

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

2.4.2 Drain, Vent, and Gage Cocks

Provide T-head 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, positive-closure devices and valve ends are mechanical joint.

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. 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 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).

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.

When it is not possible to use center-loading beam clamps,

eccentric-loading beam clamps, MSS SP-58 Type 19 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 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 pipe rolls.

Support piping in sizes larger than 8-inch ips with MSS SP-58 Type 41 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.

2.6.3 Vertical Pipe Attachments

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

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

2.6.4 Hanger Rods and Fixtures

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

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

2.6.5 Supplementary Steel

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

PART 3 EXECUTION

3.1 PIPE INSTALLATION

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

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

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

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

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

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

Ream all pipe ends before joint connections are made.

Make screwed joints with specified joint compound with not more than three

threads showing after joint is made up.

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

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

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

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

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

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

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

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

3.2 VALVES

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

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

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

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

3.3 SUPPORTING ELEMENTS INSTALLATION

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

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

Provide vibration isolation supports where needed.

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

3.4 PENETRATIONS

Provide effective sound stopping and adequate operating clearance to

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

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

3.5 SLEEVES

Provide sleeves where piping passes through roofs, masonry, concrete walls and floors.

Continuously braze sleeves passing through steel decks to the deck.

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

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

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

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

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

3.6 ESCUTCHEONS

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

3.7 FLASHINGS

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

3.8 UNDERGROUND PIPING INSTALLATION

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

Further inspect suspect cast-ferrous piping by painting with kerosene on external surfaces to reveal cracks.

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

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

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

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

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

Point bell or grooved ends of piping upstream.

Make changes in direction with long sweep fittings.

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

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

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

Properly support vertical downspouts; soil, waste, and vent stacks; water

risers; and similar work on approved piers at the base and provided with approved structural supports attached to building construction.

Provide cleanout, flushing, and observation risers.

3.9 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 . 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 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.

3.11 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.

3.12 PAINTING OF NEW EQUIPMENT

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

3.12.1 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.

3.12.2 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 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 178	30	(2002) HVAC Systems - Testing, Adjusting and Balancing, 3rd Edition
SMACNA 185	58	(2004) HVAC Sound And Vibration Manual - First Edition
SMACNA 197	72 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition

1.2 DEFINITIONS

- a. AABC: Associated Air Balance Council
- b. COTR: Contracting Officer's Technical Representative
- c. DALT: Duct air leakage test
- d. DALT'd: Duct air leakage tested
- e. HVAC: Heating, ventilating, and air conditioning; or heating, ventilating, and cooling
- f. NEBB: National Environmental Balancing Bureau
- g. Out-of-tolerance data: Pertains only to field acceptance testing of Final DALT or TAB report. When applied to DALT work, this phase means "a leakage rate measured during DALT field acceptance testing which exceeds the leakage rate allowed by SMACNA Leak Test Manual for an indicated duct construction and sealant class." When applied to TAB work this phase means "a measurement taken during TAB field acceptance testing which does not fall within the range of plus 5 to minus 5 percent of the original measurement reported on the TAB Report for a specific parameter."
- h. Season of maximum heating load: The time of year when the outdoor temperature at the project site remains within plus or minus 30 degrees Fahrenheit of the project site's winter outdoor design temperature, throughout the period of TAB data recording.
- i. Season of maximum cooling load: The time of year when the outdoor temperature at the project site remains within plus or minus 5 degrees Fahrenheit of the project site's summer outdoor design temperature, throughout the period of TAB data recording.
- j. Season 1, Season 2: Depending upon when the project HVAC is completed and ready for TAB, Season 1 is defined, thereby defining Season 2. Season 1 could be the season of maximum heating load, or the season of maximum cooling load.
- k. Sound measurements terminology: Defined in AABC MN-1, NEBB MASV, or SMACNA 1858 (TABB).
- 1. TAB: Testing, adjusting, and balancing (of HVAC systems)
- m. TAB'd: HVAC Testing/Adjusting/Balancing procedures performed

- n. TAB Agency: TAB Firm
- o. TAB team field leader: TAB team field leader
- p. TAB team supervisor: TAB team engineer
- q. TAB team technicians: TAB team assistants
- r. TABB: Testing Adjusting and Balancing Bureau
- 1.2.1 Similar Terms

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

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

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

1.3 WORK DESCRIPTION

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

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

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

1.3.1 Air Distribution Systems

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

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

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

1.3.3 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-grapheteres/form

The Testing, Adjusting, and Balancing (TAB) Specialist must review the Contract Plans and Specifications and advise the Contracting Officer of any deficiencies that would prevent the effective and accurate TAB of the system, including records of existing conditions, and systems readiness check. The TAB Specialist must provide a Design Review Report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

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

1.3.4 Related Requirements

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approavl 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

TAB Firm; G

Designation of TAB Team Assistants; G

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

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 .

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

Certified Final DALT Report; G TAB Design Review Report; G G-AE , 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 TAB Firm; G Design Review Report; G Pre-field DALT Preliminary Notification; G

Prerequisite HVAC Work Check Out List For Season 1; 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.

1.5.2 TAB Standard

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

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

1.5.3 Qualifications

1.5.3.1 TAB Firm

The TAB Firm must be either a member of AABC or certified by the NEBB or the TABB and certified in all categories and functions where measurements or performance are specified on the plans and specifications, including TAB of environmental systems .

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

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

1.5.3.2 TAB Specialist

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

1.5.3.3 TAB Specialist Responsibilities

TAB Specialist responsibilities include all TAB work specified herein and in related sections under his direct guidance. The TAB specialist is required to be onsite on a daily basis to direct TAB efforts. The TAB Specialist must participate in the commissioning process

1.5.3.4 TAB Related HVAC Submittals

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

1.5.4 Responsibilities

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

1.5.4.1 Contractor

- a. TAB personnel: Ensure that the DALT work and the TAB work is accomplished by a group meeting the requirements specified in the paragraph TAB PERSONNEL QUALIFICATION REQUIREMENTS.
- b. Pre-DALT/TAB meeting: Attend the meeting with the TAB Supervisor, and ensure that a representative is present for the sheetmetal contractor, mechanical contractor, electrical contractor, and automatic

temperature controls contractor.

- c. HVAC documentation: Furnish one complete set of the following HVAC-related documentation to the TAB agency:
 - (1) Contract drawings and specifications
 - (2) Approved submittal data for equipment
 - (3) Construction work schedule
 - (4) Up-to-date revisions and change orders for the previously listed items
- d. Submittal and work schedules: Ensure that the schedule for submittals and work required by this section and specified in the paragraph TAB SUBMITTAL AND WORK SCHEDULE is met.
- e. Coordination of supporting personnel:

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

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

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

- f. Deficiencies: Ensure that the TAB Agency supervisor submits all Design/Construction deficiency notifications directly to the Contracting officer within 3 days after the deficiency is encountered. Further, ensure that all such notification submittals are complete with explanation, including documentation, detailing deficiencies.
- g. Prerequisite HVAC work: Complete check out and debugging of HVAC equipment, ducts, and controls prior to the TAB engineer arriving at the project site to begin the TAB work. Debugging includes searching for and eliminating malfunctioning elements in the HVAC system installations, and verifying all adjustable devices are functioning as designed. Include as prerequisite work items, the deficiencies pointed out by the TAB team supervisor in the design review report.
- h. Prior to the TAB field team's arrival, ensure completion of the applicable inspections and work items listed in the TAB team supervisor's pre-field engineering report. Do not allow the TAB team to commence TAB field work until all of the following are completed.
 - (1) HVAC system installations are fully complete.
 - (2) HVAC prerequisite checkout work lists specified in the paragraph PRE-FIELD TAB ENGINEERING REPORT are completed, submitted, and approved. Ensure that the TAB Agency gets a copy of the approved

prerequisite HVAC work checklist.

- (3) DALT field checks for all systems are completed.
- (4) HVAC system filters are clean for both Season 1 and Season 2 TAB field work.
- i. Advance notice: Furnish to the Contracting Officer with advance written notice for the commencement of the DALT field work and for the commencement of the TAB field work.
- j. Insulation work: For required DALT work , ensure that insulation is not installed on ducts to be DALT'd until DALT work on the subject ducts is complete. Later, ensure that openings in duct and machinery insulation coverings for TAB test ports are marked, closed and sealed.

1.5.4.2 TAB Agency

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

- 1.5.4.3 TAB Team Supervisor
 - a. Overall management: Supervise and manage the overall TAB team work effort, including preliminary and technical DALT and TAB procedures and TAB team field work.
 - b. Pre-DALT/TAB meeting: Attend meeting with Contractor.
 - c. Design review report: Review project specifications and accompanying drawings to verify that the air systems and water systems are designed in such a way that the TAB engineer can accomplish the work in compliance with the requirements of this section. Verify the presence and location of permanently installed test ports and other devices needed, including gauge cocks, thermometer wells, flow control devices, circuit setters, balancing valves, and manual volume dampers.
 - d. Support required: Specify the technical support personnel required from the Contractor other than the TAB agency; such as factory representatives for temperature controls or for complex equipment. Inform the Contractor in writing of the support personnel needed and when they are needed. Furnish the notice as soon as the need is anticipated, either with the design review report, or the pre-field engineering report, the during the DALT or TAB field work.
 - e. Pre-field DALT preliminary notification: Monitor the completion of the duct installation of each system and provide the necessary written notification to the Contracting Officer.
 - f. Pre-field engineering report: Utilizing the following HVAC-related documentation; contract drawings and specifications, approved submittal data for equipment, up-to-date revisions and change orders; prepare this report.
 - g. Prerequisite HVAC work checklist: Ensure the Contractor gets a copy of this checklist at the same time as the pre-field engineering report

is submitted.

- h. Technical assistance for DALT work.
 - (1) Technical assistance: Provide immediate technical assistance to TAB field team.
 - (2) DALT field visit: Near the end of the DALT field work effort, visit the contract site to inspect the HVAC installation and the progress of the DALT field work. Conduct a site visit to the extent necessary to verify correct procedures are being implemented and to confirm the accuracy of the Pre-final DALT Report data which has been reported. Also, perform sufficient evaluation to allow the TAB supervisor to issue certification of the final report. Conduct the site visit full-time for a minimum of one 8 hour workday 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 8 hour workday 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 8 hour workday 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.
- 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 TAB field check.
- 1.5.4.4 TAB Team Field Leader
 - a. Field manager: Manage, in the field, the accomplishment of the work specified in Part 3, EXECUTION.
 - b. Full time: Be present at the contract site when DALT field work or TAB field work is being performed by the TAB team; ensure day-to-day TAB team work accomplishments are in compliance with this section.
 - c. Prerequisite HVAC work: Do not bring the TAB team to the contract site until a copy of the prerequisite HVAC Checklist, with all work items certified by the Contractor to be working as designed, reaches the office of the TAB Agency.
- 1.5.5 Test Reports
- 1.5.5.1 Data from DALT Field Work

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

- a. Report format: Submit report data on Air Duct Leakage Test Summary Report Forms as shown on Page 6-2 of SMACNA 1972 CD. In addition, submit in the report, a marked duct shop drawing which identifies each section of duct tested with assigned node numbers for each section. Include node numbers in the completed report forms to identify each duct section. The TAB supervisor must review and certify the report.
- b. The TAB supervisor must include a copy of all calculations prepared in determining the duct surface area of each duct test section. In addition, provide the ductwork air leak testing (DALT) reports with a copy(s) of the calibration curve for each of the DALT test orifices used for testing.
- c. Instruments: List the types of instruments actually used to measure the data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date. Instruments must have been calibrated within one year of the date of use in the field. Instrument calibration must be traceable to the measuring standards of the National Institute of Standards and Technology.
- d. Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.

1.5.5.2 Certified TAB Reports

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

a. Report format: Submit the completed pre-field data forms approved in the pre-field TAB Engineering Report completed by TAB field team, reviewed and certified by the TAB supervisor. Bind the report with a

waterproof front and back cover. Include a table of contents identifying by page number the location of each report. Report forms and report data must be typewritten. Handwritten report forms or report data are not acceptable.

- b. Temperatures: On each TAB report form reporting TAB work accomplished on HVAC thermal energy transfer equipment, include the indoor and outdoor dry bulb temperature range and indoor and outdoor wet bulb temperature range within which the TAB data was recorded. Include in the TAB report continuous time versus temperature recording data of wet and dry bulb temperatures for the rooms, or zones, as designated in the following list:
 - (1) 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 .
- 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. 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.
- e. Duct Traverses: Report duct traverses for main supply, return, exhaust, relief and outside air ducts. This includes all ducts, including those which lack 7 1/2 duct diameters upstream and 2 1/2 duct diameters downstream of straight duct unobstructed by duct fittings/offsets/elbows. The TAB Agency must evaluate and report findings on the duct traverses taken. Evaluate the suitability of the duct traverse measurement based on satisfying the qualifications for a pilot traverse plane as defined by AMCA 203, "Field Measurements", Section 8, paragraph 8.3, "Location of Traverse Plane."
- f. Instruments: List the types of instruments actually used to measure the tab data. Include in the listing each instrument's unique identification number, calibration date, and calibration expiration date.

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

- g. Certification: Include the typed name of the TAB supervisor and the dated signature of the TAB supervisor.
- h. Performance Curves: The TAB Supervisor must include, in the TAB Reports, factory pump curves and fan curves for pumps and fans TAB'd on the job.
- i. Calibration Curves: The TAB Supervisor must include, in the TAB Reports, a factory calibration curve for installed flow control balancing valves, flow venturi's and flow orifices TAB'd on the job.
- 1.6 PROJECT/SITE CONDITIONS
- 1.6.1 DALT and TAB Services to Obtain Existing Conditions

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

1.7 SEQUENCING AND SCHEDULING

1.7.1 Projects with Phased Construction

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

1.7.1.1 Phasing of Work

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

1.7.2 DALT and TAB Submittal and Work Schedule

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

Qualify TAB Personnel: Within 45 calendar days after date of contract award, submit TAB agency and personnel qualifications.

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

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

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

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

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

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

DALT Work Field Check: Upon approval of the Pre-final DALT Report,

schedule the COTR's DALT field check work with the Contracting Officer.

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

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

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:
 - 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:
 - 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 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 year contractor installation warranty.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.1 WORK DESCRIPTIONS OF PARTICIPANTS

Comply with requirements of this section.

3.2 PRE-DALT/TAB MEETING

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

3.3 DALT PROCEDURES

3.3.1 Instruments, Consumables and Personnel

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

3.3.2 Advance Notice of Pre-Final DALT Field Work

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

3.3.3 Ductwork To Be DALT'd

From each duct system indicated as subject to DALT, the COTR will randomly select sections of each completed duct system for testing by the Contractor's TAB Firm. The sections selected will not exceed 20 percent of the total measured linear footage of duct systems indicated as subject to DALT. Sections of duct systems subject to DALT will include 20 percent of main ducts, branch main ducts, branch ducts and plenums for supply, return, exhaust, and plenum ductwork.

3.3.4 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.

3.3.5 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.

3.3.6 Certified Final DALT Report

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

3.3.7 Prerequisite for TAB Field Work

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

3.4 TAB PROCEDURES

3.4.1 TAB Field Work

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

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

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.

3.4.2 Preliminary Procedures

Use the approved pre-field engineering report as instructions and procedures for accomplishing TAB field work. TAB engineer is to locate, in the field, test ports required for testing. It is the responsibility of the sheet metal contractor to provide and install test ports as required by the TAB engineer.

3.4.3 TAB Air Distribution Systems

3.4.3.1 Units With Coils

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

a. For air handlers with capacities greater than 7.5 tons (90,000 Btu) cooling, such as factory manufactured units, central built-up units

and rooftop units, conduct capacity tests in accordance with AABC MN-4, procedure 3.5, "Coil Capacity Testing."

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

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

b. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.4.3.2 Air Handling Units

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

3.4.3.3 Rooftop Air Conditioning

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

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

3.4.3.4 Heating and Ventilating Units

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

3.4.3.5 Makeup Air Units

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

3.4.3.6 Return Air Fans

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

3.4.3.7 Fan Coils

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

3.4.3.8 Exhaust Fans

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

3.4.4 TAB Water Distribution Systems

3.4.4.1 Chilled Water

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

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

3.4.4.2 Heating Hot Water

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

3.4.4.3 Dual Temperature Water

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

- 3.4.5 Sound Measurement Work
- 3.4.5.1 Areas To Be Sound Measured

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

- a. All HVAC mechanical rooms, including machinery spaces and other spaces containing HVAC power drivers and power driven equipment.
- b. All spaces sharing a common barrier with each mechanical room, including rooms overhead, rooms on the other side of side walls, and rooms beneath the mechanical room floor.
- 3.4.5.2 ProcedureMeasure 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, for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations

with the coil test reports:

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

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

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

b. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

- 3.4.7 TAB Work on Performance Tests With Seasonal Limitations
- 3.4.7.1 Performance Tests

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

3.4.7.2 Season Of Maximum Load

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

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, for the purpose of verifying that the coils meet the indicated design capacity. Submit the following data and calculations with the coil test reports:

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

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

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

b. For units with capacities of 7.5 tons (90,000 Btu) or less, such as fan coil units, duct mounted reheat coils associated with VAV terminal units, and unitary units, such as through-the-wall heat pumps:

Determine the apparent coil capacity by calculations using single point measurement of entering and leaving wet and dry bulb temperatures; submit the calculations with the coil reports.

3.4.8 Workmanship

Conduct TAB work on the HVAC systems until measured flow rates are within plus or minus 5 percent of the design flow rates as specified or indicated on the contract documents. This TAB work includes adjustment of balancing valves, balancing dampers, and sheaves. Further, this TAB work includes changing out fan sheaves and pump impellers if required to obtain air and water flow rates specified or indicated. If, with these adjustments and equipment changes, the specified or indicated design flow rates cannot be attained, contact the Contracting Officer for direction.

3.4.9 Deficiencies

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

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

3.4.10 TAB Reports

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

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

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

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

3.4.11 Quality Assurance - COTR TAB Field Acceptance Testing

3.4.11.1 TAB Field Acceptance Testing

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

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

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

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

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

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

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

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

3.4.11.2 Additional COTR TAB Field Acceptance Testing

If any of the acceptance testing measurements for a given equipment group is found not to fall within the range of plus 5 to minus 5 percent of the TAB Report data, terminate data verification for all affected data for that group. The affected data for the given group will be disapproved. Make the necessary corrections and prepare a revised TAB Report. Reschedule acceptance testing of the revised report data with the COTR.

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

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

3.4.11.3 Prerequisite for Approval

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

3.5 MARKING OF SETTINGS

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

3.6 MARKING OF TEST PORTS

The TAB team is to permanently and legibly mark and identify the location

points of the duct test ports. If the ducts have exterior insulation, make these markings on the exterior side of the duct insulation. Show the location of test ports on the as-built mechanical drawings with dimensions given where the test port is covered by exterior insulation.

-- End of Section --

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)

Residential Buildings

ASHRAE	90.1 -	SI	(2013) Except	Energy S Low-Rise	Standard Residen	for Buil tial Bui	ldir Ildi	igs Lngs
ASHRAE	90.2		(2018)	Energy-E	Efficient	Design	of	Low-Rise

ASTM INTERNATIONAL (ASTM)

ASTM	A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM	A240/A240M	(2020) 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	(2017; E 2018) Standard Specification for Cellular Glass Thermal Insulation
ASTM	C585	(2010) Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing
ASTM	C591	(2020) Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM	C592	(2016) Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM	C610	(2015) Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation
ASTM	C612	(2014; R 2019) Standard Specification for Mineral Fiber Block and Board Thermal Insulation
ASTM	C647	(2008; R 2013) Properties and Tests of Mastics and Coating Finishes for Thermal Insulation
ASTM	C755	(2019b) Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation
ASTM	C795	(2008; R 2018) Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM	C916	(2020) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM	C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM	C921	(2010) Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
ASTM	C1126	(2018) Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
ASTM	C1136	(2017a) Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
ASTM	C1710	(2011) Standard Guide for Installation of

		Flexible Closed Cell Preformed Insulation in Tube and Sheet Form
ASTM D88	32	(2012) Tensile Properties of Thin Plastic Sheeting
ASTM D28	363	(2019) Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
ASTM D55	590	(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	1	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E96	5/E96M	(2016) Standard Test Methods for Water Vapor Transmission of Materials
ASTM E22	231	(2019) Standard Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation Materials to Assess Surface Burning Characteristics
ASTM E23	336	(2020) Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems
	CALIFORNIA DEPARTMENT OF	F PUBLIC HEALTH (CDPH)
CDPH SE	CTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers
	FM GLOBAL (FM)	
FM APP (GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/
	GREEN SEAL (GS)	
GS-36		(2013) Adhesives for Commercial Use
	MANUFACTURERS STANDARDIZ INDUSTRY (MSS)	ATION SOCIETY OF THE VALVE AND FITTINGS
MSS SP-5	58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
	RACTORS ASSOCIATION (MICA)	
MICA Ins	sulation Stds	(8th Ed) National Commercial & Industrial Insulation Standards

NFPA 902	A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems		
NFPA 901	В	(2021) Standard for the Installation of Warm Air Heating and Air Conditioning Systems		
	SCIENTIFIC CERTIFICATIO	N SYSTEMS (SCS)		
SCS		SCS Global Services (SCS) Indoor Advantage		
	SOUTH COAST AIR QUALITY	MANAGEMENT DISTRICT (SCAQMD)		
SCAQMD H	Rule 1168	(2017) Adhesive and Sealant Applications		
	TECHNICAL ASSOCIATION O	F THE PULP AND PAPER INDUSTRY (TAPPI)		
TAPPI T4	403 OM	(2015) Bursting Strength of Paper		
	U.S. DEPARTMENT OF DEFE	NSE (DOD)		
MIL-A-33	316	(1987; Rev C; Am 2 1990) Adhesives, Fire-Resistant, Thermal Insulation		
MIL-A-24	4179	(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 Jun 2020) 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		

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

1.2 SYSTEM DESCRIPTION

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval.. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00

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. 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 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

2.2.2 Caulking

ASTM C920, Type S, Grade NS, Class 25, Use A.

product listed in FM APP GUIDE.

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

2.2.10 Vapor Retarder Not Required

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

2.2.11 Wire

Soft annealed ASTM A580/A580M Type 302, 304 or 316 stainless steel, 16 or 18 gauge.

2.2.12 Insulation Bands

Insulation bands shall be 1/2 inch wide; 26 gauge stainless steel.

2.2.13 Sealants

Sealants shall be chosen from the butyl polymer type, the styrene-butadiene rubber type, or the butyl type of sealants. Sealants shall have a maximum permeance of 0.02 perms based on Procedure B for ASTM E96/E96M, and a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested in accordance with ASTM E84.

2.3 PIPE INSULATION SYSTEMS

Conform insulation materials to Table 1 and minimum insulation thickness as listed in Table 2 and meet or exceed the requirements of ASHRAE 90.1 - SI. 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, $\ensuremath{\mathsf{ASTM}}$ C552, type II.

- 2.4 DUCT INSULATION SYSTEMS
- 2.4.1 Factory Applied Insulation

Provide factory-applied ASTM C552, cellular glass thermal .

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

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, and weatherproofing as specified in manufacturer's instruction. Multi-ply, Polymeric Blend Laminate Jacketing: Construction of laminate designed to provide UV

resistance, high puncture, tear resistance and an excellent WVT rate.

2.5 EQUIPMENT INSULATION SYSTEMS

Insulate equipment and accessories as specified in Tables 5 and 6. In outside locations, provide insulation 1/2 inch thicker than specified. Increase the specified insulation thickness for equipment where necessary to equal the thickness of angles or other structural members to make a smooth, exterior surface. Submit a booklet containing manufacturer's published installation instructions for the insulation systems in coordination with the submitted MICA Insulation Stds plates booklet. Annotate their installation instructions to indicate which product data and which MICA plate are applicable. The instructions must be copyrighted, have an identifying or publication number, and shall have been published prior to the issuance date of this solicitation. A booklet is also required by paragraphs titled: Pipe Insulation Systems and Duct Insulation Systems.

PART 3 EXECUTION

3.1 APPLICATION - GENERAL

Insulation shall only be applied to unheated and uncooled piping and equipment. Flexible elastomeric cellular insulation shall not be compressed at joists, studs, columns, ducts, hangers, etc. The insulation shall not pull apart after a one hour period; any insulation found to pull apart after one hour, shall be replaced.

3.1.1 Display Samples

Submit and display, after approval of materials, actual sections of installed systems, properly insulated in accordance with the specification requirements. Such actual sections must remain accessible to inspection throughout the job and will be reviewed from time to time for controlling the quality of the work throughout the construction site. Each material used shall be identified, by indicating on an attached sheet the specification requirement for the material and the material by each manufacturer intended to meet the requirement. The Contracting Officer will inspect display sample sections at the jobsite. Approved display sample sections shall remain on display at the jobsite during the construction period. Upon completion of construction, the display sample sections will be closed and sealed.

3.1.1.1 Pipe Insulation Display Sections

Display sample sections shall include as a minimum an elbow or tee, a valve, dielectric waterways and flanges, a hanger with protection shield and insulation insert, or dowel as required, at support point, method of fastening and sealing insulation at longitudinal lap, circumferential lap, butt joints at fittings and on pipe runs, and terminating points for each type of pipe insulation used on the job, and for hot pipelines and cold pipelines, both interior and exterior, even when the same type of insulation is used for these services.

3.1.1.2 Duct Insulation Display Sections

Display sample sections for rigid and flexible duct insulation used on the job. Use a temporary covering to enclose and protect display sections for duct insulation exposed to weather

3.1.2 Installation

Except as otherwise specified, material shall be installed in accordance with the manufacturer's written instructions. Insulation materials shall not be applied until tests 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 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.

3.1.4.1 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.

3.1.4.2 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.

3.1.5 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.

3.1.6 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 $\underline{\rm MSS}$ SP-58, and Section 23 05 15 COMMON PIPING FOR HVAC

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, 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.

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							
Ser	Service							
	Material	Specification	Туре	Class	VR/VB Req'd			
Chi	lled Water (Supply & Return, D	ual Temperature Piping, 40	F nomina	1)				
	Cellular Glass	ASTM C552	II	2	Yes			
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		Yes			
	Mineral Fiber with Wicking MaterialDo not use in applications exposed to outdoor ambient conditions in climatic zones 1 through 4.	ASTM C547	I		Yes			

	TABLE 1							
	Insulation Material for Piping							
Service								
	Material	Specification	Туре	Class	VR/VB Req'd			
Неа	Heating Hot Water Supply & Return, Heated Oil (Max 250 F)							
	Mineral Fiber	ASTM C547	I	1	No			
	Calcium Silicate	ASTM C533	I		No			
	Cellular Glass	ASTM C552	II	2	No			
	Faced Phenolic Foam	ASTM C1126	III		Yes			
	Perlite	ASTM C610			No			
	Flexible Elastomeric Cellular	ASTM C534/C534M	I	2	No			
Col	d Domestic Water Piping, Makeu	p Water & Drinking Fountai	n Drain	Piping				
	Cellular Glass	ASTM C552	II	2	No			
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No			
Hot	Domestic Water Supply & Recir	culating 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			
Ref	rigerant Suction Piping (35 de	grees F nominal)	1	1	1			
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No			
	Cellular Glass	ASTM C552	II	1	Yes			
Com	pressed Air Discharge, Steam a	nd Condensate Return (201	to 250 D	egrees 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			
Exp Han	osed Lavatory Drains, Exposed dicapped Personnel	Domestic Water Piping & Dr	ains to	Areas fo	r			
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No			

TABLE 1								
	Insulation Material for Piping							
Service								
	Material	Specification	Туре	Class	VR/VB Req'd			
Hor	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			
Con	densate Drain Located Inside B	uilding						
	Cellular Glass	ASTM C552	II	2	No			
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No			
Med	ium Temperature Hot Water, Ste	am and Condensate (251 to	350 Degre	ees F)	1			
	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			
Hig	h Temperature Hot Water & Stea	m (351 to 700 Degrees F)	1	1	1			
	Mineral Fiber	ASTM C547	I	2	No			
	Calcium Silicate	ASTM C533	I		No			
	Perlite	ASTM C610			No			
	Cellular Glass	ASTM C552			No			
Bri	ne Systems Cryogenics (-30 to	0 Degrees F)						
	Cellular Glass	ASTM C552	II	2	No			
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No			
Bri	ne Systems Cryogenics (0 to 34	Degrees F)						
	Cellular Glass	ASTM C552	II	2	No			
	Flexible Elastomeric Cellular	ASTM C534/C534M	I		No			
Not	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-<1.5 1.5-<4 4-<8 <1 > 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 1 1.5 1.5 2 2 Material 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 1.5 1 1.5 2 2 Material 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 N/A 1 1 1 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 N/A N/A 1 1 1 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-<1.5 1.5-<4 4-<8 <1 > or = >8 Cellular Glass 1.5 1.5 1.5 2 2 Flexible Elastomeric Cellular 1 N/A N/A 1 1 Refrigerant Suction Piping (35 degrees F nominal) Flexible Elastomeric Cellular N/A 1 1 1 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 N/A 1 1 N/A 1 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 N/A N/A 1 1 1 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-<1.5 1.5-<4 4-<8 > or = >8 <1 Cellular Glass 1.5 1.5 1.5 1.5 1.5 Flexible Elastomeric Cellular 1 1 N/A N/A 1 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 N/A N/A 1 1 1 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 4.5 4 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 N/A N/A N/A 1 Brine Systems Cryogenics (0 to 34 Degrees F) Cellular Glass 2.5 2 2 2 3 Flexible Elastomeric Cellular N/A N/A 1 1 1

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.

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.

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.

- 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 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.

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. 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 Duc	t Insulation (inches)
Cold Air Ducts	2.0
Relief Ducts	1.5
Fresh Air Intake Ducts	1.5
Warm Air Ducts	2.0
Relief Ducts	1.5
Fresh Air Intake Ducts	1.5

3.3.2 Insulation and Vapor Retarder/Vapor Barrier for Cold Air Duct

Insulation and vapor retarder/vapor barrier shall be provided for the following cold air ducts and associated equipment.

- a. Supply ducts.
- b. Return air ducts.
- c. Relief ducts.
- d. Flexible run-outs (field-insulated).
- e. Plenums.
- f. Duct-mounted coil casings.
- g. Coil headers and return bends.
- h. Coil casings.
- i. Fresh air intake ducts.
- j. Filter boxes.
- k. Mixing boxes (field-insulated).
- 1. Supply fans (field-insulated).
- m. Site-erected air conditioner casings.
- n. Ducts exposed to weather.
- o. Combustion air intake ducts.

Insulation for rectangular ducts shall be flexible type where concealed, minimum density 3/4 pcf, and rigid type where exposed, minimum density 3 pcf. Insulation for both concealed or exposed round/oval ducts shall be flexible type, minimum density 3/4 pcf or a semi rigid board, minimum density 3 pcf, formed or fabricated to a tight fit, edges beveled and joints tightly butted and staggered. Insulation for all exposed ducts shall be provided with either a white, paint-able, factory-applied Type I jacket or a field applied vapor retarder/vapor barrier jacket coating finish as specified, the total field applied dry film thickness shall be approximately 1/16 inch. Insulation on all concealed duct shall be provided with a factory-applied Type I or II vapor retarder/vapor barrier jacket. Duct insulation shall be continuous through sleeves and prepared openings except firewall penetrations. Duct insulation terminating at fire dampers, shall be continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air and which may be prone to condensate formation. Duct insulation and vapor retarder/vapor barrier shall cover the collar, neck, and any un-insulated surfaces of diffusers, registers and grills. Vapor retarder/vapor barrier materials shall be applied to form a complete unbroken vapor seal over the insulation. Sheet Metal Duct shall be sealed in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.3.2.1 Installation on Concealed Duct

- a. For rectangular, oval or round ducts, flexible insulation shall be attached by applying adhesive around the entire perimeter of the duct in 6 inch wide strips on 12 inch centers.
- b. For rectangular and oval ducts, 24 inches and larger insulation shall be additionally secured to bottom of ducts by the use of mechanical fasteners. Fasteners shall be spaced on 16 inch centers and not more than 16 inches from duct corners.
- c. For rectangular, oval and round ducts, mechanical fasteners shall be provided on sides of duct risers for all duct sizes. Fasteners shall be spaced on 16 inch centers and not more than 16 inches from duct corners.
- d. Insulation shall be impaled on the mechanical fasteners (self stick pins) where used and shall be pressed thoroughly into the adhesive. Care shall be taken to ensure vapor retarder/vapor barrier jacket joints overlap 2 inches. The insulation shall not be compressed to a thickness less than that specified. Insulation shall be carried over standing seams and trapeze-type duct hangers.
- e. Where mechanical fasteners are used, self-locking washers shall be installed and the pin trimmed and bent over.
- f. Jacket overlaps shall be secured with staples and tape as necessary to ensure a secure seal. Staples, tape and seams shall be coated with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.
- g. Breaks in the jacket material shall be covered with patches of the same material as the vapor retarder jacket. The patches shall extend not less than 2 inches beyond the break or penetration in all directions and shall be secured with tape and staples. Staples and tape joints shall be sealed with a brush coat of vapor retarder coating or PVDC adhesive tape or greater than 3 ply laminate (minimum 2 mils adhesive, 3 mils embossed) - less than 0.0000 perm adhesive tape.
- 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.
- 1. 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.

3.4 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)							
Equipm	Equipment handling media at indicated temperature							
	Material	Thickness (inches)						
35 to	60 degrees F							
	Cellular Glass	1.5						

TABLE 5	
Insulation Thickness for Cold Equipment (inch	les)
Equipment handling media at indicated temperature	
Material	Thickness (inches)
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.
- 1. 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 temp	erature 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						
Flexible Mineral Fiber	6						
Calcium Silicate/Perlite	6						
Cellular Glass	6						

TABLE 6								
	Insulation Thickness for Hot Equipment (inches)							
Equipment handling steam or media at indicated pressure or temperature limit								
	Material Thickness (inches)							
600 deg insulat substar	grees F: Thickness necessary to limit the external tempe tion to 120 F. Heat transfer calculations shall be submi ntiate insulation and thickness selection.	rature of the tted to						

3.4.3.2 Insulation of Boiler Stack and Diesel Engine Exhaust Pipe

Inside boiler House , 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 . 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							
I Boiler S	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 degree	es F)						
Mineral Fiber ASTM C585 Class B-3, ASTM C547 Class 1, or ASTM C612 Class 1	N/A	N/A	3	3.5	4		

	TABLE 7								
	Insulation and Thickness for Boiler Stack and Diesel Engine Exhaust Pipe								
Ser	vice & Surface Temperature	Range (Dec	grees F)						
	Material	Outside Diameter (Inches)							
		0.25 - 1.25	1 - 1.67	3.5-5	6 - 10	> or = 11 - 36			
	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			
Boi	l ler Stack (401 to 600 degre	es 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 Gla	ss Composi	te:		1				
	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			
Boi	ler Stack (601 to 800 degre	es F)							
	Mineral Fiber ASTM C547 Class 3, ASTM C592 Class 1, or ASTM C612 Class 3	N/A	N/A	4	4	6			

	TABLE 7							
	Insulation and Thickness for Boiler Stack and Diesel Engine Exhaust Pipe							
Ser	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		
	Calcium Silicate ASTM C533, Type I or II	N/A	N/A	4	4	6		
	Mineral Fiber/Cellular Gla	ss Composi	te:					
	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		
Die	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 09 00

INSTRUMENTATION AND CONTROL FOR HVAC 02/19, CHG 2: 02/20

PART 1 GENERAL

1.1 SUMMARY

Provide a complete Direct Digital Control (DDC) system, 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, other referenced Sections.

- 1.1.1 Proprietary Systems
- 1.1.1.1 Proprietary Systems Exempted From Open Protocol Requirements

The following systems are specifically exempted from the open protocol requirements of :

- a. A simple split (DX) system consisting of a single indoor unit and a single outdoor unit from the same manufacturer.
- b. Systems in Table I (previously approved by the designer in accordance with UFC 3-410-02).

	TABLE I: Systems Approved to Use	Proprietary Communications
System	Type (Multi-Split/VRF or Chiller/Boiler Plant)	Proprietary Multi-Split Engineering Tool Software Required (for Multi-Split/VRF only)

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

1.1.1.2 Implementation of Proprietary Systems

For proprietary systems exempted from open protocol requirements, a proprietary network and DDC hardware communicating via proprietary protocol are permitted. For these systems a building control network meeting the requirements of 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 .

1.1.1.3 Proprietary Multi-Split Engineering Tool Software

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

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

1.1.2 System Requirements

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

- a. The system implements the control sequences of operation shown in the Contract Drawings using DDC hardware to control mechanical and electrical equipment
- b. The system meet the requirements of this specification as a stand-alone system and does not require connection to any other system.
- c. Control sequences reside in DDC hardware in the building. The building control network is not dependent upon connection to a Utility Monitoring and Control System (UMCS) Front End or to any other system for performance of control sequences. To the greatest extent practical, the hardware performs control sequences without reliance on the building network.
- d. The hardware is installed such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.
- e. All necessary documentation, configuration information, programming tools, programs, drivers, and other software are licensed to and otherwise remain with the Government such that the Government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer.
- f. Sufficient documentation and data, including rights to documentation and data, are provided such that the Government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the Contractor, Vendor or Manufacturer.
- g. Hardware is installed and configured such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the Contractor, Vendor or Manufacturer.

1.1.3 End to End Accuracy

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

1.1.4 Verification of Dimensions

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

1.1.5 Drawings

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

1.2 RELATED SECTIONS

Related work specified elsewhere:

a. .

- b. Section 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC
- c. Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS

1.3 REFERENCES

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

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

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

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

(2018) 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

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-410-02 (2018; with Change 1, 2020) Direct Digital Control for HVAC and Other Building Control Systems

UNDERWRITERS LABORATORIES (UL)

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

1.4 DEFINITIONS

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

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

1.4.1 Alarm Generation (All protocols)

Alarm Generation is the monitoring of a value, comparison of the value to alarm conditions and the creation of an alarm when the conditions set for the alarm are met. Note that this does NOT include delivery of the alarm to the final destination (such as a user interface) -

1.4.2 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'.

1.4.3 Building Control Network (BCN) (All protocols)

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

1.4.4 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.)

1.4.5 Commandable (All protocols)

See Overridable.

1.4.6 Configurable (All protocols)

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

1.4.7 Control Logic Diagram (All protocols)

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

1.4.8 Digital Controller (All protocols)

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

1.4.9 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.

1.4.10 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.

1.4.11 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.

- 1.4.12 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.

1.4.13 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.

1.4.14 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".

1.4.15 I/O Expansion Unit (All protocols)

1.4.16 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.

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

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

1.4.18 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.

1.4.19 MAC Address (All protocols)

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

1.4.20 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.

1.4.21 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.

1.4.22 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).

1.4.23 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.

1.4.24 Packaged Unit (All protocols)

See packaged equipment.

1.4.25 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.

1.4.26 Polling (All protocols)

A device periodically requesting data from another device.

1.4.27 Points (All protocols)

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

1.4.28 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).

1.4.29 Repeater (All protocols)

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

1.4.30 Router (All protocols)

A device that connects two 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 and to limit network traffic.

1.4.31 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.

1.4.32 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.

1.4.33 UMCS Network (All protocols)

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

1.5 PROJECT SEQUENCING

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

- 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
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	days ACO #6
9	S	Draft As-Built Drawings	days ACO #6
10	S	Start-Up Testing Report	days ACO #6
11	S	PVT Procedures	days before schedule start of #12 and AAO #10
12	E	Execute PVT	AAO #9 and #11
13	S	PVT Report	days ACO #12

TABLE II. PROJECT SEQUENCING			
ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY OR DEADLINE FOR
14	S	Controller Application Programs Controller Configuration Settings	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	Е	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.. 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

Certificate of Networthiness Documentation; G

Programming Software; G

Proprietary Multi-Split Engineering Tool Software; G Manufacturer's Product Data; G

SD-05 Design Data

Boiler Or Chiller Plant Gateway Request

SD-06 Test Reports Existing Conditions Report

Start-Up Testing Report; G

PVT Procedures; G

PVT Report; G

Pre-Construction Quality Control (QC) Checklist; G

Post-Construction Quality Control (QC) Checklist; 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 PROGRAMMING SOFTWARE

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 Certificate of Networthiness Documentation

For all software provided, provide documentation that an Enterprise Certificate of Networthiness exists, that a Limited Certificate of Networthiness for the project site exists, or provide a completed Certificate of Networthiness "Application Checklist". Submit Certificate of Networthiness Documentation in PDF format on CD-ROM.

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 network.

1.10 QUALITY CONTROL CHECKLISTS

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, 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, , or this Section. Provide product data for all products in a single indexed compendium, organized by product type.

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Submit Manufacturer's Product Data 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:
 - 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 requirements.

2.5.2 Mechanical and Electrical Rooms

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

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 inchesorA3 17 by 11 inches sheets, and electronic drawings in PDF and in 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: <u>http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/ufgs-23-09-00</u> 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).

3.3.10 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 Configuration Information

Indicate the means of configuration associated with each point.

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

Provide HVAC control system sequence of operation and in the same format as the Contract Drawings. Within these drawings, refer to devices by their unique identifiers. Submit sequences of operation 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 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).

3.6 PERFORMANCE VERIFICATION TEST (PVT)

3.6.1 PVT Procedures

Prepare PVT Procedures 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 Endurance Test

Include a one-week endurance test as part of the PVT during which the system is operated continuously.

3.6.1.3 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.

3.7 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Provide HVAC control System Operation and Maintenance Instructions which include:

- a. "Data Package 3" as indicated in Section 01 78 23 OPERATION AND MAINTENANCE DATA for each piece of control equipment.
- b. "Data Package 4" as described in Section 01 78 23 OPERATION AND MAINTENANCE DATA for all air compressors.
- c. HVAC control system sequences of operation formatted as indicated.
- d. Procedures for the HVAC system start-up, operation and shut-down including the manufacturer's supplied procedures for each piece of equipment, and procedures for the overall HVAC system.
- e. As-built HVAC control system detail drawings formatted as indicated.
- f. Routine maintenance checklist. Provide the routine maintenance

checklist arranged in a columnar format, where the first column lists all installed devices, the second column states the maintenance activity or that no maintenance required, the third column states the frequency of the maintenance activity, and the fourth column is used for additional comments or reference.

- g. Qualified service organization list, including at a minimum company name, contact name and phone number.
- h. Start-Up Testing Report.
- i. Performance Verification Test (PVT) Procedures and Report.

Submit 2 copies of the Operation and Maintenance Instructions, indexed and in booklet form. The Operation and Maintenance Instructions may be submitted as a Technical Data Package.

3.8 MAINTENANCE AND SERVICE

Provide services, materials and equipment as necessary to maintain the entire system in an operational state as indicated for a period of one year after successful completion and acceptance of the Performance Verification Test. Minimize impacts on facility operations.

- a. The integration of the system specified in this section into a Utility Monitoring and Control System must not, of itself, void the warranty or otherwise alter the requirement for the one year maintenance and service period. Integration into a UMCS includes but is not limited to establishing communication between devices in the control system and the front end or devices in another system.
- b. The changing of configuration properties must not, of itself, void the warranty or otherwise alter the requirement for the one year maintenance and service period.

3.8.1 Description of Work

Provide adjustment and repair of the system including the manufacturer's required sensor and actuator (including transducer) calibration, span and range adjustment.

3.8.2 Personnel

Use only service personnel qualified to accomplish work promptly and satisfactorily. Advise the Government in writing of the name of the designated service representative, and of any changes in personnel.

3.8.3 Scheduled Inspections

Perform two inspections at six-month intervals and provide work required. Perform inspections in June and December. During each inspection perform the indicated tasks:

- a. Perform visual checks and operational tests of equipment.
- b. Clean control system equipment including interior and exterior surfaces.
- c. Check and calibrate each field device. Check and calibrate 50 percent

of the total analog inputs and outputs during the first inspection. Check and calibrate the remaining 50 percent of the analog inputs and outputs during the second major inspection. Certify analog test instrumentation accuracy to be twice the specified accuracy of the

device being calibrated. Randomly check at least 25 percent of all binary inputs and outputs for proper operation during the first inspection. Randomly check at least 25 percent of the remaining binary inputs and outputs during the second inspection. If more than 20 percent of checked inputs or outputs failed the calibration check during any inspection, check and recalibrate all inputs and outputs during that inspection.

- d. Run system software diagnostics and correct diagnosed problems.
- e. Resolve any previous outstanding problems.

3.8.4 Scheduled Work

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

3.8.5 Emergency Service

The Government will initiate service calls when the system is not functioning properly. Qualified personnel must be available to provide service to the system. A telephone number where the service supervisor can be reached at all times must be provided. Service personnel must be at the site within 24 hours after receiving a request for service. The control system must be restored to proper operating condition

3.8.6 Operation

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

3.8.7 Records and Logs

Keep dated records and logs of each task, with cumulative records for each major component, and for the complete system chronologically. Maintain a continuous log for all devices, including initial analog span and zero calibration values and digital points. Keep complete logs and provide logs for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

3.8.8 Work Requests

Record each service call request as received and include its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. Submit a record of the work performed within 5 days after work is accomplished.

3.8.9 System Modifications

Submit recommendations for system modification in writing. Do not make system modifications, including operating parameters and control settings, without prior approval of the Government.

3.9 TRAINING

Conduct a training course for operating staff members designated by the Government in the maintenance and operation of the system, including specified hardware and software. Conduct 32hours of training at the project site within 30 days after successful completion of the performance verification test. The Government reserves the right to make audio and visual recordings (using Government supplied equipment) of the training sessions for later use. Provide audiovisual equipment and other training materials and supplies required to conduct training. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

3.9.1 Training Documentation

Prepare training documentation consisting of:

- a. Course Attendee List: Develop the list of course attendees in coordination with and signed by the shop supervisor.
- b. Training Manuals: Provide training manuals which include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. When presenting portions of the course material by audiovisuals, deliver copies of those audiovisuals as a part of the printed training manuals.

3.9.2 Training Course Content

For guidance in planning the required instruction, assume that attendees will have a high school education, and are familiar with HVAC systems. During the training course, cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each controller enclosure, the layout of one of each type of equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, and repair procedures. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. Present the results of the performance verification test and the Start-Up Testing Report as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

3.9.3 Training Documentation Submittal Requirements

Submit hardcopy training manuals and all training materials on CD-ROM. Provide one hardcopy manual for each trainee on the Course Attendee List and 2 additional copies for archive at the project site. Provide 2 copies of the Course Attendee List with the archival copies. Training Documentation may be submitted as a Technical Data Package.

APPENDIX A

-- End of Section --

SECTION 23 09 13

INSTRUMENTATION AND CONTROL DEVICES FOR HVAC 11/15, CHG 1: 11/20

PART 1 GENERAL

1.1 SUMMARY

This section provides for the instrumentation control system components excluding direct digital controllers, network controllers, gateways etc. that are necessary for a completely functional automatic control system. When combined with a Direct Digital Control (DDC) system, the Instrumentation and Control Devices covered under this section must be a complete system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and indicated.

- a. Install hardware to perform the control sequences as specified and indicated and to provide control of the equipment as specified and indicated.
- b. Install hardware such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.
- c. Install and configure hardware such that the Government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the installing Contractor.

1.1.1 Verification of Dimensions

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

1.1.2 Drawings

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

1.2 RELATED SECTIONS

Related work specified elsewhere.

Section 01 30 00 ADMINISTRATIVE REQUIREMENTS

Section 23 30 00 HVAC AIR DISTRIBUTION

Section 23 05 15 COMMON PIPING FOR HVAC

Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

1.3 REFERENCES

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

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

- AMCA 500-D (2018) Laboratory Methods of Testing Dampers for Rating
- AMCA 511 (2010; R 2016) Certified Ratings Program for Air Control Devices

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 ((2014; Errata 2016) Electric Meters -Code for Electricity Metering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.15 (2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250 ASME B16.18 (2018) Cast Copper Alloy Solder Joint Pressure Fittings ASME B16.22 (2018) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings ASME B16.26 (2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes (2017) Valves - Flanged, Threaded and ASME B16.34 Welding End ASME B40.100 (2013) Pressure Gauges and Gauge Attachments (2019) BPVC Section VIII-Rules for ASME BPVC SEC VIII D1

Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM	A269/A269M	(2015; R 2019) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM	A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM	B32	(2020) Standard Specification for Solder Metal
ASTM	B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM	B88	(2020) Standard Specification for Seamless

LEE CDC (BUILDING 140)

Copper Water Tube

ASTM D635	(2018) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position	
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics	
ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement	
ASTM D1238	(2013) Melt Flow Rates of Thermoplastics by Extrusion Plastometer	
ASTM D1693	(2015) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics	
FLUID CONTROLS INSTITUT	E (FCI)	
FCI 70-2	(2013) Control Valve Seat Leakage	
INSTITUTE OF ELECTRICAL	AND ELECTRONICS ENGINEERS (IEEE)	
IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book	
INTERNATIONAL SOCIETY O	F AUTOMATION (ISA)	
ISA 7.0.01	(1996) Quality Standard for Instrument Air	
NATIONAL ELECTRICAL MAN	UFACTURERS ASSOCIATION (NEMA)	
ANSI C12.20	(2015; E 2018) Electricity Meters - 0.1, 0.2, and 0.5 Accuracy Classes	
NEMA 250	(2018) Enclosures for Electrical Equipment (1000 Volts Maximum)	
NEMA/ANSI C12.10	(2011) Physical Aspects of Watthour Meters - Safety Standards	
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)		
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code	
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems	
UNDERWRITERS LABORATORIES (UL)		
UL 94	(2013; Reprint Jun 2020) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and	

Appliances

UL 555	(2006; Reprint Aug 2016) UL Standard for Safety Fire Dampers
UL 555S	(2014; Reprint Oct 2020) UL Standard for Safety Smoke Dampers
UL 1820	(2004; Reprint May 2013) UL Standard for Safety Fire Test of Pneumatic Tubing for Flame and Smoke Characteristics
UL 5085-3	(2006; Reprint Nov 20121) Low Voltage Transformers - Part 3: Class 2 and Class 3 Transformers

1.4 SUBMITTALS

Submittal requirements are specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

1.5 DELIVERY AND STORAGE

Store and protect products from the weather, humidity, and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer.

1.6 INPUT MEASUREMENT ACCURACY

Select, install and configure sensors, transmitters and DDC Hardware such that the maximum error of the measured value at the input of the DDC hardware is less than the maximum allowable error specified for the sensor or instrumentation.

1.7 SUBCONTRACTOR SPECIAL REQUIREMENTS

Perform all work in this section in accordance with the paragraph entitled CONTRACTOR SPECIAL REQUIREMENTS in Section 01 30 00 ADMINISTRATIVE REQUIREMENTS.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 General Requirements

All products used to meet this specification must meet the indicated requirements, but not all products specified here will be required by every project. All products must meet the requirements both Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and this Section.

2.1.2 Operation Environment Requirements

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

2.1.2.1 Pressure

Pressure conditions normally encountered in the installed location.

2.1.2.2 Vibration

Vibration conditions normally encountered in the installed location.

2.1.2.3 Temperature

- a. Products installed indoors: Ambient temperatures in the range of 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.
- b. Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of -35 to +151 degrees F and temperature conditions outside this range normally encountered at the installed location.

2.1.2.4 Humidity

10 to 95 percent relative humidity, non-condensing and also humidity conditions outside this range normally encountered at the installed location.

2.2 WEATHERSHIELDS

Provide weathershields constructed of galvanized steel painted white, unpainted aluminum, aluminum painted white, or white PVC.

2.3 TUBING

2.3.1 Copper

Provide ASTM B75/B75M or ASTM B88 rated tubing meeting the following requirements:

- a. For tubing 0.375 inch outside diameter and larger provide tubing with minimum wall thickness equal to ASTM B88, Type M
- b. For tubing less than 0.375 inch outside diameter provide tubing with minimum wall thickness of 0.025 inch
- c. For exposed tubing and tubing for working pressures greater than 30 psig provide hard copper tubing.
- d. Provide fittings which are ASME B16.18 or ASME B16.22 solder type using ASTM B32 95-5 tin-antimony solder, or which are ASME B16.26 compression type.

2.3.2 Stainless Steel

For stainless steel tubing provide tubing conforming to ASTM A269/A269M

2.3.3 Plastic

Provide plastic tubing with the burning characteristics of linear low-density polyethylene tubing which is self-extinguishing when tested in accordance with ASTM D635, has UL 94 V-2 flammability classification or better, and which withstands stress cracking when tested in accordance with ASTM D1693. Provide plastic-tubing bundles with Mylar barrier and flame-retardant polyethylene jacket.

2.3.4 Polyethylene Tubing

Provide flame-resistant, multiple polyethylene tubing in flame-resistant protective sheath with mylar barrier, or unsheathed polyethylene tubing in rigid metal, intermediate metal, or electrical metallic tubing conduit for areas where tubing is exposed. Single, unsheathed, flame-resistant polyethylene tubing may be used where concealed in walls or above ceilings and within control panels. Do not provide polyethylene tubing for smoke removal systems, or for systems with working pressures over 30 psig. Provide compression or brass barbed push-on type fittings. Provide extruded seamless polyethylene tubing conforming to the following:

- a. Minimum Burst Pressure Requirements: 100 psig at 75 degrees F to 25 psig at 150 degrees F.
- b. Stress Crack Resistance: ASTM D1693, 200 hours minimum.
- c. Tensile Strength (Minimum): ASTM D638, 1100 psi.
- d. Flow Rate (Average): ASTM D1238, 0.30 decigram per minute.
- e. Density (Average): ASTM D792, 57.5 pounds per cubic feet.
- f. Burn rate: ASTM D635
- g. Flame Propagation: UL 1820, less than 5 feet ASTM D635
- h. Average Optical Density: UL 1820, less than 0.15 ASTM D635

2.4 WIRE AND CABLE

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

2.4.1 Terminal Blocks

For terminal blocks which are not integral to other equipment, provide terminal blocks which are insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, suitable for DIN rail mounting, and which have enclosed sides or end plates and partition plates for separation.

2.4.2 Control Wiring for Binary Signals

For Control Wiring for Binary Signals, provide 18 AWG copper or thicker wire rated for 300-volt service.

2.4.3 Control Wiring for Analog Signals

For Control Wiring for Analog Signals, provide 18 AWG or thicker, copper, single- or multiple-twisted wire meeting the following requirements:

- a. minimum 2 inch lay of twist
- b. 100 percent shielded pairs

- c. at least 300-volt insulation
- d. each pair has a 20 AWG tinned-copper drain wire and individual overall pair insulation
- e. cables have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.
- 2.4.4 Power Wiring for Control Devices

For 24-volt circuits, provide insulated copper 18 AWG or thicker wire rated for 300 VAC service. For 120-volt circuits, provide 14 AWG or thicker stranded copper wire rated for 600-volt service.

2.4.5 Transformers

Provide UL 5085-3 approved transformers. Select transformers sized so that the connected load is no greater than 80 percent of the transformer rated capacity.

2.5 AUTOMATIC CONTROL VALVES

Provide valves with stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Provide valves with bodies meeting ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure. Unless otherwise specified or indicated, provide valves meeting FCI 70-2 Class III leakage rating. Provide valves rated for modulating or two-position service as indicated, which close against a differential pressure indicated as the Close-Off pressure and which are Normally-Open, Normally-Closed, or Fail-In-Last-Position as indicated.

2.5.1 Valve Type

2.5.1.1 Liquid Service 150 Degrees F or Less

Use either globe valves or ball valves except that butterfly valves may be used for sizes 4 inch and larger.

- 2.5.1.2 Liquid Service Above 150 Degrees F
 - a. Two-position values: Use either globe values or ball values except that butterfly values may be used for sizes 4 inch and larger.
 - b. Modulating valves: Use globe valves except that butterfly valves may be used for sizes 4 inch and larger.
- 2.5.1.3 Steam Service

Use globe valves except that butterfly valves may be used for sizes 4 inch and larger.

- 2.5.2 Valve Flow Coefficient and Flow Characteristic
- 2.5.2.1 Two-Way Modulating Valves

Provide the valve coefficient (Cv) indicated. Provide equal-percentage

flow characteristic for liquid service except for butterfly valves. Provide linear flow characteristic for steam service except for butterfly valves.

2.5.2.2 Three-Way Modulating Valves

Provide the valve coefficient (Cv) indicated. Provide linear flow characteristic with constant total flow throughout full plug travel.

2.5.3 Two-Position Valves

Use full line size full port valves with maximum available (Cv).

- 2.5.4 Globe Valves
- 2.5.4.1 Liquid Service Not Exceeding 150 Degrees F
 - a. Valve body and body connections:
 - (1) valves 1-1/2 inches and smaller: brass or bronze body, with threaded or union ends
 - (2) valves from 2 inches to 3 inches inclusive: brass, bronze, or iron bodies. 2 inch valves with threaded connections; 2-1/2 to 3 inches valves with flanged connections
 - b. Internal valve trim: Brass or bronze.
 - c. Stems: Stainless steel.
 - d. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol.
- 2.5.4.2 Liquid Service Not Exceeding 250 Degrees F
 - a. Valve body and body connections:

(1) valves 1-1/2 inches and smaller: brass or bronze body, with threaded or union ends

(2) values from 2 inches to 3 inches inclusive: brass, bronze, or iron bodies. 2 inch values with threaded connections; 2-1/2 to 3 inches values with flanged connections

- b. Internal trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.
- c. Provide valves with non-metallic parts suitable for a minimum continuous operating temperature of 250 degrees F or 50 degrees F above the system design temperature, whichever is higher.
- d. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol

2.5.4.3 Hot water service 250 Degrees F and above

Provide valve bodies conforming to ASME B16.34 Class 300. For valves
1 inch and larger provide valves with bodies which are carbon steel,
globe type with welded ends. For valves smaller than 1 inch provide
valves with socket-weld ends. Provide valves with virgin polytetrafluoroethylene (PTFE) packing. Provide valve and actuator combinations which are normally closed.

b. Internal trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.

2.5.4.4 Steam Service

For steam service, provide valves meeting the following requirements:

a. Valve body and connections:

(1) values 1-1/2 inches and smaller: complete body of brass or bronze, with threaded or union ends

(2) valves from 2 inches to 3 inches inclusive: body of brass, bronze, or carbon steel

(3) values 4 inches and larger: body of carbon steel. 2 inch values with threaded connections; values2-1/2 inches and larger with flanged connections.

- b. Internal Trim: Type 316 stainless steel including seats, seat rings, modulation plugs, valve stems, and springs.
- c. Valve sizing: sized for 15 psig inlet steam pressure with a maximum 12 psi differential through the valve at rated flow, except where indicated otherwise.

2.5.5 Ball Valves

- 2.5.5.1 Liquid Service Not Exceeding 150 Degrees F
 - a. Valve body and connections:

(1) values 1-1/2 inches and smaller: bodies of brass or bronze, with threaded or union ends

(2) values from 2 inches to 3 inches inclusive: bodies of brass, bronze, or iron. 2 inch values with threaded connections; values from 2-1/2 to 3 inches with flanged connections.

- b. Ball: Stainless steel or nickel-plated brass or chrome-plated brass.
- c. Seals: Reinforced Teflon seals and EPDM O-rings.
- d. Stem: Stainless steel, blow-out proof.
- e. Provide valves compatible with a solution of 50 percent ethylene or propylene glycol.

2.5.6 Butterfly Valves

Provide butterfly valves which are threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies or with ductile iron bodies in accordance with ASTM A536. Provide butterfly valves with non-corrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from -20

to +250 degrees F. Provide values with rated Cv of the Cv at 70 percent (60 degrees) open position. Provide values meeting FCI 70-2 Class VI leakage rating.

2.5.7 Pressure Independent Control Valves (PICV)

Provide pressure independent control valves which include a regulator valve which maintains the differential pressure across a flow control valve. Pressure independent control valves must accurately control the flow from 0-100 percent full rated flow regardless of changes in the piping pressure and not vary the flow more than plus or minus 5 percent at any given flow control valve position when the PICV differential pressure lies between the manufacturer's stated minimum and maximum. The rated minimum differential pressure for steady flow must not exceed 5 psid across the PICV. Provide either globe or ball type valves meeting the indicated requirements for globe and ball valves. Provide valves with a flow tag listing full rated flow and minimum required pressure drop. Provide valves with factory installed Pressure/Temperature ports ("Pete's Plugs") to measure the pressure drop to determine the valve flow rate.

2.5.8 Duct-Coil and Terminal-Unit-Coil Valves

For duct or terminal-unit coils provide control valves with either flare-type or solder-type ends. Provide flare nuts for each flare-type end valve.

- 2.6 DAMPERS
- 2.6.1 Damper Assembly

Provide single damper sections with blades no longer than 48 inches and which are no higher than 72 inches and damper blade width of 8 inches or less. When larger sizes are required, combine damper sections. Provide dampers made of steel, or other materials where indicated and with assembly frames constructed of 0.07 inch minimum thickness galvanized steel channels with mitered and welded corners. Steel channel frames constructed of 0.06 inch minimum thickness are acceptable provided the corners are reinforced.

- a. Flat blades must be made rigid by folding the edges. Blade-operating linkages must be within the frame so that blade-connecting devices within the same damper section must not be located directly in the air stream.
- b. Damper axles must be 1/2 inch minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically must be supported by thrust bearings.
- c. Provide dampers which do not exceed a pressure drop through the damper of 0.04 inches water gauge at 1000 ft/min in the wide-open position. Provide dampers with frames not less than 2 inch in width. Provide dampers which have been tested in accordance with AMCA 500-D.

2.6.2 Operating Linkages

For operating links external to dampers, such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, provide links able to withstand a load equal to at least 300 percent of the maximum required damper-operating force without deforming.

Rod lengths must be adjustable. Links must be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises must be brass, bronze, or stainless steel. Adjustments of crank arms must control the open and closed positions of dampers.

2.6.3 Damper Types

2.6.3.1 Flow Control Dampers

Provide parallel-blade or opposed blade type dampers for outside air, return air, relief air, exhaust, face and bypass dampers as indicated on the Damper Schedule. Blades must have interlocking edges. The channel frames of the dampers must be provided with jamb seals to minimize air leakage. Unless otherwise indicated, dampers must meet AMCA 511 Class 1A requirements. Outside air damper seals must be suitable for an operating temperature range of -40 to +167 degrees F. Dampers must be rated at not less than 2000 ft/min air velocity.

2.6.3.2 Mechanical Rooms and Other Utility Space Ventilation Dampers

Provide utility space ventilation dampers as indicated. Unless otherwise indicated provide AMCA 511 class 3 dampers. Provide dampers rated at not less than 1500 ft/min air velocity.

2.6.3.3 Smoke Dampers

Provide smoke-damper and actuator assemblies which meet the current requirements of NFPA 90A, UL 555, and UL 555S. For combination fire and smoke dampers provide dampers rated for 250 degrees F Class II leakage per UL 555S.

2.7 SENSORS AND INSTRUMENTATION

Unless otherwise specified, provide sensors and instrumentation which incorporate an integral transmitter. Sensors and instrumentation, including their transmitters, must meet the specified accuracy and drift requirements at the input of the connected DDC Hardware's analog-to-digital conversion.

2.7.1 Analog and Binary Transmitters

Provide transmitters which match the characteristics of the sensor. Transmitters providing analog values must produce a linear 4-20 mAdc, 0-10 Vdc signal corresponding to the required operating range and must have zero and span adjustment. Transmitters providing binary values must have dry contacts rated at 1A at 24 Volts AC.

2.7.2 Network Transmitters

Sensors and Instrumentation incorporating an integral network connection are considered DDC Hardware and must meet the DDC Hardware requirements of these specifications

2.7.3 Temperature Sensors

Provide the same sensor type throughout the project. Temperature sensors may be provided without transmitters. Where transmitters are used, the range must be the smallest available from the manufacturer and suitable for the application such that the range encompasses the expected range of temperatures to be measured. The end to end accuracy includes the combined effect of sensitivity, hysteresis, linearity and repeatability between the measured variable and the end user interface (graphic presentation) including transmitters if used.

- 2.7.3.1 Sensor Accuracy and Stability of Control
- 2.7.3.1.1 Conditioned Space Temperature

Plus or minus 0.5 degree F over the operating range.

- 2.7.3.1.2 Unconditioned Space Temperature
 - a. Plus or minus 1 degree F over the range of 30 to 131 degrees F AND
 - b. Plus or minus 4 degrees F over the rest of the operating range.
- 2.7.3.1.3 Duct Temperature

Plus or minus 0.5 degree F

- 2.7.3.1.4 Outside Air Temperature
 - a. Plus or minus 2 degrees F over the range of -30 to +130 degrees F AND
 - b. Plus or minus 1 degree F over the range of 30 to 130 degrees F.
- 2.7.3.1.5 High Temperature Hot Water

Plus or minus 3.6 degrees F.

2.7.3.1.6 Chilled Water

Plus or minus 0.8 degrees F over the range of 35 to 65 degrees F.

2.7.3.1.7 Dual Temperature Water

Plus or minus 2 degrees F.

2.7.3.1.8 Heating Hot Water

Plus or minus 2 degrees F.

2.7.3.1.9 Condenser Water

Plus or minus 2 degrees F.

2.7.3.2 Transmitter Drift

The maximum allowable transmitter drift: 0.25 degrees F per year.

2.7.3.3 Point Temperature Sensors

Point Sensors must be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.

2.7.3.4 Temperature Sensor Details

2.7.3.4.1 Room Type

Provide the sensing element components within a decorative protective cover suitable for surrounding decor.

2.7.3.4.2 Duct Probe Type

Ensure the probe is long enough to properly sense the air stream temperature.

2.7.3.4.3 Duct Averaging Type

Continuous averaging sensors must be one foot in length for each 1 square foot of duct cross-sectional area, and a minimum length of 5 feet.

2.7.3.4.4 Pipe Immersion Type

Provide minimum 3 inch immersion. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells must be stainless steel when used in steel piping, and brass when used in copper piping.

2.7.3.4.5 Outside Air Type

Provide the sensing element rated for outdoor use

2.7.4 Relative Humidity Sensor

Relative humidity sensors must use bulk polymer resistive or thin film capacitive type non-saturating sensing elements capable of withstanding a saturated condition without permanently affecting calibration or sustaining damage. The sensors must include removable protective membrane filters. Where required for exterior installation, sensors must be capable of surviving below freezing temperatures and direct contact with moisture without affecting sensor calibration. When used indoors, the sensor must be capable of being exposed to a condensing air stream (100 percent relative humidity) with no adverse effect to the sensor's calibration or other harm to the instrument. The sensor must be of the wall-mounted or duct-mounted type, as required by the application, and must be provided with any required accessories. Sensors used in duct high-limit applications must have a bulk polymer resistive sensing element. Duct-mounted sensors must be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. Relative humidity (RH) sensors must measure relative humidity over a range of 0 percent to 100 percent with an accuracy of plus or minus 2 percent. RH sensors must function over a temperature range of 40 to 135 degrees F and must not drift more than 1 percent per year.

2.7.5 Carbon Dioxide (CO2) Sensors

Provide photometric type CO2 sensors with integral transducers and linear output. Carbon dioxide (CO2) sensors must measure CO2 concentrations between 0 to 2000 parts per million (ppm) using non-dispersible infrared (NDIR) technology with an accuracy of plus or minus 50 ppm and a maximum response time of 1 minute. The sensor must be rated for operation at ambient air temperatures within the range of 32 to 122 degrees F and relative humidity within the range of 20 to 95 percent (non-condensing).

The sensor must have a maximum drift of 2 percent per year. The sensor chamber must be manufactured with a non-corrosive material that does not affect carbon dioxide sample concentration. Duct mounted sensors must be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. The sensor must have a calibration interval no less than 5 years.

2.7.6 Differential Pressure Instrumentation

2.7.6.1 Differential Pressure Sensors

Provide Differential Pressure Sensors with ranges as indicated or as required for the application. Pressure sensor ranges must not exceed the high end range indicated on the Points Schedule by more than 50 percent. The over pressure rating must be a minimum of 150 percent of the highest design pressure of either input to the sensor. The accuracy must be plus or minus 1 percent of full scale. The sensor must have a maximum drift of 2 percent per year

2.7.6.2 Differential Pressure Switch

Provide differential pressure switches with a user-adjustable setpoint which are sized for the application such that the setpoint is between 25 percent and 75 percent of the full range. The over pressure rating must be a minimum of 150 percent of the highest design pressure of either input to the sensor. The switch must have two sets of contacts and each contact must have a rating greater than it's connected load. Contacts must open or close upon rise of pressure above the setpoint or drop of pressure below the setpoint as indicated.

- 2.7.7 Flow Sensors
- 2.7.7.1 Airflow Measurement Array (AFMA)
- 2.7.7.1.1 Airflow Straightener

Provide AFMAs which contain an airflow straightener if required by the AFMA manufacturer's published installation instructions. The straightener must be contained inside a flanged sheet metal casing, with the AFMA located as specified according to the published recommendation of the AFMA manufacturer. In the absence of published documentation, provide airflow straighteners if there is any duct obstruction within 5 duct diameters upstream of the AFMA. Air-flow straighteners, where required, must be constructed of 0.125 inch aluminum honeycomb and the depth of the straightener must not be less than 1.5 inches.

2.7.7.1.2 Resistance to Airflow

The resistance to air flow through the AFMA, including the airflow straightener must not exceed 0.085 inch water gauge at an airflow of 2,000 fpm. AFMA construction must be suitable for operation at airflows of up to 5000 fpm over a temperature range of 40 to 120 degrees F.

2.7.7.1.3 Outside Air Temperature

In outside air measurement or in low-temperature air delivery applications, provide an AFMA certified by the manufacturer to be accurate as specified over a temperature range of -20 to +120 degrees F .

2.7.7.1.4 Pitot Tube AFMA

Each Pitot Tube AFMA must contain an array of velocity sensing elements. The velocity sensing elements must be of the multiple pitot tube type with averaging manifolds. The sensing elements must be distributed across the duct cross section in the quantity and pattern specified or recommended by the published installation instructions of the AFMA manufacturer.

- a. Pitot Tube AFMAs for use in airflows over 600 fpm must have an accuracy of plus or minus 5 percent over a range of 500 to 2500 fpm.
- b. Pitot Tube AFMAs for use in airflows under 600 fpm must have an accuracy of plus or minus 5 percent over a range of 125 to 2500 fpm.

2.7.7.1.5 Electronic AFMA

Each electronic AFMA must consist of an array of velocity sensing elements of the resistance temperature detector (RTD) or thermistor type. The sensing elements must be distributed across the duct cross section in the quantity and pattern specified or recommended by the published application data of the AFMA manufacturer. Electronic AFMAs must have an accuracy of plus or minus 5 percent over a range of 125 to 5,000 fpm and the output must be temperature compensated over a range of 32 to 212 degrees F.

2.7.7.1.6 Fan Inlet Measurement Devices

Fan inlet measurement devices cannot be used unless indicated on the drawings or schedules.

2.7.7.2 Orifice Plate

Orifice plate must be made of an austenitic stainless steel sheet of 0.125 inch nominal thickness with an accuracy of plus or minus 1 percent of full flow. The orifice plate must be flat within 0.002 inches. The orifice surface roughness must not exceed 20 micro-inches. The thickness of the cylindrical face of the orifice must not exceed 2 percent of the pipe inside diameter or 12.5 percent of the orifice diameter, whichever is smaller. The upstream edge of the orifice must be square and sharp. Where orifice plates are used, concentric orifice plates must be used in all applications except steam flow measurement in horizontal pipelines.

2.7.7.3 Flow Nozzle

Flow nozzle must be made of austenitic stainless steel with an accuracy of plus or minus 1 percent of full flow. The inlet nozzle form must be elliptical and the nozzle throat must be the quadrant of an ellipse. The thickness of the nozzle wall and flange must be such that distortion of the nozzle throat from strains caused by the pipeline temperature and pressure, flange bolting, or other methods of installing the nozzle in the pipeline must not cause the accuracy to degrade beyond the specified limit. The outside diameter of the nozzle flange or the design of the flange facing must be such that the nozzle throat must be centered accurately in the pipe.

2.7.7.4 Venturi Tube

Venturi tube must be made of cast iron or cast steel and must have an accuracy of plus or minus 1 percent of full flow. The throat section must be lined with austenitic stainless steel. Thermal expansion

characteristics of the lining must be the same as that of the throat casting material. The surface of the throat lining must be machined to a plus or minus 50 micro inch finish, including the short curvature leading from the converging entrance section into the throat.

2.7.7.5 Annular Pitot Tube

Annular pitot tube must be made of austenitic stainless steel with an accuracy of plus or minus 2 percent of full flow and a repeatability of plus or minus 0.5 percent of measured value. The unit must have at least one static port and no less than four total head pressure ports with an averaging manifold.

2.7.7.6 Insertion Turbine Flowmeter

Provide dual axial turbine flowmeter with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. All parts must meet or exceed the pressure classification of the pipe system it is installed in. Insertion Turbine Flowmeter accuracy must be plus or minus 0.5 percent of rate at calibrated velocity., within plus or minus of rate over a 10:1 turndown and within plus or minus 2 percent of rate over a 50:1 turndown. Repeatability must be plus or minus 0.25 percent of reading. The meter flow sensing element must operate over a range suitable for the installed location with a pressure loss limited to 1 percent of operating pressure at maximum flow rate. The flowmeter ,must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc outputs. The turbine rotor assembly must be constructed of Series 300 stainless steel and use Teflon seals.

2.7.7.7 Vortex Shedding Flowmeter

Vortex Shedding Flowmeter accuracy must be within plus or minus 0.8 percent of the actual reading over the range of the meter. Steam meters must contain density compensation by direct measurement of temperature. Mass flow inferred from specified steam pressure are not acceptable. The flow meter body must be made of austenitic stainless steel and include a weather tight NEMA 4X electronics enclosure. The vortex shedding flowmeter body must not require removal from the piping in order to replace the shedding sensor.

2.7.7.8 Ultrasonic Flow Meter

Provide Ultrasonic Flow Meters complete with matched transducers, self aligning installation hardware and transducer cables. Ultrasonic transducers must be optimized for the specific pipe and process conditions for the application. The flow meter accuracy must plus or minus 1 percent of rate from 0 to 40 ft/sec. The flowmeter must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc output.

2.7.7.9 Insertion Magnetic Flow Meter

Provide insertion type magnetic flowmeters with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. All parts must meet or exceed the pressure classification of the pipe system it is installed in. Flowmeter accuracy must be no greater than plus or minus 1 percent of rate from 2 to 20 feet/sec. Wetted material parts must be 300 series stainless steel. The flowmeter must include either dry contact pulse outputs, 4-20mA, 0-10Vdc or 0-5Vdc outputs.

2.7.7.10 Positive Displacement Flow Meter

The flow meter must be a direct reading, gerotor, nutating disc or vane type displacement device rated for liquid service as indicated. A counter must be mounted on top of the meter, and must consist of a non-resettable mechanical totalizer for local reading, and a pulse transmitter for remote reading. The totalizer must have a six digit register to indicate the volume passed through the meter in gallons, and a sweep-hand dial to indicate down to 0.25 gallons. The pulse transmitter must have a hermetically sealed reed switch which is activated by magnets fixed on gears of the counter. The meter must have a bronze body with threaded or flanged connections as required for the application. Output accuracy must be plus or minus 2 percent of the flow range. The maximum pressure drop at full flow must be 5 psig.

2.7.7.11 Flow Meters, Paddle Type

Sensor must be non-magnetic, with forward curved impeller blades designed for water containing debris. Sensor accuracy must be plus or minus 1 percent of rate of flow, minimum operating flow velocity must be 1 foot per second. Sensor repeatability and linearity must be plus or minus 1 percent. Materials which will be wetted must be made from non-corrosive materials and must not contaminate water. The sensor must be rated for installation in pipes of 3 to 40 inch diameters. The transmitter housing must be a NEMA 250 Type 4 enclosure.

2.7.7.12 Flow Switch

Flow switch must have a repetitive accuracy of plus or minus 10 percent of actual flow setting. Switch actuation must be adjustable over the operating flow range, and must be sized for the application such that the setpoint is between 25 percent and 75 percent of the full range. The switch must have Form C snap-action contacts, rated for the application. The flow switch must have non flexible paddle with magnetically actuated contacts and be rated for service at a pressure greater than the installed conditions. Flow switch for use in sewage system must be rated for use in corrosive environments encountered.

2.7.7.13 Gas Flow Meter

Gas flow meter must be diaphragm or bellows type (gas positive displacement meters) for flows up to 2500 SCFH and axial flow turbine type for flows above 2500 SCFH, designed specifically for natural gas supply metering, and rated for the pressure, temperature, and flow rates of the installation. Meter must have a minimum turndown ratio of 10 to 1 with an accuracy of plus or minus 1 percent of actual flow rate. The meter index must include a direct reading mechanical totalizing register and electrical impulse dry contact output for remote monitoring. The electrical impulse dry contact output must not require field adjustment or calibration. The electrical impulse dry contact output must have a minimum resolution of 100 cubic feet of gas per pulse and must not exceed 15 pulses per second at the design flow.

2.7.8 Electrical Instruments

Provide Electrical Instruments with an input range as indicated or sized for the application. Unless otherwise specified, AC instrumentation must be suitable for 60 Hz operation.

2.7.8.1 Current Transducers

Current transducers must accept an AC current input and must have an accuracy of plus or minus 0.5 percent of full scale. The device must have a means for calibration. Current transducers for variable frequency applications must be rated for variable frequency operation.

2.7.8.2 Current Sensing Relays (CSRs)

Current sensing relays (CSRs) must provide a normally-open contact with a voltage and amperage rating greater than its connected load. Current sensing relays must be of split-core design. The CSR must be rated for operation at 200 percent of the connected load. Voltage isolation must be a minimum of 600 volts. The CSR must auto-calibrate to the connected load or be adjustable and field calibrated. Current sensors for variable frequency applications must be rated for variable frequency operation.

2.7.8.3 Voltage Transducers

Voltage transducers must accept an AC voltage input and have an accuracy of plus or minus 0.25 percent of full scale. The device must have a means for calibration. Line side fuses for transducer protection must be provided.

- 2.7.8.4 Energy Metering
- 2.7.8.4.1 Watt or Watthour Transducers

Watt transducers must measure voltage and current and must output kW or kWh or both kW and kWh as indicated. kW outputs must have an accuracy of plus or minus 0.5 percent over a power factor range of 0.1 to 1. kWh outputs must have an accuracy of plus or minus 0.5 percent over a power factor range of 0.1 to 1.

2.7.8.4.2 Watthour Revenue Meter (with and without Demand Register)

All Watthour revenue meters must measure voltage and current and must be in accordance with ANSI C12.1 with an ANSI C12.20 Accuracy class of 0.5 and must have pulse initiators for remote monitoring of Watthour consumption. Pulse initiators must consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets must be in accordance with NEMA/ANSI C12.10. Watthour revenue meters with demand registers must output instantaneous demand in addition to the pulse initiators.

2.7.8.4.3 Steam Meters

Steam meters must be the vortex type, with pressure compensation, a minimum turndown ratio of 10 to 1, and an output signal compatible with the DDC system.

2.7.8.4.4 Hydronic BTU Meters

The BTU meter is to be supplied with wall mount hardware and be capable of being installed remote from the flow meter. The BTU meter must include an LCD display for local indication of energy rate and for display of parameters and settings during configuration. Each BTU meter must be factory configured for its specific application and be completely field configurable by the user via a front panel keypad (no special interface device or computer required). The unit must output Energy Rate, Energy Total, Flow Rate, Supply Temperature, and Return Temperature. An integral transmitter is to provide a linear analog or configurable pulse output signal representing the energy rate; and the signal must be compatible with building automation system DDC Hardware to which the output is connected.

2.7.9 pH Sensor

The sensor must be suitable for applications and chemicals encountered in water treatment systems of boilers, chillers and condenser water systems. Construction, wiring, fittings and accessories must be corrosion and chemical resistant with fittings for tank or suspension installation. Housing must be polyvinylidene fluoride with O-rings made of chemical resistant materials which do not corrode or deteriorate with extended exposure to chemicals. The sensor must be encapsulated. Periodic replacement must not be required for continued sensor operation. Sensors must use a ceramic junction and pH sensitive glass membrane capable of withstanding a pressure of 100 psig at 150 degrees F. The reference cell must be double junction configuration. Sensor range must be 0 to 12 pH, stability 0.05, sensitivity 0.02, and repeatability of plus or minus 0.05 pH value, response of 90 percent of full scale in one second and a linearity of 99 percent of theoretical electrode output measured at 76 degrees F.

2.7.10 Oxygen Analyzer

Oxygen analyzer must consist of a zirconium oxide sensor for continuous sampling and an air-powered aspirator to draw flue gas samples. The analyzer must be equipped with filters to remove flue air particles. Sensor probe temperature rating must be 815 degrees F. The sensor assembly must be equipped for flue flange mounting.

2.7.11 Carbon Monoxide Analyzer

Carbon monoxide analyzer must consist of an infrared light source in a weather proof steel enclosure for duct or stack mounting. An optical detector/analyzer in a similar enclosure, suitable for duct or stack mounting must be provided. Both assemblies must include internal blower systems to keep optical windows free of dust and ash at all times. The third component of the analyzer must be the electronics cabinet. Automatic flue gas temperature compensation and manual/automatic zeroing devices must be provided. Unit must read parts per million (ppm) of carbon monoxide and the response time must be less than 3 seconds to 90 percent value. Unit measurement range must not exceed specified range by more that 50 percent. Repeatability must be plus or minus 1 percent of full scale with an accuracy of plus or minus 1 percent of full scale.

2.7.12 Occupancy Sensors

Occupancy sensors must have occupancy-sensing sensitivity adjustment and an adjustable off-delay timer with a setpoint of 15 minutes. Adjustments accessible from the face of the unit are preferred. Occupancy sensors must be rated for operation in ambient air temperatures ranging from 40 to 95 degrees F or temperatures normally encountered in the installed location. Sensors integral to wall mount on-off light switches must have an auto-off switch. Wall switch sensors must be decorator style and must fit behind a standard decorator type wall plate. All occupancy sensors, power packs, and slave packs must be UL listed. In addition to any outputs required for lighting control, the occupancy sensor must provide an output for the HVAC control system.

2.7.12.1 Passive Infrared (PIR) Occupancy Sensors

PIR occupancy sensors must have a multi-level, multi-segmented viewing lens and a conical field of view with a viewing angle of 180 degrees and a detection of at least 20 feet unless otherwise indicated or specified. PIR Sensors must provide field-adjustable background light-level adjustment with an adjustment range suitable to the light level in the sensed area, room or space. PIR sensors must be immune to false triggering from RFI and EMI.

2.7.12.2 Ultrasonic Occupancy Sensors

Ultrasonic sensors must operate at a minimum frequency 32 kHz and must be designed to not interfere with hearing aids.

2.7.12.3 Dual-Technology Occupancy Sensor (PIR and Ultrasonic)

Dual-Technology Occupancy Sensors must meet the requirements of both PIR and Ultrasonic Occupancy Sensors.

2.7.13 Vibration Switch

Vibration switch must be solid state, enclosed in a NEMA 250 Type 4 or Type 4X housing with sealed wire entry. Unit must have two independent sets of Form C switch contacts with one set to shutdown equipment upon excessive vibration and a second set for monitoring alarm level vibration. The vibration sensing range must be a true rms reading, suitable for the application. The unit must include either displacement response for low speed or velocity response for high speed application. The frequency range must be at least 3 Hz to 500 Hz. Contact time delay must be 3 seconds. The unit must have independent start-up and running delay on each switch contact. Alarm limits must be adjustable and setpoint accuracy must be plus or minus 10 percent of setting with repeatability of plus or minus 2 percent.

2.7.14 Conductivity Sensor

Sensor must include local indicating meter and must be suitable for measurement of conductivity of water in boilers, chilled water systems, condenser water systems, distillation systems, or potable water systems as indicated. Sensor must sense from 0 to 10 microSeimens per centimeter (μ S/cm) for distillation systems, 0 to 100 μ S/cm for boiler, chilled water, and potable water systems and 0 to 1000 μ S/cm for condenser water systems. Contractor must field verify the ranges for particular applications and adjust the range as required. The output must be temperature compensated over a range of 32 to 212 degrees F. The accuracy must be plus or minus 2 percent of the full scale reading. Sensor must have automatic zeroing and must require no periodic maintenance or recalibration.

2.7.15 Compressed Air Dew Point Sensor

Sensor must be suitable for measurement of dew point from -40 +80 degrees F over a pressure range of 0 to 150 psig. The transmitter must provide

both dry bulb and dew point temperatures on separate outputs. The end to end accuracy of the dew point must be plus or minus 5 degrees F and the dry bulb must be plus or minus 1 degree F. Sensor must be automatic zeroing and must require no normal maintenance or periodic recalibration.

2.7.16 NOx Monitor

Monitor must continuously monitor and give local indication of boiler stack gas for NOx content. It must be a complete system designed to verify compliance with the Clean Air Act standards for NOx normalized to a 3 percent oxygen basis and must have a range of from 0 to 100 ppm. Sensor must be accurate to plus or minus 5 ppm. Sensor must output NOx and oxygen levels and binary output that changes state when the NOx level is above a locally adjustable NOx setpoint. Sensor must have normal, trouble and alarm lights. Sensor must have heat traced lines if the stack pickup is remote from the sensor. Sensor must be complete with automatic zero and span calibration using a timed calibration gas system, and must not require periodic maintenance or recalibration.

2.7.17 Turbidity Sensor

Sensor must include a local indicating meter and must be suitable for measurement of turbidity of water. Sensor must sense from 0 to 1000 Nephelometric Turbidity Units (NTU). Range must be field-verified for the particular application and adjusted as required. The output must be temperature compensated over a range of 32 to 212 degrees F. The accuracy must be plus or minus 5 percent of full scale reading. Sensor must have automatic zeroing and must not require periodic maintenance or recalibration.

2.7.18 Chlorine Detector

The detector must measure concentrations of chlorine in water in the range 0 to 20 ppm with a repeatability of plus or minus 1 percent of full scale and an accuracy of plus or minus 2 percent of full scale. The Chlorine Detector transmitter must be housed in a non-corrosive NEMA 250 Type 4X enclosure. Detector must include a local panel with adjustable alarm trip level, local audio and visual alarm with silence function.

2.7.19 Floor Mounted Leak Detector

Leak detectors must use electrodes mounted at slab level with a minimum built-in-vertical adjustment of 0.125 inches. Detector must have a binary output. The indicator must be manual reset type.

2.7.20 Temperature Switch

2.7.20.1 Duct Mount Temperature Low Limit Safety Switch (Freezestat)

Duct mount temperature low limit switches (Freezestats) must be manual reset, low temperature safety switches at least 1 foot long per square foot of coverage which must respond to the coldest 18 inch segment with an accuracy of plus or minus 3.6 degrees F. The switch must have a field-adjustable setpoint with a range of at least 30 to 50 degrees F. The switch must have two sets of contacts, and each contact must have a rating greater than its connected load. Contacts must open or close upon drop of temperature below setpoint as indicated and must remain in this state until reset.

2.7.20.2 Pipe Mount Temperature Limit Switch (Aquastat)

Pipe mount temperature limit switches (aquastats) must have a field adjustable setpoint between 60 and 90 degrees F, an accuracy of plus or minus 3.6 degrees F and a 10 degrees F fixed deadband. The switch must have two sets of contacts, and each contact must have a rating greater than its connected load. Contacts must open or close upon change of temperature above or below setpoint as indicated.

2.7.21 Damper End Switches

Each end switch must be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure must be suitable for mounting on the duct exterior and must permit setting the position of the trip lever that actuates the switch. The trip lever must be aligned with the damper blade.

End switches integral to an electric damper actuator are allowed as long as at least one is adjustable over the travel of the actuator.

2.7.22 Air Quality Sensors

Provide full spectrum air quality sensors using a hot wire element based on the Taguchi principle. The sensor must monitor a wide range of gaseous volatile organic components common in indoor air contaminants like paint fumes, solvents, cigarette smoke, and vehicle exhaust. The sensor must automatically compensate for temperature and humidity, have span and calibration potentiometers, operate on 24 VDC power with output of 0-10 VDC, and have a service rating of 32 to 140 degrees F and 5 to 95 percent relative humidity.

2.8 INDICATING DEVICES

All indicating devices must display readings in English (inch-pound) units.

2.8.1 Thermometers

Provide bi-metal type thermometers at locations indicated. Thermometers must have either 9 inch long scales or 3.5 inch diameter dials, with insertion, immersion, or averaging elements. Provide matching thermowells for pipe-mounted installations. Select scale ranges suitable for the intended service, with the normal operating temperature near the scale's midpoint. The thermometer's accuracy must be plus or minus 2 percent of the scale range.

2.8.1.1 Piping System Thermometers

Piping system thermometers must have brass, malleable iron or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 9 inch scale. Piping system thermometers must have an accuracy of plus or minus 1 percent of scale range. Thermometers for piping systems must have rigid stems with straight, angular, or inclined pattern. Thermometer stems must have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem must be filled with a heat-transfer medium.

2.8.1.2 Air-Duct Thermometers

Air-duct thermometers must have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.8.2 Pressure Gauges

Provide pipe-mounted pressure gauges at the locations indicated. Gauges must conform to ASME B40.100 and have a 4 inch diameter dial and shutoff cock. Select scale ranges suitable for the intended service, with the normal operating pressure near the scale's midpoint. The gauge's accuracy must be plus or minus 2 percent of the scale range.

Gauges must be suitable for field or panel mounting as required, must have black legend on white background, and must have a pointer traveling through a 270-degree arc. Gauge range must be suitable for the application with an upper end of the range not to exceed 150 percent of the design upper limit. Accuracy must be plus or minus 3 percent of scale range. Gauges must meet requirements of ASME B40.100.

2.8.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements must be a minimum of 3.5 inch (nominal) size with two sets of pressure taps, and must have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauge range must be suitable for the application with an upper end of the range not to exceed 150 percent of the design upper limit. Accuracy must be plus or minus two percent of scale range.

2.8.4 Pressure Gauges for Pneumatic Controls

Gauges must have a 0 to 30 psi scale with 1 psi graduations.

2.9 OUTPUT DEVICES

2.9.1 Actuators

Actuators must be electric (electronic) . All actuators must be normally open (NO), normally closed (NC) or fail-in-last-position (FILP) as indicated. Normally open and normally closed actuators must be of mechanical spring return type. Electric actuators must have an electronic cut off or other means to provide burnout protection if stalled. Actuators must have a visible position indicator. Actuators must smoothly and fully open or close the devices to which they are applied. Electric actuators must have a full stroke response time in both directions of 90 seconds or less at rated load. Electric actuators must be of the foot-mounted type with an oil-immersed gear train or the direct-coupled type. Where multiple electric actuators operate from a common signal, the actuators must provide an output signal identical to its input signal to the additional devices. All actuators must be rated for their operating environment. Actuators used outdoors must be designed and rated for outdoor use. Actuators under continuous exposure to water, such as those used in sumps, must be submersible.

Actuators incorporating an integral network connection are considered DDC Hardware and must meet the DDC Hardware requirements of Section .

2.9.1.1 Valve Actuators

Valve actuators must provide shutoff pressures and torques as indicated on the Valve Schedule.

2.9.1.2 Damper Actuators

Damper actuators must provide the torque necessary per damper manufacturer's instructions to modulate the dampers smoothly over its full range of operation and torque must be at least 6 inch-pounds/1 square foot of damper area for opposed blade dampers and 9 inch-pounds/1 square foot of damper area for parallel blade dampers.

2.9.1.3 Positive Positioners

Positive positioners must be a pneumatic relay with a mechanical position feedback mechanism and an adjustable operating range and starting point.

2.9.1.4 Electric Actuators

Each actuator must have distinct markings indicating the full-open and full-closed position Each actuator must deliver the torque required for continuous uniform motion and must have internal end switches to limit the travel, or be capable of withstanding continuous stalling without damage. Actuators must function properly within 85 to 110 percent of rated line voltage. Provide actuators with hardened steel running shafts and gears of steel or copper alloy. Fiber or reinforced nylon gears may be used for torques less than 16 inch-pounds..

- a. Two-position actuators must be single direction, spring return, or reversing type. Two position actuator signals may either be the control power voltage or line voltage as needed for torque or appropriate interlock circuits.
- b. Modulating actuators must be capable of stopping at any point in the cycle, and starting in either direction from any point. Actuators must be equipped with a switch for reversing direction, and a button to disengage the clutch to allow manual adjustments. Provide the actuator with a hand crank for manual adjustments, as applicable. Modulating actuator input signals can either be a 4 to 20 mAdc or a 0-10 VDC signal.
- c. Floating or pulse width modulation actuators are acceptable for non-fail safe applications unless indicated otherwise provided that the floating point control (timed actuation) must have a scheduled re-calibration of span and position no more than once a day and no less than once a week. The schedule for the re-calibration should not affect occupied conditions and be staggered between equipment to prevent falsely loading or unloading central plant equipment.

2.9.1.5 Pneumatic Actuators

Provide piston or diaphragm type actuators with replaceable diaphragm/piston.

2.9.2 Solenoid-Operated Electric to Pneumatic Switch (EPS)

Solenoid-Operated Electric to Pneumatic Switches (EPS) must accept a voltage input to actuate its air valve. Each valve must have three-port

operation: common, normally open, and normally closed. Each valve must have an outer cast aluminum body and internal parts of brass, bronze, or stainless steel. The air connection must be a 0.38 inch NPT threaded connection. Valves must be rated for 50 psig.

2.9.3 Electric to Pneumatic Transducers (EP)

Electric to Pneumatic Transducers (EPs) must convert either a 4-20 mAdc input signal, a 0-10 Vdc input signal to a proportional 0 to 20 psig pneumatic output. The EP must withstand pressures at least 150 percent of the system supply air pressure (main air). EPs must include independent offset and span adjustment. Steady state air consumption must not be greater than 0.05 scfm. EPs must have a manual adjustable override for the EP pneumatic output. EPs must have sufficient output capacity to provide full range stroke of the actuated device in both directions within 90 seconds.

2.9.4 Relays

Relays must have contacts rated for the intended application, indicator light, and dust proof enclosure. The indicator light must be lit when the coil is energized and off when coil is not energized.

Control relay contacts must have utilization category and ratings selected for the application. Each set of contacts must incorporate a normally open (NO), normally closed (NC) and common contact. Relays must be rated for a minimum life of one million operations.

2.10 USER INPUT DEVICES

User Input Devices, including potentiometers, switches and momentary contact push-buttons. Potentiometers must be of the thumb wheel or sliding bar type. Momentary Contact Push-Buttons may include an adjustable timer for their output. User input devices must be labeled for their function.

2.11 MULTIFUNCTION DEVICES

Multifunction devices are products which combine the functions of multiple sensor, user input or output devices into a single product. Unless otherwise specified, the multifunction device must meet all requirements of each component device. Where the requirements for the component devices conflict, the multifunction device must meet the most stringent of the requirements.

2.11.1 Current Sensing Relay Command Switch

The Current Sensing Relay portion must meet all requirements of the Current Sensing Relay input device. The Command Switch portion must meet all requirements of the Relay output device except that it must have at least one normally-open (NO) contact.

Current Sensing Relays used for Variable Frequency Drives must be rated for Variable Frequency applications unless installed on the source side of the drive. If used in this situation, the threshold for showing status must be set to allow for the VFD's control power when the drive is not enabled and provide indication of operation when the drive is enabled at minimum speed. Space Sensor Modules must be multifunction devices incorporating a temperature sensor and one or more of the following as specified and indicated on the Space Sensor Module Schedule:

- a. A temperature indicating device.
- b. A User Input Device which must adjust a temperature setpoint output.
- c. A User Input Momentary Contact Button and an output to the control system indicating zone occupancy.
- d. A three position User Input Switch labeled to indicate heating, cooling and off positions ('HEAT-COOL-OFF' switch) and providing corresponding outputs to the control system.
- e. A two position User Input Switch labeled with 'AUTO' and 'ON' positions and providing corresponding output to the control system..
- f. A multi-position User Input Switch with 'OFF' and at least two fan speed positions and providing corresponding outputs to the control system.

Space Sensor Modules cannot contain mercury (Hg).

2.12 COMPRESSED AIR STATIONS

2.12.1 Air Compressor Assembly

Air compressors for pneumatic control systems must be the tank-mounted, electric motor driven, air cooled, reciprocating type with integral duplex motors and compressors, tank, controller, pressure switch, belt guard, pressure relief valve, automatic moisture drain valve and must be supported by a steel base mounted on an air storage tank. Compressor piston speeds must not exceed 450 fpm. Provide compressors with a dry-type combination intake air filter and silencer with baked enamel steel housing. The filter must be 99 percent efficient at 10 microns. The pressure switch must start the compressor at 70 psig and stop the compressor at 90 psig. The relief valve must be set for 10 to 25 psig above the control switch cut-off pressure. Provide compressor capacity suitable for not more than a 33 percent run time, at full system control load. Compressors must have a combination type magnetic starter with undervoltage protection and thermal-overload protection for each phase and must automatically restart after a power outage. Motors 0.5 hp and larger must be three-phase.

2.12.2 Compressed Air Station Specialties

2.12.2.1 Refrigerated Air Dryers

Provide each air compressor tank with a refrigerant air dryer sized for continuous operation at full delivery capacity of the compressor. The air must be dried at a pressure of not less than 70 psi to a temperature not greater than 35 degrees F and an ambient air temperature between 55 and 95 degrees F. The dryer must be provided with an automatic condensate drain trap with manual override feature with an adjustable cycle and drain time. Locate each dryer in the air piping between the tank and the pressure-reducing station. The refrigerant used in the dryer must be one of the fluorocarbon gases and have an Ozone Depletion Potential of not more than 0.05. A five micron pre-filter and coalescing-type 0.03 micron oil removal filter with shut-off valves must be provided in the dryer discharge.

2.12.2.2 Compressed Air Discharge Filters

Provide a disposable type in-line filter in the incoming pneumatic main at each pneumatic control panel. The filter must be capable of eliminating 99.99 percent of all liquid or solid contaminants 0.1 micron or larger. Provide the filter with fittings that allow easy removal/replacement. Each filter bowl must be rated for 150 psi maximum working pressure. A pressure regulator, with high side and low side pressure gauges, and a safety valve must be provided downstream of the filter.

2.12.2.3 Air Pressure-Reducing Stations

Provide air compressors with a pressure-reducing valve (PRV) with a field adjustable range of 0 to 50 psig discharge pressure, at an inlet pressure of 70 to 90 psig. Provide a factory-set pressure relief valve downstream of the PRV to relieve over-pressure. Provide a pressure gage upstream of the PRV with range of 0 to 100 psig and downstream of the PRV with range of. For two-pressure control systems, provide an additional PRV and downstream pressure gage. Pressure regulators of the relieving type must not be used.

2.12.2.4 Flexible Pipe Connections

The flexible pipe connections must be designed for 150 psi and 250 degrees F service, and must be constructed of rubber or tetrafluoroethylene resin tubing with a reinforcing protective cover of braided corrosion-resistant steel, bronze, monel, or galvanized steel. The connectors must be suitable for the service intended and must have threaded or soldered ends. The length of the connectors must be as recommended by the manufacturer for the service intended.

2.12.2.5 Vibration Isolation Units

The vibration isolation units must be standard products with published loading ratings, and must be single rubber-in-shear, double rubber-in-shear, or spring type.

2.12.3 Compressed Air Tanks

The air storage tank must be fabricated for a working pressure of not less than 200 psi and constructed and certified in accordance with ASME BPVC SEC VIII D1. The tank must be of sufficient volume so that no more than six compressor starts per hour are required with the starting pressure switch differential set at 20 psi. The tank must be provided with an automatic condensate drain trap with manual override feature. Provide drain valve and piping routing the drainage to a floor sink or other safe and visible drainage location.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 General Installation Requirements

Perform the installation under the supervision of competent technicians

regularly employed in the installation of DDC systems.

3.1.1.1 Device Mounting Criteria

All devices must be installed in accordance with manufacturer's recommendations and as specified and indicated. Control devices to be installed in piping and ductwork must be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements must not be used except as specified. Spare thermowells must be installed adjacent to each thermowell containing a sensor and as indicated. Devices located outdoors must have a weathershield.

3.1.1.2 Labels and Tags

Match labels and tags to the unique identifiers indicated on the As-Built drawings. Label all enclosures and instrumentation. Tag all sensors and actuators in mechanical rooms. Tag airflow measurement arrays to show flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient. Tag duct static pressure taps at the location of the pressure tap. Provide plastic or metal tags, mechanically attached directly to each device or attached by a metal chain or wire. Labels exterior to protective enclosures must be engraved plastic and mechanically attached to the enclosure or instrumentation. Labels inside protective enclosures may attached using adhesive, but must not be hand written.

3.1.2 Weathershield

Provide weathershields for sensors located outdoors. Install weathershields such that they prevent the sun from directly striking the sensor and prevent rain from directly striking or dripping onto the sensor. Install weather shields with adequate ventilation so that the sensing element responds to the ambient conditions of the surroundings. When installing weathershields near outside air intake ducts, install them such that normal outside air flow does not cause rainwater to strike the sensor.

3.1.3 Room Instrument Mounting

Mount room instruments, including but not limited to wall mounted non-adjustable space sensor modules and sensors located in occupied spaces, 60 inches above the floor unless otherwise indicated. Install adjustable devices to be ADA compliant unless otherwise indicated on the Room Sensor Schedule:

- a. Space Sensor Modules for Fan Coil Units may be either unit or wall mounted but not mounted on an exterior wall.
- b. Wall mount all other Space Sensor Modules.

3.1.4 Indication Devices Installed in Piping and Liquid Systems

Provide snubbers for gauges in piping systems subject to pulsation. For gauges for steam service use pigtail fittings with cock. Install thermometers and temperature sensing elements in liquid systems in thermowells. Provide spare Pressure/Temperature Ports (Pete's Plug) for all temperature and pressure sensing elements installed in liquid systems for calibration/testing.

3.1.5 Occupancy Sensors

Provide a sufficient quantity of occupancy sensors to provide complete coverage of the area (room or space). Occupancy sensors are to be ceiling mounted. Install occupancy sensors in accordance with NFPA 70 requirements and the manufacturer's instructions. Do not locate occupancy sensors within 6 feet of HVAC outlets or heating ducts, or where they can "see" beyond any doorway. Installation above doorway(s) is preferred. Do not use ultrasonic sensors in spaces containing ceiling fans. Install sensors to detect motion to within 2 feet of all room entrances and to not trigger due to motion outside the room. Set the off-delay timer to 15 minutes unless otherwise indicated. Adjust sensors prior to beneficial occupancy, but after installation of furniture systems, shelving, partitions, etc. For each controlled area, provide one hundred percent coverage capable of detecting small hand-motion movements, accommodating all occupancy habits of single or multiple occupants at any location within the controlled room.

3.1.6 Switches

3.1.6.1 Temperature Limit Switch

Provide a temperature limit switch (freezestat) to sense the temperature at the location indicated. Provide a sufficient number of temperature limit switches (freezestats) to provide complete coverage of the duct section but no less than 1 foot in length per square foot of cross sectional area. Install manual reset limit switches in approved, accessible locations where they can be reset easily. Install temperature limit switch (freezestat) sensing elements in a side-to-side (not top-to-bottom) serpentine pattern with the relay section at the highest point and in accordance with the manufacturer's installation instructions.

3.1.6.2 Hand-Off Auto Switches

Wire safety controls such as smoke detectors and freeze protection thermostats to protect the equipment during both hand and auto operation.

3.1.7 Temperature Sensors

Install temperature sensors in locations that are accessible and provide a good representation of sensed media. Installations in dead spaces are not acceptable. Calibrate and install sensors according to manufacturer's instructions. Select sensors only for intended application as designated or recommended by manufacturer.

3.1.7.1 Room Temperature Sensors

Mount the sensors on interior walls to sense the average room temperature at the locations indicated. Avoid locations near heat sources such as copy machines or locations by supply air outlet drafts. Mount the center of all user-adjustable sensors 5 feet above the finished floor. Non user-adjustable sensors can be mounted as indicated in paragraph ROOM INSTRUMENT MOUNTING.

3.1.7.2 Duct Temperature Sensors

3.1.7.2.1 Probe Type

Place tip of the sensor in the middle of the airstream or in accordance with manufacturer's recommendations or instructions.Provide a gasket between the sensor housing and the duct wall. Seal the duct penetration air tight. When installed in insulated duct, provide enclosure or stand off fitting to accommodate the thickness of duct insulation to allow for maintenance or replacement of the sensor and wiring terminations. Seal the duct insulation penetration vapor tight.

3.1.7.2.2 Averaging Type

Weave the sensing element in a serpentine fashion from side to side perpendicular to the flow, across the duct or air handler cross-section, using durable non-metal supports in accordance with manufacturer's installation instructions. Avoid tight radius bends or kinking of the sensing element. Prevent contact between the sensing element and the duct or air handler internals. Provide a duct access door at the sensor location. The access door must be hinged on the side, factory insulated, have cam type locks, and be as large as the duct will permit, maximum 18 by 18 inches. For sensors inside air handlers, the sensors must be fully accessible through the air handler's access doors without removing any of the air handler's internals.

3.1.7.3 Immersion Temperature Sensors

Provide thermowells for sensors measuring piping, tank, or pressure vessel temperatures. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. When installed on insulated piping, provide stand enclosure or stand off fitting to accommodate the thickness of the pipe insulation and allow for maintenance or replacement of the sensor or wiring terminations. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to sense flow across entire area of well. Wells must not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide the sensor well with a heat-sensitive transfer agent between the sensor and the well interior ensuring contact between the sensor and the well.

3.1.7.4 Outside Air Temperature Sensors

Provide outside air temperature sensors on the building's north side with a protective weather shade that does not inhibit free air flow across the sensing element, and protects the sensor from snow, ice, and rain. Location must not be near exhaust hoods and other areas such that it is not influenced by radiation or convection sources which may affect the reading. Provide a shield to shade the sensor from direct sunlight.

3.1.8 Air Flow Measurement Arrays (AFMA)

Locate Outside Air AFMAs downstream from the Outside Air filters.

Install AFMAs with the manufacturer's recommended minimum distances between upstream and downstream disturbances. Airflow straighteners may be used to reduce minimum distances as recommended by the AFMA manufacturer.

3.1.9 Duct Static Pressure Sensors

Locate the duct static pressure sensing tap at 75 percent of the distance between the first and last air terminal units . If the transmitter output is a 0-10Vdc signal, locate the transmitter in the same enclosure as the air handling unit (AHU) controller for the AHU serving the terminal units. If a remote duct static pressure sensor is to be used, run the signal wire back to the controller for the air handling unit.

3.1.10 Relative Humidity Sensors

Install relative humidity sensors in supply air ducts at least 10 feet downstream of humidity injection elements.

3.1.11 Meters

3.1.11.1 Flowmeters

Install flowmeters to ensure minimum straight unobstructed piping for at least 10 pipe diameters upstream and at least 5 pipe diameters downstream of the flowmeter, and in accordance with the manufacturer's installation instructions.

3.1.11.2 Energy Meters

Locate energy meters as indicated. Connect each meter output to the DDC system, to measure both instantaneous demand/energy and other variables as indicated.

3.1.12 Dampers

3.1.12.1 Damper Actuators

Provide spring return actuators which fail to a position that protects the served equipment and space on all control dampers related to freeze protection or force protection. For all outside, makeup and relief dampers provide dampers which fail closed. Terminal fan coil units, terminal VAV units, convectors, and unit heaters nay be non-spring return unless indicated otherwise. Do not mount actuators in the air stream. Do not connect multiple actuators to a common drive shaft. Install actuators so that their action seal the damper to the extent required to maintain leakage at or below the specified rate and so that they move the blades smoothly throughout the full range of motion.

3.1.12.2 Damper Installation

Install dampers straight and true, level in all planes, and square in all dimensions. Dampers must move freely without undue stress due to twisting, racking (parallelogramming), bowing, or other installation error. External linkages must operate smoothly over the entire range of motion, without deformation or slipping of any connecting rods, joints or brackets that will prevent a return to it's normal position. Blades must close completely and leakage must not exceed that specified at the rated static pressure. Provide structural support for multi-section dampers. Acceptable methods of structural support include but are not limited to U-channel, angle iron, corner angles and bolts, bent galvanized steel stiffeners, sleeve attachments, braces, and building structure. Where multi-section dampers are installed in ducts or sleeves, they must not sag due to lack of support. Do not use jackshafts to link more than three damper sections. Do not use blade to blade linkages. Install outside and return air dampers such that their blades direct their respective air streams towards each other to provide for maximum mixing of air streams.

3.1.13 Valves

Install the valves in accordance with the manufacturer's instructions.

3.1.13.1 Valve Actuators

Provide spring return actuators on all control valves where freeze protection is required. Spring return actuators for terminal fan coil units, terminal VAV units, convectors, and unit heaters are not required unless indicated otherwise.

- 3.1.14 Thermometers and Gauges
- 3.1.14.1 Local Gauges for Actuators

Provide a pressure gauge at each pneumatic control input and output. Pneumatic actuators must have an accessible and visible pressure gauge installed in the tubing lines at the actuator as indicated.

3.1.14.2 Thermometers

Mount devices to allow reading while standing on the floor or ground, as applicable.

3.1.15 Wire and Cable

Provide complete electrical wiring for the Control System, including wiring to transformer primaries. Wire and Cable must be installed without splices between control devices and in accordance with NFPA 70 and NFPA 90A. Instrumentation grounding must be installed per the device manufacturer's instructions and as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Test installed ground rods as specified in IEEE 142. Cables and conductor wires must be tagged at both ends, with the identifier indicated on the shop drawings. Electrical work must be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as indicated. Wiring external to enclosures must be run in raceways

Install control circuit wiring not in raceways in a neat and safe manner. Wiring must not use the suspended ceiling system (including tiles, frames or hangers) for support. Where conduit or raceways are required, control circuit wiring must not run in the same conduit/raceway as power wiring over 50 volts. Run all circuits over 50 volts in conduit, metallic tubing, covered metal raceways, or armored cable.

3.1.16 Copper Tubing

Provide hard-drawn copper tubing in exposed areas and either hard-drawn or annealed copper tubing in concealed areas. Use only tool-made bends. Use only brass or copper solder joint type fittings, except for connections to apparatus. For connections to apparatus use brass compression type fittings.

3.1.17 Plastic Tubing

Install plastic tubing within covered raceways or conduit except when otherwise specified. Do not use plastic tubing for applications where the tubing could be subjected to a temperature exceeding 130 degrees F. For fittings, use brass or acetal resin of the compression or barbed push-on type for instrument service. Except in walls and exposed locations, plastic multitube instrument tubing bundle without conduit or raceway protection may be used where a number of air lines run to the same points, provided the multitube bundle is enclosed in a protective sheath, is run parallel to the building lines and is adequately supported as specified.

3.1.18 Pneumatic Lines

Run tubing concealed in finished areas, run tubing exposed in unfinished areas like mechanical rooms. For tubing enclosed in concrete, provide rigid metal conduit. Run tubing parallel and perpendicular to building walls. Use 5 foot maximum spacing between tubing supports. With the compressor turned off, test each tubing system pneumatically at 1.5 times the working pressure and prove it air tight, locating and correcting leaks as applicable. Caulking joints is not permitted. Do not run tubing and electrical power conductors in the same conduit.

- a. Install pneumatic lines must such that they are not exposed to outside air temperatures. Conceal pneumatic lines except in mechanical rooms and other areas where other tubing and piping is exposed.
- b. Install all tubes and tube bundles exposed to view in lines parallel to the lines of the building. Route tubing in mechanical/electrical so that the lines are easily traceable.
- c. Purge air lines of dirt, impurities and moisture before connecting to the control equipment. Number-code or color-code air lines and key the coding in the As-Built Drawings for future identification and servicing the control system.

3.1.18.1 Pneumatic Lines In Mechanical/Electrical Spaces

In mechanical/electrical spaces, use plastic or copper tubing for pneumatic lines. Install horizontal and vertical runs of plastic tubing or soft copper tubing min raceways or rigid conduit dedicated to tubing. Support dedicated raceways, conduit, and hard copper tubing not installed in raceways every 6 feet for horizontal runs and every 8 feet for vertical runs.

3.1.18.2 Pneumatic Lines External to Mechanical/Electrical Spaces

External to mechanical/electrical spaces, use plastic tubing in raceways not containing power wiring or copper tubing with sweat fittings. Support raceways and tubing not in raceways every 8 feet. For pneumatic lines concealed in walls use hard-drawn copper tubing or plastic tubing in rigid conduit. Plastic tubing in a protective sheath, run parallel to the building lines and supported as specified, may be used above accessible ceilings and in other concealed but accessible locations.

3.1.18.3 Terminal Single Lines

For terminal single lines use hard-drawn copper tubing, except when the run is less than 12 inches in length, flexible polyethylene may be used.

3.1.18.4 Connection to Liquid and Steam Lines

Use copper with brass compression fittings for connection of sensing elements and transmitters to liquid and steam lines.

3.1.18.5 Connection to Ductwork

Use plastic tubing for connections to sensing elements in ductwork.

3.1.18.6 Tubing in Concrete

Install tubing in concrete in rigid conduit. Install tubing in walls containing insulation, fill, or other packing materials in raceways dedicated to tubing.

3.1.18.7 Tubing Connection to Actuators

For final connections to actuators use plastic tubing no more than 12 inches long and unsupported at the actuator.

3.1.19 Compressed Air Stations

Mount the air compressor assembly on vibration eliminators, in accordance with ASME BPVC SEC VIII D1 for tank clearance. Connect the air line to the tank with a flexible pipe connector. Provide compressed air station specialties with required tubing, including condensate tubing to a floor drain. Compressed air stations must deliver control air meeting the requirements of ISA 7.0.01. Provide foundations and housekeeping pads for the HVAC control system air compressors in accordance with the air compressor manufacturer's instructions.

-- 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 HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 189	1 (2014) Standard	for the	e Design of	Ē
	High-	Performance	Green	Buildings	Except
	Low-R	ise Residen	tial Bu	uildings	

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003;	R	201	18) U	nified	l Inch	Screw	Threads
	(UN an	dι	JNR	Thre	ad For	rm)		

- ASME B4.1 (1967; R 1994; R 2004; R 2009; R 2020) Preferred Limits and Fits for Cylindrical Parts
- ASME B16.1 (2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA E103 (2015) Horizontal and Vertical Line-Shaft Pumps

ASTM INTERNATIONAL (ASTM)

ASTM	A48/A48M	(2003; R 2016) 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	A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM	A159	(1983; R 2020) Standard Specification for Automotive Gray Iron Castings
ASTM	A307	(2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength

ASTM	A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM	A582/A582M	(2012; R 2017) Standard Specification for Free-Machining Stainless Steel Bars
ASTM	B584	(2014) Standard Specification for Copper Alloy Sand Castings for General Applications

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			
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)				
NEMA MG 1	(2018) Motors and Generators			
NEMA Z535.4	(2011; R 2017) Product Safety Signs and Labels			
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)				
NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code			

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, Linsee

C 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 2020) 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. 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 AE

SD-03 Product Data

Instructions; G AE

Equipment Data; G AE

Training Period; G AE

SD-06 Test Reports

Factory Tests

Field Quality Control

SD-07 Certificates

Manufacturer's Representative

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G AE

Training; G AE

1.3 QUALITY ASSURANCE

1.3.1 Manufacturer Services

Provide the services of a manufacturer's representative experienced in the installation, adjustment, and operation of the equipment specified. The representative must supervise the installation, adjustment, testing of the equipment, and conduct training.

Submit the names and qualifications of the manufacturer's representative and training engineers and written certification from the manufacturer that the representative and trainers are technically qualified.

1.3.2 Standard Products

Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate equipment that has been in satisfactory HVAC operation at least 2 years prior to issuance of this solicitation. Support equipment with a service organization that is reasonably convenient to the jobsite. Pumps 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. 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. 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 .

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, 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, 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 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

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 , in-line, single stage, for installation in 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 .

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, 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 open drip proof motor efficiencies as shown in ASHRAE 189.1. 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 psig working pressure with integral cast iron flanges drilled for ASME B16.1 ANSI Class 125 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 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.

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 . 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. Open drip proof motor efficiencies must comply with ASHRAE 189.1.

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 . 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 open drip proof motor efficiencies in compliance with ASHRAE 189.1. Totally enclosed fan cooled motor efficiencies must be as shown in NEMA MG 1.

2.3.6 Base-Mounted, Flexible Coupled, Double Suction

Provide pumps with capacities as indicated; base mounted, flexible coupled, double-suction, horizontal and vertical split case design, single stage centrifugal pump. Construction must be cast iron - bronze fitted, equipped with mechanical seals. Bearings and seals must be serviceable without disturbing piping or motor. Factory hydrostatically test the pump in accordance with Hydraulic Institute standards and thoroughly clean.

2.3.6.1 Casing

Provide ASTM A48/A48M Class 30 or ASTM A159 cast iron pump casing, suitable for 175 psig working pressure, with integral cast iron flanges drilled for ASME B16.1 ANSI Class 125 flanges. Supply the pump volute with plugged vent, drain, and gauge tappings.

2.3.6.2 Bearings

Incorporate maintenance free, permanently lubricated and sealed bearings with an L10 life of 60,000 hours minimum in the pump bearing frame.

Incorporate regreasable ball bearing type pump bearing frame with provision for purging or flushing through the bearing surface and greased while running after start-up.

2.3.6.3 Seal Assembly

Seal off liquid cavity by an internally-flushed seal assembly. Seal assembly must have a brass housing, Buna bellows and seat gasket, stainless steel spring, and be of a carbon face rotating against a stationary silicon carbide seat. Provide replaceable mechanical seals without disturbing the upper casing half and system piping. Seals must be suitable for continuous operation at 225 degrees F. Arrange to assure that seal leakage cannot enter the bearing housings.

2.3.6.4 Coupler

Provide a flexible-type coupler between the pump and motor capable of absorbing torsional vibration and variable speed operation. 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 and 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. Shield the coupler by a coupler guard securely fastened to the base. Coupler guard 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, of safety orange in color, and have an NEMA Z535.4 compliant warning label.

2.3.6.5 Base Plate

Provide baseplate 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.

2.3.6.6 Impeller

Bronze or brass enclosed double suction type, both hydraulically and dynamically balanced to HI 9.6.4 grade G6.3, keyed to shaft and fixed in an axial position. Hub must have sufficient metal thickness to allow machining for installation of impeller rings.

2.3.6.7 Motor

Provide electric motor conforming to NEMA MG 1 and of the horsepower, and voltage indicated. Motor enclosure must be open drip proof ; 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. Open drip proof motor efficiencies must be as shown in ASHRAE 189.1. Totally enclosed fan cooled motor efficiencies must be as shown in NEMA MG 1.

2.3.6.8 Pump Shaft

Provide pump shaft of solid 416 stainless steel shaft or solid carbon steel shaft with replaceable bronze or 304 stainless steel shaft sleeve covering wetted area of shaft.

2.3.7 Vertical Lineshaft Turbine

Provide pumps with capacities as indicated. Pump must be vertical lineshaft turbine manufactured for lubrication of the line-shaft bearings by the water being pumped. Design and manufacture the pumping unit in accordance with HI ANSI/HI 2.1-2.2 standards AWWA E103.

2.3.7.1 Bowl Assembly

Flange type construct the intermediate bowls, discharge cases and suction bowls from ASTM A48/A48M Class 30 close grain cast iron. They must be free of defects and accurately machined and fitted to ASME B4.1 close tolerances. Epoxy enamel coat the intermediate bowls waterways for maximum efficiency. Thread all threaded discharge cases for water lubricated column assembly. All assembly bolting must be stainless steel. Provide intermediate bowl bearings.

2.3.7.2 Pump Shaft

Construct the bowl shaft from ASTM A582/A582M type 416 stainless steel, precision ground and polished with surface finish better than 40 RMS.

2.3.7.3 Lineshaft

Vertical pump lineshaft must be open and constructed from ASTM A582/A582M type 416 stainless steel. Straighten lineshaft sections to 0.0005inch/foot total runout. Lineshaft sections must not exceed 10 feet in length and must be coupled with threaded stainless steel couplings. Design the diameter of the lineshaft and coupling in accordance with AWWA E103.

2.3.7.4 Impeller

Provide impellers of ASTM B584 silicon bronze or stainless steel, the enclosed type. They must be free from defects, machined, and balanced to HI 9.6.4 balance grade G6.3 for optimum efficiency and performance. Securely fasten to the bowl shaft with stainless steel taper lock collets. The impellers must be adjustable by means of a top shaft adjusting nut or adjustable solid shaft coupling.

2.3.7.5 Discharge Head

Construct the discharge head, sized for pump capacity, of ASTM A48/A48M Class 30 high grade ductile iron or fabricated steel of the high profile type with an integral motor base which allows the head shaft to be coupled to the top shaft above the stuffing box. A separate motor stand is not acceptable. The discharge head must have an ASME B16.1 (for cast iron) or Class 150 (for steel) discharge flange supplied with dual 1/4 inch NPT ports at the top. Thread the head to accept the column pipe.

2.3.7.6 Stuffing Box

Provide stuffing box of cast or ductile iron, ASTM A536 class 65, and containing a minimum of five rings of packing; with an available fitting for pressure relief. The packing follower gland must be stainless steel and secured in place by stainless steel studs and nuts. The packing box bearing must be bronze. Provide a water slinger to operate on the top shaft, above the packing gland.

2.3.7.7 Mechanical Seal

Provide a mechanical seal.

2.3.7.8 Column Pipe

Provide column pipe of ASTM A53/A53M grade B steel pipe not less than Schedule 30. Machine the column ends with threads and faced parallel to the threads to ensure proper alignment. Connect the pipe with threaded sleeve type ductile iron couplings or flanges that will accept 3/4 inch stainless steel or bonze bearing retainers. Lineshaft bearings must be fluted rubber retained in a centering spider retainer.

2.3.7.9 Basket Strainer

Provide and attach a stainless steel basket strainer of a suitable size to the pump suction with stainless steel fasteners. Strainer must have a net inlet area equal to at least three times the impeller inlet area. The maximum opening must not be more than 75 percent of the maximum opening of the water passage through the bowl or impeller.

2.3.7.10 Motor

Electric motor must meet NEMA MG 1 and be the size and voltage indicated. Provide 1800RPM motor with NEMA Class B or Class F insulation. The motor must have a vertical hollow (or solid) shaft motor with space heaters and a non-reverse ratchet (or self-release coupling) to prevent reverse rotation. The motor must have an angular contact thrust bearing to meet the designed pump's hydraulic thrust load plus the weight of the rotating parts under operating conditions. Provide high efficiency motor with a weather protected WP-1 enclosure, 230/460 volt, 3 phase, 60HZ, and a 1.15 service factor. Motor must be non-overloading at any point on the pump curve and premium efficiency. Provide motor with efficiencies in compliance with NEMA MG 1.

2.3.8 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 installed check valve and a 72 inch minimum, electrical power cord with plug for 120V/1PH/60HZ electrical service.

2.3.8.1 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 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 ASHRAE 189.1, Table C-13. 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 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.

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 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. 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.

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. 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 4 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 25 00

CHEMICAL TREATMENT OF WATER FOR MECHANICAL SYSTEMS 11/08

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME	B40.100	(2013)	Pressure	Gauges	and	Gauge
		Attachr	nents			

ASTM INTERNATIONAL (ASTM)

ASTM D596	(2001; R 2018) Standard Guide for Reporting Results of Analysis of Water
ASTM D1384	(2005; R 2019) Corrosion Test for Engine Coolants in Glassware
ASTM D2688	(2015; E 2016) Standard Test Method for Corrosivity of Water in the Absence of Heat Transfer (Weight Loss Methods)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA	250 (201	.8)	Enclosures	for	Electrical	Equipment
	(100	0 0	Volts Maximu	ım)		

NEMA MG 1 (2018) Motors and Generators

U.S. ARMY CORPS OF ENGINEERS (USACE)

PWTB 420-49-5(1998) Industrial Water TreatmentProcedures

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-230-03 (2012; with Change 2, 2020) Water Treatment

1.2 SUMMARY

This section covers the provisions and installation procedures necessary for a complete and totally functional water system(s) chemical treatment. Provide and install the system with all necessary System Components, Accessories, Piping Components, and Supplemental Components/Services.

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

Water Treatment System; G Water Analysis; G Spare Parts Field Instructions Tests; G Training Course; G

SD-06 Test Reports

Condenser Water QA Tests Steam Boiler Water QA Tests

SD-10 Operation and Maintenance Data

Water Treatment System

1.4 QUALITY CONTROL

1.4.1 Safety

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. Install safety devices so that proper operation of equipment is not impaired.

1.4.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.6 MAINTENANCE

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings, not later than months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with source of supply

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

a. Provide materials and equipment which are standard products of a

manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship and that have been in satisfactory commercial or industrial use for two years prior to bid opening.

- b. The two-year use shall include applications of equipment and materials under similar circumstances and of similar size. The two years experience shall have been satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a two-year field service record 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. All products shall be supported by a service organization. Submit a certified list of qualified permanent service organizations for support of the equipment, including their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and shall be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.
- d. The selected service organization shall provide the chemicals required, the concentrations required, and the water treatment equipment sizes and flow rates required. The company shall provide all chemicals required for the condenser and chilled water systems and fill the systems with chemicals to the levels specified. The chemical shall meet the requirements of this specification as well as the recommendations from the manufacturers of the condenser and cooling tower. Acid treatment chemicals shall not be used.

2.2 NAMEPLATES

Each major component of equipment shall have the manufacturer's name, address, type or style, and catalog or serial number on a plate securely attached to the item of equipment. Nameplates shall be provided for:

- a. Pump(s)
- b. Pump Motor(s)

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide electrical motor driven equipment specified complete with motors, motor starters, and controls. Electrical characteristics and enclosure type shall be as shown, and unless otherwise indicated, all motors of 1 horsepower and above with open, dripproof, or totally enclosed fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. All motors shall be continuous duty with the enclosure specified. Provide motor starters complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Furnish motors with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor starter shall be provided with NEMA 1 enclosures. 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.

2.4 GAUGES

Gauges shall conform to ASME B40.100, Class 1, 2, or 3, Style X, Type I or III as required, 4-1/2 inches in diameter with phenolic or metal case.

2.5 WATER ANALYSIS

Conditions of make-up water to be supplied to the boilers, cooling towers and chilled water systems reported in accordance with ASTM D596 are as follows:

Date of Sample	
Temperature	degrees C
Silica (SiO 2)	ppm (mg/L)
Insoluble	ppm (mg/L)
Iron, total (Fe)	ppm (mg/L)
Aluminum (Al)	ppm (mg/L)
Calcium (Ca)	ppm (mg/L)
Magnesium (Mg)	ppm (mg/L)
Carbonate (HCO 3)	ppm (mg/L)
Sulfate (SO 4)	ppm (mg/L)
Chloride (Cl)	ppm (mg/L)
Nitrate (NO 3)	ppm (mg/L)
Turbidity	ntu
рН	
Residual Chlorine	ppm (mg/L)
Total Alkalinity	ppm (mg/L)
Non-Carbonate Hardness	ppm (mg/L)
Total Hardness	ppm (mg/L)
Dissolved Solids	ppm (mg/L)
Conductivity	micromho/cm

2.6 CONDENSER WATER TREATMENT SYSTEMS

The use of chemical-treatment products containing hexavalent chromium (Cr) is prohibited. Treat the water to be used in the condenser water systems to maintain the conditions recommended by this specification as well as the recommendations from the manufacturers of the condenser and evaporator coils. Chemicals shall meet all required federal, state, and local environmental regulations for the treatment of condenser-side heat exchangers, cooling towers and direct discharge to the sanitary sewer.

2.6.1 Condenser Water Limits

The condenser water limits shall be as follows, unless dictated differently by the cooling tower or chiller manufacturer's recommendations:

Treatment type	Phosphonate/Polymer
Puckorius Index	4 minimum
Langelier Index	4 maximum
Total Dissolved Solids	5000 ppm maximum
Calcium Hardness	1200 ppm maximum
Silica	150 ppm maximum
рН	7.5 - 8.5

For treated condenser/cooling tower water, blowdown must be minimized until the first of one of the top 5 limits is reached. Specific requirements for treatment chemicals and levels are listed below in paragraphs dealing with small and large systems.

2.6.2 Glycol Solution

Provide for the system a percent concentration by volume of industrial grade ethylene glycol, and corrosion inhibitors. Test the glycol in accordance with ASTM D1384 with less than 0.5 mils penetration per year for all system metals. The glycol shall contain corrosion inhibitors. Silicate based inhibitors are not acceptable. The solution shall be compatible with pump seals, other elements of the system, and water treatment chemicals used within the system.

2.6.3 Chemical Treatment for Small Systems

For cooling systems with a capacity of 50 tons or less, provide the following chemical treatment. For corrosion control provide 15 to 20 pounds polyphosphate in nylon mesh bag in cooling tower sump. If biocide is needed, use either 1-bromo-3-chloro-5.5-dimethylhydantoin or gluteraldehyde as recommended by manufacturer.

2.6.4 Chemical Treatment for Large Systems

For cooling systems with capacities greater than 50 tons provide one of the three following chemical treatments with the limits indicated. The

zinc and molybdate in the last two treatments help to meet the maximum corrosion requirements in waters that tend to be more corrosive. Biocides must be maintained to control bacteria below 10,000 colony forming units per milliliter.

a. Phosphonate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
ТТ	1-2 ppm
Biocides	as required

b. Zinc-Phosphonate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
Zinc	1-2 ppm
ТТ	1-2 ppm
Biocides	as required

c. Zinc-Molybdate Type Treatment

Phosphate	3-5 ppm
Polymer	3-4 ppm
Molybdate	10-15 ppm
Zinc	2-3 ppm
TT	1-2 ppm
Biocides	as required

2.6.4.1 General Requirements

Provide a water treatment system capable of automatically feeding chemicals and bleeding the system to prevent corrosion, scale, and biological formations. Submit 6 complete copies, at least 5 weeks prior to the purchase of the water treatment system, of the proposed water treatment plan including a layout; control scheme; a list of existing make-up water chemistry, including the items listed in paragraph Water Analysis; a list of treatment chemicals to be added; the proportion of chemicals to be added; the final treated water control levels; and a description of health, safety and environmental concerns for handling the chemicals plus any special ventilation requirements. Automatic chemical feed systems shall automatically feed chemicals into the condenser water based on makeup water rate. Electrical signals from a water meter on the makeup water line shall be used to control the output of chemical feed pumps. The system shall be initially set manually based on the water analysis of the make-up water. Submit 6 complete copies of operating and maintenance manuals for the step-by-step water treatment procedures. The manuals shall include testing procedures used in determining water quality.

2.6.4.2 Chemical Feed Pumps and Tanks

- a. Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. The chemical feed pumps shall be positive displacement diaphragm type. The pump's cylinders, plungers, ball check valves, and check valve bodies shall be of corrosion resistant materials suitable for the chemicals being pumped. Cylinders shall be replaceable for increased or reduced pressure or capacity ranges.
- b. The flow rate of the pumps shall be adjustable from 0 to 100 percent while in operation. Volumetric accuracy of the pumps shall be within one percent over the range indicated. Pump capacities shall be adjustable by positioning crank pin with micrometer setscrews. Stroke length scale shall be divided in percentage graduations engraved on scale. The discharge pressure of pumps shall not be less than 1.5 times the line pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge. The pumps shall be controlled by an external controller/timer receiving signals from the makeup water meter.
- c. Drive motors shall be 110 volt, single phase and shall have drip-proof enclosures. Provide two chemical tanks. The tanks shall be constructed of materials compatible with the chemicals to be stored in the tank with a hinged cover and mounted on legs. Tanks shall have filling and drain connections and gauge glass. Each tank shall be furnished with one pump, mounted and piped with black iron pipe and fittings, with suction strainer and stainless steel screen, and with 1/2 inch relief valve with steel body and stainless steel trim. Tank bottom shall be dished concave to a radius equal to the diameter of the tank. Motor-driven agitator shall be provided. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation.

2.6.4.3 Chemical Injection Assembly

Provide an injection assembly at each chemical feed point. Locate the injection assembly downstream of recirculating pumps and upstream of the condenser. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the condenser water piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the condenser water line.

2.6.4.4 Water Meter

Provide water meters with an electric contacting register and remote accumulative counter. Install the meter within the make-up water line, as indicated.

Timers shall be of the automatic reset, adjustable type, and electrically operated. The timers shall be designed to work with the contacting head water meters. The timer should include the water meter cable. The timers will control operation of the chemical feed pumps. The timers shall be suitable for a 120 volt current. The timers shall be located within the water treatment control panel.

2.6.4.6 Bleed (Blowdown) Line

Control the flow through the bleed line by a conductivity meter and probe installed to measure the conductivity of the condenser water. The conductivity meter shall have a high and low set point above which the conductivity meter shall open a solenoid valve on the bleed line. The bleed line attachment to the condenser water piping shall be located downstream of the recirculating pumps and upstream of the chemical injection point. The bleed line shall be extended to the nearest drain for continuous discharge.

2.6.4.7 Control Panel

The control panel shall be a NEMA 12 enclosure suitable for surface mounting. The panel shall be constructed of stainless steel with a hinged door and lock. The panel shall contain a laminated plastic nameplate identifying each of the following functions:

- (1) Main power switch and indicating light
- (2) MAN-OFF-AUTO selector switch
- (3) Indicating lamp for bleed-off valve
- (4) Indicating lamp for each chemical feed pump
- (5) Set point reading for each timer

2.6.4.8 Chemical Piping

The piping and fittings shall be constructed of schedule 80 PVC suitable for the water treatment chemicals.

2.6.4.9 Sequence of Operation

The chemicals shall be added based upon sensing the make-up water flow rate and activating appropriate timers. A separate timer shall be provided for each chemical. The blow down shall be controlled based upon the conductivity of the condenser water. The injection of the chemical required for biological control shall be controlled by a timer that can be manually set for proper chemical feed. All timer set points, blow down rates, and chemical pump flow rates shall be determined and set by the water treatment company.

2.6.4.10 Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided.

2.7 CHILLED WATER SYSTEM

A 2 gallon shot feeder shall be provided on the chilled water piping as indicated. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.7.1 Requirements for Glycol Solution

Provide a percent concentration by volume of industrial grade ethylene glycol, and corrosion inhibitors, for the system. Test the glycol in accordance with ASTM D1384 with less than 0.5 mils penetration per year for all system metals. The glycol shall contain corrosion inhibitors. Silicate based inhibitors shall not be used. The solution shall be compatible with pump seals, other elements of the system, and water treatment chemicals used within the system.

2.7.2 Chilled Water Treatment

Treat chilled water with either a borax/nitrite type treatment or a molybdate type treatment. Both types of treatment can be used with glycol. Borax/nitrite treatment shall be maintained at the limits of 600 to 1000 ppm nitrite, 40 - 50 ppm copper corrosion inhibitor (TT or MBT), and pH of 8.5 to 9.5. Molybdate treatment shall be maintained at the limits of 100 to 125 ppm molybdate, 40 - 50 ppm copper corrosion inhibitor (TT or MBT), and pH of 8.0 to 9.0.

2.7.3 Dual Temperature Systems

Dual hot/chilled water systems treated with borax/nitrite shall also be treated with a biocide.

2.7.4 Chilled Water Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided (e.g. pH and nitrite or molybdate).

2.8 LOW AND MEDIUM TEMPERATURE HOT WATER BOILERS AND HEAT EXCHANGERS

Low and medium temperature hot water boilers are defined as those operating below 350 degrees F, (250 degrees F for Low Temperature).

2.8.1 Chemical Feeder

A 2 gallon shot feeder shall be provided on the hot water piping as indicated. Size and capacity of feeder shall be based on local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.8.2 Low and Medium Temperature Hot Water Treatment

Hot water shall be treated with either a borax/nitrite type treatment or a molybdate type treatment. Both types of treatment can be used with glycol. Borax/nitrite treatment shall be maintained at the limits of 600 to 1000 ppm nitrite, 40 - 50 ppm copper corrosion inhibitor (TT or MBT) and pH of 8.5 to 9.5. Molybdate treatment shall be maintained at the limits of 100 to 125 ppm molybdate, 40 - 50 ppm copper corrosion inhibitor (TT or MBT) and pH of 8.0 to 9.0.

2.8.3 Dual Temperature Systems

Dual hot/chilled water systems treated with borax/nitrite shall also be treated with a biocide.

2.8.4 Test Kit Requirements

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided (e.g. pH and nitrite or molybdate).

2.9 HIGH TEMPERATURE HOT WATER BOILERS

2.9.1 Chemical Feeder Unit

A feeder unit shall be provided for each boiler. Chemical feeder shall be automatic proportioning, shot type, or pump type. All appurtenances necessary for satisfactory operation shall be provided. Size and capacity of feeder shall be based upon local requirements and water analysis.

2.9.2 Pumps and Tanks

- a. Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. The chemical feed pumps shall be positive displacement diaphragm type. The pump cylinders, plungers, ball check valves, and check valve bodies shall be of corrosion resistant materials suitable for the chemicals being pumped. Cylinders shall be replaceable for increased or reduced pressure or capacity ranges.
- b. The flow rate of the pumps shall be adjustable from 0 to 100 percent while in operation. Volumetric accuracy of the pumps shall be within one percent over the range indicated. Pump capacities shall be adjustable by positioning crank pin with micrometer setscrews. Stroke length scale shall be divided in percentage graduations engraved on scale. The discharge pressure of pumps shall not be less than 1.5 times the line pressure at the point of connection. The pump shall be designed to feed the chemical solutions into the HTW return line to the system circulating pumps and shall have capacity to feed a maximum of 5 gph. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge. The pumps shall be controlled by an external controller/timer receiving signals from the makeup water meter.
- c. Drive motors shall be 110 volt, single phase and shall have drip-proof enclosures. The tanks shall be constructed of materials compatible with the chemicals to be stored in the tank with a hinged cover and mounted on legs. Tanks shall have filling and drain connections and gauge glass. Each tank shall be furnished with one pump, mounted and piped with black iron pipe and fittings, with suction strainer and stainless steel screen, and with 1/2 inch relief valve with steel body and stainless steel trim. Tank bottom shall be dished concave to a radius equal to the diameter of the tank. Units shall be for phosphate, caustic feed and sulfite feeding. Sulfite tank shall have a floating cover to completely cover the surface of the solution. Motor-driven agitator shall be provided. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation.

2.9.3 Treated Water Limits

The boiler manufacturer shall be consulted for the determination of the boiler water chemical composition limits. The recirculating hot water chemical limits shall be as follows unless dictated differently by the

рн	9.3-9.9
Sulfite	30-60 ppm
Hardness	Less than 2.0 ppm

2.10 Test Kit

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided (e.g. pH, hardness and sulfite).

2.11 STEAM BOILER WATER TREATMENT

Provide a water treatment system capable of feeding chemicals and blowdown of the system to prevent corrosion and scale within the boiler and piping distribution system. Treat the water to maintain the conditions recommended by the boiler manufacturer or UFC 3-230-03 (Central Boiler Plants) and PWTB 420-49-5 (Industrial Water Treatment Procedures). Chemicals shall meet required federal, state, and local environmental regulations for the treatment of boilers and discharge to the sanitary sewer. The services of a company regularly engaged in the treatment of boilers shall be used to determine the correct concentrations required for water treatment. The company shall maintain the chemical treatment and provide all chemicals required for a period of 1 year from the date of occupancy. Filming amines, hydrazine and chelants shall not be used. The water treatment chemicals shall remain stable throughout the operating temperature range of the system and shall be compatible with pump seals and other elements of the system.

2.11.1 Boiler Water Limits

The boiler water limits shall be as follows unless dictated differently by the boiler manufacturer's recommendations:

Causticity (OH)	20-200 ppm
Total Alkalinity (CaCO3)	200-800 ppm
Phosphate (PO4)	30-60 ppm
Polymer (dispersant) or Tannin	5-10 ppm or medium color, respectively
Dissolved Solids (water tube boilers)	3000-3500 ppm
Dissolved Solids (fire tube boilers)	3500-5000 ppm
Suspended Solids	15 ppm Maximum
Sodium Sulfite	20-40 ppm

Silica	Less than 200 ppm
Dissolved Oxygen	Less than 7 ppb
Iron	Less than 10 ppm
pH (Condensate)	7.5 - 8
Conductivity (Condensate)	Less than 35 micromhos
Hardness (Condensate and makeup)	Less than 2 ppm

The above limits apply to boilers operating above 15 psi up 300 psi. Above 300 psi these limits decrease. Use ABMA or chemical vendor recommended limits above 300 psi.

2.11.2 Boiler Water Treatment System

The water treatment system shall be capable of automatically feeding chemicals to prevent corrosion and scale within the boiler and condensate system. Automatic chemical feed systems shall feed chemicals into the boiler based on makeup water rate. Electrical signals from a water meter on the makeup water line shall be used to control the output of chemical feed pumps.

- 2.11.3 Steam Boiler Chemical Feed Pumps and Tanks
 - a. Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. The chemical feed pumps shall be positive displacement diaphragm type. The pump cylinders, plungers, ball check valves, and check valve bodies shall be of corrosion resistant materials suitable for the chemicals being pumped. Cylinders shall be replaceable for increased or reduced pressure or capacity ranges. The flow rate of the pumps shall be adjustable from 0 to 100 percent while in operation. Volumetric accuracy of the pumps shall be within one percent over the range indicated. Pump capacities shall be adjustable by positioning crank pin with micrometer setscrews. Stroke length scale shall be divided in percentage graduations engraved on scale.
 - b. The discharge pressure of pumps shall not be less than 1.5 times the line pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge. The pumps shall be controlled by an external controller/timer receiving signals from the makeup water meter.
 - c. Drive motors shall be 110 volt, single phase and shall have drip-proof enclosures. The tanks shall be constructed of materials compatible with the chemicals to be stored in the tank with a hinged cover and mounted on legs. Tanks shall have filling and drain connections and gauge glass. Each tank shall be furnished with one pump, mounted and piped with black iron pipe and fittings, with suction strainer and stainless steel screen, and with 1/2 inch relief valve with steel body and stainless steel trim. Tank bottom shall be dished concave to a radius equal to the diameter of the tank. The tank for sodium sulfite will have a floating cover to minimize contact with air. Motor-driven

2.11.4 Steam Boiler Chemical Injection Assemblies

Provide an injection assembly at each chemical injection point located along the boiler piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the water line.

2.11.5 Steam Boiler Water Meter

Provide the water meter with an electric contacting register and remote accumulative counter. Install the meter within the makeup water line, as indicated.

2.11.6 Steam Boiler Timers

Timers shall be of the automatic reset, adjustable type, and electrically operated. The timers shall be designed to work with the contacting head water meters. The timer should include the water meter cable. The timers will control operation of the chemical feed pumps. The timers shall be suitable for a 120 volt current. The timers shall be used to control the electrical signals from the water meters to the chemical feed pumps.

2.11.7 Steam Boiler Control Panel

The control panel shall be a NEMA 12, single door, wall-mounted box conforming with NEMA 250. The panel shall be constructed of coated steel with a hinged door and lock. The panel shall contain, as a minimum, the following functions identified with a laminated plastic nameplate:

- a. Main power switch and indicating light
- b. MAN-OFF-AUTO selector switch
- c. Indicating lamp for each chemical feed pump
- d. Indicating lamp for the water softener

2.11.8 Boiler Blowdown

Provide the boiler with continuous blowdown . Bottom blowdown connection and valve shall also be present to allow removal of solids and water from the bottom of the boiler.

2.11.9 Boiler Chemical Piping

The piping and fittings shall be constructed of steel .

2.11.10 Boiler Test Kits

One test kit of each type required to determine the water quality as outlined in paragraph Boiler Water Limits above and within the operation and maintenance manuals.

2.12 SUPPLEMENTAL COMPONENTS/SERVICES

Drain and makeup water piping shall comply with the documents. Drains which connect to sanitary sewer systems shall be connected by means of an indirect waste.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

Provide all chemicals, equipment and labor necessary to bring all system waters in conformance with the specified requirements. Perform all work in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements.

3.3 PIPING

Connections between dissimilar metals shall be made with a dielectric union.

3.4 TRAINING COURSE

Submit a schedule, at least 2 weeks prior to the date of the proposed training course, that identifies the date, time, and location for the training. Conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. Submit field instructions, at least 2 weeks prior to construction completion, including equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall 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 shall be framed under glass or laminated plastic and posted where indicated by the Contracting Officer. The field instructions shall cover all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

3.5 TESTS

If the waters of the mechanical systems are not in conformance with the specified requirements or in accordance with manufacturer's recommendations, the water treatment company shall take corrective action to enable compliance. Daily operational tests shall be performed in the directed frequencies to maintain required control to prevent corrosion, scaling and damage to equipment during operation Submit test schedules, at least 2 weeks prior to the start of related testing, for the condenser/chilled/boiler/condensate/feedwater water quality tests. The schedules shall identify the date, time, frequency and collection location for each test.

- 3.5.1 Condenser Water Quality Tests
- 3.5.1.1 Small Systems (weekly)

Once a week, for cooling systems with a capacity of 50 tons or less, the following items shall be recorded.

рн	
Total Alkalinity (as CaCO3)	ppm (mg/L)
Conductivity	micromho/cm

3.5.1.2 Tests for Large Systems (daily)

Daily, for cooling systems with a capacity larger than 50 tons, the following items shall be recorded.

PH	
Total Alkalinity (as CaCO3)	ppm (mg/L)
Conductivity	micromho/cm
Phosphate	ppm (mg/L)
Zinc, if used (Zn)	ppm (mg/L)
Molybdate, if used (Mo)	ppm (mg/L)

3.5.2 Chilled Water Testing (monthly)

Once a month, the following tests will be performed on chilled water.

рН	
Nitrite or Molybdate	ppm (mg/L)
Conductivity	micromho/cm

3.5.3 Hot Water Boiler Water Quality Testing

3.5.3.1 Low and Medium Temperature Systems (monthly)

Monthly testing shall be completed and recorded for the following parameters.

рН	
Nitrite or Molybdate	ppm (mg/L)

3.5.3.2 High Temperature Hot Water Systems (daily)

Daily testing shall be completed and recorded for the following parameters.

рН	
Sulfite	ppm (mg/L)
Hardness	ppm (mg/L)

3.5.4 Steam Boiler Water Testing

3.5.4.1 Small Steam Systems

The type of treatment required for small steam systems (below 25 hp) varies greatly depending on local water and system conditions. The type of treatment and frequency of testing shall be determined by the water treatment chemical vendor.

3.5.4.2 Medium Steam Systems (twice weekly)

Twice a week for steam boiler systems operating between 25 hp and 100 hp the following items will be recorded and utilized for operation purposes.

рH	
P Alkalinity (as CaCO3)	ppm (mg/L)
Total Dissolved Solids	ppm (mg/L)
Phosphate (PO4)	ppm (mg/L)
Sulfite (NaSO3)	ppm (mg/L)

3.5.4.3 Large Steam Systems (daily)

Daily, for steam boiler systems operating above 15 psi and 100 hp, the following items will be recorded and utilized for operational purposes.

Sulfite (NaSO3)	ppm (mg/L)
P Alkalinity (as CaCO3)	ppm (mg/L)
Conductivity	micromho/cm
Neutralized Conductivity	micromho/cm
Total Dissolved Solids	ppm (mg/L)
Phosphate (PO4)	ppm (mg/L)
Condensate pH	
Condensate Conductivity	micromho/cm

Condensate Hardness (as CaCO3)	ppm (mg/L)
Makeup Water Hardness (as CaCO3)	ppm (mg/L)

3.5.5 Quality Assurance Testing

Conduct QA testing periodically by an independent water treatment lab/consultant to verify to managers that the mechanical and water treatment systems are being maintained properly. Provide the QA evaluation reports to the government COR.

3.5.5.1 Condenser Water QA Tests

Submit test reports in bound 8-1/2 by 11 inch booklets. The reports shall identify the chemical composition of the condenser water. The reports shall also include a comparison of the manufacturer's or chemical vendor's recommended operating conditions for the cooling tower and condenser in relation to the actual condition of the condenser water. Any required corrective action shall be documented within the report.

a. For cooling systems with a capacity of 50 ton or less, the following tests shall be performed

Presence of scale/corrosion	
Polyphosphate	ppm (mg/L)
Biocide	ppm (mg/L)
рН	
Total Alkalinity (as CaCO3)	ppm (mg/L)
Calcium Hardness (as CaCO3)	ppm (mg/L)
Conductivity	micromho/cm
Written evaluation summary	

b. For cooling systems with capacities greater than 50 ton), the condenser water shall be analyzed a minimum of once a month for a period of one year by the water treatment company. The analysis shall include the following information recorded in accordance with ASTM D596.

Date of Sample	
Temperatures (before & after condenser)	& degrees C
PH	

Silica (SiO2)	ppm (mg/L)
Iron (total, as Fe(2)O(3))	ppm (mg/L)
Copper (Cu)	ppm (mg/L)
Calcium Hardness(CaCO3)	ppm (mg/L)
Total Hardness (as CaCO3)	ppm (mg/L)
Chloride (Cl)	ppm (mg/L)
Total Alkalinity (as CaCO3)	ppm (mg/L)
Conductivity	micromho/cm
Total Dissolved Solids	ppm (mg/L)
Phosphonate (as PO4)	ppm (mg/L)
Zinc (if used) (Zn)	ppm (mg/L)
Molybdate (if used) (Mo)	ppm (mg/L)
Tolyltriazole (TT)	ppm (mg/L)
Biocide	ppm (mg/L)
Bacteria colony count	colonies/mL
Makeup water pH	ppm (mg/L)
Makeup water Iron	ppm (mg/L)
Makeup water Silica	ppm (mg/L)
Makeup water Calcium Hardness	ppm (mg/L)
Makeup water Total Hardness	ppm (mg/L)
Makeup water Total Alkalinity	ppm (mg/L)
Makeup water Chloride (Cl)	ppm (mg/L)
Makeup water Conductivity	micromho/cm
Written evaluation summary	1

3.5.5.2 Chilled Water Quality Assurance Testing (quarterly)

Quarterly, the following tests shall be performed on chilled water.

рН	
Nitrite or Molybdate	ppm (mg/L)
Conductivity	micromho/cm
Iron (total, as Fe(2)O(3))	ppm (mg/L)
Written evaluation summary	

- 3.5.5.3 Hot Water Boiler Water Quality Assurance Testing
 - a. Quarterly testing of Low and Medium Temperature Systems shall be completed and recorded for the following parameters.

рН	
Nitrite or Molybdate	ppm (mg/L)
Iron (total, as Fe(2)O(3))	ppm (mg/L)
Written evaluation summary	

b. The hot water boiler water shall be analyzed once a month for a period of 1 year by an independent consultant. The analysis shall include the following information recorded in accordance with ASTM D596.

рн	
Sulfite (Na2SO3)	ppm (mg/L)
Hardness(as CaCO3)	ppm (mg/L)
Iron (total, as Fe(2)O(3))	ppm (mg/L)
Written evaluation summary	

3.5.5.4 Steam Boiler Water QA Tests

Submit the water quality test report identifying the chemical composition of the boiler, feedwater and condensate water. The report shall include a comparison of the condition of the boiler water with the manufacturer's or chemical vendor's recommended conditions. Any required corrective action shall be documented within the report.

a. Small and Medium Steam Boiler Systems (quarterly)are systems operating between 25 hp and 100 hp. The following tests shall be performed quarterly.

рH	
Sulfite, if used, (NaSO3)	ppm (mg/L)
P Alkalinity (as CaCO3)	ppm (mg/L)
Total Dissolved Solids	ppm (mg/L)
Phosphate, if used, (PO4)	ppm (mg/L)
Polymer, if used	ppm (mg/L)
Iron (total, as Fe(2)O(3))	ppm (mg/L)
Condensate pH	
Condensate Conductivity	micromho/cm
Condensate Hardness (as CaCO3)	ppm (mg/L)
Condensate Iron (total, as Fe(2)O(3))	ppm (mg/L)
Makeup Water Hardness (as CaCO3)	ppm (mg/L)
Written evaluation summary	

b. Large steam boilers are those operating above 15 psi and 100 hp. The boiler water shall be analyzed a minimum of once a month for a period of 1 year by an independent consultant. The analysis shall include the following information recorded in accordance with ASTM D596.

Date of Sample	
рн	
Sulfite (NaSO3)	ppm (mg/L)
P Alkalinity (as CaCO3)	ppm (mg/L)
Conductivity	micromho/cm
Neutralized Conductivity	micromho/cm
Total Dissolved Solids	ppm (mg/L)
Phosphate (PO4)	ppm (mg/L)
Polymer, if used	ppm (mg/L)
Silica (SiO2)	ppm (mg/L)

<pre>Iron (total, as Fe(2)O(3))</pre>	ppm (mg/L)
Condensate pH	
Condensate Conductivity	micromho/cm
Condensate Hardness (as CaCO3)	ppm (mg/L)
Condensate Iron (total, as Fe(2)O(3))	ppm (mg/L)
Makeup Water Hardness (as CaCO3)	ppm (mg/L)
Written evaluation summary	

3.5.6 Corrosion Testers

Install corrosion coupon and rack systems to verify corrosion control in the systems. Testers or coupons are installed in flowing system water through a sidestream or rack system. Both mild steel and copper metal samples are to be tested in the corrosion testers in accordance with ASTM D2688. Samples are to be replaced and analyzed every 3 months. Rates of corrosion less than 3 mpy for steel and 0.2 mpy for copper are acceptable. Corrosion testers shall be installed on the piping systems of the following systems.

Condenser loop Chilled water system Hot water loop Condensate

3.6 INSPECTIONS

3.6.1 Inspection General Requirements

Thirty days after project completion, inspect the cooling tower and condenser for problems due to corrosion, scale, and biological growth. If the cooling tower and condenser are found not to conform to the manufacturer's recommended conditions, and the water treatment company recommendations have been followed; the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations.

3.6.2 Boiler/Piping Test

Thirty day after project completion, inspect the boiler and condensate piping for problems due to corrosion and scale. If the boiler is found not to conform to the manufacturer's recommendations, and the water treatment company recommendations have been followed, the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations. If corrosion is found within the condensate piping, proper repairs shall be made by the water treatment company.

-- End of Section --

SECTION 23 30 00

HVAC AIR DISTRIBUTION 05/20

PART 1 GENERAL

1.1 REFERENCES

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

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S12.51	(2012; R 2017) American National Standard
	Acoustics - Determination of Sound Power
	Levels and Sound Energy Levels of Noise
	Sources using Sound Pressure - Precision
	Methods for Reverberation Test Rooms

AIR CONDITIONING CONTRACTORS OF AMERICA (ACCA)

ACCA	Manual 4	(2001) Installation Techniques for Perimeter Heating and Cooling; 11th Edition
	AIR MOVEMENT AND CONTROL	L ASSOCIATION INTERNATIONAL, INC. (AMCA)
AMCA	201	(2002; R 2011) Fans and Systems
AMCA	210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA	220	(2005;R 2012) Test Methods for Air Curtain Units
AMCA	300	(2014) Reverberant Room Method for Sound Testing of Fans
AMCA	301	(2014) Methods for Calculating Fan Sound Ratings from Laboratory Test Data
AMCA	500-D	(2018) Laboratory Methods of Testing Dampers for Rating
AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)		
AHRI	260 I-P	(2012) Sound Rating of Ducted Air Moving and Conditioning Equipment
AHRI	350	(2015) Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment
AHRI	410	(2001; Addendum 1 2002; Addendum 2 2005;

I 410 (2001; Addendum 1 2002; Addendum 2 2005; Addendum 3 2011) Forced-Circulation Air-Cooling and Air-Heating Coils

AHRI	430	(2009)	Central-Station Air-Handling Units
AHRI 4	440	(2008)	Performance Rating of Room Fan-Coils
AHRI	880 I-P	(2011)	Performance Rating of Air Terminals
AHRI	885	(2008; Estima the Ap Outlet	Addendum 2011) Procedure for ting Occupied Space Sound Levels in plication of Air Terminals and Air s
AHRI I	DCAACP	(Onlin Air-Co	e) Directory of Certified Applied onditioning Products
AHRI (Guideline D	(1996) Centra	Application and Installation of l Station Air-Handling Units
	AMERICAN	BEARING MANUFACTURERS	ASSOCIATION (ABMA)
ABMA	9	(2015) Ball B	Load Ratings and Fatigue Life for earings
ABMA	11	(2014) Roller	Load Ratings and Fatigue Life for Bearings
	AMERICAN ENGINEERS	SOCIETY OF HEATING, R 5 (ASHRAE)	EFRIGERATING AND AIR-CONDITIONING
ASHRA	E 15 & 34	(2013) Standa Standa Classi Standa	ASHRAE Standard 34-2016 Safety rd for Refrigeration Systems/ASHRAE rd 34-2016 Designation and Safety fication of Refrigerants-ASHRAE rd 34-2016
ASHRA	E 52.2	(2012) Ventil Remova	Method of Testing General ation Air-Cleaning Devices for l Efficiency by Particle Size
ASHRA	E 62.1	(2010) Air Qu	Ventilation for Acceptable Indoor ality
ASHRA	E 68	(1997) Determ	Laboratory Method of Testing to ine the Sound Power In a Duct
ASHRA	E 70	(2006; Rating Inlets	R 2011) Method of Testing for the Performance of Air Outlets and
ASHRA	E 84	(2020) Exchan	Method of Testing Air-to-Air Heat gers
ASHRA	E 90.1 - IP	(2013) Except	Energy Standard for Buildings Low-Rise Residential Buildings
	AMERICAN	SOCIETY OF MECHANICAL	ENGINEERS (ASME)
ASME 2	A13.1	(2020) Piping	Scheme for the Identification of Systems

ASTM INTERNATIONAL (ASTM)

ASTM	A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM	A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM	A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM	A924/A924M	(2020) Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM	B75/B75M	(2020) Standard Specification for Seamless Copper Tube
ASTM	B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM	B152/B152M	(2019) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM	B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM	B280	(2020) Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM	B766	(1986; R 2015) Standard Specification for Electrodeposited Coatings of Cadmium
ASTM	C553	(2013; R 2019) Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM	C916	(2020) Standard Specification for Adhesives for Duct Thermal Insulation
ASTM	C1071	(2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM	D520	(2000; R 2011) Zinc Dust Pigment
ASTM	D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM	D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120

ASTM D2466	(2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40	
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems	
ASTM D2855	(2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings	
ASTM D3359	(2017) Standard Test Methods for Rating Adhesion by Tape Test	
ASTM E84	(2020) Standard Test Method for Surface Burning Characteristics of Building Materials	
ASTM E2016	(2020) Standard Specification for Industrial Woven Wire Cloth	
CALIFORNIA DEPARTMENT O	F PUBLIC HEALTH (CDPH)	
CDPH SECTION 01350	(2010; Version 1.1) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers	
GERMAN INSTITUTE FOR STA	ANDARDIZATION (DIN)	
DIN EN 14037	(2016) Free Hanging Heating and Cooling Surfaces for Water with a Temperature Below 120 Degrees C - Part 1: Pre-Fabricated Ceiling Mounted Radiant Panels for Space Heating	
DIN EN 14240	(2004) Ventilation for Buildings	
INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY (IEST)		
IEST RP-CC-001	(2016; Rev 6) HEPA and ULPA Filters	
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)		
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures	
NEMA MG 1	(2018) Motors and Generators	
NEMA MG 10	(2017) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors	
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors	

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code	
NFPA 90A	(2021) Standard for the Installation of Air Conditioning and Ventilating Systems	
NFPA 96	(2021) Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations	
NFPA 701	(2019) Standard Methods of Fire Tests for Flame Propagation of Textiles and Films	
SHEET METAL AND AIR CONI (SMACNA)	DITIONING CONTRACTORS' NATIONAL ASSOCIATION	
SMACNA 1403	(2008) Accepted Industry Practice for Industrial Duct Construction, 2nd Edition	
SMACNA 1819	(2002) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 5th Edition	
SMACNA 1966	(2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition	
SMACNA 1972 CD	(2012) HVAC Air Duct Leakage Test Manual - 2nd Edition	
SMACNA 1981	(2008) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd Edition	
SOUTH COAST AIR QUALITY	MANAGEMENT DISTRICT (SCAQMD)	
SCAQMD Rule 1168	(2017) Adhesive and Sealant Applications	
U.S. DEPARTMENT OF ENERG	GY FEDERAL ENERGY MANAGEMENT PROGRAM (FEMP)	
PL-109-58	(1992; R 2005) Energy Efiicient Procument Requirements	
U.S. NATIONAL ARCHIVES A	AND RECORDS ADMINISTRATION (NARA)	
40 CFR 82	Protection of Stratospheric Ozone	
UNDERWRITERS LABORATORIES (UL)		
UL 6	(2007; Reprint Sep 2019) UL Standard for Safety Electrical Rigid Metal Conduit-Steel	
UL 94	(2013; Reprint Jun 2020) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances	
UL 181	(2013; Reprint Apr 2017) UL Standard for	

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	Safety Factory-Made Air Ducts and Air Connectors
UL 555	(2006; Reprint Aug 2016) UL Standard for Safety Fire Dampers
UL 586	(2009; Reprint Dec 2017) UL Standard for Safety High-Efficiency Particulate, Air Filter Units
UL 705	(2017; Reprint Oct 2018) UL Standard for Safety Power Ventilators
UL 723	(2018) UL Standard for Safety Test for Surface Burning Characteristics of Building Materials
UL 900	(2015) Standard for Air Filter Units
UL 1995	(2015) UL Standard for Safety Heating and Cooling Equipment
UL 2021	(2015; Reprint Dec 2016) UL Standard for Safety Fixed and Location-Dedicated Electric Room Heaters
UL Bld Mat Dir	(updated continuously online) Building Materials Directory
UL Electrical Construction	(2012) Electrical Construction Equipment Directory
UL Fire Resistance	(2014) Fire Resistance Directory

1.2 SYSTEM DESCRIPTION

Furnish ductwork, piping offsets, fittings, and accessories as required to provide a complete installation. Coordinate the work of the different trades to avoid interference between piping, equipment, structural, and electrical work. Provide complete, in place, all necessary offsets in piping and ductwork, and all fittings, and other components, required to install the work as indicated and specified.

1.2.1 Mechanical Equipment Identification

The number of charts and diagrams must be equal to or greater than the number of mechanical equipment rooms. Where more than one chart or diagram per space is required, mount these in edge pivoted, swinging leaf, extruded aluminum frame holders which open to 170 degrees.

1.2.1.1 Charts

Provide chart listing of equipment by designation numbers and capacities such as flow rates, pressure and temperature differences, heating and cooling capacities, horsepower, pipe sizes, and voltage and current characteristics.

1.2.1.2 Diagrams

Submit proposed diagrams, at least 2 weeks prior to start of related testing. provide neat mechanical drawings provided with extruded aluminum frame under 1/8-inch glass or laminated plastic, system diagrams that show the layout of equipment, piping, and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system. After approval, post these items where directed.

1.2.2 Service Labeling

Label equipment, including fans, air handlers, terminal units, etc. with labels made of self-sticking, plastic film designed for permanent installation. Provide labels in accordance with the typical examples below:

SERVICE	LABEL AND TAG DESIGNATION
Air handling unit Number	AHU -
Control and instrument air	CONTROL AND INSTR.
Exhaust Fan Number	EF -
VAV Box Number	VAV -
Fan Coil Unit Number	FC -
Terminal Box Number	TB -
Unit Ventilator Number	UV -

Identify similar services with different temperatures or pressures. Where pressures could exceed 125 pounds per square inch, gage, include the maximum system pressure in the label. Label and arrow piping in accordance with the following:

- a. Each point of entry and exit of pipe passing through walls.
- b. Each change in direction, i.e., elbows, tees.
- c. In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard.
- d. In long straight runs, locate labels at distances within eyesight of each other not to exceed 75 feet. All labels must be visible and legible from the primary service and operating area.
| For Bare or Insulated Pipes | | |
|-----------------------------|------------|--|
| for Outside Diameters of | Lettering | |
| 1/2 thru 1-3/8 inch | 1/2 inch | |
| 1-1/2 thru 2-3/8 inch | 3/4 inch | |
| 2-1/2 inch and larger | 1-1/4 inch | |

1.2.3 Color Coding

Color coding of all piping systems must be in accordance with ASME A13.1 .

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. 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

SD-03 Product Data

Metallic Flexible Duct

Insulated Nonmetallic Flexible Duct Runouts

Duct Connectors

Duct Access Doors; G

Fire Dampers

Manual Balancing Dampers; G

Sound Attenuation Equipment

Acoustical Duct Liner

Diffusers

Registers and Grilles

Louvers

Air Vents, Penthouses, and Goosenecks

Centrifugal Fans

In-Line Centrifugal Fans Axial Flow Fans Panel Type Power Wall Ventilators Centrifugal Type Power Wall Ventilators Centrifugal Type Power Roof Ventilators Propeller Type Power Roof Ventilators Air-Curtain Fans Ceiling Exhaust Fans PL-109-58 label for ceiling exhaust fan product; S Air Handling Units; G Room Fan-Coil Units; G Coil Induction Units; G Constant Volume, Single Duct Terminal Units; G Variable Volume, Single Duct Terminal Units; G Variable Volume, Single Duct, Fan-Powered Terminal Units; G Dual Duct Terminal Units; G Ceiling Induction Terminal Units; G Reheat Units; G Unit Ventilators Energy Recovery Devices; G Hydronic Modular Panels; G Prefabricated Radiant-Heating Electric Panels; G Test Procedures Diagrams; G Indoor Air Quality for Duct Sealants; S SD-06 Test Reports Performance Tests; G

Damper Acceptance Test; G

SD-07 Certificates

SD-08 Manufacturer's Instructions Manufacturer's Installation Instructions Operation and Maintenance Training SD-10 Operation and Maintenance Data Operation and Maintenance Manuals; G Fire Dampers; G Manual Balancing Dampers; G

Centrifugal Fans; G In-Line Centrifugal Fans; G Axial Flow Fans; G Panel Type Power Wall Ventilators; G Centrifugal Type Power Wall Ventilators; G Centrifugal Type Power Roof Ventilators; G Propeller Type Power Roof Ventilators; G Air-Curtain Fans; G Ceiling Exhaust Fans; G Air Handling Units; G Room Fan-Coil Units; G Coil Induction Units; G Constant Volume, Single Duct Terminal Units; G Variable Volume, Single Duct Terminal Units; G Variable Volume, Single Duct, Fan-Powered Terminal Units; G Dual Duct Terminal Units; G Ceiling Induction Terminal Units; G Reheat Units; G Unit Ventilators; G Energy Recovery Devices; G

Hydronic Modular Panels; G

Prefabricated Radiant-Heating Electric Panels; G

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.4 QUALITY ASSURANCE

Except as otherwise specified, approval of materials and equipment is based on manufacturer's published data.

- a. Where materials and equipment are specified to conform to the standards of the Underwriters Laboratories, the label of or listing with reexamination in UL Bld Mat Dir, and UL 6 is acceptable as sufficient evidence that the items conform to Underwriters Laboratories requirements. In lieu of such label or listing, submit a written certificate from any nationally recognized testing agency, adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the specified requirements. Outline methods of testing used by the specified agencies.
- b. Where materials or equipment are specified to be constructed or tested, or both, in accordance with the standards of the ASTM International (ASTM), the ASME International (ASME), or other standards, a manufacturer's certificate of compliance of each item is acceptable as proof of compliance.
- c. Conformance to such agency requirements does not relieve the item from compliance with other requirements of these specifications.
- d. Where products are specified to meet or exceed the specified energy efficiency requirement of FEMP-designated or ENERGY STAR covered product categories, equipment selected must have as a minimum the efficiency rating identified under "Energy-Efficient Products" at http://femp.energy.gov/procurement.

1.4.1 Prevention of Corrosion

Protect metallic materials against corrosion. Provide rust-inhibiting treatment and standard finish for the equipment enclosures. Do not use aluminum in contact with earth, and where connected to dissimilar metal. Protect aluminum by approved fittings, barrier material, or treatment. Provide hot-dip galvanized ferrous parts such as anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous parts not of corrosion-resistant steel or nonferrous materials in accordance with ASTM A123/A123M for exterior locations and cadmium-plated in conformance with ASTM B766 for interior locations.

1.4.2 Asbestos Prohibition

Do not use asbestos and asbestos-containing products.

1.4.3 Ozone Depleting Substances Technician Certification

All technicians working on equipment that contain ozone depleting

refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.4.4 Detail Drawings

Submit detail drawings showing equipment layout, including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications. Include any information required to demonstrate that the system has been coordinated and functions properly as a unit on the drawings and show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Submit drawings showing bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Submit function designation of the equipment and any other requirements specified throughout this Section with the shop drawings.

1.4.5 Test Procedures

Conduct performance tests as required in Section 23 05 93 Testing, Adjusting and Balancing for HVAC and Section 23 09 00 Instrumentation and Control for HVAC.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect stored equipment at the jobsite from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all pipes until installed.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Provide components and equipment that are "standard products" of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. "Standard products" is defined as being in satisfactory commercial or industrial use for 2 years before bid opening, including applications of components and equipment under similar circumstances and of similar size, satisfactorily completed by a product that is sold on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record are acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Provide equipment items that are supported by a service organization. In product categories covered by ENERGY STAR or the Federal Energy Management Program, provide equipment that is listed on the ENERGY STAR Qualified Products List or that meets or exceeds the FEMP-designated Efficiency Requirements.

2.2 IDENTIFICATION PLATES

In addition to standard manufacturer's identification plates, provide engraved laminated phenolic identification plates for each piece of mechanical equipment. Identification plates are to designate the function of the equipment. Submit designation with the shop drawings. Provide identification plates that are layers, black-white-black, engraved to show white letters on black background. Letters must be upper case. Identification plates that are 1-1/2-inches high and smaller must be 1/16-inch thick, with engraved lettering 1/8-inch high; identification plates larger than 1-1/2-inches high must be 1/8-inch thick, with engraved lettering of suitable height. Identification plates 1-1/2-inches high and larger must have beveled edges. Install identification plates using a compatible adhesive.

2.3 EQUIPMENT GUARDS AND ACCESS

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact according to OSHA requirements. Properly guard or cover with insulation of a type specified, high temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard.

2.4 ELECTRICAL WORK

- a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00INTERIOR DISTRIBUTION SYSTEM. Provide manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown. For packaged equipment, include manufacturer provided controllers with the required monitors and timed restart.
- b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11. Provide premium efficiency type integral size motors in accordance with NEMA MG 1.
- c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system , and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Select premium efficiency polyphase motors in accordance with NEMA MG 10.
- d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Provide motors rated for continuous duty with the enclosure specified. Provide motor duty that allows for maximum frequency start-stop operation and minimum encountered interval between start and stop. Provide motor torque capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Fit motor bearings with grease supply fittings and grease relief to outside of the enclosure.
- e. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers are allowed to accomplish the same function. Use solid-state variable-speed controllers for motors rated 10 hp or less and adjustable frequency drives for larger motors.

Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE SYSTEMS UNDER 600 VOLTS.

2.5 ANCHOR BOLTS

Provide anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts to be of the size and number recommended by the equipment manufacturer and located by means of suitable templates. Installation of anchor bolts must not degrade the surrounding concrete.

2.6 SEISMIC ANCHORAGE

Anchor equipment in accordance with applicable seismic criteria for the area and as defined in SMACNA 1981

2.7 PAINTING

Paint equipment units in accordance with approved equipment manufacturer's standards unless specified otherwise. Field retouch only if approved. Otherwise, return equipment to the factory for refinishing.

2.8 INDOOR AIR QUALITY

Provide equipment and components that comply with the requirements of ASHRAE 62.1 unless more stringent requirements are specified herein.

2.9 DUCT SYSTEMS

2.9.1 Metal Ductwork

Provide metal ductwork construction, including all fittings and components, that complies with SMACNA 1966, as supplemented and modified by this specification .

- b. Provide radius type elbows with a centerline radius of 1.5 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes are allowed.
- c. Provide ductwork that meets the requirements of Seal Class A. Provide ductwork in VAV systems upstream of the VAV boxes that meets the requirements of Seal Class A.
- e. Provide sealants that conform to fire hazard classification specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS and are suitable for the range of air distribution and ambient temperatures to which it is exposed. Do not use pressure sensitive tape as a sealant. Provide duct sealant products that meet either emissions requirements of CDPH SECTION 01350 (limit requirements for either office or classroom spaces regardless of space type) or VOC content requirements of SCAQMD Rule 1168 (HVAC duct sealants are classified as "Other" within the SCAQMD Rule 1168 sealants table). Provide validation of indoor air quality for duct sealants.
- f. Make spiral lock seam duct, and flat oval with duct sealant and lock

with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA 1966. Apply the sealant to the exposed male part of the fitting collar so that the sealer is on the inside of the joint and fully protected by the metal of the duct fitting. Apply one brush coat of the sealant over the outside of the joint to at least 2 inch band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar are not acceptable.

g. Fabricate outdoor air intake ducts and plenums with watertight soldered or brazed joints and seams.

2.9.1.1 Metallic Flexible Duct

- a. Provide duct that conforms to UL 181 and NFPA 90A with factory-applied insulation, vapor barrier, and end connections. Provide duct assembly that does not exceed 25 for flame spread and 50 for smoke developed. Provide ducts designed for working pressures of 2 inches water gauge positive and 1.5 inches water gauge negative. Provide flexible round duct length that does not exceed 5 feet. Secure connections by applying adhesive for 2 inches over rigid duct, apply flexible duct 2 inches over rigid duct, apply metal clamp, and provide minimum of three No. 8 sheet metal screws through clamp and rigid duct.
- b. Inner duct core: Provide interlocking spiral or helically corrugated flexible core constructed of zinc-coated steel, aluminum, or stainless steel; or constructed of inner liner of continuous galvanized spring steel wire helix fused to continuous, fire-retardant, flexible vapor barrier film, inner duct core.
- c. Insulation: Provide inner duct core that is insulated with mineral fiber blanket type flexible insulation, minimum of 1 inch thick. Provide insulation covered on exterior with manufacturer's standard fire retardant vapor barrier jacket for flexible round duct.

2.9.1.2 Insulated Nonmetallic Flexible Duct Runouts

Use flexible duct runouts only where indicated. Runout length is indicated on the drawings, and is not to exceed 5 feet. Provide runouts that are preinsulated, factory fabricated, and that comply with NFPA 90A and UL 181. Provide either field or factory applied vapor barrier. Provide not less than 20 ounce glass fabric duct connectors coated on both sides with neoprene. Where coil induction or high velocity units are supplied with vertical air inlets, use a streamlined, vaned and mitered elbow transition piece for connection to the flexible duct or hose. Provide a die-stamped elbow and not a flexible connector as the last elbow to these units other than the vertical air inlet type. Insulated flexible connectors are allowed as runouts. Provide insulated material and vapor barrier that conform to the requirements of Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Do not expose the insulation material surface to the air stream.

2.9.1.3 General Service Duct Connectors

Provide a flexible duct connector approximately 6 inches in width where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, secure the flexible material by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, install the flexible material locked to metal collars using normal duct construction methods. Provide a composite connector system that complies with NFPA 701 and is classified as "flame-retardent fabrics" in UL Bld Mat Dir.

2.9.1.4 High Temperature Service Duct Connections

Provide material that is approximately 3/32 inch thick, 35 to 40-ounce per square yard weight, plain weave fibrous glass cloth with, nickel/chrome wire reinforcement for service in excess of 1200 degrees F.

2.9.1.5 Aluminum Ducts

ASTM B209, alloy 3003-H14 for aluminum sheet and alloy 6061-T6 or equivalent strength for aluminum connectors and bar stock.

2.9.1.6 Copper Sheets

ASTM B152/B152M, light cold rolled temper.

2.9.1.7 Corrosion Resisting (Stainless) Steel Sheets

ASTM A167

2.9.2 Duct Access Doors

Provide hinged access doors conforming to SMACNA 1966 in ductwork and plenums where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system. Provide access doors upstream and downstream of air flow measuring primaries and heating and cooling coils. Provide doors that are a minimum 15 by 18 inches, unless otherwise shown. Where duct size does not accommodate this size door, make the doors as large as practicable. Equip doors 24 by 24 inches or larger with fasteners operable from inside and outside the duct. Use insulated type doors in insulated ducts.

2.9.3 Fire Dampers

Use 1.5 hour rated fire dampers unless otherwise indicated. Provide fire dampers that conform to the requirements of NFPA 90A and UL 555. Perform the fire damper test as outlined in NFPA 90A. Provide a pressure relief door upstream of the fire damper. If the ductwork connected to the fire damper is to be insulated then provide a factory installed pressure relief damper. Provide automatic operating fire dampers with a dynamic rating suitable for the maximum air velocity and pressure differential to which it is subjected. Provide fire dampers approved for the specific application, and install according to their listing. Equip fire dampers with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, does not impair the operation of the damper. Equip sleeves or frames with perimeter mounting angles attached on both sides of the wall or floor opening. Construct ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies in conformance with UL Fire Resistance. Provide curtain type with damper blades or single blade type or multi-blade type fire dampers. Install dampers that do not reduce the duct or the air transfer opening cross-sectional area. Install dampers so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness. Unless otherwise indicated, comply with the installation details given in SMACNA 1819 and in manufacturer's instructions for fire

dampers. Perform acceptance testing of fire dampers according to paragraph Fire Damper Acceptance Test and NFPA 90A.

2.9.4 Manual Balancing Dampers

Furnish manual balancing dampers with accessible operating mechanisms. Use chromium plated operators (with all exposed edges rounded) in finished portions of the building. Provide manual volume control dampers that are operated by locking-type quadrant operators. Install dampers that are 2 gauges heavier than the duct in which installed. Unless otherwise indicated, provide opposed blade type multileaf dampers with maximum blade width of 12 inches. Provide access doors or panels for all concealed damper operators and locking setscrews. Provide stand-off mounting brackets, bases, or adapters not less than the thickness of the insulation when the locking-type quadrant operators for dampers are installed on ducts to be thermally insulated, to provide clearance between the duct surface and the operator. Provide stand-off mounting items that are integral with the operator or standard accessory of the damper manufacturer.

2.9.5 Air Supply And Exhaust Air Dampers

Provide outdoor air supply and exhaust air dampers that have a maximum leakage rate when tested in accordance with AMCA 500-D as required by ASHRAE 90.1 - IP, including maximum Damper Leakage for:

- a. Climate Zones 1,2,6,7,8 the maximum damper leakage at 1.0 inch w.g. for motorized dampers is 4 cfm per square foot of damper area and non-motorized dampers are not allowed.
- All other Climate Zones the maximum damper leakage at 1.0 inch w.g. is 10 cfm per square foot and for non-motorized dampers is 20 cfm per square foot of damper area.

Dampers smaller than 24 inches in either direction may have leakage of 40 cfm per square foot.

2.9.6 Air Deflectors (Volume Extractors) and Branch Connections

Provide air deflectors (volume extractors) at all duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections are allowed in lieu of deflectors for branch connections. Furnish all air deflectors (volume extractors), except those installed in 90 degree elbows, with an approved means of adjustment. Provide easily accessible means for adjustment inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, provide external adjustments with stand-off mounting brackets, integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Provide factory-fabricated air deflectors consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Provide factory or field assembled air deflectors (volume extractors). Make adjustment from the face of the diffuser or by position adjustment and lock external to the duct. Provide stand-off brackets on insulated ducts as described herein. Provide fixed air deflectors (volume extractors), also called

turning vanes, in 90 degree elbows.

2.9.7 Plenums and Casings for Field-Fabricated Units

2.9.7.1 Plenum and Casings

Fabricate and erect plenums and casings as shown in SMACNA 1966, as applicable. Construct system casing of not less than 16 gauge galvanized sheet steel. Furnish cooling coil drain pans with 1 inch threaded outlet to collect condensation from the cooling coils. Fabricate drain pans from not lighter than 16 gauge steel, galvanized after fabrication or of 18 gauge corrosion-resisting sheet steel conforming to ASTM A167, Type 304, welded and stiffened. Thermally insulate drain pans exposed to the atmosphere to prevent condensation. Coat insulation with a flame resistant waterproofing material. Provide separate drain pans for each vertical coil section, and a separate drain line for each pan. Size pans to ensure capture of entrained moisture on the downstream-air side of the coil. Seal openings in the casing, such as for piping connections, to prevent air leakage. Size the water seal for the drain to maintain a pressure of at least 2 inch water gauge greater than the maximum negative pressure in the coil space.

2.9.7.2 Casing

Terminate casings at the curb line and bolt each to the curb using galvanized angle, as indicated in SMACNA 1966.

2.9.7.3 Access Doors

Provide access doors in each section of the casing. Weld doorframes in place, gasket each door with neoprene, hinge with minimum of two brass hinges, and fasten with a minimum of two brass tension fasteners operable from inside and outside of the casing. Where possible, make doors 36 by 18 inches and locate them 18 inches above the floor. Where the space available does not accommodate doors of this size, use doors as large as the space accommodates. Swing doors so that fan suction or pressure holds doors in closed position, airtight. Provide a push-button station, located inside the casing, to stop the supply.

2.9.7.4 Factory-Fabricated Insulated Sheet Metal Panels

Factory-fabricated components are allowed for field-assembled units, provided all requirements specified for field-fabricated plenums and casings are met. Provide panels of modular design, pretested for structural strength, thermal control, condensation control, and acoustical control. Seal and insulate panel joints. Provide and gasket access doors to prevent air leakage. Provide panel construction that is not less than 20 gauge galvanized sheet steel, assembled with fasteners treated against corrosion. Provide standard length panels that deflect not more than 1/2 inch under operation. Construct details, including joint sealing, not specifically covered, as indicated in SMACNA 1966. Construct the plenums and casings to withstand the specified internal pressure of the air systems.

2.9.7.5 Duct Liner

Unless otherwise specified, duct liner is not permitted.

2.9.8 Sound Attenuation Equipment

2.9.8.1 Systems with total pressure above 4 Inches Water Gauge

Provide sound attenuators on the discharge duct of each fan operating at a total pressure above 4 inch water gauge, and, when indicated, at the intake of each fan system. Provide sound attenuators elsewhere as indicated. Provide factory fabricated sound attenuators, tested by an independent laboratory for sound and performance characteristics. Provide a net sound reduction as indicated. Maximum permissible pressure drop is not to exceed 0.63 inch water gauge. Construct traps to be airtight when operating under an internal static pressure of 10 inch water gauge. Provide air-side surface capable of withstanding air velocity of 10,000 fpm. Certify that the equipment can obtain the sound reduction values specified after the equipment is installed in the system and coordinated with the sound information of the system fan to be provided. Provide sound absorbing material conforming to ASTM C1071, Type I or II. Provide sound absorbing material that meets the fire hazard rating requirements for insulation specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. For connection to ductwork, provide a duct transition section. Factory fabricated double-walled internally insulated spiral lock seam and round duct and fittings designed for high pressure air system can be provided if complying with requirements specified for factory fabricated sound attenuators, in lieu of factory fabricated sound attenuators. Construct the double-walled duct and fittings from an outer metal pressure shell of zinc-coated steel sheet, 1 inch thick acoustical blanket insulation, and an internal perforated zinc-coated metal liner. Provide a sufficient length of run to obtain the noise reduction coefficient specified. Certify that the sound reduction value specified can be obtained within the length of duct run provided. Provide welded or spiral lock seams on the outer sheet metal of the double-walled duct to prevent water vapor penetration. Provide duct and fittings with an outer sheet that conforms to the metal thickness of high-pressure spiral and round ducts and fittings shown in SMACNA 1966. Provide acoustical insulation with a thermal conductivity "k" of not more than 0.27 Btu/inch/square foot/hour/degree F at 75 degrees F mean temperature. Provide an internal perforated zinc-coated metal liner that is not less than 24 gauge with perforations not larger than 1/4 inch in diameter providing a net open area not less than 10 percent of the surface.

2.9.8.2 System with total pressure of 4 Inch Water Gauge and Lower

Use sound attenuators only where indicated. Provide factory fabricated sound attenuators that are constructed of galvanized steel sheets. Provide attenuator with outer casing that is not less than 22 gauge. Provide fibrous glass acoustical fill. Provide net sound reduction indicated. Obtain values on a test unit not less than 24 by 24 inches outside dimensions made by a certified nationally recognized independent acoustical laboratory. Provide air flow capacity as indicated or required. Provide pressure drop through the attenuator that does not exceed the value indicated, or that is not in excess of 15 percent of the total external static pressure of the air handling system, whichever is less. Acoustically test attenuators with metal duct inlet and outlet sections while under the rated air flow conditions. Include with the noise reduction data the effects of flanking paths and vibration transmission. Construct sound attenuators to be airtight when operating at the internal static pressure indicated or specified for the duct system, but in no case less than 2 inch water gauge.

2.9.8.3 Acoustical Duct Liner

Use fibrous glass designed or flexible elastomeric duct liner for lining ductwork and conforming to the requirements of ASTM C1071, Type I and II. Provide uniform density, graduated density, or dual density liner composition, as standard with the manufacturer. Provide not less than 1 inch thick coated lining. Where acoustical duct liner is used, provide the thermal equivalent of the insulation specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS for liner or combination of liner and insulation applied to the exterior of the ductwork. Increase duct sizes shown to compensate for the thickness of the lining used. In lieu of sheet metal duct with field-applied acoustical lining, provide acoustically equivalent lengths of fibrous glass duct, elastomeric duct liner or factory fabricated double-walled internally insulated duct with perforated liner.

2.9.9 Diffusers, Registers, and Grilles

Provide factory-fabricated units of steel that distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 50 fpm in occupied zone, or dead spots anywhere in the conditioned area. Provide outlets for diffusion, spread, throw, and noise level as required for specified performance. Certify performance according to ASHRAE 70. Provide sound rated and certified inlets and outlets according to ASHRAE 70. Provide sound power level as indicated. Provide diffusers and registers with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device is acceptable. Provide opposed blade type volume dampers for all diffusers and registers, except linear slot diffusers. Provide linear slot diffusers with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 7 feet above the floor, protect them by a grille or screen according to NFPA 90A.

2.9.9.1 Diffusers

Provide diffuser types indicated. Furnish ceiling mounted units with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Provide diffusers with air deflectors of the type indicated. Provide air handling troffers or combination light and ceiling diffusers conforming to the requirements of UL Electrical Construction for the interchangeable use as cooled or heated air supply diffusers or return air units. Install ceiling mounted units with rims tight against ceiling. Provide sponge rubber gaskets between ceiling and surface mounted diffusers for air leakage control. Provide suitable trim for flush mounted diffusers. For connecting the duct to diffuser, provide duct collar that is airtight and does not interfere with volume controller. Provide return or exhaust units that are similar to supply diffusers.

2.9.9.2 Registers and Grilles

Provide units that are four-way directional-control type, except provide return and exhaust registers that are fixed horizontal or vertical louver type similar in appearance to the supply register face. Furnish registers with sponge-rubber gasket between flanges and wall or ceiling. Install wall supply registers at least 6 inches below the ceiling unless otherwise indicated. Locate return and exhaust registers 6 inches above the floor unless otherwise indicated. Achieve four-way directional control by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Provide grilles as specified for registers, without volume control damper.

2.9.10 Louvers

Provide louvers for installation in exterior walls that are associated with the air supply and distribution system as specified in Section 07 60 00 FLASHING AND SHEET METAL .

2.9.11 Air Vents, Penthouses, and Goosenecks

Fabricate air vents, penthouses, and goosenecks from galvanized steel or aluminum sheets with galvanized or aluminum structural shapes. Provide sheet metal thickness, reinforcement, and fabrication that conform to SMACNA 1966. Accurately fit and secure louver blades to frames. Fold or bead edges of louver blades for rigidity and baffle these edges to exclude driving rain. Provide air vents, penthouses, and goosenecks with bird screen.

2.9.12 Bird Screens and Frames

Provide bird screens that conform to ASTM E2016, No. 2 mesh, aluminum or stainless steel. Provide "medium-light" rated aluminum screens. Provide "light" rated stainless steel screens. Provide removable type frames fabricated from either stainless steel or extruded aluminum.

2.9.13 Radon Exhaust Ductwork

Fabricate radon exhaust ductwork installed in or beneath slabs from Schedule 40 PVC pipe that conforms to ASTM D1785. Provide fittings that conform to ASTM D2466. Use solvent cement conforming to ASTM D2564 to make joints. Otherwise provide metal radon exhaust ductwork as specified herein.

2.10 AIR SYSTEMS EQUIPMENT

2.10.1 Fans

Test and rate fans according to AMCA 210. Calculate system effect on air moving devices in accordance with AMCA 201 where installed ductwork differs from that indicated on drawings. Install air moving devices to minimize fan system effect. Where system effect is unavoidable, determine the most effective way to accommodate the inefficiencies caused by system effect on the installed air moving device. The sound power level of the fans must not exceed 85 dBA when tested according to AMCA 300 and rated in accordance with AMCA 301. Provide all fans with an AMCA seal. Connect fans to the motors either directly or indirectly with V-belt drive. Use V-belt drives designed for not less than 150 percent of the connected driving capacity. Provide variable pitch motor sheaves for 15 hp and below, and fixed pitch as defined by AHRI Guideline D (A fixed-pitch sheave is provided on both the fan shaft and the motor shaft. This is a non-adjustable speed drive.). Select variable pitch sheaves to drive the fan at a speed which can produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, provide a replaceable sheave when needed to achieve system air balance. Provide motors for V-belt drives with adjustable rails or bases. Provide removable metal guards for all exposed V-belt drives, and provide speed-test openings at the center of all rotating shafts. Provide fans with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Provide fan and motor assemblies with vibration-isolation supports or mountings as indicated. Use vibration-isolation units that are standard products with published loading ratings. Select each fan to produce the capacity required at the fan static pressure indicated. Provide sound power level as indicated. Obtain the sound power level values according to AMCA 300. Provide standard AMCA arrangement, rotation, and discharge as indicated. Provide power ventilators that conform to UL 705 and have a UL label.

2.10.1.1 Centrifugal Fans

Provide fully enclosed, single-width single-inlet, or double-width double-inlet centrifugal fans, with AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Provide impeller wheels that are rigidly constructed and accurately balanced both statically and dynamically. . Provide fan wheels over 36 inches in diameter with overhung pulleys and a bearing on each side of the wheel. Provide fan wheels 36 inches or less in diameter that have one or more extra long bearings between the fan wheel and the drive. Provide sleeve type, self-aligning and self-oiling bearings with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Connect grease fittings to tubing for serviceability from a single accessible point. Provide L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide steel, accurately finished fan shafts, with key seats and keys for impeller hubs and fan pulleys. Provide fan outlets of ample proportions, designed for the attachment of angles and bolts for attaching flexible connections. Provide automatically operated inlet vanes on suction inlets. Provide automatically operated outlet dampers. Unless otherwise indicated, provide motors that do not exceed 1800 rpm and have open enclosures.

2.10.1.2 In-Line Centrifugal Fans

Provide in-line fans with centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Mount fans in a welded tubular casing. Provide a fan that axially flows the air in and out. Streamline inlets with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Enclose and isolate fan bearings and drive shafts from the air stream. Provide precision, self aligning ball or roller type fan bearings that are sealed against dust and dirt and are permanently lubricated. Provide L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11.

2.10.1.3 Axial Flow Fans

Provide axial flow fans complete with drive components and belt guard, with steel housing, cast fan wheel, cast or welded steel diffusers, fan shaft, bearings, and mounting frame as a factory-assembled unit. Provide fan wheels that are dynamically balanced and keyed to the fan shaft, with radially projecting blades of airfoil cross-section. Enclose and isolate fan bearings and drive shafts from the air stream. Permanently lubricate fan bearings or provide them with accessible grease fittings. Provide precision self-aligning ball or roller type fan bearings that are sealed against dust and dirt. Provide fan bearings that have a L50 rated bearing life at not less than 200,000 hours of operation as defined by ABMA 9 and ABMA 11. Provide fan inlets with an aerodynamically shaped bell and an inlet cone. Install diffuser or straightening vanes at the fan discharge to minimize turbulence and provide smooth discharge air flow. Furnish fan unit with inlet and outlet flanges, inlet screen, duct equalizer section, and automatic operation adjustable inlet vanes.

2.10.1.4 Panel Type Power Wall Ventilators

Provide propeller type fans, assembled on a reinforced metal panel with venturi opening spun into panel. Provide direct or V-belt driven fans with wheels less than 24 inches in diameter and provide V-belt driven fans with wheels 24 inches in diameter and larger. Provide fans with wall mounting collar. Provide lubricated bearings. Equip fans with wheel and motor side metal or wire guards which have a corrosion-resistant finish. Provide dripproof type motor enclosure. Install motor operated backdraft dampers where indicated.

2.10.1.5 Centrifugal Type Power Wall Ventilators

Provide direct or V-belt driven centrifugal type fans with backward inclined, non-overloading wheel. Provide removable and weatherproof motor housing. Provide unit housing that is designed for sealing to building surface and for discharge and condensate drippage away from building surface. Construct housing of heavy gauge aluminum. Equip unit with an aluminum or plated steel wire discharge bird screen, disconnect switch, anodized aluminum wall grille, manufacturer's standard motor-operated damper, an airtight and liquid-tight metallic wall sleeve. Provide totally enclosed fan cooled type motor enclosure. Use only lubricated bearings.

2.10.1.6 Centrifugal Type Power Roof Ventilators

Provide direct or V-belt driven centrifugal type fans with backward inclined, non-overloading wheel. Provide hinged or removable and weatherproof motor compartment housing, constructed of heavy gauge aluminum. Provide fans with birdscreen, disconnect switch, motorized dampers, and . Provide dripproof type motor enclosure. Provide centrifugal type kitchen exhaust fans according to UL 705, fitted with V-belt drive, round hood, and windband upblast discharge configuration, integral residue trough and collection device, with motor and power transmission components located in outside positively air ventilated compartment. Use only lubricated bearings.

2.10.1.7 Propeller Type Power Roof Ventilators

Provide direct or V-belt driven fans. Provide hinged or removable weathertight fan housing, fitted with framed rectangular base constructed of aluminum or galvanized steel. Provide totally enclosed fan cooled type motors. Furnish motors with nonfusible, horsepower rated, manual disconnect mount on unit. Furnish fans with motor operated dampers, birdscreen. Use only lubricated bearings.

2.10.1.8 Air-Curtain Fans

Provide fans that conform to AMCA 220 with AMCA seal. Furnish air curtains with a weatherproof housing constructed of high impact plastic or minimum 18 gauge rigid welded steel. Provide backward curved, non-overloading, centrifugal type fan wheels, accurately balanced statically and dynamically. Provide motors with totally enclosed fan cooled enclosures. Provide remote manual type motor starters with weather-resistant enclosure actuated when the doorway served is open. Provide air curtains that attain the air velocities specified within 2 seconds following activation. Provide bird screens at air intake and discharge openings. Provide air curtain unit or a multiple unit installation that is at least as wide as the opening to be protected. Provide the air discharge openings to permit outward adjustment of the discharge air. Place installation and adjust according to the manufacturer's written recommendation. Furnish directional controls on air curtains for service windows for easy clean or convenient removal. Design air curtains to prevent the adjustment of the air velocities specified. Make the interior surfaces of the air curtain units accessible for cleaning. Provide certified test data indicating that the fan can provide the air velocities required when fan is mounted as indicated. Provide air curtains designed as fly fans unless otherwise indicated.

2.10.1.9 Ceiling Exhaust Fans

Provide centrifugal type, direct driven suspended cabinet-type ceiling exhaust fans. Provide fans with acoustically insulated housing. Provide chatter-proof backdraft damper. Provide egg-crate design or louver design integral face grille. Mount fan motors on vibration isolators. Furnish unit with mounting flange for hanging unit from above. Provide U.L. listed fans. Provide PL-109-58 labeled ceiling exhaust fan product. Provide proof of PL-109-58 label for ceiling exhaust fan product.

2.10.2 Coils

Provide fin-and-tube type coils constructed of seamless copper tubes and aluminum or copper fins mechanically bonded or soldered to the tubes... Provide casing and tube support sheets that are not lighter than 16 gauge galvanized steel, formed to provide structural strength. When required, provide multiple tube supports to prevent tube sag. Mount coils for counterflow service. Rate and certify coils to meet the requirements of AHRI 410.

2.10.2.1 Direct-Expansion Coils

Provide suitable direct-expansion coils for the refrigerant involved. Provide refrigerant piping that conforms to ASTM B280 and clean, dehydrate and seal. Provide seamless copper tubing suction headers or seamless or resistance welded steel tube suction headers with copper connections. Provide supply headers that consist of a distributor which distributes the refrigerant through seamless copper tubing equally to all circuits in the coil. Provide circuited tubes to ensure minimum pressure drop and maximum heat transfer. Provide circuiting that permits refrigerant flow from inlet to suction outlet without causing oil slugging or restricting refrigerant flow in coil. Provide field installed coils which are completely dehydrated and sealed at the factory upon completion of pressure tests. Pressure test coils in accordance with UL 1995.

2.10.2.2 Water Coils

Install water coils with a pitch of not less than 1/8 inch/foot of the tube length toward the drain end. Use headers constructed of cast iron, welded steel or copper. Furnish each coil with a plugged vent and drain connection extending through the unit casing. Provide removable water coils with drain pans. Pressure test coils in accordance with UL 1995.

2.10.2.3 Steam Heating Coils

Construct steam coils from cast semisteel, welded steel or copper headers, and copper tubes. Construct headers from cast iron, welded steel or copper. Provide fin tube and header section that float within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Provide each coil with a field or factory installed vacuum breaker. Provide single-tube type coils with tubes not less than 1/2 inch outside diameter, except for steam preheat coils. Provide supply headers that distribute steam evenly to all tubes at the indicated steam pressure. Factory test coils to ensure that, when supplied with a uniform face velocity, temperature across the leaving side is uniform with a maximum variation of no more than 5 percent. Pressure testcoils in accordance with UL 1995.

2.10.2.4 Steam Preheat (Nonfreeze) Coils

Provide steam-distribution-tube type steam (nonfreeze) coils with condensing tubes not less than 1 inch outside diameter for tube lengths under 60 inches and over and 1/2 inch outside diameter for tube lengths under 60 inches. Construct headers from cast iron, welded steel, or copper. Provide distribution tubes that are not less than 5/8 inch outside diameter for tube lengths 60 inches and over and 3/8 inch outside diameter for tube lengths under 60 inches with orifices to discharge steam to condensing tubes. Install distribution tubes concentric inside of condensing tubes and hold securely in alignment. Limit maximum length of a single coil to 144 inches. Factory test coils to ensure that, when supplied with a uniform face velocity, temperature across the leaving side is uniform with a maximum variation of no more than 5 percent. Pressure test coils in accordance with UL 1995.

2.10.3 Air Filters

List air filters according to requirements of UL 900, except list high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method under the Label Service to meet the requirements of UL 586.

2.10.3.1 Extended Surface Pleated Panel Filters

Provide 2 inch depth, sectional, disposable type filters of the size indicated with a MERV of 8 when tested according to ASHRAE 52.2. Provide initial resistance at 500 fpm that does not exceed 0.36 inches water gauge. Provide UL Class 2 filters, and nonwoven cotton and synthetic fiber mat media. Attach a wire support grid bonded to the media to a moisture resistant fiberboard frame. Bond all four edges of the filter media to the inside of the frame to prevent air bypass and increase rigidity.

2.10.3.2 Extended Surface Nonsupported Pocket Filters

Provide 30 inch depth, sectional, replaceable dry media type filters of the size indicated with a MERV of 13 when tested according to ASHRAE 52.2. Provide initial resistance at 500 fpm that does not exceed 0.45 inches water gauge. Provide UL Class 1 filters. Provide fibrous glass media, supported in the air stream by a wire or non-woven synthetic backing and secured to a galvanized steel metal header. Provide pockets that do not sag or flap at anticipated air flows. Install each filter in a factory preassembled, side access housing or a factory-made sectional frame bank, as indicated.

2.10.3.3 Cartridge Type Filters

Provide 12 inch depth, sectional, replaceable dry media type filters of the size indicated with a MERV of 13 when tested according to ASHRAE 52.2. Provide initial resistance at 500 fpm that does not exceed 0.56 inches, water gauge. Provide UL class 1 filters, and pleated microglass paper media with corrugated aluminum separators, sealed inside the filter cell to form a totally rigid filter assembly. Fluctuations in filter face velocity or turbulent airflow have no effect on filter integrity or performance. Install each filter in a factory preassembled side access housing, or a factory-made sectional frame bank, as indicated.

2.10.3.4 Sectional Cleanable Filters

Provide 1 inch thick cleanable filters. Provide viscous adhesive in 5 gallon containers in sufficient quantity for 12 cleaning operations and not less than one quart for each filter section. Provide one washing and charging tank for every 100 filter sections or fraction thereof; with each washing and charging unit consisting of a tank and single drain rack mounted on legs and drain rack with dividers and partitions to properly support the filters in the draining position.

2.10.3.5 Replaceable Media Filters

Provide the dry-media type replaceable media filters, of the size required to suit the application. Provide filtering media that is not less than 2 inches thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Enclose pad in a holding frame of not less than 16 gauge galvanized steel, equipped with quick-opening mechanism for changing filter media. Base the air flow capacity of the filter on net filter face velocity not exceeding 300 fpm, with initial resistance of 0.13 inches water gauge. Provide MERV that is not less than when tested according to ASHRAE 52.2.

2.10.3.6 Automatic Renewable Media Filters

Provide the following:

- a. Automatic, renewable media filters consisting of a horizontal or vertical traveling curtain of adhesive-coated bonded fibrous glass supplied in convenient roll form, and filter that does not require water supply, sewer connections, adhesive reservoir, or sprinkler equipment as part of the operation and maintenance requirements.
- b. Basic frame that is fabricated of not less than 14 gauge galvanized steel, and sectional design filters with each section of each filter fully factory assembled, requiring no field assembly other than setting in place next to any adjacent sections and the installation of media in roll form.
- c. Each filter complete with initial loading of filter media drive motor adequate to handle the number of sections involved, and stainless steel control box containing a warning light to indicate media runout, a runout switch, and a Hand-Off-Auto selector switch.
- d. Media feed across the filter face in full-face increments automatically controlled as determined by filter pressure differential to provide substantially constant operating resistance to airflow and varying not more than plus or minus 10 percent. Roll or enclose media

in such a way that collected particulates can not re-entrain.

- e. Rolls of clean media, no less than 65 feet long, rerolled on disposable spools in the rewind section of the filter after the media has accumulated its design dirt load. Equip rewind section with a compression panel to tightly rewind used media for ease of handling. Provide media made of continuous, bonded fibrous glass material, UL Class 2, that does not compress more than 1/4 inch when subjected to air flow at 500 fpm. Factory charge media with an odorless and flame retardant adhesive which does not flow while in storage nor when subjected to temperatures up to 175 degrees F. Support media on both the leaving and entering air faces. Clean media must have initial resistance that does not exceed 0.18 inch water gauge at its rated velocity of 500 fpm. Set control so that the resistance to air flow is between 0.40-and 0.50 inch water gauge unless otherwise indicated.
- f. Dust holding capacity, of 80 percent average arrestance under these operating conditions, when operating at a steady state with an upper operating resistance of 0.50 inch water gauge, that is at least 592 (55) grams of ASHRAE Standard Test Dust per square foot of media area, when tested according to the dynamic testing provisions of ASHRAE 52.2.
- g. The horizontal type automatic renewable media filters, when used in conjunction with factory fabricated air handling units, that are dimensionally compatible with the connecting air handling units, and horizontal type filter housings with all exposed surfaces factory insulated internally with 1 inch, 1-1/2 pound density neoprene coated fibrous glass with thermal conductivity not greater than 0.27 Btu/hour/degree F/square foot/inch of thickness.
- h. Access doors for horizontal filters with double wall construction as specified for plenums and casings for field-fabricated units in paragraph DUCT SYSTEMS.
- 2.10.3.7 Electrostatic Filters

Provide the following:

- a. The combination dry agglomerator/extended surface, nonsupported pocket electrostatic filters or the combination dry agglomerator/automatic renewable, media (roll) type electrostatic filters, as indicated (except as modified). Supply each dry agglomerator electrostatic air filter with the correct quantity of fully housed power packs and equip with silicon rectifiers, manual reset circuit breakers, low voltage safety cutout, relays for field wiring to remote indication of primary and secondary voltages, with lamps mounted in the cover to indicate these functions locally. Equip power pack enclosure with external mounting brackets, and low and high voltage terminals fully exposed with access cover removed for ease of installation. Furnish interlock safety switches for each access door and access panel that permits access to either side of the filter, so that the filter is de-energized in the event that a door or panel is opened.
- b. Ozone generation within the filter that does not exceed five parts per one hundred million parts of air. Locate high voltage insulators in a serviceable location outside the moving air stream or on the clean air side of the unit. Fully expose ionizer wire supports and furnish ionizer wires precut to size and with formed loops at each end to facilitate ionizer wire replacement.

- c. Agglomerator cell plates that allow proper air stream entrainment of agglomerates and prevent excessive residual dust build-up, with cells that are open at the top and bottom to prevent accumulation of agglomerates which settle by gravity. Where the dry agglomerator electrostatic filter is indicated to be the automatic renewable media type, provide a storage section that utilizes a horizontal or vertical traveling curtain of adhesive-coated bonded fibrous glass for dry agglomerator storage section service supplied in 65 foot lengths in convenient roll form. Otherwise, provide section construction and roll media characteristics as specified for automatic renewable media filters. Also a dry agglomerator/renewable media combination with an initial air flow resistance, after installation of clean media, that does not exceed 0.25 inch water gauge at 500 fpm face velocity.
- d. A MERV of the combination that is not less than 15 when tested according to ASHRAE 52.2 at an average operating resistance of 0.50 inch water gauge. Where the dry agglomerator electrostatic filter is indicated to be of the extended surface nonsupported pocket filter type, provide a storage section as specified for extended surface non-supported pocket filters, with sectional holding frames or side access housings as indicated.
- e. A dry agglomerator/extended surface nonsupported pocket filter section combination with initial air flow resistance, after installation of clean filters, that does not exceed 0.65 inch water gauge at 500 fpm face velocity, with a MERV of the combination not less than 16 when tested according to ASHRAE 52.2. Furnish front access filters with full height air distribution baffles and upper and lower mounting tracks to permit the baffles to be moved for agglomerator cell inspection and service. When used in conjunction with factory fabricated air handling units, supply side access housings which have dimensional compatibility.

2.10.3.8 High-Efficiency Particulate Air (HEPA) Filters

Provide HEPA filters that meet the requirements of IEST RP-CC-001 and are individually tested and certified to have an efficiency of not less than 95 percent, and an initial resistance at fpm that does not exceed inches water gauge. Provide filters that are constructed by pleating a continuous sheet of filter medium into closely spaced pleats separated by corrugated aluminum or mineral-fiber inserts, strips of filter medium, or by honeycomb construction of the pleated filter medium. Provide interlocking, dovetailed, molded neoprene rubber gaskets of 5-10 durometer that are cemented to the perimeter of the upstream face of the filter cell sides. Provide self-extinguishing rubber-base type adhesive or other materials conforming to fire hazard classification specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Provide filter cell sides that are 3/4 inch thick exterior grade fire-retardant plywood assembled in a rigid manner. Provide overall cell side dimensions that are correct to 1/16 inch, and squareness that is maintained to within 1/8 inch. Provide holding frames that use spring loaded fasteners or other devices to seal the filter tightly within it and that prevent any bypass leakage around the filter during its installed life. Provide air capacity and the nominal depth of the filter as indicated. Install each filter in a factory preassembled side access housing or a factory-made sectional supporting frame as indicated. Provide prefilters of the type, construction and efficiency indicated.

2.10.3.9 Holding Frames

Fabricate frames from not lighter than 16 gauge sheet steel with rust-inhibitor coating. Equip each holding frame with suitable filter holding devices. Provide gasketed holding frame seats. Make all joints airtight.

2.10.3.10 Filter Gauges

Provide dial type filter gauges, diaphragm actuated draft for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Provide gauges that are at least 3-7/8 inches in diameter, with white dials with black figures, and graduations with a minimum range of 1 inch of water beyond the specified final resistance for the filter bank on which each gauge is applied. Provide each gauge with a screw operated zero adjustment and two static pressure tips with integral compression fittings, two molded plastic vent valves, two 5 foot minimum lengths of 1/4 inch diameter aluminum tubing, and all hardware and accessories for gauge mounting.

2.11 AIR HANDLING UNITS

2.11.1 Field-Fabricated Air Handling Units

Provide built-up units as specified in paragraph DUCT SYSTEMS. Provide fans, coils spray-coil dehumidifiers, and air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types indicated.

2.11.2 Factory-Fabricated Air Handling Units

Provide single-zone draw-through type or single-zone blow-through type or multizone blow-through type units as indicated. Units must include fans, coils, airtight insulated casing, vibration-isolators, and appurtenances required for specified operation. Provide vibration isolators as indicated. Physical dimensions of each air handling unit must be suitable to fit space allotted to the unit with the capacity indicated. Provide air handling unit that is rated in accordance with AHRI 430 and AHRI certified for cooling.

2.11.2.1 Casings

Provide the following:

- a. Design and construct casing with an integral insulated structural galvanized steel frame such that exterior panels are non-load bearing.
- b. Individually removable exterior panels with standard tools. Removal must not affect the structural integrity of the unit. Furnish casings with access sections, according to paragraph AIR HANDLING UNITS, inspection doors, and access doors, all capable of opening a minimum of 90 degrees, as indicated.
- c. Insulated, fully gasketed, double-wall type inspection and access doors, of a minimum 18 gauge outer and 20 gauge inner panels made of either galvanized steel or corrosion-resisting sheet steel conforming to ASTM A167, Type 304. Provide rigid doors with heavy duty hinges and latches. Inspection doors must be a minimum 12 inches wide by 12 inches high. Access doors must be a minimum 24 inches wide, the full height of the unit casing or a minimum of 6 foot, whichever is less.

Install a minimum 8 by 8 inches sealed glass window suitable for the intended application, in all access doors.

- d. Double-wall insulated type drain pan (thickness equal to exterior casing) constructed of 16 gauge galvanized steel , conforming to ASHRAE 62.1. Construct drain pans water tight, treated to prevent corrosion, and designed for positive condensate drainage. When 2 or more cooling coils are used, with one stacked above the other, condensate from the upper coils must not flow across the face of lower coils. Provide intermediate drain pans or condensate to the unit drain pan out of the air stream and without moisture carryover. Construct drain pan to allow for easy visual inspection, including underneath the coil without removal of the pan underneath the coil without removal of the coil without removable from the casing.
- e. Casing insulation that conforms to NFPA 90A. Insulate single-wall casing sections handling conditioned air with not less than 1 inch thick, 1-1/2 pound density coated fibrous glass material having a thermal conductivity not greater than 0.23 Btu/hr-sf-F. Insulate double-wall casing sections handling conditioned air with not less than 2 inches of the same insulation specified for single-wall casings. Foil-faced insulation is not an acceptable substitute for use with double wall casing. Seal double wall insulation completely by inner and outer panels.
- f. Factory applied fibrous glass insulation that conforms to ASTM C1071, except that the minimum thickness and density requirements do not apply, and that meets the requirements of NFPA 90A. Make air handling unit casing insulation uniform over the entire casing. Foil-faced insulation is not an acceptable substitute for use on double-wall access doors and inspections doors .
- g. Duct liner material, coating, and adhesive that conforms to fire-hazard requirements specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Protect exposed insulation edges and joints where insulation panels are butted with a metal nosing strip or coat to meet erosion resistance requirements of ASTM C1071.
- h. A latched and hinged inspection door, in the fan and coil sections. Plus additional inspection doors, access doors and access sections where indicated.
- 2.11.2.2 Heating and Cooling Coils

Provide coils as specified in paragraph AIR SYSTEMS EQUIPMENT.

2.11.2.3 Air Filters

Provide air filters as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

2.11.2.4 Fans

Provide the following:

a. Fans that are double-inlet, centrifugal type with each fan in a

separate scroll. Dynamically balance fans and shafts prior to installation into air handling unit, then after it has been installed in the air handling unit, statically and dynamically balance the entire fan assembly. Mount fans on steel shafts, accurately ground and finished.

- b. Fan bearings that are sealed against dust and dirt and are precision self-aligning ball or roller type, with L50 rated bearing life at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Provide bearings that are permanently lubricated or lubricated type with lubrication fittings readily accessible at the drive side of the unit. Support bearings by structural shapes, or die formed sheet structural members, or support plates securely attached to the unit casing. Do not fasten bearings directly to the unit sheet metal casing. Furnish fans and scrolls with coating indicated.
- c. Fans that are driven by a unit-mounted, or a floor-mounted motor connected to fans by V-belt drive complete with belt guard for externally mounted motors. Furnish belt guards that are the three-sided enclosed type with solid or expanded metal face. Design belt drives for not less than a 1.3 service factor based on motor nameplate rating.
- d. Where fixed sheaves are required, the use of variable pitch sheaves is allowed during air balance, but replace them with an appropriate fixed sheave after air balance is completed. Select variable pitch sheaves to drive the fan at a speed that produces the specified capacity when set at the approximate midpoint of the sheave adjustment. Furnish motors for V-belt drives with adjustable bases, and with enclosures.
- e. Motor starters of type with general-purpose enclosure. Select unit fan or fans to produce the required capacity at the fan static pressure with sound power level as indicated. Obtain the sound power level values according to AMCA 300, ASHRAE 68, or AHRI 260 I-P.
- 2.11.2.5 Access Sections and Filter/Mixing Boxes

Provide access sections where indicated and furnish with access doors as shown. Construct access sections and filter/mixing boxes in a manner identical to the remainder of the unit casing and equip with access doors. Design mixing boxes to minimize air stratification and to promote thorough mixing of the air streams.

2.11.2.6 Diffuser Sections

Furnish diffuser sections between the discharge of all housed supply fans . Provide diffuser sections that are fabricated by the unit manufacturer in a manner identical to the remainder of the unit casing, designed to be airtight under positive static pressures up to 8 inches water gauge and with an access door on each side for inspection purposes. Provide a diffuser section that contains a perforated diffusion plate, fabricated of galvanized steel, Type 316 stainless steel, aluminum, or steel treated for corrosion with manufacturer's standard corrosion-resisting finish, and designed to accomplish uniform air flow across the down-stream coil while reducing the higher fan outlet velocity to within plus or minus 5 percent of the required face velocity of the downstream component.

2.12 TERMINAL UNITS

2.12.1 Room Fan-Coil Units

Provide base units that include galvanized coil casing, coil assembly drain pan air filter, fans, motor, fan drive, motor switch, an enclosure for cabinet models and casing for concealed models, leveling devices integral with the unit for vertical type units, and sound power levels as indicated. Obtain sound power level data or values for these units according to test procedures based on AHRI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles. Values obtained for the standard cabinet models are acceptable for concealed models without separate test provided there is no variation between models as to the coil configuration, blowers, motor speeds, or relative arrangement of parts. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Fasten each unit securely to the building structure. Provide units with capacity indicated. Provide room fan-coil units that are certified as complying with AHRI 440, and meet the requirements of UL 1995.

2.12.1.1 Enclosures

Fabricate enclosures from not lighter than 18 gauge steel, reinforced and braced. Provide enclosures with front panels that are removable and have 1/4 inch closed cell insulation or 1/2 inch thick dual density foil faced fibrous glass insulation. Make the exposed side of a high density, erosion-proof material suitable for use in air streams with velocities up to 4,500 fpm. Provide a discharge grille that is adjustable and that is of such design as to properly distribute air throughout the conditioned space. Plastic discharge and return grilles are acceptable provided the plastic material is certified by the manufacturer to be classified as flame resistant according to UL 94 and the material complies with the heat deflection criteria specified in UL 1995. Provide galvanized or factory finished ferrous metal surfaces with corrosion resistant enamel, and access doors or removable panels for piping and control compartments, plus easy access for filter replacement. Provide duct discharge collar for concealed models.

2.12.1.2 Fans

Provide steel or aluminum, multiblade, centrifugal type fans. In lieu of metal, fans and scrolls could be of non-metallic materials of suitably reinforced compounds with smooth surfaces. Dynamically and statically balance the fans. Provide accessible assemblies for maintenance. Disassemble and re-assemble by means of mechanical fastening devices and not by epoxies or cements.

2.12.1.3 Coils

Fabricate coils from not less than 3/8 inch outside diameter seamless copper tubing, with copper or aluminum fins mechanically bonded or soldered to the tubes. Provide coils with not less than 1/2 inch outside diameter flare or sweat connectors, accessory piping package with thermal connections suitable for connection to the type of control valve supplied, and manual air vent. Test coils hydrostatically at 300 psi or under water at 250 psi air pressure. Provide coils suitable for 200 psi working pressure. Make provisions for coil removal.

2.12.1.4 Drain Pans

Size and locate drain and drip pans to collect all water condensed on and dripping from any item within the unit enclosure or casing. Provide condensate drain pans designed for self-drainage to preclude the buildup of microbial slime and thermally insulated to prevent condensation and constructed of not lighter than 21 gauge type 304 stainless steel or noncorrosive ABS plastic. Provide insulation with a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and of a waterproof type or coated with a waterproofing material. Design drain pans so as to allow no standing water and pitch to drain. Provide minimum 3/4 inch NPT or 5/8 inch OD drain connection in drain pan. Provide plastic or metal auxiliary drain pans to catch drips from control and piping packages, eliminating insulation of the packages; if metal, provide auxiliary pans that comply with the requirements specified above. Extend insulation at control and piping connections 1 inch minimum over the auxiliary drain pan.

2.12.1.5 Manually Operated Outside Air Dampers

Provide manually operated outside air dampers according to the arrangement indicated, and parallel airfoil type dampers of galvanized construction. Provide blades that rotate on stainless steel or nylon sleeve bearings.

2.12.1.6 Filters

Provide disposable type filter that complies with ASHRAE 52.2. Provide filters in each unit that are removable without the use of tools.

2.12.1.7 Motors

Provide motors of the permanent split-capacitor type with built-in thermal overload protection, directly connected to unit fans. Provide motor switch with two or three speeds and off, manually operated, and mounted on an identified plate inside the unit below or behind an access door. In lieu of the above fan speed control, a solid-state variable-speed controller having a minimum speed reduction of 50 percent is allowed. Provide motors with permanently-lubricated or oilable sleeve-type or combination ball and sleeve-type bearings with vibration isolating mountings suitable for continuous duty. Provide a motor power consumption, shown in watts, at the fan operating speed selected to meet the specified capacity that does not exceed the following values:

Free Discharge Motors				
Unit Capacity (cfm)	Maximum Power Consumption (Watts)			
	115V	230V	277V	
200	70	110	90	
300	100	110	110	
400	170	150	150	

Free Discharge Motors				
Unit Capacity (cfm)	Maximum Power Consumption (Watts)			
	115V	230V	277V	
600	180	210	220	
800	240	240	230	
1000	310	250	270	
1200	440	400	440	

High Static Motors			
Unit Capacity (cfm)	Maximum Power Consumption (Watts)		
200	145		
300	145		
400	210		
600	320		
800	320		
1000	530		
1200	530		

2.12.2 Coil Induction Units

Provide base unit that includes air plenums, air-discharge nozzles, air discharge grilles, recirculation grilles, water coil assembly, valve and piping package, condensate drain pan, and adjustable air-balancing dampers, plus an enclosure for cabinet models and casing for concealed models. Make each unit capable of producing not less than the capacity indicated without exceeding the indicated static pressure. Provide a sound power level as indicated with power level data or values for these units based on tests conducted according to ASA S12.51. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles. The values obtained for the standard cabinet models are acceptable for concealed models without separate tests, provided there is no variation between models as to coil configuration, air discharge nozzles, air balancing dampers, or relative arrangement of parts. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Secure each unit to the building structure. Provide units with capacity indicated.

2.12.2.1 Enclosures

Fabricate enclosures from not lighter than 18 gauge steel, reinforced and braced. Provide a removable front panel of enclosure and insulate when required acoustically and to prevent condensation. Provide discharge grilles that are adjustable and properly distribute air throughout the conditioned space. Plastic discharge and return grilles are not acceptable. Provide access doors for all piping and control compartments.

2.12.2.2 Air Plenums

Fabricate plenums from galvanized steel with interior acoustically baffled and lined with sound absorbing material to attenuate the sound power from the primary air supply to the room. Provide heat-resistant nozzles that are integral with or attached airtight to the plenum. Where coil induction units are supplied with vertical runouts, furnish a streamlined, vaned, mitered elbow transition piece for connection between the unit and ductwork. Provide an adjustable air-balancing damper in each unit.

2.12.2.3 Coils

Fabricate coils from not less than 3/8 inch outside diameter seamless copper tubing, with copper or aluminum fins, mechanically bonded or soldered to the tubes. Furnish coil connections with not less than 1/2 inch outside diameter flare or sweat connectors, accessory piping package with terminal connections suitable for connection to the type of control valve supplied, and manual air vent. Test coils hydrostatically at 300 psi or under water at 250 psi air pressure and provide coils suitable for 200 psi working pressure.

2.12.2.4 Screens

Provide easily accessible lint screens or throwaway filters for each unit.

2.12.2.5 Drain Pan

Size and locate drain and drip pans to collect condensed water dripping from any item within the unit enclosure. Provide drain pans constructed of not lighter than 21 gauge steel, galvanized after fabrication, and thermally insulated to prevent condensation. Provide insulation that has a flame spread rating not over 25 without evidence of continued progressive combustion, a smoke developed rating no higher than 50, and that is a waterproof type or coated with a waterproofing material. In lieu of the above, drain pans constructed of die-formed 22 gauge steel are allowed, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 21 gauge steel material or of die-formed 21 gauge type 304 stainless steel insulated as specified above. Pitch drain pans to drain. Provide drain connection when a condensate drain system is indicated. Make connection a minimum 3/4 inch NPT or 5/8 inch OD.

2.12.3 Variable Air Volume (VAV) and Dual Duct Terminal Units

a. Provide VAV and dual duct terminal units that are the type, size, and capacity shown, mounted in the ceiling or wall cavity, plus units that are suitable for single or dual duct system applications. Provide actuators and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS.

- b. Provide unit enclosures that are constructed of galvanized steel not lighter than 22 gauge or aluminum sheet not lighter than 18 gauge. Provide single or multiple discharge outlets as required. Units with flow limiters are not acceptable. Provide unit air volume that is factory preset and readily field adjustable without special tools. Provide reheat coils as indicated.
- c. Attach a flow chart to each unit. Base acoustic performance of the terminal units upon units tested according to AHRI 880 I-P with the calculations prepared in accordance with AHRI 885. Provide sound power level as indicated. Show discharge sound power for minimum and 1-1/2 inches water gauge inlet static pressure. Provide acoustical lining according to NFPA 90A.

2.12.3.1 Constant Volume, Single Duct Terminal Units

Provide constant volume, single duct, terminal units that contain within the casing, a constant volume regulator. Provide volume regulators that control air delivery to within plus or minus 5 percent of specified air flow subjected to inlet pressure from 3/4 to 6 inch water gauge.

2.12.3.2 Variable Volume, Single Duct Terminal Units

Provide variable volume, single duct, terminal units with a calibrated air volume sensing device, air valve or damper, actuator, and accessory relays. Provide units that control air volume to within plus or minus 5 percent of each air set point volume as determined by the thermostat with variations in inlet pressures from 3/4 to 6 inch water gauge. Provide units with an internal resistance not exceeding 0.4 inch water gauge at maximum flow range. Provide external differential pressure taps separate from the control pressure taps for air flow measurement with a 0 to 1 inch water gauge range.

2.12.3.3 Variable Volume, Single Duct, Fan-Powered Terminal Units

Provide variable volume, single duct, fan-powered terminal units with a calibrated air volume sensing device, air valve or damper, actuator, fan and motor, and accessory relays. Provide units that control primary air volume to within plus or minus 5 percent of each air set point as determined by the thermostat with variations in inlet pressure from 3/4 to 6 inch water gauge. Provide unit fan that is centrifugal, direct-driven, double-inlet type with forward curved blades. Provide either single speed with speed controller or three-speed, permanently lubricated, permanent split-capacitor type fan motor. Isolate fan/motor assembly from the casing to minimize vibration transmission. Provide factory furnished fan control that is wired into the unit control system. Provide a factory-mounted pressure switch to operate the unit fan whenever pressure exists at the unit primary air inlet or when the control system fan operates.

2.12.3.4 Dual Duct Terminal Units

Provide dual duct terminal units with hot and cold inlet valve or dampers that are controlled in unison by single or dual actuators. Provide actuator as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Provide unit that controls delivered air volumes within plus or minus 5 percent with inlet air variations from 1 to 8 inch water gauge in either duct. Include mixing baffles with the unit casing. Provide cabinet and closed duct leakage that does not exceed 2 percent of maximum rated air volume. Provide units with an internal resistance that does not exceed inch water gauge at maximum flow range.

2.12.3.5 Ceiling Induction Terminal Units

Provide ceiling induction unit with a calibrated primary air volume sensing device, primary air valve, induced air damper, and insulated induction tube. Arrange unit to induce air from the ceiling plenum to maintain a maximum total flow circulated to the conditioned space. Vary primary air upon demand of the room thermostat. Upon a demand for maximum cooling, provide a unit that delivers 100 percent primary air and, at minimum cooling, delivers 50 percent primary air. Provide a terminal unit capable of closing to full shut off without additional actuators or linkage changes. Provide terminals that reset primary air volume within plus or minus 5 percent determined by the thermostat regardless of upstream changes in the static pressure. Provide a minimum inlet static pressure that does not exceed 1 inch water gauge, including a maximum of 0.3 inch water gauge downstream static pressure. Provide external differential pressure taps separate from control pressure taps for primary air flow measurement with 0 to 1 inch water gauge range. Make each unit normally open upon loss of pneumatic pressure. Factory pipe actuator and accuracy controls requiring only field installation of 20 psi pneumatic main air and room thermostat.

2.12.3.6 Series Fan Powered Variable Air Volume (VAV) Terminals

Provide units factory assembled, designed, tested, rated in accordance with AHRI 880 I-P, that are AHRI certified, listed in the AHRI DCAACP and that produce a supply air discharge mix by modulation of conditioned primary air and recirculating of return air. Provide units that include casing, centrifugal fan and motor, primary VAV damper or valve, electronic volume regulator, discharge air damper, primary air inlet cone with high and low pressure flow sensors, recirculating air filter frames, filter, and electrical disconnect.

2.12.3.6.1 Casing

Provide removable full bottom access panels for servicing internal components without disturbing duct connections. Insulate inside of casing with manufacturer's standard insulation. Provide units that have recirculating air inlet equipped with filter frame, round primary damper or valve, and unit mounting brackets.

2.12.3.6.2 Fans and Motors

Provide centrifugal, forward curved, multiblade, fan wheels with direct-drive motors. Provide motors that are the high efficiency permanent-split capacitor type with thermal overload protection, permanently lubricated bearings, and have three speeds or are equipped with solid state speed controllers. Provide isolation between fan motor assembly and unit casing. Provide fan and motor that is removable through casing access panel.

2.12.3.6.3 Flow Sensor

Provide ring or cross type sensor with minimum of two pickup points which average the velocity across the inlet. Obtain flow measurement within plus or minus 5 percent of rated airflow with 1.5 diameters of straight duct upstream of unit and inlet static variation of 0.5 to 5.0 inches 2.12.3.6.4 Primary VAV Damper or Valve

Provide galvanized steel damper blade that closes against gasket inside unit. Connect damper to operating shaft with a positive mechanical connection. Provide nylon bearing for damper shaft. Cylindrical die cast aluminum valve inlet tapered to fit round flexible ducts with integral flow diffuser and beveled self-centering disc. Provide damper or valve leakage at shutoff that does not exceed 2 percent of capacity at 1 inch water gauge pressure.

2.12.3.6.5 Regulator

Provide electronic volume regulator. Electronic controls contained in NEMA ICS 6, Type 1 enclosure sealed from airflow. Provide unit with controls mounted on side or on air valve. System powered regulators are not permitted. Provide volume regulator that resets primary air volume as determined by thermostat, within upstream static pressure variation noted in paragraph titled "Flow Sensor." Provide volume regulators that are field adjustable, factory set and calibrated to indicated maximum and minimum primary airflows, direct acting and normally open upon loss of pneumatic pressure.

2.12.3.6.6 Electrical

Provide unit that incorporates single point electrical connection with electrical disconnect. Provide electrical components that are UL or ETL listed, installed in accordance with NFPA 70 and mounted in control box. Units UL or ETL listed as an assembly do not require airflow switch interlock with electric heating coil, when factory assembled.

2.12.3.6.7 Filters

Provide UL listed throwaway one inch thick fiberglass filters, standard dust-holding capacity.

2.12.3.7 Reheat Units

2.12.3.7.1 Hot Water Coils

Provide fin-and-tube type hot-water coils constructed of seamless copper tubes and copper or aluminum fins mechanically bonded or soldered to the tubes. Provide headers that are constructed of cast iron, welded steel or copper. Provide casing and tube support sheets that are 16 gauge, galvanized steel, formed to provide structural strength. Provide tubes that are correctly circuited for proper water velocity without excessive pressure drop and are drainable where required or indicated. At the factory, test each coil at not less than 250 psi air pressure and provide coils suitable for 200 psi working pressure. Install drainable coils in the air handling units with a pitch of not less than 1/8 inch per foot of tube length toward the drain end. Coils must conform to the provisions of AHRI 410.

2.12.3.7.2 Steam Coils

Provide steam coils constructed of cast semisteel, welded steel, or copper headers, red-brass or copper tubes, and copper or aluminum fins

mechanically bonded or soldered to the tubes. Roll and bush, braze or weld tubes into headers. Provide coil casings and tube support sheets, with collars of ample width, that are not lighter than 16 gauge galvanized steel formed to provide structural strength. When required, furnish multiple tube supports to prevent tube sag. Float the fin tube and header section within the casing to allow free expansion of tubing for coils subject to high pressure steam service. Provide coils that are factory pressure tested and capable of withstanding 250 psi hydrostatic test pressure or 250 psi air pressure, and are for 100 psi steam working pressure. Provide steam-distribution tube type preheat coils with condensing tubes having not less than 5/8 inch outside diameters. Provide distribution tubes that have not less than 3/8 inch outside diameter, with orifices to discharge steam to condensing tubes. Install distribution tubes concentric inside of condensing tubes held securely in alignment. Limit the maximum length of a single coil to 120 times the diameter of the outside tube. Other heating coils must be single tube type with an outside diameter not less than 1/2 inch. Provide supply headers that distribute steam evenly to all tubes at the indicated steam pressure. Provide coils that conform to the provisions of AHRI 410.

2.12.3.7.3 Electric Resistance Heaters

Provide the duct-mounting type electric resistance heaters consisting of a nickel-chromium resistor mounted on refractory material and a steel or aluminum frame for attachment to ductwork. Provide electric duct heater that meets the requirement of Underwriters Laboratories and NFPA 70 and is provided with a built-in or surface-mounted high-limit thermostat. Interlock electric duct heaters electrically so that they cannot be energized unless the fan is running.

2.12.4 Unit Ventilators

Provide unit ventilators that include an enclosure, coil assembly, drain pan, air filters, fan assembly, fan drive, motor, motor controller, dampers, damper operators, and sound power level as indicated. Obtain sound power level data or values for these units according to test procedures based on AHRI 350. Sound power values apply to units provided with factory fabricated cabinet enclosures and standard grilles, when handling standard flow for which the unit air capacity is rated. Secure each unit to the building structure. Provide the unit ventilators with capacity indicated. Provide the year-round classroom type unit ventilator with automatic controls arranged to properly heat, cool, and ventilate the room. Provide automatic valves and controls as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS. Make the sequence of control any one of the standard ANSI cycles specified in paragraph CONTROLS.

2.12.4.1 Enclosures

Fabricate enclosures from not lighter than 16 gauge galvanized steel, reinforced and braced, or all welded framework with panels to provide equivalent strength. Provide casing that is acoustically and thermally insulated internally with not less than 1/2 inch thick dual density fibrous glass insulation. Make the exposed side a high density, erosion-proof material suitable for use in air streams with velocities up to 4500 fpm. Fasten the insulation with waterproof, fire-resistant adhesive. Design front panel for easy removal by one person. Provide discharge grilles that properly distribute air throughout the conditioned space. Provide return grilles that are removable where front panel does not provide access to interior components. Plastic discharge or return grilles are not acceptable. Furnish removable panels or access doors for all piping and control compartments. Provide fan switch that is key operated or accessible through a locked access panel. Install gaskets at the back and bottom of the unit for effective air seal, as required.

2.12.4.2 Electric Resistance Heating Elements

Provide electric resistance heating elements that are of the sheathed, finned, tubular type, or of the open resistance type designed for direct exposure to the air stream. Provide heating element electrical characteristics as indicated. Where fan motor or control voltage is lower than required for the electric-resistance heating element, install a fused factory mounted and wired transformer.

2.12.4.3 Fans

Provide fans that meet the requirements as specified in paragraph AIR SYSTEMS EQUIPMENT. Provide galvanized steel or aluminum, multiblade, centrifugal type fans, dynamically and statically balanced. Equip fan housings with resilient mounted, self-aligning permanently lubricated ball bearings, sleeve bearings, or combination ball and sleeve bearings, capable of not less than 2000 hours of operation on one oiling. Provide direct-connected fans.

2.12.4.4 Coils

Provide coils that are circuited for a maximum water velocity of 8 fps without excessive pressure drop and are otherwise as specified for hot water coils in paragraph TERMINAL UNITS.

2.12.4.5 Drain Pans

Size and locate drain and drip pans to collect all condensed water dripping from any item within the unit enclosure. Provide drain pans constructed of not lighter than 18 gauge steel, galvanized after fabrication, and thermally insulated to prevent condensation. Provide insulation that is coated with a fire-resistant waterproofing material. In lieu of the above, drain pans constructed of die-formed 20 gauge steel is allowed, formed from a single sheet and galvanized after fabrication and insulated and coated as for the 18 gauge steel material, or of die-formed 18 gauge type 304 stainless steel insulated as specified above. Pitch drain pans to drain. Furnish drain connection unless otherwise indicated. Make the minimum connection 3/4 inch NDT or 5/8 inch OD.

2.12.4.6 Filters

Disposable type rated in accordance with ASHRAE 52.2, installed upstream of coil.

2.12.4.7 Dampers

Provide an outside air proportioning damper on each unit. In addition, provide a vane to prevent excessive outside air from entering unit and to prevent blow-through of outside air through the return air grille under high wind pressures. Where outside air and recirculated air proportioning dampers are provided on the unit, an additional vane is not required. Provide face and bypass dampers for each unit to ensure constant air volume at all positions of the dampers. Furnish each unit with a factory installed control cam assembly, pneumatic motor, or electric motor to operate the face and bypass dampers and outside air damper or outside air and recirculated air dampers in the sequence as specified in paragraph SUPPLEMENTAL COMPONENTS/SERVICES, subparagraph CONTROLS.

2.12.4.8 Motors

Provide permanent split-capacitor type motors with built-in thermal overload protection and automatic reset. Mount motor on a resilient mounting, isolated from the casing and suitable for operation on electric service available. Provide a manually operated motor switch that provides for 2 or 3 speeds and off, mounted on an identified plate . In lieu of speed control, provide a solid state variable speed controller having minimum speed reduction of 50 percent.

2.12.4.9 Outside Air Intakes

Provide the manufacturer's standard design outside air intakes furnished with 1/2 inch mesh bird screen or louvers on 1/2 inch centers.

2.13 ENERGY RECOVERY DEVICES

2.13.1 Rotary Wheel

Provide unit that is a factory fabricated and tested assembly for air-to-air energy recovery by transfer of sensible heat from exhaust air to supply air stream, with device performance according to ASHRAE 84 and that delivers an energy transfer effectiveness of not less than 70 percent with cross-contamination not in excess of 0.1 percent of exhaust airflow rate at system design differential pressure, including purging sector if provided with wheel. Provide exchange media that is chemically inert, moisture-resistant, fire-retardant, laminated, nonmetallic material which complies with NFPA 90A. Isolate exhaust and supply streams by seals which are static, field adjustable, and replaceable. Equip chain drive mechanisms with ratcheting torque limiter or slip-clutch protective device. Fabricate enclosure from galvanized steel and include provisions for maintenance access. Provide recovery control and rotation failure provisions as indicated.

2.13.2 Run-Around-Coil

Provide assembly that is factory fabricated and tested air-to-liquid-to-air energy recovery system for transfer of sensible heat from exhaust air to supply air stream and that delivers an energy transfer effectiveness not less than that indicated without cross-contamination with maximum energy recovery at minimum life cycle cost. Computer optimize components for capacity, effectiveness, number of coil fins per inch, number of coil rows, flow rate, heat transfer rate of percent by volume of ethylene glycol solution, and frost control. Provide coils that conform to paragraph AIR HANDLING UNITS. Provide related pumps, and piping specialties that conform to requirements of .

2.13.3 Heat Pipe

Provide a device that is a factory fabricated, assembled and tested, counterflow arrangement, air-to-air heat exchanger for transfer of sensible heat between exhaust and supply streams and that delivers an energy transfer effectiveness not less than that indicated without cross-contamination. Provide heat exchanger tube core that is 1/2 inch nominal diameter, seamless aluminum or copper tube with extended surfaces, utilizing wrought aluminum Alloy 3003 or Alloy 5052, temper to suit. Provide maximum fins per unit length and number of tube rows as indicated. Provide tubes that are fitted with internal capillary wick, filled with a refrigerant complying with ASHRAE 15 & 34, selected for system design temperature range, and hermetically sealed. Refrigerants containing chlorofluorocarbons (CFC) are prohibited. Provide heat exchanger frame that is constructed of not less than 16 gauge galvanized steel and fitted with intermediate tube supports, and flange connections. Provide tube end-covers and a partition of galvanized steel to separate exhaust and supply air streams without cross-contamination and in required area ratio. Provide heat recovery regulation by system face and bypass dampers and related control system as indicated. Coil must be fitted with pleated flexible connectors.

2.13.4 Desiccant Wheel

Provide counterflow supply, regeneration airstreams, a rotary type dehumidifier designed for continuous operation, and extended surface type wheel structure in the axial flow direction with a geometry that allows for laminar flow over the operating range for minimum air pressure differentials. Provide the dehumidifier complete with a drive system utilizing a fractional-horsepower electric motor and speed reducer assembly driving the rotor. Include a slack-side tensioner for automatic take-up for belt-driven wheels. Provide an adsorbing type desiccant material. Apply the desiccant material to the wheel such that the entire surface is active as a desiccant and the desiccant material does not degrade or detach from the surface of the wheel which is fitted with full-face, low-friction contact seals on both sides to prevent cross leakage. Provide rotary structure that has underheat, overheat and rotation fault circuitry. Provide wheel assembly with a warranty for a minimum of five years.

2.13.5 Plate Heat Exchanger

Provide energy recovery ventilator unit that is factory-fabricated for indoor installation, consisting of a flat plate cross-flow heat exchanger, cooling coil, supply air fan and motor and exhaust air fan and motor. The casing must be 20 gauge G90, galvanized steel, double wall construction with one inch insulation. Provide fibrous desiccant cross-flow type heat exchanger core capable of easy removal from the unit.

2.14 FACTORY PAINTING

Factory paint new equipment, which are not of galvanized construction. Paint with a corrosion resisting paint finish according to ASTM A123/A123M or ASTM A924/A924M. Clean, phosphatize and coat internal and external ferrous metal surfaces with a paint finish which has been tested according to ASTM B117, ASTM D1654, and ASTM D3359. Submit evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors. Provide rating of failure at the scribe mark that is not less than 6, average creepage not greater than 1/8 inch. Provide rating of the inscribed area that is not less than 10, no failure. On units constructed of galvanized steel that have been welded, provide a final shop docket of zinc-rich protective paint on exterior surfaces of welds or welds that have burned through from the interior according to ASTM D520 Type I. Field paint factory painting that has been damaged prior to acceptance by the Contracting Officer in compliance with the requirements of paragraph FIELD PAINTING OF MECHANICAL EQUIPMENT.

- 2.15 SUPPLEMENTAL COMPONENTS/SERVICES
- 2.15.1 Condensate Drain Lines

Provide and install condensate drainage for each item of equipment that generates condensate except as modified herein.

2.15.2 Backflow Preventers

The requirements for backflow preventers are specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.15.3 Insulation

The requirements for shop and field applied insulation are specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.15.4 Controls

The requirements for controls are specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

- 2.16 RADIANT PANELS
- 2.16.1 Hydronic Modular Panels
- 2.16.1.1 Panels

Modular radiant panels will fit into a standard 24 inch x 24 inch or 24 inch x 48 inch suspended T-Bar ceiling grid or flush mounted on a drywall ceiling. For flush mounted ceiling applications, the manufacturer will provide a one piece extruded aluminum frame. Panels must be supported from the T-bar assembly. Panels must be 14 gauge or 16 gauge extruded aluminum or sheet steel.

2.16.1.2 Heat Sink

The modular panels must use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face.

2.16.1.3 Water Tubes

Tubes must consist of ASTM B75/B75M 1/2 inch O.D. nominal copper tubing. Water connections will be suitable for solder or compression fittings. Heat pads will be used between the soldered fitting and the panel to protect the panel surface. The manufacturer will provide water pressure drop data as well as heating and cooling output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling). The panels will have the capacity to have multiple passes with connections either on the same end or opposite ends, dependent on the number of passes.

2.16.1.4 Finish

All visible components must be powder coated with highly emissive powder
coat polyester paint for optimal radiative properties as well as durability and easy cleaning. Standard finish color must be white.

2.16.1.5 Performance

Manufacturer will provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling).

2.16.1.6 Capacity

Modular radiant panel capacity will be tested and certified by manufacturer in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling) to meet the required performance. Should any performance rating, chilled or hot water supply temperature, water pressure drop, etc. deviate from the schedule, the manufacturer will submit the updated capacity.

2.16.1.7 Water Connections

Connections will be shipped sealed to limit the introduction of dust and dirt during shipping and construction.

2.16.1.8 Installation

Panels will be installed as recommended by the manufacturer.

2.16.1.9 Accessories

Stainless steel braded hoses, 12 inches or 18 inches long will be supplied with the panels.

The top of the heating and cooling panels must be covered with 1-1/2 inches thick 1 lb/cu ft formaldehyde-free fiber glass insulation with a minimum R = 4.5 (hr ft2 deg F)/BTU. The insulation must be covered with a foil scrim kraft vapor barrier facing.

2.16.2 Hydronic Linear Panels

2.16.2.1 Panels

Linear radiant panels must use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face. The linear radiant panel is to radiate or absorb heat from or to the zone below. Panels must be 14 gauge or 16 gauge extruded aluminum.

2.16.2.2 Heat Sink

The modular panels must use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face.

2.16.2.3 Water Tubes

Tubes must consist of ASTM B75/B75M 1/2 inch or 5/8 inch O.D. nominal copper tubing. Water connections will be suitable for solder or compression fittings. The manufacturer will provide water pressure drop data as well as heating and cooling output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling).

2.16.2.4 Mounting

Units must be provided with mounting hardware as required for mounting in T-Bar applications or ceiling flush mounting. The manufacturer's standard hardware for mounting panels abutting each other must be submitted for approval.

2.16.2.5 Finish

All visible components must be powder coated with highly emissive powder coat polyester paint for optimal radiative properties as well as durability and easy cleaning. Standard finish color must be white.

2.16.2.6 Performance

Manufacturer must provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling).

2.16.2.7 Capacity

Modular radiant panel capacity must be tested and certified by manufacturer in accordance with DIN EN 14037 (heating) and DIN EN 14240 (cooling) to meet the required performance. Should any performance rating, chilled or hot water supply temperature, water pressure drop, etc. deviate from the schedule, the manufacturer must submit the updated capacity.

2.16.2.8 Water Connections

Connections will be shipped sealed to limit the introduction of dust and dirt during shipping and construction.

2.16.2.9 Accessories

Stainless steel braded hoses, 12 inches or 18 inches long will be supplied with the panels.

The top of the heating and cooling panels must be covered with 1-1/2 inches thick 1 lb/cu ft formaldehyde-free fiber glass insulation with a minimum R = 4.5 (hr ft2 deg F)/BTU. The insulation must be covered with a foil scrim kraft vapor barrier facing.

2.16.3 Prefabricated Radiant-Heating Electric Panels

2.16.3.1 Description

Sheet metal enclosed panel with heating element suitable for lay-in installation flush with T-bar ceiling grid. Comply with UL 2021

2.16.3.2 Panel

Minimum 0.027 inch thick, galvanized steel sheet back panel riveted to minimum 0.040 inch thick, galvanized steel sheet front panel with fused-on crystalline surface.

2.16.3.3 Heating Element

Powdered graphite sandwiched between sheets of electric insulation.

2.16.3.4 Electrical Connections

Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.

2.16.3.5 Exposed-Side Panel Finish

Apply silk-screened finish to match appearance of Architect selected acoustical ceiling tiles.

2.16.3.6 Surface-Mounting Trim

Sheet metal with baked-enamel finish in color as selected by Architect.

2.16.3.7 Wall Thermostat

Bimetal, sensing elements; with contacts suitable for -voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- a. Install materials and equipment in accordance with the requirements of the contract drawings and approved manufacturer's installation instructions. Accomplish installation by workers skilled in this type of work. Perform installation so that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors.
- b. No installation is permitted to block or otherwise impede access to any existing machine or system. Install all hinged doors to swing open a minimum of 120 degrees. Provide an area in front of all access doors that clears a minimum of 3 feet. In front of all access doors to electrical circuits, clear the area the minimum distance to energized circuits as specified in OSHA Standards, part 1910.333 (Electrical-Safety Related work practices) and an additional 3 feet.
- c. Except as otherwise indicated, install emergency switches and alarms in conspicuous locations. Mount all indicators, to include gauges, meters, and alarms in order to be easily visible by people in the area.

3.2.1 Condensate Drain Lines

Provide water seals in the condensate drain from all units . Provide a depth of each seal of 2 inches plus the number of inches, measured in water gauge, of the total static pressure rating of the unit to which the drain is connected. Provide water seals that are constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Provide pipe cap or plug cleanouts where indicated. Connect drains indicated to connect to the sanitary waste system using an indirect waste fitting. Insulate air conditioner drain lines as specified in Section 23 07 00

THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.2.2 Equipment and Installation

Provide frames and supports for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Floor mount or ceiling hang air handling units as indicated. Anchor and fasten as detailed. Set floor-mounted equipment on not less than 6 inch concrete pads or curbs doweled in place unless otherwise indicated. Make concrete foundations heavy enough to minimize the intensity of the vibrations transmitted to the piping, duct work and the surrounding structure, as recommended in writing by the equipment manufacturer. In lieu of a concrete pad foundation, build a concrete pedestal block with isolators placed between the pedestal block and the floor. Make the concrete foundation or concrete pedestal block a mass not less than three times the weight of the components to be supported. Provide the lines connected to the pump mounted on pedestal blocks with flexible connectors.

3.2.3 Access Panels

Install access panels for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance of sufficient size, and locate them so that the concealed items are easily serviced and maintained or completely removed and replaced.

3.2.4 Flexible Duct

Install pre-insulated flexible duct in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Provide hangers, when required to suspend the duct, of the type recommended by the duct manufacturer and set at the intervals recommended.

3.2.5 Metal Ductwork

Install according to SMACNA 1966 unless otherwise indicated. Install duct supports for sheet metal ductwork according to SMACNA 1966, unless otherwise specified. Do not use friction beam clamps indicated in SMACNA 1966. Anchor risers on high velocity ducts in the center of the vertical run to allow ends of riser to move due to thermal expansion. Erect supports on the risers that allow free vertical movement of the duct. Attach supports only to structural framing members and concrete slabs. Do not anchor supports to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, provide suitable intermediate metal framing. Where C-clamps are used, provide retainer clips.

3.2.5.1 Underground Ductwork

Provide PVC plastisol coated galvanized steel underground ductwork with coating on interior and exterior surfaces and watertight joints. Install ductwork as indicated, according to ACCA Manual 4 and manufacturer's instructions. Maximum burial depth is 6 feet.

3.2.5.2 Radon Exhaust Ductwork

Perforate subslab suction piping where indicated. Install PVC joints as specified in ASTM D2855.

3.2.5.3 Light Duty Corrosive Exhaust Ductwork

For light duty corrosive exhaust ductwork, use PVC plastisol coated galvanized steel with PVC coating on interior surfaces.

3.2.6 FRP Ductwork

Provide fibrous glass reinforced plastic ducting and related structures that conform to SMACNA 1403. Provide flanged joints where indicated. Crevice-free butt lay-up joints are acceptable where flanged joints are not indicated. When ambient temperatures are lower than 50 degrees F, heat cure joints by exothermic reaction heat packs.

3.2.7 Kitchen Exhaust Ductwork

3.2.7.1 Ducts Conveying Smoke and Grease Laden Vapors

Provide ducts conveying smoke and grease laden vapors that conform to requirements of NFPA 96. Make seams, joints, penetrations, and duct-to-hood collar connections with a liquid tight continuous external weld. Provide duct material that is a minimum 18 gauge, Type 304L or 316L, stainless steel . Include with duct construction an external perimeter angle sized in accordance with SMACNA 1966, except place welded joint reinforcement on maximum of 24 inch centers; continuously welded companion angle bolted flanged joints with flexible ceramic cloth gaskets where indicated; pitched to drain at low points; welded pipe coupling-plug drains at low points; welded fire protection and detergent cleaning penetration; steel framed, stud bolted, and flexible ceramic cloth gasketed cleaning access provisions where indicated. Make angles, pipe couplings, frames, bolts, etc., the same material as that specified for the duct unless indicated otherwise.

3.2.7.2 Exposed Ductwork

Provide exposed ductwork that is fabricated from minimum 18 gauge, Type 304L or 316L, stainless steel with continuously welded joints and seams. Pitch ducts to drain at hoods and low points indicated. Match surface finish to hoods.

3.2.7.3 Concealed Ducts Conveying Moisture Laden Air

Fabricate concealed ducts conveying moisture laden air from minimum 16 gauge, galvanized steel . Continuously weld, braze, or solder joints to be liquid tight. Pitch ducts to drain at points indicated. Make transitions to other metals liquid tight, companion angle bolted and gasketed.

3.2.8 Acoustical Duct Lining

Apply lining in cut-to-size pieces attached to the interior of the duct with nonflammable fire resistant adhesive conforming to ASTM C916, Type I, NFPA 90A, UL 723, and ASTM E84. Provide top and bottom pieces that lap the side pieces and are secured with welded pins, adhered clips of metal, nylon, or high impact plastic, and speed washers or welding cup-head pins installed according to SMACNA 1966. Provide welded pins, cup-head pins, or adhered clips that do not distort the duct, burn through, nor mar the finish or the surface of the duct. Make pins and washers flush with the surfaces of the duct liner and seal all breaks and punctures of the duct liner coating with the nonflammable, fire resistant adhesive. Coat exposed edges of the liner at the duct ends and at other joints where the lining is subject to erosion with a heavy brush coat of the nonflammable, fire resistant adhesive, to prevent delamination of glass fibers. Apply duct liner to flat sheet metal prior to forming duct through the sheet metal brake. Additionally secure lining at the top and bottom surfaces of the duct by welded pins or adhered clips as specified for cut-to-size pieces. Other methods indicated in SMACNA 1966 to obtain proper installation of duct liners in sheet metal ducts, including adhesives and fasteners, are acceptable.

3.2.9 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, perform temporary dust control protection. Protect the distribution system (supply and return) with temporary seal-offs at all inlets and outlets at the end of each day's work. Keep temporary protection in place until system is ready for startup.

3.2.10 Insulation

Provide thickness and application of insulation materials for ductwork, piping, and equipment according to Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Externally insulate outdoor air intake ducts and plenums .

3.2.11 Duct Test Holes

Provide holes with closures or threaded holes with plugs in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Plug insulated duct at the duct surface, patched over with insulation and then marked to indicate location of test hole if needed for future use.

3.2.12 Power Roof Ventilator Mounting

Provide foamed 1/2 inch thick, closed-cell, flexible elastomer insulation to cover width of roof curb mounting flange. Where wood nailers are used, predrill holes for fasteners.

3.2.13 Power Transmission Components Adjustment

Test V-belts and sheaves for proper alignment and tension prior to operation and after 72 hours of operation at final speed. Uniformly load belts on drive side to prevent bouncing. Make alignment of direct driven couplings to within 50 percent of manufacturer's maximum allowable range of misalignment.

3.3 EQUIPMENT PADS

Provide equipment pads to the dimensions shown or, if not shown, to conform to the shape of each piece of equipment served with a minimum 3-inch margin around the equipment and supports. Allow equipment bases and foundations, when constructed of concrete or grout, to cure a minimum of 28 calendar days before being loaded.

3.4 CUTTING AND PATCHING

Install work in such a manner and at such time that a minimum of cutting and patching of the building structure is required. Make holes in exposed locations, in or through existing floors, by drilling and smooth by sanding. Use of a jackhammer is permitted only where specifically approved. Make holes through masonry walls to accommodate sleeves with an iron pipe masonry core saw.

3.5 CLEANING

Thoroughly clean surfaces of piping and equipment that have become covered with dirt, plaster, or other material during handling and construction before such surfaces are prepared for final finish painting or are enclosed within the building structure. Before final acceptance, clean mechanical equipment, including piping, ducting, and fixtures, and free from dirt, grease, and finger marks. When the work area is in an occupied space such as office, laboratory or warehouse protect all furniture and equipment from dirt and debris. Incorporate housekeeping for field construction work which leaves all furniture and equipment in the affected area free of construction generated dust and debris; and, all floor surfaces vacuum-swept clean.

3.6 PENETRATIONS

Provide sleeves and prepared openings for duct mains, branches, and other penetrating items, and install during the construction of the surface to be penetrated. Cut sleeves flush with each surface. Place sleeves for round duct 15 inches and smaller. Build framed, prepared openings for round duct larger than 15 inches and square, rectangular or oval ducts. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Provide one inch clearance between penetrating and penetrated surfaces except at grilles, registers, and diffusers. Pack spaces between sleeve or opening and duct or duct insulation with mineral fiber conforming with ASTM C553, Type 1, Class B-2.

3.6.1 Sleeves

Fabricate sleeves, except as otherwise specified or indicated, from 20 gauge thick mill galvanized sheet metal. Where sleeves are installed in bearing walls or partitions, provide black steel pipe conforming with ASTM A53/A53M, Schedule 20.

3.6.2 Framed Prepared Openings

Fabricate framed prepared openings from 20 gauge galvanized steel, unless otherwise indicated.

3.6.3 Insulation

Provide duct insulation in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS continuous through sleeves and prepared openings except firewall penetrations. Terminate duct insulation at fire dampers and flexible connections. For duct handling air at or below 60 degrees F, provide insulation continuous over the damper collar and retaining angle of fire dampers, which are exposed to unconditioned air.

3.6.4 Closure Collars

Provide closure collars of a minimum 4 inches wide, unless otherwise indicated, for exposed ducts and items on each side of penetrated surface, except where equipment is installed. Install collar tight against the surface and fit snugly around the duct or insulation. Grind sharp edges smooth to prevent damage to penetrating surface. Fabricate collars for round ducts 15 inches in diameter or less from 20 gauge galvanized steel. Fabricate collars for square and rectangular ducts, or round ducts with minimum dimension over 15 inches from 18 gauge galvanized steel. Fabricate collars for square and rectangular ducts with a maximum side of 15 inches or less from 20 gauge galvanized steel. Install collars with fasteners a maximum of 6 inches on center. Attach to collars a minimum of 4 fasteners where the opening is 12 inches in diameter or less, and a minimum of 8 fasteners where the opening is 20 inches in diameter or less.

3.6.5 Firestopping

Where ducts pass through fire-rated walls, fire partitions, and fire rated chase walls, seal the penetration with fire stopping materials as specified in Section 07 84 00 FIRESTOPPING.

3.7 FIELD PAINTING OF MECHANICAL EQUIPMENT

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except clean to bare metal on metal surfaces subject to temperatures in excess of 120 degrees F. Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Provide aluminum or light gray finish coat.

3.7.1 Temperatures less than 120 degrees F

Immediately after cleaning, apply one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat to metal surfaces subject to temperatures less than 120 degrees F.

3.7.2 Temperatures between 120 and 400 degrees F

Apply two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of two mils to metal surfaces subject to temperatures between 120 and 400 degrees F.

3.7.3 Temperatures greater than 400 degrees F

Apply two coats of 315 degrees C 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of two mils to metal surfaces subject to temperatures greater than 400 degrees F.

3.7.4 Color Coding Scheme for Locating Hidden Utility Components

Use scheme in buildings having suspended grid ceilings. Provide color coding scheme that identifies points of access for maintenance and operation of components and equipment that are not visible from the finished space and are accessible from the ceiling grid, consisting of a color code board and colored metal disks. Make each colored metal disk approximately 3/8 inch diameter and secure to removable ceiling panels with fasteners. Insert each fastener into the ceiling panel so as to be concealed from view. Provide fasteners that are manually removable without the use of tools and that do not separate from the ceiling panels

when the panels are dropped from ceiling height. Make installation of colored metal disks follow completion of the finished surface on which the disks are to be fastened. Provide color code board that is approximately 3 foot wide, 30 inches high, and 1/2 inches thick. Make the board of wood fiberboard and frame under glass or 1/16 inch transparent plastic cover. Make the color code symbols approximately 3/4 inch in diameter and the related lettering in 1/2 inch high capital letters. Mount the color code system as indicated below:

Color	System	Item	Location

3.8 IDENTIFICATION SYSTEMS

Provide identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number on all valves and dampers. Provide tags that are 1-3/8 inch minimum diameter with stamped or engraved markings. Make indentations black for reading clarity. Attach tags to valves with No. 12 AWG 0.0808-inch diameter corrosion-resistant steel wire, copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

3.9 DUCTWORK LEAK TEST

Perform ductwork leak test for the entire air distribution and exhaust system, including fans, coils, Provide test procedure, apparatus, and report that conform to SMACNA 1972 CD. The maximum allowable leakage rate is cfm. Complete ductwork leak test with satisfactory results prior to applying insulation to ductwork exterior or concealing ductwork.

3.10 DAMPER ACCEPTANCE TEST

Submit the proposed schedule, at least 2 weeks prior to the start of test. Operate all fire dampers and smoke dampers under normal operating conditions, prior to the occupancy of a building to determine that they function properly. Test each fire damper equipped with fusible link by having the fusible link cut in place. Test dynamic fire dampers with the air handling and distribution system running. Reset all fire dampers with the fusible links replaced after acceptance testing. To ensure optimum operation and performance, install the damper so it is square and free from racking.

3.11 TESTING, ADJUSTING, AND BALANCING

The requirements for testing, adjusting, and balancing are specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC. Begin testing, adjusting, and balancing only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.12 PERFORMANCE TESTS

Conduct performance tests as required in Section 23 05 93 Testing, Adjusting and Balancing for HVAC and Section 23 09 00 Instrumentation and Control for HVAC.

3.13 CLEANING AND ADJUSTING

Provide a temporary bypass for water coils to prevent flushing water from passing through coils. Inside of room fan-coil units thoroughly clean ducts, plenums, and casing of debris and blow free of small particles of rubbish and dust and then vacuum clean before installing outlet faces. Wipe equipment clean, with no traces of oil, dust, dirt, or paint spots. Provide temporary filters prior to startup of all fans that are operated during construction, and provide new filters after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. Perform and document that proper "Indoor Air Quality During Construction" procedures have been followed; provide documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. Maintain system in this clean condition until final acceptance. Properly lubricate bearings with oil or grease as recommended by the manufacturer. Tighten belts to proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions. Maintain all equipment installed under the contract until close out documentation is received, the project is completed and the building has been documented as beneficially occupied.

3.14 RADIANT PANELS

3.14.1 Installation

Install radiant panels level and plumb, maintaining sufficient clearance for normal services and maintenance.

3.14.2 Soldering

When soldering copper fittings at the panel, a heat pad will be used to protect the panel finish.

3.14.3 Connections

Install piping adjacent to radiant panels to allow for service and maintenance.

3.15 OPERATION AND MAINTENANCE

3.15.1 Operation and Maintenance Manuals

Submit six manuals at least 2 weeks prior to field training. Submit data complying with the requirements specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit Data Package 3 for the items/units listed under SD-10 Operation and Maintenance Data

3.15.2 Operation And Maintenance Training

Conduct a training course for the members of the operating staff as designated by the Contracting Officer. Make the training period consist of a total of hours of normal working time and start it after all work specified herein is functionally completed and the Performance Tests have been approved. Conduct field instruction that covers all of the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations. Submit the proposed -- End of Section --

SECTION 23 36 00.00 40

AIR TERMINAL UNITS 05/16

PART 1 GENERAL

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

1.1 REFERENCES

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

AIR DUCT COUNCIL (ADC)

ADC Standards Manual (2008; 5th Edition) Flexible Duct Performance Installation Standards

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 880 I-P

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

(2011) Performance Rating of Air Terminals

ASHRAE 130 (2008) Method of Testing for Rating Ducted Air Terminal Units

ASTM INTERNATIONAL (ASTM)

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

ASTM C1071 (2019) Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2018) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA	70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA
		20-1; TIA 20-2; TIA 20-3; TIA 20-4)
		National Electrical Code

NFPA 90A (2021) Standard for the Installation of

Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

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(2013; Reprint Apr 2017) UL Standard for Safety Factory-Made Air Ducts and Air Connectors

UL	486A-486B	(2018)	UL	Standard	for	Safety	Wire
		Connec	tor	S			

1.2 ADMINISTRATIVE REQUIREMENTS

Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, communication and security systems, and partition assemblies.

1.2.1 Pre-Installation Meetings

Submit itemized lists for all materials, equipment, and fixtures to be incorporated in the work 30 days prior to commencement of work. Ensure list includes manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information. Submit product data for each type of air terminal unit indicated, including rated capacities, furnished specialties, sound-power ratings, and accessories:

- a. Bypass Single-Duct Air Terminal Units
- b. Dual-Duct Air Terminal Units
- c. Fan-Powered Air Terminal Units
- d. Induction Air Terminal Units
- e. Shutoff Single-Duct Air Terminal Units
- f. Integral-Diffuser Air Terminal Units
- g. High-Pressure Dual-Duct Mixing Boxes
- h. Low-Pressure Dual-Duct Mixing Boxes

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

Submit shop drawings which detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished. Include wiring diagrams to show power, signal, and control wiring.

Provide units with the configuration, capacity, and static-pressure characteristics indicated.

Ensure dimensional data stated constitutes nominal sizing, which has been adjusted by the manufacturer when necessary to accommodate acoustic material thickness.

Ensure units proposed are identical to units having at least 2 years of proven satisfactory field service.

Provide certification that units and the list of spare parts are ADC Standards Manual tested and rated.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. 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

SD-02 Shop Drawings

Bypass Single-Duct Air Terminal Units; G,

Dual-Duct Air Terminal Units; G

Fan-Powered Air Terminal Units; G

Induction Air Terminal Units; G

Shutoff Single-Duct Air Terminal Units; G

Integral-Diffuser Air Terminal Units; G

High-Pressure Dual-Duct Mixing Boxes; G

Low-Pressure Dual-Duct Mixing Boxes; G

SD-03 Product Data

Bypass Single-Duct Air Terminal Units; G Dual-Duct Air Terminal Units; G Fan-Powered Air Terminal Units; G Induction Air Terminal Units; G Shutoff Single-Duct Air Terminal Units; G Integral-Diffuser Air Terminal Units; G High-Pressure Dual-Duct Mixing Boxes; G Low-Pressure Dual-Duct Mixing Boxes; G SD-06 Test Reports

Test Report

SD-07 Certificates

List of Spare Parts

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Record Drawings

1.4 QUALITY CONTROL

Indicate on drawings the size, profiles, and dimensional requirements of air terminal units that are based on the specific system indicated.

Conform to NFPA 70, Article 100 for electrical components, devices, and accessories. List and label items as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

Ensure Air Terminals are certified under the AHRI 880 I-P Certification Program and carry the ARI Seal.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Verification of Performance

Rate air terminal units according to AHRI 880 I-P.

2.1.2 Bypass Single-Duct Air Terminal Units

2.1.2.1 Configuration

Provide diverting-damper assembly inside unit casing with control components located inside a protective metal shroud.

2.1.2.2 Casing

Provide 0.034-inch steel casing. Provide 1/2-inch thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. For the air inlet, provide round stub connection for duct attachment. For the air outlet, provide s-slip and drive connections. Provide removable panels, with airtight gaskets, for access to diverter and other parts requiring service, adjustment, or maintenance.

2.1.2.3 Diverter Assembly

Provide galvanized-steel gate, with polyethylene linear bearings diverter assembly.

2.1.2.4 Multi-Outlet Attenuator Section

Provide two, 6-inch diameter collars, each with locking butterfly balancing damper.

2.1.2.5 Hot-Water Heating Coil

Provide a copper tube heating coil, mechanically expanded into aluminum-plate fins. Verify heating coil passes underwater leak test to 200 psig.

2.1.2.6 Electric Heating Coil

Provide a factory installed and wired slip-in-type, open-coil design with integral control box. Include the following features:

- a. Primary and secondary over temperature protection
- b. Nickel chrome 80/20 heating elements
- c. Airflow switch
- d. Non-interlocking disconnect switch
- e. Fuses (for coils more than 48 A)
- f. Mercury contactors
- g. Pneumatic-electric switches and relays.
- h. Magnetic contactor for each step of control (for three-phase coils)

2.1.2.7 Electric Controls

Provide a 24 V damper actuator that is powered closed and powered open with a microswitch to energize heating control circuit.

Provide a wall-mounting electric type thermostat with temperature display in Celsius and Fahrenheit, and with a space temperature set point.

Provide a changeover thermostat of duct-mounting, electric type that reverses action of controls when the duct temperature rises 70 degrees F.

2.1.2.8 Electronic Controls

Provide a 24 V damper actuator that is powered closed and powered open.

2.1.2.9 Pneumatic Controls

Provide a pneumatic damper operator with a 8 to 13 psig spring range.

Provide a factory calibrated and field adjustable velocity controller capable of handling minimum and maximum air volumes. Ensure controllers maintain a constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inches wg when tested in accordance with ASHRAE 130. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlets and air outlets.

2.1.2.10 Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature. Ensure thermostat is time-proportional type with a reheat-coil control feature. Display temperature set-points in Celsius and Fahrenheit. Ensure the auxiliary switch energizes the heating control circuit, and changeover thermistor has a reverse action feature.

2.1.3 Dual-Duct Air Terminal Units

2.1.3.1 Configuration

Provide two volume dampers inside the unit casing with mixing attenuator section and control components located inside a protective metal shroud.

2.1.3.2 Casing

Provide 0.034-inch-inch casing. Include with casing an integral mixing baffle to efficiently mix the hot and cold airstream.

a. Casing Lining

Provide 0.034-inch casing. Provide 1/2-inch thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. Cover liner with nonporous foil.Cover liner with nonporous foil and perforated metal.

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with a NFPA 90A approved seal.

For the air inlet, provide round stub connection for duct attachment. For the air outlet, provide s-slip and drive connections. Provide removable panels with an airtight gasket for access to the diverter and other parts requiring service, adjustment, or maintenance.

2.1.3.3 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearings.

Perform a Maximum Damper Leakage Test (MDLT) in conformance to AHRI 880 I-P, for 3 percent of nominal airflow at 3-inch wginlet static pressure.

Select either Damper Position, Hot Deck: normally open or Damper Position, Cold Deck: normally closed.

2.1.3.4 Attenuator Section

Provide 0.034-inch sheet metal. Provide 1/2-inch thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. Cover liner with nonporous foil.

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of

fiberglass exposed to the airstream with NFPA 90A approved seal.

2.1.3.5 Multi-Outlet Attenuator Section

Provide two, 6 inch diameter collars; each with locking butterfly balancing damper.

2.1.3.6 Pneumatic Controls

a. Pneumatic Damper Operator

Provide a pneumatic damper operator with a 8 to 13 psig spring range.

b. Velocity Controllers

Provide a factory calibrated velocity controller, field adjustable to minimum and maximum air volumes. Ensure controllers maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg when tested in accordance with ASHRAE 130. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

- 2.1.3.7 Electronic Controls
 - a. Damper Actuator

Provide a 24 V, powered closed, spring return open damper actuator.

b. Velocity Control

Provide a factory calibrated controller, with settings for minimum and maximum air volumes, and field adjustable at thermostat. Ensure controller maintains constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg, when tested in accordance with ASHRAE 130. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature, time-proportional with reheat-coil control feature. Provide a temperature set-point display in Celsius and Fahrenheit.

2.1.3.8 DDC Controls

a. Damper Actuators

Provide a 24 V, powered closed, powered open damper actuator.

b. Velocity Sensors

Provide a multipoint array with velocity sensors in cold-deck and hot-deck

air inlet and air outlet.

c. Terminal Unit Controller

Provide a pressure independent, variable-air volume controller with electronic airflow transducers factory calibrated to minimum and maximum air volumes. Include the following features:

- (1) Proportional, plus integral control of room temperature
- (2) Time-proportional reheat-coil control
- (3) Occupied and unoccupied operating mode
- (4) Remote reset of airflow or temperature set points
- (5) Adjusting and monitoring with portable terminal
- d. Room Sensor

Provide a wall mounting room sensor, with temperature set-point adjustment and access for connection of portable operator terminal.

2.1.3.9 Control Sequence

Modulate cold-air damper to maintain room temperature. Modulate warm-air damper to maintain constant airflow.

- 2.1.4 Fan-Powered Air Terminal Units
- 2.1.4.1 Configuration

Provide volume-damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud.

2.1.4.2 Casing

Provide 0.034-inch casing. Include with casing an integral mixing baffle to efficiently mix the hot and cold airstream.

a. Casing Lining

Provide 1/2-inch thick with 1.5 pounds per cubic foot density, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive.

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

Provide a round stub connection for the air inlet duct attachment. For the air outlet provide s-slip and drive connections. Provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn gaskets. Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearings.

Perform a Maximum Damper Leakage Test (MDLT) in conformance to AHRI 880 I-P, for 2 percent of nominal airflow at 3-inch wg inlet static pressure, when tested in accordance with ASHRAE 130.

Select damper position: Normally open.

2.1.4.4 Fan Section

Provide a galvanized-steel plenum, with direct-drive, forward-curved fan with air filter and backdraft damper.

a. Lining

Provide 1/2-inch thick, coated, fibrous-glass duct liner complying with ASTM C1071; secured with adhesive.

b. Motor

Comply with requirements in Section 26 60 13.00 40 LOW-VOLTAGE MOTORS for Multi-speed motors. Provide motor which includes a speed control feature that is infinitely adjustable with pneumatic-electric and electronic controls. Provide rubber isolators with fan-motor assembly.

c. Air Filter

Provide 2-inchthick, fiberglass throwaway air-filter.

2.1.4.5 Attenuator Section

Provide 0.034-inch sheet metal. Provide 1/2-inch, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive.

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

2.1.4.6 Hot-Water Heating Coil

Provide a copper tube mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.

2.1.4.7 Electric Heating Coil

Provide a slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

- a. Primary and secondary over-temperature protection
- b. Nickel chrome 80/20 heating elements
- c. Fan interlock contacts

- d. Non-interlocking disconnect switch
- e. Fuses (for coils more than 48 A)
- f. Mercury contactors
- g. Pneumatic-electric switches and relay
- h. Magnetic contactor for each step of control (for three-phase coils)
- 2.1.4.8 Factory-Mounted and -Wired Controls

Mount electrical components in control box with removable cover. Incorporate single-point electrical connection to power source.

Provide factory mounted control transformer for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.

Provide fan and controls to terminal strip, with terminal lugs which match quantities, sizes, and materials of branch-circuit conductors for wiring terminations. Enclose terminal lugs in terminal box that is sized according to NFPA 70.

Factory-mount a fused type disconnect switch.

2.1.4.9 Control Panel Enclosure

Provide control panel enclosure conforming to NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

2.1.4.10 Electric Controls

Provide a 24 V damper actuator with wall-mounting electric thermostat and appropriate mounting hardware.

- 2.1.4.11 Pneumatic Controls
 - a. Pneumatic Damper Operator

Provide a pneumatic damper operator with a 8 to 13 psig spring range.

b. Velocity Controllers

Provide a factory calibrated velocity controller, field adjustable to minimum and maximum air volumes. Ensure controllers maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg when tested in accordance with ASHRAE 130. Provide controller with a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

Provide a bi-directional damper operator and microprocessor-based controller with integral airflow transducer and room sensor compatible with temperature controls, having the following features:

- a. Proportional, plus integral control of room temperature
- b. Time-proportional reheat-coil control
- c. Occupied and unoccupied operating mode
- d. Remote reset of airflow or temperature set points
- e. Adjusting and monitoring with portable terminal
- f. Communication with temperature-control system

2.1.5 Induction Air Terminal Units

2.1.5.1 Configuration

Provide a volume-damper assembly inside the unit casing with a mechanical induction damper mounted on the casing with control components located inside a protective metal shroud.

2.1.5.2 Casing

Provide 0.034-inch casing. Ensure the casing includes an integral mixing baffle to efficiently mix the hot and cold airstream.

a. Casing Lining

Provide 1/2-inch thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive.

For the air inlet provide round stub connection for duct attachment. For the air outlet provide s-slip and drive connections . Provide removable panels with an airtight gasket, for access to diverter and other parts requiring service, adjustment, or maintenance.

2.1.5.3 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearing.

Perform a Maximum Damper Leakage Test (MDLT) in conformance to AHRI 880 I-P, for 2 percent of nominal airflow at 3-inch wg inlet static pressure, when tested in accordance with ASHRAE 130.

Select Damper Position, normally openclosed.

2.1.5.4 Induction Damper

Provide galvanized-steel, multi-blade assembly with self-lubricating bearings.

Provide a with a factory installed copper tube mechanically expanded into aluminum-plate fins and leak tested underwater to 200 psig.

2.1.5.6 Electric Heating Coil

Provide a slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

- a. Primary and secondary over-temperature protection
- b. Nickel chrome 80/20 heating elements
- c. Airflow switch
- d. Non-interlocking disconnect switch
- e. Fuses (for coils more than 48 A)
- f. Mercury contactors
- g. Pneumatic-electric switches and relays
- h. Magnetic contactor for each step of control (for three-phase coils)

2.1.5.7 Pneumatic Controls

a. Damper Operator

Provide a pneumatic, 5 to 10 psig spring range damper operator.

b. Velocity Controller

Provide a factory calibrated velocity controller; field adjustable to minimum and maximum air volumes. Ensure controller is capable of maintaining constant airflow dictated by a thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4 inch wg when tested in accordance with ASHRAE 130. Ensure controller has a multipoint velocity sensor at air inlet.

c. Induction Damper Operator

Provide a pneumatic, spring range induction damper operator matching reset range of controller.

d. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

- 2.1.5.8 Electronic Controls
 - a. Damper Actuator

Provide a pneumatic, 5 to 10 psig spring range damper operator.

b. Velocity Controller

Provide a factory calibrated velocity controller; field adjustable to minimum and maximum air volumes. Ensure controller is capable of maintaining constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg when tested in accordance with ASHRAE 130. Ensure controller has a multipoint velocity sensor at air inlet.

c. Induction Damper Operator

Provide a pneumatic, spring range induction damper operator matching reset range of controller.

d. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware with the following features:

- (1) Proportional, plus integral control of room temperature
- (2) Time-proportional reheat-coil control
- (3) Temperature set-point display in Celsius and Fahrenheit

2.1.6 Shutoff Single-Duct Air Terminal Units

2.1.6.1 Configuration

Provide a volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

2.1.6.2 Casing

Provide 0.034-inch casing. Ensure the casing includes an integral mixing baffle to efficiently mix the hot and cold airstream.

a. Casing Lining

Provide 1/2-inch thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive.

Attach a 3/4-inch adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

For the air inlet provide round stub connection for duct attachment. For the air outlet provide s-slip and drive connections. Provide removable panels for access to diverter and other parts requiring service, adjustment, or maintenance; with airtight gasket.

2.1.6.3 Regulator Assembly

Provide galvanized-steel components with key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.

a. Automatic Flow-Control Assembly

Match combined spring rates for each volume-regulator size with machined

dashpot for stable operation. Provide factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

2.1.6.4 Regulator Assembly

Provide system-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Ensure the bellows operate at temperatures from 0 to 140 degrees F; are impervious to moisture and fungus; are suitable for 10-inch wg static pressure when tested in accordance with ASHRAE 130, and are factory tested for leaks.

2.1.6.5 Volume Damper

Provide a galvanized steel volume damper with peripheral gasket and self-lubricating bearings.

Perform a Maximum Damper Leakage Test (MDLT) in conformance to AHRI 880 I-P, for 2 percent of nominal airflow at 3-inch wg inlet static pressure when tested in accordance with ASHRAE 130.

Select Damper Position, normally open.

2.1.6.6 Attenuator Section

Provide 0.034-inch sheet metal attenuator section.

Provide 1/2-inch thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. Cover liner with nonporous foil.

Attach a 3/4-inch thick adhesive of polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25, and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E84. Coat any cut edges of fiberglass exposed to the airstream with NFPA 90A approved seal.

2.1.6.7 Multi-Outlet Attenuator Section

Provide two, 6-inch diameter collars; each with locking butterfly balancing damper.

2.1.6.8 Hot-Water Heating Coil

Provide a copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.

2.1.6.9 Electric Heating Coil

Provide a slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

- a. Primary and secondary over-temperature protection
- b. Nickel chrome 80/20 heating elements
- c. Airflow switch
- d. Non-interlocking disconnect switch

- e. Fuses (for coils more than 48 A)
- f. Mercury contactors
- g. Pneumatic-electric switches and relays
- h. Magnetic contactor for each step of control (for three-phase coils)

2.1.6.10 Electric Controls

a. Damper Actuator

Provide a 24 V, powered closed, powered open damper actuator.

b. Thermostat

Provide a wall-mounting electronic type thermostat with clock display, temperature display in Celsius and Fahrenheit, and space temperature set point.

- 2.1.6.11 Pneumatic Controls
 - a. Pneumatic Damper Operator

Provide a* 8 to 13 psig spring range.

b. Velocity Controllers

Provide a factory calibrated controller, field adjustable to minimum and maximum air volumes. Ensure controllers maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg, when tested in accordance with ASHRAE 130. Ensure controller has a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

2.1.6.12 Electronic Controls

Provide bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer. Ensure room sensor is compatible with temperature controls specified.

a. Damper Actuator

Provide a 24 V, powered closed, spring return open damper actuator.

b. Velocity Controller

Provide a factory calibrated controller set to minimum and maximum air volumes, field adjustable at thermostat. Ensure controller maintains constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg, when tested in accordance with ASHRAE 130. Ensure controller has a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlet and air outlet.

c. Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature, time-proportional with reheat-coil control feature, and displaying a temperature set-point in Celsius and Fahrenheit.

2.1.6.13 DDC Controls

Provide bidirectional damper operators and microprocessor-based controller. Provide with room sensor that is compatible with temperature controls specified.

a. Damper Actuators

Provide a 24 V, powered closed, spring return open damper actuator.

b. Terminal Unit Controller

Provide a pressure independent, variable-air volume controller with electronic airflow transducers factory calibrated to minimum and maximum air volumes. Include the following features:

- (1) Proportional, plus integral control of room temperature
- (2) Time-proportional reheat-coil control
- (3) Occupied and unoccupied operating mode
- (4) Remote reset of airflow or temperature set points
- (5) Adjusting and monitoring with portable terminal
- (6) Room Sensor

Provide a wall mounting room sensor, with temperature set-point adjustment and access for connection of portable operator terminal.

2.1.6.14 Control Sequence

Make suitable for operation with duct pressures between 0.25 and 3.0-inch wg inlet static pressure. Provide a factory-mounted and -piped, 5-micron filter; velocity-resetting, adjustable, high-limit control, with amplifying relay. Provide a system-powered, wall-mounting thermostat.

2.1.7 Integral-Diffuser Air Terminal Units

2.1.7.1 Configuration

Provide a volume-damper assembly inside unit casing with integral diffuser.

2.1.7.2 Casing

Provide 0.034-inch steel casing, including an integral mixing baffle to efficiently mix the hot and cold airstream.

a. Casing Lining

Provide 0.034-inch steel casing. Provide 1/2-inch thick, coated, fibrous-glass duct casing lining complying with ASTM C1071. Secure with adhesive. For the air inlet provide round stub connection for duct attachment.

2.1.7.3 Volume Damper

Provide galvanized steel with peripheral gasket and self-lubricating bearings.

Damper Position: Normally open.

2.1.7.4 Diffuser

Provide a galvanized-steel insulated plenum with extruded-aluminum or sheet-steel diffuser, having fixed or variable geometry designed to operate from 100 percent to minimum airflow, manual adjustment of airflow direction.

2.1.7.5 Electric Controls

a. Damper Actuator

Provide a 24 V, powered closed, spring return open.

b. Thermostat

Provide a wall-mounting electronic type thermostat with clock display, temperature display in Celsius and Fahrenheit, and space temperature set point.

2.1.7.6 Pneumatic Controls

Provide damper operator and thermostat compatible with temperature controls specified.

a. Pneumatic Damper Operator

Provide a 8 to 13 psig spring range.

b. Velocity Controller

Provide a factory calibrated velocity controller, which is field adjustable to minimum and maximum air volumes capable of maintaining constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg when tested in accordance with ASHRAE 130. Ensure controller has a multipoint velocity sensor at air inlet.

c. Thermostat

Provide a wall-mounting pneumatic type thermostat with appropriate mounting hardware.

2.1.7.7 Electronic Controls

Provide bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer. Provide with room sensor that is compatible with temperature controls specified.

a. Damper Actuator

Provide a 24 V, powered closed, spring return open.

b. Velocity Controller

Provide a factory calibrated velocity controller, field adjustable to minimum and maximum air volumes. Ensure controller is capable of maintaining constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg when tested in accordance with ASHRAE 130. Provide controller with a multipoint velocity sensor at air inlet.

c. Thermostat

Provide a wall-mounting electronic type thermostat with integral control of room temperature. Ensure thermostat is time-proportional with reheat-coil control feature, and displays a temperature set-point in Celsius and Fahrenheit.

2.1.7.8 Control Sequence

Make suitable for operation with duct pressures between 0.25 and 3.0-inch wg inlet static pressure. Provide factory-mounted and -piped, 5-micron filter; velocity-resetting, adjustable, high-limit control; and amplifying relay with a system-powered, wall-mounting thermostat.

2.1.8 High-Pressure Dual-Duct Mixing Boxes

Provide mechanical constant-volume control type units with a mechanical controller that is operated by the entering mixed-airstream and maintains a constant airflow through the unit.

Provide factory preset units to deliver air volumes indicated.

2.1.8.1 Construction

Provide factory assembled units, complete with casing, air mixing valve assembly, single air mixing valve operator, and mechanical constant-volume control, ready for field mounting and connection to control.

Verify casing exterior is not less than 0.040-inch thick aluminum, or 20 gage mill-galvanized steel with not less than 1.25 ounces of zinc per square foot of two-sided surface, conforming to ASTM A653/A653M.

Ensure casing interior is acoustically baffled and lined with fibrous glass thick enough to attain required sound power level performance and preclude condensation on any exterior surface, but in no case less than 1-inch. Verify air side of fibrous glass is chloroprene-impregnated and manufactured to resist delamination or surface erosion at air velocities to

4,000-feet per minute. Ensure liner edges exposed to airstream are protected by metal turnovers. Verify liner and fibrous-glass baffle material conforms to NFPA 90A.

Ensure inlet valves and connecting linkage are constructed for modulation by a single operator. Verify hot inlet valve is normally open, and the cold inlet valve is normally closed. Ensure hot and cold inlet ports are field reversible. Verify mechanical constant-volume control is externally adjustable and has a cubic feet-per-minute graduated capacity scale, which also indicates minimum/maximum range of the unit.

Ensure mechanical constant-volume control is externally adjustable. Provide a calibration chart with each unit indicating capacity per revolution of mechanical constant-volume device. Clearly label each unit with minimum/maximum volume range to facilitate field adjustment.

Ensure components subject to friction have oil-impregnated bronze bearings, graphite-impregnated nylon bearings, and lubricant-impregnated elastomers, corrosion-resistant steel, and similar materials.

Ensure casing is fitted with rigid, airtight access panels, easily removable and of ample size to give free access to interior parts. Verify closure is achieved by spring-retained, quarter-turn, slotted-cam captive devices, or similar operating fasteners.

Verify that all caulking compounds are chloroprene, polyurethane polysulfides, or silicone elastomers, with chloroprene, polyurethane, or vinyl gaskets.

2.1.8.2 Casing Leakage

Verify casing joints are sealed to prevent leakage of more than 2 percent of rated capacity with all connections sealed and with an internal static pressure of 1-inch wg.

2.1.8.3 Inlet Valve Leakage

Verify leakage in fully closed valve position does not exceed 2 percent of unit rated capacity against inlet pressure of 8-inches wg.

2.1.8.4 Mixed-Air Temperature Requirements

Verify that a thermometer traverse of all unit outlets shows variation of not more than 5 percent of the difference, at the time, between the temperatures of equal quantities of cold and warm airstreams entering the unit.

2.1.8.5 Volume Control Requirements

Verify mechanical constant-volume control maintains design volume within plus or minus 5 percent, regardless of the modulation position of inlet valves or the fluctuation of inlet or outlet pressure, within limits of indicated minimum pressure.

2.1.8.6 Sound Level Requirements

When determining equipment sound-power level performance and when no space-attenuation criteria are given, assume 18 dB space attenuation in all octave bands. Verify manufacturer's design incorporates sound correction factors for equipment.

Verify the scheduled airborne and radiated sound-power level (PWL) requirements, to attain the specified NC levels. Assume an 18 dB space attenuation in all octave bands with consideration given to downstream duct construction and configuration in determining airborne NC levels.

OCTAVE BAND	<u>2ND</u>	<u>3RD</u>	<u>4TH</u>	<u>5TH</u>	<u>6TH</u>	7TH
PWL-TL	-2	- 4	- 9	-10	-13	-15

NC40 is the limiting factor.

2.1.8.7 Control Requirements

Ensure operating-control power source is dry, compressed air of instrument quality at 15 psig, unless otherwise approved.

Provide for an air mixing valve operator from the automatic temperature control manufacturer, and installation by the unit manufacturer, unless field installation for specific construction is pre-approved by the Contracting Officer. Ensure operator is controlled by a direct-acting thermostat.

Provide copper pneumatic control tubing brought to the exterior of the casing for connection to automatic temperature control system.

2.1.9 Low-Pressure Dual-Duct Mixing Boxes

Provide manual-damper volume control type units. Provide a calibration chart with each unit. Label each unit with capacity minimum/maximum range to facilitate field adjustment.

Verify volume control damper is externally adjustable over an inlet pressure range of 0.05 to 1-inch wg.

Ensure components subject to friction have oil-impregnated bronze bearings, graphite-impregnated nylon bearings, and lubricant-impregnated elastomers, corrosion-resistant steel, and similar materials.

Ensure casings are fitted with rigid, airtight access panels, easily removable, and of ample size to give free access to interior parts. Provide closure mechanism which is achieved by spring-retained, quarter-turn, slotted-cam captive devices or similar operating fasteners.

Provide caulking compounds which are chloroprene, polyurethane polysulfides, or silicone elastomers. Provide chloroprene, polyurethane, or vinyl gaskets.

2.1.9.1 Casing Leakage

Seal all casing joints to prevent leakage of more than 2 percent of rated capacity, with all connections sealed and with an internal static pressure of 1-inch wg.

2.1.9.2 Inlet Valve Leakage

Leakage in fully closed valve position is not to exceed 2 percent of unit rated capacity against inlet pressure of 1 inch wg.

2.1.9.3 Mixed-Air Temperature Requirements

Ensure a thermometer traverse of all unit outlets shows variation of not more than 5 percent of the difference, at the time, between the temperatures of equal quantities of cold and warm airstreams entering the unit.

2.1.9.4 Sound Level Requirements

When determining equipment sound power level performance when no space-attenuation criteria are given, assume 18 dB space attenuation in all octave bands. Verify manufacturer designs incorporates sound correction factors for equipment.

2.1.9.5 Control Requirements

Ensure operating-control power source is dry, compressed air of instrument quality at 15 psig, unless otherwise approved.

Provide an air mixing valve operator from the automatic temperature control manufacturer and install using the unit manufacturer, unless field installation for specific construction is pre-approved by the Contracting Officer. Ensure operator is controlled by a direct-acting thermostat.

Provide copper pneumatic control tubing brought to the exterior of the casing for connection to the automatic temperature control system.

PART 3 EXECUTION

3.1 INSTALLATION

Install air terminal units level and plumb, and in accordance with NFPA 90A. Maintain sufficient clearance for normal service and maintenance.

3.1.1 Identification

Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

3.1.2 Connections

Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems.

Install piping adjacent to air terminal units to allow service and maintenance.

3.1.2.1 Hot-Water Piping

Connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

Connect ducts to air terminal units.

Ground units with electric heating coils.

Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are

not indicated, use those specified in UL 486A-486B.

3.2 FIELD QUALITY CONTROL

Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections, and to assist in field testing.

Perform the following field tests and inspections and prepare a test report.

After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.

3.2.1 Leak Test

After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

3.2.2 Operational Test

After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Remove and replace malfunctioning units and retest.

3.3 SYSTEM STARTUP

Engage a factory-authorized service representative to perform startup service.

Complete installation and startup checks according to manufacturer's written instructions and do the following:

- a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
- b. Verify that controls and control enclosure are accessible.
- c. Verify that control connections are complete.
- d. Verify that nameplate and identification tag are visible.
- e. Verify that controls respond to inputs as specified.
- 3.4 CLOSEOUT ACTIVITIES

3.4.1 Operation and Maintenance

Submit 6 copies of the operation and maintenance manuals 30 calendar days prior to testing the following items. Update and re-submit data for final approval no later than 30 calendar days prior to contract completion. Concurrently, submit record drawings providing current factual information, including deviations and amendments to the drawings, and concealed and visible changes in the work.

3.4.2 Demonstration

Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

-- End of Section --

SECTION 23 37 13.00 40

DIFFUSERS, REGISTERS, AND GRILLES 05/15

PART 1 GENERAL

1.1 REFERENCES

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

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

ASHRAE 113		(2013) Method of Testing for Room Air Diffusion
ASHRAE EQUIP IP	HDBK	(2012) Handbook, HVAC Systems and Equipment (IP Edition)
ASHRAE FUN IP		(2017) Fundamentals Handbook, I-P Edition

1.2 ADMINISTRATIVE REQUIREMENTS

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

1.3 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. 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

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.

2.2 COMPONENTS

2.2.1 Air Diffusion Device Construction

Preclude flutter, rattle, or vibration on air-diffusion device construction and mounting. 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.

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 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 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 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, perforated, hinged, face plate with opposed blade volume control, white baked enamel exterior finish, and black matte finish on exposed-to-view interior surface.

Provide one-way deflection.

Provide two-way opposed deflection.

Provide two-way diagonal deflection.

Provide three-way deflection.

Provide four-way deflection.

2.2.2.7 Type DLB

Provide type DLB supply diffuser, linear bar type, frame mounted, with extruded-aluminum bar and frame.

For floor- and sill-mounted diffusers provide heavy-duty reinforced construction to carry loads of not less than pounds per square foot.

Provide continuous length diffuser with hairline butt joints.

Provide mitered end caps where diffuser run terminates.

Provide opposed-blade type dampers.

Provide an integral, pivoted, bar-type access door where indicated.

Provide straightening grids where indicated.

2.2.2.8 Type DLS

Provide type DLS supply diffuser, linear slot type, extruded aluminum construction, with fully adjustable integral air pattern and volume control vanes that deflect air pattern from horizontal along ceiling to straight down. Ensure any intermediate setting and a pattern control element that permits complete blanking-off of slot.

Slot width: 3/4 inch.

Provide number of slots per unit run as indicated.

Align butts in continuous runs for hairline joints.

Butt ends of diffuser against walls without mitered end caps. Provide end caps where slot terminates.

Provide exposed-to-view part of frame with anodized aluminum, and all interior exposed-to-view components with a black matte finish.

2.2.2.9 Type DSA

Provide type DSA supply diffuser, square with four expanding flared members to provide radially diffused discharge air. Arrange flared members to provide a minimum of four air paths which simultaneously diffuse air at 20 to 50 fpm. Include pattern adjustments horizontal, vertical projection, and an intermediate position or range.

Provide a baked enamel finish.

Provide aluminum construction.

Provide antismudge rings.

Provide integral extended surface to fit into module of lay-in ceiling.

2.2.2.10 Type GS

Provide type GS supply grilles double deflection type with adjustable face bars parallel to short dimension and adjustable rear bars parallel to long dimension.

Provide a baked enamel finish.

Provide aluminum construction.

Provide antismudge rings.

Provide integral extended surface to fit into module of lay-in ceiling.

2.2.2.11 Type GR

Provide type GR return grilles, single deflection type with fixed face bars.

Provide grilles installed in vertical surfaces with horizontal face bars set downward at 35 degrees from vertical.

Provide grilles installed in horizontal surfaces with face bars straight and parallel to short dimension.

Provide a baked enamel finish.

Provide aluminum construction.

Provide antismudge rings.

Provide integral extended surface to fit into module of lay-in ceiling.

2.2.2.12 Type GCA

Provide type GCA with an individually adjustable, horizontal, curved-blade grilles and a one-way pattern.

Provide a baked enamel finish.

Provide aluminum construction.

2.2.2.13 Type GCB

Provide type GCB with an individually adjustable, vertical, curved-blade grilles and a one-way pattern.

Provide a baked enamel finish.

Provide aluminum construction.

2.2.2.14 Type GCD

Provide type GCD with an individually adjustable, vertical, curved-blade grilles and a two-way pattern.

Provide a baked enamel finish.

Provide aluminum construction.

2.2.2.15 Type GCE

Provide type GCE with an individually adjustable, vertical and horizontal, curved-blade grilles and a three-way pattern.

Provide a baked enamel finish.

Provide aluminum construction.

2.2.2.16 Type GCF

Provide type GCF with an individually adjustable, vertical and horizontal, curved-blade grilles and a four-way pattern.

Provide a baked enamel finish.

Provide aluminum construction.

2.2.2.17 Type RS

Provide type RS supply register, double-deflection type, with adjustable face bars parallel to short dimension and adjustable rear bars parallel to long dimension with opposed-blade type dampers.

Provide a baked enamel finish.

Provide aluminum construction.

Provide integral extended surface to fit into module of lay-in ceiling.

2.2.2.18 Type RR

Provide type RR return register, single-deflection type with fixed face bars with opposed-blade dampers.

Provide registers installed in vertical surfaces with horizontal face bars set downward at approximately 35 degrees from vertical.

Provide registers installed in horizontal surfaces with face bars set straight and parallel to short dimension.

Provide a baked enamel finish.

2.2.2.19 Type RCA

Provide type RCA with an individually adjustable, horizontal, curved-blade register and a one-way pattern with opposed-blade damper.

Provide a baked enamel finish.

Provide aluminum construction.

2.2.2.20 Type RCB

Provide type RCB with individually adjustable, vertical, curved-blade register and a one-way pattern with opposed blade damper.

Provide a baked enamel finish.

Provide aluminum construction.

2.2.2.21 Type RCC

Provide type RCC with an individually adjustable, horizontal, curved-blade register and a two-way pattern with opposed blade damper.

Provide a baked enamel finish.

Provide aluminum construction.

2.2.2.22 Type RCD

Provide type RCD with an individually adjustable, vertical, curved-blade register and a two-way pattern with opposed blade damper.

Provide a baked enamel finish.

Provide aluminum construction.

2.2.2.23 Type RCE

Provide type RCE with an individually adjustable, vertical and horizontal, curved-blade register and a three-way pattern with opposed-blade damper.

Provide a baked enamel finish.

Provide aluminum construction.

2.2.2.24 Type RCF

Provide type RCF with an individually adjustable, vertical and horizontal, curved-blade register and a four-way pattern with opposed-blade damper.

Provide a baked enamel finish.

Provide aluminum construction.

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 00

HEATING BOILERS 04/08, CHG 5: 11/19

PART 1 GENERAL

1.1 REFERENCES

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

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

AMCA 801 (2001; R 2008) Industrial Process/Power Generation Fans: Specification Guidelines

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	B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME	B16.3	(2016) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME	B16.4	(2016) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME	B16.5	(2017) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME	B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME	B16.11	(2016) Forged Fittings, Socket-Welding and Threaded
ASME	B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME	B16.18	(2018) Cast Copper Alloy Solder Joint Pressure Fittings
ASME	B16.20	(2017) Metallic 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 (2017) 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 B31.5 (2020) Refrigeration Piping and Heat Transfer Components
- ASME B40.100 (2013) Pressure Gauges and Gauge Attachments
- ASME BPVC SEC IV (2017) BPVC Section IV-Rules for Construction of Heating Boilers
- ASME BPVC SEC IX (2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
- ASME BPVC SEC VIII D1 (2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
- ASME CSD-1 (2016) Control and Safety Devices for Automatically Fired Boilers

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606 (2015) Grooved and Shouldered Joints AMERICAN WELDING SOCIETY (AWS) AWS A5.8/A5.8M (2019) Specification for Filler Metals for Brazing and Braze Welding AWS B2.2/B2.2M (2016) Specification for Brazing Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2020) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A105/A105M	(2018) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A183	(2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts

ASTM	A193/A193M	(2020) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM	A234/A234M	(2019) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM	A515/A515M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM	A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM	A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
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	B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM	B813	(2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM	B828	(2016) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM	C27	(1998; R 2008) Fireclay and High-Alumina Refractory Brick
ASTM	C34	(2017) Standard Specification for Structural Clay Loadbearing Wall Tile
ASTM	C155	(1997; R 2013) Standard Specification for Insulating Firebrick
ASTM	C401	(2012) Alumina and Alumina-Silicate Castable Refractories

ASTM D596 (2001; R 2018) Standard Guide for Reporting Results of Analysis of Water ASTM D1784 (2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds ASTM D2000 (2018) Standard Classification System for Rubber Products in Automotive Applications ASTM F1097 (2017) Standard Specification for Mortar, Refractory (High-Temperature, Air-Setting) ASTM F1139 (1988; R 2019) Steam Traps and Drains COMPRESSED AIR AND GAS INSTITUTE (CAGI) CAGI B19.1 (2010) Safety Standard for Compressor Systems COPPER DEVELOPMENT ASSOCIATION (CDA) CDA A4015 (2016; 14/17) Copper Tube Handbook EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA) (2015) (10th Ed) EJMA Standards EJMA Stds HYDRONICS INSTITUTE DIVISION OF AHRI (HYI) HYI-005 (2008) I=B=R Ratings for Boilers, Baseboard Radiation and Finned Tube (Commercial) MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS) MSS SP-25 (2018) Standard Marking System for Valves, Fittings, Flanges and Unions MSS SP-58 (2018) Pipe Hangers and Supports -Materials, Design and Manufacture, Selection, Application, and Installation MSS SP-70 (2011) Gray Iron Gate Valves, Flanged and Threaded Ends (2018) Gray Iron Swing Check Valves, MSS SP-71 Flanged and Threaded Ends (2011) Cast Iron Plug Valves, Flanged and MSS SP-78 Threaded Ends MSS SP-80 (2019) Bronze Gate, Globe, Angle and Check Valves MSS SP-85 (2011) Gray Iron Globe & Angle Valves

LEE CDC (BUILDING 140)

Flanged and Threaded Ends

221241

MSS SP-110 (2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA) NEMA 250 (2018) Enclosures for Electrical Equipment (1000 Volts Maximum) NEMA MG 1 (2018) Motors and Generators NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) (2020) Standard for the Installation of NFPA 31 Oil-Burning Equipment (2021) National Fuel Gas Code NFPA 54 U.S. DEPARTMENT OF ENERGY (DOE) (1992; R 2006) Energy Star Energy Energy Star Efficiency Labeling System (FEMP) UNDERWRITERS LABORATORIES (UL) UL 726 (1995; Reprint Oct 2013) Oil-Fired Boiler Assemblies UL 1738 (2010; Reprint Feb 2020) Venting Systems for Gas-Burning Appliances, Categories II, III and IV UL FLAMMABLE & COMBUSTIBLE (2012) Flammable and Combustible Liquids and Gases Equipment Directory 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

classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings
Detail Drawings
SD-03 Product Data
Materials and Equipment; G
Spare Parts
Water Treatment System
Boiler Water Treatment
Heating System Tests

Fuel System Tests

Welding

Qualifications

Field Instructions

Tests

SD-06 Test Reports

Heating System Tests; G.

Fuel System Tests;G

SD-07 Certificates

Bolts

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions; G

Water Treatment System; G

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

1.3 QUALITY ASSURANCE

Submit a copy of qualified welding procedures and a list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations. Boilers and piping shall be welded and brazed in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests, and the tests shall be performed at the work site if practical. The welder or welding operator shall apply the personally assigned symbol near each weld made as a permanent record.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings and no later than 2 months prior to the date of beneficial occupancy. Submit Detail Drawings consisting of equipment layout including installation details and

electrical connection diagrams; combustion and safety control diagrams; ductwork layout showing the location of supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of guides and anchors, the load imposed on each support or anchor (not required for radiant floor tubing), and typical support details. Include on the drawings any information required to demonstrate that the system has been coordinated and will properly function as a unit and to show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Include in the data a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 years of service.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Submit manufacturer's catalog data included with the detail drawings for the following:

- a. Radiant floor heating system including tubing, joints, and manifold for radiant floor heating systems.
- b. Data showing model, size, options, etc., that are intended for consideration. Data submitted shall be adequate to demonstrate compliance with contract requirements. Data shall include manufacturer's written installation instructions and manufacturer's recommendations for operation and maintenance clearances for the following:
 - (1) Boilers
 - (2) Unit Heaters
 - (3) Fuel Burning Equipment
 - (4) Combustion Control Equipment
 - (5) Pumps
 - (6) Fittings and Accessories
 - (7) Fuel Oil Storage System
 - (8) Water Treatment System

2.1.2 Asbestos Prohibition

Asbestos and asbestos-containing products will not be allowed.

2.1.3 Nameplates

Secure a plate to each major component of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number. Also, display an Energy Star label as applicable. Each pressure vessel shall have an approved ASME stamp.

2.1.4 Equipment Guards

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded in accordance with OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. Catwalks, operating platforms, ladders, and guardrails shall be provided where shown and shall be constructed in accordance with Section .

2.2 BOILERS

Each boiler shall have the output capacity in British thermal units per hour (Btuh) as indicated when fired with the specified fuels. The boiler shall be furnished complete with the gas burning equipment, boiler fittings and trim, automatic controls, forced draft fan, electrical wiring, insulation, piping connections, and protective jacket. The boiler shall be completely assembled and tested at the manufacturer's plant. Boiler auxiliaries including fans, motors, drives, and similar equipment shall be provided with at least 10 percent excess capacity to allow for field variations in settings and to compensate for any unforeseen increases in pressure losses in appurtenant piping and ductwork. However, the boiler safety devices shall not be sized for a 10 percent excess capacity. The boiler and its accessories shall be designed and installed to permit ready accessibility for operation, maintenance, and service. Boilers shall be designed, constructed, and equipped in accordance with ASME BPVC SEC IV. Each boiler shall be of the condensing type and designed for water service as specified herein. The boiler capacity shall be based on the ratings shown in HYI-005 or as certified by the American Boiler Manufacturers Association, or American Gas Association.

2.2.1 Firetube Boiler

Boiler shall be self-contained, multipass, packaged type, complete with all accessories, mounted on a structural steel base. When the boilers are operating at maximum output, the heat input rates shall not be greater than 6,700 Btuh per square ft of fireside heating surface.

2.2.2 Watertube Boiler

The boiler shall be a standard type of water tube boiler. Boiler shall be self-contained, packaged type, complete with all accessories, mounted on a structural steel base. The boiler heating surface area for bent or flexible tube boilers shall be at least 4 square feet/boiler horse power. Bent or flexible tube boilers shall be provided with single or multiple downcomers for circulation without the need for exterior pumping. The tubes for bent or flexible tube boilers shall be designed for replacement without requiring welding or rolling of tubes. Any special tools required for bent or flexible tube removal or installation shall be provided with the boiler.

2.2.3 Condensing Boiler

Each boiler shall be a self-contained packaged type, complete with accessories, mounted on a structural steel base or a steel base which is integral to the boiler shell. Each boiler shall conform to the commercial design used by the manufacturer and shall permit free thermal expansion without placing undue stress on any part of the boiler. Each boiler which

experiences the formation of condensate within the flue gas shall be specifically designed for condensing application. Each boiler shall withstand the corrosive effects of condensate for each part which may be in contact with the condensate at all possible operating conditions. Each boiler shall be provided with a separate air intake, exhaust, and condensate drain. Each boiler shall be designed to withstand the water temperature differentials anticipated at the required operating conditions without experiencing any damage due to thermal shock.

2.2.4 Modular Configuration

Modular boilers shall be of the condensing type. Modular boilers shall have the capability of independent operation. Upon failure of any module, the remaining modules shall be capable of operating at their designed capacity. The size of the individual modules shall be as indicated.

2.2.5 Hot Water Heating Boilers

The hot water heating boiler shall be capable of operating at the specified maximum continuous capacity without damage or deterioration to the boiler, its setting, firing equipment, or auxiliaries. The rated capacity shall be the capacity at which the boiler will operate continuously while maintaining at least the specified minimum efficiency.

2.3 FUEL BURNING EQUIPMENT

Boiler shall be designed to burn gas . Each boiler shall comply with Federal, state, and local emission regulations.

- 2.3.1 Burners
- 2.3.1.1 Gas and Combination Gas-Oil Fired Burners and Controls

Burners shall be UL approved

2.3.1.2 Oil-Fired Burners and Controls

Oil-fired burners and controls for oil-fired units firing oil shall be atomizing, forced-draft type in conformance with UL 726. Oil-fired units less than 12,500,000 Btuh input shall conform to ASME CSD-1.

2.3.2 Draft Fans

Fans conforming to AMCA 801 forced-draft shall be furnished as an integral part of boiler design. Fans shall be centrifugal with backward-curved blades or axial flow type. Each fan shall be sized for output volume and static pressure rating sufficient for pressure losses, excess air requirements at the burner, leakages, temperature, and elevation corrections for worst ambient conditions, all at full combustion to meet net-rated output at normal firing conditions, plus an overall excess air volume of 10 percent against a 20 percent static overpressure. Noise levels for fans shall not exceed 85 decibels in any octave band at a 3 foot station. Forced draft fan bearings shall be air cooled.

2.3.2.1 Draft Fan Control

Forced-draft centrifugal fans shall have inlet vane controls or shall have variable speed control where indicated. Inlet vanes shall be suitable for use with combustion control equipment. Axial propeller fans shall have

variable propeller pitch control.

2.3.2.2 Draft Fan Drives

Fans shall be driven by electric motors. Electric motor shall be drip proof . Motor starter shall be magnetic across-the-line type with general purpose enclosure and shall be furnished with four auxiliary interlock contacts.

2.3.3 Draft Damper

Boilers shall be provided with manual dampers, draft hoods, or barometric dampers as recommended by the boiler manufacturer to maintain proper draft in the boiler. Draft damper shall be provided in a convenient and accessible location in the flue gas outlet from the boiler. Automatic damper shall be arranged for automatic operation by means of a damper regulator .

2.3.4 Ductwork

Air ducts connecting the forced-draft fan units with the plenum chamber shall be designed to convey air with a minimum of pressure loss due to friction. Ductwork shall be galvanized sheet metal conforming to ASTM A653/A653M. Ducts shall be straight and smooth on the inside with laps made in direction of air flow. Ducts shall have cross-break with enough center height to assure rigidity in the duct section, shall be angle iron braced, and shall be completely free of vibration. Access and inspection doors shall be provided as indicated and required, with a minimum of one in each section between dampers or items of equipment. Ducts shall be constructed with long radius elbows having a centerline radius 1-1/2 times the duct width, or where the space does not permit the use of long radius elbows, short radius or square elbows with factory-fabricated turning vanes may be used. Duct joints shall be substantially airtight and shall have adequate strength for the service, with $1-1/2 \ge 1/8$ inch angles used where required for strength or rigidity. Duct wall thickness shall be 16 gauge (0.0598 inch) for ducts 60 inches or less and 12 gauge (0.1046 inch) for ducts larger than 60 inches in maximum dimension. Additional ductwork shall be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.4 COMBUSTION CONTROL EQUIPMENT

Combustion control equipment shall be provided as a system by a single manufacturer. Field installed automatic combustion control system shall be installed in accordance with the manufacturer's recommendations and under the direct supervision of a representative of the control manufacturer. The boiler water temperature shall be controlled by a water temperature controller. The equipment shall operate electronically . On multiple boiler installations, each boiler unit shall have a completely independent system of controls responding to the load and to a plant master controller. If recording instruments are provided, a 1 year supply of ink and 400 blank charts for each recorder shall be furnished.

2.4.1 Pneumatic Controls

If pneumatic operation is provided, a regenerant desiccant air dryer unit shall be provided. Boiler shall shut down on loss of control air pressure. Pneumatic control systems shall conform to CAGI B19.1. Air filter regulator sets shall be installed at each control valve and transmitter in the system. The master air filter regulator set on the control panel shall be the dual type where one side can be cleaned and repaired while the other is operating. Exterior control air piping and devices shall be protected from freezing.

2.4.1.1 Air Compressor Unit

The air compressor unit shall be electric-motor driven, polytetrafluoroethylene or carbon ring type automatic air compressor. The compressor unit shall be sized to run not more than 60 percent of the time when all controls are in service. The air compressor unit shall be complete with necessary accessories including automatic pressure control equipment, relief valves, check valves, air filters, moisture traps, and a receiver with ample capacity for emergency operation of the controls for 15 minutes after compressor shutdown. Compressor speed shall not exceed 900 rpm. Motor speed shall not exceed 1750 rpm. The compressor air intake shall be provided with a low drop type air suction filter/silencer suitable for outdoor installation.

2.4.1.2 Air Receiver

The air receiver shall be constructed in accordance with ASME BPVC SEC VIII D1for unfired pressure vessels for 200 psi working pressure, and shall be equipped with inlet and outlet connections, valved drain connection, minimum 6 inch dial pressure gauge, pop safety valves, and regulator connections.

2.4.2 Electrical controls

Electrical control devices shall be rated at 120 volts and shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.4.3 Water Temperature Controller

The controller shall be of sturdy construction and shall be protected against dust and dampness. The thermostatic element shall be inserted in a separable socket installed in the upper part of the boiler near the water outlet . Modulating controllers shall control the fuel burning equipment to maintain set boiler water temperature within 2 percent.

2.5 PUMPS

2.5.1 Hot Water and Boiler Circulating Pumps

Circulating pumps for hot water shall be electrically driven single-stage centrifugal type and have a capacity not less than indicated. Boiler circulating pumps shall be supported on a concrete foundation with a cast iron or structural steel base and shall be closed-coupled shaft . The boiler circulating pumps shall be vertical split case type. Hot water circulating pumps shall be supported by the piping on which installed and shall have a flexible-coupled shaft. The hot water circulating pumps shall be vertical split case type. The pump shaft shall be constructed of corrosion-resistant alloy steel, sleeve bearings and glands of bronze designed to accommodate a mechanical seal, and the housing of close-grained cast iron. Pump seals shall be capable of withstanding 240 degrees F temperature without external cooling. The motor shall have sufficient power for the service required, shall be of a type approved by the manufacturer of the pump, shall be suitable for the available electric service, and shall conform to the requirements of paragraph ELECTRICAL EQUIPMENT. Each pump suction and discharge connection shall be provided with a pressure gauge as specified. The boiler circulating pump discharge heater shall be provided with a flow switch . Flow switch unit shall be a self-contained swinging vane type to indicate fluid flow. Pressure switch unit shall be a self-contained snap action type to indicate fluid pressure. Switch shall be a SPDT with 120-volt, 15-ampere rating.

2.6 FITTINGS AND ACCESSORIES

Boiler fittings and accessories shall be installed with each boiler in accordance with ASME BPVC SEC IV, unless otherwise specified.

2.6.1 Direct Vents

Direct venting shall be used for condensing type boilers. Both the air intake and exhaust vents shall be sized and located as indicated on the drawings and as recommended by the boiler manufacturer. A separate combustion air intake vent and exhaust vent shall be provided for each boiler.

2.6.1.1 Combustion Air Intake Vent

The combustion air intake piping shall be constructed of Schedule 40 PVC in accordance with ASTM D1784. The vent shall be suitable for the temperature at the boiler combustion air intake connection point. Each intake shall be provided complete with bird screen.

2.6.1.2 Exhaust Vent

The exhaust vent piping shall be constructed of Schedule 40 CPVC or stainless steel conforming to UL 1738 and the boiler manufacturer's recommendations. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. The exhaust vent shall be suitable for the maximum anticipated boiler exhaust temperature and shall withstand the corrosive effects of the condensate. A 0.3125 inch diameter hole shall be provided in the stack not greater than 6 inches from the boiler flue outlet for sampling of the exit gases. A method shall be provided to seal the hole to prevent exhaust gases from entering the boiler room when samples are not being taken. Each exhaust stack shall be provided complete with bird screen.

2.6.2 Expansion Tank

The hot water pressurization system shall include a diaphragm-type expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The only air in the system shall be the permanent sealed-in air cushion contained in the diaphragm-type tank. The sizes shall be as indicated. The expansion tank shall be welded steel, constructed, tested, and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 125 psi and precharged to the minimum operating pressure. The tank's air chamber shall be fitted with an air charging valve and pressure gauge. The tank shall be supported by steel legs or bases for vertical installation or steel saddles for horizontal installations. The tank shall have lifting rings and a drain connection. All components shall be suitable for a maximum operating temperature of 250 degrees F.

2.6.3 Air Separator

External air separation tank shall be steel, constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of 125 psi. The capacity of the air separation tank indicated is minimum.

2.6.4 Filters

Filters shall conform to ASHRAE 52.2.

- 2.6.5 Foundation (Setting) Materials
- 2.6.5.1 Firebrick

Firebrick shall be ASTM C27 class as recommended by boiler manufacturer.

2.6.5.2 Tile

Tile shall be ASTM C34, Grade LBX.

2.6.5.3 Insulating Brick

Insulating brick shall comply with ASTM C155.

2.6.5.4 Refractory Mortar

Refractory mortar shall comply with ASTM F1097.

2.6.5.5 Castable Refractories

Castable refractories shall be ASTM C401. The minimum modulus of rupture for transverse strength shall be not less than 600 psi after being heat soaked for 5 hours or more at a temperature in excess of 2500 degrees F.

- 2.6.6 Steel Sheets
- 2.6.6.1 Galvanized Steel

Galvanized steel shall be ASTM A653/A653M.

2.6.6.2 Uncoated Steel

Uncoated steel shall be composition, condition, and finish best suited to the intended use.

2.6.7 Gaskets

Gaskets shall be nonasbestos material in accordance with ASME B16.20, full face or self-centering type. The gaskets shall be of the spiral wound type with graphite filler material.

2.6.8 Steel Pipe and Fittings

2.6.8.1 Steel Pipe

Steel pipe shall be ASTM A53/A53M, Type E or S, Grade A or B, black steel, standard weight.

2.6.8.2 Steel Pipe Fittings

Fittings shall have the manufacturer's trademark affixed in accordance with MSS SP-25 so as to permanently identify the manufacturer.

2.6.8.3 Steel Flanges

Flanged fittings including flanges, bolts, nuts, bolt patterns, etc. shall be in accordance with ASME B16.5 class 150 and shall have the manufacturer's trademark affixed in accordance with MSS SP-25. Flange material shall conform to ASTM A105/A105M. Flanges for high temperature water systems shall be serrated or raised-face type. Blind flange material shall conform to ASTM A516/A516M cold service and ASTM A515/A515M for hot service. Bolts shall be high strength or intermediate strength with material conforming to ASTM A193/A193M. Submit written certification by the bolt manufacturer that the bolts furnished comply with the requirements of this specification. The certification shall include illustrations of product markings, the date of manufacture, and the number of each type of bolt to be furnished based on this certification.

2.6.8.4 Welded Fittings

Welded fittings shall conform to ASTM A234/A234M with WPA marking. Buttwelded fittings shall conform to ASME B16.9, and socket-welded fittings shall conform to ASME B16.11.

2.6.8.5 Cast-Iron Fittings

Fittings shall be ASME B16.4, Class 125, type required to match connecting piping.

2.6.8.6 Malleable-Iron Fittings

Fittings shall be ASME B16.3, type as required to match connecting piping.

2.6.8.7 Unions

Unions shall be ASME B16.39, Class 150.

2.6.8.8 Threads

Pipe threads shall conform to ASME B1.20.1.

2.6.8.9 Grooved Mechanical fittings

Joints and fittings shall be designed for not less than 125 psig service and shall be the product of the same manufacturer. Fitting and coupling houses shall be ductile iron conforming to ASTM A536. Gaskets shall be molded synthetic rubber with central cavity, pressure responsive configuration and shall conform to ASTM D2000 for circulating medium up to 230 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A183.

- 2.6.9 Copper Tubing and Fittings
- 2.6.9.1 Copper Tubing

Tubing shall be ASTM B88, Type K or L. Adapters for copper tubing shall be brass or bronze for brazed fittings.

2.6.9.2 Solder-Joint Pressure Fittings

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B75/B75M. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18 and ASTM B828.

2.6.9.3 Flared Fittings

Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B62.

2.6.9.4 Adapters

Adapters may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

2.6.9.5 Threaded Fittings

Cast bronze threaded fittings shall conform to ASME B16.15.

2.6.9.6 Brazing Material

Brazing material shall conform to AWS A5.8/A5.8M.

2.6.9.7 Brazing Flux

Flux shall be in paste or liquid form appropriate for use with brazing material. Flux shall be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides, and contain fluorides. Silver brazing materials shall be in accordance with AWS A5.8/A5.8M.

2.6.9.8 Solder Material

Solder metal shall conform to ASTM B32 95-5 tin-antimony.

2.6.9.9 Solder Flux

Flux shall be either liquid or paste form, non-corrosive and conform to ASTM B813.

2.6.9.10 Grooved Mechanical Fittings

Joints and fittings shall be designed for not less than 125 psig service and shall be the product of the same manufacturer. Fitting and coupling houses shall be ductile iron conforming to ASTM A536. Gaskets shall be molded synthetic rubber with central cavity, pressure responsible configuration and shall conform to ASTM D2000, for circulating medium up to 230 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A183.

2.6.10 Dielectric Waterways and Flanges

Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall include dielectric unions to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

2.6.11 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 125 psi or 150 psi service. Connectors shall be installed where indicated. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. Materials used and the configuration shall be suitable for the pressure, vacuum, and temperature medium. The flexible section shall be suitable for service intended and may have threaded, welded, soldered, flanged, or socket ends. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Covers to protect the bellows shall be provided where indicated.

2.6.12 Pipe Supports

Pipe supports shall conform to MSS SP-58.

- 2.6.13 Pipe Expansion
- 2.6.13.1 Expansion Loops

Expansion loops and offsets shall provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. The loops and offsets shall be cold-sprung and installed where indicated. Pipe guides and anchors shall be provided as indicated.

2.6.13.2 Expansion Joints

Expansion joints shall provide for either single or double slip of the connected pipes, as required or indicated, and for not less than the transverse indicated. The joints shall be designed for a hot water working pressure not less than psig and shall be in accordance with applicable requirements of EJMA Stds and ASME B31.1. End connection shall be flanged. Anchor bases or support bases shall be provided as indicated or required. Sliding surfaces and water wetted surfaces shall be chromium plated or fabricated of corrosion resistant steel. Initial setting shall be made in accordance with the manufacturer's recommendations to compensate for an ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer, but in any case shall not be more than 5 feet from expansion joint, except in lines 4 inches or smaller guides shall be installed not more than 2 feet from the joint. Service outlets shall be provided where indicated.

2.6.13.2.1 Bellows-Type joint

Bellows-type joints shall be flexible, guided expansion joints. The expansion element shall be stabilized corrosion resistant steel. Bellows-type expansion joints shall conform to the applicable requirements of EJMA Stds and ASME B31.1 with internal lines. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint. The joints shall be designed for the working temperature and pressure suitable for the application but shall not be less than 150 psig.

2.6.13.2.2 Flexible Ball Joint

Flexible ball joints shall be constructed of alloys as appropriate for the service intended. The joints shall be threaded, grooved, flanged, or welded end as required and shall be capable of absorbing the normal operating axial, lateral, or angular movements or combination thereof. Balls and sockets shall be polished, chromium-plated when materials are not of corrosion-resistant steel. The ball type joint shall be designed and constructed in accordance with ASME B31.1 and EJMA Stds. Flanges shall conform to the diameter and drilling of ASME B16.5. Molded gaskets shall be suitable for the service intended.

2.6.13.2.3 Slip Type Expansion Joint

Slip type expansion joints shall be EJMA Stds and ASME B31.1, Class 1 or 2. Type II joints shall be suitable for repacking under full line pressure.

2.6.14 Valves

Valves shall be Class 125 and shall be suitable for the application. Grooved ends in accordance with AWWA C606 may be used for water service only. Valves in nonboiler external piping shall meet the material, fabrication and operating requirements of ASME B31.1. The connection type of all valves shall match the same type of connection required for the piping on which installed.

2.6.14.1 Gate Valves

Gate valves 2-1/2 inches and smaller shall conform to MSS SP-80 bronze rising stem, threaded, solder, or flanged ends. Gate valves 3 inches and larger shall conform to MSS SP-70 cast iron bronze trim, outside screw and yoke, flanged, or threaded ends.

2.6.14.2 Globe Valves

Globe valves 2-1/2 inches and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Globe valves 3 inches and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

2.6.14.3 Check Valves

Check valves 2-1/2 inches and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Check valves 3 inches and larger shall conform to MSS SP-71, cast iron, bronze trim, flanged, or threaded ends.

2.6.14.4 Angle Valves

Angle valves 2-1/2 inches and smaller shall conform to MSS SP-80 bronze, threaded, soldered, or flanged ends. Angle valves 3 inches and larger shall conform to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

2.6.14.5 Ball Valves

Ball valves 1/2 inch and larger shall conform to MSS SP-110, ductile iron or bronze, threaded, soldered, or flanged ends.

2.6.14.6 Plug Valves

Plug valves 2 inch and larger shall conform to MSS SP-78. Plug valves smaller than 2 inch shall conform to ASME B16.34.

2.6.14.7 Grooved End Valves

Valves with grooved ends in accordance with AWWA C606 may be used if the valve manufacturer certifies that their performance meets the requirements of the standards indicated for each type of valve.

2.6.14.8 Balancing Valves

Balancing valves shall have meter connections with positive shutoff valves. An integral pointer shall register the degree of valve opening. Valves shall be calibrated so that flow rate can be determined when valve opening in degrees and pressure differential across valve is known. Each balancing valve shall be constructed with internal seals to prevent leakage and shall be supplied with preformed insulation. Valves shall be suitable for 250 degrees F temperature and working pressure of the pipe in which installed. Valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential. One portable differential meter shall be furnished. The meter suitable for the operating pressure specified shall be complete with hoses, vent, and shutoff valves, and carrying case. In lieu of the balancing valve with integral metering connections, a ball valve or plug valve with a separately installed orifice plate or venturi tube may be used for balancing.

2.6.14.9 Automatic Flow Control Valves

In lieu of the specified balancing valves, automatic flow control valves may be provided to maintain constant flow and shall be designed to be sensitive to pressure differential across the valve to provide the required opening. Valves shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Valves shall control the flow within 5 percent of the tag rating. Valves shall be suitable for the maximum operating pressure of 125 psi or 150 percent of the system operating pressure, whichever is greater. Where the available system pressure is not adequate to provide the minimum pressure differential that still allows flow control, the system pump head capability shall be increased. Valves shall be suitable for 250 degrees F temperature service. Valve materials shall be same as specified for the heating system check, globe, angle, and gate valves. Valve operator shall be the electric motor type or pneumatic type as applicable. Valve operator shall be capable of positive shutoff against the system pump head. Valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential across the automatic flow control valve. A portable meter shall be provided with accessory kit as recommended for the project by the automatic valve manufacturer.

2.6.14.10 Butterfly Valves

Butterfly valves shall be 2-flange type or lug wafer type, and shall be bubbletight at 150 psig. Valve bodies shall be cast iron, malleable iron, or steel. ASTM A167, Type 404 or Type 316, corrosion resisting steel stems, bronze, or corrosion resisting steel discs, and synthetic rubber seats shall be provided. Valves smaller than 8 inches shall have throttling handles with a minimum of seven locking positions. Valves 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Valves in insulated lines shall have extended neck to accommodate insulation thickness.

2.6.14.11 Drain valves

Drain valves shall be provided at each drain point of blowdown as recommended by the boiler manufacturer. Piping shall conform to ASME BPVC SEC IV and ASTM A53/A53M.

2.6.14.12 Safety Valves

Safety valves shall have steel bodies and shall be equipped with corrosion-resistant trim and valve seats. The valves shall be properly guided and shall be positive closing so that no leakage can occur. Adjustment of the desired back-pressure shall cover the range between 2 and 10 psig. The adjustment shall be made externally, and any shafts extending through the valve body shall be provided with adjustable stuffing boxes having renewable packing. Boiler safety valves of proper size and of the required number, in accordance with ASME BPVC SEC IV, shall be installed so that the discharge will be through piping extended to a location as indicated.

2.6.15 Pressure Gauges

Gauges shall conform to ASME B40.100 and shall be provided with throttling type needle valve or a pulsation dampener and shutoff valve. Minimum dial size shall be 3-1/2 inches. A pressure gauge shall be provided for each boiler in a visible location on the boiler. Pressure gauges shall be provided with readings in psi. Pressure gauges shall have an indicating pressure range that is related to the operating pressure of the fluid in accordance with the following table:

Operating Pressure (psi)	Pressure Range (psi)
76-150	0-200
16-75	0-100
2-15	0-30 (retard)

2.6.16 Thermometers

Thermometers shall be provided with wells and separable corrosion-resistant steel sockets. Mercury shall not be used in thermometers. Thermometers for inlet water and outlet water for each hot water boiler shall be provided in a visible location on the boiler. Thermometers shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a minimum 9 inch scale. The operating range of the thermometers shall be 32-212 degrees F. The thermometers shall be provided with readings in degrees F.

2.6.17 Air Vents

2.6.17.1 Manual Air Vents

Manual air vents shall be brass or bronze valves or cocks suitable for the pressure rating of the piping system and furnished with threaded plugs or caps.

2.6.17.2 Automatic Air Vents

Automatic air vents shall be 3/4 inch quick-venting float and vacuum air valves. Each air vent valve shall have a large port permitting the expulsion of the air without developing excessive back pressure, a noncollapsible metal float which will close the valve and prevent the loss of water from the system, an air seal that will effectively close and prevent the re-entry of air into the system when subatmospheric pressures prevail therein, and a thermostatic member that will close the port against the passage of steam from the system. The name of the manufacturer shall be clearly stamped on the outside of each valve. The air vent valve shall be suitable for the pressure rating of the piping system.

2.6.18 Steam Traps

2.6.18.1 Thermostatic Traps

Thermostatic traps shall conform to the requirements of ASTM F1139 and shall be installed in the return connection from each radiator and elsewhere as indicated. Drip traps for mains, risers, and similar lines shall be installed with a cooling leg of 5 feet of uncovered 3/4 inch pipe. The capacity of traps shall be based on a pressure differential of 2 psi. The traps shall be designed for a steam working pressure of 15 psig but shall operate with a supply pressure of approximately 2 psig. The traps shall be angle or straight-through pattern with union inlet connections as indicated. The trap bodies and covers shall be brass. Valve mechanisms and seats shall be monel, stainless steel or hard bronze and shall be removable for servicing or replacement.

2.6.18.2 Float-and-Thermostatic Traps

Float-and-thermostatic traps shall conform to the requirements of ASTM F1139 and be designed for a steam working pressure of 15 psig but shall operate with a supply pressure of approximately 5 psig. The trap capacity shall be based on a pressure differential of 2 psig. Each float-and-thermostatic trap shall have a cast iron body and shall be provided with a hard bronze, monel, or corrosion-resisting steel valve seat and mechanism, an open- or closed-type float of brass or equally corrosion-resistant metal, and a corrosion-resisting steel thermostatic air vent, all of which can be easily removed for inspection or replacement without disturbing the piping connections. The inlet to each trap shall have a brass or stainless steel strainer, either as an integral part of the trap or as a separate item of equipment.

2.6.18.3 Inverted Bucket Traps

Inverted bucket traps shall conform to the requirements of ASTM F1139 and be designed for a steam working pressure of 15 psig but shall operate with a supply pressure of approximately 5 psig. Each trap shall have a cast iron body and shall have a corrosion-resistant steel valve and seat and a brass or corrosion-resistant steel bucket, all of which can be easily removed for inspection or replacement without disturbing the piping connections. The inlet to each trap shall have a brass or stainless steel strainer, either as an integral part of the trap or as a separate item of equipment.

2.7 ELECTRICAL EQUIPMENT

Electric motor-driven equipment shall be provided complete with motors, motor starters, and necessary control devices. Electrical equipment, motor control devices, motor efficiencies and wiring shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Motors which are not an integral part of a packaged boiler and which are integral in size shall be the premium efficiency type in accordance with NEMA MG 1. Motors which are an integral part of the packaged boiler shall be the highest efficiency available by the manufacturer of the packaged boiler. Motor starters shall be provided complete with properly sized thermal overload protections and other appurtenances necessary for the motor control specified. Starters shall be furnished in general purpose enclosures. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices but not shown shall be provided.

2.7.1 Motor Ratings

Motors shall be suitable for the voltage and frequency provided. Motors 1/2 hp and larger shall be three-phase, unless otherwise indicated. Motors shall be of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating on the motor.

2.7.2 Motor Controls

Motor controllers shall be provided complete with properly sized thermal overload protection. Manual or automatic control and protective or signal devices required for the operation specified and any wiring required to such devices shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function. Solid state variable speed controllers shall be utilized for fractional through 10 hp ratings. Adjustable frequency drives shall be used for larger motors.

2.8 INSULATION

Shop and field-applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.9 TOOLS

Special tools shall be furnished. Special tools shall include uncommon tools necessary for the operation and maintenance of boilers, burners, pumps, fans, controls, meters, special piping systems, and other equipment. Small hand tools shall be furnished within a suitable cabinet, mounted where directed.

2.9.1 Breeching Cleaner

A cleaner shall be provided to clean the breeching. The cleaner shall have a jointed handle of sufficient length to clean the breeching without dismantling.

2.9.2 Tube Cleaner

If a watertube boiler is being furnished, a water-driven tube cleaner with three rotary cutters and rotary wire brush complete with the necessary length of armored water hose, valves, and other appurtenances necessary for operation shall be provided. Tube cleaner and rotary brush shall be provided for each size of water tube in the boiler, with one extra set of cutters for each size cleaner. Necessary valves and fittings shall be provided to permit ready connection of the cleaner hose to a high-pressure pump for cold water supply to operate the cleaner.

2.9.3 Tube Brush

If a firetube boiler is being furnished, a tube brush, with steel bristles and jointed handle of sufficient length to clean full length of firetubes, shall be provided.

2.9.4 Wrenches

Wrenches shall be provided as required for specialty fittings such as manholes, handholes, and cleanouts. One set of extra gaskets shall be provided for all manholes and handholes, for pump barrels, and other similar items of equipment. Gaskets shall be packaged and properly identified.

2.10 BOILER WATER TREATMENT

Submit six complete copies of the proposed water treatment plan. The plan shall include a layout, control scheme, a list of the existing water conditions including the items listed in this paragraph, a list of all chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals. The water treatment system shall be capable of feeding chemicals and bleeding the system to prevent corrosion and scale within the boiler and piping distribution system. Submit 6 complete copies of operating and maintenance manuals for the step-by-step water treatment procedures, including procedures for testing the water quality. The water shall be treated to maintain the conditions recommended by the boiler manufacturer. Chemicals shall meet required federal, state, and local environmental regulations for the treatment of boilers and discharge to the sanitary sewer. The services of a company regularly engaged in the treatment of boilers shall be used to determine the correct chemicals and concentrations required for water treatment. The company shall maintain the chemical treatment and provide all chemicals required for a period of 1 year from the date of occupancy. Filming amines and proprietary chemicals shall not be used. The water treatment chemicals shall remain stable throughout the operating temperature range of the system and shall be compatible with pump seals and other elements of the system.

2.10.1 MakeUp Water Analysis

The makeup water conditions reported as prescribed in ASTM D596

2.10.2 Boiler Water Limits

The boiler manufacturer shall be consulted for the determination of the boiler water chemical composition limits. The boiler water limits shall be as follows unless dictated differently by the boiler manufacturer's recommendations:

Causticity	20-200 ppm
Total Alkalinity (CACO3)	900-1200 ppm
Phosphate	30-60 ppm
Tanin	Medium
Dissolved Solids	3000-5000 ppm
Suspended Solids	300 ppm Max
Sodium Sulfite	20-40 ppm Max
Silica	Less than 150 ppm
Dissolved Oxygen	Less than 7 ppm
Iron	10 ppm
pH (Condensate)	7 - 8

Sodium Sulfite	20-40 ppm
Hardness	Less than 2 ppm
рн	9.3 - 9.9

2.10.3 Chemical Feed Pumps

One pump shall be provided for each chemical feed tank. The chemical feed pumps shall be positive displacement diaphragm type. The capacity of the pumps shall be adjustable from 0 to 100 percent while in operation. The discharge pressure of the pumps shall be not less than 1.5 times the pressure at the point of connection. The pumps shall be provided with a pressure relief valve and a check valve mounted in the pump discharge.

2.10.4 Tanks

The tanks shall be constructed of high density polyethylene with a hinged cover. The tanks shall have sufficient capacity to require recharging only once per 7 days during normal operation. A level indicating device shall be included with each tank. An electric agitator shall be provided

for each tank.

2.10.5 Injection Assemblies

An injection assembly shall be provided at each chemical injection point located along the boiler piping as indicated. The injection assemblies shall be constructed of stainless steel. The discharge of the assemblies shall extend to the centerline of the piping. Each assembly shall include a shutoff valve and check valve at the point of entrance into the water line.

2.10.6 Water Meter

The water meter shall be provided with an electric contacting register and remote accumulative counter. The meter shall be installed within the makeup water line, as indicated.

2.10.7 Water Treatment Control Panel

The control panel shall be a NEMA 12, single door, wall-mounted box conforming with NEMA 250. The panel shall be constructed of stainless steel with a hinged door and lock. The panel shall contain, as a minimum, the following functions identified with a laminated plastic nameplate:

- a. Main power switch and indicating light
- b. MAN-OFF-AUTO selector switch
- c. Indicating lamp for blow down
- d. Indicating lamp for each chemical feed pump
- e. Indicating lamp for the water softener
- 2.10.8 Sequence of Operation

The flow rate of chemical addition shall be based upon a manual setting. The boiler shall be provided with continuous blowdown. The required rate of chemical feed and boiler blowdown shall be determined by the water treatment company.

2.10.9 Chemical Shot Feeder

A shot feeder shall be provided as indicated. Size and capacity of feeder shall be based upon local requirements and water analysis. The feeder shall be furnished with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.10.10 Chemical Piping

The piping and fittings shall be constructed of schedule 80 PVC steel .

2.10.11 Test Kits

One test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals shall be provided.

Design the Glycol feed system to automatically maintain the desired glycol content of the closed water recirculation system(s). Each system shall consist of the following components:

2.10.12.1 Supply Tank and Stand

Include a 50 gallon cross lined polyethylene tank and steel support stand. The tank shall have a cover and bottom outlet fitting for pump suction. Equip the tank stand with a pump mounting platform and support for the control panel and level switch.

2.10.12.2 Glycol Pump

Rotary gear type of bronze construction with a capacity of 1.8 gpm at 40 psi. The pump shall have a 1/3 horsepower, 1/115V/60hz motor and internal pressure relief. Provide the pump with a discharge check valve and shutoff valve.

2.10.12.3 Pressure Switch

The pressure switch shall be adjustable over the range of 3 - 15 psi with a 6 psi differential and have contacts rated for 115V.

2.10.12.4 Level Switch

Equipped with N/O and N/C contacts to activate upon sensing a low level condition.

2.10.12.5 Control Panel

The control panel shall be installed in a NEMA 1 enclosure with terminal strip and shall include a red low level alarm light, low level alarm bell and silence button, full voltage motor starter for the glycol pump, and a Hand-Off-Auto selector switch.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 ERECTION OF BOILER AND AUXILIARY EQUIPMENT

Boiler and auxiliary equipment shall be installed in accordance with manufacturer's written instructions. Proper provision shall be made for expansion and contraction between boiler foundation and floor. This joint shall be packed with suitable nonasbestos rope and filled with suitable compound that will not become soft at a temperature of 100 degrees F. Boilers and firing equipment shall be supported from the foundations by structural steel completely independent of all brickwork. Boiler supports shall permit free expansion and contraction of each portion of the boiler without placing undue stress on any part of the boiler or setting. Boiler breeching shall be as indicated with full provision for expansion and contraction between all interconnected components.

3.3 PIPING INSTALLATION

Unless otherwise specified, nonboiler external pipe and fittings shall conform to the requirements of ASME B31.1. Pipe installed shall be cut accurately to suit field conditions, shall be installed without springing or forcing, and shall properly clear windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted. Pipes shall be free of burrs, oil, grease and other foreign material and shall be installed to permit free expansion and contraction without damaging the building structure, pipe, pipe joints, or pipe supports. Changes in direction shall be made with fittings, except that bending of pipe 4 inches and smaller will be permitted provided a pipe bender is used and wide sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Vent pipes shall be carried through the roof as directed and shall be properly flashed. Unless otherwise indicated, horizontal supply mains shall pitch down in the direction of flow with a grade of not less than 1 inch in 40 feet. Open ends of pipelines and equipment shall be properly capped or plugged during installation to keep dirt or other foreign materials out of the systems. Pipe not otherwise specified shall be uncoated. Unless otherwise specified or shown, final connections to equipment shall be made with malleable-iron unions for steel pipe 2-1/2 inches or less in diameter and with flanges for pipe 3 inches or more in diameter. Unions for copper pipe or tubing shall be brass or bronze. Reducing fittings shall be used for changes in pipe sizes. In horizontal hot water lines, reducing fittings shall be eccentric type to maintain the top of the lines at the same level to prevent air binding.

3.3.1 Hot Water Piping and Fittings

Pipe shall be black steel or copper tubing. Fittings for steel piping shall be black malleable iron or cast iron to suit piping. Fittings adjacent to valves shall suit valve material. Grooved mechanical fittings will not be allowed for water temperatures above 230 degrees F.

3.3.2 Vent Piping and Fittings

Vent piping shall be black steel. Fittings shall be black malleable iron or cast iron to suit piping.

3.3.3 Gauge Piping

Piping shall be copper tubing.

3.3.4 Steam Piping and Fittings

Piping shall be black steel. Fittings shall be black, malleable iron, cast iron or steel. Fittings adjacent to valves shall suit valves specified. Grooved mechanical fittings will not be allowed for steam piping.

3.3.5 Condensate Return Pipe and Fittings

Piping shall be black steel. Fittings shall be malleable iron, cast iron, or steel. Grooved mechanical fittings will not be allowed for condensate piping.

3.3.6 Joints

Joints between sections of steel pipe and between steel pipe and fittings shall be threaded, grooved, flanged or welded as indicated or specified. Except as otherwise specified, fittings 1 inch and smaller shall be threaded; fittings 1-1/4 inches and up to but not including 3 inches shall be either threaded, grooved, or welded; and fittings 3 inches and larger shall be either flanged, grooved, or welded. Pipe and fittings 1-1/4 inches and larger installed in inaccessible conduit or trenches beneath concrete floor slabs shall be welded. Connections to equipment shall be made with black malleable-iron unions for pipe 2-1/2 inches or smaller in diameter and with flanges for pipe 3 inchesor larger in diameter. Joints between sections of copper tubing or pipe shall be flared, soldered, or brazed.

3.3.6.1 Threaded Joints

Threaded joints shall be made with tapered threads properly cut and shall be made perfectly tight with a stiff mixture of graphite and oil or with polytetrafluoroethylene tape applied to the male threads only and in no case to the fittings.

3.3.6.2 Welded Joints

Welded joints shall be in accordance with paragraph GENERAL REQUIREMENTS unless otherwise specified. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connections may be made with either welding tees or forged branch outlet fittings, either being acceptable without size limitation. Branch outlet fittings, where used, shall be forged, flared for improved flow characteristics where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength. Socket weld joints shall be assembled so that the space between the end of the pipe and the bottom of the socket is no less than 1/16 inch and no more than 1/8 inch.

3.3.6.3 Grooved Mechanical Joints

Grooved mechanical joints may be provided for hot water systems in lieu of unions, welded, flanged, or screwed piping connections in low temperature hot water systems where the temperature of the circulating medium does not exceed 230 degrees F. Grooves shall be prepared according to the coupling manufacturer's instructions. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations. Mechanical joints shall use rigid mechanical pipe couplings, except at equipment connections. At equipment connections, flexible couplings may be used. Coupling shall be of the bolted type for use with grooved end pipes, fittings, valves, and strainers. Couplings shall be self-centering and shall engage in a watertight couple.

3.3.6.4 Flared and Brazed Copper Pipe and Tubing

Tubing shall be cut square, and burrs shall be removed. Both inside of fittings and outside of tubing shall be cleaned thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing shall not occur when making connections. Installation shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Brazed joints shall be made in conformance with AWS B2.2/B2.2M and CDA A4015 with flux. Copper-to-copper joints shall include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorous, copper-phosphorous-silver or a silver brazing filler metal. Joints for flared fittings shall be of the compression pattern. Swing joints or offsets shall be provided in all branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing. Flared or brazed copper tubing to pipe adapters shall be provided where necessary for joining threaded pipe to copper tubing.

3.3.6.5 Soldered Joints

Soldered joints shall be made with flux and are only acceptable for lines 2 inches and smaller. Soldered joints shall conform to ASME B31.5 and CDA A4015.

3.3.6.6 Copper Tube Extracted Joint

An extruded mechanical tee joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. The branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.3.7 Flanges and Unions

Flanges shall be faced true, provided with 1/16 inch thick gaskets, and made square and tight. Where steel flanges mate with cast-iron flanged fittings, valves, or equipment, they shall be provided with flat faces and full face gaskets. Union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Dielectric pipe unions shall be provided between ferrous and nonferrous piping 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.

3.3.8 Branch Connections

3.3.8.1 Branch Connections for Hot Water Systems

Branches from the main shall pitch up or down as shown to prevent air entrapment. Connections shall ensure unrestricted circulation, eliminate air pockets, and permit complete drainage of the system. Branches shall pitch with a grade of not less than 1 inch in 10 feet. When indicated, special flow fittings shall be installed on the mains to bypass portions of the water through each radiator. Special flow fittings shall be standard catalog products and shall be installed as recommended by the manufacturer.

3.3.9 Flared, Brazed, and Soldered Copper Pipe and Tubing

Copper tubing shall be flared, brazed, or soldered. Tubing shall be cut square, and burrs shall be removed. Both inside of fittings and outside of tubing shall be cleaned thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing shall not occur when making connections. Installation shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints for flared fittings shall be of the compression pattern. Swing joints or offsets shall be provided on branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing. Pipe adapters shall be provided where necessary for joining threaded pipe to copper tubing. Brazed joints shall be made in conformance with CDA A4015. Copper-to-copper joints shall include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) shall include the use of flux with either a copper-phosphorous, copper-phosphorous-silver, or a silver brazing filler metal. Soldered joints shall be made with flux and are only acceptable for lines 2 inches or smaller. Soldered joints shall conform to ASME B31.5 and shall be in accordance with CDA A4015.

3.3.10 Copper Tube Extracted Joint

An extracted mechanical tee joint may be made in copper tube. Joint shall be produced with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, dimpled depth stops shall be provided. The branch tube shall be notched for proper penetration into fitting to assure a free flow joint. Extracted joints shall be brazed using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.3.11 Supports

Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. Threaded rods which are used for support shall not be formed or bent. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.3.11.1 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58, except as modified herein.

3.3.11.1.1 Types 5, 12, and 26

Use of Types 5, 12, and 26 is prohibited.

3.3.11.1.2 Type 3

Type 3 shall not be used on insulated pipe which has a vapor barrier. Type 3 may be used on insulated pipe that does not have a vapor barrier if clamped directly to the pipe, if the clamp bottom does not extend through the insulation, and if the top clamp attachment does not contact the insulation during pipe movement.

3.3.11.1.3 Type 18

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.

3.3.11.1.4 Type 19 and 23 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.

3.3.11.1.5 Type 20 Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.3.11.1.6 Type 24

Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.3.11.1.7 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-58 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves.

3.3.11.1.8 Vertical Pipe Support

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 feet, not more than 8 feet from end of risers, and at vent terminations.

3.3.11.1.9 Type 35 Guides

Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures,
atmospheric conditions, and bearing loads encountered.

- a. Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4 inches and larger, a Type 39 saddle may be welded to the pipe and freely rested on a steel plate. On piping under 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rested on a steel slide plate.
- b. Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide shall include a pipe cradle welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 4 inches or by an amount adequate for the insulation, whichever is greater.
- 3.3.11.1.10 Horizontal Insulated Pipe

Except for Type 3, pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation.

3.3.11.1.11 Piping in Trenches

Support piping in trenches as indicated.

3.3.11.1.12 Structural Steel Attachments

Structural steel attachments and brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Pipe hanger loads suspended from steel joist between panel points shall not exceed 50 pounds. Loads exceeding 50 pounds shall be suspended from panel points.

3.3.11.2 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support member shall not exceed the hanger and support spacing required for any individual pipe in the multiple pipe run. The clips or clamps shall be rigidly attached to the common base member. A clearance of 1/8 inch shall be provided between the pipe insulation and the clip or clamp for piping which may be subjected to thermal expansion.

3.3.12 Anchors

Anchors shall be provided where necessary to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results, using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline.

3.3.13 Valves

Valves shall be installed where indicated, specified, and required for functioning and servicing of the systems. Valves shall be safely accessible. Swing check valves shall be installed upright in horizontal lines and in vertical lines only when flow is in the upward direction. Gate and globe valves shall be installed with stems horizontal or above. Valves to be brazed shall be disassembled prior to brazing and all packing removed. After brazing, the valves shall be allowed to cool before reassembling.

3.3.14 Pipe Sleeves

Pipe passing through concrete or masonry walls or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. A waterproofing clamping flange shall be installed as indicated where membranes are involved. Sleeves shall not be installed in structural members except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective wall, floor, or roof. Sleeves through walls shall be cut flush with wall surface. Sleeves through floors shall be cut flush with floor surface. Sleeves through roofs shall extend above the top surface of roof at least 6 inches for proper flashing or finishing. Unless otherwise indicated, sleeves shall be sized to provide a minimum clearance of 1/4 inch between bare pipe and sleeves or between jacket over insulation and sleeves. Sleeves in waterproofing membrane floors, bearing walls, and wet areas shall be galvanized steel pipe or cast-iron pipe. Sleeves in nonbearing walls, floors, or ceilings may be galvanized steel pipe, cast-iron pipe, or galvanized sheet metal with lock-type longitudinal seam. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve in nonfire rated walls shall be sealed as indicated and specified in Section 07 92 00 JOINT SEALANTS. Metal jackets shall be provided over insulation passing through exterior walls, firewalls, fire partitions, floors, or roofs.

- a. Metal jackets shall not be thinner than 0.006 inch thick aluminum, if corrugated, and 0.016 inch thick aluminum, if smooth.
- b. Secure metal jackets with aluminum or stainless steel bands not less than 3/8 inch wide and not more than 8 inches apart. When penetrating roofs and before fitting the metal jacket into place, a 1/2 inch wide strip of sealant shall be run vertically along the inside of the longitudinal joint of the metal jacket from a point below the backup material to a minimum height of 36 inches above the roof. If the pipe turns from vertical to horizontal, the sealant strip shall be run to a point just beyond the first elbow. When penetrating waterproofing membrane for floors, the metal jacket shall extend from a point below the back-up material to a minimum distance of 2 inches above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 12 inches above material to a minimum distance of 2 inches above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 12 inches above the floor; when passing through walls above grade, the jacket shall extend at least 4 inches beyond each side of the wall.

3.3.14.1 Pipes Passing Through Waterproofing Membranes

In addition to the pipe sleeves referred to above, pipes passing through waterproofing membranes shall be provided with a 4 pound lead flashing or a 16 ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the skirt or flange shall extend not less than 8 inches from the pipe and shall set over the membrane in a troweled coating of bituminous cement. The flashing shall extend above the roof or floor a minimum of 10 inches. The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Pipes up to and including 10 inches in diameter which pass through 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.

3.3.14.2 Optional Modular Mechanical Sealing Assembly

At the option of the Contractor, a modular mechanical type sealing assembly may be installed in the annular space between the sleeve and conduit or pipe in lieu of a waterproofing clamping flange and caulking and sealing specified above. The seals shall include 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. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved.

3.3.14.3 Optional Counterflashing

As alternates to caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may consist of standard roof coupling for threaded pipe up to 6 inches in diameter, lead flashing sleeve for dry vents with the sleeve turned down into the pipe to form a waterproof joint, or a tack-welded or banded-metal rain shield around the pipe, sealed as indicated.

3.3.14.4 Fire Seal

Where pipes pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.3.15 Balancing Valves

Balancing valves shall be installed as indicated.

3.3.16 Thermometer Wells

Provide a thermometer well in each return line for each circuit in multicircuit systems.

3.3.17 Air Vents

Install air vents in piping at all system high points. The vent shall remain open until water rises in the tank or pipe to a predetermined level at which time it shall close tight. An overflow pipe from the vent shall be run to a point designated by the Contracting Officer's representative. The inlet to the air vent shall have a gate valve or ball valve.

3.3.18 Escutcheons

Provide escutcheons at all finished surfaces where exposed piping, bare or insulated, passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be chromium-plated iron or chromium-plated brass, either one-piece or split pattern, held in place by internal spring tension or setscrews.

3.3.19 Drains

A drain connection with a 1 inch gate valve or 3/4 inch hose bib shall be installed at the lowest point in the return main near the boiler. In addition, threaded drain connections with threaded cap or plug shall be installed on the heat exchanger coil on each unit heater or unit ventilator and wherever required for thorough draining of the system.

3.3.20 Strainer Blow-Down Piping

Strainer blow-down connections shall be fitted with a black steel blow-down pipeline routed to an accessible location and provided with a blow-down valve.

3.3.21 Direct Venting for Combustion Intake Air and Exhaust Air

The intake air and exhaust vents shall be installed in accordance with NFPA 54 and boiler manufacturer's recommendations. The exhaust vent shall be sloped 1/4 inch/ft toward the boiler's flue gas condensate collection point.

3.4 GAS FUEL SYSTEM

Gas piping, fittings, valves, regulators, tests, cleaning, and adjustments shall be in accordance with these specifications. Submit proposed test schedules for the heating system and fuel system tests, at least 2 weeks prior to the start of related testing. NFPA 54 shall be complied with unless otherwise specified. Burners, pilots, and all accessories shall be listed in UL FLAMMABLE & COMBUSTIBLE. The fuel system shall be provided with a gas tight, manually operated, UL listed stop valve at the gas-supply connections, a gas strainer, a pressure regulator, pressure gauges, a burner-control valve, a safety shutoff valve suitable for size of burner and sequence of operation, and other components required for safe, efficient, and reliable operation as specified. Approved permanent and ready facilities to permit periodic valve leakage tests on the safety shutoff valve or valves shall be provided.

3.5 FUEL OIL SYSTEM

Fuel oil system shall be installed in accordance with NFPA 31, unless otherwise indicated.

3.5.1 Piping and Storage Tank

Fuel oil piping and storage tanks shall be installed in accordance with thses documents

3.5.2 Fuel-Oil Storage Tank Heating-Coil Piping

Supply and return piping and fittings for the heating coil shall be

installed in accordance with paragraph PIPING INSTALLATION. The hot water supply line to the heating coil shall be provided with an automatic temperature-control valve, a strainer and a three-valve bypass. The return line from the coil shall be provided with a check valve and a block valve.

3.5.3 Automatic Safety Shutoff Valve

Oil supply line to each oil burner shall be equipped with an automatically operated valve designed to shut off the oil supply in case of fire in the immediate vicinity of the burner. The valve shall be thermoelectrically actuated or thermomechanically actuated type and shall be located immediately downstream of the manual shutoff valve at the day tank inside of the building. If a day tank is not used, the automatic safety valve shall be located immediately downstream of the building shutoff devices where oil supply line enters the building. A thermoelectrical or thermomechanical detection device shall be located over the oil burner to activate the valve. A fire shutoff valve may be combined with other automatic shutoff devices if listed in UL FLAMMABLE & COMBUSTIBLE.

3.5.4 Earthwork

Excavation and backfilling for tanks and piping shall be as specified in Section 31 00 00 EARTHWORK.

3.6 MANUFACTURER'S SERVICES

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified to supervise the installing, adjusting, and testing of the equipment.

3.7 TEST OF BACKFLOW PREVENTION ASSEMBLIES

Backflow prevention assemblies shall be tested in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.8 HEATING SYSTEM TESTS

Submit the Qualifications of the firms in charge of installation and testing as specified. Submit a statement from the firms proposed to prepare submittals and perform installation and testing, demonstrating successful completion of similar services of at least five projects of similar size or scope, at least 2 weeks prior to the submittal of any other item required by this section. Before any covering is installed on pipe or heating equipment, the entire heating system's piping, fittings, and terminal heating units shall be hydrostatically tested and proved tight at a pressure of 1.5 times the design working pressure, but not less than 100 psi. Submit proposed test procedures for the heating system tests and fuel system tests, at least 2 weeks prior to the start of related testing.

- a. Before pressurizing system for test, items or equipment (e.g., vessels, pumps, instruments, controls, relief valves) rated for pressures below the test pressure shall be blanked off or replaced with spool pieces.
- Before balancing and final operating test, test blanks and spool pieces shall be removed; and protected instruments and equipment shall be reconnected. With equipment items protected, the system shall be pressurized to test pressure. Pressure shall be held for a period of

time sufficient to inspect all welds, joints, and connections for leaks, but not less than 2 hours. No loss of pressure will be allowed. Leaks shall be repaired and repaired joints shall be retested.

- c. Repair joints shall not be allowed under the floor for floor radiant heating systems. If a leak occurs in tubing located under the floor in radiant heating systems, the entire zone that is leaking shall be replaced. If any repair is made above the floor for floor radiant heating systems, access shall be provided for the installed joint. Caulking of joints shall not be permitted.
- d. System shall be drained and after instruments and equipment are reconnected, the system shall be refilled with service medium and maximum operating pressure applied. The pressure shall be held while inspecting these joints and connections for leaks. The leaks shall be repaired and the repaired joints retested.

Upon completion of hydrostatic tests and before acceptance of the installation, submit test reports for the heating system tests. Upon completion of testing complete with results, balance the heating system in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS and operating tests required to demonstrate satisfactory functional and operational efficiency. The operating test shall cover a period of at least 24 hours for each system, and shall include, as a minimum, the following specific information in a report, together with conclusions as to the adequacy of the system:

- a. Certification of balancing.
- b. Time, date, and duration of test.
- c. Outside and inside dry bulb temperatures.
- d. Temperature of hot water supply leaving boiler .
- e. Temperature of heating return water from system at boiler inlet.
- f. Quantity of water feed to boiler.
- g. Boiler make, type, serial number, design pressure, and rated capacity.
- h. Fuel burner make, model, and rated capacity; ammeter and voltmeter readings for burner motor.
- j. Flue-gas temperature at boiler outlet.
- k. Percent carbon dioxide in flue-gas.
- 1. Grade or type and calorific value of fuel.
- m. Draft at boiler flue-gas exit.
- n. Draft or pressure in furnace.
- o. Quantity of water circulated.
- p. Quantity of fuel consumed.

q. Stack emission pollutants concentration.

3.8.1 Boiler/Piping Test

At the conclusion of the 1 year period, the boiler and condensate piping shall be inspected for problems due to corrosion and scale. If the boiler is found not to conform to the manufacturer's recommendations, and the water treatment company recommendations have been followed, the water treatment company shall provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations. If corrosion is found within the condensate piping, proper repairs shall be made by the water treatment company.

3.9 CLEANING

3.9.1 Boilers and Piping

After the hydrostatic tests have been made and before the system is balanced and operating tests are performed, the boilers and piping shall be thoroughly cleaned by filling the system with a solution consisting of either 1 pound of caustic soda or 1 pound of trisodium phosphate per 50 gallons of water. The proper safety precautions shall be observed in the handling and use of these chemicals. The water shall be heated to approximately 150 degrees F and the solution circulated in the system for a period of 48 hours. The system shall then be drained and thoroughly flushed out with fresh water. Strainers and valves shall be thoroughly cleaned. Prior to operating tests, air shall be removed from all water systems by operating the air vents.

3.9.2 Heating Units

Inside space heating equipment, ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided for fans that are operated during construction, and new provide filters after construction dirt has been removed from the building, and the ducts, plenum, casings, and other items specified have been vacuum cleaned. Perform and document that proper "Indoor Air Quality During Construction" procedures have been followed; provide documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.10 FIELD TRAINING

a. The field instructions shall cover all of the items contained in the approved operation and maintenance manuals, as well as demonstrations of routine maintenance operations and boiler safety devices.

- b. Submit system layout diagrams that show the layout of equipment, piping, and ductwork and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system, framed under glass or laminated plastic, at least 2 weeks prior to the start of related testing. After approval, these items shall be posted where directed.
- c. Submit six complete operation and maintenance instructions listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to field training. The manuals shall include the manufacturer's name, model number, parts list, simplified wiring and control diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization shall be capable of providing 4 hour onsite response to a service call on an emergency basis.
- d. Notify the Contracting Officer at least 14 days prior to date of proposed conduction of the training course.

3.11 FUEL SYSTEM TESTS

Submit test reports for the fuel system tests, upon completion of testing complete with results.

3.11.1 Gas System Test

The gas fuel system shall be tested in accordance with the test procedures outlined in NFPA 54.

-- End of Section --

SECTION 23 64 00

PACKAGED WATER CHILLERS, ABSORPTION TYPE 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 WELDING SOCIETY (AWS)

AWS Z49.1 (2012) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A307 (2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength

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

ASTM F104 (2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA	MG	1	(2018)	Mot	tors	and	Ger	nerators	5		
NEMA	MG	11	(1977;	R 2	2012)	Ene	ergy	v Manage	ement	Guide	for
			Select:	ion	and	Use	of	Single	Phase	e Motor	ŝ

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54 (2021) National Fuel Gas 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.. 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

Drawings; G

SD-03 Product Data

Posted Instructions; G

Verification of Dimensions; G

System Performance Tests; G

Demonstrations

SD-06 Test Reports

Field Acceptance Testing; G

System Performance Tests; G

SD-07 Certificates

SD-08 Manufacturer's Instructions

Water Chiller - Installation Instructions; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

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. Fuel-fired equipment must be in accordance with NFPA 54.

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 must be replaced at the Contractor's expense. During installation, piping and similar openings must be capped to keep out dirt and other foreign matter.

1.5 PROJECT REQUIREMENTS

1.5.1 Verification of Dimensions

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

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. The Contractor must submit detailed drawings consisting of:

- a. Equipment layouts which identify assembly and installation details.
- b. Plans and elevations which identify clearances required for maintenance and operation.
- c. Wiring diagrams which identify each component individually and all interconnected or interlocked relationships between components.
- d. Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations.
- e. Details, if piping and equipment are to be supported other than as indicated, which include loadings and type of frames, brackets, stanchions, or other supports.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment must be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products must have been in satisfactory commercial or industrial use for two years prior to bid opening. The two year use must include applications of equipment and materials under similar circumstances and of similar size. The two 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 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. System components must be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including chillers, water coolers, heat exchanges, and motors must have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates must be durable and legible throughout equipment life and made of anodized aluminum. Plates must be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

a. Provide motors, controllers, integral disconnects, contactors, and controls with their respective pieces of equipment, except controllers indicated as part of motor control centers. Provide electrical equipment, including motors and wiring, as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Manual or automatic control and protective or signal devices required for the operation specified and control wiring required for controls and devices specified, but not shown, must be provided. For packaged equipment, the manufacturer must provide controllers including the required monitors and timed restart.

- b. For single-phase motors, provide high-efficiency type, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 11.
- c. For polyphase motors, provide squirrel-cage medium induction motors, including motors that are part of a system, and that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.
- d. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor. Motors must be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Motor enclosure type may be either TEAO or TEFC.
- e. Where two-speed motors are indicated, variable-speed controllers may be provided to accomplish the same function. 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 CHILLER COMPONENTS

2.4.1 Tools

One complete set of special tools, as recommended by the manufacturer for field maintenance of the system, must be provided. Tools must be mounted on a tool board in the equipment room or contained in a toolbox as directed by the Contracting Officer.

2.5 ACCESSORIES

2.5.1 Cleaning Brushes

Furnish chiller with two brushes, having jointed rods, suitable for cleaning evaporator and condenser tubes.

2.5.2 Gaskets

Gaskets shall conform to ASTM F104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 700 degrees F service.

2.5.3 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall be in accordance with ASTM A307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A307.

2.6 FABRICATION

2.6.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish.

2.6.2 Factory Applied Insulation

Chiller shall be provided with factory installed insulation on surfaces subject to sweating including the water cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it shall be installed to provide easy removal and replacement of heads without damage to the insulation. As a minimum, factory insulated items installed indoors shall have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes shall be determined by ASTM E84. Insulation shall be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket shall be tested as a composite material. Jackets, facings, and adhesives shall have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.7 SUPPLEMENTAL COMPONENTS/SERVICES

2.7.1 Charging and Testing

Unless fully assembled, tested, evacuated, and charged at factory, components shall be dried and sealed to prevent corrosion of internal surfaces prior to field assembly. Assemble, test, evacuate, and charge units under supervision of manufacturer's representative. Periodic tests shall be readily made on the concentration of the inhibitor and lithium bromide solution with a field test kit furnished by the manufacturer, or as recommended by the manufacturer.

2.7.2 Temperature Controls

Chiller control packages shall be fully coordinated with and integrated into the temperature control system indicated in Section 23 30 00 HVAC AIR DISTRIBUTION, into the existing air-conditioning system.

PART 3 EXECUTION

3.1 INSTALLATION

Installation of absorption chiller systems including materials, installation, workmanship, fabrication, assembly, erection, examination,

inspection, and testing shall be in accordance with the manufacturer's written installation instructions, including the following:

(1) Water chiller - installation instructions

3.1.1 Installation Instructions

Provide manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show features such as materials 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

3.1.2 Vibration Isolation

If vibration isolation is specified for a unit, vibration isolator literature must be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

3.1.3 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.

3.1.4 Verification of Dimensions

Provide a letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

3.1.5 System Performance Test Schedules

Provide a schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules must identify the proposed date, time, and location for each test.

3.1.6 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.

3.1.7 Certificates

Where the system, components, or equipment are specified to comply with requirements of AGA, NFPA, ARI, ASHRAE, ASME, or UL, proof of such compliance must be provided. The label or listing of the specified agency must be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above must be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

3.1.8 Operation and Maintenance Manuals

Provide Six complete copies of an operation manual in bound 8 1/2 by 11 inch booklets listing step-by-step procedures required for system startup, operation, abnormal shutdown, emergency shutdown, and normal shutdown at least 4 weeks prior to the first training course. The booklets must include the manufacturer's name, model number, and parts list. The manuals must include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. Six complete copies of maintenance manual in bound 8 1/2 by 11 inch booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide. The manuals must include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

3.1.9 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems.

3.1.10 Mechanical Room Ventilation

Mechanical ventilation systems shall be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.1.11 Field Applied Insulation

Field installed insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.12 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory.

3.2 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative shall be provided. The representative shall advise on the following:

Absorption Units:

- (1) Testing and evacuation.
- (2) Charging the machine with lithium bromide solution and refrigerant water (distilled or deionized water).

(3) Starting the machine.

3.3 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Provide temporary filters for all fans that are operated during construction. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions. Testing, adjusting, and balancing shall be as specified in Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC.

3.4 FIELD ACCEPTANCE TESTING

- 3.4.1 Test Plans
 - a. Manufacturer's Test Plans: Within 120 calendar days after contract award, submit the following plans:

Field acceptance test plans shall be developed by the absorption chiller manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance tests of the absorption chiller and subsequent test reporting.

- b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls for the equipment provided under Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.
- c. Prerequisite testing: Absorption chillers 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 shall include the required test reporting forms to be completed by the Contractor's testing representatives. Procedures shall be structured to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control.

Controller 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. Chiller manufacturer shall furnish with each test procedure a description of acceptable results that have been verified.

Chiller manufacturer shall identify the acceptable limits or tolerance within which each tested performance variable shall acceptably operate.

- f. Job specific: Each test plan shall be job specific and shall address the particular cooling towers and particular conditions which exist in this contract. Generic or general preprinted test procedures are not acceptable.
- g. Specialized components: Each test plan shall include procedures for field testing and field adjusting specialized components, such as pressure valves.
- 3.4.2 Testing
 - a. Each absorption chiller system shall be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:
 - 3.5 SYSTEM PERFORMANCE TESTS

Six copies of the report must be provided in bound 8 1/2 by 11 inch booklets.

3.5.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's start-up representative experienced in system start-up and testing, at such times as directed. Tests shall cover a period of not less than 48 hours for each system and shall demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened. Any refrigerant lost during the system startup shall be replaced. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and the system shall be retested. Tests shall be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. Field tests shall be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.5.2 Test Report

The report shall document compliance with the specified performance criteria upon completion and testing of the system. The report shall indicate the number of days covered by the tests and any conclusions as to the adequacy of the system. The report shall also include the following information and shall be taken at least three different times at outside dry-bulb temperatures that are at least 5 degrees F apart:

- a. Date and outside weather conditions.
- b. The load on the system based on the following:
 - For absorption units, the cooling water pressures and temperatures entering and exiting the absorber and condenser. Also the refrigerant solution pressures, concentrations, and temperatures at each measurable point within the system.
 - (2) Running current, voltage and proper phase sequence for each phase of all motors.
 - (3) The actual on-site setting of all operating and safety controls.
 - (4) Chilled water pressure, flow and temperature in and out of the chiller.
 - (5) The position of the gas supply control valve at machine off, one-third loaded, one-half loaded, two-thirds loaded, and fully loaded.

3.6 DEMONSTRATIONS

Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total 4 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.

-- End of Section --

SECTION 23 64 10

WATER CHILLERS, VAPOR COMPRESSION TYPE 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.

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI	550/590	I-P	(2015; ERTA 2016) Performance Rating Of Water-Chilling and Heat Pump Water-Heatin Packages Using the Vapor Compression Cycl
AHRI	575		(2008) Method of Measuring Machinery Soun Within an Equipment Space

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA	9	(2015)	Load	Ratings	and	Fatigue	Life	for
		Ball B	earing	gs				

ABMA 11 (2014) Load Ratings and Fatigue Life for Roller Bearings

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

ANSI/ASHRAE 15 & 34 (2013) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME BPVC SEC VIII D1 (2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

AMERICAN WELDING SOCIETY (AWS)

AWS Z49.1 (2012) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A307	(2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D520	(2000; R 2011) Zinc Dust Pigment

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

ASTM F104 (2011; R 2020) Standard Classification System for Nonmetallic Gasket Materials

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 11 (1977) Selec	; R 2012) Energy Management Guide for	r

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

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40 CFR 82 Protection of Stratospheric Ozone
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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. 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

Posted Instructions Verification of Dimensions; G Factory Tests; G System Performance Tests; G Demonstrations Refrigerant; G Water Chiller - Field Acceptance Test Plan SD-06 Test Reports; G Field Acceptance Testing Factory Tests System Performance Tests; G SD-07 Certificates Refrigeration System; G

Ozone Depleting Substances Technician Certification

SD-08 Manufacturer's Instructions

SD-11 Closeout Submittals

Indoor Air Quality During Construction; G; S

1.3 CERTIFICATIONS

1.3.1 Ozone Depleting Substances Technician Certification

All technicians working on equipment that contain ozone depleting refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.4 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices must be installed so that proper operation of equipment is not impaired. Welding and cutting safety requirements must be in accordance with AWS Z49.1.

1.5 DELIVERY, STORAGE, AND HANDLING

Stored items must be protected from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Proper protection and care of all material both before and during installation will be the Contractor's responsibility. Any materials found to be damaged must be replaced at the Contractor's expense. During installation, piping and similar openings must be capped to keep out dirt and other foreign matter.

1.6 PROJECT REQUIREMENTS

1.6.1 Verification of Dimensions

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

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment will be standard Commercial cataloged products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. These products must have a two year record of satisfactory field service prior to bid opening. The two year record of service must include applications of equipment and materials under similar circumstances and of similar size. Products having less than a two year record of satisfactory field service will be acceptable if a certified record of satisfactory field service for not less than 6000 hours can be shown. The 6000 hour service record must not include any manufacturer's prototype or factory testing. Satisfactory field service must have been completed by a product that has been, and

- 2.2 MANUFACTURER'S STANDARD NAMEPLATES
- 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. Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.
 - f. Provide inverter duty premium efficiency motors for use with variable frequency drives.
- 2.4 SELF-CONTAINED WATER CHILLERS, VAPOR COMPRESSION TYPE

Unless necessary for delivery purposes, units must be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the factory. In lieu of delivery constraints, a chiller may be assembled, leak-tested, charged (refrigerant and oil), and adjusted at the job site by a factory representative. Unit components delivered separately must be sealed and charged with a nitrogen holding charge. Parts weighing 50 pounds or more which must be removed for inspection, cleaning, or repair, such as motors, gear boxes, cylinder heads, casing tops, condenser, and cooler heads, must have lifting eyes or lugs. Chiller must be provided with a single point wiring connection for incoming power supply. Chiller's condenser and 2.4.1 Scroll, Reciprocating, or Rotary Screw Type

Chiller must be certified for performance per AHRI 550/590 I-P. If specified performance is outside of the Application Rating Conditions of AHRI 550/590 I-P, Table 2 then the chiller's performance must be rated in accordance with AHRI 550/590 I-P. Chiller must conform to ANSI/ASHRAE 15 & 34. As a minimum, chiller must include the following components as defined in paragraph CHILLER COMPONENTS.

- a. Refrigerant and oil
- b. Structural base
- c. Chiller refrigerant circuit
- d. Controls package
- e. Scroll, reciprocating, or rotary screw compressor
- f. Compressor driver, electric motor
- g. Compressor driver connection
- h. Water cooler (evaporator)
- i. Air-cooled condenser coil

2.5 CHILLER COMPONENTS

2.5.1 Refrigerant and Oil

Refrigerants must be one of the fluorocarbon gases. Refrigerants must have number designations and safety classifications in accordance with ANSI/ASHRAE 15 & 34. CFC-based refrigerants are prohibited. Refrigerants must have an Ozone Depletion Potential (ODP) no greater than 0.0, with the exception of R-123. Provide SDS sheets for all refrigerants.

2.5.2 Structural Base

Chiller and individual chiller components must be provided with a factory-mounted structural steel base (welded or bolted) or support legs. Chiller and individual chiller components must be isolated from the building structure by means of molded neoprene isolation pads.

2.5.3 Chiller Refrigerant Circuit

Chiller refrigerant circuit must be completely piped and factory leak tested in accordance with ANSI/ASHRAE 15 & 34. Circuit must include as a minimum a combination sight glass and moisture indicator, an electronic or thermostatic expansion valve with external equalizer or float valve, charging ports, compressor service valves for field-serviceable compressors, and superheat adjustment.

2.5.4 Controls Package

Provide chillers with a complete factory-mounted , microprocessor based operating and safety control system. Controls package must contain as a minimum a digital display, an on-auto-off switch, motor starters, disconnect switches, power wiring, and control wiring. Controls package must provide operating controls, monitoring capabilities, programmable setpoints, safety controls, and interfaces as defined below.

2.5.4.1 Operating Controls

Chiller must be provided with the following adjustable operating controls as a minimum.

- a. Leaving chilled water temperature control
- b. Adjustable timer or automated controls to prevent a compressor from short cycling
- c. Automatic lead/lag controls (adjustable) for multi-compressor units
- d. Load limiting
- e. System capacity control to adjust the unit capacity in accordance with the system load and the programmable setpoints. Controls must automatically re-cycle the chiller on power interruption.
- f. Startup and head pressure controls to allow system operation at all ambient temperatures down to degrees F.
- g. Fan sequencing for air-cooled condenser
- 2.5.4.2 Monitoring Capabilities

During normal operations, the control system must be capable of monitoring and displaying the following operating parameters. Access and operation of display must not require opening or removing any panels or doors.

- a. Entering and leaving chilled water temperatures
- b. Chilled water flow
- с.
- d. Self diagnostic
- e. Operation status
- f. Operating hours
- g. Number of starts
- h. Compressor status (on or off)
- i. Compressor load (percent)
- j. Refrigerant discharge and suction pressures
- k. Magnetic bearing levitation status (if applicable)

- 1. Magnetic bearing temperatures (if applicable)
- m. Oil pressure
- 2.5.4.3 Configurable Setpoints

The control system must be capable of being configured directly at the unit's interface panel. The programmable setpoints must include the following as a minimum:

- a. Leaving Chilled Water Temperature
- c. Time Clock/Calendar Date
- 2.5.4.4 Safety Controls with Manual Reset

Chiller must be provided with the following safety controls which automatically shutdown the chiller and which require manual reset.

- a. Low chilled water temperature protection
- b. High condenser refrigerant discharge pressure protection
- c. Low evaporator pressure protection
- d. Chilled water flow detection
- e. High motor winding temperature protection
- f. Low oil flow protection if applicable
- g. Magnetic bearing controller (MBC), Internal fault (if applicable)
- h. MBC, High bearing temperature (if applicable)
- i. MBC, Communication fault (if applicable)
- j. MBC, Power supply fault (if applicable)
- 2.5.4.5 Safety Controls with Automatic Reset

Chiller must be provided with the following safety controls which automatically shutdown the chiller and which provide automatic reset.

- a. Over/under voltage protection
- b. Chilled water flow interlock
- c. MBC, Vibration (if applicable)
- d. MBC, No levitation (if applicable)
- 2.5.4.6 Remote Alarm

During the initiation of a safety shutdown, a chiller's control system must be capable of activating a remote alarm bell. In coordination with the chiller, the Contractor must provide an alarm circuit (including transformer if applicable) and a minimum 4 inch diameter alarm bell. Alarm circuit must activate bell in the event of machine shutdown due to the chiller's monitoring of safety controls. The alarm bell must not sound for a chiller that uses low-pressure cutout as an operating control.

2.5.4.7 Utility Monitoring and Control System Interface

Provide a Utility Monitoring and Control System (UMCS) interface meeting the requirements of Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and the requirements of . The interface must provide all system operating conditions, capacity controls, and safety shutdown conditions as network points. In addition, the following points must be overridable via the network interface:

- a. Unit Start/Stop
- b. Leaving Chilled Water Temperature Setpoint
- 2.5.5 Compressor(s)
- 2.5.5.1 Scroll Compressor(s)

Compressors must be of the hermetically sealed design. Compressors must be mounted on vibration isolators to minimize vibration and noise. Rotating parts must be statically and dynamically balanced at the factory to minimize vibration. Lubrication system must be centrifugal pump type equipped with a means for determining oil level and an oil charging valve. Crankcase oil heater must be provided. Provide continuous compressor unloading to 10 percent of full-load capacity by way of variable speed compressor motor controller or variable unloading of the scroll.

2.5.5.2 Rotary Screw Compressor(s)

Compressors must operate stably for indefinite time periods to at least 25 percent capacity reduction without gas bypass external to the compressor. Provision must be made to insure proper lubrication of bearings and shaft seals on shutdown with or without electric power supply. Rotary screw compressors must include:

- a. An open or hermetic, positive displacement, oil-injected design directly driven by the compressor driver. Allow access to internal compressor components for repairs, inspection, and replacement of parts.
- b. Rotors must be solid steel, possessing sufficient rigidity for proper operation.
- c. A maximum rotor operating speed no greater than 3600 RPM. Provide cast iron rotor housing.
- d. Casings of cast iron, precision machined for minimal clearance about periphery of rotors with minimal clearance at rotor tops and rotor ends.
- e. A lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.
- f. Bearing housing must be conservatively loaded and rated for an L(10) life of not less than 200,000 hours. Shaft main bearings of the

sleeve type with heavy duty bushings or rolling element type in accordance with ABMA 9 or ABMA 11.

- g. A differential oil pressure or flow cutout to allow the compressor to operate only when the required oil pressure or flow is provided to the bearings.
- h. A temperature- or pressure-initiated, hydraulically actuated, single-slide-valve, capacity-control system to provide minimum automatic capacity modulation from 100 percent to 15 percent.
- i. An oil separator and oil return system to remove oil entrained in the refrigerant gas and automatically return the oil to the compressor.
- j. Crankcase oil heaters must be provided.
- 2.5.5.3 Centrifugal Compressor(s)

Centrifugal compressors may be either single or multistage, having dynamically balanced impellers, either direct or gear driven by the compressor driver. Impellers must be over-speed tested at 1.2 times the impeller-shaft speed. Impeller shaft must be steel with sufficient rigidity for proper operation at any required operating speed. Compressors must be capable of variable speed operation and may have either oil-free bearing drives or oil-lubricated bearing drives. Centrifugal compressors must include:

- a. Shaft main bearings that are either oil lubricated, oil free ceramic or magnetic levitated. The oil lubricated bearings must be the rolling element type in accordance with ABMA 9 or ABMA 11, journal type with bronze or babbitt liners, or of the aluminum-alloy one-piece insert type. Oil lubricated or oil free ceramic bearings must be rated for an L(10) life of not less than 200,000 hours. Magnetic levitated main shaft bearings must be in accordance with ISO 14839-1, ISO 14839-2, ISO 14839-3, ISO 14839-4, and provided with radial and axial magnetic levitated bearings (combination permanent and electro magnets) to levitate the shaft thereby eliminating metal to metal contact and thus eliminating the need for oil. The active magnetic bearings must be equipped with an automatic vibration reduction and balancing system. Each bearing position must be sensed by position sensors and provide real time positioning of the rotor shaft, controlled by on-board digital electronics. In the event of a power failure, the magnetic bearings will remain in operation throughout the compressor coast-down using a reserve power supply. Provide mechanical bearings designed for emergency touchdowns, as a backup to the magnetic bearings.
- b. Casing of cast iron, aluminum, or steel plate with split sections gasketed and bolted or clamped together.
- c. Lubrication system of the forced-feed type that provides oil at the proper pressure to all parts requiring lubrication.
- d. Provisions to ensure proper lubrication of bearings and shaft seals prior to starting and upon stopping with or without electric power supply (if applicable). On units providing forced-feed lubrication prior to starting, a differential oil pressure cutout interlocked with the compressor starting equipment must allow the compressor to operate only when the required oil pressure is provided to the bearings (if

applicable).

- e. Oil sump heaters controlled as recommended by the manufacturer.
- f. Temperature-or pressure-actuated prerotation vane, variable geometry diffuser or suction damper to provide automatic capacity modulation from 100 percent capacity to 25 percent capacity. If operation to 25 percent capacity cannot be achieved without providing gas bypass external to the compressor, then the Contractor must indicate in the equipment submittal the load percent at which external hot gas bypass is required to prevent surge and to provide the specified capacity reduction and its impact on performance.
- 2.5.6 Compressor Driver, Electric Motor

Components such as motors, starters, and wiring must be in accordance with paragraph ELECTRICAL WORK. Motor starter must be unit mounted as indicated with starter type, wiring, and accessories coordinated with the chiller manufacturer.

2.5.7 Air-Cooled Condenser Coil

Condenser coil must be of the extended-surface fin-and-tube type and must be constructed of seamless copper or aluminum tubes with compatible copper or aluminum fins. Fins must be soldered or mechanically bonded to the tubes and installed in a metal casing. Coils must be circuited and sized for a minimum of 5 degrees F subcooling and full pumpdown capacity. Coil must be factory leak and pressure tested after assembly in accordance with ANSI/ASHRAE 15 & 34.

2.5.8 Receivers

Receiver must bear a stamp certifying compliance with ASME BPVC SEC VIII D1 and must meet the requirements of ANSI/ASHRAE 15 & 34. Inner surfaces must be thoroughly cleaned by sandblasting or other approved means. Each receiver must have a storage capacity not less than 20 percent in excess of that required for the fully-charged system. Each receiver must be equipped with inlet, outlet drop pipe, drain plug, purging valve, relief valves of capacity and setting required by ANSI/ASHRAE 15 & 34, and two bull's eye liquid-level sight glasses. Sight glasses must be in the same vertical plane, 90 degrees apart, perpendicular to the axis of the receiver, and not over 3 inches horizontally from the drop pipe measured along the axis of the receiver. In lieu of bull's eye sight glass, external gauge glass with metal glass guard and automatic closing stop valves may be provided.

2.5.9 Chiller Purge System

Chillers which operate at pressures below atmospheric pressure must be provided with a purge system. Purge system must automatically remove air, water vapor, and non-condensible gases from the chiller's refrigerant while keeping refrigerant emissions below requirements of ASHRAE Std 147. Purge units must be certified per AHRI 580. Purge system must condense, separate, and return all refrigerant back to the chiller. An oil separator must be provided with the purge system if required by the manufacturer. Purge system must not discharge to occupied areas, or create a potential hazard to personnel. Purge system must include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system must include lights or an alarm which indicate excessive purge or an abnormal air leakage into chiller.

2.5.10 Tools

One complete set of special tools, as recommended by the manufacturer for field maintenance of the system, must be provided. Tools must be mounted on a tool board in the equipment room or contained in a toolbox as directed by the Contracting Officer.

2.6 ACCESSORIES

2.6.1 Refrigerant Leak Detector

Detector must be the continuously-operating, halogen-specific type. Detector must be appropriate for the refrigerant in use. Detector must be specifically designed for area monitoring and must include a single sampling point installed where indicated. Detector design and construction must be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector must have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector must be supplied factory-calibrated for the appropriate refrigerant(s). Detector must be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant(s) in use. The detector's relay must be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector must be provided with a failure relay output that energizes when the monitor detects a fault in its operation.

2.6.2 Refrigerant Relief Valve/Rupture Disc Assembly

The assembly must be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly must be in accordance with ASME BPVC SEC VIII D1 and ANSI/ASHRAE 15 & 34. The assembly must be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc must be the non-fragmenting type.

2.6.3 Refrigerant Signs

Refrigerant signs must be a medium-weight aluminum type with a baked enamel finish. Signs must be suitable for indoor or outdoor service. Signs must have a white background with red letters not less than 0.5 inches in height.

2.6.3.1 Installation Identification

Each new refrigerating system must be provided with a refrigerant sign which indicates the following as a minimum:

- a. Contractor's name.
- b. Refrigerant number and amount of refrigerant.
- c. The lubricant identity and amount.
- d. Field test pressure applied.

2.6.3.2 Controls and Piping Identification

Refrigerant systems containing more than 110 lb of refrigerant must be provided with refrigerant signs which designate the following as a minimum:

- a. Valves or switches for controlling the refrigerant flow and the refrigerant compressor(s).
- b. Pressure limiting device(s).
- 2.6.4 Automatic Tube Brush Cleaning System
- 2.6.4.1 Brush and Basket Sets

One brush and basket set (one brush and two baskets) must be furnished for each condenser tube. Brushes must be made of nylon bristles, with titanium wire. Baskets must be polypropylene.

2.6.4.2 Flow-Diverter Valve

Each system must be equipped with one flow-diverter valve specifically designed for the automatic tube brush cleaning system and have parallel flow connections. The flow-diverter valve must be designed for a working pressure of 150 psig. End connections must be flanged. Each valve must be provided with an electrically operated air solenoid valve and position indicator.

2.6.4.3 Control Panel

The control panel must provide signals to the diverter valve at a preset time interval to reverse water flow to drive the tube brushes down the tubes and then signal the valve to reverse the water flow to drive the brushes back down the tubes to their original position. The controller must have the following features as a minimum:

- a. Timer to initiate the on-load cleaning cycle.
- b. Manual override of preset cleaning cycle.
- c. Power-on indicator.
- d. Diverter-position indicator.
- e. Cleaning-cycle-time adjustment
- f. Flow-switch bypass.
- 2.6.5 Gaskets

Gaskets must conform to ASTM F104 - classification for compressed sheet with nitrile binder and acrylic fibers for maximum 700 degrees F service.

2.6.6 Bolts and Nuts

Bolts and nuts, except as required for piping applications, must be in accordance with ASTM A307. The bolt head must be marked to identify the manufacturer and the standard with which the bolt complies in accordance with ASTM A307.

2.7 FABRICATION

2.7.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, must be factory finished with the manufacturer's standard finish, except that items located outside of buildings must have weather resistant finishes that will withstand 125 hours exposure to the salt spray test specified in ASTM B117 using a 5 percent sodium chloride solution. Immediately after completion of the test, the specimen must show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 1/8 inch on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used must be coated with a zinc-rich coating conforming to ASTM D520, Type I.

2.7.2 Factory Applied Insulation

Chiller must be provided with factory installed insulation on surfaces subject to sweating including the water cooler, suction line piping, economizer, and cooling lines. Insulation on heads of coolers may be field applied, however it must be installed to provide easy removal and replacement of heads without damage to the insulation. Where motors are the gas-cooled type, factory installed insulation must be provided on the cold-gas inlet connection to the motor per manufacturer's standard practice. Factory insulated items installed outdoors are not required to be fire-rated. As a minimum, factory insulated items installed indoors must have a flame spread index no higher than 75 and a smoke developed index no higher than 150. Factory insulated items (no jacket) installed indoors and which are located in air plenums, in ceiling spaces, and in attic spaces must have a flame spread index no higher than 25 and a smoke developed index no higher than 50. Flame spread and smoke developed indexes must be determined by ASTM E84. Insulation must be tested in the same density and installed thickness as the material to be used in the actual construction. Material supplied by a manufacturer with a jacket must be tested as a composite material. Jackets, facings, and adhesives must have a flame spread index no higher than 25 and a smoke developed index no higher than 50 when tested in accordance with ASTM E84.

2.8 FACTORY TESTS

2.8.1 Chiller Performance Test

The Contractor and proposed chiller manufacturer shall be responsible for performing the chiller factory test to validate the specified full load capacity, full load EER, and IPLV in accordance with AHRI 550/590 I-P except as indicated. The Contractor and chiller manufacturer must provide to the Government a certified chiller factory test report in accordance with AHRI 550/590 I-P to confirm that the chiller performs as specified. Tests must be conducted in an AHRI certified test facility in conformance with AHRI 550/590 I-P procedures and tolerances, except as indicated. At a minimum, chiller capacity must be validated to meet the scheduled requirements indicated on the drawings. Tolerance or deviation must be in strict accordance with AHRI 550/590 I-P. Stable operation at minimum load of 10 percent of total capacity must be demonstrated during the factory test.

2.8.1.1 Temperature Adjustments

Temperature adjustments must adhere to AHRI 550/590 I-P to adjust from the design fouling factor to the clean tube condition. Test temperature adjustments must be verified prior to testing by the manufacturer. There must be no exceptions to conducting the test with clean tubes with the temperature adjustments per AHRI 550/590 I-P. The manufacturer must clean the tubes prior to testing to obtain a test fouling factor of 0.0000.

2.8.1.2 Test Instrumentation

The factory test instrumentation must be per AHRI 550/590 I-P and the calibration must be traceable to the National Institute of Standards and Technology.

2.8.1.3 Equipment Adjustments

If the equipment fails to perform within allowable tolerances, the manufacturer must be allowed to make necessary revisions to his equipment and retest as required. The manufacturer shall assume all expenses incurred by the Government to witness the retest.

2.8.2 Chiller Sound Test

Chillers must be sound tested at the factory prior to shipment to confirm the sound pressure level specified herein. Tests and data must be conducted and measured in strict accordance with AHRI 575 at the full load system operating conditions. The chiller sound pressure level, in decibels (dB), with a reference pressure of 20 micropascals, must not exceed 85 dB, A weighted. Ratings must be in accordance with AHRI 575. No reduction of entering condenser water temperature or raising of leaving chilled water temperature will be allowed. A minimum of 75 percent of the sound data points must be taken along the length of the machine, and established as the minimum percentage of total possible points used to determine sound levels. In the event that the chiller does not meet the dBA sound pressure level, the manufacturer shall, at his expense, provide sufficient attenuation to the machine to meet the specified value. This attenuation must be applied in such a manner that it does not hinder the operation or routine maintenance procedures of the chiller. The attenuation material, adhesives, coatings, and other accessories must have surface burning characteristics as determined by ASTM E84.

2.9 SUPPLEMENTAL COMPONENTS/SERVICES

2.9.1 Temperature Controls

Chiller control packages must be fully coordinated with and integrated into the temperature control system indicated in Section 23 30 00 HVAC AIR DISTRIBUTION and Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC .

PART 3 EXECUTION

3.1 INSTALLATION

Installation of water chiller systems including materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing must be in accordance with the manufacturer's written installation instructions.

3.1.1 Installation Instructions

Provide manufacturer's standard catalog data, at least 5 weeks prior to the purchase or installation of a particular component, highlighted to show features such as materials, dimensions, options, performance and efficiency. Data must include manufacturer's recommended installation instructions and procedures. Data must be adequate to demonstrate compliance with contract requirements.

3.1.2 Vibration Isolation

If vibration isolation is specified for a unit, vibration isolator literature must be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

3.1.3 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.

3.1.4 Verification of Dimensions

Provide a letter including the date the site was visited, conformation of existing conditions, and any discrepancies found.

3.1.5 System Performance Test Schedules

Provide a schedule, at least 2 weeks prior to the start of related testing, for the system performance tests. The schedules must identify the proposed date, time, and location for each test.

3.1.6 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.

3.1.7 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.

3.1.8 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.

3.1.9 Refrigeration System

3.1.9.1 Equipment

Refrigeration equipment and the installation thereof must conform to ANSI/ASHRAE 15 & 34. Necessary supports must be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps, cooling towers, condensers, water coolers, and similar items. Compressors must be isolated from the building structure. If mechanical vibration isolators are not provided, vibration absorbing foundations must be provided. Each foundation must include isolation units consisting of machine and floor or foundation fastenings, together with intermediate isolation material. Other floor-mounted equipment must be set on not less than a 6 inch concrete pad doweled in place. Concrete foundations for floor mounted pumps must have a mass equivalent to three times the weight of the components, pump, base plate, and motor to be supported. In lieu of concrete pad foundation, concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. Concrete pedestal block must be of mass not less than three times the combined pump, motor, and base weights. Isolators must be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Isolators must limit vibration to percent at lowest equipment rpm. Lines connected to pumps mounted on pedestal blocks must be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts must be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Equipment must be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions.

3.1.9.2 Field Refrigerant Charging

a. Initial Charge: Upon completion of all the refrigerant pipe tests, the vacuum on the system must be broken by adding the required charge of dry refrigerant for which the system is designed, in accordance with the manufacturer's recommendations. Contractor must provide the complete charge of refrigerant in accordance with manufacturer's recommendations. Upon satisfactory completion of the system performance tests, any refrigerant that has been lost from the system must be replaced. After the system is fully operational, service valve seal caps and blanks over gauge points must be installed and tightened.

- b. Refrigerant Leakage: If a refrigerant leak is discovered after the system has been charged, the leaking portion of the system must immediately be isolated from the remainder of the system and the refrigerant must be pumped into the system receiver or other suitable container. The refrigerant must not be discharged into the atmosphere.
- c. Contractor's Responsibility: The Contractor must, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps must include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. At no time must more than 3 ounces of refrigerant be released to the atmosphere in any one occurrence. Any system leaks within the first year must be repaired in accordance with the specified requirements including material, labor, and refrigerant if the leak is the result of defective equipment, material, or installation.

3.1.9.3 Oil Charging

Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase must be furnished. One charge must be used during the performance testing period, and upon the satisfactory completion of the tests, the oil must be drained and replaced with the second charge.

3.1.10 Mechanical Room Ventilation

Mechanical ventilation systems must be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

3.1.11 Field Applied Insulation

Field installed insulation must be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except as defined differently herein.

3.1.12 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory.

3.2 FACTORY TEST SCHEDULING AND REPORTS

Provide schedules which identify the date, time, and location for each test. Schedules must be submitted for the Chiller Performance Tests .

Six copies of the certified test report must be forwarded to the Government for approval prior to project acceptance. Calibration curves and information sheets for all instrumentation must be included. Provide copies in bound 8 1/2 by 11 inch booklets. Reports must certify the compliance with performance requirements and follow the format of the required testing standard for the Chiller Performance Tests and the Chiller Sound Tests. Test report must include certified calibration report of all test instrumentation. Calibration report must include certification that all test instrumentation has been calibrated within 6 months prior to the test date, identification of all instrumentation, and certification that all instrumentation complies with requirements of the test standard. Test report must be submitted 1 week after completion of the factory test.

3.3 MANUFACTURER'S FIELD SERVICE

The services of a factory-trained representative must be provided. The representative shall advise on the following:

- a. Hermetic machines:
 - Testing hermetic water-chilling unit under pressure for refrigerant leaks; evacuation and dehydration of machine to an absolute pressure of not over 300 micrometers.
 - (2) Charging the machine with refrigerant.
 - (3) Starting the machine.
- b. Open Machines:
 - (1) Erection, alignment, testing, and dehydrating.
 - (2) Charging the machine with refrigerant.
 - (3) Starting the machine.

3.4 CLEANING AND ADJUSTING

Equipment must be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. Provide temporary filters for all fans that are operated during construction. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. System must be maintained in this clean condition until final acceptance. Bearings must be properly lubricated with oil or grease as recommended by the manufacturer. Belts must be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment must be adjusted to setting indicated or directed. Fans must be adjusted to the speed indicated by the manufacturer to meet specified conditions. At least one week before the official equipment warranty start date, all condenser coils on air-cooled water chillers and split-system water chillers must be cleaned in accordance with the chiller manufacturer's instructions. This work covers two coil cleanings. The condenser coils must be cleaned with an approved coil cleaner by a service technician, factory trained by the chiller manufacturer. The condenser coil cleaner must not have any detrimental affect on the materials or protective coatings on the condenser coils. Testing, adjusting, and balancing must be as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.
3.5 FIELD ACCEPTANCE TESTING

3.5.1 Test Plans

- a. Manufacturer's Test Plans: Within 120 calendar days after contract award, submit the following plans:
 - (1) Water chiller Field Acceptance Test Plan

Field acceptance test plans must be developed by the chiller manufacturer detailing recommended field test procedures for that particular type and size of equipment. Field acceptance test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment, will not be acceptable.

The Contracting Officer will review and approve the field acceptance test plan for each of the listed equipment prior to commencement of field testing of the equipment. The approved field acceptance tests of the chiller and subsequent test reporting.

- b. Coordinated testing: Indicate in each field acceptance test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of tower system controls which interlock and interface with controls for the equipment provided under Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC .
- c. Prerequisite testing: Chillers 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.

Controller must be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.

e. Performance variables: Each test plan must list performance variables that are required to be measured or tested as part of the field test.

Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Chiller manufacturer must furnish with each test procedure a description of acceptable results that have been verified. Chiller manufacturer must identify the acceptable limits or tolerance within which each tested performance variable must acceptably operate.

- f. Job specific: Each test plan must be job specific and must address the particular cooling towers and particular conditions which exist in this contract. Generic or general preprinted test procedures are not acceptable.
- g. Specialized components: Each test plan must include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.
- 3.5.2 Testing
 - a. Each water chiller system must be field acceptance tested in compliance with its approved field acceptance test plan and the resulting following field acceptance test report submitted for approval:
 - b. Manufacturer's recommended testing: Conduct the manufacturer's recommended field testing in compliance with the approved test plan. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field acceptance testing.
 - c. Operational test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every two hours. Use the test report forms for logging the operational variables.
 - d. Notice of tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.
 - e. Report forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment must be reviewed, approved, and signed by the Contractor's test director. The manufacturer's field test representative must review, approve, and sign the report of the manufacturer's recommended test. Signatures must be accompanied by the person's name typed.
 - f. Deficiency resolution: The test requirements acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations and corrections retested in order to verify compliance.

3.6 SYSTEM PERFORMANCE TESTS

Six copies of the report must be provided in bound 8 1/2 by 11 inch booklets.

3.6.1 General Requirements

Before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment must be conducted by the manufacturer's approved start-up representative experienced in system start-up and testing, at such times as directed. Tests must cover a period of not less than 48 hours for each system and must demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments must be made as necessary and tests must be re-conducted to demonstrate that the entire system is functioning as specified. Prior to acceptance, service valve seal caps and blanks over gauge points must be installed and tightened. Any refrigerant lost during the system startup must be replaced. If tests do not demonstrate satisfactory system performance, deficiencies must be corrected and the system must be retested. Tests must be conducted in the presence of the Contracting Officer. Water and electricity required for the tests will be furnished by the Government. Any material, equipment, instruments, and personnel required for the test must be provided by the Contractor. Field tests must be coordinated with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.7 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.

-- End of Section --

SECTION 23 73 13.00 40

MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS 05/17

PART 1 GENERAL

1.1 REFERENCES

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

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

AMCA 99	(2016) Standards Handbook
AMCA 211	(2013; Rev 2017) Certified Ratings Program Product Rating Manual for Fan Air Performance
AMCA 300	(2014) Reverberant Room Method for Sound Testing of Fans
AIR-CONDITIONING, HEATIN	NG AND REFRIGERATION INSTITUTE (AHRI)
AHRI 430 I-P	(2014) Performance Rating of Central Station Air-handling Unit Supply Fans
AHRI 880 I-P	(2011) Performance Rating of Air Terminals
AMERICAN SOCIETY OF HEA ENGINEERS (ASHRAE)	FING, REFRIGERATING AND AIR-CONDITIONING
ASHRAE 51	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
ASHRAE 52.2	(2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASTM INTERNATIONAL (AST	(1)
ASTM A653/A653M	(2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

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

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 21940-11 (2016) Mechanical vibration -- Rotor balancing -- Part 11: Procedures and Tolerances for Rotors with Rigid Behavior NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

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

UNDERWRITERS LABORATORIES (UL)

UL 900

(2015) Standard for Air Filter Units

1.2 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. 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

Installation Drawings; G

Fabrication and Connection Drawings; G

SD-03 Product Data

Equipment and Performance Data; G

Sample Warranty; G

Air Filter Gauges; G

SD-04 Samples

Coating Specimen; G

SD-06 Test Reports

Final Test Reports; G

SD-07 Certificates

List of Product Installations

Certificates of Conformance; G

Unit Cabinet

Fan

Drain Pans

Insulation

Plenums

Multizone AHU

Blow-Through AHU

Spare Parts

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Warranty

1.3 QUALITY CONTROL

Submit a list of product installations for air-handling units showing a minimum of five installed units, similar to those proposed for use, that have been in successful service for at least 5 years. Provide a list that includes the purchaser, address of installation, service organization, and date of installation.

1.3.1 Certification of Conformance

Submit certificates of conformance for the following items, showing conformance with the referenced standards contained in this section:

- a. Unit Cabinet
- b. Fan
- c. Drain Pans
- d. Insulation
- e. Plenums
- f. Multizone AHU
- g. Blow-Through AHU
- h. Spare Parts
- 1.3.2 Sample Warranty

Submit samples of warranty language concurrently with Certificates for review and approval by the Contracting Officer.

Submit a sample warranty for the following items:

- a. Unit Cabinet
- b. Fan
- c. Drain Pans
- d. Insulation

- e. Plenums
- f. Multizone AHU
- g. Blow-Through AHU
- h. Spare Parts
- 1.4 DELIVERY, STORAGE, AND HANDLING

Deliver, handle, and store equipment and accessories in a manner that prevents damage or deformity. Provide temporary skids under units.

1.5 WARRANTY

Final acceptance is dependent upon providing the warranty, based on approved sample warranty, to the Contracting Officer, along with final test reports. Ensure that the warranty is valid for at least 2 years from the date of project closeout, showing Government as the warranty recipient.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Submit equipment and performance data for air-handling units, including use life, total static pressure and coil face area classifications, and performance ratings.

Submit all required fabrication and connection drawings and obtain approval from the Contracting Officer before the start of work shown on these drawings.

Submit drawings and manuals that include a spare parts data sheet, with manufacture's recommended stock levels.

2.2 COMPONENTS

2.2.1 Air-Handling Unit (AHU)

Provide a central-station type, factory-fabricated, and fully assembled AHU. Provide AHU that includes components and auxiliaries in accordance with AHRI 430 I-P. Balance the AHU fan and motor according to ISO 21940-11.

Ensure that the total static pressure and coil face area classification conforms to AMCA 99.

Fans with enlarged outlets are not permitted.

2.2.2 Unit Cabinet

2.2.2.1 Class A and Class B Cabinets

Provide an AHU cabinet suitable for the pressure class shown and has leaktight joints, closures, penetrations, and access provisions. Provide a cabinet that does not expand or contract perceptibly when fans are starting or stopping and that does not pulsate during operation. Reinforce cabinet surfaces with deflections in excess of 0.004167 of unsupported span before acceptance. Stiffen pulsating panels, which produce low-frequency noise due to diaphragming of unstable panel walls, to raise the natural frequency to an easily attenuated level. Fabricate the enclosure from continuous hot-dipped-galvanized steel no lighter than 20 gauge thickness, to match the industry standard. Provide mill-galvanized sheet-metal that conforms to ASTM A653/A653M and that is coated with not less than 1.25 ounces of zinc per square foot of a two-sided surface. Provide mill-rolled structural-steel that is hot-dip-galvanized or primed and painted. Corrosion-protect cut edges, burns, and scratches in galvanized surfaces. Provide primed and painted black carbon steel cabinet construction that complies with this specification.

Provide removable panels to access the interior of the unit cabinet. Provide seams that are welded, bolted, or gasketed and sealed with a rubber-based mastic. Make entire cabinet floor and ceiling hot-dipped-galvanized steel. Provide removable access doors on both sides of all access, filter, and fan sections for inspection and maintenance.

2.2.2.2 Class C Cabinets

Provide an AHU cabinet that is suitable for the pressure class shown and has leaktight joints, closures, penetrations, and access provisions. Provide a cabinet that does not expand or contract perceptibly when the fans are starting or stopping and that does not pulsate during operation. Reinforce cabinet surfaces with deflections in excess of 0.002778 of unsupported span before acceptance by the Contracting Officer. Stiffen pulsating panels, which produce low-frequency noise due to diaphragming of unstable panel walls, to raise the natural frequency to an easily attenuated level. Provide the enclosure that is fabricated from mill-galvanized or primed and painted carbon sheet steel. Provide mill-galvanized sheet metal that conforms to ASTM A653/A653M and that is coated with not less than 1.25 ounces of zinc per square foot of a two-sided surface. Provide mill-rolled structural steel that is hot-dip galvanized or primed and painted. Corrosion-protect edges, burns, and scratches in galvanized surfaces. Provide primed and painted black carbon steel cabinet construction that complies with this specification.

Provide removable panels to access the interior of the unit cabinet. Provide seams that are welded, bolted, or gasketed and sealed with a rubber-based mastic. Make the entire cabinet floor and ceiling hot-dipped galvanized steel. Provide removable access doors on both sides of all access, filter, and fan sections for inspection and maintenance.

2.2.2.3 Cabinet Construction

Where the cabinet size is such that personnel access is possible, strengthen the cabinet floor to permit entry without damaging any component. Hinge and latch the access doors and panels sufficiently close together to preclude leaks caused by distortion, and effectively gasket.

Black carbon steel cabinet construction is acceptable when the following conditions are met:

- a. Coat all interior and exterior surfaces, including the lapped contacting surfaces, with a corrosion-protective coating.
- b. Certify the coating as passing a 500-hour-exposure salt-spray fog test in accordance with ASTM B117.
- c. Immediately after completing the test, provide a coating specimen that

shows no signs of wrinkling, cracking, or loss of adherence and no signs of rust creep beyond 1/8 inch on either side of the scratch mark.

d. Ensure that inspection of interior and exterior cabinet surfaces will pass examination for the same defects as the salt-spray fog test specimen, after 11 months of service and before the guarantee expires.

Interior surfaces of cabinets that are constructed of intact mill-galvanized steel require no further protection.

Provide cabinets with exterior surfaces constructed of mill-galvanized-steel that are left unpainted.

Provide cabinets and casings that are double-walled with 1 inch insulation. Provide a interior wall.

Weigh the fan and motor assembly at the AHU manufacturer's factory for isolator selection. Statically and dynamically balance fan section assemblies, including fan wheels, shafts, bearings, drives, belts, isolation bases, and isolators. Allow isolators to free-float when performing fan balance. Measure vibration at each fan shaft bearing in horizontal, vertical, and axial directions.

Factory install all motors on slide bases to permit adjustment of belt tension.

Provide heavy-duty, open drip-proof, three-phase fan motors, operable at 460 volts (V), 60 hertz (Hz). Provide high-efficiency motors.

Provide a marine-type, vapor-proof service light in the fan segment. Provide a 100 watt (W) service light that is wired to an individual switch and operates on 115 V, single-phase, 60 Hz service that is separate from the main power to the AHU. Provide a single 115 V outlet at the light switch.

2.2.3 Fan

Ensure that fan wheels are dynamically and statically balanced at the factory. Provide a fan with RPM that is 25 percent less than the first critical speed. Provide a fan shaft that is solid, ground and polished steel and coated with a rust inhibitor. Provide V-belt-driven fans that are designed for 50 percent overload capacity. For variable air volume AHUs that are provided with variable-frequency drives, have their fans balanced over the entire range of operation (20 percent to 100 percent RPM). Balancing fans of only 100 percent design of RPM is not acceptable for AHUs to be used with variable-frequency drives.

Mount fans on isolation bases. Internally mount motors on the same isolation bases and internally isolate fans and motors. Install flexible canvas ducts or a vibration absorbent fan discharge seal between the fan and casings to ensure complete isolation. Provide flexible canvas ducts that comply with NFPA 90A.

Provide an overall fan-section depth that is equal to or greater than the manufacturer's free-standing fan.

Locate the fan inlet where it provides not less than one-half fan-wheel diameter clearance from the cabinet wall or the adjacent fan inlet where double wheels are permitted.

Mount the AHU fan drive external to the casing.

Install the AHU fan motor and drive inside the fan cabinet. Provide a motor that conforms to NEMA MG 1 and is installed on an adjustable base. Provide an access door of adequate size for servicing the motor and drive. Provide a belt guard inside the cabinet or interlock the access door with the supply fan so that power to the fan is interrupted when the access door is opened.

2.2.4 Drain Pans

Provide intermediate-coil, 3 inch deep drip pans for each tiered coil bank.

Extend the top pan 12 inches beyond the face of the coil, and extend the bottom pan not less than 24 inches beyond the face of the coil. Where more than two pans are used, make the pan extension proportional. Make adequate supports from the same type of material as the pans or from hot-dip galvanized angle iron with isolation at the interface. Use 22-gauge, AISI Type 304, corrosion-resistant steel for pan material, with silver-soldered joints. Minimum size of the drain opening is 1-1/4 inches. Pipe the pan to the drain.

Extend the integral cabinet drain pan under all areas where condensate is collected and make it watertight with welded or brazed joints, piped to the drain. Provide corrosion protection in condensate collection areas, and insulate against sweating. Provide minimum 14-gauge sheet metal; however 16-gauge double-drain-pan construction is also acceptable.

Provide cooling coil ends that are enclosed by the cabinet and are factory insulated against sweating or drain to a drain pan.

Provide drain pans that are double-pan construction, thermally isolated from the exterior casing with 1 inch thick fiberglass insulation. Provide drain pans that slope to the drain and drain substantially dry by gravity alone when the drains are open.

Provide pans that have a double slope to the drain point.

2.2.5 Insulation

Provide a unit that is internally fitted at the factory with a sound-attenuating, thermal-attenuating, fibrous-glass material not less than 2 inches thick. Ensure that the insulation precludes any condensation on any exterior cabinet surface under conditions that are normal to the unit's installed location. Provide acoustic treatment that attenuates fan noise in compliance with specified noise criteria. Apply material to the entire cabinet with waterproof adhesives and permanent fasteners. Provide adhesive and insulating material in accordance with NFPA 90A.

2.2.6 Plenums

Provide plenums in the following minimum widths:

- a. 6 inches for mounting temperature controls and to separate two or more coils of different size that are mounted in series
- b. 14 inches between face and bypass dampers and upstream accessories and

- at change in cross-section
- c. 24 inches for access sections

2.2.7 Multizone AHU

Provide multizone unit delivery dampers that are part of the manufacturer's standard unit construction and that meet the requirements specified in the paragraph POWER-OPERATED DAMPERS of Section 23 09 33.00 40 ELECTRIC AND ELECTRONIC CONTROL SYSTEM FOR HVAC.

2.2.8 Blow-Through AHU

Fit the blow-through AHU with pressure-equalizing baffles.

2.2.9 Coils

2.2.9.1 Coil Section

Provide a coil section that encases cooling coils and drain pipes. Arrange coils for horizontal air flow. Provide intermediate drain pans for multiple-coils installation. Completely enclose coil headers with the insulated casing with only the connections extending through the cabinet.

2.2.9.2 Coil Pressure and Temperature Ratings

Ensure that the coils are designed for the following fluid operating pressures and temperatures:

SERVICE	PRESSURE	TEMPERATURE	
Hot Water	200 PSI	250 degrees F	
Chilled Water	200 PSI	40 degrees F	

Provide coils that are air-pressure-tested under water at the following minimum pressures:

SERVICE	PRESSURE
Water (hot and chilled)	250 PSI

2.2.9.3 Coil Casings

Provide coils that are factory-tested, dehydrated, vacuum-tested, purged with inert gas, and sealed before shipped to the job site.

Provide stainless-steel casings. Provide cast iron, brass, or copper coil headers. Fit water coil headers with 0.25 inch ips spring-loaded plug drains and vent petcocks. Provide automatic air vents with ball-type isolation valves for each coil that is piped to the drain pan.

2.2.9.4 Chilled Water Coils

Provide 0.625 inch outside diameter copper tubing for coils. Provide fins that are aluminum and mechanically bonded by tubing expansion with a maximum spacing of 12 fins per 1 inch unless otherwise noted. Provide

coils that have supply and return connections on the same end. Provide a maximum of four coil rows.

2.2.9.5 Hot Water Coils

Provide heating coils that have copper tubing aluminum fins.

2.2.9.6 Drainable Coils

Provide drainable coils that are capable of being purged free of water with compressed air.

Provide self-draining coils that have a drain point at the end of every tube and are pitched to that point. Drain provisions include drained headers, U-bends with integral plugs, or nonferrous plugs in cast-iron headers. Provide tubes that drain substantially dry by gravity alone when the drains and vents are open.

2.2.10 Eliminators

Provide eliminators that are SMACNA three-break, hooked-edge design, constructed of reinforced 16 gauge galvanized steel with assembled brazed joints. Provide easily removable eliminator sections for cleaning from the side of the AHU without requiring partial or complete disassembly of the AHU casing.

2.2.11 Filters

2.2.11.1 Filter Housing

Provide factory-fabricated filter sections of the same construction and finish as the unit casings. Provide filter sections that have filter guides and full height, double-wall, hinged, and removable access doors for filter removal. Provide air sealing gaskets to prevent air bypass around filters. Provide visible identification on media frames showing the model number and airflow direction. Where a filter bank is indicated or required, provide a means of sealing to prevent bypass of unfiltered air. Ensure that the filters perform in accordance with ASHRAE 52.2.

2.2.11.2 Replaceable Air Filters

Select filters conforming to UL 900, Class 1. Ensure that when clean filters are exposed to flame, the filters do not contribute fuel when attacked by flame and emit only negligible amount of smoke. Provide permanent frames with replaceable media, 1 inch thickness, size as indicated.

2.2.11.3 Disposable Cartridge Air Filters

Provide UL 900, Class 2, UL-classified, and factory-assembled filters. Provide media of ultra-fine glass fibers having 50 to 55 percent average dust spot efficiencies with a maximum final resistance 0.75-inch water gauge, and maximum face velocity of 500 feet per minute. Construct filter frames of 18 gauge galvanized steel or aluminum with welded or riveted joints. Caulk or gasket the entire assembly to prevent air leakage around the frames. Ensure that the minimum efficiency of the filter is 60 percent per ASHRAE 52.2. 2.2.11.4 Outside Air Filters

Provide an extended-surface, factory-assembled air filters with supported cartridges. Provide extended surface filter units fabricated for disposal when the dust-load limit is reached as indicated by maximum (final) pressure drop.

Filter Classification: UL-approved for Class 1 or 2 conforming to UL 900.

Filter Grades, Nominal Efficiency and Application:

a. Grade B: 80 to 85 percent nominal efficiency outfitter

b. Grade D: 25 to 30 percent nominal efficiency prefilter

Filter Media: Grade B Supported (Rigid Pleated) Type: Provide media that is composed of high-density glass fibers. Use fastening methods to maintain pleat shape, seal aluminum separators in a proper enclosing frame to ensure that there is no air leakage for the life of filter. Staples and stays are prohibited.

Grade D Type: Provide media that is composed of synthetic/natural fibers. Bond a metal grid backing to the air leaving side of the media to maintain uniform pleat shape and stability for proper airflow and maximum dust loading. Provide a media frame that is constructed of high-strength, moisture-resistant fiber or beverage board. Bond the pleated media pack on all four edges to ensure that there is no air leakage for the life of the filter. Staples and stays are prohibited.

Filter Efficiency and Arrestance: Determine the efficiency and arrestance of filters in accordance with ASHRAE 52.2 Standard Atmospheric dust spot efficiency and synthetic dust weight arrestance that is not less than the following:

	Initial Efficiency (Percent)	Average Efficiency (Percent)	Final Efficiency (Percent)
Grade B	58	79	98
Grade D	Less than 20	22	89

Maximum initial and final resistance and inches of water gauge for each filter cartridge when operated at a face velocity of 500-feet per minute are as follows:

	Initial Resistance	Final Resistance
Grade B, Rigid Pleated	0.60	1.00
Grade D, 2-inches deep	0.32	0.70

Dust-Holding Capacity: When tested to 1.00 inch w.g. at 500 feet per minute face velocity, provide a dust-holding capacity from each 24 inch by 24 inch (face area) filter that is at least equal to the values listed below. For other filter sizes, provide a dust-holding capacity that is proportionally higher or lower.

Grade	Β,	Rigid Pleated	6.17	ounces
Grade	D,	2 inches Deep	2.29	ounces
Grade	D,	4 inches Deep	10.58	ounces

Minimum Media Area: Provide a minimum net effective area in square feet for each 24 inch by 24 inch (face area) filter at 500 feet per minute face velocity of at least the values listed below. For other filter sizes, provide a net effective media that is proportionally higher or lower.

Grade B, Rigid Pleated 57.0 Grade D, 2-inches Deep 14.8

2.2.11.5 Air Filter Gauges

Provide manometer air filter gauges of the inclined tube differential type that have solid acrylic plastic construction with a built-in level vial and with an adjustable mirror-polished scale. Equip gauges with vent valves for zeroing and over-pressure safety traps. Ensure that the gauge range is adequate for the particular installation.

Provide one air filter gauge at each filter bank.

PART 3 EXECUTION

3.1 PREPARATION

Coordinate the size and location of concrete equipment pads, variable frequency drives, control, and electrical requirements.

3.2 INSTALLATION

Install equipment in accordance with the manufacturer's recommendations.

Provide installation drawings in accordance with referenced standards in this section.

3.2.1 Temporary Construction Filters

Have temporary construction filters in place during normal building construction whenever the AHUs are run for general ventilation, building dehumidification, or other purposes during construction. Install two layers of blanket filter at a time. Replace temporary construction filters as required during construction and after duct system cleaning is completed.

After systems have been cleaned and temporary construction filters are removed, and before test and balance operations are started, install a set of final filters. Avoid loading the filter with construction dust; do not have final filters in place while general building construction is taking place. Clean the permanent filter bank before testing and balancing.

The maximum number of coil rows is four. Maximum number of fins per inch is ten.

Provide variable air volume (VAV) terminal units that are certified by AHRI 880 I-P and UL-listed.

3.3 FIELD QUALITY CONTROL

3.3.1 Vibration Analyzer

Use an Fast Fourier Transform (FFT) analyzer to measure vibration levels. The following characteristics are required: A dynamic range greater than 70 dB; a minimum of 400-line resolution; a frequency response range of 5 Hz to 10 KHz(300-600000 cpm); the capacity to perform ensemble averaging, the capability to use a Hanning window; auto-ranging frequency amplitude; a minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB.

Use an accelerometer, either stud-mounted or mounted using a rare earth, low-mass magnet and sound disk (or finished surface) with the FFT analyzer to collect data. Ensure that the mass of the accelerometer and its mounting have minimal influence on the frequency response of the system over the selected measurement range.

3.3.2 Acceptance

Before final acceptance, use dial-indicator gauges to demonstrate that the fan and motor are aligned as specified.

Before final acceptance, verify conformance to specifications using vibration analysis. Ensure that the maximum vibration levels are 0.075 inches per second at 1 times run speed and at fan/blade frequency, and 0.04 inches per second at other multiples of run speed.

3.3.3 AHU Testing

Conduct performance test and rate the AHU and components in accordance with AMCA 211, AMCA 300, and ASHRAE 51. Provide AHU ratings in accordance with AHRI 430 I-P.

Provide final test reports to the Contracting Officer. Provide reports with a cover letter/sheet clearly marked with the system name, date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

Perform AHU start-up in the presence of the Contracting Officer.

3.4 CLOSEOUT ACTIVITIES

3.4.1 Operation And Maintenance

Submit operation and maintenance manuals before testing the AHUs. Update and resubmit data for final approval no later than 30 calendar days before contract completion.

3.4.2 Acceptance

With the warranty, provide a cover letter/sheet clearly marked with the system name, date, and the words "Equipment Warranty" - "Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

-- End of Section --

SECTION 23 80 20.00 10

GAS-FIRED HEATING EQUIPMENT 05/20

PART 1 GENERAL

1.1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI	Z21.66/CGA 6.14	(2015; R 2020) Automatic Vent Damper Devices for Use with Gas-Fired Appliances
ANSI	Z21.86/CSA 2.32	(2016) Vented Gas-Fired Space Heating Appliances
ANSI	Z83.4/CSA 3.7	(2017) Non-Recirculating Direct Gas-Fired Heating and Forced Ventilation Appliances for Commercial and Industrial Application
ANSI	Z83.8/CSA 2.6	(2016; Errata 2017) Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters, and Gas-Fired Duct Furnaces
ANSI	Z83.19/CSA 2.35	(2017) Gas-Fired High-Intensity Infrared Heaters

CSA GROUP (CSA)

CSA Directory (updated continuously online) Product Index

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 54	(2021)	National	Fuel	Gas	Code	
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NFPA 2	211 (2019)	Standard i	for Chimneys,	Fireplaces,
	Vents,	and Solid	Fuel-Burning	Appliances

UNDERWRITERS LABORATORIES (UL)

UL	FLAMMABLE	&	COMBUSTIBLE	(201	L2)	Flammable	and	Combustible	Liquids
				and	Gas	es Equipm	ent I	Directory	

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. 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 Installation; G

SD-03 Product Data

Spare Parts; G

SD-06 Test Reports

Testing, Adjusting, and Balancing; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions; G

1.3 QUALITY ASSURANCE

Submit detail drawings consisting of illustrations, schedules, performance charts, instructions, brochures, diagrams, and other information to illustrate the requirements and operation of the system. Detail drawings for space heating equipment, controls, associated equipment, and for piping and wiring. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

1.4 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings, and not later than 3 months prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 General

Provide materials and equipment which are standard products of a manufacturer regularly engaged in manufacturing of the products and that essentially duplicate equipment that has been in satisfactory use at least 2 years prior to bid opening. All gas fired appliances shall meet the requirements of NFPA 54.

2.1.2 Nameplates

Secure a plate to each major component of equipment containing the

manufacturer's name, address, type or style, model or serial number, and catalog number. Also, affix an ENERGY STAR label as applicable.

2.1.3 Equipment Guards

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts so located that any person may come in close proximity thereto shall be completely enclosed or guarded. High-temperature equipment and piping so located as to endanger personnel or create a fire hazard shall be guarded or covered with insulation of type specified for service.

2.2 ELECTRICAL WORK

Electrical motor driven equipment shall be provided complete with motors, motor starters, and controls. Motors shall conform to NEMA MG 1. Electrical equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics shall be as specified or indicated. Integral size motors shall be premium efficiency type in accordance with NEMA MG 1. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control specified. Each motor shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. 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.

2.3 HEATERS

Heaters shall be equipped for and adjusted to burn natural gas. Each heater shall be provided with a gas pressure regulator that will satisfactorily limit the main gas burner supply pressure. Heaters shall have an intermittent or interrupted electrically ignited pilot or a direct electric ignition system. Safety controls shall conform to the ANSI standard specified for each heater. Mounting brackets and hardware shall be furnished by the heater manufacturer and shall be factory finished to match the supported equipment. Seismic details shall be as indicated.

2.3.1 Direct Fired Make-Up Air Heaters

Heaters shall be in accordance with ANSI Z83.4/CSA 3.7. Direct fired make-up air heaters use outside air directly ducted to the heater. The products of combustion generated by the heater are released into the outside air stream being heated. Heaters shall be equipped with motorized inlet and outlet dampers, duct collar, air filters, and bird screen. Gas control valve shall be modulating type. Maximum air temperature rise during minimum burner fire shall be 7 degrees F. Fan shall be variable speed. Outdoor heaters shall be weatherized and shall have manufacturer's standard exterior finish for outdoor units. Motorized inlet and outlet dampers shall be closed when the unit is shut down. Dampers shall be interlocked to prevent burner operation when dampers are closed. Heaters shall be provided with a thermostat, a low limit air stream thermostat, and an ambient air thermostat. The thermostat shall control the gas control valve. The low limit air stream thermostat shall shut down the entire unit if the discharge air temperature drops below the thermostat setting. The ambient air thermostat shall shut down the burner if the outside air exceeds the thermostat setting.

2.3.2 Indirect Fired Make-Up Heaters

Heaters shall be in accordance with ANSI and CSA Standards. Heaters shall be equipped with motorized inlet dampers, duct collar, and air filters. Gas control valve shall be modulating type. Maximum air temperature rise during minimum burner fire shall be 7 degrees F. Fan shall be two speed, with low speed approximately two-thirds of high speed. Motorized inlet dampers shall be closed when the unit is shut down. Dampers shall be interlocked to prevent burner operation when dampers are closed. Heaters shall be provided with a space thermostat, a low limit air stream thermostat, and an ambient air thermostat. The space thermostat shall control the modulating gas control valve. The low limit air stream thermostat shall shut down the entire unit if the discharge air temperature drops below the space thermostat setting. The ambient air thermostat shall shut down the burner if the outside air exceeds the space thermostat setting.

2.3.3 Unit Heaters

Heaters shall conform to requirements of ANSI Z83.8/CSA 2.6. Heat exchangers shall be aluminized steel or stainless steel. Air discharge section shall be equipped with adjustable horizontal louvers. Fan shafts shall be either directly connected to the driving motor, or indirectly connected by multiple V-belt drive. Fans in one unit shall be of the same size. Heaters shall be power-vented type, suitable for sidewall vent discharge and single-wall-thickness vent piping. Heaters shall have automatic ignition. Heaters shall employ metered combustion air with enclosed draft diverter (no open flue collar). Heaters shall be provided with a space thermostat which controls both unit's fan and burner.

2.3.4 Wall Furnace

Wall furnace shall be the gravity type in accordance with ANSI Z21.86/CSA 2.32 and as indicated. Furnace shall be provided with a space thermostat which controls both the unit's fan and burner.

2.3.5 Duct Furnace

Duct furnace shall be in accordance with ANSI Z83.8/CSA 2.6. Furnace shall be power-vented type, suitable for sidewall vent discharge and single wall thickness vent piping. Furnace shall have automatic ignition. Furnace shall employ metered combustion air with enclosed draft diverter (no open flue collar). Furnace heat exchangers shall be aluminized steel or stainless steel. Furnace shall have minimum steady state thermal efficiency of 80 percent at maximum rated capacity and 75 percent at minimum rated capacity that is provided and allowed by the controls. Furnace shall be provided with a thermostat which controls the unit's burner.

2.3.6 Infrared Heaters

Heaters shall conform to the requirements of ANSI Z83.19/CSA 2.35 and shall be vented or unvented type. Heater style shall be surface combustion type. Reflector shape shall be parabolic or standard. Heaters shall be provided with space thermostats which control the unit's burner. Thermostats located in the direct radiation pattern shall be covered with a metal shield.

2.4 THERMOSTATS

Thermostats shall be the adjustable electric or electronic type. Control wiring required to complete the space temperature control system shall be included. Thermostats shall have a 3 degree F differential and a set point range of 0 to 100 degrees F. Thermostats shall be the single stage type.

2.5 VENT PIPING

Vent piping shall conform to the requirements of NFPA 54. Plastic material polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.6 ELECTRIC AUTOMATIC VENT DAMPERS

Electric automatic vent dampers shall conform to the requirements of ANSI Z21.66/CGA 6.14 and shall be provided in the vents of heaters using indoor air for combustion air.

2.7 INSULATION

Insulation for piping and equipment and application shall be in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.8 FACTORY FINISHES

Equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

install equipment as indicated and in accordance with the recommendations of the equipment manufacturer and the listing agency, except as otherwise specified.

3.2.1 Heating Equipment

Install heaters with clearance to combustibles, complying with minimum distances as determined by CSA Directory, UL FLAMMABLE & COMBUSTIBLE and as indicated on each heater approval and listing plate. Support heaters independently from the building structure, as indicated, but not relying on suspended ceiling systems for support.

3.2.2 Vents

Locate vent dampers, piping and structural penetrations as indicated. Vent damper installation shall conform to ANSI Z21.66/CGA 6.14. Vent pipes, where not connected to a masonry chimney conforming to NFPA 211, shall extend through the roof or an outside wall and shall terminate, in compliance with NFPA 54. Vents passing through waterproof membranes shall be provided with the necessary flashings to obtain waterproof installations.

3.2.3 Gas Piping

Connect gas piping as indicated.

3.3 TRAINING

Conduct a training course for the maintenance and operating staff. The training period of 4 hours normal working time shall start after the system is functionally complete but before the final acceptance tests. Give the Contracting Officer at least two weeks advance notice of such training. The training shall include all of the items contained in the approved operation and maintenance instructions as well as demonstrations of routine maintenance operations. Submit 6 complete copies of operating instructions outlining the step-by-step procedures required for system startup, operation and shutdown. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and basic operating routine maintenance, possible breakdowns, repairs and troubleshooting guide. The instructions shall include simplified piping, wiring, and control diagrams for the system as installed.

3.4 TESTING, ADJUSTING, AND BALANCING

Perform testing, adjusting, and balancing as specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. 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 shall indicate the final position of controls.

-- End of Section --

SECTION 23 82 19.00 40

FAN COIL UNITS 05/17

PART 1 GENERAL

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

1.1 REFERENCES

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

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S12.23 (1989; R 2016) Method for the Designation of Sound Power Emitted by Machinery and Equipment

AIR-CONDITIONING, HEATING AND REFRIGERATION INSTITUTE (AHRI)

AHRI 440 (2008) Performance Rating of Room Fan-Coils

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1

(2003; R 2008) Mechanical Vibration -Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerances

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (2018) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

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

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-810 (2019; Rev H) Environmental Engineering Considerations and Laboratory Tests

UNDERWRITERS LABORATORIES (UL)

UL 1995 (2015) UL Standard for Safety Heating and Cooling Equipment

UL Bld Mat Dir (updated continuously online) Building Materials Directory

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. 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; G,

Installation Drawings; G

SD-03 Product Data

Equipment and Performance Data; G

Coils; G

Casing; G

Enclosure; G

Motors; G

Fan; G

Drain Pans; G

Filters; G

Controls; G

Vibration Isolation; G

SD-04 Samples

Manufacturer's Standard Color Chart; G

SD-07 Certificates

List of Product Installations

Certificates of Conformance

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals

SD-11 Closeout Submittals

Warranty

1.3 QUALITY ASSURANCE

Submit a list of product installations for fan coil units showing a minimum of five installed units, similar to those proposed for use, that

have been in successful service for a minimum of 5 years. Include the name of the purchaser, address of installation, name of service organization, and date of installation.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Include an enclosure for cabinet models and a casing for concealed models.

Provide a base unit complete with galvanized casing, a water coil assembly with an auxiliary water or steam heating-coil, valve and piping package, drain pans, air filter, fan motor, and motor control. Ensure that the sound power level, as measured in decibels at 10 to the minus 12 watt at the fan operating speed selected to meet the specified capacity, does not exceed the following values at the midfrequency of each octave band:

OCTAVE BANDS								
3rd 4th 5th 6th 7th								
Frequency (hertz)	250	500	1,000	2,000	4,000			
Power Level (decibels)	60	55	53	50	48			

Obtain values for sound power level for these units in accordance with the test procedures specified in ASA S12.23. Sound power values apply to units provided with factory-fabricated cabinet enclosures and standard grilles. Values obtained for the standard cabinet models are acceptable for concealed models without the need for separate tests, provided there is no variation between models as to the coil configuration, blowers, motor speeds, and relative arrangement of parts. Fasten each unit securely to the building structure. Ensure that the capacity of the units is as indicated. Ensure that room fan coil units are certified as complying with AHRI 440 and meet the requirements of UL 1995.

2.2 COMPONENTS

Provide a list of material and equipment including the manufacturer's style or catalog numbers, specification and drawing reference numbers, and warranty information.

Submit fabrication drawings for fan coil units including the fabrication and assembly details performed in the factory.

Submit equipment and performance data for fan coil units including information on the service life, system functional flows, safety features, and mechanical automated details. Also submit curves indicating that the equipment response and performance characteristics, including vibration isolation have been tested and certified. Submit certificates of conformance for the following:

- a. Enclosure
- b. Casing
- c. Fan

- d. Coils
- e. Drain Pans
- f. Filters
- g. Motors
- h. Controls

Submit product data for vibration isolation components.

Submit the manufacturer's standard color chart, indicating the manufacturer's standard color selections and finishes for fan coil units.

2.2.1 Enclosure

Construct an enclosure of 18-gage or heavier steel, properly reinforced and braced. Ensure that the front panel of the enclosure is removable. Ensure that discharge louvers are four-way adjustable and are designed to properly distribute air throughout the conditioned space. Ensure that ferrous surfaces are galvanized or treated with a rust-inhibiting finish. Ensure that exposed enclosure corners and edges are rounded. Ensure that discharge louvers are mounted in a top panel that can be removed to allow for coil cleaning. Ensure that access doors are hinged and provided for all piping and control compartments. Ensure that the finish is in the manufacturer's standard color, as selected by the Contracting Officer.

2.2.2 Casing

Ensure that the interior of the casing is acoustically and thermally insulated with insulation that is not less than 1/2-inch thick, that conforms to NFPA 90A, and that is fastened with waterproof and fire-resistant adhesive.

2.2.3 Fan

Provide a centrifugal fan made of galvanized steel or aluminum, with blades. In lieu of metal, fabricate or mold the wheels and scrolls from reinforced nonmetallic compounds certified to have passed the low-temperature, high-temperature, temperature-shock, and sand and dust tests for ground equipment, as outlined in MIL-STD-810. Ensure that the fan passes tests without showing characteristics that indicate deformation, cracking, corrosion, or loss of balance. Ensure that surfaces are smooth, that assemblies are accessible for maintenance, and that disassembly and reassembly are done by mechanical fastening devices, not adhesives. After the fan is assembled in the unit, ensure that the fan was dynamically and statically balanced to ISO 1940-1 standards at the factory.

2.2.4 Coils

Ensure that the water coil was constructed with not less than 1/2-inch outside diameter (OD) seamless copper tubing with copper or aluminum plate fins mechanically bonded or soldered to the tubes. Ensure that the coil construction includes at least 5/8-inch OD female solder connectors, an accessory piping package with terminal connections for control valves, and manual air vents on returns. Make provisions for coil removal.

2.2.5 Drain Pans

Size and locate drain pans to collect condensed water dripping from any item within the unit enclosure. Do not construct drain pans of galvanized steel that is lighter than 20-gage and thermally insulated to prevent condensation. Coat the thermal insulation with a waterproofing compound. Provide a copper drain connection in the drain pan that is no less than 3/4-inch National Pipe Thread (NPT) or 5/8-inch OD. Ensure that the drain pan slopes not less than 1/8-inch per foot to the drain.

2.2.6 Filters

For each unit, provide filters that are glass fiber throwaway or permanent and washable, with a 1 inch nominal thickness, in conformance with UL Bld Mat Dir. Ensure that filters can be removed without tools.

2.2.7 Motors

Provide permanent split-capacitor motors that are direct connected, two-bearing, and built-in overload protection, and that conform to NEMA MG 1. Mount motors on a resilient base. Furnish motors with three built-in speeds and with four insulated leads (common, high, medium, and low) that terminate in a control-junction box.

When specified, provide a solid-state variable speed controller capable of not less than 50 percent speed reduction in lieu of step speed control.

2.2.8 Controls

Provide a unit with factory-installed control valves furnished by the automatic temperature-control manufacturer.

Ensure that the motor speed-control switch provides for speed selection, has an off position, and is mounted for convenient use from an access door.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment in accordance with the manufacturer's recommendations. Set the dampers in a fixed position to provide outside air in the quantity scheduled.

Submit installation drawings for fan coil systems in accordance with referenced standards in this section.

Contain thermal and acoustical insulation within a double-walled enclosure or seal the insulation with a moistureproof coating impervious.

Install the controls in a unit-mounted control panel. Provide remote-mounted controllers where indicated.

3.2 FIELD QUALITY CONTROL

Hydrostatically the test coils at 250 pounds per square inch (psi) or under water at 250 psi air pressure. Ensure that the coils are suitable for 200 psi working pressure.

3.3 CLOSEOUT ACTIVITIES

Submit six copies of the operation and maintenance manuals at least 30 calendar days before the fan coil units are tested. Update and resubmit data for final approval no later than 30 calendar days before contract completion.

Submit the manufacturer's standard warranty to the Contracting Officer.

-- End of Section --