

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water closets.
2. Urinals.
3. Lavatories.
4. Sinks.
5. Supply and drain boxes.
6. Emergency fixtures.
7. Drinking fountains.
8. ADA plumbing fixture piping insulation.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200548 - Mechanical Vibration and Seismic Control
4. 200553 - Mechanical Identification
5. 200700 - Mechanical Insulation
6. 204100 - Mechanical Demolition
7. 221100 - Domestic Water Piping and Specialties
8. 221300 - Sanitary Waste and Vent Piping and Specialties

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. American Society of Safety Engineers (ASSE).

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. See Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.
4. GPF - Gallons Per Flush.
5. PSI - Pounds per Square Inch.
6. PSIG - Pounds per Square Inch Gauge.
7. "Handicap", "handicapped", or "ADA compliant": Refers to fixtures that comply with the requirements of ANSI A117.1.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. This section describes specific requirements, products and methods of execution for plumbing fixtures.
2. Plumbing fixtures in potable water systems shall be lead free as defined by the 2011 Reduction of Lead in Drinking Water Act.

B. Performance Requirements:

1. Potable water systems shall perform quietly, with no objectionable vibration transmitted to the surrounding construction.
2. Replace piping and fixtures that do not perform as intended with properly operating piping and fixtures.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data:

1. Provide plumbing specialty component sizes, rough-in requirements, service sizes, and finishes.
2. Provide catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.

C. Shop Drawings:

1. This Section shop drawings to be submitted under Section 200000 - Mechanical General Requirements.
2. Indicate dimensions and weights of fixtures and equipment, and placement of openings and holes.

- D. Manufacturer's Installation, Operation, and Maintenance (IO&M) Manual.

1.6 CLOSEOUT SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.

1.9 DELIVERY, STORAGE AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 FIXTURES

- A. Traps, Stops and Supplies:
 - 1. Provide traps, stops and supplies for fixtures.
 - 2. Sink/lavatory P-Traps: 17 gauge chrome-plated tubular brass or cast brass.
 - 3. Supplies: Flexible, stainless steel.
 - 4. Stops: Quarter-turn, removable key type. Commercial quality metal components only; no plastic parts.
- B. Escutcheons: Provide chrome plated wall escutcheons for pipe penetrations into walls.
- C. Flush Valve Manufacturers: Sloan, Zurn, no substitutions.
- D. Lavatory Faucet Manufacturers: Delta, Chicago Faucets, no substitutions.
- E. Carriers:
 - 1. Manufacturer: J.R. Smith, Josam, Zurn, MIFAB.
 - 2. Provide carriers for wall mounted fixtures.
- F. Fixtures specified elsewhere, or otherwise furnished:
 - 1. Provide appropriate strainer, tailpiece, trap, waste and supplies.
 - 2. Rough in and connect only.
- G. Handicapped Fixtures:
 - 1. Provide fixtures in compliance with the appropriate standard listed in Part 1.
 - 2. Provide fixtures operable with one hand without grasping, pinching or twisting of the wrist, and requiring not more than five pounds of operating force.
 - 3. Handicap accessible lavatories and sinks: Where piping is exposed, provide fixture insulation assembly. Refer to Section 200700 - Mechanical Insulation.

- H. Sensors operated fixtures: In addition to features described in the Fixture list, provide the following features:
1. General:
 - a. Provide with Infra-red sensors, solid state circuitry, 24 VDC operation.
 - b. Provide battery operated fixtures.
 - c. Adjustable sensor range, variable time-out adjustment.
 - d. Filtered solenoid valves.
 2. Flush valves:
 - a. Wall mounted sensors.
 - b. Over-ride button.
 3. Hand faucet:
 - a. ADA compliant.
 - b. Splash proof electronic circuitry.
 - c. Aerator/spray head with pressure compensating flow control.
 - d. Trim plate for 4-inch center-set sink.
 - e. Under-counter control module.
 4. Manufacturer: Sloan, Zurn, Symmons.

2.2 WATER CLOSETS

A. P-1HS - Water Closet:

1. Fixture: Floor mount, floor outlet, 16.5-inch height, siphon jet, elongated bowl, low consumption (1.6 gpf), 1-1/2 inch top spud. Color: White. American Standard Madera FloWise.
2. Flush valve: Sloan Solis model 8110, chrome plated, with automatic sensor actuation, over-ride button and battery backup.
3. Seat: Open front, commercial weight, heavy duty, solid plastic, stainless steel check hinge, without cover, white.
4. ADA: ADA compliant. Handicapped mounting height.

2.3 URINALS

A. P-11HS - Urinal:

1. Fixture: Siphon jet, vitreous china, low consumption (1.0 gpf). Integral flush rim, wall hangers, 3/4 inch top spud. Color: White. American Standard model Trimbrook 1.0.
2. Flush valve: Sloan Solis model 8180, chrome plated, with automatic sensor actuation, over-ride button and battery backup.
3. Carrier: Floor mounted. No residential.
4. ADA: ADA compliant. Handicapped mounting height.

2.4 LAVATORIES

A. P-2HS - Wall Lavatory:

1. Fixture: Wall mounted, vitreous china, 20-1/2 inch by 18-1/4 inch, front overflow, single faucet hole. Color: White. American Standard model Lucerne 0356.421.
2. Faucet: Electronic proximity, battery powered, deck mounted. American Standard Selectronic 6055.105.
3. Mixing Valve: Thermostatic, ASSE 1070 listed and labeled. Leonard 270-LF or equal.
4. Drain: Metal grid strainer.
5. Floor mounted carrier. No residential.
6. ADA: ADA compliant. Handicapped mounting height.

B. P-10HS - Counter Lavatory:

1. Fixture: Counter mounted, vitreous china, self-rimming, 20-3/8 inch by 17-3/8 inch oval, front overflow, faucet ledge, single faucet hole. Color: White. American Standard model Aqualyn 0475.047.
2. Faucet: Electronic proximity, battery powered, deck mounted. American Standard Selectronic 6055.105.
3. Mixing Valve: Thermostatic, ASSE 1070 listed and labeled. Leonard 270-LF or equal.
4. Drain: Metal grid strainer.
5. ADA: ADA compliant. Pipe drain for handicapped access.

2.5 SINKS

A. D-1 - Dental Treatment Room Sink:

1. Fixture is furnished by others.
2. Rough-in and connect. Provide traps, stops, supplies, and accessories. Coordinate with Owner furnished equipment.

B. D-2 - Dental Treatment Room Sink:

1. Fixture: Single compartment, 18 gauge, type 304 stainless steel, 15 inch by 17-1/2 inch by 10 inch deep, self rimming, sound deadened, with strainer. 2 holes at 4 inches on center. Elkay model DLR151710.
2. Faucet: 8 inch gooseneck swing spout with vacuum breaker, 4 inch wrist blade handles, 2.2 GPM outlet, 4-inch fixed centers. Chicago Faucets 895-317GN8BVBE3MAB.
3. Foot pedal controls: Tapmaster Model 1750 Hands Free Faucet Kick Plate Controller.

C. P-3H - Single Compartment Sink:

1. Fixture: Single compartment, 18 gauge, type 304 stainless steel, 19-1/2 inch by 19 inch by 6-1/2 inch deep, self rimming, sound deadened, with strainer. 2 holes at 4 inches on center. Elkay model LRAD191965.
2. Faucet: Delta HDF Commercial model 2529LF-LGHDF, 4 inch centers.
3. ADA: ADA compliant. Pipe drain for handicapped access.

D. P-4 - Meds Room Sink:

1. Fixture: Single compartment, 18 gauge, type 304 stainless steel, 17 inch by 20 inch by 10-1/8 inch deep, 3 holes for faucet, self-rimming, sound deadened, with strainer. Elkay model DLR172010.
2. Faucet: Faucet with integrated eyewash, 5-1/2 inch gooseneck spout, 4 inch wrist blade handles, 2.2 GPM faucet flowrate, ANSI Z358.1 certified eyewash integrated into spout with pull handle activator, eyewash flip top dust caps, separate supplies for eyewash and faucet. Speakman
3. Eyewash Thermostatic Mixing Valve: ASSE-1071 certified, integral check stops with filters, cold water bypass. Speakman SE-TW-EW with STW-370 mixing valve.

E. P-5 - Single Compartment Lab Sink:

1. Fixture: Single compartment, 18 gauge, type 304 stainless steel, 22 inch by 22 inch by 10-1/8 inch deep, 2 holes for faucet, self-rimming, sound deadened, with strainer. Elkay model DLR222210.
2. Faucet: 6 inch gooseneck swing spout with vacuum breaker, 4 inch wrist blade handles, 2.2 GPM outlet, 4-inch fixed centers. Chicago Faucets 895-300845AB.
3. Foot pedal controls: Tapmaster Model 1750 Hands Free Faucet Kick Plate Controller.
4. For Lab Sinks Only: With Owner Furnished Contractor Installed (OFCI) Plaster Trap PT-1: 64 oz replaceable bottle, Gleco GT-64 (Basis of Design), or approved equal.

F. P-6 - Wash Down Sink:

1. Fixture: Custom fabricated, 14 gauge, type 304 stainless steel sink, 36 inches tall, double bowls at 24" x 24" x 16" deep each, rounded interior corners, with an approximate 12 inch drain board between the two bowls, 8 inch high backsplash. Floor mounted. Two faucets. See Sjoquist Architects EQ drawings for elevation view and additional details. Elkay Model LK50-5656 Custom.
2. Faucet: Wall mount, pre-rinse style with ceramic quarter-turn cartridges, check stops, 24 inch stainless steel spring hose, self-closing 1.6 GPM hand held valve control with spray head, pipe support, and hook. Zurn Z841X1.
3. ADA: ADA compliant.

G. P-7 - Break Room Sink:

1. Fixture: Single compartment, 18 gauge, type 304 stainless steel, 33 inch by 22 inch by 10-1/2 inch deep bowl, self rimming, sound deadened, with strainer. Coordinate faucet hole punching locations for faucet, instant hot water dispenser, and dishwasher airgap fitting. Elkay model DLRS332210.
2. Faucet: Single hole, single handle, with pull down sprayer. ADA compliant. Delta 9159-DST.
3. Hot water dispenser: In-Sink-Erator Model H-HOT100; 200 degrees F, 115 volt, 750 watts.

H. P-7H - Break Room Sink:

1. Fixture: Single compartment, 18 gauge, type 304 stainless steel, 31 inch by 22 inch by 5-1/2 inch deep bowl, self rimming, sound deadened, with strainer. Coordinate faucet hole punching locations for faucet, instant hot water dispenser, and dishwasher airgap fitting. ADA compliant. Elkay model DLRS332210.

2. Faucet: Single hole, single handle, with pull down sprayer. ADA compliant. Delta 9159-DST.
3. Hot water dispenser: In-Sink-Erator Model H-HOT100; 200 degrees F, 115 volt, 750 watts.

I. P-8 - Service Sink:

1. Fixture: Single compartment, floor mounted, structural plastic polymer, 23 inch by 23-1/2 inch by 13 inch deep. Mustee model 17F.
2. Faucet: Chicago Faucets 786-GN2BVBE3-2ABCP.

J. P-12 - Pot Fill Faucet:

1. Faucet: Single hole, wall mount, chrome plated, double-jointed swing spout, 21 inches center-to-center. Full-flow outlet with single-screen design; 2-3/8 inch metal, vandal-proof, lever handle with sixteen-point, tapered broach and secured. Rebuildable compression cartridge, opens and closes 90 degrees, closes with water pressure, features square, tapered stem. 1/2 inch NPT female thread inlet. Meets ADA ANSI/ICC A117.1. Meets and is tested and certified to industry standards: ASME A112.18.1/CSA B125.1, NSF/ANSI 61.
2. Faucet: Chicago Faucets 332-DJ21ABCP.

K. P-13 - Single Compartment Clean Supply Handwash Sink:

1. Fixture: Wall mount single compartment, 20 gauge, type 304 stainless steel, 16.75 inches by 15.5 inches by 13 inches deep, 2 holes for faucet, self-rimming, sound deadened, with strainer. Elkay model LRQ2022.
2. Faucet: 8 inch center set wall mount faucet with 4 inch gooseneck spout, 2 inch lever handles, 1/2 inch offset inlets. Faucet has a flow rate of 1.5 GPM, and is made of chrome-plated brass material, with a quarter turn ceramic disk valve. Faucet requires 2 faucet holes. Ekay model LK940GN04L2H.
3. Foot pedal controls: Tapmaster Model 1750 Hands Free Faucet Kick Plate Controller.

2.6 SUPPLY BOXES

A. P-9 - Icemaker, Coffee Maker, and Refrigerator Outlet Box:

1. Fixture: 18 gage steel box and cover, bottom water supply
2. Piping: Bottom water supply, 1/4-inch compression outlet, 1/2-inch NPT or 5/8-inch OD sweat combo connection inlet.
3. Guy Gray MIB1HAAB.

2.7 PLASTER TRAP

A. PT-1 - Plaster Trap:

1. Fixture: Poly bottle, 64-ounce size, extra bottle with lid, 1-1/2" x 8" tailpiece, 1-1/2" slip joint washers, 1-1/2" slip joint nuts, 1-1/2" flat washer, extra O-ring.
2. Gleco Trap GT64, marketed by Liquid Assets, Inc.

2.8 EMERGENCY FIXTURES

A. EWS-1 - Emergency Eyewash Station:

1. Fixture: Counter mounted, in-line strainer, 90 degree swivel activation. Guardian model G1805.
2. With ASSE 1071 rated tempering valve. Guardian model G3600LF tempering valve.
3. ADA: ADA compliant.

2.9 DRINKING FOUNTAINS AND BOTTLE FILLER STATIONS

A. DF-1H - Drinking Fountain/Bottle Fill:

1. Fixture: Wall mounted, single station with bottle filling station, polished stainless steel, hooded stream projector with push-button controls, perforated strainer, back panel, 1.1-1.5 GPM fill rate. 120 V power connection.
2. Carrier: Floor mounted. No residential.
3. ADA: ADA compliant. Handicapped mounting height.
4. Elkay model LZSDWSLK or approved equal.

B. DF-2H - Bottle Filler Station:

1. Fixture: Wall mounted bottle filling station, surface mounted, polished satin finish stainless steel, filtered, non-refrigerated, sensor operated, laminar flow, piped drain outlet, LED visual filter status indicator, LCD ticker display indicating water bottles saved, 1.5 GPM fill rate, 120 V power connection.
2. Furnish Owner with one spare filter assembly.
3. ADA: ADA compliant.
4. Elkay Model LZWSSM, or approved equal.

2.10 TEMPERING VALVES

A. TV-1 - Thermostatic Tempering Valve:

1. Pressure regulating valve, integral check stops, supply and outlet pressure gauges.
2. Rough bronze finish.
3. Wall mount, no cabinet.
4. Maximum pressure drop 10 psi at 91 GPM.
5. Bradley TMV200 model S59-2200.

2.11 FLOOR DRAINS

A. FS-1 - Floor Sink:

1. Fixture: Cast iron, 16-1/2 inch square top, 12-inch deep, flanged receptor with acid resistant coated interior, nickel bronze rim. Dome bottom strainer. No-hub outlet.
2. Grate: No grate.
3. Trap primer connection.
4. J.R. Smith 3200Y.

- B. Manufacturers: J.R. Smith, Zurn, Josam, MIFAB.

2.12 ADA PLUMBING FIXTURE PIPING INSULATION ASSEMBLY

- A. Manufacturer: Skal+Gard, Model SG-100B, TCI Products, or approved equal.
- B. Description: Protective, molded, fire-resistant foam, single piece insulation manufactured specifically for plumbing fixture supplies and drains.
- C. Performance/Design Criteria: Insulation R factor 2.
- D. Materials:
 - 1. Foam: 4.5 pounds per cubic foot.
 - 2. Skin: White fire retardant polyurethane.
 - 3. Twist fasteners.

PART 3 - EXECUTION

3.1 INSTALLERS

- A. Installer: Perform work by experienced personnel previously engaged in plumbing system construction and fixture installation, and under the supervision of a qualified installation supervisor.

3.2 PREPARATION

- A. Confirm location and size of fixtures and openings before piping rough-in and installation.
- B. Verify that rough-ins have been provided, are correctly sized and are located within dimensional tolerances for fixtures to be installed prior to installation of fixtures.
- C. Interface with other Work: Review Architectural drawings and millwork shop drawings to verify correct fixture locations.

3.3 INSTALLATION

- A. Install piping and plumbing products in accordance with UPC and manufacturer's instructions. Provide seismic anchoring, bracing, supports, and clearance for equipment, piping, and sprinkler heads per UPC, IBC, and ASCE-07; most conservative criteria shall govern.
- B. Provide permanent metal and wire positioners, supports, and carriers to secure fixtures and piping rigidly in proper alignment without sway or sideplay.
- C. Anchor fixtures securely to withstand applied vertical load of not less than 250 pounds on the front of the fixture, without noticeable movement.

- D. Install fixtures plumb, level and to the finished architectural surface, so that the maximum gap between the fixture and the surface does not exceed 3/16 inch. Caulk the edge of the joint between fixture and surface with silicone or butyl type waterproof caulking compound.
- E. Install and connect hot water on left and cold water on right, as viewed when facing the fixture.
- F. Locate flush valve handles on handicapped accessible water closets on the wide side of the stall. Mount Accessible fixtures shown in the ADA guidelines to the heights indicated.
- G. ADA Plumbing Fixture Insulation Assembly:
 - 1. Insulate hot water supply and waste piping exposed beneath sink and lavatory fixtures designated on drawings or specified in this section, as intended for use by the handicapped.
 - 2. Install in accordance with ANSI A117.1.
- H. Coordinate plumbing rough-in with Owner Furnished equipment and fixtures.

3.4 REPAIR/RESTORATION

- A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.
- B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 SITE QUALITY CONTROL

- A. Non-Conforming Work: Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

3.6 ADJUSTING

- A. Adjust functional components for proper operation in accordance with manufacturers' recommendations, or as otherwise directed.

3.7 CLEANING

- A. Clean fixtures and trim to a clean condition. Obtain a written certification from the Owner that this has been accomplished and accepted.

3.8 CLOSEOUT ACTIVITIES

- A. Demonstration: Provide 1hour of demonstration conducted by authorized factory start-up personnel to the Contracting Agencies authorized maintenance personnel.

- B. Training: Provide 1hour of operational instruction conducted by authorized factory start-up personnel to the Contracting Agencies authorized maintenance personnel.

END OF SECTION 224000

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PART 1 - GENERAL

1.1 SUMMARY

- A. Furnish and install complete piped and wired Category 3 medical gas system.
- B. Section includes Medical Gas Systems consisting of Oxygen (O₂), Nitrous Oxide (N₂O), Dental Compressed Air (DA, CA), and Dental Vacuum (DV) systems. These systems shall be installed complete, ready for operation and certified, including necessary piping, fittings, purge ports, valves, cabinets, station outlets and inlets, rough-ins, ceiling services, gauges, alarms (including low voltage wiring) and all necessary parts, accessories, connections and equipment in accordance with NFPA 99.
- C. Related Sections:
 - 1. 019100 - Commissioning
 - 2. 200000 - Mechanical General Requirements
 - 3. 200529 - Mechanical Hangers and Supports
 - 4. 200548 - Mechanical Vibration and Seismic Control
 - 5. 200553 - Mechanical Identification
 - 6. 204100 - Mechanical Demolition
 - 7. 253000 - Building Automation System Field Devices
 - 8. 255000 - Building Automation Systems
 - 9. 259000 - Sequence of Operations

1.2 PRODUCTS NOT FURNISHED BUT CONNECTED BY THIS SECTION

- A. Scope: Make connection to Owner furnished equipment. Pressure test and certify Owner-furnished device. If leaks are detected coordinate repair with manufacturer and Owner. The actual repair of Owner furnished equipment is not in the scope of this section.

1.3 REFERENCES

- A. Provide medical gas systems in accordance with the minimum provisions of the following codes and standards:
 - 1. See Section 200000 - Mechanical General Requirements.
 - 2. ASTM B88 Seamless Copper Water Tube.
 - 3. ASTM B280 Seamless Copper Tubing for Air Conditioning and Refrigeration Field Service.
 - 4. ASTM B819 Seamless Copper Tube for Medical Gas Systems.
 - 5. American Welding Society (AWS) B2.2 Brazing Procedure and Performance Qualifications.
 - 6. NFPA 99 - 2015, Health Care Facilities Code.
 - 7. NFPA 101 - 2012, Life Safety Code (LSC).

8. Facilities Guideline Institute, FGI - 2018 Guidelines for Design and Construction of Health Care Facilities

1.4 SYSTEM DESCRIPTION

- A. Provide complete medical gas system for the facility, complete and fully operational. Comply with the Contract Documents requirements, applicable codes and standards, as well as the Authority Having Jurisdiction requirements.
- B. Final location of outlets and inlets shall be field coordinated and approved by Owner.
- C. Systems to be compatible with, and extension of, existing system, or new, as indicated.
- D. Contractor shall coordinate with phasing and temporary services as required for maintaining existing healthcare facility operational services, temporary connections, and routing. Service disruptions shall be coordinated with Owner.
- E. System Operating Pressures:
 1. Nitrous oxide: N₂O deliver 50-55 PSIG at outlets.
 2. Oxygen: O₂ deliver 50-55 PSIG at outlets.
 3. Dental Air: DA. Field verify with existing equipment.
 4. Dental Vacuum: DV. Field verify with equipment.
- F. Gas Sources:
 1. Gas for purging and testing shall be NF nitrogen only.
 2. Gas for final purging shall be provided from the Owner's supply source and shall be paid for by the Owner.

1.5 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.6 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.
- B. Product Data: Submit product data for items and materials listed in Part 2.
- C. Materials Cleaned for Oxygen Service: Documentation certifying that piping components for all pressure gas systems (except dental vacuum) has been cleaned as if for oxygen service. This includes tubes, valves, fittings, and station outlets.
- D. Brazing procedures.
- E. Brazer Performance Qualification: Test records for each brazer used on the installation.

- F. System Certification Agency and Test Agenda:
 - 1. Submit Certification Agency's and verifier's qualifications for approval.
 - 2. Submit the Certification Agency's detailed procedure which will be followed in the testing of this project. Include details of the testing sequences, procedures for cross connection test, valve test, flow test, alarm tests, purity tests, etc., as required by this specification. For purity test procedures, include data on test methods, types of equipment to be used, calibration sources and method references.
- G. Pre-certification Report: Submit the Pre-certification report as required by the Quality Assurance Article below.
- H. Test Reports: At the completion of the project submit pressure test reports with the signature of the witness.
- I. System Certification: Submit a document that certifies that the completed systems have been installed, purged, tested, and documented in accordance with the requirements of this specification and NFPA 99.
- J. As-built drawings.
- K. Closeout Submittals
 - 1. Project Record Documents: Record actual locations of valves, strainers, air vents, flexible pipe connectors, expansion joints, other components, and locations of access doors required for access.
 - 2. Operation and Maintenance (O&M) Manuals.
 - a. Refer to Section 200000 - Mechanical General Requirements, for O&M Manual formatting requirements and number of copies required.
 - b. Provide copies of approved submittal information for inclusion within the project O&M Manual. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, parts listings, and spare parts list.

1.7 CLOSEOUT SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.
- B. Record Drawings:
 - 1. Submit under provision of 200000 Mechanical General Requirements
 - 2. Maintain current and up-to-date red-lines, As-Built, prints of the medical gas system at the job site.
 - 3. Approved full size As-Built drawings and electronic copy of as-built drawing files in PDF and DWG formats shall be submitted with IO&M manuals.
- C. Operation and Maintenance Data:
 - 1. Submit under provision of 200000 Mechanical General Requirements

2. Maintenance Data: Submit a copy of submittal product data, the manufacturer's installation and O&M information.
3. Final Verifier test results and certification.
4. Valve and equipment schedules.
5. Copy of zone valve box and area alarm maps.
6. As-built drawings.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.9 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.
- B. Perform work in accordance with NFPA 99.
- C. Pre-certification Report: Prior to any installation work the Medical Gas System Certification Agency shall review the plans and report any conditions which would prevent them from certifying the system. Any suggested modifications should be included.
- D. Brazing Qualifications: Brazing shall be performed by individuals who are qualified per AWS B2.2 or ASME Section IX as modified by NFPA 99.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

1.11 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

1.12 PRE-BRAZING MEETING

- A. Requirements: Prior to the start of brazing conduct a job walk thru with the Owners representative and demonstrate the following:
 1. System materials are carefully stored and protected from contamination.
 2. Valves and fittings are prewashed and bagged.
 3. Procedures for cutting pipe and preparing ends.
 4. Installed piping runs have ends capped.
 5. The brazing purge connection and the plan for purging and brazing the piping system.
 6. The plan for pressure testing the piping system.
 7. The plan for testing the piping system with outlets attached.
 8. The location of purge ports at main shutoff valves.

1.13 COORDINATION

- A. Coordinate work under the provisions of Divisions 20, 21, 22, 23, 25.
- B. Coordinate the work with the structural system, wall framing and device installations, and above ceiling installations of other trades.

PART 2 - PRODUCTS

2.1 MATERIALS AND PRODUCTS

- A. Materials and products shall be new unless otherwise noted.
- B. Materials designated or required to be "Oxygen Clean" shall be purchased as "Oxygen Clean" and delivered to the project site in the original packing.
 - 1. This material shall be stored in such a manner as to remain "Oxygen Clean".
 - 2. Contractor is not allowed to clean "Oxygen Clean" material which has been contaminated, except as allowed in this specification and with Owner pre-approval.
- C. Provide products, equipment, and components by a single manufacturer.

2.2 PIPE AND FITTINGS

- A. Pipe (except DV): Pipe shall be hard drawn seamless medical gas tubing, ATM B819, factory prewashed and capped for oxygen service. Use type L for medical gases and dental compressed air. All piping shall be labeled with the ASTM number. Category 3 gas powered, nonmedical air, devices shall meet the above requirements for medical air.
- B. Fittings (except DV): Fittings shall be wrought copper brazed fittings ASTM B16.50 or cut ASTM B16.22 solder fittings for brazing, cleaned and bagged for oxygen service. Soldered connections are not allowed. Cast copper alloy fittings shall not be permitted.
- C. Mechanically formed, drilled, or extruded tree-branch connections are not allowed.
- D. Pipe - Dental Vacuum (DV):
 - 1. Category 3 Dental Vacuum wet systems:
 - a. CPVC plastic piping iron pipe size (IPS) schedule 40 or schedule 80, ASTM F 441.
 - 1). Pipe and fittings shall be suitable for installation in return air plenums per the IMC, shall meet the 25/50 flame and smoke requirements in accordance with ASTM E84 or UL 723.
 - b. CPVC plastic piping copper tube size (CTS) 1/2" through 2" SDR 11, ASTM D 2846.

- 1). Pipe and fittings shall be suitable for installation in return air plenums per the IMC, and shall meet the 25/50 flame and smoke requirements in accordance with ASTM E84 or UL 723.
 - c. Manufacturer: Spears Manufacturing, EVERTUFF CPVC pipe and fittings, or approved equal.
- E. Fittings - DV:
1. Level III wet systems: Piping meeting Level I or Level II requirements and the following for corrosive resistant system segments:
 - a. CPVC plastic pipe fittings to match pipe schedule/diameter.
 - 1). Pipe and fittings shall be suitable for installation in return air plenums per the IMC, and shall meet the 25/50 flame and smoke requirements in accordance with ASTM E84 or UL 723.
 - b. Manufacturer: Spears Manufacturing, EVERTUFF CPVC pipe and fittings, or approved equal.
- F. Joints:
1. Brazed joints shall use Sil-Fos or other self-fluxing silver brazing alloy with a 1,190 degrees F minimum melting point per ANSI/AWS A5.8 and NFPA 99. All brazing shall be done utilizing a nitrogen purge.
 2. Where threaded joints are required for connection of equipment and or gauges, a Teflon tape shall be used; pipe thread dope is not allowed. The tape shall be a special oil free PTFE oxygen thread green seal tape as manufactured by the Mill Rose Company.
 3. Stainless tube shall be welded using metal inert gas (MIG) welding, or tungsten inert gas (TIG) welding. Welders shall be qualified to ASME BPVC Section IX.
 4. Plastic pipe joints shall be made with solvent cement.
- G. Pipe and Fittings for Dental Air Compressor Intake and Dental Vacuum Exhaust to Exterior Building Penetration:
1. Pipe 3" and under: Provide type L copper tubing and fittings with brazed joints.
 2. Pipe 4" and over: Provide type L copper tubing, copper fittings with mechanical joints or brazed joints.
- H. Dielectric Fittings shall be permitted only required by the manufacturer of special medical equipment to electrically isolate the equipment from the system distribution piping.

2.3 VALVES

- A. Manufacturers: Hill-Rom, Allied Health Care, Tri-Tech Medical, Beacon Medical Products, Nibco, Stockham, Grinnell, Milwaukee, and Apollo.
- B. Ball Valves (4" and under) (Except DV): Brass or bronze body 3 piece bolted construction, full port, 600 PSIG WOG, dual bleed ports, TFE seats and seals, chrome plated brass ball with brass

blow-out proof stem. Handles shall be equipped with mechanism to lock valve open utilizing an Owner-furnished padlock. Valves shall be cleaned for oxygen service. Valves shall have copper tubing extensions brazed to valve sweat connection ends. The downstream tubing extension bleed port shall have a FPT gauge port with plug.

- C. Ball Valve for DV: CPVC full port ball valve compatible with piping system and suitable for vacuum service.
- D. Dental air shutoff valve for dental equipment connection at treatment rooms: Provide full port ball isolation valve with threaded outlet at each level 1 stub up for connection to dental equipment. Coordinate outlet connection type, valve type, and valve orientation with dental equipment supplier.
- E. Oxygen and Nitrous Oxide shutoff valves for dental equipment connection: Shut-off valves for connection to dental equipment at each level 1 stub up in closed dental treatment rooms are furnished by dental equipment supplier and installed by plumbing contractor. Valves shall meet 2012 NFPA-99 criteria for category 1 medical gas systems and shall include demand check and DISS threaded outlet for connection to dental equipment hose connection; coordinate with dental equipment supplier and include the proposed shut-off valves in medical gas product submittals.
- F. Zone Valve Box (OFCI):
 - 1. Manufacturers: Parker/Porter.
 - 2. Refer to Sjoquist Architects Dental Equipment 'EQ' Drawings for additional information.

2.4 LAB AIR OUTLETS

- A. At each compressed air outlet in the dental lab, provide a three-outlet manifold with quarter-turn isolation valve on each outlet. Coordinate with lab equipment requirements for equipment connection types; provide fittings, quick connect couplers, and threaded connectors to connect equipment to compressed air outlets. Provide cap or plug for any unused outlets not connected to lab equipment.
- B. Basis of design for lab compressed air outlets: Amflo, or approved equal.

2.5 MEDICAL GAS OUTLETS AND INLETS, TERMINAL DEVICES

- A. Medical gas outlets and inlets are furnished and installed by dental equipment supplier. Refer to Sjoquist Architects Dental Equipment 'EQ' Drawings for additional information.

2.6 MEDICAL GAS MANIFOLD (OFCI)

- A. Combination Oxygen and Nitrous Oxide medical gas manifold is furnished by dental equipment supplier and installed by Contractor. Refer to Sjoquist Architects Dental Equipment 'EQ' Drawings for additional information.
- B. Manufacturer: Parker/Porter.

2.7 MEDICAL GAS ALARM PANEL (OFCI)

- A. Combination Oxygen and Nitrous Oxide medical gas alarm panel is furnished by dental equipment supplier and installed by Contractor. Refer to Sjoquist Architects Dental Equipment 'EQ' Drawings for additional information.
- B. Manufacturer: Parker/Porter.

2.8 DENTAL COMPRESSED AIR SOURCE EQUIPMENT (OFCI)

- A. Project includes addition of one new dental air compressor to the two existing units to serve the dental clinic. The two existing dental air compressors will be reconfigured. Dental compressed air system equipment is Owner Furnished, Contractor Installed (OFCI).
- B. Dental compressed air system equipment to be added under this project includes: One dental air compressor unit. Remote alarm/monitoring panel to be relocated to the dental clinic reception area on level 1.
- C. Provide all required piping, fittings, and appurtenances for a complete and operating system. Refer to Sjoquist Architects Dental Equipment 'EQ' Drawings for additional information.
- D. Manufacturer: Ramvac, No substitutions. Refer to schedules for equipment model numbers.

2.9 DENTAL VACUUM SOURCE EQUIPMENT (OFCI)

- A. Project includes addition of new dental vacuum system equipment to serve the new dental clinic. Dental vacuum system equipment is Owner Furnished, Contractor Installed (OFCI).
- B. Dental vacuum system equipment to be added under this project includes: Three dental vacuum pumps with vacuum pump exhaust filters, one separator tank, one infini-tank with washdown, one amalgam separator, and one dental vacuum system main controller. Main control panel is located in basement dental utilities room and remote alarm/monitoring panel to be relocated in the dental clinic reception area on level 1.
- C. Provide all required piping, fittings, and appurtenances for a complete and operating system. Refer to Sjoquist Architects Dental Equipment 'EQ' Drawings for additional information.
- D. Manufacturer: Ramvac, No substitutions. Refer to schedules for equipment model numbers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Cleaning: Handle piping to prevent entry of dirt and contaminants. Factory-cleaned and sealed piping, cleaned as specified herein, shall have ends kept sealed until immediately ready for use. Provide temporary caps for pipes and stations during construction. Comply with NFPA 99 regarding special washing, cleaning, and flushing required before installation.

B. System Installation:

1. Install medical oxygen and medical nitrous oxide systems in accordance with 2015 NFPA-99 criteria for Category 2 medical gases.
2. Install dental air systems in accordance with 2015 NFPA-99 criteria for Category 3 Gas Powered Device Supply Systems (Dental Compressed Air). Joints shall be brazed utilizing a nitrogen purge.
3. Install dental vacuum systems in accordance with 2015 NFPA-99 criteria for Category 3 Dental Vacuum Systems.
4. Cutting and Fitting: Cut tubing with a tubing cutter (sawing is not permitted), ream end of tubing and deburr any chips. Blow out tube with nitrogen prior to assembly into the system.
5. Pipe Bending: Field bends in piping are not permitted.
6. Pipe Isolation: Isolate copper tubing from contact with dis-similar metal contact using tape or plastic grommets. Medical gas piping shall not be used as a part of an electrical grounding system.
7. Hanger Spacing: Tubing shall be hung on the following hanger spacing dimensions.

1/2"	6 feet
3/4"	7 feet
1"	8 feet
1-1/4"	9 feet
1-1/2" & larger	10 feet

8. Riser Supports: Tubing risers shall be supported at each floor but in no case shall the support distance exceed 15 feet. In such cases provide additional support.
9. Joint Preparation: Clean surfaces to be brazed with a clean stainless steel brush or emery cloth. Do not use steel wool as it may contain oil. After mechanical cleaning the surfaces shall be wiped using a clean, lint-free white cloth. Joints shall be brazed within one hour of being cleaned.
10. Brazing: Joints shall be brazed by qualified brazers. A nitrogen purge shall be used during brazing and until the joints are cool to the touch. After brazing wash the outside of each joint with a wet rag and a wire brush. The use of flux is prohibited.
11. Dielectric Fittings shall be permitted only required by the manufacturer of special medical equipment to electrically isolate the equipment from the system distribution piping.
12. The following joints shall not be used throughout the medical gas and vacuum distribution system:
 - a. Flared and compression type connections, including connections to station outlets, inlets, alarm devices, and other components.
 - b. Other straight threaded connections, including unions.
 - c. Pipe-crimping tools used to permanently stop the flow.
 - d. Removable and nonremovable push-fit fittings that employ a quick assembly push fit connector.
13. Plastic pipe shall not be installed in air plenums unless it meets the 25/50 flame and smoke ratings required by the IMC or the pipe is protected by an approved 1-hour fire barrier.
14. Pipe sizes shall meet the minimum requirements:

- a. Mains and branches in medical gas piping systems - 1/2".
 - b. Drops to individual station inlets and outlets - 1/2".
15. Two or more medical gas or vacuum piping systems shall not be interconnected for installation, testing, or any other reason.
 16. After installation of the piping and before installation of outlets, pipes shall be blown clean with nitrogen.
 17. Piping Identification: Apply pipe labeling during installation process and not after installation is completed.
 18. Purge Ports: At mainline shutoff valves which serve more than 1 room, and which are not located in a zone valve box, install a 1/2" tee with ball valve just downstream of the shutoff valve to facilitate purging during initial installation of future system changes. Finish open end of purge valve with a female adapter and a brass plug.
 19. Shutoff and service valves installed in ceiling space shall be provided with handle locks to secure valve in open position. Handle lock shall be provide with means to be padlocked.
 20. Shutoff and service valves shall be accessible when installed in ceiling spaces. Accessible is defined as immediately adjacent to an access panel or above suspended acoustic tile system on which the tiles are not secured or restricted in removal.
 21. Terminal Support: Provide backing as required to firmly attach outlets to wall and/or ceiling framing. Ceiling backing shall be sturdy enough to support a 10 pound load on the outlet without noticeable deflection of the ceiling or the outlet.
 22. Piping protection: Exposed piping in areas subject to physical damage by carts, stretchers, portable equipment, or vehicles shall be protected with stainless steel barriers. Piping shall be protected against freezing, corrosion, and physical damage.
 23. Shutdowns: Prior to submitting a shutdown request determine the areas affected by the valves(s) being shut down. Submit the shutdown request for approval.
 24. Install equipment in accordance with manufacturer's recommendations.
 25. Connections to existing systems: Final tie-in connections to existing systems shall be leak tested with source gas at normal operating pressures. Maintain pressure while each new joint is examined for leakage with soapy water. Do not connect to existing system until the installer's tests are complete and verification are complete up to and including piping purity test.
 26. Coordinate pipe floor and wall penetrations and provide materials to maintain assembly fire ratings.

3.2 LABELING AND IDENTIFICATION

- A. Piping labels shall be provided during installation, before testing.
 1. Piping, both exposed and concealed, shall be labeled with the gas/vacuum system name or chemical system and color code per NFPA 99. Medical gas piping shall not be painted. Labels shall be located as follows:
 - a. Operating pressure shall be include with gas name where positive pressure gas operate at pressures other than NFPA 99 standards.
 - b. At intervals of not more than 20 feet.
 - c. At least once in or above every room.
 - d. On both sides of walls, partitions, or floors penetrated by the piping.
 - e. At least once in every story height on risers.

- B. Valve and equipment tags shall be provided during installation, before testing.
 - 1. Shutoff valves shall be identified with the following:
 - a. Name or symbol of the specific system.
 - b. Name of the room(s) or area(s) served.
 - c. Caution to not close (or open) the valve except in an emergency.
- C. Outlets and inlets shall be identified with the name or symbol of the specific system.
 - 1. Operating pressure shall be included with gas name where positive pressure gas operate at pressures other than NFPA 99 standards.
- D. Zone Valve Box Map: Provide a medical gas zone valve box control floor plan area drawing located at each zone valve box. Obtain an ACAD background of the area served by the zone valves. Draw as-built locations of rooms served and the zone valve box location. Symbols shall be colored to match existing placards. Install zone valve box control floor plan area drawing in 8-1/2" x 11" clear sign holder next to the zone valve.
 - 1. Provide nameplate next to area drawing (or below if insufficient space) which says, "Warning: Medical Gas Valves In case of fire or other emergency, these valves may be closed to shut off medical gases to rooms: (see map above).
- E. Area Alarm Panel Map: Provide a drawing (similar to zone valve box) showing the zone valves and the rooms covered by that alarm. Install the drawing in an 8-1/2" x 11" sign holder next to the area alarm panel. If the zone valve box and area alarm panel are installed in the same location only one map is required showing zone valve box and area alarm panel.
- F. Valves: Provide a typed list of the areas served and the valve number. Chain the tag to the valve with a metallic chain.

3.3 CONTRACTOR'S INSTALLER TESTS

- A. Do not interconnect medical gas pipelines. Perform pressure testing with individual charging and measurement for each system.
- B. Provide testing in accordance with NFPA 99 requirements.
- C. After installation of shutoff valves and outlets, but before installation of system components (switches, gauges, alarms, manifolds, etc.) each section of the piping system shall be subjected to a test pressure of 1.5 times the working pressure, but not less than 150 PSIG, by means of oil free, dry nitrogen. This test pressure shall be maintained until each joint has been examined for leakage by means of soapy water. Leaks shall be repaired and the section retested.
- D. After completion of the above test procedure, the finishing assemblies of station outlets, alarms, and other components (e.g. pressure switches, gauges, relief valves, etc.), except those for Vacuum, shall be installed and medical gas piping systems shall be subjected to a 24 hour standing pressure test at 20 percent above the normal operating line pressure. Use oil free, dry nitrogen for test gas. The source shutoff valve shall be closed during this test. Pressure gas systems are to remain leak free. Vacuum is to be subjected to a test pressure of 60 PSIG. Vacuum test

pressure at the end of 24 hours is to be within 5 PSIG of initial test pressure. Any leaks shall be located, repaired, and systems retested.

- E. Blowdown each pressure gas system in order to remove particulate matter in pipelines. A high flow, intermittent purge shall be put on each outlet using appropriate adapters. Continue until purge produces no discoloration in a white cloth.
- F. Determine that no cross connections to other pipeline systems exist, reduce systems to atmospheric pressure. Disconnect sources of test gas from of the system with the exception of the one system to be checked. Pressure this system with oil-free dry nitrogen to a pressure of 50 PSIG. With appropriate adapters matching outlet labels, check each individual station outlet of all systems installed to determine that test gas is being dispensed from only the outlets of this system.
- G. Disconnect the source of test gas and reduce the system tested to atmospheric pressure. Proceed to test each additional pipeline system in accordance with the procedure outlined above. Vacuum systems can be tested with vacuum instead of pressure.
- H. Pressure tests should be witnessed by an Owner's representative. The installing contractor shall supply written documentation that the pressure tests have been completed and the systems meet these specifications.
- I. After 24 hour standing leakage testing is completed, allow piping to remain pressurized with test gas until certification agency performs final tests.
- J. Vacuum Vent Pipe Test: Cap pipes at the vacuum pumps and fill with water to the roof terminus. There shall be no perceptible drop in water level over a 2 hour period.
- K. Dental Air Compressor suction piping test: Test with nitrogen at 25 PSIG for 24 hours with no perceptible drop in pressure.

3.4 SYSTEM VERIFICATION, CERTIFICATION, AGENCY TESTS

- A. System verification shall be performed by the approved medical gas certification agency. Verify that systems as installed, meet or exceed the requirements of NFPA 99 and this specification and operate as required. Contractor's installer tests shall have been successfully completed as required by NFPA before verification activities start.
- B. Certification shall be performed by an independent testing agent. Certification shall be performed after closing of walls and after completion of required testing. Coordinate timing of system verification activities with Owner; notify Owner a minimum of 2 weeks prior to readiness.
- C. Hoses are to be installed in rail systems and hose drops for certifier's outlet tests.
- D. Medical gas concentration analysis is to be performed with instruments designed to measure the specific gas dispensed.
- E. Perform and document tests and verification requirements per NFPA 99 including:
 - 1. Cross connection.

2. Valve test.
 3. Outlet flow and pressure drop.
 4. Master alarms.
 5. Area alarms.
 6. Piping purge with a 0.45-micron filter.
 7. Piping purity.
 8. Final tie-in and blowdown of existing piping.
 9. Operational pressure test with source gas.
 10. Medical gas concentration.
 11. Labeling of outlets, valves, and alarms.
 12. Source equipment operation.
- F. Discrepancies discovered during the inspection shall be noted and corrected. All portions of the system affected by corrective action shall be retested and findings recorded after retest.
- G. Installer and verifier test reports shall be submitted for review prior to use of medical gas systems. Systems shall not be considered in service until satisfactory test results are obtained.
- H. Verified final results shall be incorporated in the operations and maintenance manuals as separate indexed item.

END OF SECTION 226300

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PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Ductwork and ventilation system equipment cleaning, servicing, and adjustment.
- B. Related Sections:
 - 1. 200000 - Mechanical General Requirements
 - 2. 200700 - Mechanical Insulation
 - 3. 233100 - Ducts and Accessories
 - 4. 233400 - HVAC Fans
 - 5. 233600 - Air Terminal Units
 - 6. 233700 - Air Outlets and Inlets
 - 7. 237413 - Packaged Rooftop Units

1.2 REFERENCES

- A. Codes and Standards:
 - 1. See Section 200000 - Mechanical General Requirements.
 - 2. ACR the National Air Duct Cleaners Association (NADCA) Standard for Assessment, Cleaning and Restoration of HVAC Systems, 2013.
 - 3. NFPA 90A - Installation of Air-Conditioning and Ventilating Systems.

1.3 SYSTEM DESCRIPTION

- A. Design Requirements: This section describes specific requirements and methods for cleaning existing ventilation ductwork and equipment.
- B. Performance Requirements:
 - 1. Install new and replace existing duct access doors as required.
 - 2. Clean supply air diffusers and return air grilles to remain.
 - 3. Clean existing terminal air units to include fans and reheat coils.
 - 4. Clean supply, return and exhaust ductwork from fan connection points to each air discharge point.
 - 5. Clean central air handling unit internal surfaces and components.
 - 6. Clean outside air louvers, plenums, and dampers.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.
- B. Product Data: Submit material safety data sheets (MSDS) for chemical products proposed to be used in cleaning process
- C. Shop Drawings:
 - 1. Select and document new duct access point/door locations and sizes on a clean set of Contract Drawings during cleaning preparation, using the access door symbol provided in the Legend.
 - 2. Submit for approval by the Contracting Agency prior to installing duct access points/doors.
- D. Test and Evaluation Reports:
 - 1. Preliminary Report:
 - a. Prior to any cleaning or duct repair work, provide a formal written preliminary report which:
 - 1). Defines the physical limits/boundaries of the existing central air distribution system ductwork and equipment to be cleaned.
 - 2). Provides a general assessment of the condition of the existing ductwork and equipment to be cleaned.
 - 3). Includes “before” digital photographs for each section of ductwork and equipment to be cleaned which clearly documents the existing condition of the ductwork. Include a key map (floor plan(s)) which clearly shows the location and direction of each photograph taken.
 - 4). Includes official laboratory analysis report of representative duct contamination samples. Indicate where samples were taken on key map (floor plans).
 - 5). Provides recommendations regarding the most appropriate cleaning method(s) for each portion of the duct system and equipment to be cleaned. Use cleaning methods selected from the National Air Duct Cleaners Association (NADCA) Industry Standard for Mechanical Cleaning of Non-Porous Air Conveyance System Components.
 - 6). Includes a copy of the specific recommended cleaning procedures to be implemented.
 - 2. Final Condition Report:
 - a. Within 15 days of completed duct and equipment cleaning, provide a formal written final condition report which:
 - 1). Demonstrates that there is no visible dirt, contamination, or bacterial growth, at any point within the systems which were cleaned.
 - 2). Includes “after” digital photographs next to each “before” digital photograph for each section of ductwork and each piece of equipment which clearly

documents the cleaning process. Take the “after” photograph from the same orientation as the previously submitted “before” photograph.

- E. Quality Control Submittals: Submit references for a minimum of five recently successfully duct cleaning projects.

1.6 CLOSEOUT SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.7 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.
- B. Qualifications: Duct cleaning work shall be performed by a firm with three years of continuous, documented experience with similar work.
- C. Certifications: The HVAC system cleaning contractor shall have a minimum of one Air System Cleaning Specialist (ASCS) certified by NADCA on a full time basis, or shall have staff certified by a nationally recognized certification program and organization dedicated to the cleaning of HVAC systems.

PART 2 - PRODUCTS

2.1 CLEANING EQUIPMENT AND CLEANING PERSONNEL

- A. Provide equipment and materials for cleaning, inspection and repair work including scaffolding, wire brushes, rotary brushes, filters, air lances, mechanical agitators, fiber-optic bore scopes, vacuums, and other equipment and materials necessary for workmen to perform the specified work.
- B. Cleaning personnel shall be properly supervised by a qualified, experienced foreman. Foreman shall be prepared to discuss work in progress, at any time with the Contracting Agency.
- C. Provide HEPA systems which are self-contained units with appropriate components and appurtenances, to adequately prevent dirt and debris loosed from duct mains and branches during cleaning operations from entering sensitive locations. Utilize industrial grade HEPA filter elements labeled and certified for 99.9 percent efficiency (0.3 micron particles at rated air flow). Wherever practicable, do not discharge air from HEPA systems to clean spaces. Size volumetric capacity of HEPA filter system to match CFM rating of diffuser, mixing box, ductwork section or device to which unit is being connected.

2.2 ACCESS DOORS

- A. Refer to Section 233100 - Ducts and Accessories.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions:

1. Study the Contract Documents and facility record drawings provided by the Contracting Agency to become familiar with the general layout of the existing systems to be cleaned.
2. Conduct site visit(s) to verify the scope of work, accessibility to ductwork and equipment and existing conditions.

3.2 PREPARATION

A. Protection of In-Place Conditions:

1. Prior to cleaning, provide temporary 30 percent filters fitted and sealed at supply grilles and diffusers.
2. Protect openings to avoid particulate contamination and debris from falling into conditioned air spaces.

3.3 INSTALLATION

- A. Install access points/doors as needed at locations throughout supply, return and exhaust air ductwork to clean systems.
- B. Where existing access doors are missing or poorly fitted, report condition to the Contracting Agency.

3.4 DUCT CLEANING

- A. Control access for cleaning personnel and equipment through installed access points, existing ceiling tiles, access doors, diffusers or grilles. Replace items removed for access to their original state upon completion of work.
- B. Upon satisfactory laboratory analyses of duct contamination samples and with temporary filters installed, remove loose contaminants from the interior ductwork surfaces. Perform visual inspections throughout the entire process to ensure that no area(s) are left untreated.
- C. By inserting special air lances, mechanical agitators and rotary brushes through the installed access points, gently loosen and remove contaminants from the interior surfaces of the ductwork. Utilize temporary filters and blanking pieces to protect areas that are not currently being treated.
- D. Utilize specialized fan-powered, HEPA filtered dust and particulate collection systems in areas designated as being sensitive and as directed by the Contracting Agency. Take precautions to prevent dirt and debris greater or equal to 0.5 microns from entering these sensitive areas.

- E. Hand wash duct mounted coils (using air or water) on both coil faces carefully to avoid damage to tubes and fins. Hand brush and vacuum clean coil frames to remove corrosion from around coil frames. Paint exposed metal frame surfaces to match existing coatings. Comb coil fins to restore them to original alignment.
- F. Mark duct mounted dampers at their current setting. Then inspect and clean dampers by manually hand scraping, sanding or wire brushing. Lubricate external moving parts with an approved dry lubricant material (Aerolox Dry Moly or equal). After cleaning, repair damaged dampers to provide proper operation and return and lock dampers at original setting positions.
- G. Whenever supply/diffusers and return/exhaust grilles are removable, mark existing damper settings (as applicable) and remove them prior to cleaning. Vacuum clean, wash, dry and reinstall diffusers and grilles. Clean welded grilles in place. Return dampers to original setting positions after reinstallation.

3.5 ROOF TOP AIR HANDLING UNITS

- A. Shutdown/restart central roof top air handling systems based upon a pre-arranged schedule approved in advance by the Contracting Agency. Once cleaning is complete, restore central air handling equipment to their normal operating mode.
- B. Clean and repair central air handling units located in mechanical rooms or equipment areas as follows:
 - 1. Remove existing filter bank elements.
 - 2. Hand wire brush interior sides, ceiling and floor areas to loosen surface contaminants and vacuum clean.
 - 3. Hand scrape/wire brush, vacuum clean, prime and paint filter holding frames with a chromate based primer and a gray epoxy paint top coat. Replace holding frame rubber seals.
 - 4. Utilizing a high pressure water cleaning system with a suitable cleaning agent to thoroughly clean heating/cooling coil faces.
 - 5. Hand scrape/wire brush, vacuum clean, prime and paint coil frames and drain pans with a chromate based primer and a gray epoxy paint top coat. Replace holding frame rubber seals.
 - 6. Vacuum clean and hand wash control dampers. Replace damaged rubber seals.
 - 7. Vacuum clean and hand wash fan casing and motors to remove grease debris.
 - 8. Hand scrape/wire brush, vacuum clean, fan impellers and casings.
 - 9. Repair/replace existing damaged duct insulation. If existing insulation is exposed without neoprene, foil or approved facing, coat surface with sealer. See Section 20 0700 - Mechanical Insulation, for sealer requirements.
 - 10. After interior surfaces and equipment are cleaned and refurbished, sanitize the air handling unit interiors with an approved broad spectrum biocide.
 - 11. Grease and repack fan bearings. Provide new belts. Align drive belts and adjust tension.
 - 12. Provide new filter bank elements.
 - 13. Hand wash and rinse exterior air handler surfaces.
- C. Prior to reactivating of air handler system:
 - 1. Verify that painted surfaces are properly dried and cured.

2. Verify that air handler surfaces are thoroughly cleaned and dried.
3. Filter elements are installed.
4. Fan belt guards are installed.
5. Notify the Contracting Agency prior to restart of air handler and coordinate system restart with facility operation.

3.6 REPAIR/RESTORATION

- A. Upon completion of the ductwork and equipment cleaning, carefully remove filters from the ceiling diffusers to avoid spilling loose contamination onto room surfaces. Dispose of filters in sealed containers.
- B. Shut and latch access doors. Adjust as necessary for a tight air seal.

3.7 CLEANING

- A. Upon completion of work, and at the end of each shift, clean work area of trash, rubble, rags, containers, materials and equipment resulting from the work and remove from site. Broom clean Contracting Agency designated work/storage areas.
- B. When cleaning procedures are completed, return electrical switches, detection devices and system components to an operable state by qualified personnel.
- C. Plug access ports with plugs specifically designed for the intended purpose.

3.8 SITE TESTS AND INSPECTIONS

- A. Provide Contracting Agency with 48 hours advanced notice prior to site inspection.
- B. Visually inspect cleaned duct interior surfaces, ductwork accessories and air handlers as identified in the project's scope of work.
- C. Inspect ductwork interior surfaces and non-accessible ductwork components within the air stream via the installed access points/doors, utilizing the fiber optic bore scope with dedicated light source.
- D. Photo document post cleaning conditions and submit with Final Condition Report. See Submittals - Test and Evaluation Reports for specific report requirements.

END OF SECTION 230131

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: General requirements and methods of execution relating to the testing and balancing of the mechanical systems provided on this project.
- B. Related Sections:
 - 1. 019100 - Commissioning
 - 2. 200000 - Mechanical General Requirements
 - 3. 221100 - Domestic Water Piping and Specialties
 - 4. 232113 - Hydronic Piping and Specialties
 - 5. 232123 - Hydronic Pumps
 - 6. 233100 - Ducts and Accessories
 - 7. 233400 - HVAC Fans
 - 8. 233600 - Air Terminal Units
 - 9. 233700 - Air Outlets and Inlets
 - 10. 238200 - Terminal Heating Units
 - 11. 259000 - Sequence of Operations

1.2 REFERENCES

- A. Codes and Standards:
 - 1. See Section 200000 - Mechanical General Requirements.
 - 2. National Environmental Balancing Bureau - Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
 - 3. National Environmental Balancing Bureau - Testing, Adjusting, Balancing Manual for Technicians.
 - 4. SMACNA - HVAC SYSTEMS Testing, Adjusting, and Balancing.
- B. Abbreviations and Acronyms:
 - 1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
 - 2. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.
 - 3. TAB: Testing, Adjusting, and Balancing.
 - 4. NEBB: National Environmental Balancing Bureau
- C. Definitions:
 - 1. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
 - 2. Accuracy: Capability of an instrument to indicate the true value of a measured quantity.

3. Adjusting: Varying of system flows by partially closing balancing devices, such as dampers, and valves, and varying fan speeds to achieve optimum system operating conditions within design and installation limitations.
4. Balancing: Methodical proportioning of air and hydronic flows through the system main, branches, and terminal devices using acceptable procedures to achieve the specified air or hydronic flow with testing and design limitations.
5. Calibrate: The act of comparing an instrument of unknown accuracy with a standard of known accuracy to detect, correlate, report, or eliminate by adjustment any variation in the accuracy of the tested instrument.
6. NEBB Certified TAB Firm: A Firm that has met and maintains all the requirements of the NEBB for Firm certification in TAB and is currently certified by NEBB. A NEBB Certified Firm shall employ at least one NEBB Qualified TAB Supervisor in the full time management position.
7. NEBB Certified TAB Report: Data presented in a NEBB Certified TAB Report accurately represents system measurements obtained in accordance with the current edition of the *NEBB Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems*. Variances from design quantities that exceed NEBB or contract document tolerances are to be noted in the TAB report project summary.
8. NEBB Qualified TAB Supervisor: Full time employee of the TAB Firm in a management position who has successfully passed the supervisor level written and practical qualification examinations and maintains the Supervisor re-qualification requirements of NEBB.
9. NEBB Qualified Technician: Full time employee of the TAB Firm who has met the technician level experience requirements of NEBB and has successfully passed the technician level written and practical qualification examinations. A NEBB Qualified TAB Technician shall be supervised by a NEBB Qualified TAB Supervisor. Supervision does not infer constant oversight; a NEBB Qualified Technician is capable of performing assigned tasks with periodic supervision.
10. Precision: Ability of an instrument to produce repeatable readings of the same quantity, or a tightly grouped set of values, under the same conditions.
11. Range: Upper and lower limits on an instrument's ability to measure the value of a quantity for which the instrument is calibrated.
12. Resolution: Smallest change in a measured variable that an instrument can detect.
13. Testing: Use of specialized and calibrated instruments to measure temperatures, pressures, rotational speeds, electrical characteristics, velocities, and air and hydronic quantities for an evaluation of flow conditions.
14. Testing and Balancing: As used in these specifications, testing and balancing refers to testing, adjusting, and balancing (TAB) as described in the above references.
15. TAB: A systematic process or service applied to heating, ventilating and air-conditioning (HVAC) systems and other environmental systems to achieve and document air and hydronic flow rates. The standards and procedures for providing these services are referred to as "Testing, Adjusting, and Balancing" and are described in this document.

1.3 SYSTEM DESCRIPTION

- A. Design Requirements: This section describes specific requirements, products and methods of execution for the testing, adjusting and balancing of the project.

- B. Performance Requirements: Furnish the services of a qualified and approved TAB Firm to perform the work of this specification section.
- C. The work of this section includes but is not necessarily limited to:
 - 1. Test and balance fans and supply, exhaust, and relief ventilating systems.
 - 2. Test and balance hydronic heating systems.
 - 3. Test and balance domestic hot water recirculation flow rate.
 - 4. Test and balance room air pressure relationships.
 - 5. Work directly with the control subcontractor to obtain proper system adjustments. This includes, but is not limited to:
 - a. VAV box controller airflow coefficient adjustments.
 - b. Airflow measuring device calibration adjustments.
 - c. Fluid flow measuring device calibration adjustments.
 - 6. Measure sound power levels if so directed.
 - 7. Provide a final report.
- D. The work of this section does not include:
 - 1. Adjusting burners for proper combustion operation.
 - 2. Liquid waste transfer system adjustment.
 - 3. Refrigeration work.
 - 4. Control system adjustments, unless noted otherwise herein.

1.4 PRE-BALANCING MEETING

- A. Coordinate TAB work with other trades and requirements of other related sections of the Project Manual prior to commencing work.
- B. Schedule a pre-balancing meeting one week prior to commencing work of this Section. Refer to Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.
- B. Product Data: Sample report forms and outlines indicating adjusting, balancing, and equipment data required prior to commencing work.
- C. Certificates:
 - 1. Submit the name and qualifications of TAB Firm for approval with general product submittals. Submit copy of TAB Firm's NEBB certification.
 - 2. Submit the names and certifications of the Firm's NEBB Qualified TAB Supervisor and NEBB Certified Technician.

D. Balancing Report:

1. Submit a complete report of the testing and balancing of all devices in a format equivalent to that shown in the SMACNA HVAC Systems Testing, Adjusting and Balancing manual. Compile the test data and submit eight copies of the complete test data for acceptance and/or analysis and recommendations.
2. Provide report in soft cover, letter size, comb bound binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include drawings within report.
3. Report Cover Sheet. Include the following data:
 - a. Project Name.
 - b. Project Address.
 - c. Names of Architect and Engineer.
 - d. Names of General Contractor and HVAC Contractor.
 - e. Report date.
 - f. Names of TAB technicians responsible for the measurements and report.
4. System Review Sheet:
 - a. List air and hydronic systems balanced, with systems highlighted that were found to be performing outside design tolerances.
 - b. Include a summary of problems encountered, deviations from design, deficiencies in performance, remaining problems, recommendations, and comments.
5. Instrument Calibration Report:
 - a. Include a complete list of test equipment used, including apparatus manufacturer's name, model number, serial number, and date last calibrated.
 - b. List the instruments used on the project during the balancing work, on a NEBB "Instrument Calibration Report" form, or equivalent form. This includes flow measuring hoods and other related devices.
6. Air Systems Report: Prepare a report for each air system balanced. Tabulate data separately for each system. Describe balancing method used for each system. At minimum, include the following:
 - a. System Diagram: Include locations of air terminal units and pitot tube traverses. Include appropriate notes, static pressure reading locations, etc., taken during testing and balancing.
 - b. Air Apparatus or Fan Test Report: Include pertinent data on the test report forms. If test data could not be measured, or is not applicable, indicate such on report forms. List how each actual cfm measurement was obtained (duct traverse, total of outlet airflows, or a combination).
 - c. Duct Pitot Tube Traverse Reports: Include actual temperature and pressure readings recorded at the time of testing and balancing.
 - d. Air Outlet Test Reports: Include applicable A_k factors and terminal device sizes. If flow measuring hoods are used, indicate their use in the remarks column.

- e. Include complete identification of elements. Identify by box number, room name and number, air outlet symbol, orientation in room, etc., as necessary to clearly and positively identify the location of each element.
7. Hydronic Heating System Reports. Prepare a report for each hydronic system balanced. Tabulate data separately for each system. Describe balancing method used for each system. At minimum, include the following:
 - a. Schematic Diagram: Include heat exchange equipment and locations of flow measuring devices.
 - b. Pump Test Report: Confirm test data was recorded and properly entered on form. Attach manufacturer's pump capacity curves, with the actual pump operating point plotted, to the test report form. List how the actual pump flow rate was determined (flow meter, pump curve, etc.).
 - c. Primary Heat Exchange Equipment: Confirm that appropriate test data has been recorded for the boilers, heat exchangers, chillers, and other primary heat exchange equipment. List how the actual flow rate(s) of each item was determined.
 - d. Terminal Heat Exchange Equipment: Confirm that heating coil and terminal unit temperatures and pressures were recorded and properly entered on form. List how each terminal unit flow rate was determined.
 - e. Include complete identification of elements. Identify by equipment tag number, room name and number, baseboard symbol, orientation in room, etc., as necessary to clearly and positively identify the location of each element.
 8. Reduced Size Drawings: Provide with air outlets and equipment identified to correspond with data sheets. Record actual locations of thermostats, flow measuring stations, and balancing valves with settings.
 9. Reduced Sized Pressure Maps and/or Environmental Drawings: Provide marked up record drawings, recording actual room by room airflows, pressure relationships, and /or equipment offsets as indicated on contract drawings.

1.6 QUALITY ASSURANCE

A. Qualifications:

1. The work described in this section shall be performed by a Firm certified by the National Environmental Balancing Bureau for air and hydronic balancing.
2. The Firm shall have a record of operation within Alaska for at least three years prior to bid date of this project and shall have demonstrated satisfactory completion of five projects of similar size and scope in the State of Alaska. Provide references if requested.
3. The Firm's Technician and Supervisor for this project shall be NEBB certified for their respective positions.
4. Bids by suppliers, contractors or any Firm whose principal business is not that of testing, adjusting, and balancing HVAC systems are not acceptable.

B. Balancing Standards:

1. Perform total system balance in accordance with NEBB Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

2. Maintain one copy of balancing procedural document on site.
3. Use standard NEBB forms.

C. Timing of Work:

1. Sequence work to commence after completion of systems. Do not begin balancing and testing until the systems are complete and in full working order.
2. Schedule the testing and balancing work in cooperation with other trades.
3. Schedule completion of testing and balancing before Substantial Completion of Project.

D. Construction team responsibility to TAB Agency: Refer to 200000 - Mechanical General Conditions.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 GENERAL SUMMARY OF BALANCING WORK

A. Provide TAB for the systems and equipment revised under this project including, but not limited to:

1. RTU-1.
2. Existing glycol heating loop serving RTU heating coils, including replacement piping.
3. Hydronic balancing for revised and new terminal heating units and air terminal units.
4. Hydronic heating system circulation pump balancing and revised performance verification.
5. New exhaust fan system for level 1 dental clinic and general building.
6. New exhaust fan system for and medical gas storage room.
7. Existing, new, and revised exhaust air inlets, connected to existing exhaust fan systems, in the areas of work.
8. Existing, new, and revised supply air terminal units and air outlets in the areas of work.
9. Domestic hot water circulation system. Entire system to be rebalanced to accommodate project revisions.
10. Provide room pressure measurements for the following spaces:
 - a. Closed dental treatment rooms (rooms designed to be negative pressure).
 - b. Sterile supply/Hygiene Supply (room designed to be positive pressure).
 - c. Lab (room designed to be negative pressure).

B. Commissioning Support:

1. TAB Agency shall provide support for commissioning services including office and field support; refer to Section 019100 Commissioning.
2. TAB Agency shall provide commissioning support for field support for verification/spot checking of TAB report values and commissioning field adjustments.
3. Upon completion of commissioning activities, TAB Agency shall provide an updated and final TAB report incorporating any field adjustments during commissioning.

3.2 EXAMINATION

- A. Verify systems are complete and operable before commencing work.
- B. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- C. Report defects and deficiencies that may preclude proper TAB of systems and equipment.

3.3 PREPARATION

- A. Schedule work under the provisions of Section 200000 - Mechanical General Conditions.
- B. Provide calibrated instruments required for testing, adjusting, and balancing operations.
- C. Prior to starting work, review drawings and actual field conditions for additional balancing devices or components required for correct balance. Coordinate provision of additional balancing devices as required elsewhere in these specifications. Refer to Related Sections above.
- D. Preliminarily adjust grille, register, and diffuser blades or pattern controllers per drawings. If airflow blow patterns are not shown on drawings, adjust for uniform diffusion pattern(s) or diffusion into long dimension of room.

3.4 SPECIAL TECHNIQUES:

- A. Use instrumentation in accordance with NEBB requirements, calibrated to the accuracy standards specified by this organization.
- B. Flow measuring hoods are acceptable for measurement of ceiling diffuser performance if used in a manner as recommended by the manufacturer and calibration and accuracy data is provided with the balancing report.
- C. Upon request, make available to the Contracting Agency copies of current calibration certificates.

3.5 ACCEPTABLE CRITERIA

- A. Systems will be considered balanced in accordance with NEBB *Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems* when the following conditions are satisfied:
 - 1. Air Handling Systems:
 - a. Measured airflow quantities are within plus or minus 10 percent of design quantities. Deficiencies shall be noted in the TAB report.
 - b. There is at least one direct path with fully open dampers from the fan or terminal unit device to an air inlet or outlet. Additionally, if a system contains branch dampers, there will be at least one wide open path downstream of every adjusted branch damper.

2. Air Outlets and Inlets:
 - a. Measured airflow quantities total to within plus or minus 10 percent of design to space and individual outlets and inlets in space to within plus or minus 10 percent of design.
 - b. Grilles, registers, and diffusers blades or pattern controllers are adjusted for uniform diffusion in the space. Re-adjust airflow patterns that result in airflow velocities greater than 50 FPM (feet per minute) at 5 feet above finish floor (AFF).
 3. Hydronic Systems:
 - a. Manually balanced systems:
 - 1). Measured fluid flow quantities are within plus or minus 10 percent of design.
 - 2). There is at least on direct path with fully open balancing valves from the pump discharge balancing valve (if present) to a terminal device. Additionally, if a system contains branch balancing valves, there will be at least one wide open path downstream of every adjusted branch balancing valve.
 - b. Automatically balanced systems: Pressure drops across a sample of system's automatic balance valves are within the manufacturer's recommended operating range for the device.
- B. If systems or components cannot be adjusted to within specified tolerances:
1. Coordinate the replacement of sheaves, belts, or other components or devices needed for correct balance as required elsewhere in these specifications.
 2. Note deficiencies in the TAB report.

3.6 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on equipment sheaves, belts, dampers, valves, air outlets and inlets and each system according to the procedures contained in the current edition of the NEBB *Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems* and this section.
- B. Adjustments shall be made with air handler filters blanked off to create a filter pressure drop of 60 percent of the manufacturer's recommended filter final pressure. Where multiple filters are encountered each set shall be individually blanked off, for a cumulated pressure drop of 60 percent of each filters final pressure.
- C. Ensure recorded data represents actual measured or observed conditions.
- D. Permanently mark final settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- E. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

- F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- G. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Contracting Agency.
- H. Schedule and provide assistance in final adjustment and test of fire alarm system with Authority Having Jurisdiction.

3.7 SITE QUALITY CONTROL

- A. Make calibrated test instruments available to Contracting Agency to facilitate spot checks during testing and commissioning as appropriate.
- B. Re-balance components or systems found to be out of tolerance at no additional expense to the Owner.

END OF SECTION 230593

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PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Specific requirements, products, and methods of execution relating to the provision of fuel gas systems for the project.
- B. Related Sections:
 - 1. 200000 - Mechanical General Requirements
 - 2. 200529 - Mechanical Hangers and Supports
 - 3. 200553 - Mechanical Identification
 - 4. 225216 - Condensing Boilers and accessories

1.2 REFERENCES

- A. Codes and Standards:
 - 1. See Section 200000 - Mechanical General Requirements.
 - 2. NFPA 54 - National Fuel Gas Code.
- B. Abbreviations, Acronyms and Definitions:
 - 1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
 - 2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
 - 3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

- A. Design Requirements:
 - 1. This section describes specific requirements, products and methods of execution for interrelated systems necessary for the distribution of natural gas within the building.
 - 2. Provide products including above and below ground piping, connections to gas burning apparatus, and work at the gas source to provide complete fuel gas systems where required. Provide gas equipment pressure regulator vents to outside the building at fuel gas trains.
- B. Performance Requirements:
 - 1. Gas service and meter are existing to remain.
 - 2. Verify natural gas service volume and pressure to the building as shown on drawings.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.
- B. Product Data: Provide manufacturers' product literature for items specified in Part 2 and those products required by the performance standards of this section, clearly annotated to indicate specified salient features and performance criteria.
- C. Shop Drawings: Submit dimensioned shop drawings of gas piping size and routing as part of the plumbing shop drawings, with callouts indicating deviations from layout shown.
- D. Test and Evaluation Reports:
 - 1. Obtain a certificate of final inspection from the Contracting Agency.
 - 2. Submit a letter of certification with copy of certificate of final inspection, indicating that the gas piping has been completed, tested, and inspected.
- E. Quality Control Submittals: Provide a certified test report showing the system has been tested in accordance with Code requirements and is in compliance.

1.6 CLOSEOUT SUBMITTALS:

- A. See Section 200000 - Mechanical General Requirements.
- B. Record Documentation: Record actual locations of equipment, piping, and components, and areas required for maintenance access.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.
- B. Regulatory Requirements: NFPA 54.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 PIPING

- A. Above ground, pressure less than 14 inches water column:
 - 1. Schedule 40 black steel pipe.
 - 2. Welded or threaded black malleable iron fittings.
 - 3. Corrugated Stainless Steel Tubing (CSST):
 - a. CSST complying with ASTM A 240, 125 PSIG maximum operating pressure and 200 degrees F maximum operating temperature.
 - b. Fittings and appurtenances by same manufacturer as CSST product.
 - c. Manufacturer: OmegaFlex TracPipe PS-II, or approved equal.
- B. Above ground, pressure greater than or equal to 14 inches water column:
 - 1. Welded schedule 40 black steel pipe.
 - 2. Welded schedule 40 steel fittings.

2.2 BALL VALVES

- A. Brass or bronze construction, threaded ends, 600 PSIG rating, listed for natural gas service.

2.3 ZONE VALVE BOX

- A. Provide 18 gauge steel box with white epoxy finish and brackets to mount box to studs. Size of box shall be specifically designed to house the natural gas isolation valve. The valve box shall have an opaque cover with pull ring for easy removal. The cover shall have view ports to observe the valve and label. Valves shall be oriented so cover cannot be installed with any valve closed. The valves inside and the cover shall be labeled per NFPA 99.
- B. Manufacturers: Tri-Tech Medical Z Series, Parker/Porter, or equal.

PART 3 - EXECUTION

3.1 INSTALLERS

- A. Installer: Perform work by experienced personnel under the supervision of a qualified installation supervisor.

3.2 PREPARATION

- A. Protection of In-Place Conditions: Plug piping connections for protection from construction dirt and debris.
- B. Surface Preparation: Prior to installation of stacks, verify that shop drawings are approved and stack locations and routing have been coordinated with other trades.

3.3 INSTALLATION

- A. Special Techniques:
 - 1. Install equipment in accordance with manufacturer's instructions and requirements of the codes specified herein.
 - 2. Arrange products to be readily accessible for inspection, testing, and shutting off gas supply.
 - 3. Install pipe and fittings clean and free from cuttings, burrs, and defects in structure of threading, and thoroughly brushed and scale blown.
 - 4. Do not install any piping in concrete, in masonry, or below grade inside the building.
 - 5. Provide connection to gas consuming appliances. Connect gas appliances and fixtures with flexible connectors in accordance with the requirements of the appliance listing and manufacturer's instructions.
 - 6. Provide independent gas pressure relief pipes to outside the building from each fuel gas train. Size and install reliefs in accordance with the written UL listing installation instructions. Gang piping to penetrate exterior building skin at a common location. Terminate relief vents not less than 10 feet from openings to the building and not less than 25 feet from building outside air intakes.
- B. Interface with Other Work: Coordinate and sequence installation of gas piping and equipment with trades responsible for portions of this and other related sections of the Project Manual.

3.4 REPAIR/RESTORATION

- A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.
- B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 RE-INSTALLATION

- A. Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

3.6 SITE QUALITY CONTROL

- A. Site Test and Inspections:

1. Test gas piping before connection to the gas source. Do not enclose or conceal any untested portion of the gas system.
 2. Test piping in accordance with IFGC requirements.
- B. Non-Conforming Work: Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

3.7 CLEANING

- A. Clean gas piping, fittings, valves, etc., of grease, rust, dust and dirt.

END OF SECTION 231123

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings for:
 - a. Hydronic heating piping.
 - b. Equipment drains and overflows.
2. Piping accessories.
3. Flexible pipe connectors.
4. Pipe loops, offsets, alignment guides.
5. Hydronic Specialties:
 - a. Expansion tanks.
 - b. Air vents.
 - c. Air separators.
 - d. Strainers.
 - e. Flow indicators, controls, meters.
 - f. Flushing agents.
 - g. Water treatment chemicals.
 - h. Glycol specialties.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 200700 - Mechanical Insulation
7. 204100 - Mechanical Demolition
8. 230593 - Testing, Adjusting and Balancing
9. 232123 - Hydronic Pumps
10. 233600 - Air Terminal Units
11. 235216 - Condensing Boilers and Accessories
12. 237413 - Packaged Rooftop Units
13. 238132 - Storage Vault HVAC Equipment
14. 238200 - Terminal Heating and Cooling Units
15. 253000 - Building Automation System Field Devices
16. 255000 - Building Automation System
17. 259000 - Sequence of Operations

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. ANSI/ASHRAE/IESNA Standard 90.1-2001 Energy Standard for Buildings Except Low-Rise Residential Buildings.
3. ASME Boilers and Pressure Vessel Code (1998), Sections IV & VI.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. This section describes specific requirements, products, and methods of execution for the system of liquid heat transfer throughout the project. The system of heat generation is specified elsewhere.
2. Design expansion compensation system to adequately protect piping and structure from thermal expansion and contraction forces.

B. Performance Requirements:

1. Provide performance and output shown or scheduled on drawings.
2. Provide loops, pipe offsets, and swing joints, or expansion joints where required or indicated.
3. Pipes shall be capable of thermal expansion movement without disengagement of supports or forces on equipment connections.
4. Provide structural work and equipment required to control expansion and contraction of piping. Verify that anchors, guides, and expansion joints provided, adequately protect system.
5. Expansion Calculations:
 - a. Installation Temperature: 40 degrees F.
 - b. Hot Water Heating: 210 degrees F.
 - c. Domestic Hot Water: 140 degrees F.
 - d. Safety Factor: 30 percent.

1.4 PRE-INSTALLATION MEETINGS

- A. See section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.
- B. Product Data:
1. Submit product literature for items specified in Part 2 and those products required by the performance standards of this section. Literature clearly annotated to indicate specified salient features and performance criteria.
 2. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot (meter) and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
 3. Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.
 4. Submit selection calculations for expansion joints and compensators.
 5. Design Data: Submit calculations for performance specified products and systems.
- C. Shop Drawings:
1. Submit shop drawings for performance-specified products and systems.
 2. Submit shop drawings for piping systems to demonstrate proper layout and coordination.
 3. Provide shop drawings to show system layout with location and detail of flexible pipe connectors and expansion joints.
 4. Drawings of boiler room, fan rooms, and other areas with high-density piping, shall be shown at 1/4-inch scale or larger.
 5. Indicate elevation of piping above finish floor.
 6. Indicate dimensions and weights of equipment, and placement of openings and holes.
 7. Include reference to ductwork and other equipment where space coordination is necessary to avoid conflicts.
 8. Indicate mechanical and electrical service locations and requirements.
- D. Manufacturer Reports:
1. Certificates, Manufacturer's Instructions, and Manufacturer's Field Reports:
 - a. Provide a complete manufacturer's written installation, operation and maintenance manual for each type of installed equipment. Annotate the manual to indicate applicable information for the specific equipment model(s) installed.
 - b. Included with the manual one copy of the completed start-up and operation checklist. The checklist shall include:
 - 1). Printed names and signatures of the installers.
 - 2). Documentation from Manufacturer's representative and Contracting Agency that the equipment has been properly installed and is fully operational, thus validating the equipment warranty.
 2. Test reports:
 - a. Provide certificate that cleaning of hydronic systems has been accomplished.

- b. Provide certificate listing satisfactory results for the hydrostatic pressure tests.
 - c. Provide certificate listing satisfactory results for the operational tests.
 3. Submit a letter to document that the training was conducted. Include in the letter the date, start/stop times for the training, list of attendees and signature/title of the person(s) providing the training.
- E. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.

1.6 CLOSEOUT SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.
- B. Operation and Maintenance (IO&M) Manuals:
 1. Refer to Section 200000 - Mechanical General Requirements, for IO&M Manual formatting requirements and number of copies required.
 2. Include the following:
 - a. Copies of approved submittal information.
 - b. Manufacturer's installation, operating and maintenance/repair instructions, parts listings, and spare parts list for each product. Annotate the manual to indicate applicable information for the specific equipment model(s) installed.
 - c. Computer software manuals and applicable licenses.
 - d. Completed start-up and operational test report as required to validate equipment warranty.
 - e. Start-up and operational test reports for each piece of equipment. Report shall include printed names and signatures of the installers and documentation that the equipment has been properly installed and is fully operational, thus validating the equipment warranty.
- C. Record Documentation: Record actual locations of equipment, valves, strainers, air vents, flexible pipe connectors, expansion joints, other components, and locations of access doors required for maintenance access in accordance with Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Water Systems:

1. Copper pipe three inches and smaller:
 - a. Type L copper, wrought copper fittings.
 - b. Fit joints using 430 silver solder, 95-5 tin-antimony or other approved lead-free solder. Solder type must be compatible with pipe and fittings. Solder containing lead shall not be allowed on the job site.
 - c. Soldering flux: Water flushable, low corrosivity type meeting the requirements of ASTM B813. Flux shall have label indicating it meets these requirements.
 - d. Extracted branch joints (T-Drill) may be approved when Contractor can demonstrate satisfactory experience with this method. Joints shall be brazed in accordance with the Copper Development Association Copper Tube Handbook using B-Cup series filler metal.
2. Steel pipe four inches and larger: Welded pipe and fittings.
 - a. Grade B, seamless, ASTM A53 or A106.
 - b. Schedule 40 black with ANSI B16 butt weld fittings of type and wall thickness to suit pipe.
3. Galvanized piping is not permitted.

B. Glycol Systems (Copper or Steel Option):

1. Copper pipe three inches and smaller:
 - a. Type L copper, wrought copper fittings.
 - b. Fit joints using 430 silver solder, 95-5 tin-antimony or other approved lead-free solder. Solder type must be compatible with pipe and fittings. Solder containing lead shall not be allowed on the job site.
 - c. Soldering flux: Water flushable, low corrosivity type meeting the requirements of ASTM B813. Flux shall have label indicating it meets these requirements.
 - d. Extracted branch joints (T-Drill) may be approved when Contractor can demonstrate satisfactory experience with this method. All joints shall be brazed in accordance

with the Copper Development Association Copper Tube Handbook using B-Cup series filler metal.

2. Steel pipe four inches and larger: Welded pipe and fittings. No threaded pipe allowed.
 - a. Grade B, seamless, ASTM A53 or A106.
 - b. Schedule 40 black with ANSI B16 butt weld fittings of type and wall thickness to suit pipe.
3. Viega ProPress copper press-fit joint-type pipe systems are not permitted.
4. Victaulic mechanical joint-type pipe systems are not permitted.
5. Galvanized piping is not permitted.

C. Copper Press Fitting System:

1. Limited to tubing sizes 4 inch and smaller.
2. Cast or wrought copper fittings, ASME B16.51. Pre-formed grooves with pre-lubricated EPDM O-rings designed to seal fitting to copper tubing water tight with the use of manufacturer's crimping tool. Fittings shall be rated for 250 Degrees F., and 200 psi.
3. IAPMO UPC listing.
4. Manufacturer: Viega ProPress, NIBCO Press System, no substitutions.

D. Equipment drains and overflows: Type L copper pipe, wrought copper fittings.

2.2 VALVES

- A. Select valves of the best quality and type suited for the specific service and piping system used. Minimum working pressure rating 125 PSIG saturated steam or 200 PSIG WOG. Packing material or seals shall not contain asbestos.
- A. Manufacturers: Crane, Nibco, Hammond, Jenkins, Grinnell, Milwaukee, Stockham.
- B. Ball Valves 2 inch and smaller: Two piece type, full port, bronze body and silicone bronze ball or chrome plated brass ball, TFE seats, blowout proof stem, 150 PSIG pressure/temperature rating (steam).
- C. Ball Valves 2-1/2 inches through 4 inch: Two piece type, full port, bronze body and silicone bronze ball or chrome plated brass ball, TFE seats, 150 PSIG pressure/temperature rating (steam). May be substituted for gate valves except where otherwise indicated.
- B. Gate Valves, two inch and smaller: Bronze body and trim, rising stem, solid wedge. Use only where shown on drawings.
- C. Gate valves, six inch and larger: Iron body bronze trim, flanged. Rising stem: OS&Y, or non-rising stem with solid wedge.
- D. Globe Valve two inch and smaller: Bronze body, renewable disc suitable for service.
- E. Globe or Angle Valve 2-1/2 inch and larger: Iron body, bronze trim, flanged, bronze disc. Bronze valves optional for 2-1/2 inch and three-inch.

- F. Swing Check Valves two inch and smaller: Bronze body, horizontal swing, Y-pattern, Buna-N-disc for water, oil and gas. TFE disc for steam.
- G. Swing Check Valves 2-1/2 inch and larger: Iron body, horizontal swing, bolted bonnet, renewable bronze seat and disc, flanged or grooved. Bronze valves optional for 2-1/2 inch and three-inch.
- H. Drain Valves: Full port ball valve with threaded hose adapter with bronze end cap. Do not use sillcocks or butterfly valves as drain valves.
- I. Valves Specified Elsewhere: Provide special valves such as motor-operated valves, relief valves, temperature regulating valves, etc., as specified under the individual system, or as indicated on the drawings.

2.3 UNIONS (STANDARD)

- A. Steel Piping (Threaded):
 - 1. Class 150 (150 PSIG steam, 300 PSIG WOG) malleable iron, ground joint, ASME B1.20.1, ASME B16.39. McMaster-Carr.
 - 2. Where indicated: Class 250 malleable iron ground joint, copper or copper alloy seat. McMaster-Carr.
- B. Copper Piping (Sweat): Cast bronze, ASTM B584 Alloy C84400, copper to copper. Nibco No. 733.

2.4 DIELECTRIC ISOLATORS (ELECTRICALLY INSULATING)

- A. Provide dielectric unions for two inch pipe and smaller.
- B. Provide dielectric flanges for 2-1/2 inch pipe and larger.
- C. Insulating gaskets shall be suitable for fluid type, temperature and pressure.
- D. Galvanized pipe to copper: Brass threaded end and sweat copper end.
- E. Black steel to copper: Zinc plated steel threaded end and sweat copper end.
- F. Manufacturers: Capitol, EpcO, Control Plastics, Watts, or approved equal.

2.5 PRESSURE GAUGES

- A. Provide where shown on drawings, specified in Part 3, or as required.
- B. Bourdon tube type with 4-1/2-inch dial (minimum) accuracy plus or minus one-percent span, recalibratable. Normal operating pressure near midpoint of range. Industrial quality.
- C. Gauge cock on gauges and pulsation damper (snubber). Steam gauges shall have siphon to isolate gauge from steam, except where remotely mounted and connected by looped tubing.

- D. Differential pressure gauges shall be piston or diaphragm type with range suitable for application and static pressure capability suitable for system pressure. Orange Research.

2.6 THERMOMETERS

- A. Provide where shown on drawings, specified in Part 3, or as required.
- B. Liquid in glass type: Industrial quality blue-reading with nine-inch scale length (minimum). Straight angle or adjustable as necessary for visibility. Trerice, Marsh, Weksler, or approved equal.
- C. Dial Type: Industrial quality three-inch dial with a 270 degrees (minimum) scale. Straight, angle or remote as necessary for visibility. Trerice, Marsh, Weksler, or approved equal.
- D. Digital, self-powered type: Weiss DVU or equal.
- E. Normal operating temperature at scale midpoint and sufficient range to cover operating conditions.
- F. Provide separable wells of suitable material for piping and mounting hardware for ducts. Set probe in heat transfer paste recommended by thermometer manufacturer.

2.7 PRESSURE AND TEMPERATURE TEST PLUGS

- A. Provide where shown on drawings, specified in Part 3 or as required.
- B. Standard type for 1/8-inch diameter pressure or temperature probes. Self seal when probe removed and complete with threaded cap. Minimum continuous rating 125 PSIG and 220 degrees F coincident. Sealing element suitable for fluid in pipe.
- C. Provide one thermometer and one pressure gauge for each range required by system parameters.
- D. Manufacturers: Sisco, Peterson Equipment, or approved equal.

2.8 FLEXIBLE PIPE CONNECTORS

- A. General:
 - 1. System Application: Hot water heating or 50 percent propylene glycol solution (heating) or 30 percent propylene glycol solution (cooling).
 - 2. System Maximum Operating Temperature: 210 degrees F.
 - 3. Pressure: Internal.
 - 4. Installation: Straight or Offset as shown.
 - 5. Movement: Constant or Intermittent.
 - 6. Maximum offset: Not to exceed 25 percent of the centerline bend radius.
 - 7. Determine appropriate minimum "live hose length" (flexible portion of assembly) based on the centerline bend radius for each application in accordance with manufacturer's sizing tables.

- B. Copper Pipe Flexible Connectors - Small Diameter (Sweat):
1. Size: 3/4 inch through 2-1/2 inch nominal pipe size (NPS).
 2. Pipe Ends: Copper tube sweat.
 3. Corrugated Hose: Bronze.
 4. Outer Braid: Single braided bronze.
 5. Minimum Working Pressure Rating: 120 PSIG at 250 degrees F.
 6. Maximum Temperature Rating: 250 degrees F.
- C. Copper Pipe Flexible Connectors - Small Diameter (Removable):
1. Size: 3/4 inch through 2-1/2 inch nominal pipe size (NPS).
 2. Pipe Ends: Female pipe coupling, Female union, Male Hex Nipple, Male Pipe with Hex Nut.
 3. Corrugated Hose: Bronze.
 4. Outer Braid: Single braided bronze.
 5. Minimum Working Pressure Rating: 120 PSIG at 250 degrees F.
 6. Maximum Temperature Rating: 250 degrees F.
- D. Steel Pipe Flexible Connectors - Small Diameter (welded):
1. Size: 3/4 inch through 2-1/2 inch nominal pipe size (NPS).
 2. Pipe Ends: Weld nipple.
 3. Corrugated Hose: Bronze.
 4. Outer Braid: Single braided bronze.
 5. Minimum Working Pressure Rating: 300 PSIG at 250 degrees F.
 6. Maximum Temperature Rating: 250 degrees F.
- E. Steel Pipe Flexible Connectors - Small Diameter (Removable):
1. Size: 3/4 inch through 2-1/2 inch nominal pipe size (NPS).
 2. Pipe Ends: Schedule 40 steel with male pipe thread (MPT).
 3. Corrugated Hose: Bronze.
 4. Outer Braid: Single braided bronze.
 5. Minimum Working Pressure Rating: 300 PSIG at 250 degrees F.
 6. Maximum Temperature Rating: 250 degrees F.
- F. Steel Pipe Flexible Connectors - Large Diameter:
1. Size: 3 inch through 10 inch nominal pipe size (NPS).
 2. Pipe Ends: 150 LB plate steel flat faced flange.
 3. Corrugated Hose: Type 304 stainless steel.
 4. Outer Braid: Single braided Type 304 stainless steel.
 5. Minimum Working Pressure Rating: 150 PSIG at 250 degrees F.
 6. Maximum Temperature Rating: 250 degrees F.
- G. Manufacturers: Metraflex, Keflex, or equal.

2.9 ACCESSORIES

A. Pipe Alignment Guides:

1. Two piece welded steel with enamel paint, bolted, with spider to fit standard pipe, frame with four mounting holes.
2. Clearance for minimum one inch thick insulation.
3. Minimum three inches travel.

2.10 EXPANSION TANKS

A. General:

1. Performance as scheduled.
2. Full acceptance flexible heavy duty butyl removable bladder or flexible heavy duty butyl diaphragm sealed into tank, as scheduled.

B. Construction:

1. Designed, tested and stamped in accordance with ASME SEC 8-D standards; supplied with National Board Form U-1.
2. Welded steel shell and base.
3. Forged steel system connections.
4. Steel support stand.

C. Ratings:

1. Working pressure: 125 PSIG.
2. Working Temperature: 240 degrees F.
3. Precharge: As Scheduled.

D. Accessories:

1. Pressure gage.
2. Air charging fitting.
3. Tank drain isolation valve.
4. System connection isolation valve.

E. Model and size: As scheduled.

F. Manufacturers: Taco, Amtrol, Armstrong, Bell & Gossett, or equal.

2.11 AIR VENTS

A. Coin operated vent: Manual low profile vent for use in baseboard and other enclosures where automatic vent will not fit. 150 PSIG working pressure, 212 degrees F. operating temperature. Bell & Gossett No. 4V or approved equal.

B. Float Type:

1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
2. Iron body and cover, float, bronze pilot valve mechanism suitable for system operating temperature and pressure; with isolating valve.
3. Operating pressure 150 PSIG, 250 deg F maximum temperature, intended for use in hot or cold lines. Provide ball type isolation valves for air vents that do not have integral shut off valves.
4. Manufacturers: Spirotherm Spirotop, Honeywell EA791004, or equal.

C. Disc Type:

1. Designed to be replaced without removal from line, with built-in check valve.
2. Limited to baseboard, unit ventilators, cabinet unit heaters, convectors, and elsewhere where air vent must be installed in a cabinet or enclosure, unless other type detailed on drawings.
3. Maximum working pressure: 50 PSIG.
4. Manufacturer: Hoffman No. 500, or equal.

2.12 AIR SEPARATORS

A. Construction:

1. Designed, tested and stamped in accordance with ASME standards.
2. Welded steel shell with flanged connections.
3. Entering velocity not to exceed 4 feet per second.
4. Internal copper wound coalescing eliminator.
5. Top venting chamber with integral full port float actuated brass venting mechanism.
6. Side tap with valve to flush dirt or liquids and quick air bleed.

B. Ratings:

1. Working pressure: 150 PSIG (minimum).
2. Working Temperature: 125 degrees F (minimum).
3. Capable of removing 100 percent of free air, 100 percent of entrained air, and 99.6 percent of dissolved air in the system fluid.
4. Dirt separation of at least 80 percent of all particles larger than 30 micron and larger within 100 passes.

C. Size: As scheduled.

D. Manufacturer: Spirotherm VDX (Basis of Design), B&G CRS, Wessels.

2.13 STRAINERS

A. Size two inch and under:

1. Screwed brass or iron body for 175 PSIG working pressure.
2. Y pattern with 1/32-inch stainless steel perforated screen.

- B. Size 2-1/2 inches to four inches:
 - 1. Flanged or grooved iron body for 175 PSIG working pressure.
 - 2. Y pattern with 3/64-inch stainless steel perforated screen.
- C. Size five inches and larger:
 - 1. Flanged or grooved iron body for 175 PSIG working pressure.
 - 2. Basket pattern with 1/8-inch stainless steel perforated screen.
- D. Manufacturers: Metraflex, Armstrong, Crane, Hayward, Watts Regulator, Hoffman, Sarco.

2.14 AUTOMATIC FLOW LIMITING AND ISOLATION VALVES

- A. Supply pipe side: Brass alloy body with stainless steel flow cartridge assembly, integral ball valve, 20 mesh strainer element, two pressure/temperature test valves and drain valve with hose bibb adapter and end cap. Body design allows removal of flow cartridge without disturbing piping connections. Threaded sweat adapter inlet. Union with sweat adapter outlet.
- B. Return pipe side: Forged brass body with integral ball valve, pressure/temperature test valve and manual air vent. Union with sweat adapter inlet. Threaded sweat adapter outlet.
- C. Calibration: Control flow within five percent of selected rating, over operating pressure range of at least 10 times minimum pressure required for control. Provide three operating pressure ranges with a minimum range requiring less than 3.5 PSID to actuate flow control cartridge.
- D. Flow Control Cartridge: Stainless steel one piece cartridge with segmented port design and full travel linear coil spring.
- E. Provide supply and return components packaged as a system and labeled in accordance with the equipment schedule tag to match terminal heating unit served.
- F. Manufacturer: Griswold Controls, Bell & Gossett, or approved equal.

2.15 BALANCING VALVES

- A. Provide calibrated plug or ball valve type balancing valves with self-sealing quick connect pressure taps, scale and locking device. Include schedule with submittal.
- B. Manufacturers: Bell & Gossett, Taco, or equal.

2.16 FLUSHING AGENT

- A. Synthetic organic dispersant manufacturer: CH2O, Product 6149 or approved equal.

2.17 WATER TREATMENT

- A. Hydronic loop treatment manufacturer: CH2O, Product 6439 or approved equal.

2.18 GLYCOL SYSTEMS

- A. Provide equipment and products specifically designed and approved for continuous operation with the glycol solution specified.
- B. Glycol Solution:
 - 1. Inhibited propylene glycol solution premixed to 50 percent by volume for use with hydronic heating systems.
 - 2. Fluid analysis test kit.
 - 3. Manufacturer: Dow Chemical Company Dowfrost. No substitutes.
- C. Automatic Glycol Make-up System:
 - 1. Provide packaged glycol make-up system as scheduled with single point electrical connection.
 - 2. Fill glycol make-up tank one half full with clean solution after testing and final system check out has been completed.

PART 3 - EXECUTION

3.1 INSTALLERS

- A. Installer: Perform work by experienced personnel previously engaged in hydronic system construction and under the supervision of a qualified installation supervisor.

3.2 PREPARATION

- A. Protection of In-Place Conditions: Cover equipment and plug piping connections to protect components from construction dirt and debris.
- B. Surface Preparation:
 - 1. Prior to installation of equipment, verify concrete housekeeping pads are complete and properly sized for equipment mounting.
 - 2. Prior to installation of piping and equipment, verify that shop drawings are approved, and locations and routing have been coordinated with the work of other trades.

3.3 INSTALLATION

- A. Special Techniques:

1. Install equipment in accordance with manufacturer's instructions and requirements of the codes specified herein.
2. Provide finished products with protective covers during balance of construction.
3. Provide accessible ball type isolation valves at major piping branches, and on main lines as shown, and at terminal devices. Provide drains and manual vents at main line and branch line valves to facilitate draining and filling piping sections. Provide caps on drain outlets.
4. Access Doors: Provide appropriate size and install such that hydronic system features are readily accessible and maintainable.
5. Install balancing valves and automatic flow limiting valves to be accessible and adjustable.
6. Install piping to maintain headroom, conserve space, and not interfere with use of space.
7. Use of bullhead tee with opposed flow, double inlet configuration not allowed.
8. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
9. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
10. Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting. Refer to Division 9 - Finishes.
11. Thermal Expansion:
 - a. Install piping to allow for normal thermal expansion and contraction without stressing pipe, joints, or connected equipment.
 - b. Provide anchors where necessary and as shown.
 - c. Provide support and expansion loops, expansion compensators, and alignment guides to suit conditions and as shown on drawings.
 - d. Piping shall be guided and restrained as recommended by the manufacturer.
12. Provide test plugs on both inlet and outlet sides of heat transfer elements to allow measurement of both fluid pressure drop and differential temperature.
13. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.
14. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor the other end. Install in horizontal plane unless indicated otherwise.
15. Provide pipe anchors, offsets, loops and expansion compensators as required to control the expansion of pipelines.
16. Flushing:
 - a. Where hydronic piping installed under this project is connected to an existing hydronic system, provide branch isolation valves and provision for cleaning and flushing consisting of tees with valve, hose fittings and caps immediately adjacent to the branch isolation valves.
 - b. Clean internal surfaces of the completed heating system as follows:
 - 1). Flush hydronic piping to remove black magnetic iron oxide and mill scale from the system.
 - 2). Flush system piping with synthetic organic dispersant to remove grease. Circulate solution through system at 150 degrees F or greater for 12 to 24 hours.

- 3). Repeat process until the system is clean to the satisfaction of the Contracting Agency.
 - 4). Flush system with fresh water as necessary to remove residual cleaning agent.
 - 5). Exercise proper care during flushing and cleaning of systems to make sure no damage is done to equipment, valves, fittings, or Work of other trades. Restore damaged system components or Work of other trades to new or original condition at no additional cost to Owner.
- B. Interface with Other Work: Coordinate and sequence installation of hydronic products with trades responsible for portions of this and other related sections of the Project Manual.

3.4 REPAIR/RESTORATION

- A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.
- B. Substitute replacement parts from other manufacturers are not acceptable.
- C. Touch-up finished surfaces with touch-up paint provided by the equipment manufacturer.

3.5 SITE QUALITY CONTROL

- A. Non-Conforming Work: Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.
- B. Manufacturer Services:
 1. Verify units are installed and operational in accordance with the manufacturer's written installation instructions.
 2. Both the Contractor and Manufacturer's Representative(s) shall sign start-up and operational checklist to confirm proper unit installation and operation.
 3. Provide samples of the inhibited propylene glycol solution to the manufacturer for testing using the fluid analysis test kit provided.
 4. The manufacturer of the inhibited propylene glycol solution shall provide free testing of the solution 24 hours after system startup and again 90 days later to verify proper fluid performance for both tests.
 5. Provide one copy of manufacturer's test reports to the Owner. Adjust fluid concentration and/or correct deficiencies as addressed in the report.
- C. Hydronic System Cleaning and Treatment Coordination Meeting:
 1. Conduct a meeting prior to flush cleaning and treatment of the hydronic heating system to discuss cleaning agents, treatment chemicals and procedures to be used. Discuss system fill procedures with inhibited propylene glycol solution.
 2. Participants shall include the Contractor and Subcontractor directly performing the work and the Owner's Maintenance Staff personnel.
 3. Provide one week notice prior to the meeting.

4. Cleaning, filling and treatment of any hydronic system is not permitted until this coordination meeting has been conducted and the Contracting Agency's concerns have been adequately addressed.

D. System fill:

1. After flush cleaning the hydronic heating system, fill the primary system with water and add treatment chemicals to the concentration recommended by the manufacturer. Fill the secondary loop system with inhibited propylene glycol solution as specified.
2. Thoroughly vent the systems to include piping high points and equipment vents (pump casings, air separators, etc.).

E. Site Tests:

1. Hydrostatic Pressure Test:

- a. Make sure hydronic heating system is filled with clean operating fluid. Hydrostatically test system to 100 PSIG. System must hold test pressure for a two hour period with no pressure drop to pass test.
- b. Inspect system during test and repair leaks.
- c. Provide written report indicating that the pressure test has been satisfactorily completed.

2. Operational Test:

- a. Inspect system for proper fluid circulation, sufficient clearance for expansion and contraction of piping and proper system pressure control.
- b. Note and correct discrepancies and deficiencies.
- c. Provide written report indicating that the operational test has been satisfactorily completed.

3. Test results shall be certified in writing as required by General Conditions. Include dates and sections tested, test pressure, test duration, printed names and signatures of person performing the test and Contracting Agency witnessing the test.

- F. Inspection: Arrange for inspections and provide written notice to the Contracting Agency when the entire work or logical portions thereof, is ready for inspection.

- G. Verify penetrations are installed to maintain assembly integrity.

3.6 SYSTEM STARTUP

- A. Start-up and operate hydronic heating systems and equipment in accordance with the manufacturer's written installation and operation manual checklist.

- A. Document start-up and operational checks using the checklist and submit in accordance with submittal requirements.

3.7 ADJUSTING

- A. Adjust functional components for proper operation in accordance with manufacturer's recommendations, or as otherwise directed.
- B. Coordinate and work directly with the Balancing and Testing Agency and the requirements of Section 230593 - Testing, Adjusting and Balancing, to provide systems in proper operating order.
- C. Make corrections and adjustments as required by the Testing, Adjusting and Balancing (TAB) Agency in a timely manner.

3.8 CLEANING

- A. Waste Management: After construction is completed, clean and wipe down exposed surfaces of pumps, piping and appurtenances.

3.9 CLOSEOUT ACTIVITIES

- A. Demonstration: Provide 2 hours of demonstration conducted by authorized factory start-up personnel to the Contracting Agencies authorized maintenance personnel.
- B. Training: Provide 4 hours of operational instruction conducted by authorized factory start-up personnel to the Contracting Agencies authorized maintenance personnel.

END OF SECTION 232113

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. In-line circulators.
2. Vertical in-line pumps.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 204100 - Mechanical Demolition
7. 230593 - Testing, Adjusting and Balancing
8. 232113 - Hydronic Piping and Specialties
9. 235216 - Condensing Boilers and Accessories
10. 253000 - Building Automation System Field Devices
11. 254000 - Variable Speed Drives
12. 255000 - Building Automation System
13. 259000 - Sequence of Operations

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. UL 778 - Motor Operated Water Pumps.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. This section describes specific requirements, products and methods of execution for interrelated systems necessary for the pumping of heating fluid, which will be distributed to the locations shown.
2. The method of generation of, and distribution of, this heat is specified elsewhere.

B. Performance Requirements:

1. Select pumps to operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

2. Provide performance and output shown or scheduled on drawings.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

- B. Product Data:

1. Provide manufacturers' product literature, clearly annotated to indicate specified salient features and performance criteria.
2. Include the following:
 - a. Catalog data sheets for each pump scheduled. Indicate which model is being submitted.
 - b. Certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
 - c. Dimensional data.
 - d. Features and appurtenances being provided.
 - e. Electrical characteristics and connection requirements.

- C. Shop Drawings:

1. Submit fully dimensioned shop drawings of boiler room showing major equipment and housekeeping pads, with clear callouts indicating deviations from layout shown.
2. Indicate mechanical and electrical service locations and requirements.

- D. Quality Assurance/Control Submittals:

1. Design Data and Test Reports: Provide design data and test reports for each pump.
2. Certificates, Manufacturer's Instructions, and Manufacturer's Field Reports:
 - a. Provide a complete manufacturer's written installation, operation and maintenance manual for each installed pump. Clearly annotate the manual to indicate applicable information for the specific equipment model(s) installed.
 - b. Test pump operation and sequencing in accordance with the manufacturer's written installation and testing instructions and Section 259000 - Sequence of Operations.
 - c. Submit a letter of certification indicating that the pump installation and start-up has been completed, that the pumps are properly adjusted and operating within the tolerances as specified by the manufacturer, and that the sequence of operation is fulfilled.
 - d. Included with the manual one copy of the completed start-up and operation checklist. The checklist shall include:
 - 1). Printed names and signatures of the installers.

- 2). Documentation from Manufacturer's representative and Contracting Agency that the pumps have been properly installed and each is fully operational, thus validating the equipment warranty.

1.6 CLOSEOUT SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.
- B. Closeout Submittals:
- C. Project Record Documents: Record actual locations of pumps and associated valves, and areas required for maintenance access.
- D. Operation and Maintenance (IO&M) Manuals:
 1. Provide copies of approved submittal information for inclusion within the project IO&M Manual.
 2. Include manufacturer's descriptive literature, operating instructions, installation instructions, assembly views, lubrication instructions, maintenance and repair data, parts listings, and spare parts list.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.
- B. Regulatory Requirements: Products Requiring Electrical Connection shall be listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.9 DELIVERY, STORAGE AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 IN-LINE CIRCULATORS

- A. Type: Horizontal shaft, single stage, direct connected, with resiliently mounted motor for in-line mounting.
- B. Materials:
 - 1. Pump Volute: Cast iron, with 125 pound ANSI flanged pump connections.
 - 2. Impeller: Stainless Steel.
 - 3. Shaft: Alloy steel copper sleeve.
 - 4. Mechanical Seal Assembly: Carbon brass trim, ceramic seat.
- C. Performance:
 - 1. As scheduled.
 - 2. Maximum working temperature: 230 degrees F.
 - 3. Maximum working pressure: 145 PSIG.
- D. Electrical Characteristics:
 - 1. As scheduled.
 - 2. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.
- E. Manufacturers: Taco (Basis of Design), Grundfos UPS Series, Armstrong, Bell and Gossett.

2.2 VERTICAL IN-LINE PUMPS

- A. Type: Single stage, single suction, split coupled, vertical in-line pump with inverter duty motor for VSD operation.
- B. Materials:
 - 1. Pump Body: Cast iron, with 125 PSIG ANSI flanged connections.
 - 2. Impeller: Stainless Steel.
 - 3. Bearings: Sleeve, Oil Lubricated.
 - 4. Shafts: Stainless steel.
 - 5. Mechanical Seal Assembly.
 - a. Stationary face: Carbon.
 - b. Rotating face: Tungsten Carbide.
- C. Performance:
 - 1. As scheduled.
 - 2. Maximum working temperature: 230 degrees F.
 - 3. Maximum working pressure: 145 PSIG.

- D. Electrical Characteristics:
 - 1. As scheduled.
 - 2. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.
- E. Manufacturers: Taco (Basis of Design), Grundfos, Armstrong, Bell and Gossett.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protection: Cover pumps and plug piping connections to protect pumps from construction dirt and debris.
- B. Preparation: Prior to installation of pumps, verify that electrical power is available and of the same voltage and phase characteristics as the pump being installed.

3.2 INSTALLATION

- A. Install pumps, pump supports, suction guides, mechanical seal piping, pressure gauges and other pump appurtenances in accordance with the manufacturer's written installation instructions.
- B. Provide access space around pumps for service. Provide no less than the minimum as recommended by manufacturer.
- C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings.
- D. Provide line sized shut-off valve on pump suction, and line sized soft seat check valve.
- E. Provide air cock and drain connection on horizontal pump casings.
- F. Provide gauges with connections to suction and discharge.
- G. Lubricate pumps before start-up.

3.3 CONSTRUCTION

- A. Interface with Other Work:
 - 1. Coordinate and sequence installation of pumps and appurtenances with trades responsible for portions of this and other related sections of the Project Manual.
 - 2. Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

3.4 REPAIR/RESTORATION

- A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.
- B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services:
 - 1. After completion of the installation, a qualified representative of the pump manufacturer shall conduct pump start-up and written certification.
 - 2. Start-up and adjust the system to within the tolerances as specified by the equipment manufacturer. Verify pump impellers rotate in the correct direction.
 - 3. Provide two hours operating instruction to authorized Owner's Representative.
 - 4. Test pump operation and sequencing in accordance with submittal requirements.
 - 5. Submit a letter of certification indicating that the pump installation and start-up has been completed.

3.6 ADJUSTING

- A. Coordinate and work directly with the Testing, Adjusting and Balancing Agency to provide systems in proper operating order. Make corrections and adjustments as required by the Balancing and Testing Agency in a timely manner.

3.7 CLEANING

- A. After construction is completed, clean and wipe down exposed surfaces of pumps, piping and appurtenances.
- B. Touch up marred or scratched factory finished surfaces using finish materials furnished by manufacturer.

3.8 DEMONSTRATION & START-UP

- A. Start-up and operate hydronic pumps in accordance with the manufacturer's written installation and operation manual checklist.
- B. Document start-up and operational checks using the checklist and submit in accordance with submittal requirements.

END OF SECTION 232123

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal Ductwork and Fittings.
2. Flexible Ductwork.
3. Acoustical Linings.
4. Volume Dampers.
5. Smoke and Combination Fire/Smoke Dampers.
6. Flexible Duct Connectors.
7. Access Panels and Doors.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200700 - Mechanical Insulation
6. 230593 - Testing, Adjusting and Balancing
7. 233400 - HVAC Fans
8. 233600 - Air Terminal Units
9. 233700 - Air Outlets and Inlets
10. Division 28 - Electrical

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. ASHRAE Standard 90.1-2010 Energy Standard for Buildings Except Low-Rise Residential Buildings.
3. SMACNA HVAC Duct Construction Standards - Metal and Flexible, Third Edition 2005.
4. SMACNA HVAC Air Duct Leakage Test Manual, Second Edition 2012.
5. SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, Fifth Edition 2002.
6. NFPA 90A - Installation of Air-Conditioning and Ventilating Systems.
7. ACR the National Air Duct Cleaners Association (NADCA) Standard for Assessment, Cleaning and Restoration of HVAC Systems, 2013.

1.3 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.4 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.
- B. Product Data: Include manufacturer's detailed fire, smoke, and combination fire/smoke damper installation instructions for each specific wall, ceiling, and floor construction type(s) for the project.
- C. Shop Drawings:
 - 1. Include the following information in the scaled ventilation system shop drawings:
 - a. Label duct sizes using the same labeling method as the Contract Documents.
 - b. Show terminal equipment ductwork connections.
 - c. Volume, control, backdraft, fire, smoke, and combination fire/smoke damper locations as applicable.
 - d. Flexible connection locations.
 - e. Access panels and doors with sizes and swing directions shown.
 - 2. Casings and plenums: Submit detailed shop drawings showing the proposed plenum and casing materials to be used and the construction method.
- D. Test and Evaluation Reports:
 - 1. Provide written certification to the Contracting Agency that smoke and combination fire/smoke dampers have been operationally tested and function in accordance with Section 283100 - Addressable Fire Alarm sequences of operation.
- E. Installation, Operation and Maintenance (IO&M) Manuals.

1.5 CLOSEOUT SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.
- B. Record Documentation: Record actual locations of ductwork and areas required for maintenance access in accordance with Section 200000 - Mechanical General Requirements.

1.6 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

1.8 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 METAL DUCTWORK AND FITTINGS

- A. General: Provide metal ductwork and fittings fabricated in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, G90 zinc coated unless otherwise noted.
- B. Medium Pressure/Velocity Ductwork:
 - 1. Duct Pressure Class: 6 inches WC.
 - 2. Seal Class: A.
 - 3. Maximum Velocity: 2,200 FPM.
- C. Low Pressure/Velocity Ductwork:
 - 1. Duct Pressure Class: 2 inches WC.
 - 2. Seal Class: A.
 - 3. Maximum Velocity: 1,500 FPM.

2.2 FLEXIBLE DUCTWORK

- A. Manufacturers:
 - 1. Thermaflex, Model M-KE.
 - 2. Hart & Cooley.
 - 3. JPL.
 - 4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.
- B. Description: UL listed, Class 1 flexible ductwork in compliance with NFPA 90A and 90B.
- C. Performance/Design Criteria:

1. Positive Pressure Rating:

Ten inches WC	(4"-12" ID).
Six inches WC	(14"-16" ID).
Four inches WC	(18"-20" ID).

2. Negative Pressure Rating:

One inch WC	(4"-12" ID).
One half inch WC	(14"-20" ID).

3. Maximum Velocity: 5000 FPM.
4. Operating Temperature Range:
 - a. 0 degrees F to 140 degrees F (continuous).
 - b. Minus 20 degrees F to 250 degrees F (intermittent).
5. Insulating Value: R-4.2.

D. Materials:

1. Acoustically rated black polyester core permanently bonded to coated spring steel wire helix.
2. Fiberglass insulation.
3. Tear resistant, reinforced metalized vapor barrier.

2.3 ACOUSTICAL LININGS

A. Manufacturers:

1. Knauf.
2. Johns Manville.
3. Owens-Corning.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Description:

1. UL listed.
2. NFPA 90A and 90B compliant.
3. One inch thick, 1.5 PCF, flexible, edge-coated, mat-faced glass fiber insulation bonded with thermosetting resin.
4. Does not promote growth of fungi or bacteria.

C. Performance/Design Criteria:

1. Maximum Velocity: 6000 FPM.
2. Operating Temperature Range: Up to 250 degrees F.
3. Maximum Water Vapor Sorption: Three percent by weight.

2.4 VOLUME / BALANCING DAMPERS

A. Manufacturers:

1. Ruskin.
2. Greenheck.
3. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Materials:

1. Refer to SMACNA HVAC Duct Construction Standards - Metal and Flexible for fabricated volume damper construction requirements.
 2. Round ducts to 12 inches diameter and rectangular to 18 inches width:
 - a. Flat sheet, galvanized steel, single blade damper.
 - b. Damper blade two gauges thicker than the duct gauge at the location installed (24 gauge minimum for round, 22 gauge minimum for rectangular).
 - c. Manual hand quadrant.
 3. Round ducts over 12 inches diameter:
 - a. Flat sheet, galvanized steel, single blade damper.
 - b. Damper blade two gauges thicker than the duct gauge at the location installed (22 gauge minimum).
 - c. Manual hand quadrant with continuous steel rod.
 4. Rectangular ducts over 18 inches width:
 - a. Flat sheet, galvanized steel, single blade damper.
 - b. Damper blade 18 gauge minimum.
 - c. Manual hand quadrant with continuous steel rod.
 5. Accessible and lockable damper operators.
- C. Extractors: Not Permitted.
- D. Splitter Dampers: Not Permitted.

2.5 REMOTE VOLUME DAMPER OPERATORS

- A. Manufacturers:
1. Duro-dyne.
 2. Young Regulator.
 3. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.
- B. Provide flush mounted chrome plated remote operators with tamperproof cover, extension rod, and not more than one 90 degree angle gear drive.
- C. Regulator: Duro-dyne Series SRC-380 or Young Regulator 301.
- D. Angle Drive: Duro-dyne Model AD-38 or Young Regulator 927.

2.6 SMOKE AND COMBINATION FIRE / SMOKE DAMPERS

- A. Manufacturers:
1. Ruskin FSD60 (Basis of Design).

2. Greenheck.
3. Pottorff.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Regulatory Requirements:

1. Smoke dampers UL listed and labeled in accordance with UL Standard 555S.
2. Combination fire/smoke dampers also listed in accordance with UL Standard 555.

C. Performance/Design Criteria:

1. Fire rating suitable for the applicable wall construction rating in accordance with IBC.
2. Rated for use in dynamic system with maximum velocity of 4,000 FPM and maximum 8 inches WC static pressure.
3. Elevated temperature rating: Minimum 250 degrees F.
4. Leakage classification: Class I.
5. Supply damper actuators as part of the listed damper assembly. If the damper actuators must be provided separately, actuators must be UL listed for a temperature rating greater than or equal to that of the damper.
6. Provide damper actuators powered by 120 VAC, energized in the normal open position and spring driven closed on loss of power. See Section 283100 - Addressable Fire Alarm for sequences of operation.
7. Provide thermal actuation of combination fire/smoke dampers by a UL listed electric temperature-sensing device (165 degrees F electric fuse) with manual remote reset capability from the fire alarm system.

2.7 FLEXIBLE DUCT CONNECTORS

A. Manufacturers:

1. Duro-dyne Corporation.
2. Vent Fabrics.
3. Ductmate.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Performance/Design Criteria: Provide fan connectors with static pressure ratings suitable for each specific application. Minimum pressure ratings must be greater than, or equal to, the fan's shut-off static pressure, as indicated by the submitted fan curve, with a 50 percent safety factor.

C. Materials:

1. Metal edging: 24 gauge galvanized steel.
2. Fabric: UL Listed, polyester blend with vinyl coating. Double folded seams. Four inches width.

2.8 ACCESS PANELS AND DOORS FOR DUCTS AND PLENUMS

A. Manufacturers:

1. Air Balance Inc. model FSA-100 (Basis of Design).
2. Ruskin.
3. Ductmate.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Material:

1. Frame and Door: Minimum 24 gauge galvanized steel.
2. Reinforced doors with cross-bracing and/or otherwise stiffened to prevent rattling and vibration.
3. Seals: Rubber gaskets, secured to door or frame.
4. Where ductwork is insulated or lined, provide double-walled access door panels with one inch of internal insulation to match duct or plenum insulating and/or sound attenuating characteristics.
5. Walk Through Doors:
 - a. Construct in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
 - b. Provide insulation and inner liner to match plenum or casing.

C. Hinges and Latches:

1. Low velocity system access panels:
 - a. Sizes 12 inches by 12 inches through 24 inches by 24 inches.
 - b. Continuous steel hinge mechanically fastened to frame and quarter turn cam latches.
2. Medium velocity system access panels:
 - a. Sizes 12 inches by 12 inches through 24 inches by 24 inches.
 - b. Continuous steel hinge mechanically fastened to frame.
 - c. Provide a minimum of two latches for rolled plate doors.
 - d. Cement sheet rubber gasket to door.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify location, size and type (i.e. fire resistive construction) of wall, floor and ceiling/roof penetrations.

3.2 PREPARATION

- A. Protection on In-Place Conditions: During construction, install temporary closures of sheet metal, cardboard or polyethylene taped over ductwork openings to prevent construction dust and debris from entering duct systems.

3.3 INSTALLATION

A. Metal Ductwork and Fittings:

1. Install, seal and support ductwork and fittings in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible for the duct pressure class and seal class specified. The use of “duct tape” as a duct seal method is prohibited.
2. Provide medium pressure/velocity ductwork at the following locations: VAV ventilation systems from air handler cabinet discharge plenum connection to VAV terminal unit inlet neck connection.
3. Provide low pressure/velocity ductwork at the following locations:
 - a. VAV terminal unit discharge connections to air outlet connections.
 - b. Outside air intake ductwork.
 - c. Exhaust air ductwork.
 - d. Constant volume ventilating systems.
4. Proprietary or other joint systems may be substituted for SMACNA details when submitted and approved in writing before starting work.
5. Where ducts penetrate through walls exposed in occupied spaces, provide sheet metal escutcheons at each penetration to provide a clean, finished appearance.
6. Duct penetrations: See Section 200529 - Mechanical Hangers and Supports.
7. Provide standard 45-degree lateral wye takeoffs. When space does not allow 45-degree lateral wye takeoffs, use 90-degree conical tee or low-loss tee connections.
8. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream of equipment.
9. Provide orifice plates or balance dampers at branch connections as required for proper ventilation system balancing. Select balancing device and installation method to limit noise from mechanical vibration or air bypass.
10. Do not use turning vanes in medium velocity duct systems.
11. Support duct mounted equipment equal to or greater than 40 pounds, such as heating coils, independently from ductwork.
12. Support duct mounted equipment less than 40 pounds using standard duct supports and sway bracing located within 12 inches of equipment.
13. Where offsetting ductwork is not possible, ducts may be reduced a maximum of 20 percent to clear obstacles with Contracting Agency’s permission.
14. Where steel ductwork is visible through air outlets or inlets, paint visible interior ductwork flat black.

B. Flexible Ductwork:

1. Install, connect and support flexible ductwork in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
 2. Connection to air outlets in suspended grid ceiling systems: Provide a flexible duct length of 6 to 8 feet with one 90-degree bend or large radius 180-degree curve in addition to outlet connection. Support flexible duct at connections to air outlets to maintain minimum recommended bend radius.
 3. Seal flexible duct connections to rigid ductwork with draw bands to the pressure class of the rigid duct system.
 4. Flexible duct connections between medium pressure ductwork and air terminal units are prohibited.
 5. Flexible ductwork is prohibited in inaccessible locations, such as above "hard" ceilings.
 6. Flexible ductwork is prohibited at penetrations through walls.
- C. Acoustical Lined Ductwork:
1. Provide standard one inch thick acoustically lined ductwork as indicated using the acoustical liner material specified. Attach the lining material to the ductwork in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. Provide thicker acoustical lining where specifically noted.
 2. Duct dimensions indicated are net free-area duct dimensions. Add twice the liner thickness to obtain outside duct dimensions.
 3. Sleeve acoustical duct penetrations through full height walls perpendicular to wall surface. Provide 1/2-inch minimum gap between sleeve and duct. Fill gap with mineral wool backer and seal each side of penetration with acoustical sealant.
- D. Volume Dampers:
1. Provide air volume dampers at each low-pressure duct main and branch take-off for proper air balancing.
 2. Locate dampers a minimum of 10 feet from diffusers except where shown otherwise.
 3. Volume dampers are not to be installed in medium pressure, variable air volume systems.
- E. Control Dampers:
1. Provide opposed blade type dampers for the following applications:
 - a. Exhaust fan discharge dampers.
 - b. Outside air intake dampers.
 - c. Isolation dampers.
 2. Provide parallel dampers for the following application: Air handling unit mixing box.
- F. Fire, Smoke and Combination Fire/Smoke Dampers:
1. Before starting work, verify the location and types of fire resistive construction as indicated by the Contract Drawings. Typical fire rated separations include:
 - a. Area separation walls, vertical only.
 - b. Occupancy separation walls, or partitions and floors. Vertical or horizontal.
 - c. Fire resistive egress corridors, halls and vestibules.

- d. Fire resistive enclosures of hazardous spaces within an occupancy, including rooms for fuel-fired or electric heating equipment.
 - e. Fire resistive floor/ceiling assemblies associated with any of the above.
2. Verify locations and types of dampers indicated on drawings. If dampers appear to be incorrectly located or missing, obtain clarification from Contracting Agency.
 3. Install dampers at locations indicated on the Drawings and in accordance with manufacturer's UL approved installation instructions.
 4. Install round dampers plumb and free from racking. Install rectangular dampers square and free from racking.
 5. Do not compress or stretch damper sleeve into duct or opening.
 6. Handle damper using frame/sleeve. Do not lift damper using blade, actuator, or jackshaft.
- G. Flexible Duct Connectors:
1. Install duct connectors in accordance with the manufacturers written installation instructions.
 2. Provide a flexible airtight joint between fans and other vibrating equipment and the air distribution ductwork systems.
 3. Externally isolated air handling units and fans: Provide flexible connections where ducts attach to unit inlet and outlet(s) of unit.
- A. Penetrations:
1. Coordinate mechanical penetrations with architectural and structural construction details prior to installation. Set sleeves in position in concrete formwork. Provide reinforcement around sleeves as required.
 2. Provide compatible materials, fasteners, adhesives, sealants, and other products required for proper installation.
 3. Penetrations through roof, exterior walls and floors to be weather and water tight.
 4. Penetrations through fire rated assemblies to be UL listed.
 5. Penetrations through smoke partitions and barriers to resist passage of smoke.
 6. Other penetrations to have acoustical seals.
- H. Access Panels and Doors:
1. Locate access doors to enable in-duct equipment to be easily inspected, cleaned, maintained and tested and/or reset.
 2. Provide access doors at the following locations:
 - a. Fire, smoke and combination fire/smoke dampers.
 - b. Motor operated dampers.
 - c. Each side of duct mounted coils.
 - d. As necessary for duct cleaning in accordance with NADCA Industry Standard for Mechanical Cleaning of Non-Porous Air Conveyance System Components.
 - e. As necessary for maintenance access to serviceable instrumentation and control equipment.
 3. Coordinate location and size of access doors in walls, partitions and ceilings to correspond with duct access doors, dampers and automatic control devices and instruments.

4. Coordinate with supplier of component air handlers, package units and similar equipment to ensure that access doors and panels will not be obstructed when the equipment is installed.

I. Interface with Other Work:

1. Assist electrical and controls trades in mounting instrumentation devices and safety controls in ductwork and air handling units.
2. Make penetrations through exterior building walls watertight. Detail ductwork connections to prevent condensation or leakage from entering into surrounding building construction. Provide sleeves, special connections and sealant as required to accomplish this performance requirement.

3.4 SITE QUALITY CONTROL

A. Site Tests and Inspections:

1. Smoke and Combination Fire/Smoke Dampers: Test automatic closure and reset of smoke and combination fire/smoke dampers in accordance with Section 283100 - Addressable Fire Alarm sequences of operation.

B. Verify accessibility to ventilation system components for maintenance, adjustment and cleaning.

3.5 ADJUSTING

- A. Adjust and balance dampers in accordance with Section 230593 - Testing, Adjusting and Balancing.

3.6 CLEANING

- A. Refer to section 230131 - Duct Cleaning.

END OF SECTION 233100

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PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. In-line centrifugal fans.
2. Roof exhaust fans.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 230593 - Testing, Adjusting and Balancing
7. 233100 - Ducts and Accessories
8. 233700 - Air Outlets and Inlets
9. 253000 - Building Automation System Field Devices
10. 254000 - Variable Speed Drives
11. 255000 - Building Automation System
12. 259000 - Sequence of Operations
13. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. Air Movement and Control Association (AMCA) 99 - Standards Handbook.
3. ANSI/AMCA 210 (ANSI/ASHRAE Standard 51) - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
4. AMCA Publication 261 Directory of Products Licensed to Bear the AMCA Certified Rating Seal.
5. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
6. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

1.3 SYSTEM DESCRIPTION

- #### A. Performance Requirements: Provide product performance characteristics and output as specified or scheduled on drawings.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.
- B. Product Data:
 - 1. Provide fan curves with scheduled operating point clearly plotted.
 - 2. Provide sound power levels (in decibels) for each octave band for inlet, discharge, and radiated sound power for the assembled fan unit. Obtain sound level data by one of the following methods:
 - a. Actual measurements from tests performed in accordance with AMCA Standards in an AMCA registered test chamber.
 - b. Documented calculations that start with AMCA tested fan sound data and are modified in accordance with ASHRAE procedures identified in Chapter 48 of the 2011 ASHRAE HVAC Applications Handbook to accurately predict the sound power levels for the configuration shown.
 - 3. Provide electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- C. Shop Drawings. Include the following information in the scaled ventilation system shop drawings:
 - 1. Location, orientation, and size of fans.
 - 2. Maintenance access and clearance requirements.
 - 3. Fan support methods (i.e. housekeeping pads, roof curbs, etc.).
 - 4. Ductwork connections and sizes.
- D. Operation and Maintenance (IO&M) Manuals.

1.6 CLOSEOUT SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.
- B. Record Documentation: Record actual locations of fans and components and areas required for maintenance access.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.

1.9 DELIVERY, STORAGE AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Manufacturers:
 - 1. Greenheck.
 - 2. Cook.
 - 3. Acme.
 - 4. Substitution request required.
- B. Regulatory Requirements:
 - 1. AMCA Certified Ratings seal for sound and air performance.
 - 2. Products Requiring Electrical Connection - Listed and classified by Underwriters Laboratories Inc., or by a testing firm acceptable to the Authority Having Jurisdiction as suitable for the purpose specified and indicated.
- C. Performance/Design Criteria: As scheduled.
- D. Manufacturer's Nameplate: Permanently affixed, embossed metal containing model number and individual serial number for future identification, located on a permanent part of the fan.

2.2 IN-LINE CENTRIFUGAL FANS

- A. Duct mounted, direct drive, in-line centrifugal type fans. Rectangular fan housing design constructed of heavy gauge galvanized steel with rectangular duct mounting collars.
- B. Removable panel in fan cabinet of sufficient size to permit access for service to internal components without dismantling the cabinet.
- C. Centrifugal backward inclined fan wheel, constructed of aluminum and matched wheel and inlet cones for precise running tolerances. Dynamically and statically balanced at the factory.

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- D. Heavy duty ball bearing type fan motors, carefully matched to the fan load, and furnished at the specified voltage, phase, and enclosure. Motors and drives readily accessible for maintenance.
- E. NEMA 1 disconnect switch provided as standard. Factory wiring provided from motor to the handy box.
- F. AMCA Certified Ratings. Seal for both sound and air performance.
- G. Electronically Commutated Motor (ECM) with manual speed adjustment for balancing.
- H. Basis of Design: Greenheck SQ with VariGreen ECM.

2.3 ROOF EXHAUST FAN

A. Description:

- 1. General: Provide roof curb mounted up-blast type roof exhauster.
- 2. Regulatory Requirements:
 - a. UL 762 listed.
 - b. IMC compliant.
 - c. AMCA certified ratings seal for sound and air performance.

B. Construction: Heavy gauge aluminum, leak-proof construction.

C. Standard Components:

- 1. Fan wheel: Backward inclined, non-overloading centrifugal fan wheel.
- 2. Motor and drive assembly:
 - a. Provide heavy duty ball bearing type motor with voltage and phase as scheduled.
 - b. Belt drive with adjustable pulleys for final system balancing. Drives sized for 150 percent of driven horsepower.
 - c. Heavy gauge galvanized steel drive frame assembly.
 - d. Precision ground and polished fan shafts mounted in permanently sealed or pillow block ball bearings. Bearings selected for a minimum (L10) life in excess of 100,000 hours (or (L50) life in excess of 500,000 hours) at maximum cataloged operating speed.
 - e. Motors and drives mounted on vibration isolators and located out of air stream and readily accessible for maintenance. Out of air stream motor cooling intake.
- 3. Wind band:
 - a. One piece, heavy duty aluminum construction, continuously welded to aluminum roof cap and drain trough. Aluminum motor cover.
 - b. Galvanized steel bird screen.
 - c. Aluminum drain trough.

D. Vibration Isolation:

- 1. Double studded or pedestal style true vibration isolators.

2. No metal to metal contact.
 3. Sized to match the weight of each fan.
- E. Electrical:
1. Wiring located out of air stream.
 2. Factory installed, NEMA -3R disconnect switch.
- F. Accessories:
1. Non-stick fan wheel coating.
 2. Hinged roof cap for access to fan wheel and ductwork with rubber curb seal.
 3. Breather tube shall be 10 square inches in size for fresh air motor cooling and designed to allow wiring to be run through it.
 4. Removable grease repellent compression rubber plug to allow access for cleaning wheel through wind band.
 5. Corrosion resistant, lockable curb cap closure device.
- G. Coordinate with existing roof curb. Modify curb as needed.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation:
1. Provide roof penetrations and level roof curbs for roof mounted fans.
 2. Coordinate penetration locations with structure.

3.2 INSTALLATION

- A. General:
1. Install fans in compliance with manufacturer's written installation instructions.
 2. Provide flexible connections at fan duct connections as shown or specified. See Section 233100 - Ducts and Accessories for flexible duct connectors.
 3. Support fans independently from ductwork. Provide fan support in accordance with 200529 - Mechanical Hangers and Supports.
 4. Provide vibration isolation and seismic restraint for fans in accordance with 200548 - Mechanical Vibration and Seismic Control.
 5. Ensure that fan access doors and panels are not obstructed when the equipment is installed.
 6. Extend lubrication points so each is easily reached for maintenance.
- B. Interface with Other Work:
1. Coordinate and sequence installation of fans with trades responsible for portions of this and other related sections of the Project Manual.

2. Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate the installation with related work shall be completed at no additional expense to the Owner.

3.3 REPAIR/RESTORATION

- A. Refer to Section 200000 - Mechanical General Requirements for general repair/restoration requirements.

3.4 SITE QUALITY CONTROL

- A. Manufacturer Services: Verify fans are installed and operational in accordance with the manufacturer's written installation instructions.

3.5 SYSTEM STARTUP

- A. Start-up and operate fans in accordance with the manufacturer's written installation and operation manual check list.

3.6 ADJUSTING

- A. Adjust and balance fans in accordance with Section 230593 - Testing, Adjusting and Balancing.

3.7 CLEANING

- A. Upon completion of installation and prior to initial start-up, vacuum clean and wipe down external system components and internal shrouded areas.

3.8 CLOSEOUT ACTIVITIES

- A. Demonstration: Demonstrate proper system operation in accordance with Section 259000 – Sequence of Operations, utilizing the building automation system.

END OF SECTION 233400

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Single duct variable air volume terminal units.
- B. Products Installed But Not Supplied Under This Section: Coordinate installation of damper control actuators and application specific controllers, furnished under Section 255000 - Building Automation System. Control enclosure shall be factory mounted by the air terminal unit manufacturer.
- C. Related Sections:
 - 1. 019100 - Commissioning
 - 2. 200000 - Mechanical General Requirements
 - 3. 200529 - Mechanical Hangers and Supports
 - 4. 200548 - Mechanical Vibration and Seismic Control
 - 5. 200553 - Mechanical Identification
 - 6. 200700 - Mechanical Insulation
 - 7. 230131 - Duct Cleaning
 - 8. 230593 - Testing, Adjusting and Balancing
 - 9. 232113 - Hydronic Piping and Specialties
 - 10. 233100 - Ducts and Accessories
 - 11. 233700 - Air Outlets and Inlets
 - 12. 255000 - Building Automation System
 - 13. 259000 - Sequence of Operations
 - 14. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

- A. Codes and Standards:
 - 1. See Section 200000 - Mechanical General Requirements.
 - 2. SMACNA - HVAC Duct Construction Standards, Metal and Flexible, Third Edition 2005.
 - 3. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
 - 4. ANSI/AHRI 880-2011 - Performance Rating of Air Terminals.
- B. Abbreviations, Acronyms and Definitions:
 - 1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
 - 2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
 - 3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. This section describes specific requirements, products and methods of execution for the single duct, variable air volume, direct digital control terminal units.
2. The method of distribution of air is specified elsewhere.

B. Performance Requirements:

1. Provide product performance characteristics as specified or scheduled on drawings.
2. Operate ventilation system in accordance with Section 259000 - Sequence of Operations.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data.

C. Shop drawings:

1. This Section shop drawings to be submitted under Section 200000 - Mechanical General Requirements.
2. Include the following information on the scaled ventilation system shop drawings:
 - a. Air terminal unit locations and sizes, including discharge plenum.
 - b. Equipment tags.
 - c. Control enclosure orientation and access clearance requirements.
 - d. Ductwork connections and sizes.
 - e. Reheat coil and hydronic piping connections and valving as applicable.
 - f. Coil access door locations.

D. Installation, Operation and Maintenance (IO&M) Manuals.

1.6 CLOSEOUT SUBMITTALS:

- A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE:

- A. See Section 200000 - Mechanical General Requirements.
- B. Certifications: Air terminal units shall be certified under AHRI Standard 880 Certification Program and carry the AHRI seal.

1.9 DELIVERY, STORAGE AND HANDLING

- A. See Section 200000 - Mechanical General Requirements for general delivery, storage and handling requirements.

1.10 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 SINGLE DUCT VARIABLE AIR VOLUME TERMINAL UNITS

- A. Manufacturers:
 - 1. Titus, model DESV (basis of design).
 - 2. Price.
 - 3. Nailor Industries.
 - 4. Substitution request required.
- B. Performance/Design Criteria:
 - 1. Capacities: Provide terminal units of the sizes and performance capacities as scheduled.
 - 2. Sound Rating:
 - a. Sound data certified by AHRI.
 - b. Sound ratings for basic air terminal units with inlet diameters less than or equal to 16 inches shall not exceed NC-20 at maximum rated flow (CFM) with a differential static pressure drop of 1.0 inch water column.
 - c. Sound ratings for basic air terminal units with inlet diameters larger than 16 inches shall not exceed NC-30 at maximum rated flow (CFM) with a differential static pressure drop of 1.0 inch water column.
 - d. Radiated and discharge sound power levels at maximum air flow operating conditions shall be submitted with product information.
 - 3. Casing Leakage: Less than 2 percent of nominal CFM at 1.5 inches WC differential pressure.

- C. Control Actuator and Application Specific Controller: NEMA 1 control enclosures/digital control packages furnished by Section 255000 - Building Automation System to the air terminal unit manufacturer for factory mounting on side of casing.
- D. Materials:
1. Casing:
 - a. Minimum 22 gauge galvanized steel.
 - b. Mechanically sealed and gasketed, leak resistant construction.
 - c. Beaded inlet for low leakage construction, sized to fit standard round duct.
 - d. Rectangular discharge opening designed for slip and drive cleat connection to low pressure ductwork or reheat coil.
 - e. Multi-port, center averaging inlet velocity sensor with sensor tubing. Flow measurement taps provided for connection to application specific controller.
 - f. Internally line casing with sound liner specified below.
 2. Control Damper:
 - a. Heavy gauge galvanized steel, butterfly type damper.
 - b. One-piece, 1/2-inch diameter damper shaft with self-lubricating Delrin® or bronze oilite bearings or self-lubricating. Notched shaft end, to indicate damper position.
 - c. Synthetic damper seal to limit close-off leakage to less than 1% of terminal rated airflow at 3.0 inches water column differential pressure.
 - d. Mechanical stop to prevent damper over-stroking.
 3. Duct Transitions:
 - a. Provide rectangular reheat coil discharge plenum:
 - 1). Minimum width to match reheat coil width.
 - 2). Minimum height to match reheat coil height or maximum downstream branch duct spin-in connection diameter plus 4 inches, whichever is greater.
 - 3). Minimum length 36 inches or longer to accommodate branch ducts, or as indicated on drawings.
 - b. Sound line duct transitions and plenums to match terminal unit casing liner.
- E. Accessories:
1. Sound Liner:
 - a. UL Listed and in conformance with NFPA Standard 90A. Liners shall be fungi and bacterial resistant.
 - b. Liners shall be fiberglass with foil facing such that no fibers are exposed to airstream, as follows:
 - 1). 1" thick aluminum foil faced fiberglass insulation, 4 pound per cubic foot density, cut edges sealed from airstream using mechanically bonded metal barrier strips.

- 2). Cut liner edges and seal to prevent erosion with discharge edges secured with metal barrier strips for fiberglass or similar insulation.
2. Hydronic Reheat Coils:
 - a. Performance characteristics as scheduled.
 - b. Constructed from seamless copper tubing (minimum 0.016-inch wall thickness) with aluminum fins, enclosed in 20 gauge (minimum) galvanized steel casing with slip and drive connections. Provide extended copper sweat connections.
 3. Access Doors: Provide access doors upstream and downstream of reheat coils for coil cleaning. Refer to Section 233100 - Ducts and Accessories.

PART 3 - EXECUTION

3.1 INSTALLERS

- A. Installer: Perform work by experienced personnel previously engaged in ventilation system construction and under the supervision of a qualified installation supervisor.

3.2 PREPARATION

- A. Protection of In-Place Conditions: Cover air terminal unit inlet and discharge openings to protect components from construction dirt and debris.

3.3 INSTALLATION

- A. General:
 1. Install air terminal units in strict compliance with the manufacturer's written installation instructions.
 2. Do not locate any part or the terminal unit assembly, including reheat coil and associated low pressure sound lined plenums, such that it passes over a partition wall or through a full height wall penetration.
 3. Locate terminal units such that the bottom of the complete assembly is 6 to 18 inches above the top of the ceiling grid or hard lid ceiling framing as applicable.
 4. Locate terminal unit controller, coil hydronic piping/valves, and coil access doors on same side of unit. Locate on side that maximizes accessibility (i.e. above accessible ceiling tiles, away from full height walls and main duct runs).
 5. Support air terminal units independent of duct system. Provide sway bracing within 12 inches of support attachment.
 6. Connect air terminal unit inlets to ductwork using straight sections of unrestricted rigid duct of the same inlet diameter as terminal unit inlet. Provide a minimum straight duct length of 4 duct diameters at each terminal unit inlet. Medium pressure flexible duct connections to terminal units is not allowed except where specifically shown.

7. Close-coupling of a terminal inlet to the side of a main supply duct is not acceptable without written permission from the Contracting Agency. When this method is approved, provide an inlet flow straightening device.
8. Install low pressure ductwork branches vertically centered along the sides of the low pressure sounded lined plenum. A minimum of two (2) inches of sheet metal is required between the spin-in (or similar connection) and top and bottom external edge of the metal plenum.
9. Provide insulated access doors upstream and downstream of reheat coil for coil cleaning.
10. Secure control enclosure cover in place as intended by the manufacturer.
11. Verify mechanical connections, electrical and control wiring and sensor tubing are properly secured.

B. Interface with Other Work:

1. Coordinate and sequence the installation of air terminal units with trades responsible for portions of this and other related sections of the Project Manual.
2. Coordinate ceiling and/or wall access panel locations to provide convenient maintenance and cleaning access for each air terminal unit.
3. Coordinate air terminal unit locations with ceiling grids, lighting troffers, air outlets and return grilles to maximize accessibility and minimize interference.
4. Rework required as a result of failure to follow the manufacturer's written installation instructions, properly coordinate the installation with related work, or provide adequate access (as determined by the Contracting Agency) shall be completed at no additional cost to the Owner.

3.4 REPAIR/RESTORATION

- A. Refer to Section 200000 - Mechanical General Requirements for general repair/restoration requirements.

3.5 SYSTEM START-UP

- A. With the applicable central ventilation system air balancing completed and the ventilation system operating under automatic control utilizing the BAS, cycle each air terminal unit control damper between minimum and maximum scheduled air flow settings to demonstrate proper operation and capacity in accordance with 259000 - Sequence of Operations for verification by the Contracting Agency.
- B. Verify reheat coil and auxiliary heating unit (as applicable) hydronic control valves properly cycle with terminal unit control damper, in accordance with Section 259000 - Sequence of Operations.

3.6 ADJUSTING

- A. Adjust velocity sensor bias adjustment as necessary to provide accurate air flow measurement.
- B. For units with reheat coil supply temperature sensors, verify maximum supply temperature is limited to 20 degrees F above zone temperature setpoint.

3.7 CLEANING

- A. Upon completion of installation and prior to initial operation, vacuum clean and wipe down air terminal units and control enclosures.
- B. Remove any debris from control enclosure.
- C. Inspect and clean reheat coils. Re-straighten coil fins if necessary.

END OF SECTION 233600

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air Diffusers and Registers.
2. Return/Exhaust Grilles.

B. Related Sections:

1. 200000 - Mechanical General Requirements
2. 200529 - Mechanical Hangers and Supports
3. 230593 - Testing, Adjusting and Balancing
4. 233100 - Ducts and Accessories

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. SMACNA HVAC Duct Construction Standards - Metal and Flexible Third Edition 2005.
3. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
4. ARI Standard 890-2001 - Air Diffusers and Air Diffuser Assemblies.
5. MOA Handout A.04 - Suspended Ceilings Industry Standard Construction, May 1, 2008.

1.3 SYSTEM DESCRIPTION

- A. Performance Requirements: Provide product performance characteristics as specified or scheduled on drawings.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS:

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.
- B. Product Data: Air outlets and inlets performance data at operating conditions.
- C. Shop Drawings:

1. This Section shop drawings to be submitted under Section 200000 - Mechanical General Requirements.
 2. Include the following information on scaled ventilation system shop drawings:
 - a. Air diffuser, register and grille locations, duct connection sizes and throw directions.
- D. Installation, Operation and Maintenance (IO&M) Manuals.
- 1.6 CLOSEOUT SUBMITTALS:
- A. See Section 200000 - Mechanical General Requirements.
- 1.7 MAINTENANCE MATERIAL SUBMITTALS
- A. See Section 200000 - Mechanical General Requirements.
- 1.8 QUALITY ASSURANCE:
- A. See Section 200000 - Mechanical General Requirements.
- 1.9 DELIVERY, STORAGE AND HANDLING
- A. See Section 200000 - Mechanical General Requirements.
- 1.10 WARRANTY
- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

- 2.1 AIR DIFFUSERS AND REGISTERS
- A. Manufacturers:
1. Titus (Basis of Design).
 2. Price.
 3. Nailor Industries Inc.
 4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.
- B. Performance/Design Criteria: As scheduled.
- C. Finishes: Unless noted otherwise, standard white baked enamel or powder coated finish suitable for field application of custom finish color as required.

D. Accessories:

1. Equalizing grids.
2. Earthquake tabs.

E. Correlate diffuser style, dimension, and fit with ceiling. Provide diffusers with modules of the proper size to match the suspended ceiling layout or with appropriate factory provided frame for surface mounting.

2.2 RETURN/EXHAUST GRILLES

A. Manufacturers:

1. Titus (Basis of Design).
2. Price.
3. Nailor Industries Inc.
4. Any other manufacturer meeting the requirements of the Contract Documents. Substitution request not required.

B. Performance/Design Criteria: As scheduled.

C. Finishes: Unless noted otherwise, standard white baked enamel or powder coated finish suitable for field application of custom finish color as required.

D. Accessories: Earthquake tabs.

E. Correlate grille style, dimension, and fit with ceiling. Provide grilles with modules of the proper size to match the suspended ceiling layout or with appropriate factory provided frame for surface mounting.

PART 3 - EXECUTION

3.1 PREPARATION

A. Removal: Remove existing air diffusers, registers and grilles designated for relocation and reuse after repair and cleaning.

3.2 INSTALLATION

A. General:

1. Install products in compliance with the manufacturer's written installation instructions.
2. Connect air outlets, registers, grilles, and louvers to ventilation duct systems in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

B. Air Diffusers, Registers and Grilles:

1. Install air diffusers, registers and return/exhaust grilles at the locations shown.

2. Orient and adjust diffusers to provide the throw directions indicated.
3. Provide appropriate borders for the ceiling, wall, or floor construction type.

3.3 REPAIR/RESTORATION

- A. Refer to Section 200000 - Mechanical General Requirements for general repair/restoration requirements.
- B. Where air outlets and inlets are indicated for reuse, clean and repair existing air outlets and inlets to function as originally intended prior to reinstallation. Air outlets and inlets which require major repair may be replaced at the Contractor's option.

3.4 CLEANING

- A. Clean exposed surfaces of air outlets and inlets, with water and mild soap or detergent not harmful to finish, in order to remove fingerprints and dirt.

END OF SECTION 233700

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes: Boiler venting system.
- B. Related sections:
 - 1. 200000 - Mechanical General Requirements
 - 2. 200529 - Mechanical Hangars and Supports
 - 3. 200548 - Mechanical Vibration and Seismic Control
 - 4. 235216 - Condensing Boilers and Accessories

1.2 REFERENCES

- A. Codes and Standards: See Section 200000 - Mechanical General Requirements.
- B. Abbreviations, Acronyms and Definitions:
 - 1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
 - 2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
 - 3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

- A. Design Requirements: This section describes specific requirements, products, and methods of execution for boiler venting systems.
- B. Performance Requirements: Provide product performance characteristics as specified or scheduled on drawings.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.
- B. Product Data:
 - 1. Provide manufacturers' product literature.

2. Annotate to indicate specified salient features and performance criteria for each product specified.

C. Calculations:

1. Provide calculations from the stack manufacturer based on the submitted stack shop drawings and submitted and approved boiler draft requirements to demonstrate adequate draft available under the following operating conditions:
 - a. Boiler high and low firing rates for winter conditions of -19 degrees F.
 - b. Boiler high and low firing rates for summer conditions of 75 degrees F.
2. For multiple boilers with a common boiler stack, identify number of operating boilers and the boiler flue connection position in the manifold.

D. Shop Drawings:

1. Submit fully dimensioned shop drawings of boiler room(s) showing the following:
 - a. Major equipment and housekeeping pads, with clear callouts indicating deviations from layout shown:
 - 1). Submitted boiler shall be dimensionally equal to scheduled product within 6 inches in each dimension. Maintain clearances shown on drawings. Submit fully dimensioned shop drawings of boiler room(s) at drawing scale of 1/4-inch equals 1 foot 0 inches or larger, showing entire boiler room, equipment and deviations. Provide boiler room modifications required due to dimensional and technical deviation at no additional cost to the Owner. Submit shop drawings of proposed equipment layout and base or pad for each piece of equipment.
 - 2). If equipment to be provided exceeds the weight of the specified equipment by more than 20 percent, or if the location is to be altered, submit shop drawings and calculations of proposed revised structural design, noting location of pertinent loads, stamped by a registered professional engineer.
 - b. Service area boundaries as required by manufacturer's installation.
 - c. Boiler piping and vent stack locations with dimensions. Coordinate stack roof penetrations with roof structure.
 - d. Indicate mechanical and electrical service locations and requirements.

1.6 CLOSEOUT SUBMITTALS:

- A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 BOILER VENTING SYSTEMS

- A. Manufacturers:

1. Schebler.
2. Heat-Fab.
3. Approved equal.

- B. Description:

1. Provide complete, engineered venting system for flue gas exhaust for each boiler to include straight duct, fittings, connections, adapters, thimbles, terminations and support brackets.
2. Provide supports and seismic restraints in accordance with the manufacturer's UL listing, Section 200529 - Mechanical Hangers and Supports, and Section 200548 - Mechanical Vibration and Seismic Control.

- C. Performance/Design Criteria: UL 1738 listed for use with Category IV appliances (operating temperatures up to 600 Degrees F, positive pressure, condensing flue gas service).

- D. Materials:

1. Inner wall shall be AL29-4C stainless steel.
2. Outer wall shall be type 304 stainless steel.

- E. Assembly/Fabrication:

1. Double walled venting system with 1 inch air space between walls.
2. Vent sections shall be sealed with banded flanges and silicone joint sealant for temperatures up to 600 degrees F with a UL tested pressure rating of 4.0 inches WC.
3. Inner liner seams shall be fully welded. Riveted, tack or spot welded seams are not permitted.

4. Supports and seismic restraints in accordance with the manufacturer's UL listing.

PART 3 - EXECUTION

3.1 INSTALLERS

- A. Installer: Perform work by experienced personnel under the supervision of a qualified installation supervisor.

3.2 PREPARATION

- A. Surface Preparation: Prior to installation of stacks, verify that shop drawings are approved and stack locations and routing have been coordinated with other trades.

3.3 INSTALLATION

- A. Special Techniques:
 1. Install equipment in accordance with manufacturer's instructions and requirements of the codes specified herein.
 2. Install with clearances from building elements in accordance with chimney listing and IMC.
 3. Install components that were furnished loose with equipment for field installation.
 4. Touch up marred or scratched factory finished surfaces using finish materials furnished by manufacturer.
- B. Interface with Other Work: Coordinate and sequence installation of boiler and water heater and stacks with trades responsible for portions of this and other related sections of the Project Manual.

3.4 REPAIR/RESTORATION

- A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.
- B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 SITE QUALITY CONTROL

- A. Non-Conforming Work: Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

3.6 CLEANING

- A. Waste Management: After construction is completed, clean and wipe down exposed surfaces of boiler stacks.

END OF SECTION 235100

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PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Packaged condensing gas fired boilers and appurtenances.
2. Packaged boiler management system.

B. Related sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 230593 - Testing, Adjusting and Balancing
7. 231123 - Fuel Gas Piping and Specialties
8. 232113 - Hydronic Piping and Specialties
9. 232123 - Hydronic Pumps
10. 235100 - Breechings, Chimneys and Stacks
11. 255000 - Building Automation System
12. 259000 - Sequence of Operations
13. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. NFPA 54 - National Fuel Gas Code.
3. ASME Boilers and Pressure Vessel Code (1998), Sections IV & VI.
4. ASME CSD-1 - Controls and Safety Devices for Automatically Fired Boilers.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. This section describes specific requirements, products and methods of execution for the generation of heat, which will be distributed to the locations shown.
2. The method of distribution of this heat is specified elsewhere.

B. Performance Requirements:

1. Provide product performance characteristics as specified or scheduled on drawings.
2. Operate central heating system in accordance with Section 259000 - Sequence of Operations.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data:

1. Provide manufacturers' product literature, clearly annotated to indicate specified salient features and performance criteria to include:
 - a. Product model and selected optional equipment, appurtenances and special features.
 - b. Boiler physical and performance characteristics as scheduled.
 - c. Total equipment weight (filled with water). Boilers weighing 20 percent more than the scheduled equipment will be disapproved unless it is determined by the Owner's Representative that the structure as designed is capable of bearing the additional load with an adequate safety margin.
 - d. Dimensional data.
 - e. Anchoring method.
2. Regulatory Requirements: Provide automatic boiler controls listed in the IMC and ASME CSD-1, latest edition, together with most current addenda and interpretations.

C. Shop Drawings:

1. Submit fully dimensioned shop drawings of boiler room(s) showing the following:
 - a. Major equipment and housekeeping pads, with clear callouts indicating deviations from layout shown:
 - 1). Submitted boiler shall be dimensionally equal to scheduled product within 6 inches in each dimension. Maintain clearances shown on drawings. Submit fully dimensioned shop drawings of boiler room(s) at drawing scale of 1/4-inch equals 1 foot 0 inches or larger, showing entire boiler room, equipment and deviations. Provide boiler room modifications required due to

dimensional and technical deviation at no additional cost to the Owner. Submit shop drawings of proposed equipment layout and base or pad for each piece of equipment.

- 2). If equipment to be provided exceeds the weight of the specified equipment by more than 20 percent, or if the location is to be altered, submit shop drawings and calculations of proposed revised structural design, noting location of pertinent loads, stamped by a registered professional engineer.
 - b. Service area boundaries as required by manufacturer's installation.
 - c. Boiler piping and vent stack locations with dimensions. Coordinate stack roof penetrations with roof structure.
 - d. Indicate mechanical and electrical service locations and requirements.
 - e. Boiler management system location.
- D. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.
- E. Manufacturer Reports:
1. Provide start-up and operational test reports for each boiler. Refer to Article on Site Quality Control.
 2. Provide start-up report for boiler control system with selected presets annotated.
 3. Submit a letter to document that the training was conducted. Include in the letter the date, start/stop times for the training, list of attendees and signature/title of the person(s) providing the training.

1.6 CLOSEOUT SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

- A. See Section 200000 - Mechanical General Requirements.

- B. Provide prorated 10-year warranty on pressure vessel/heat exchanger against failure due to condensate corrosion, thermal stress, mechanical defects or workmanship.
- C. Provide 2-year warranty on control circuit boards.

PART 2 - PRODUCTS

2.1 CONDENSING GAS FIRED BOILERS

- A. Manufacturer:
 - 1. Aerco Benchmark series.
 - 2. Approved equal.
- A. Description:
 - 3. Gas fired, condensing fire tube design with modulating power burner and positive pressure discharge.
 - 4. UL Listed, CSD-1 approved, ASME coded and stamped.
 - 5. IRI gas train.
- B. Performance/Design Criteria: Manufacturer must publish known partial load efficiencies, and the thermal efficiency must increase as the firing rate decreases.
- B. Assembly/Fabrication:
 - 1. Size and clearances:
 - a. Minimum 28 inches wide, 44.5 inches long and 79 inches high.
 - b. Listed for 0 wall clearance.
 - c. Max weight 1533 pounds dry.
 - 2. Air/Fuel Supply/Burner:
 - d. Turndown capacity: 20 to 1 without loss of combustion efficiency or staging of gas valves.
 - e. Burner shall produce less than 16 PPM of NO_x corrected.
 - f. Burner shall be metal fiber mesh covering a stainless steel body, with spark ignition and flame rectification.
 - g. All material exposed to combustion shall be stainless steel.
 - h. Modulating air/fuel valve with single linkage that does not require field adjustment. VFD pre-mix blower for optimum air/gas mixture.
 - i. Gas train safety shut-off valve with proof of closure switch.
 - j. Minimum 4.2 inch W.C. gas input at rated capacity.
 - 3. Pressure Vessel/Heat Exchanger:

- k. Boiler capable of sustained operation with return water temperature down to 40 Degree F without failure due to thermal shock or fireside condensation.
 - l. ASME steel construction for working pressure: 160 PSIG.
 - m. Pressure vessel of SA53 carbon steel, 1/4 inch wall and upper head.
 - n. Heat exchanger of 316L stainless steel fire tube and 3/8 inch tube sheets, one-pass combusting gas flow.
 - o. 3-inch steel flange water connection.
 - p. Maximum water pressure drop through boiler: 4.9 PSIG at 130 GPM.
 - q. Working temperature: 200 degrees F.
 - r. ASME approved relief valve: 50 PSIG.
4. Exhaust Flue and Condensate Drain:
- s. Corrosion resistant stainless with 6-inch diameter steel flue connection.
 - t. Gravity condensate drain with collecting reservoir.
5. Packaged Boiler Controls:
- u. UL approved.
 - v. Control panel consisting of multiple circuit boards for separate control functions that area individually field replaceable. Boards provide display functions, low water cutoff, power supply, ignition control, a connector board, and a control function board.
 - w. The control panel hardware shall support both RS-232 and RS-485 remote communications.
 - x. The controls shall annunciate boiler & sensor status and include extensive self-diagnostic capabilities that incorporate a minimum of 8 separate status messages and 34 separate fault messages.
 - y. Integrated control panel with operating sequence, system fault and outlet temperature display, operating mode selector switch.
 - z. Self-governing features to take over controlled as set up by user in the event of over temperature, improper control signal, or loss of signal.
 - aa. Combustion safeguard/flame control and monitoring system with spark ignition and rectification type flame sensor.
 - bb. Electric low water cutoff with test and manual reset functions.
 - cc. Each boiler shall utilize an electric single seated combination safety shutoff valve/regulator with proof of closure switch in its gas train and incorporate dual over-temperature protection with manual reset in accordance with ASME Section IV and CSD-1.
 - dd. Self-diagnostic capabilities.
 - ee. Adjustable high and low setpoint limits.
 - ff. Temperature control modes:
 - 1). Internal setpoint.
 - 2). Indoor/outdoor Reset.
 - 3). 4mA to 20mA Temperature Setpoint.
 - 4). Network Temperature Setpoint.
 - 5). 4 mA to 20 mA Direct Drive.
 - 6). Network Direct Drive.

7). Boiler management system (ACS) with Combination Control System (CCP).

gg. Additional control system features to include:

- 1). Ambient temperature system start/stop.
- 2). Circulator pump delay timer.
- 3). Auxiliary start delay timer.
- 4). Auxiliary temperature sensor.
- 5). Analog output (mA) monitoring of temperature setpoint, supply temperature, or boiler fire rate.
- 6). Remote interlock circuit.
- 7). Delayed interlock circuit.
- 8). Remote alarm fault relay.

6. Electrical Power: 120 VAC/1 PH/60 Hz.

2.2 BOILER MANAGEMENT SYSTEM

A. Manufacturers:

1. Aerco Boiler Control System (ACS).
2. Approved equal.

B. Description: Boiler manufacturer's boiler management system control the integrated operation of the boilers on the project, and to provide a communication gateway to the building automation system. The boiler management system shall control operation and sequencing of multi-boiler central heating system.

C. Operation:

1. Control all operation and energy input of the multiple boiler heating plant.
2. Utilize MODBUS protocol to communicate with the boilers via a RS-485 port.
3. Controller shall have the following capabilities:
 - a. Vary the firing rate and energy input of each individual boiler throughout its full modulating range to maximize condensing capability and thermal efficiency.
 - b. Maintain boiler header temperature setpoint within 2 degrees F. Control will be PID.
 - c. Provide contact closure for auxiliary equipment such as pumps and combustion air inlets dampers.
 - d. Operational modes:
 - 1). Internal setpoint.
 - 2). Outdoor temperature reset control.
 - 3). 4 mA to 20 mA setpoint control.
 - 4). Network temperature setpoint control.

D. Assembly/Fabrication:

1. Other features shall include:

- a. UL approved.
 - b. Microprocessor based PID type control.
 - c. LCD display monitoring of sensors and interlocks.
 - d. Non-volatile backup of control setpoints.
 - e. Automatic rotation of lead boiler to balance operating time.
 - f. Provision for setback and remote alarm contacts.
 - g. Adjustable seasonal start/stop ambient temperature.
 - h. Contact closure control for auxiliary equipment (i.e. circulator pumps).
 - i. Supply header temperature control utilizing external inputs:
 - 1). Temperature Setpoint (4-20 mA): Boiler outlet temperature setpoint controlled linearly using a 4-20 mA input signal supplied from the building automation system.
 - 2). MODBUS Temperature Setpoint: Boiler outlet temperature setpoint controlled by external communication utilizing MODBUS protocol via a RS-232 port.
2. Open Protocol Interface: When the building automation system does not have MODBUS protocol capability and interoperability is required, provide MODBUS Gateway to act as interface/translator between the BAS and the boiler management system. Supported protocols to include BACNET, LON and N2. Provide protocol interface for the HVAC control system selected for the project.

2.3 EMERGENCY BOILER SHUTOFF

- A. Provide an emergency boiler shutoff switch. See Division 26.

PART 3 - EXECUTION

3.1 INSTALLERS

- A. Installer: Perform work by experienced personnel previously engaged in boiler plant construction and under the supervision of a qualified installation supervisor.

3.2 PREPARATION

- A. Protection of In-Place Conditions: Cover products and plug piping connections to protect equipment from construction dirt and debris.
- B. Surface Preparation:
1. Prior to installation of boilers, verify concrete housekeeping pads are complete and properly sized for boiler mounting.
 2. Prior to installation of stacks, verify that shop drawings are approved and stack locations and routing have been coordinated with required roof penetrations and the work of other trades.

3.3 INSTALLATION

A. Special Techniques:

1. Install equipment in accordance with manufacturer's instructions and requirements of the codes specified herein.
2. Install Boiler management system (BMS) in accordance with manufacture's installation instructions. Connect each of the boilers to the BMS. Program BMS to maintain boiler water temperature control as described in Sequence of Operation below.
3. Connect to the building automation system through the open protocol communication port in the BMS.
4. Setting of equipment:
 - a. Set equipment on concrete housekeeping pads compatible with the building structural system.
 - b. Level equipment to within recommended tolerances.
5. Anchoring:
 - a. Anchor boilers to housekeeping pads as recommended by the manufacturer and to allow for normal expansion and contraction.
 - b. Coordinate with Section 20 0548 - Vibration and Seismic Control.
6. Thermal Expansion:
 - a. Install hydronic piping to allow for normal thermal expansion and contraction.
 - b. Provide anchors where necessary and as indicated.
 - c. Provide expansion loops, anchors and alignment guides to suit conditions and as indicated.
7. In systems containing glycol, provide only products specifically designed and approved for continuous operation with the glycol solution specified.
8. Install components that were removed from equipment for shipping purposes.
9. Install components that were furnished loose with equipment for field installation.
10. Provide interconnecting electrical control and power wiring.
11. Provide fuel gas vent and service piping.
12. Provide piping for boiler pipe connections.
13. Program, adjust and operationally test boiler operation and sequencing in accordance with the manufacturer's written installation and testing instructions and Section 25 9000 - Sequence of Operations.
14. Touch up marred or scratched factory finished surfaces using finish materials furnished by manufacturer.
15. Install emergency boiler shutoff switch outside the boiler room at each exit at 48 inches above finished floor.

B. Interface with Other Work: Coordinate and sequence installation of boilers and stacks with trades responsible for portions of this and other related sections of the Project Manual.

C. Systems Integration: Coordinate location and operation of boiler emergency shutoff switch(es) with Divisions 26, 27 and 28.

3.4 REPAIR/RESTORATION

- A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.
- B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 SITE QUALITY CONTROL

- A. Non-Conforming Work: Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.
- B. Manufacturer Services:
 - 1. Provide manufacturer's representative start-up and instruction of each complete boiler system including all components assembled and furnished by the manufacturer whether or not of his own manufacture.
 - 2. Start-up shall be conducted by experienced and factory authorized technician in the regular employment of the authorized service organization.
 - 3. Start-up and adjust the system to within the tolerances as specified by the equipment manufacturer.
 - 4. Operationally test safety devices and record settings. Test and record oxygen, carbon dioxide, stack temperature, and calculate excess air and steady state efficiency. Make final lead/lag setpoint adjustments. List setpoints in report. Submit final data for review.
 - 5. Test boiler operation and sequencing in accordance with the manufacturer's written installation and testing instructions and Section 25 9000 - Sequence of Operations.
 - 6. Provide a start-up report that includes final control settings, and a performance chart of the control system furnished.
 - 7. Submit a letter of certification with copy of start-up report, indicating that the boiler start-up has been completed, that the boilers are properly adjusted and operating within the tolerances as specified by the manufacturer, and that the sequence of operation is fulfilled.

3.6 ADJUSTING

- A. Coordinate and work directly with the requirements of Section 230593 - Testing, Adjusting and Balancing, to provide systems in proper operating order.
- B. Make corrections and adjustments as required by the Balancing and Testing Agency in a timely manner.

3.7 CLEANING

- A. Waste Management: After construction is completed, clean and wipe down exposed surfaces of boilers and burners.

3.8 CLOSEOUT ACTIVITIES

- A. Demonstration: Provide 2 hours of demonstration conducted by authorized factory start-up personnel to the Contracting Agencies authorized maintenance personnel.
- B. Training: Provide 2 hours of operational instruction conducted by authorized factory start-up personnel to the Contracting Agencies authorized maintenance personnel.

END OF SECTION 235216

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Roof top air handling units.
2. Air filter media and support frames.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 230131 - Duct Cleaning
7. 230593 - Testing, Adjusting and Balancing
8. 232113 - Hydronic Piping and Specialties
9. 233100 - Ducts and Accessories
10. 254000 - Variable Speed Drives
11. 255000 - Building Automation System
12. 259000 - Sequence of Operations
13. Divisions 26, 27 and 28 - Electrical

1.2 REFERENCES

A. Codes and Standards:

1. See Section 200000 - Mechanical General Requirements.
2. AMCA 99 (Air Movement and Control Association) - Standards Handbook.
3. ASHRAE Standard 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.
4. ASHRAE Standard 52.2-2012 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements:

1. This section describes specific requirements, products and methods of execution for the packaged rooftop air handling equipment, which will be distributed to the locations shown.
2. The method of air distribution is specified elsewhere.

B. Performance Requirements:

1. Provide product performance characteristics as specified or scheduled on drawings.
2. Operate ventilation systems in accordance with Section 259000 - Sequence of Operations.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

B. Product Data:

1. Provide clearly annotated manufacturer's product literature that demonstrates compliance with the specified performance, manufacturing methods, appurtenances and salient features.
2. Provide fully labeled fan curve(s) with system curve and operating point clearly plotted. For variable speed fans, provide fan curves for both minimum and maximum operating points.
3. Provide custom sound power level data (decibels) for each octave band for fan inlet, fan discharge and radiated sound power of the assembled air handling unit as shown. Determine sound level data using one of the following methods:
 - a. Actual measurements from tests performed in accordance with AMCA Standards in an AMCA registered test chamber.
 - b. Documented calculations that start with AMCA tested fan sound data and are modified in accordance with 2011 ASHRAE HVAC Applications, Chapter 48 - Noise and Vibration Control accurately predict the sound power levels for the configuration shown.
4. Provide electrical connection requirements.
5. Provide electrical power connection and control logic wiring diagrams. Diagrams must differentiate between factory installed and field-installed wiring.

- C. Substitutions: Cost of any design modifications as a result of proposed product substitutions shall be borne by the Contractor.

D. Shop Drawings:

1. Provide dimensional and orientation information (plan and elevation) for the approved rooftop air handling unit(s) incorporated into the ventilation system shop drawings.

2. Indicate actual cabinet location, sectional and overall cabinet dimensions, roof curb dimensional requirements, mixing box damper sizes and arrangement, access door locations, access clearances for filter, coil and fan replacement, duct connections, and electrical connection points.
3. Provide detail for filter holding frames, grids and filter housing arrangements as applicable. Indicate filter sizes and number of each filter size necessary to complete each filter bank, Using 24 inch x 24 inch filter dimensions whenever possible.
4. Coordinate roof curb requirements and roof penetration location with Architectural and Structural.
5. Label overall roof top unit(s) as scheduled. Label each cabinet section as specified.
6. Provide cabinet anchoring method approved by the seismic design engineer in accordance with Section 200548 – Mechanical Vibration and Seismic Control.

E. Operation and Maintenance (O&M) Manual:

1. Provide a complete copy of the manufacturer's written installation, operation and maintenance manual to include the following information:
 - a. Approved product data submittal information.
 - b. Installation instructions.
 - c. Operating instructions.
 - d. Troubleshooting guide.
 - e. Preventative maintenance requirements.
 - f. Complete parts list.
 - g. Recommended spare parts list.
2. Neatly annotate the O&M manual to clearly indicate information applicable to the equipment installed.

F. Manufacturer Reports:

1. Provide a certificate from the Manufacturer's Representative indicating that the roof top unit(s) is/are installed and operational in accordance with the manufacturer's written installation, operation and maintenance manual.
2. Provide start-up and operational checks using manufacturer checklists, signed by both the installing Contractor and Manufacturer's Representatives.

G. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.

1.6 CLOSEOUT SUBMITTALS

- A. See section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

- B. Extra Stock Materials: Spare Filters. Furnish one complete set of replacement filters for each roof top unit upon final completion of project. Filters are to remain sealed in their original boxes and labeled by equipment tag as scheduled. Locate filters in storage area designated by the Contracting Agency.

1.8 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.
- B. Manufacturer qualifications: Company specializing in manufacturing the products specified in this section with a minimum of 10 years' documented experience.
- C. Certifications: Air filters certified and tested in accordance with ASHRAE Standard 52.2.
- D. Regulatory requirements: Products requiring electrical connection shall be listed and classified by Underwriters Laboratories Incorporated, or by a testing firm acceptable to the Authority Having Jurisdiction.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.
- B. Storage and Handling Requirements: Maintain access doors shut, dampers and supply duct connections covered, and drain connections capped to protect components from construction dirt and debris.

1.10 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Trane.
- B. Daikin-McQuay.
- C. Approved equal.

2.2 ROOFTOP AIR HANDLING UNITS (RTU-1)

- A. Dimensions:

1. Overall roof top unit dimensions scheduled are for the basis of design air handler manufacturer as indicated.
2. The dimensions for “as equal” manufacturers may differ.

B. Unit Casing Construction:

1. Heavy gauge steel cabinet, reinforced, and braced with steel angle framing for maximum rigidity. Designed for outdoor use and roof curb mounting. Unit base shall be watertight.
2. Exterior panels shall be zinc-coated, galvanized steel painted with gray air-dry finish.
3. Unit shall be double-wall construction in the air handling section with insulation. Interior insulation subject to the airstream shall be lined.
4. Acoustically lined cabinet interior with 2-inch thick UL listed acoustical liner materials.
5. Exterior casing, base frame and accessories coated with baked enamel finish.
6. Internal components and accessories coated with baked enamel finish or galvanized.
7. Connect parts with plated, galvanized steel fasteners.
8. Provide interior liner type and drain pan as indicated under each air handler section.
9. Provide steel stamped nameplate with air handler performance date clearly indicated.

C. Weather Hood: Galvanized steel construction with intake mounted bird screen painted to match cabinet.

D. Mixing Box Section:

1. Twenty gauge solid galvanized steel interior liner.
2. Hinged, insulated, double walled access door.
3. Interior lighting with wall switch for maintenance and general cleaning.
4. Sloped, galvanized steel drip pan with capped drain plug and drain hose adapter.
5. Outside Air Damper:
 - a. Manufacturer: Tamco, Series 9000 or pre-approved equal.
 - b. Low leakage, heavy gauge, internally insulated, extruded aluminum, air foil blades with extruded EDPM blade gaskets and frame seals.
 - c. Galvanized steel frame with parallel blade action.
 - d. Damper Sizing: Size outside air damper for maximum RTU air flow rate (CFM) scheduled using a flow velocity of 1,000 FPM not to exceed 0.1-inch static pressure drop with damper fully open.
6. Return Air Damper:
 - a. Manufacturer: Ruskin, Model CD50 or pre-approved equal.
 - b. Low leakage, heavy gauge, extruded aluminum, parallel arrangement, air foil blades with vinyl edge seals.
 - c. Galvanized steel frame with parallel blade action.
 - d. Damper Sizing: Size return air damper for maximum RTU air flow rate (CFM) scheduled using a flow velocity of 1,000 FPM not to exceed 0.1-inch static pressure drop with damper fully open.
7. Damper Arrangement:
 - a. Provide dampers, factory installed and sealed to the mixing box as indicated.
 - b. Provide outside air intake damper horizontally centered to front of mixing box

- c. Provide return air damper horizontally centered on base of mixing box.

E. Filter Section:

1. Twenty gauge solid galvanized steel interior liner.
2. Two sets of pre-filters for summer/winter arrangement with preheat coil.
3. Provide factory installed filter frames by the roof top unit by manufacturer with closed cell synthetic rubber and positive spring type clamps to hold filter elements securely against gaskets.
4. Provide access for changing filters from one or both sides of housing.
5. Filters:
 - a. Provide disposable, pleated dry media filters having a Minimum Efficiency Reporting Value of MERV 8 for prefilters, and MERV 14 for final filters when tested in accordance with ASHRAE 52.2.
 - b. 2-inch filter depth for prefilters, 12-inch filter depth for final filters.
 - c. Complete filter shall be UL listed as a Class 2 air filter.
 - d. Filter shall be constructed from pleated media supported and bonded to welded wire grid within a rigid beverage board frame. Media shall be non-woven, reinforced cotton and synthetic fabric. Media shall provide not less than 4.6 square feet of filter area for each square foot of face area. Media and frame shall be bonded to prevent air leakage.
 - e. Design of filter bank shall be based on an airflow rate of not more than 350 CFM per square foot of gross face area unless otherwise indicated. Initial static pressure loss shall not exceed 0.08 inches water column at 250 feet per minute face velocity. Filter shall be designed to operate at up to 0.9 inch water column, if required.
 - f. Preferred filter sizes are 24 by 24 by 2 inches with maximum of one 24 by 12 by 2 inches per row. Filter banks shall be designed to use the minimum number of readily available standard filter sizes.
 - g. Manufacturers: Farr 30/30 (Basis of Design), American Air Filter, or approved equal.
6. Filter Gauges:
 - a. Provide a dial type gauge with diaphragm magnetically coupled to pointer and with connections to upstream and downstream static pressure probes for each filter bank.
 - b. Provide monitoring contacts for connection to the BAS. Coordinate with 255000 - Building Automation System and Section 25 9000 - Sequence of Operations to connect filter monitoring pressure switches to same probes as the gauge.
 - c. Gauge scale range shall be 0 to 1 inch water column.
 - d. Manufacturers: Magna-helic (Basis of Design) or approved equal.

F. Refrigeration System:

1. Compressor:
 - a. Industrial grade, energy efficient direct drive speed scroll type.
 - b. Motor shall be suction gas cooled hermetic design.
 - c. Include centrifugal oil pump with dirt separator, oil sight glass, and oil charging valve.

2. Evaporator Coil:
 - a. Heavy duty aluminum fins mechanically bonded to copper tubes.
 - b. Provide thermostatic expansion valve for each refrigerant circuit.
 - c. Positive pitched galvanized drain pan.

3. Air Cooled Condenser Section:
 - a. Coil shall have aluminum microchannel coils.
 - b. Vertical discharge, direct drive fan.
 - c. Factory installed electronic low ambient option to allow for operation down to 0 degrees F.
 - d. Factory-installed louvered steel guards around perimeter of condensing section.

G. Preheat and Heating Coil Sections:

1. Cabinet:
 - a. Twenty gauge solid galvanized steel interior liner with sloped drip pan and capped drain plug with hose adapter.
 - b. Sloped, galvanized steel drip pan with capped drain plug and drain hose adapter.
 - c. Provide split casing panel to facilitate coil removal. Coordinate panel location with coil access and coil piping.

2. Preheat and Heating Coil:
 - a. Factory assembled and installed, non-freeze Type 5W AHRI Certified coil, with hot water modulating valve and actuator. Coil construction shall allow for complete drainage.
 - b. Provide heating coil section with adequate interior space for terminal hydronic heating piping and components as shown.
 - c. Provide coil with scheduled operational performance characteristics.
 - d. Coils designed for counter-flow heat transfer with equal pressure drop through each circuit.
 - e. Working Pressure: 250 PSIG.
 - f. Primary surface:
 - 1). Round, seamless, 0.020 inch thick copper tubing.
 - 2). Tubes mechanically expanded into fins over the entire finned length.
 - 3). Brazed joints.
 - g. Secondary surface:
 - 1). Solid aluminum fins (no punched openings to accumulate lint and dirt) with full drawn collars (Bare copper tube not visible between fins).
 - 2). Fin thickness: 0.0075 inches.
 - h. Coil Casing: Continuous 16 gauge galvanized steel with reinforced flange type side plates.
 - i. Coil Headers:
 - 1). Seamless, copper tubing.

2). Low point coil drain and high point coil vent.

H. Fan Section:

1. Cabinet:
 - a. Twenty gauge perforated, galvanized steel interior liner.
 - b. Hinged, insulated, double walled access door.
 - c. Interior lighting with wall switch for maintenance and general cleaning.
 - d. Sloped, galvanized steel drip pan with capped drain plug and drain hose adapter.
2. Fan Manufacturers:
 - a. Greenheck.
 - b. Cook.
 - c. Barry Blower.
 - d. Twin City.
3. General Fan Requirements:
 - a. Provide factory assembled, balanced and tested fan unit of the size, type and capacity scheduled. AMCA listed and labeled.
 - b. Provide factory applied enamel coating system to fan assembly components (except aluminum).
 - c. Provide fan arrangement with accessibility for complete cleaning, component replacement and preventative maintenance. Provide grease fitting(s) with extended grease lines (as necessary for direct access).
4. Vibration Isolation:
 - a. Isolate fan frame from unit casing using stable spring vibration isolators with a seismic snubbers.
 - b. Bearings: Greater than 200,000 hours average rated life at rated load and speed specified.
5. Fan Drives:
 - a. Provide v-belt drive for each fan selected for not less than 1.5 times the motor nameplate horsepower. Light duty belts (FHP) acceptable only with motors less than one (1)-horsepower. Sheaves shall be cast iron or steel.
 - b. Provide fixed speed drive sheave. Change fan and drive sheave in the field as necessary to attain required fan performance.
 - c. Provide OSHA belt guard with hinged tachometer cap.
6. Motors: See Section 200513 – Common Motor Requirements, for detailed fan motor specifications.
7. Sound data:
 - a. Factory test fan assemblies to determine suction, discharge and radiated sound levels (decibels) for each octave band in accordance with AMCA Standards. Include sound level data with fan submittals.

- b. When sound ratings are not specified, physical characteristics including type, wheel diameter and fan speed shall be the basis of comparison with specified requirements.
- c. Octave band sound power levels shall not exceed those scheduled.

I. Electrical:

- 1. Factory pre-wired for single point connection.
- 2. Auxiliary fan motor starter contact.
- 3. High voltage control panel shall have door handle disconnect switch.
- 4. Unit mounted 115 volt convenience outlet.

2.3 BUILDING AUTOMATION SYSTEM CONTROLS

- A. Provide roof top unit controls in accordance with Section 255000 - Building Automation System to include temperature and pressure sensors, damper actuators, controllers, and interface panels to control the roof top unit in accordance with Section 259000 -Sequence of Operations.

PART 3 - EXECUTION

3.1 INSTALLERS

- A. Installer: Perform work by experienced personnel previously engaged in ventilation system construction and air handling unit installation, and under the supervision of a qualified installation supervisor.

3.2 PREPARATION

A. Protection:

- 1. Maintain access doors shut, air handler box dampers and supply duct connections covered and drain connections capped to protect components from construction dirt and debris.
- 2. Provide a complete set of pre-filters for use during construction. Final filter bank media is to remain sealed in original boxes until final building housekeeping has been completed.
- 3. Protect return air inlet with 30 percent filters during construction.

3.3 EXAMINATION

- A. Verify that roof curb is installed, level and of the correct dimensions to accept and support the weight of the roof top unit.
- B. Verify that the roof curb's interior footprint has been pre-insulated with vapor barrier to match the adjacent roof R-value.
- C. Verify power supply is roughed in, located, and sized properly for the unit's single point power connection.

- D. Verify that hydronic piping penetrations have been installed, sleeved water-tight and are aligned with the heating coil section coil piping chase locations. Piping shall penetrate up through bottom of unit at pipe chase locations.

3.4 INSTALLATION

- A. Install rooftop air handling units and components in compliance with the manufacturer's written installation instructions and the following:
 - 1. Install BAS actuators, sensors, controls and control wiring in accordance with Section 25 5000 - Building Automation System.
 - 2. Install electrical power and wiring in accordance with Divisions 26, 27 and 28.

3.5 CONSTRUCTION

- A. Interface with other Work:
 - 1. Coordinate and sequence installation of each component with trades responsible for portions of this and other related sections of the Project Manual.
 - 2. Rework required, as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work, shall be completed at no additional expense to the Owner.

3.6 REPAIR/RESTORATION

- A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.
- B. Substitute replacement parts from other manufacturers are not acceptable.

3.7 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services:
 - 1. Verify roof top unit(s) is/are installed and operational in accordance with the manufacturer's written installation instructions.
 - 2. Both the Contractor and Manufacturer's Representative(s) shall sign start-up and operational checklist to confirm proper system installation and operation.
- B. Site testing, conducted with ventilation system operating at maximum air volume flow rate with clean filter media installed:
 - 1. Verify each filter bank is properly sealed and filter bank leakage is within manufacturer's performance tolerances.
 - 2. Verify that filter bank differential pressure gauges are operating properly in accordance with manufacturer's written installation, operation and maintenance instructions.

3. Verify that clean filter differential pressures are as indicated in manufacturer's submittal data (within 5 percent) for actual filter bank flow velocity.

3.8 CLEANING

- A. Upon completion of installation and prior to initial start-up, vacuum clean internal and external surfaces.
- B. Upon completion of final housekeeping and with written approval of the Contracting Agency, replace construction filters with a complete set of new filters for use during testing and balancing.

3.9 SYSTEM START-UP

- A. Start-up and operate roof top units in accordance with the manufacturer's written installation, operation and maintenance (IO&M) manual.
- B. Verify proper operation of sequences in accordance with Section 259000 - Sequence of Operations.
- C. Document start-up and operational checks using manufacturer and PC/FC checklists and submit in accordance with submittal requirements.

3.10 ADJUSTING

- A. Test, adjust and balance roof top air handling equipment in accordance with Section 23 0593 - Testing, Adjusting and Balancing, the manufacturer's recommendations, and as otherwise directed by the Contracting Agency.

END OF SECTION 237416

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PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Packaged, direct expansion, air conditioning systems with microprocessor based controls for electrical room cooling.
- B. Related Sections:
 - 1. 019100 - Commissioning
 - 2. 200000 - Mechanical General Requirements
 - 3. 200548 - Mechanical Vibration and Seismic Control
 - 4. 221300 - Sanitary Waste and Vent Piping and Specialties
 - 5. 259000 - Sequence of Operations

1.2 REFERENCES

- A. Codes and Standards:
 - 1. See Section 200000 - Mechanical General Requirements.
 - 2. ARI 360 - Commercial and Industrial Unitary Air Conditioning Equipment testing and rating standard.
 - 3. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.
 - 4. ANSI/ASHRAE 37 - Testing Unitary Air Conditioning and Heat Pump Equipment.
 - 5. ANSI/UL 465 - Central Cooling Air Conditioners Standard for Safety Requirements.

1.3 SYSTEM DESCRIPTION

- A. Design Requirements: This section describes specific requirements, products and methods of execution for the dedicated air conditioning units.
- B. Performance Requirements:
 - 1. Provide product performance characteristics as specified or scheduled on drawings.
 - 2. Operate system in accordance with Section 259000 - Sequence of Operations.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.
- B. Product Data: Submit copies of product data indicating rated capacities, weights, accessories, and electrical requirements.
- C. Shop Drawings: Submit drawings indicating components, dimensions, weights and loadings, required clearances, and location, routing and size of refrigerant lines and condenser discharge ductwork.
- D. Closeout Submittals: Submit copies of operation and maintenance manuals in accordance with Section 20 0000 - Mechanical General Requirements.
- E. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.

1.6 CLOSEOUT SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.
- B. Regulatory Requirements: Units shall be UL listed.

1.9 DELIVERY, STORAGE AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.

PART 2 - PRODUCTS

2.1 SELF-CONTAINED AIR CONDITIONING UNIT (AC-1/CU-1, AC-2/CU-2)

A. General:

1. Provide packaged, direct expansion, self-contained air conditioning systems as scheduled. System consists of ceiling wall mounted evaporator unit with a variable speed inverter driven compressor and fan motor and a separate, remote, mounted condenser unit. System refrigerant shall be R-410A. The system shall maintain zone setpoint temperatures using a packaged wall mounted controller.
2. Basis of Design: Mitsubishi P Series.

B. Indoor Unit:

1. The indoor unit shall be factory assembled and tested complete with factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
2. Indoor unit and refrigerant pipes shall be charged with dehydrated air prior to shipment from the factory.
3. Cabinet:
 - a. The cabinet shall be fixed to factory supplied wall hanging brackets.
 - b. Multi-directional refrigerant and drain piping offering four (4) directions for refrigerant piping and two (2) directions for draining are required.
4. Fans and Motors:
 - a. The fan shall be direct-drive fan type with statically and dynamically balanced impeller with high and low fan speeds available.
 - b. The fan motor shall operate on voltage as scheduled on the drawings.
 - c. The fan motor shall be thermally protected.
5. Filter: Filter return air by means of an easily removable, washable filter.
6. Evaporator Coil:
 - a. Coils shall be of nonferrous construction with smooth plate fins on copper tubing. Tubing shall have inner grooves for high efficiency heat transfer. Tube joints shall be brazed with phos-copper or silver alloy.
 - b. The coil shall be pressure tested at the factory.
7. Electrical:
 - a. The fan motor shall operate on voltage as scheduled on the drawings.
 - b. 208-230 volts, 1 phase, 60 hertz. System shall be capable of satisfactory operation within voltage limits of 198 to 253 volts. Power to the unit shall be supplied from the outdoor unit, using the Mitsubishi Electric A-Control system. For A-Control, a

three (3) conductor AWG-14/16 wire with ground shall provide power feed and bidirectional control transmission between the outdoor and indoor units.

C. Remote Condensing Unit:

1. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of a swing compressor, motors, fan, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, service ports and suction accumulator.
2. The outdoor unit shall be equipped with front, rear, and side advanced wind baffles.
3. The system will automatically restart operation after a power failure and will not cause any settings to be lost, eliminating the need for re-programming.
4. The following safety devices shall be included on the condensing unit; high pressure switch, control circuit fuses, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
5. The condensing unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.
6. Fans and Motors:
 - a. The condensing unit fan shall consist of one propeller type, direct-drive fan motor that has multiple speed operation via a DC (digitally commutating) inverter.
 - b. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.
 - c. The fan motor shall be provided with a fan guard to prevent contact with moving parts.
7. Condenser Coil:
 - a. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
8. Compressor:
 - a. The compressor for models PUZ(Y)-A12/18/24/30/36/42NH/KA7 shall be a DC twin-rotor rotary compressor with Variable Speed Inverter Drive Technology.
 - b. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which shall result in significant energy savings.
 - c. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be automatically, intermittently applied to the compressor motor windings to maintain sufficient heat to vaporize any refrigerant. No crankcase heater is to be used.
 - d. The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.

D. Quality Assurance:

1. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), and bear the ETL label.
2. Wiring shall be in accordance with the National Electric Code (NEC).
3. System rated in accordance with Air Conditioning Refrigeration Institute's (ARI) Standard 210/240 and bear the ARI label.
4. Provide a holding charge of dry nitrogen in the evaporator.
5. System efficiency meets or exceeds 17.6 SEER.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Install units in accordance with manufacturer's written installation instructions.
2. Install units plumb and level, firmly anchored in the locations indicated while maintaining manufacturer's recommended clearances.
3. Adjust evaporator unit location to align with ceiling grid.

B. Electrical Wiring: Furnish one copy of manufacturer's electrical connection diagrams to the electrical subcontractor.

C. Piping Connections: Furnish one copy of manufacturer's condensate pump connection diagram to the plumbing subcontractor.

3.2 FIELD QUALITY CONTROL

A. Startup air conditioning unit in accordance with the manufacturer's written start up instructions.

B. Test control features and demonstrate compliance with operational requirements.

END OF SECTION 238123

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Unit heaters.
2. Radiant ceiling panels.

B. Related Sections:

1. 019100 - Commissioning
2. 200000 - Mechanical General Requirements
3. 200529 - Mechanical Hangers and Supports
4. 200548 - Mechanical Vibration and Seismic Control
5. 200553 - Mechanical Identification
6. 200700 - Mechanical Insulation
7. 204100 - Mechanical Demolition
8. 230593 - Testing, Adjusting and Balancing
9. 232113 - Hydronic Piping and Specialties
10. 233100 - Ducts and Accessories
11. 233600 - Air Terminal Units
12. 233700 - Air Outlets and Inlets
13. 253000 - Building Automation System Field Devices
14. 255000 - Building Automation System
15. 259000 - Sequence of Operations

1.2 REFERENCES

A. Codes and Standards: See Section 200000 - Mechanical General Requirements.

B. Abbreviations, Acronyms and Definitions:

1. Refer to Division 01 for general abbreviations, acronyms, and definitions.
2. Refer to Section 200000 - Mechanical General Requirements for general mechanical related definitions.
3. Refer to Mechanical Drawings legend sheet for general mechanical related abbreviations.

1.3 SYSTEM DESCRIPTION

A. Design Requirements: Provide terminal heating and cooling units, piping, appurtenances, and controls to automatically maintain interior temperature setpoint for each area of the building.

B. Performance Requirements: Provide performance and output shown or scheduled on drawings.

1.4 PRE-INSTALLATION MEETINGS

- A. See Section 200000 - Mechanical General Requirements.

1.5 SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements for general submittal requirements for the items listed below, supplemented with the additional requirements listed.

- B. Product Data:

- 1. Submit product literature for items specified in Part 2 and those products required by the performance standards of this section. Literature clearly annotated to indicate specified salient features and performance criteria.
- 2. Include the following:
 - a. Performance characteristics as scheduled.
 - b. Enclosure style, material and grille arrangement.
 - c. Dimensional data.

- C. Shop Drawings:

- 1. For custom architectural fintube heating enclosures, provide shop drawings which include:
 - a. Custom enclosure dimensions and method of construction.
 - b. Fintube location and support method to include expansion/contraction compensation.
 - c. Inlet and outlet grille model and fastening method.
- 2. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
- 3. Indicate mechanical and electrical service locations and requirements.

- D. Samples:

- 1. Provide color samples of fintube and cabinet unit heater enclosures.
- 2. Colors to be selected by the Contracting Agency.

- E. Provide certificates, manufacturer's instructions, and manufacturer's field reports for Quality Assurance/Control Submittals:

- 1. Provide a complete manufacturer's written installation, operation and maintenance manual for each type of installed equipment.
- 2. Clearly annotate the manual to indicate applicable information for the specific equipment model(s) installed.
- 3. Included with the manual one copy of the completed start-up and operation checklist. The checklist shall include:

- a. Printed names and signatures of the installers.
- b. Documentation from Manufacturer's representative and Contracting Agency that the equipment has been properly installed and is fully operational, thus validating the equipment warranty.

F. Closeout Submittals:

1. Project Record Documents: Record actual locations of components and locations of access doors in terminal unit cabinets required for access or valves.
2. Operation and Maintenance (IO&M) Manuals:
 - a. Refer to Section 200000 - Mechanical General Requirements, for IO&M Manual formatting requirements and number of copies required.
 - b. Provide copies of approved submittal information for inclusion within the project IO&M Manual. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, parts listings, and spare parts list.

- G. Quality Control Submittals: Refer to Section 019100 - Commissioning for submittal requirements.

1.6 CLOSEOUT SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. See Section 200000 - Mechanical General Requirements.
- B. Extra Stock Materials: Provide one set replacement filters for cabinet unit heaters and fan coil units.

1.8 QUALITY ASSURANCE

- A. See Section 200000 - Mechanical General Requirements.
- B. Regulatory requirements: Products requiring electrical connection shall be listed and classified by Underwriters Laboratories Incorporated, or by a testing firm acceptable to the Authority Having Jurisdiction.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. See Section 200000 - Mechanical General Requirements.

1.10 WARRANTY

- A. Manufacturer Warranty: See Section 200000 - Mechanical General Requirements, for general mechanical warranty requirements.
- B. Provide 5-year manufacturer's warranty for unit heaters and cabinet unit heaters.

PART 2 - PRODUCTS

2.1 UNIT HEATERS

- A. Coils: Seamless copper tubing, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.
- B. Casing: 0.0478-inch steel with threaded pipe connections for hanger rods.
- C. Finish: Factory applied baked enamel finish.
- D. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.
- E. Air Outlet: Adjustable pattern diffuser on projection models and two way louvers on horizontal throw models.
- F. Motor: Permanently lubricated sleeve bearings on horizontal models, grease lubricated ball bearings on vertical models. Refer to Section 200513 - Common Motor Requirements.
- G. Control: Local disconnect switch.
- H. Capacity: As scheduled.
- I. Electrical Characteristics:
 - 1. Horsepower, voltage, and phase as scheduled on the Drawings, 60 Hz.
 - 2. Refer to Divisions 26, 27 and 28.
- J. Manufacturers: Sterling, Modine, Rittling, Trane, Vulcan, JAGA.

2.2 HYDRONIC RADIANT CEILING PANELS

- A. Panel shall consist of extruded aluminum with copper tubing of 0.50 inch ID mechanically attached to the aluminum faceplate. Hold copper tubing in place with an integral aluminum saddle or similar metal fastener which positively secures the tube to the panel. Use of adhesives or clips is not acceptable.

- B. Not all panel hardware, mounting and attachment components and features are detailed on the Mechanical and Architectural Drawings. Provide backing, supports, moldings, hangers, cross tees, seismic restraints, hardware, and other appurtenances required for a complete and properly operating finished system. Mechanical fasteners shall not be exposed in the finish work.
- C. In addition to the Mechanical Drawings, refer to Architectural reflected ceiling plans and room finish schedule to determine other panel requirements.
- D. Provide finish and color selected by the Contracting Agency.
- E. Cross brace entire assembly with structural members and insulate with 1-inch thick fiberglass insulation. Configure panels within T-bar ceiling module and run wall to wall.
- F. Heating Capacity: Panel total output rating shall be not less than 250 Btuh/SF at 190 degrees F when tested against an average unheated surface temperature (AUST) of 70 degrees F. Data shall be certified by qualified independent test lab.
- G. Manufacturers: Airtex, Sterling, or Aero Tech AX.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protection: Cover equipment and plug piping connections to protect components from construction dirt and debris.
- B. Preparation: Prior to installation of terminal units, make sure wall construction is complete enough to correctly locate and mount units.

3.2 INSTALLATION

- A. Install terminal equipment in accordance with manufacturer's instructions.
- B. Install equipment exposed to finished areas after walls and ceilings are finished and painted.
- C. Unit Heaters: Hang from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.
- D. Hydronic Units:
 - 1. Provide accessible ball type isolation valves on supply and return lines to each terminal unit to allow for unit drain down and repair.
 - 2. Provide low-point drain valve that allows for complete gravity draining of terminal unit.
 - 3. Provide balancing valve as specified elsewhere.
 - 4. Provide high-point automatic air vent as specified elsewhere.
- E. Radiant Panels:

1. Provide each panel circuit with shutoff valve on supply and balancing valve on return piping.
 2. Install in accordance with the manufacturer's shop drawings.
 3. Coordinate with ceiling system and other related work.
 4. Mechanical fastenings shall not be exposed in the finished work.
 5. Install suspension system in accordance with ASTM C636.
 6. Completely cover panel with minimum of 2 inches of fibrous glass, unfaced blanket insulation.
 7. Do not connect to supply and return system until system has been flushed and cleaned.
- F. Access Doors: Install such that a drain hose may be easily connected to each drain line hose bibb, allowing the applicable portion of the system to be completely drained.
- G. Install balancing valves and serviceable products for heating terminal units to be operable and adjustable without removal of the finish cover.
- H. Provide pressure and temperature test plugs on both sides of heat transfer elements to measure the drop across runs of heat transfer elements.
- I. In systems containing glycol, provide only products specifically designed and approved for continuous operation with the glycol solution specified.

3.3 CONSTRUCTION

A. Interface with Other Work:

1. Coordinate and sequence installation of terminal heating and cooling units with trades responsible for portions of this and other related sections of the Project Manual.
2. Rework required as a result of failure to follow the manufacturer's written installation instructions or to properly coordinate with related Work shall be completed at no additional expense to the Owner.

3.4 REPAIR/RESTORATION

- A. Repair any product components broken during installation or startup with replacement parts supplied by the product manufacturer.
- B. Substitute replacement parts from other manufacturers are not acceptable.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. Verify units are installed and operational in accordance with the manufacturer's written installation instructions.
2. Both the Contractor and Manufacturer's Representatives shall sign start-up and operational checklist to confirm proper unit installation and operation.

3.6 ADJUSTING

- A. Adjust functional components for proper operation in accordance with manufacturer's recommendations, or as otherwise directed.
- B. Coordinate and work directly with the Testing, Adjusting and Balancing Agency to provide systems in proper operating order. Make corrections and adjustments as required by the Balancing and Testing Agency in a timely manner.

3.7 CLEANING

- A. After construction is completed (including painting), and prior to initial start-up, clean and wipe down exposed surfaces of units. Vacuum clean coils and inside of cabinets and enclosures.
- B. Touch up marred or scratched surfaces of factory finished cabinets and enclosures, using finish materials furnished by manufacturer.
- C. Clean permanent filters or install new disposable filters.

3.8 DEMONSTRATION AND START-UP

- A. Start-up and operate terminal heating and cooling units in accordance with the manufacturer's written installation and operation manual check list.
- B. Demonstrate proper system operation using the building automation system.
- C. Document start-up and operational checks using the checklist and submit in accordance with submittal requirements.

END OF SECTION 238200

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Requirements, products, procedures, performance requirements, and methods of execution relating to the Building Automation System (BAS) terminal devices and field hardware.
2. Refer to related sections for other technical requirements, products, and methods of execution relating to the controls system for monitoring and control of mechanical systems.

B. Related Sections: Refer to Section 255000 - Building Automation System

1.2 REFERENCES

A. Refer to Section 255000 - Building Automation System.

1.3 SYSTEM DESCRIPTION

A. Refer to Section 255000 - Building Automation System.

1.4 PREINSTALLATION MEETINGS

A. Refer to Section 255000 - Building Automation System.

1.5 SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

1.6 CLOSEOUT SUBMITTALS

A. Submit in accordance with Section 255000 - Building Automation System and in accordance with Division 1.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. See Section 200000 - Mechanical General Requirements.

1.8 QUALITY ASSURANCE

- A. Refer to Section 255000 - Building Automation System.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Refer to Section 255000 - Building Automation System.

1.10 WARRANTY

- A. Refer to Section 255000 - Building Automation System.

PART 2 - PRODUCTS

2.1 TEMPERATURE SENSOR

- A. Digital room sensors:

1. Temperature monitoring range: 55/95 degrees F.
2. Network jack.
3. Output signal: Changing resistance.
4. Accuracy at Calibration point: Plus or minus 0.5 degrees F.
5. Wall Mounted unit with finished cover:

- a. Private offices and rooms:

- 1). LCD display, day/night override button, and setpoint slide adjustment override options. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment.
- 2). Set Point and Display Range: 55 degrees to 95 degrees F.

- b. Public Spaces: Blank Cover.

- B. Duct (single point) temperature:

1. Temperature monitoring range: 20/120 degrees F.
2. Output signal: Changing resistance.
3. Accuracy at Calibration point: Plus or minus 0.5 degrees F.
4. Sensing element shall be located a minimum of 25 percent across duct width.

- C. Duct Average temperature:

1. Temperature monitoring range: 20/120 degrees F.
2. Output signal: 4-20 mA DC.
3. Accuracy at Calibration point: Plus or minus 0.5 degrees F.
4. Sensor Probe Length: 25 feet.

2.2 WALL MOUNTED SENSOR GUARD

- A. Heavy-duty wire cage type with mounting plate.
- B. Cast Aluminum Guard and mounting bracket.
- C. Clear or opaque butyrate plastic guard, key lock, mounting plate.

2.3 MEDICAL GAS ROOM HYDRONIC UNIT HEATER THERMOSTAT AND ROOM TEMPERATURE MONITORING

- A. Unit Heater Thermostat: Amperage capacity sufficient to cycle fan without need for contactor.
- B. Provide a blank face BAS temperature sensor for monitoring of medical gas room temperatures.

2.4 BOILER ROOM HYDRONIC UNIT HEATER THERMOSTAT

- A. Unit Heater Thermostat: Amperage capacity sufficient to cycle fan without need for contactor.

2.5 DIGITAL STATUS POINTS

- A. Digital status shall be monitored by sensing normally closed contacts (contact closed in alarm conditions). The addition of the monitoring relay shall not affect the operation of the systems involved.

2.6 DIGITAL COMMAND POINTS

- A. Command relays shall be momentary, automatic, maintained, or magnetic latch fail/safe as required. Maintained contacts located in occupied spaces or plenum spaces shall be mechanically latched. Relays shall be plug in and field replaceable. Contact ratings shall be in accordance with service.

2.7 CURRENT SENSOR

- A. Provide current sensors that convert AC current to a proportional (4-20 mA) DC current.
- B. Provide reverse voltage and high over current capacity.
- C. Provide red LED light to indicated relay status and power.
- D. Temperature operating range: 5 to 140 degrees F.
- E. Provide UL Listed device.

2.8 CURRENT SENSING RELAY

- A. Provide solid-state, self-calibrating, current operated relay suitable for equipment status monitoring. Provide a relay that changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit.
- B. Provide red LED light to indicated relay activation.
- C. Temperature operating range: minus 30 to 140 degrees F.
- D. Provide UL Listed device that is rated for plenum installation.

2.9 RELAYS

- A. Applications: Relays external to the controls shall include (but not be limited to) the following:
 - 1. Control relays for start/stop or open/close control of equipment.
 - 2. Monitoring relays for electrical circuit on/off or open/closed status detection.
 - 3. Interposing relays to provide interface between solid state circuitry and ac-driven control relays.
- B. Requirements: Relays shall be housed in dust-tight cases conveniently located for wiring and inspection:
 - 1. Control Relay: Control relays shall be suitable for continuous operation of 120 VAC and be able to interrupt the control circuits of various HVAC equipment. The number of contacts required for the relay shall be determined from the number of independent equipment to be controlled. The number of control relays required for the motor start/stop circuit shall be determined from examination of the equipment to be controlled.
 - 2. Monitoring Relay: Monitoring relays shall be suitable for continuous operation at the voltages of the circuits to be monitored. The monitoring relays shall be connected in such a way that the operation of the relay contact shall represent the change of status of the monitored circuit (i.e. ON/OFF, etc.) or duplicate the operation of the existing alarm circuit (i.e. high/low, etc.). The addition of the monitoring relay shall not affect the operation of the systems involved.
 - 3. Interposing Relay: Interposing relays shall be DC driven and be utilized to provide interface between solid state circuitry and ac-driven control relays as required.

2.10 CONTROL VALVE

- A. Control Valve: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- B. Globe Valve 2 inch and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and sweat ends.
- C. Globe Valve 2-1/2 inch and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.

D. Hydronic system globe valve shall have the following characteristics:

1. Rating: ANSI Class 125 for service at 125 PSIG and 32/250 degrees F operating conditions.
2. Internal Construction:
 - a. Replaceable plugs and seats of stainless steel or brass.
 - b. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
 - c. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
3. Sizing: 3 PSIG maximum pressure drop at design flow rate.
4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Operators shall close valves against pump shutoff head.
5. Select heating valves shall fail to a Normally Open to heat position, unless otherwise indicated. Select cooling valves to normally closed to cooling position.
6. Three-way valves: Mixing type, unless otherwise indicated.

2.11 CONTROL DAMPER

A. Rectangular:

1. Frame: Five inches by one inch by minimum 0.125 inch 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.
2. Blades: Provide airfoil-shaped, single-piece blades made of heavy-duty 6063-T5 extruded aluminum. Maximum six inch blade width.
3. Bearings: Molded synthetic sleeve, turning in hole in frame.
4. Seals:
 - a. Blade: Extruded vinyl type for ultra-low leakage from minus 50 degrees F. to 350 degrees F. Mechanically attached to blade edge.
 - b. Jamb: Flexible metal compression type.
5. Linkage: Concealed in frame.
6. Axles: Minimum 1/2-inch diameter plated steel, hex-shaped, mechanically attached to blade.
7. Finish: Mill aluminum.
8. Performance Data:
 - a. Temperature Rating: Withstand minus 50 degrees F. to 350 degrees F.
 - b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions:
 - 1). Closed Position: Maximum pressure of 13 inches W.C. at a 12-inch blade length.
 - 2). Open Position: Maximum air velocity of 6,000 feet per minute.

- c. Leakage: Maximum 2.0 cubic feet per minute per square foot at 1.0 W.C. for sizes 24 inches wide and above.
 - d. Pressure Drop: Maximum 0.03 inch W.C. at 1,500 feet per minute across 24 inch by 24 inch damper.
 9. Manufacturer: Ruskin CD50, Louvers and Dampers, Air Balance, Pottorff, or equal.
- B. Round:
 1. Frame:
 - a. Under 6 inches Diameter: 2 inches by 1/2 inch minimum 12 gage galvanized steel tube.
 - b. 6 thru 12 inches Diameter: 2 inches by 1/2 inch by minimum 14 gage galvanized steel channel.
 - c. Above 12 thru 24 inches Diameter: 2 inches by 1/2 inch by minimum 1/8 inch galvanized steel channel.
 - d. Above 24 inches Diameter: 2 inches by 1 inch by minimum 3/16 inch galvanized steel channel.
 2. Blade: Provide single-piece construction made of the following material:
 - a. 18 inches diameter and smaller: Minimum 12 gage galvanized steel.
 - b. Over 18 inches diameter: Minimum 10 gage galvanized steel, stiffeners as required.
 3. Blade Seals: Closed cell polyethylene foam rubber fully encompassing and mechanically attached to blade edge.
 4. Bearings: Self-lubricating stainless steel sleeve.
 5. Axles:
 - a. 22 inches Diameter and smaller: Minimum 1/2 inch diameter, full length, plated steel, mechanically attached to blade.
 - b. Over 22 inches Diameter: Minimum 3/4 inch diameter, full length, plated steel, mechanically attached to blade.
 6. Finish: Mill.
 7. Performance Data.
 - a. Temperature Rating: Withstand maximum 250 degrees F.
 - b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.
 - 1). Closed Position: Maximum pressure of 10 inches W.C.
 - 2). Open Position: Maximum air velocity of 4,000 feet per minute /min.
 - c. Leakage: Maximum 10 cubic feet per minute total at 1 inch W.C.
 - d. Pressure Drop: Maximum 0.05 inch W.C. at air volume of 7,000 cubic feet per minute through 24 inch diameter damper.
 8. Manufacturer: Ruskin CDR25, Louvers and Dampers, Air Balance, Pottorff, or equal.

2.12 VALVE AND DAMPER ACTUATORS

A. General:

1. Provide electronic direct-coupled actuation for control valves and dampers.
2. Proportional actuators shall accept a 0-10 VDC or 0-20 mA control input and provide a 2-10 VDC or 4-20 mA operating range. Damper actuators and control valve actuators serving valves larger than 3/4" shall provide a 2-10 VDC position feedback signal. The feedback signal shall be independent of the input signal.
3. Actuators indicated by Normally Closed or Normally Open designation on drawings or in sequence of operation shall be spring return type.
4. The actuator shall have electronic overload circuitry to prevent damage to the actuator.
5. Provide actuators listed by Underwriters Laboratories Standard 873 Standard for Safety Temperature-Indicating and -Regulating Equipment.

B. Damper Actuator:

1. Provide damper actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage.
2. Spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.
3. Non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose.
4. Provide actuators in sufficient size, quantity and type to match application. Provide a minimum of one damper actuator for each 24 square feet of damper area. Damper areas shall not exceed manufacturer's ratings.
5. Outside air and return air dampers on mixing boxes shall be linked such that one opens while the other closes. It shall not be possible to close both dampers simultaneously.
6. Dampers: Size for minimum running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-pounds/sq. ft. of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper.
 - e. Dampers with 2 to 3 Inches WC of Pressure Drop or Face Velocities of 1000 to 2500 FPM: Multiply the minimum full-stroke cycles above by 1.5.
 - f. Dampers with 3 to 4 Inches WC of Pressure Drop or Face Velocities of 2500 to 3000 FPM: Multiply the minimum full-stroke cycles above by 2.0.
 - g. Values noted above do not include normally open or normally closed open spring return dampers. Provide additional torque as required.
7. Size operators with ample power to overcome friction of damper linkage and air pressure acting on the damper blades.

C. Valve Actuator:

1. Provide actuators with enough torque and force required for proper valve close-off against the system pressure.

- 2. The valve actuator shall be sized based on valve manufacturer’s recommendations for flow and pressure differential.
- D. Actuators shall be of the following types, unless noted otherwise on the drawings or in the sequences of operation:

Service	Type (1)
Exhaust Air Damper	NC
Air handler/MUA units with outside air:	
Heating Coil valves	NO
Cooling Coil Valves	NC
Air Terminal Units Heating Coil Valves	Floating
Reheat Coil Valves	Floating
Glycol Loop Control valve	NO
Heating Zone Temperature Control Valve	NO
Fan Coil Units	NO

(1) NC = Normally closed. NO = Normally open

2.13 INSTRUMENT ENCLOSURE

- A. Steel construction with hinged and lockable doors.
- B. NEMA 12 construction only in areas where panels are subject to moisture damage.
- C. Wiring connections including I/O and power shall be extended to a numbered, color-coded, and labeled terminal strip for ease of maintenance and expansion.
- D. Provide labeling and color coding for wiring. Wiring shall follow a common format typical for the entire facility. Terminal strip color coding and numbering shall follow a common format. Wiring shall be neatly installed in plastic trays or tie-wrapped.
- E. Line voltage wiring shall be segregated from I/O wiring and shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
- F. Provide a convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers. Provide convenience receptacle for enclosures containing equipment that can be configured or adjusted with a portable computer.

2.14 POWER SUPPLY

- A. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75 percent of the rated capacity of the power supply.

- B. Input: 120 VAC plus 10 percent, 60Hz.
- C. Output: 24 VDC.
- D. Line Regulation: Plus 0.05 percent for 10 percent line change.
- E. Load Regulation: Plus 0.05 percent for 50 percent load change.
- F. Provide an appropriately sized fuse and fuse block shall be provided and located next to the power supply.
- G. Provide a power disconnect switch shall be provided next to the power supply.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Special Techniques:

1. Wiring:

- a. The HVAC Control Contractor shall provide conduit, wiring, accessories, and wiring connections required for the installation of the control system, as herein specified, unless specifically shown in Divisions 26, 27 and 28.
- b. Conduit and wiring shall comply with the requirements of applicable portions of Divisions 26, 27 and 28 and local and national electric codes, unless specified otherwise in this section.
- c. System input wiring shall be twisted shielded pair, minimum 20 gauge wire. System analog output wiring shall be twisted shielded pair/3-wire as required, minimum 20 gauge wire. Preconfigured cables between Terminal Unit Controllers and Thermostats are acceptable, minimum 24 gauge.
- d. Internal panel device wiring for binary outputs and pilot relay shall be minimum 16 gauge wire.
- e. Provide separate conduit for control system power wiring including but not limited to 120 VAC and greater. I/O sensor wiring and data communication cabling shall be segregated from 120 VAC control system power wiring.
- f. Wiring in mechanical rooms shall be in conduit. Minimum control wiring conduit size 3/4 inch. One half inch conduit may be used for thermostats and valve stub-ups where conduit contains only a single pair.

2. Temperature Sensors:

- a. Temperature sensor assemblies shall be readily accessible and adaptable to each type of application in such manner as to allow for quick, easy replacement and servicing without special tools or skills.
- b. Outdoor installations shall be of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. Protective shield shall be stainless steel.

- c. Wall Mounted Sensor and Thermostats:
 - 1). Install wall mounted room sensors at a height of 44 inches above finish floor level.
 - 2). Locate sensors as shown on the Drawings.
 - 3). Provide insulated base for sensors mounted on sheet metal, steel columns or exterior walls. Wire penetrations shall be caulked airtight to prevent thermal convection.
 - 4). Provide heavy-duty guards for sensors and thermostats in public areas and as shown on the Drawings.
 - d. Duct Temperature Sensor: The sensor shall measure the representative temperature of the entire cross-section of the duct or plenum. Sensors in ducts shall be mounted in locations to sense the correct temperature of the air only and shall not be located in dead air spaces. Ductwork shall be securely sealed where elements or connections penetrate ducts to avoid measuring false conditions.
 - e. Fluid Temperature Sensors: Provide sensors with thermal wells fabricated and installed for the intended service. Wells shall be non-corrosive to the medium being measured and shall have sufficient physical strength to withstand all pressures, (including test pressures) and velocities to which they are subjected. Well shall not restrict flow area to less than 70 percent of line-size-pipe normal flow area. Where piping is smaller than the length of the well or exceeds the area requirements, the well shall be installed at an elbow and installed to effect uniform flow across the well. Sensors installed in wells shall be installed in horizontal piping below the pipe centerline.
 - f. Low Temperature Detection Thermostats: Mount sensor element similar to Mixed Air Temperature Sensors.
3. Current Sensors:
- a. Provide flow proof for constant volume fans and pumps with a current sensor connected to the motor wiring at the starter. Set upper alarm limit to the maximum rated current of the motor, or as advised by the TAB Agency. Set lower alarm limit at 1/2 the motor running amps.
 - b. Provide flow proof for variable speed control system through utilization of the variable speed drive serial communication option. Drive will communicate directly with BAS system.
4. Digital Status, Digital Command Points, Lighting Controls:
- a. Provide relays in a separate instrument enclosure or control panel adjacent to the monitored or controlled equipment. The relays shall mounted and connected in a manner that does not violate controlled equipment listing or code requirements.
 - b. Provide relays that operate in conjunction with the motor control system. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.
 - c. Coordinate motor control requirements with Divisions 26, 27 and 28.
 - d. Coordinate lighting control requirements with Divisions 26, 27 and 28.

5. Identification:

- a. Panel and Instrument Enclosure Identification: Panels and instrument enclosures shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.
- b. Field Devices: Field devices shall be identified by a typed (not handwritten) securely attached tag label.
- c. Panel or Instrument Enclosure Devices: Devices shall be identified by a typed label securely fastened to the backplane of the local control panel or instrument enclosure.
- d. Wall Mounted Temperature Sensors: Device covers shall be identified by a typed label securely fastened to the front cover. The label shall indicate the terminal unit zone identification tag.
- e. Raceway Identification: The covers to junction and pull boxes of the control system raceways shall be painted blue or have identification labels stating "Control System" affixed to the covers. This requirement includes control system tubing. Labels shall be typed, not hand written.
- f. Wire Identification: Low and line voltage control wiring shall be identified by a number, as referenced to the associated control diagram, at each end of the conductor or cable. Identification number shall be permanently secured to the conductor or cable and shall be typed.

3.2 SYSTEM STARTUP

- A. Commissioning: Perform tests and verification procedures required for the commissioning process as requested by the Owner and directed by the Owner's Commissioning Authority.

3.3 MAINTENANCE

- A. Arrange work so that wherever possible serviceable or operable products are located within mechanical or electrical spaces and are accessible.

END OF SECTION 253000