SECTION 23 01 00 - MECHANICAL GENERAL

1 GENERAL

1.1 The work covered by this division consists of providing all labor, equipment and materials and performing all operations necessary for the installation of the mechanical work as herein called for and shown on the drawings.

1.2 Related Documents:

1.2.1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.

1.2.2 This is a Basic Mechanical Requirements Section. Provisions of this section apply to work of all Division 23 sections.

1.2.3 Review all other contract documents to be aware of conditions affecting work herein.

1.2.4 Definitions:

1.2.4.1 Provide: Furnish and install, complete and ready for intended use.

1.2.4.2 Furnish: Supply and deliver to project site, ready for subsequent requirements.

1.2.4.3 Install: Operations at project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar requirements.

1.3 Permits and Fees: Contractor shall obtain all necessary permits, meters, and inspections required for his work and pay all fees and charges incidental thereto.

1.4 Verification of Owner's Data: Prior to commencing any work the Contractor shall satisfy himself as to the accuracy of all data as indicated in these plans and specifications and/or as provided by the Owner. Should the Contractor discover any inaccuracies, errors, or omissions in the data, he shall immediately notify the Architect/Engineer in order that proper adjustments can be anticipated and ordered. Commencement by the Contractor of any work shall be held as an acceptance of the data by him after which time the Contractor has no claim against the Owner resulting from alleged errors, omissions or inaccuracies of the said data.

1.5 Delivery and Storage of Materials: Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. All material shall be stored to provide protection from the weather and accidental damage.

1.6 Extent of work is indicated by the drawings, schedules, and the requirements of the specifications. Singular references shall not be constructed as requiring only one device if multiple devices are shown on the drawings or are required for proper system operation.

1.7 Field Measurements and Coordination:

1.7.1 The intent of the drawings and specifications is to obtain a complete and satisfactory installation. Separate divisional drawings and specifications shall not relieve the Contractor or subcontractors from full compliance of work of his trade indicated on any of the drawings or in any section of the specifications.

1.7.2 Verify all field dimensions and locations of equipment to insure close, neat fit with other trades' work. Make use of all contract documents and approved shop drawings to verify exact dimension and locations.

1.7.3 Coordinate work in this division with all other trades in proper sequence to insure that the total work is completed within contract time schedule and with a minimum cutting and patching.

1.7.4 Locate all apparatus symmetrical with architectural elements. Install to exact height and locations when shown on architectural drawings. When locations are shown only on mechanical drawings, be guided by architectural details and conditions existing at job and correlate this work with that of others.

1.7.5 Install work as required to fit structure, avoid obstructions, and retain clearance, headroom, openings and passageways. Cut no structural members without written approval.

1.7.6 Carefully examine any existing conditions, piping, and premises. Compare drawings with existing conditions. Report any observed discrepancies. It shall be the Contractor's responsibility to properly coordinate the work and to identify problems in a timely manner. Written instructions will be issued to resolve discrepancies.

1.7.7 Because of the small scale of the drawings, it is not possible to indicate all offsets and fittings or to locate every accessory. Drawings are essentially diagrammatic. Study carefully the sizes and locations of structural members, wall and partition locations, trusses, and room dimensions and take actual measurements on the job. Locate piping, ductwork, equipment and accessories with sufficient space for installing and servicing. Contractor is responsible for accuracy of his measurements and for coordination with all trades. Contractor shall not order materials or perform work without such verification. No extra compensation will be allowed because field measurements vary from the dimensions on the drawings. If field measurements show that equipment or piping cannot be fitted, the Architect/Engineer shall be consulted. Remove and relocate, without additional compensation, any item that is installed and is later found to encroach on space assigned to another use.

1.8 Guarantee:

1.8.1 The Contractor shall guarantee labor, materials and equipment for a period of *five* ~~one~~ (~~1~~ *5*) years from Final Completion, or from Owner's occupancy, whichever is earlier. Contractor shall make good any defects and shall include all necessary adjustments to and replacement of defective items without expense to the Owner.

1.8.2 Owner reserves right to make emergency repairs as required to keep equipment in operation without voiding Contractor's Guarantee Bond nor relieving Contractor of his responsibilities during guarantee period.

1.9 Approval Submittals:

1.9.1 When approved, the submittal control log and submittals shall be an addition to the specifications herewith, and shall be of equal force in that no deviation will be permitted except with the approval of the Architect/Engineer.

1.9.1.1 Shop drawings, product literature, and other approval submittals will only be reviewed if they are submitted in full accordance with the General and Supplementary Conditions and Division 1 Specification sections and the following.

1.9.1.1.1 Submittals shall be properly organized in accordance with the approved submittal control log.

1.9.1.1.2 Submittals shall not include items from more than one specification section in the same submittal package unless approved in the submittal control log.

1.9.1.1.3 Submittals shall be properly identified by a cover sheet showing the project name, Architect and Engineer names, submittal control number, specification section, a list of products or item names with model numbers in the order they appear in the package, and spaces for approval stamps. A sample cover sheet is included at the end of this section.

1.9.1.1.4 Submittals shall have been reviewed and approved by the General Contractor (or Prime Contractor). Evidence of this review and approval shall be an "Approved" stamp with a signature and date on the cover sheet.

1.9.1.1.5 Submittals that include a series of fixtures or devices (such as plumbing fixtures or valves) shall be organized by the fixture number or valve type and be marked accordingly. Each fixture must include all items associated with that fixture regardless of whether or not those items are used on other fixtures.

1.9.1.1.6 The electrical design shown on the drawings supports the mechanical equipment basis of design specifications at the time of design. If mechanical equipment is submitted with different electrical requirements, it is the responsibility of the mechanical contractor to resolve all required electrical design changes (wire and conduit size, type of disconnect or overload protection, point(s) of connection, etc.) and clearly show the new electrical design on the mechanical submittal with a written statement that this change will be provided at no additional cost. Mechanical submittals made with no written reference to the electrical design will be presumed to work with the electrical design. Any corrections required will be at no additional cost.

1.9.2 If the shop drawings show variation from the requirements of contract because of standard shop practice or other reasons, the Contractor shall make specific mention of such variation in writing in his letter of transmittal and on the submittal cover sheet in order that, if acceptable, Contractor will not be relieved of the responsibility for executing the work in accordance with the contract.

1.9.3 Review of shop drawings, product literature, catalog data, or schedules shall not relieve the Contractor from responsibility for deviations from contract drawings or specifications, unless he has in writing called to the attention of the Architect/Engineer each such deviation in writing at the time of submission, nor shall it relieve him from responsibility for errors of any sort in shop drawings, product literature, catalog data, or schedules. Any feature or function specified but not mentioned in the submittal shall be assumed to be included per the specification.

1.9.4 Submit shop drawings as called for in other sections after award of the contract and before any material is ordered or fabricated. Shop drawings shall consist of plans, sections, elevations and details to scale (not smaller than ¼" per foot), with dimensions clearly showing the installation. Direct copies of small scale project drawings issued to the Contractor are not acceptable. Drawings shall take into account equipment furnished under other sections and shall show space allotted for it. Include construction details and materials.

1.10 Test Reports and Verification Submittals: Submit test reports, certifications and verification letters as called for in other sections. Contractor shall coordinate the required testing and documentation of system performance such that sufficient time exists to prepare the reports, submit the reports, review the reports and take corrective action within the scheduled contract time.

1.11 O&M Data Submittals: Submit Operation and Maintenance data as called for in other sections. When a copy of approval submittals is included in the O&M Manual, only the final "Approved" or "Approved as Noted" copy shall be used. Contractor shall organize these data in the O&M Manuals tabbed by specification number. Prepare O&M Manuals as required by Division 1 and as described herein. Submit manuals at the Substantial Completion inspection.

2 PRODUCTS

2.1 All materials shall be new or Owner-supplied reused as shown on the drawings, the best of their respective kinds, suitable for the conditions and duties imposed on them at the building and shall be of reputable manufacturers. The description, characteristics, and requirements of materials to be used shall be in accordance with qualifying conditions established in the following sections.

2.2 Equipment and Materials:

2.2.1 Shall be new and the most suitable grade for the purpose intended. Equipment furnished under this division shall be the product of a manufacturer regularly engaged in the manufacture of such items for a period of three years. Where practical, all of the components shall be products of a single manufacturer in order to provide proper coordination and responsibility. Where required, Contractor shall furnish proof of installation of similar units or equipment.

2.2.2 Each item of equipment shall bear a name plate showing the manufacturer's name, trade name, model number, serial number, ratings and other information necessary to fully identify it. This plate shall be permanently mounted in a prominent location and shall not be concealed, insulated or painted.

2.2.3 The label of the approving agency, such as UL, IBR, ASME, ARI, AMCA, by which a standard has been established for the particular item shall be in full view.

2.2.4 The equipment shall be essentially the standard product of a manufacturer regularly engaged in the production of such equipment and shall be a product of the manufacturer's latest design.

2.2.5 A service organization with personnel and spare parts shall be available within two hours for each type of equipment furnished.

2.2.6 Install in accordance with manufacturer's recommendations. Place in service by a factory trained representative where required.

2.2.7 Materials and equipment are specified herein by a single or by multiple manufacturers to indicate quality, material and type of construction desired. Manufacturer's products shown on the drawings have been used as basis for design; it shall be the Contractor's responsibility to ascertain that alternate manufacturer's products, or the particular products of named manufacturers, meet the detailed specifications and that size and arrangement of equipment are suitable for installation.

2.2.8 Model Numbers: Catalog numbers and model numbers indicated in the drawings and specifications are used as a guide in the selection of the equipment and are only listed for the contractor's convenience. The contractor shall determine the actual model numbers for ordering materials in accordance with the written description of each item and with the intent of the drawings and specifications.

2.3 Requests for Substitution:

2.3.1 Where a particular system, product or material is specified by name, consider it as standard basis for bidding, and base proposal on the particular system, product or material specified.

2.3.2 Requests by Contractor for substitution will be considered only when reasonable, timely, fully documented, and qualifying under one or more of the following circumstances.

2.3.2.1 Required product cannot be supplied in time for compliance with Contract time requirements.

2.3.2.2 Required product is not acceptable to governing authority, or determined to be non-compatible, or cannot be properly coordinated, warranted or insured, or has other recognized disability as certified by Contractor.

2.3.2.3 Substantial cost advantage is offered Owner after deducting offsetting disadvantages including delays, additional compensation for redesign, investigation, evaluation and other necessary services and similar considerations.

2.3.3 All requests for substitution shall contain a "Comparison Schedule" and clearly and specifically indicate any and all differences or omissions between the product specified as the basis of design and the product proposed for substitution. Differences shall include but shall not be limited to data as follows for both the specified and substituted products:

Principal of operation.
Materials of construction or finishes.
Thickness of gauge of materials.
Weight of item.
Deleted features or items.
Added features or items.
Changes in other work caused by the substitution.
Performance curves.

If the approved substitution contains differences or omissions not specifically called to the attention of the Architect/Engineer, the Owner reserves the right to require equal or similar features to be added to the substituted products (or to have the substituted products replaced) at the Contractor's expense.

3 EXECUTION

3.1 Workmanship: All materials and equipment shall be installed and completed in a first-class workmanlike manner and in accordance with the best modern methods and practice. Any materials installed which do not present an orderly and reasonably neat and/or workmanlike appearance, or do not allow adequate space for maintenance, shall be removed and replaced when so directed by the Architect/Engineer.

3.2 Coordination:

3.2.1 The Contractor shall be responsible for full coordination of the mechanical systems with shop drawings of the building construction so the proper openings and sleeves or supports are provided for piping, ductwork, or other equipment passing through slabs or walls.

3.2.2 Any additional steel supports required for the installation of any mechanical equipment, piping, or ductwork shall be furnished and installed under the section of the specifications requiring the additional supports.

3.2.3 It shall be the Contractor's responsibility to see that all equipment such as valves, dampers, filters and such other apparatus or equipment that may require maintenance and operation are made easily accessible, regardless of the diagrammatic location shown on the drawings.

3.2.4 All connections to fixtures and equipment shown on the drawings shall be considered diagrammatic unless otherwise indicated by detail. The actual connections shall be made to fully suit the requirements of each case and adequately provide for expansion and servicing.

3.2.5 The contractor shall protect equipment, material, and fixtures at all times. He shall replace all equipment, material, and fixtures which are damaged as a result of inadequate protection.

3.2.6 Prior to starting and during progress of work, examine work and materials installed by others as they apply to work in this division. Report conditions which will prevent satisfactory installation.

3.2.7 Start of work will be construed as acceptance of suitability of work of others.

3.3 Interruption of Service: Before any equipment is shut down for disconnecting or tie-ins, arrangements shall be made with the Architect/Engineer and this work shall be done at the time best suited to the Owner. This will typically be on weekends and/or holidays and/or after normal working hours. Services shall be restored the same day unless prior arrangements are made. All overtime or premium costs associated with this work shall be included in the base bid.

3.4 Phasing: Provide all required temporary valves, piping, ductwork, equipment and devices as required. Maintain temporary services to areas as required. Remove all temporary material and equipment on completion of work unless Engineer concurs that such material and equipment would be beneficial to the Owner on a permanent basis.

3.5 Cutting and Patching: Notify General Contractor to do all cutting and patching of all holes, chases, sleeves, and other openings required for installation of equipment furnished and installed under this section. Utilize experienced trades for cutting and patching. Obtain permission from Architect/Engineer before cutting any structural items.

3.6 Equipment Setting: Bolt equipment directly to concrete pads or vibration isolators as required, using hot-dipped galvanized anchor bolts, nuts and washers. Level equipment.

3.7 Painting: Touch-up factory finishes on equipment located inside and outside shall be done under Division 23. Obtain matched color coatings from the manufacturer and apply as directed. If corrosion is found during inspection on the surface of any equipment, clean, prime, and paint, as required.

3.8 Clean-up: Thoroughly clean all exposed parts of apparatus and equipment of cement, plaster, and other materials and remove all oil and grease spots. Repaint or touch up as required to look like new. During progress of work, contractor is to carefully clean up and leave premises and all portions of building free from debris and in a clean and safe condition.

3.9 Start-up and Operational Test: Start each item of equipment in strict accordance with the manufacturer's instructions; or where noted under equipment specification, start-up shall be done by a qualified representative of the manufacturer. Alignment, lubrication, safety, and operating control shall be included in start-up check.

3.10 Climate Control: Operate heating and cooling systems as required after initial startup to maintain temperature and humidity conditions to avoid freeze damage and warping or sagging of ceilings and carpet.

3.11 Record Drawings:

3.11.1 During the progress of the work the Contractor shall record on their field set of drawings the exact location, as installed, of all piping, ductwork, equipment, and other systems which are not installed exactly as shown on the contract drawings.

3.11.2 Upon completion of the work, record drawings shall be prepared as described in the General Conditions, Supplementary Conditions, and Division 1 sections.

3.12 Acceptance:

3.12.1 Punch List: Submit written confirmation that all punch lists have been checked and the required work completed.

3.12.2 Instructions: At completion of the work, provide a competent and experienced person who is thoroughly familiar with project, for one day to instruct permanent operating personnel in operation of equipment and control systems. This is in addition to any specific equipment operation and maintenance training.

3.12.3 Operation and Maintenance Manuals: Furnish four complete manuals bound in ring binders with Table of Contents, organized, and tabbed by specification section. Manuals shall contain:

Detailed operating instructions and instructions for making minor adjustments.
Complete wiring and control diagrams.
Routine maintenance operations.
Manufacturer's catalog data, service instructions, and parts lists for each piece of operating equipment.
Copies of approved submittals.
Copies of all manufacturer's warranties.
Copies of test reports and verification submittals.

3.12.4 Record Drawings: Submit record drawings.

3.12.5 Test and Balance Report: Submit four certified copies. The Report shall be submitted for review prior to the Substantial Completion Inspection unless otherwise required by Division 1.

3.12.6 Acceptance will be made on the basis of tests and inspections of job. A representative of firm that performed test and balance work shall be in attendance to assist. Contractor shall furnish necessary mechanics to operate system, make any necessary adjustments and assist with final inspection.

3.12.7 Control Diagrams: Frame under glass and mount on equipment room wall.

END OF SECTION 23 01 00

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SECTION 23 05 13 - ELECTRIC MOTORS

1 GENERAL

1.1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specifications Section apply to work of this Section.

1.2

1.3 Extent of motors required by this section is indicated on drawings and/or specified in other Division-23 sections.

1.4 Comply with the requirements of Division 26.

1.5 UL Compliance: Comply with applicable UL standards pertaining to motors.

1.6 Approval Submittals:

1.6.1 Product Data: When required by other Division-23 sections, submit manufacturers standard product data sheets for each type of motor provided. Submit with Division-23 section using the motors, not as a separate submittal. Mark data sheet with arrows indicating product being supplied and list by unique descriptive name all motors to which each data sheet applies. Clearly indicate type, service factor, rpm, duty cycle, voltage, phase, nominal full load efficiency, power factor and insulation class. Field verify and coordinate mounting and frame requirements for matching the drive.

1.7 O&M Data Submittals: Submit a copy of approval submittals. Submit operation and maintenance data for each type of motor. Include these data in O&M Manual. Submit two copies of nameplate data sheet for each motor. One copy shall be included with the O&M Manual and a second copy shall be inserted in a waterproof pouch or bag and attached to the motor. Nameplate data sheets shall be typed or neatly printed and shall include all data on the motor nameplate plus a unique motor description such as "AHU-3 Fan Motor", "Distribution Pump #1" or similar description.

2 PRODUCTS

2.1 Acceptable Manufacturers: Subject to compliance with requirements, General Electric, Baldor, US Electric, or approved equal.

2.2 General:

2.2.1 Motors shall conform to applicable portions of NEMA Standard MG-1, Motors and Generators.

2.2.2 Motors shall be sized for the application such that when the driven equipment is operated at rated capacity the motor current will not exceed the full-load nameplate current. Service factor shall not be used in normal operation.

2.3 Motor Design:

2.3.1 Integral Horsepower Motors:

2.3.1.1 Motors shall be open drip-proof or totally enclosed fan cooled as shown on the drawings or listed in the Division 23 section requiring motors.

2.3.1.2 Motors shall be three phase, 60 hertz, nominal 1800 rpm, rated at 200 volts for 208 volt systems, 230 volts for 240 volt systems and 460 volts for 480 volt systems.

2.3.1.3 Motors shall be NEMA Design B and shall have 1.15 service factor or greater at 60 hertz.

2.3.1.4 Insulation Systems

2.3.1.4.1 In fixed speed applications, motors shall have Class B insulation with 80ºC rise over 40ºC ambient.

2.3.1.4.2 For variable frequency drive (VFD) applications, motors shall have Class F insulation with 105ºC rise over 40ºC ambient. Motor manufacturer shall identify motors being used for VFD applications by marking the motor with a stainless steel name-plate "Inverter Ready".

2.3.1.5 Motor efficiencies shall be based on IEEE-112, 1984, Test Method B, as specified in NEMA Standard MG1-12.53. NEMA motor efficiency and power factor shall be clearly shown on the motor nameplate. Inverter duty motors shall have a CIV rating based on NEMA.

2.3.1.6 Motors shall be premium efficiency type and shall meet or exceed the following minimum nominal efficiencies at rated voltage.

230/460 VOLT, 3 PHASE

HORSEPOWER RANGE	MINIMUM NOMINAL EFFICIENCY	MINIMUM ACCEPTABLE POWER FACTOR
1 to 2 hp	84.0 pct.	75.0 pct
3 to 5 hp	87.5 pct.	77.0 pct
7.5 hp	89.5 pct.	80.0 pct
10 hp	90.2 pct.	80.0 pct
15 hp	91.0 pct.	82.0 pct
20 to 25 hp	92.0 pct.	82.0 pct
30 hp	92.4 pct.	82.0 pct
40 to 50 hp	93.0 pct.	85.0 pct
60 hp	93.6 pct.	85.0 pct
75 hp	94.1 pct.	85.0 pct
100 to 125 hp	94.5 pct.	85.0 pct
150 to 200 hp	95.0 pct.	85.0 pct
over 200 hp	95.4 pct.	87.0 pct

200 VOLT, 3 PHASE

HORSEPOWER RANGE	MINIMUM NOMINAL EFFICIENCY	MINIMUM ACCEPTABLE POWER FACTOR
1 to 2 hp	84.0 pct.	75.0 pct
3 to 5 hp	87.5 pct.	77.0 pct
7.5 hp	89.5 pct.	80.0 pct
10 hp	90.2 pct.	80.0 pct
15 hp	91.0 pct.	80.0 pct
20 to 25 hp	92.0 pct.	80.0 pct

2.3.1.7 Motors 25 hp and larger which are to be installed outdoors or in other high humidity areas shall be equipped with silicone rubber space heaters. Space heaters shall be energized when motor is de-energized.

2.3.2 Fractional Horsepower Motors one-half hp and above:

2.3.2.1 Motors shall be open drip-proof or totally enclosed fan cooled as shown on the drawings or listed in the Division 23 section requiring motors.

2.3.2.2 Motors shall be three phase, 60 hertz, nominal 1800 rpm, rated at 200, 230 or 460 volts as shown on the drawings.

2.3.2.3 Motors shall be NEMA Design B with class B insulation, unless used with variable frequency drives.

2.3.3 Fractional Horsepower Motors less than one-half hp:

2.3.3.1 Motors shall be single phase, 60 hertz, rated at 120 volts with integral thermal protection.

2.4 Overload Protection: Properly sized overload protection shall be provided for each motor. This protection may be an integral part of the motor or may be part of the motor controller and shall interrupt each ungrounded conductor.

3 EXECUTION

3.1 Motor Size and Location:

3.1.1 Size and location of motors shown on the drawings are based on a particular design and may change with a different manufacturer. Submittal of shop drawings or product literature indicating motor sizes or locations different from that designed indicates that Contractor has fully coordinated any required changes to the electrical system with other trades. Approval (if made) is on this basis and no additional cost will be allowed for any changes.

3.1.2 Contractor shall verify and make any necessary adjustments to electrical service, branch circuit wiring, branch circuit protection, overload protection, disconnect and controller (starter), or VFD based on actual nameplate data of the motors supplied prior to installation. Where applicable, connect motor winding thermostat to VFD.

3.2 Motor Voltages: Contractor shall field verify system voltage prior to ordering or installing any motors. Submittal of shop drawings or product literature indicating motor voltages indicates that Contractor has fully coordinated the motor with the electrical system and that

any discrepancies have been resolved. Approval (if made) is on this basis and no additional cost will be allowed for any changes.

3.3 Motor Mounting: Adjust motor mounting as required to adjust the drive train for proper belt operation and to accommodate sheave changes or other requirements of the test and balance work.

END OF SECTION 23 05 13

SECTION 23 05 19 - METERS AND GAUGES

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 This section is a Division-23 Basic Mechanical Materials and Methods section, and is part of each Division-23 section making reference to or requiring meters and gauges specified herein.

1.3 Extent of meters and gauges required by this section is indicated on drawings and/or specified in other Division-23 sections.

1.4 UL Compliance: Comply with applicable UL standards pertaining to meters and gauges.

1.5 ANSI and ISA Compliance: Comply with applicable portions of ANSI and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.

1.6 Approval Submittals:

1.6.1 Product Data: When required by other Division-23 sections, submit manufacturer's technical product data for each type of meter and gauge. Submit with Division-23 section using meters and gauges, not as a separate submittal. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit for:

Thermometers
Pressure gauges
Gauge connector plugs
Venturi flow meters
Automatic balancing valves

1.7 O&M Data Submittals: Submit a copy of approval submittals. Submit calibration curves and operating instructions for each type of meter or gauge. Include this data in O&M Manual.

2 PRODUCTS

2.1 Acceptable Manufacturers (Thermometers and Pressure Gauges): Subject to compliance with requirements, Ashcroft, Ernst Gauge Company, Weksler, Marshalltown Instruments, Trerice, Weiss Instruments, Wheatley, Fluidyne or approved equal.

2.2 Glass Thermometers:

2.2.1 General: Provide glass thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

2.2.2 Case: Die cast aluminum finished in baked epoxy enamel, glass front, spring secured, 9" long.

2.2.3 Adjustable Joint: Die cast aluminum, finished to match case, 180° adjustment in vertical plane,

360° adjustment in horizontal plane, with locking device.

2.2.4 Tube and Capillary: Liquid filled, magnifying lens, 1% scale range accuracy, shock mounted.

2.2.5 Scale: Satin faced, non-reflective aluminum, permanently etched markings.

2.2.6 Stem: Copper-plated steel or brass for separable socket, length to suit installation.

2.2.7 Range: Conform to the following:

2.2.7.1 Hot Water: 30° - 240°F with 2°F scale divisions.

2.2.7.2 Chilled Water: 30° - 180°F with 2°F scale divisions.

2.3 Thermometer Wells: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2" extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well if wells do not have a permanent instrument installed. Same manufacturer as thermometers.

2.4 Pressure Gauges:

2.4.1 General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

2.4.2 Type: General use, 1% accuracy, ANSI B40.1 grade A, phosphor bronze bourdon type, bottom connection.

2.4.3 Case: Drawn steel or brass, glass lens, 4-½" diameter.

2.4.4 Connector: Brass with ¼" male NPT.

2.4.5 Scale: White coated aluminum with black scale.

2.4.6 Range: Select so that highest possible pressure does not exceed 75% of full scale.

2.5 Pressure Gauge Cocks:

2.5.1 General: Provide ¼" ball valves for use as pressure gauge cocks.

2.5.2 Snubber: ¼" brass bushing with corrosion resistance porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.

2.6 Gauge Connector Plugs:

2.6.1 Provide temperature gauge connector plugs pressure rated for 500 psi and 200ºF. Construct of brass and finish in nickel-plate, equip with 1/2" NPT fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/2" O.D. probe assembly from dial type insertion thermometer. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping. Pete's Plug or approved equal.

2.6.2 Provide pressure gauge connector plugs pressure rated for 500 psi and 200ºF. construct of brass and finish in nickel-plate, equip with 1/2" NPT fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/2" O.D. probe assembly from dial type insertion pressure gauge. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to

insulation thickness, for insulated piping. Pete's Plug or approved equal.

2.6.3 Provide master test kit with hard plastic case including one 2-1/2" test gauge of suitable range, one gauge adapter probe, and one stem pocket testing thermometer (0ºF-220ºF).

2.7 Venturi Stations:

2.7.1 Provide as indicated for digital controls measurement of flow, complete venturi stations with quick disconnect valves, safety shutoff valves, venturi, and metal or plastic identification tag on chain indicating size, series, and meter reading at specified flowrate. Accuracy plus or minus 2%.

2.7.2 Venturis for pipe 2" and smaller shall be threaded bronze body. Venturis for pipe 2-1/2" and larger shall be steel body with weld ends.

2.7.3 Venturis shall not require greater than 5 pipe diameters of straight pipe upstream nor 2 pipe diameters of straight pipe downstream to achieve rated accuracy.

2.7.4 Select venturis so that design flowrate reads between 20% and 80% of the full range on the linear meter.

2.7.5 Acceptable Manufacturers: Barco Venturi (Aeroquip Corporation), Gerand Engineering Company, Preso, or approved equal.

2.8 Automatic Balancing Valves:

2.8.1 General: Provide as indicated, threaded automatic balancing valves equipped with optional valve kits to measure the flow rate. Valves shall utilize a stainless steel flow mechanism that is factory-set with ±5% accuracy. The flow mechanism shall be removable with standard tools to change the flow rate setting. Provide dual hose meter kit. Provide threaded mini's for terminal unit coils and threaded high capacity for air handlers. Provide metal nameplate to indicate flow rate. Provide valves with pre-formed polyurethane insulation suitable for use on heating and cooling systems.

2.8.2 Acceptable Manufacturers: Griswold, Autoflow Products, Bell & Gossett, Flow Design Inc.

3 EXECUTION

3.1 Installation Of Temperature Gauges:

3.1.1 General: Install temperature gauges in vertical upright position, and tilt so as to be easily read by observer standing on floor.

3.1.2 Locations: Install in the following locations, and elsewhere as indicated:

3.1.2.1 At inlet and outlet of each hydronic coil in air handling units.

3.1.2.2 At inlet and outlet of each hydronic boiler and chiller.

3.1.3 Thermometer Wells: Install in piping tee where indicated, in vertical upright position. Thermometers shall have at least 75% of stem in moving fluid.

3.1.4 Temperature Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.2 Installation of Pressure Gauges:

3.2.1 General: Install pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.

3.2.2 Locations: Install in the following locations, and elsewhere as indicated:

3.2.2.1 At suction and discharge of each pump.

3.2.2.2 At discharge of each water pressure reducing valve.

3.2.2.3 At inlet and outlet of water cooled condensers and refrigerant cooled chillers.

3.2.3 Pressure Gauge Cocks: Install in piping tee with snubber.

3.2.4 Pressure Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.

3.3 Installation of Flow Measuring Meters:

3.3.1 General: Install flow measuring meters on piping systems located in accessible locations at most readable position.

3.3.2 Locations: Install in the following locations, and elsewhere as indicated:

3.3.3 Venturi Stations: Install on piping with readout valves in vertical upright position. Maintain recommended straight lengths of unobstructed pipe both upstream and downstream. Install in accordance with manufacturer's printed instructions.

3.4 Automatic Balancing Valves: Install on piping in accordance with the manufacturer’s printed instructions. Verify proper operation over full range of control valve and pump operation.

3.5 Adjusting and Cleaning:

3.5.1 Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.

3.5.2 Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked or broken windows; repair any scratched or marred surfaces with manufacturer's touch-up paint.

END OF SECTION 23 05 19

SECTION 23 05 20 - PIPES AND PIPE FITTINGS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 This section is a Division-23 Basic Mechanical Materials and Methods section, and is part of each Division-23 section making reference to pipes and pipe fittings specified herein.

1.3 Extent of pipes and pipe fittings required by this section is indicated on drawings and/or specified in other Division-23 sections.

1.4 Codes and Standards:

1.4.1 Welding: Qualify welding procedures, welders and operators in accordance with ASME B31.1, or ASME B31.9, as applicable, for shop and project site welding of piping work.

1.4.2 Brazing: Certify brazing procedures, brazers, and operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, for shop and job-site brazing of piping work.

1.5 Test Report and Verification Submittals:

Submit welding certification for all welding installers.
Submit brazing certification for all brazing installers.

2 PRODUCTS

2.1 Piping Materials: Provide pipe and tube of type, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class is not indicated, provide proper selection as determined by Installer for installation requirements, and comply with governing regulations and industry standards.

2.2 Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections, and with pipe manufacturer's recommendations where applicable.

2.3 Piping Materials/Products:

2.3.1 Soldering Materials:

2.3.1.1 Tin-Antimony (95-5) Solder: ASTM B-32, Grade 95TA.

2.3.1.2 Silver-Phosphorus Solder: ASTM B-32, Grade 96TS.

2.3.2 Pipe Thread Tape: Teflon tape.

2.3.3 Protective Coating: Koppers Bitumastic No. 505 or equal.

2.3.4 Gaskets for Flanged Joints: ANSI B16.21; full-faced for cast iron flanges; raised-face for steel flanges, unless otherwise noted.

2.3.5 Welding Materials: Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials. Materials shall be determined by installer to comply with installation requirements.

2.3.6 Brazing Materials: Silver content of not less than 15%. Materials shall be determined by installer to comply with installation requirements.

2.4 Copper Tube and Fittings:

2.4.1 Copper Tube:

2.4.1.1 Copper Tube: ASTM B88; Type K or L as indicated for each service; hard-drawn temper unless specifically noted as annealed.

2.4.1.2 ACR Copper Tube: ASTM B280.

2.4.2 Fittings:

2.4.2.1 Wrought-Copper Solder-Joint Fittings: ANSI B16.22.

2.4.2.2 Copper Tube Unions: Provide standard products recommended by manufacturer for use in service indicated.

2.4.2.3 Cast-Copper Flared Tube Fittings: ANSI B16.26.

2.5 Steel Pipes and Pipe Fittings

2.5.1 Pipes:

2.5.1.1 Black Steel Pipe: ASTM A-53 or A-120, seamless.

2.5.1.2 Galvanized Steel Pipe: ASTM A-53 or A-120, seamless.

2.5.2 Pipe Fittings:

2.5.2.1 Threaded Cast Iron: ANSI B16.4.

2.5.2.2 Threaded Malleable Iron: ANSI B16.3; plain or galvanized as indicated.

2.5.2.3 Malleable Iron Threaded Unions: ANSI B16.39; selected by installer for proper piping fabrication and service requirements including style, end connections, and metal-to-metal seats (iron, bronze or brass); plain or galvanized as indicated.

2.5.2.4 Threaded Pipe Plugs: ANSI B16.14.

2.5.2.5 Flanged Cast Iron: ANSI B16.1, including bolting.

2.5.2.6 Steel Flanges/Fittings: ANSI B16.5, including bolting and gasketing.

2.5.2.7 Wrought-Steel Buttwelding Fittings: ANSI B16.9, except ANSI B16.28 for short radius elbows and returns, rated to match connected pipe.

2.5.2.8 Pipe Nipples: Fabricated from same pipe as used for connected pipe; except do not use less than schedule 80 pipe where length remaining unthreaded is less than 1 ½ inches, and where pipe size is less than 1 ½ inches, and do not thread nipples full length (no close-nipples).

2.6 Plastic Pipes and Fittings:

2.6.1 Pipes:

2.6.1.1 PVC DWV Pipe: ASTM D-2665, Schedule 40.

2.6.2 Fittings:

2.6.2.1 PVC Solvent Cement: ASTM D-2564.

2.6.2.2 PVC DWV Socket: ASTM D-2665.

3 EXECUTION

3.1 Installation

3.1.1 General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently-leak proof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance or replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings, not bushings. Align piping accurately at connections, within 1/16" misalignment tolerance.

3.1.2 Comply with ANSI B31 Code for Pressure Piping.

3.1.3 Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. Orient horizontal runs parallel with walls and column lines. Locate runs as shown or described by diagrams, details and notations or, if not otherwise indicated, run piping in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Hold piping close to walls, overhead construction, columns and other structural and permanent-enclosure elements of building; limit clearance to ½" where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1" clearance outside insulation.

3.1.4 Concealed Piping: Unless specifically noted as “Exposed” on the drawings, conceal piping from view in finished and occupied spaces, by locating in column enclosures, chases, in hollow wall construction or above suspended ceilings; do not encase horizontal runs in solid partitions, except as indicated.

3.1.5 Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical, communications, or data equipment spaces and enclosures unless shown. Install drip pan under piping that must run through electrical spaces.

3.1.5.1 Cut pipe from measurements taken at the site, not from drawings. Keep pipes free of contact with building construction and installed work.

3.2 Piping System Joints: Provide joints of the type indicated in each piping system.

3.2.1 Solder copper tube-and-fitting joints where indicated, in accordance with recognized industry practice. Cut tube ends squarely, ream to full inside diameter, and clean outside of tube ends and inside of fittings. Apply non-acid type solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.

3.2.2 Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed. Paint exposed threads to retard rusting.

3.2.3 Flanged Joints: Match flanges within piping system, and at connection with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets. Bolts shall project 1/8" to 3/8" beyond nut face when tight.

3.2.4 Weld pipe joints in accordance with recognized industry practice and as follows. Be guided by ANSI B.31.

3.2.4.1 Weld pipe joints only when ambient temperature is above 0°F.

3.2.4.2 Bevel pipe ends at a 37.5° angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.

3.2.4.3 Use pipe clamps or tack-weld joints; 4 welds for pipe sizes to 10". All welds shall be open-butt.

3.2.4.4 Build up welds with root pass, followed by filler pass and then a cover pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and non-metallic inclusions.

3.2.4.5 Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.

3.2.4.6 At Installer's option, install forged branch-connection fittings wherever branch pipe is less than 3" and at least two pipe sizes smaller than main pipe indicated; or install regular "T" fitting. Weld-O-Let or equal.

3.2.5 Plastic Pipe Joints: Comply with manufacturer's instructions and recommendations, and with applicable industry standards.

3.2.5.1 Solvent-cemented joints shall be made in accordance with ASTM D-2235 and ASTM F-402.

3.2.5.2 PVC sewer pipe bell/gasket joints shall be installed in accordance with ASTM D-2321.

3.2.6 Braze copper tube-and-fitting joints where indicated, in accordance with ANSI B.31.

3.3 Piping Installation

3.3.1 Install piping to allow for expansion and contraction.

3.3.2 Isolate all copper tubing from steel and concrete by wrapping the pipe at the contact point, and for one inch on each side, with a continuous plastic sleeve. Isolate all copper tubing installed in block walls with a continuous plastic sleeve.

3.3.3 Underground Piping:

3.3.3.1 Provide plastic tape markers over all underground piping. Provide copper wire over all underground plastic piping outside the building. Locate markers 18" above piping.

3.3.3.2 Coat the following underground (uninsulated) pipes with a heavy coat of bitumastic or provide an 8 mil polyvinyl sleeve: black steel pipe, galvanized steel pipe, copper tubing.

END OF SECTION 23 05 20

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SECTION 23 05 21 - PIPING SPECIALTIES

1 GENERAL

1.1 Drawings and general provisions of contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 This section is a Division-23 Basic Mechanical Materials and Methods section, and is part of each Division-23 section making reference to or requiring piping specialties specified herein.

2 PRODUCTS

2.1 General: Provide factory-fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service, or if not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.

2.2 Escutcheons:

2.2.1 General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.

2.2.2 Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.

2.2.3 Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

2.3 Dielectric Unions: Provide standard products recommended by manufacturer Victaulic Style 47 dielectric waterways for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action and stop corrosion. .

2.4 Fire Barrier Penetration Seals:

2.4.1 Provide seals for any opening through fire-rated walls, floors, or ceilings used as passage for mechanical components such as piping or ductwork in accordance with the requirements of Division 7.

2.5 Fabricated Piping Specialties:

2.5.1 Drip Pans: Provide drip pans fabricated from corrosion-resistant sheet metal with watertight joints, and with edges turned up 2-1/2". Reinforce top, either by structural angles or by rolling

top over ¼" steel rod. Provide hole, gasket, and flange at low point for watertight joint and 1" drain line connection.

2.5.2 Pipe Sleeves: Provide pipe sleeves of one of the following:

2.5.2.1 Sheet-Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gages: 3" and smaller, 20 gage; 4" to 6" 16 gage; over 6", 14 gage.

2.5.2.2 Steel-Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.

2.5.2.3 Iron-Pipe: Fabricate from cast-iron or ductile-iron pipe; remove burrs.

2.5.3 Sleeve Seals: Provide sleeve seals for sleeves located in foundation walls below grade, or in exterior walls, of one of the following:

2.5.3.1 Caulking and Sealant: Provide foam or caulking and sealant compatible with piping materials used.

2.6 Low Pressure Y-Type Pipeline Strainers:

2.6.1 General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Provide Type 304 stainless steel screens.

2.6.1.1 Water Strainers: Select for 200 psi working pressure (water, oil or gas). Provide 20 mesh screens through 2" size and 1/16" perforations for 2½" size and larger.

2.6.2 Select from the following types:

2.6.2.1 Threaded Ends, 2" and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

2.6.2.2 Threaded Ends, 2-1/2" and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

2.6.2.3 Flanged Ends, 2-1/2" and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

3 EXECUTION

3.1 Pipe Escutcheons: Install pipe escutcheons on each pipe penetration through floors, walls, partitions, and ceilings where penetration is exposed to view; and on exterior of building. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole, and is flush with adjoining surface.

3.2 Dielectric Unions: Install at each piping joint between ferrous and non-ferrous piping. Comply with manufacturer's installation instructions.

3.3 Fire Barrier Penetration Seals: Provide pipe sleeve as required. Fill entire opening with sealing compound. Adhere to manufacturer's installation instructions. Refer to Division 7.

3.4 Drip Pans: Locate drip pans under piping passing over or within 3' horizontally of electrical equipment, and elsewhere as indicated. Hang from structure with rods and building

attachments, weld rods to sides of drip pan. Brace to prevent sagging or swaying. Connect 1" drain line to drain connection, and run to nearest plumbing drain or elsewhere as indicated.

3.5 Pipe Sleeves: Install pipe sleeves of types indicated where piping passes through walls, floors, ceilings, and roofs. Do not install sleeves through structural members of work, except as detailed on drawings, or as reviewed by Architect/Engineer. Install sleeves accurately centered on pipe runs. Size sleeves so that piping and insulation (if any) will have free movement in sleeve, including allowance for thermal expansion; but not less than 2 pipe sizes larger than piping run. Where insulation includes vapor-barrier jacket, provide sleeve with sufficient clearance for installation. Install length of sleeve equal to thickness of construction penetrated, and finish flush to surface; except floor sleeves. Extend floor sleeves ¼" above level floor finish, and ¾" above floor finish sloped to drain. Provide temporary support of sleeves during placement of concrete and other work around sleeves, and provide temporary closure to prevent concrete and other materials from entering sleeves.

3.5.1 Install sleeves in fire-rated assemblies in accordance with the listing of the assembly and the fire barrier sealant.

3.5.2 Install sheet-metal sleeves at interior partitions and ceilings other than suspended ceilings. Fill annular space with caulking or fire barrier sealant as required.

3.5.3 Install steel-pipe sleeves at floor penetrations. Fill annular space with caulking or fire barrier sealant as required.

3.5.4 Install iron-pipe sleeves at all foundation wall penetrations and at exterior penetrations; both above and below grade. Fill annular space with caulking or mechanical sleeve seals.

3.6 Y-Type Strainers: Install Y-type strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shutoff valve in strainer blow down connection, full size of connection, except for strainers ¾" and smaller installed ahead of control valves feeding individual terminals. Where indicated, provide drain line from shutoff valve to plumbing drain, full size of blow down connection.

3.7 Locate Y-type strainers in supply line ahead of the following equipment, and elsewhere as indicated, if integral strainer is not included in equipment:

Pumps
Temperature control valves.
Pressure reducing valves.
Temperature or pressure regulating valves.

END OF SECTION 23 05 21

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SECTION 23 05 23 - VALVES

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to the work of this section.

1.2 This section is a Division-23 Basic Materials and Methods section, and is part of each Division-23 section making reference to or requiring valves specified herein.

1.3 Extent of valves required by this section is indicated on drawings and/or specified in other Division-23 sections.

1.4 Quality Assurance:

1.4.1 Valve Dimensions: For face-to-face and end-to-end dimensions of flanged or welding-end valve bodies, comply with ANSI B16.10.

1.4.2 Valve Types: Provide valves of same type by same manufacturer.

1.4.3 Valve Listing: For valves on fire protection piping, provide UL listing.

1.4.4 Valves Installed in Boiler Rooms: Comply with ASME Boiler and Pressure Vessel Code.

1.5 Approval Submittals: Submit product data, catalog cuts, specifications, and dimensioned drawings for each type of valve. Include pressure drop curve or chart for each type and size of valve. Submit valves with Division-23 section using the valves, not as a separate submittal. For each valve, identify systems where the valve is intended for use.

Gate Valves. Type GA.
Check Valves. Type CK.
Ball Valves. Type BA.
Butterfly Valves. Type BF.

1.6 O&M Data Submittals: Submit a copy of approval submittals. Submit installation instructions, maintenance data and spare parts lists for each type of valve. Include this data in the O&M Manual.

2 PRODUCTS

2.1 General: Provide factory-fabricated valves recommended by manufacturer for use in service indicated. Provide valves of types and pressure ratings indicated; provide proper selection as determined by Installer to comply with specifications and installation requirements. Provide sizes as indicated, and connections which properly mate with pipe, tube, and equipment connections.

2.2 Acceptable Manufacturers: Subject to compliance with requirements, provide valves of one of the producers listed for each valve type. The model numbers are listed for contractor's

convenience only. In the case of a model number discrepancy, the written description shall govern.

2.3 Gate Valves:

2.3.1 Packing: Select valves designed for repacking under pressure when fully opened, equipped with non-asbestos packing suitable for intended service. Select valves designed so back seating protects packing and stem threads from fluid when valve is fully opened, and equipped with gland follower.

2.3.2 Comply with the following standards:

Cast Iron Valves: MSS SP-70. Cast Iron Gate Valves, Flanged and Threaded Ends.
Bronze Valves: MSS SP-80. Bronze Gate, Globe, Angle and Check Valves.
Steel Valves: ANSI B16.34. Steel Standard Class Valve Ratings.

2.3.3 Types of gate (GA) valves:

1 Threaded Ends 2" and Smaller (GA1): Class 125, bronze body, screwed bonnet, rising stem, solid wedge. Stockham B-100. Nibco T-111. Crane 428. Milwaukee 148.

2 Soldered Ends 2" and Smaller (GA2): Class 125, bronze body, screwed bonnet, non-rising stem, solid wedge. Stockham B-108 or B-109. Nibco S-111. Crane 1334. Milwaukee 149.

3 Flanged Ends 2½" and Larger (GA3): Class 125, iron body, bronze mounted, bolted bonnet, rising stem, OS&Y, solid wedge. Stockham G-623. Nibco F617-0. Crane 465½. Milwaukee F2885.

4 Threaded Ends 2" and Smaller (GA4): Class 150, bronze body, screwed bonnet, rising stem, solid wedge. Stockham B-122. Nibco T-131. Crane 431. Milwaukee 1150.

5 Soldered Ends 2" and Smaller (GA5): Class 150, bronze body, screwed bonnet, rising stem, solid wedge. Stockham B-124. Nibco S-134. Milwaukee 1169.

6 Threaded Ends 2" and Smaller (GA6): 175 WWP, bronze body, screwed bonnet, rising stem, OS&Y, solid wedge, UL-listed. Stockham B-133. Nibco T-104-0.

7 Flanged Ends 2½" and Larger (GA7): 175 WWP, iron body, bolted bonnet, rising stem, OS&Y, solid wedge, UL listed. Stockham G-634. Nibco F-607-0TS

8 Threaded Ends 2" and Smaller (GA8): Class 200, bronze body, union bonnet, rising stem, solid wedge, renewable seat. Stockham B-132. Nibco T-154-SS. Milwaukee 1174.

9 Flanged Ends 2½" and Larger (GA9): Class 250, iron body bronze mounted, bolted bonnet, rising stem, OS&Y, solid wedge. Stockham F-667. Nibco F-667-0. Crane 7½E. Milwaukee F-2894.

10 Threaded Ends 2" and Smaller (GA10): Class 300, bronze body, union bonnet, rising stem, solid wedge, renewable seat. Stockham B-145. Nibco T-174-SS. Crane 634E. Milwaukee 1184.

11 Flanged Ends 2½" and Larger (GA11): Class 300, cast steel body, bolted bonnet, rising

stem, solid wedge, seal-welded seat rings. Provide trim to match use. Stockham 30-0F. Crane 33.

12 Flanged Ends 2½" and Larger (GA12): 300 WWP, iron body, bolted bonnet, bronze mounted, rising stem, OS&Y, solid wedge, UL-listed. Stockham F-670. Nibco F-697-0.

2.4 Check Valves:

2.4.1 Construction: Construct valves of castings free of any impregnating materials. Construct valves with a bronze regrinding disc with a seating angle of 40º to 45º, unless a composition disc is specified. Provide stop plug as renewable stop for disc hanger, unless otherwise specified. Disc and hanger shall be separate parts with disc free to rotate. Support hanger pins on both ends by removable side plugs.

2.4.2 Comply with the following standards:

Cast Iron Valves: MSS SP-71. Cast Iron Swing Check Valves, Flanged and Threaded Ends.
Bronze Valves: MSS SP-80. Bronze Gate, Globe, Angle and Check Valves.
Steel Valves: ANSI B16.34. Steel Standard Class Valve Ratings.

2.4.3 Types of check (CK) valves:

1 Threaded Ends 2" and Smaller (CK1): Class 125, bronze body, screwed cap, horizontal swing, bronze disc. Stockham B-319. Nibco T-413-BY. Crane 1707. Milwaukee 509.

2 Soldered Ends 2" and Smaller (CK2): Class 125, bronze body, screwed cap, horizontal swing, bronze disc. Stockham B-309. Nibco S-413-B. Crane 1707S. Milwaukee 1509.

3 Flanged Ends 2½" and Larger (CK3): Class 125, iron body, bronze-mounted, bolted cap, horizontal swing, cast-iron or composition disc. Stockham G-931 or G-932 as applicable. Nibco F918-B. Crane 373. Milwaukee F2974 as applicable.

4 Threaded Ends 2" and Smaller (CK4): 200 WWP, bronze body, screwed cap, horizontal swing, regrinding type bronze disc, for fire sprinkler use. Nibco KT-403-W.

5 Flanged Ends 2½" and Larger (CK5): 175 WWP, iron body, bolted cap, bronze mounted, composition disc, UL listed, with ball drip if required. Stockham G-940. Nibco F-908-W.

6 Threaded Ends 2" and Smaller (CK6): Class 200, bronze body, screwed cap, Y-pattern swing, regrinding bronze disc. Stockham B-345. Nibco T-453-B. Crane 36. Milwaukee 518/508.

7 Flanged Ends 2½" and Larger (CK7): Class 250, iron body, bronze mounted, bolted cap, cast-iron disc. Stockham F-947. Nibco F-968-B. Crane 39E. Milwaukee F2970.

8 Threaded Ends 2" and Smaller (CK8): Class 300, bronze body, screwed cap, Y-pattern swing, regrinding bronze disc. Stockham B-375. Nibco T-473-B. Crane 76E. Milwaukee 517/507.

9 Flanged Ends 2½" and Larger (CK9): Class 300, cast steel body, bolted cap, horizontal swing, seal welded seat rings, chromium stainless disc. Stockham 30-SF. Crane 159.

2.5 Ball Valves:

2.5.1 General: Select with port area equal to or greater than connecting pipe area, include seat ring designed to hold sealing material.

2.5.2 Construction: Ball valves shall be rated for 150 psi saturated steam and 600 psi non-shock cold water. Pressure containing parts shall be constructed of ASTM B-584 alloy 844, or ASTM B-124 alloy 377. Valves shall be furnished with blow-out proof bottom loaded stem constructed of ASTM B-371 alloy 694 or other approved low zinc material. Provide TFE packing, TFE thrust washer, chrome-plated ball and reinforced teflon seats. Valves 1" and smaller shall be full port design. Valves 1¼" and larger shall be conventional port design. Stem extensions shall be furnished for use in insulated piping where insulation exceeds ½" thickness.

2.5.3 Comply with the following standards:

MSS SP-72. Ball Valves with Flanged or Butt Welding Ends for General Service.
MSS SP-110. Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

2.5.4 Types of ball (BA) valves:

1 Threaded Ends 2" and Smaller (BA1): Bronze two-piece full port body with adjustable stem packing, stainless steel ball, trim, and handle. Nibco T-585-66. Stockham T285-BR-R-T. Milwaukee BA100S. Apollo 77-100.

2 Soldered Ends 2" and Smaller (BA2): Bronze three-piece full port body with adjustable stem packing. Nibco S-595-Y-66. Milwaukee BA350. Apollo 82-200.

3 Threaded Ends 1" and Smaller (BA3): Bronze two-piece full port body, UL listed (UL 842) for use with flammable liquids and LP gas. Nibco T-585-70-UL.

4 Threaded Ends 2" and Smaller (BA4): 175 WWP, bronze two-piece body, UL listed for fire protection service. Nibco KT-585-70-UL and KT-580-70-UL.

5 Threaded Ends 2" and Smaller (BA5): 400 WWP, bronze two-piece body, for fire protection service. Nibco KT-580.

6 Threaded Ends 2½" and Smaller (BA6): 300 WWP, bronze three-piece body, gear operator with handwheel, indicator flag, accepts tamper switch, for fire protection, UL listed. Nibco T-505-4 and G-505-4.

7 Flanged Ends 2½" and Larger (BA7): Class 150, carbon steel full bore two-piece body with adjustable stem packing, stainless steel ball, trim, and handle. Nibco F515-S6 series. Apollo 88A-240.

2.6 Butterfly Valves:

2.6.1 General: Comply with MSS SP-67, Butterfly Valves. Provide butterfly valves designed for tight shut-off. Where used for terminal or equipment removal or repair, select lug type valves. Select wafer type valves for other applications. Provide gear operators on all butterfly valves 6" and larger.

2.6.2 Types of butterfly (BF) valves:

1 Wafer Type 3" and Larger (BF1): 200 CWP, cast-iron body, lever-operated, cadmium-plated ductile iron disc, Type 410 stainless steel stem, EPT seat. Stockham LG-512. Nibco WD 2110-3. Crane 42-FXB-TL. Milwaukee MW222E-8416.

2 Lug Type 3" and Larger (BF2): 200 CWP, cast-iron body, lever-operated, cadmium-plated ductile iron disc, Type 410 stainless steel stem, EPT seat. Stockham LG-712. Nibco LD 2110-3. Crane 44-FXB-TL. Milwaukee ML132B-8416.

3 Wafer Type 3" and Larger (BF3): 150/200 CWP, cast-iron body, gear-operated, cadmium-plated ductile iron disc, Type 410 stainless steel stem, EPT seat. Stockham LG-522 and LG-521. Nibco WD 2110-5. Crane 42-FXB-G. Milwaukee MW 122B-8115.

4 Lug Type 3" and Larger (BF4): 150/200 CWP, cast-iron body, gear-operated, cadmium-plated ductile iron disc, Type 410 stainless steel stem, EPT seat. Stockham LG-722 and LG-721. Nibco LD 2110-5. Crane 44-FXB-G. Milwaukee ML 132B-8115.

5 Wafer Type 4" and Larger (BF5): 175 WWP, cast-iron body, gear-operated, nickel-plated ductile iron disc, Type 410 stainless steel stem, EPT seat, UL listed. Stockham LG-52U. Nibco WD 3510-8.

6 Lug Type 4" and Larger (BF6): 175 WWP, cast-iron body, gear-operated, nickel-plated ductile iron or aluminum bronze disc, Type 410 stainless steel stem, EPT seat, UL listed. Stockham LG-72U. Nibco LD 3510-8.

7 Grooved Type 4" and Larger (BF7): 175 WWP, cast-iron body, gear-operated, nickel-plated ductile iron or aluminum bronze disc, Type 410 stainless steel stem, EPT seat, UL listed. Stockham LG-82U. Nibco GD 1765-2.

2.7 Valve Features:

2.7.1 General: Provide valves with features indicated and, where not otherwise indicated, provide proper valve features as determined by Installer for installation requirements. Comply with ANSI B31.1

2.7.2 Valve features specified or required shall comply with the following:

1 Bypass: Comply with MSS SP-45, and except as otherwise indicated, provide manufacturer's standard bypass piping and valving. Provide for gate valves 8" and larger.

2 Drain: Comply with MSS SP-45, and provide threaded pipe plugs complying with applicable Division-22 pipe or tube section. Provide for gate valves 8" and larger.

3 Flanged: Provide valve flanges complying with ANSI B16.1 (cast iron), ANSI B16.5 (steel), or ANSI B16.24 (bronze).

4 Threaded: Provide valve ends complying with ANSI B2.1.

5 Solder-Joint: Provide valve ends complying with ANSI B16.18.

6 Trim: Fabricate pressure-containing components of valve, including stems (shafts) and seats from brass or bronze materials, of standard alloy recognized in valve manufacturing industry unless otherwise specified.

7 Non-Metallic Disc: Provide non-metallic material selected for service indicated in accordance with manufacturer's published literature.

8 Renewable Seat: Design seat of valve with removable disc, and assemble valve so disc can be replaced when worn.

9 Extended Stem: Increase stem length by 2" minimum, to accommodate insulation applied over valve.

10 Mechanical Actuator: Provide factory-fabricated gears, gear enclosure, external chain attachment and chain designed to provide mechanical advantage in operating valve for all valves 4" and larger that are mounted more than 7'-0" above the floor, or are otherwise difficult to operate regardless of height.

3 EXECUTION

3.1 Installation:

3.1.1 General: Install valves where required for proper operation of piping and equipment, including valves in branch lines to isolate sections of piping. Locate valves so as to be accessible and so that separate support can be provided when necessary. Install valves with stems pointed up, in vertical position where possible, but in no case with stems pointed downward below horizontal plane.

3.1.2 Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

3.1.3 Applications Subject to Corrosion: Do not install bronze valves and valve components in direct contact with steel, unless bronze and steel are separated by dielectric insulator.

3.1.4 Mechanical Actuators: Install mechanical actuators as recommended by valve manufacturer.

3.2 Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select and install valves with the following ends or types of pipe/tube connections:

3.2.1 Tube Size 2" and Smaller: Threaded valves.

3.2.2 Pipe Size 2" and Smaller: Threaded valves.

3.2.3 Pipe Size 2½" and Larger: Flanged valves.

3.3 Non-Metallic Disc: Limit selection and installation of valves with non-metallic disc to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.

3.4 Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

3.5 Installation of Check Valves: Install in horizontal position with hinge pin horizontally perpendicular to center line of pipe. Install for proper direction flow.

END OF SECTION 23 05 23

SECTION 23 05 29 - SUPPORTS, ANCHORS, AND SEALS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 This section is a Division-23 Basic Materials and Methods section, and is a part of each Division-23 section making reference to or requiring supports, anchors, and seals specified herein.

1.3 Extent of supports, anchors, and seals required by this section is indicated on drawings and/or specified in other Division-23 sections.

1.4 Code Compliance: Comply with applicable codes pertaining to product materials and installation of supports, anchors, and seals.

1.5 MSS Standard Compliance:

1.5.1 Provide pipe hangers and supports of which materials, design, and manufacture comply with ANSI/MSS SP-58.

1.5.2 Select and apply pipe hangers and supports, complying with MSS SP-69.

1.5.3 Fabricate and install pipe hangers and supports, complying with MSS SP-89.

1.5.4 Terminology used in this section is defined in MSS SP-90.

1.6 UL Compliance: Provide products which are Underwriters Laboratories listed .

2 PRODUCTS

2.1 Acceptable Manufacturers: Subject to compliance with requirements, provide supports and hangers by Grinnel, Michigan Hanger Company, B-Line Systems, or approved equal.

2.2 Horizontal-Piping Hangers and Supports: Except as otherwise indicated, provide factory-fabricated horizontal-piping hangers and supports complying with ANSI/MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping. Provide copper-plated hangers and supports for copper-piping systems.

2.2.1 Adjustable Steel Clevises: MSS Type 1.

2.2.2 Steel Double Bolt Pipe Clamps: MSS Type 3.

2.2.3 Adjustable Steel Band Hangers: MSS Type 7.

2.2.4 Steel Pipe Clamps: MSS Type 4.

2.2.5 Pipe Stanchion Saddles: MSS Type 37, including steel pipe base support and cast-iron floor flange.

2.2.6 Single Pipe Rolls: MSS Type 41.

2.2.7 Adjustable Roller Hanger: MSS Type 43.

2.2.8 Pipe Roll Stands: MSS Type 44 or Type 47.

2.3 Vertical-Piping Clamps: Except as otherwise indicated, provide factory-fabricated vertical-piping clamps complying with ANSI/MSS SP-58, of one of the following MSS types listed, selected by Installer to suit vertical piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated clamps for copper-piping systems.

2.3.1 Two-Bolt Riser Clamps: MSS Type 8.

2.3.2 Four-Bolt Riser Clamps: MSS Type 42.

2.4 Hanger-Rod Attachments: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments complying with ANSI/MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping hangers and building attachments, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hanger-rod attachments to suit hanger rods. Provide copper-plated hanger-rod attachments for copper-piping systems.

2.4.1 Steel Turnbuckles: MSS Type 13.

2.4.2 Malleable Iron Sockets: MSS Type 16.

2.5 Building Attachments: Except as otherwise indicated, provide factory-fabricated building attachments complying with ANSI/MSS SP-58, of one of the following MSS types listed, selected by Installer to suit building substrate conditions, in accordance with MSS SP-69 and manufacturer's published product information. Select size of building attachments to suit hanger rods.

2.5.1 Center Beam Clamps: MSS Type 21.

2.5.2 C-Clamps: MSS Type 23.

2.5.3 Malleable Beam Clamps: MSS Type 30.

2.5.4 Side Beam Brackets: MSS Type 34.

2.5.5 Concrete Inserts: MSS Type 18.

2.6 Saddles and Shields: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.

2.6.1 Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.

2.6.2 Protection Saddles: MSS Type 39; use with rollers, fill interior voids with segments of insulation matching adjoining insulation.

2.7 Miscellaneous Materials:

2.7.1 Metal Framing: Provide products complying with NEMA STD ML 1.

2.7.2 Steel Plates, Shapes and Bars: Provide products complying with ANSI/ASTM A 36.

2.7.3 Cement Grout: Portland cement (ANSI/ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ANSI/ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.

2.7.4 Heavy-Duty Steel Trapezes: Fabricate from steel shapes or continuous channel struts selected for loads required; weld steel in accordance with AWS standards.

3 EXECUTION

3.1 Preparation

3.1.1 Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors and other building structural attachments.

3.1.2 Prior to installation of hangers, supports, anchors and associated work, Installer shall meet at project site with Contractor, installer of each component of associated work, and installers of other work requiring coordination with work of this section for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified.

3.2 Installation of Building Attachments:

3.2.1 Install building attachments at required locations within concrete or on structural steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert securely to forms. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through openings at top of inserts.

3.2.2 In areas of work requiring attachments to existing concrete, use self drilling rod inserts, Phillips Drill Co., "Red-Head" or equal.

3.3 Installation of Hangers and Supports:

3.3.1 General: Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacings complying with MSS SP-69 or as listed herein, whichever is most limiting. Where piping of various sizes is to be supported together by trapeze hangers,

space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

3.3.1.1 Horizontal steel pipe and copper tube 1-1/4" diameter and smaller: support on 6 foot centers.

3.3.1.2 Horizontal steel pipe and copper tube 1-1/2" diameter and larger: support on 10 foot centers.

3.3.1.3 Vertical steel pipe and copper tube: support at each floor.

3.3.1.4 Plastic pipe: support in accordance with manufacturer's recommendations and the Florida Building Code, Plumbing.

3.3.1.5 Fire protection piping: support in accordance with NFPA 13.

3.3.2 Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories.

3.3.3 Paint all black steel hangers with black enamel. Galvanized steel and copper clad hangers do not require paint.

3.3.4 Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

3.3.5 Provision for Movement:

3.3.5.1 Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends and similar units.

3.3.5.2 Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

3.3.5.3 Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 are not exceeded.

3.3.6 Insulated Piping: Comply with the following installation requirements.

3.3.6.1 Shields: Where low-compressive-strength insulation or vapor barriers are indicated, install coated protective shields.

3.3.6.2 Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.

3.3.7 Support fire protection piping independently of other piping.

3.4 Installation of Anchors:

3.4.1 Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31, and to prevent transfer of loading and stresses to connected equipment.

3.4.2 Fabricate and install anchors by welding steel shapes, plates and bars to piping and to structure. Comply with ANSI B31 and with AWS standards.

3.4.3 Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and elbows. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

3.4.4 Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions to limit movement of piping and forces to maximums recommended by manufacturer for each unit.

3.5 Equipment Bases:

3.5.1 Provide concrete housekeeping bases for all floor mounted equipment furnished as part of the work of Division 23. Size bases to extend minimum of 4" beyond equipment base in any direction; and 4" above finished floor elevation. Construct of reinforced concrete, roughen floor slab beneath base for bond, and provide steel rod anchors between floor and base. Locate anchor bolts using equipment manufacturer's templates. Chamfer top and edge corners.

3.5.2 Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks mounted on steel stands. Prime and paint with black enamel.

END OF SECTION 23 05 29

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SECTION 23 05 48 - VIBRATION ISOLATION

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 This section is a Division-23 Basic Mechanical Materials and Methods section, and is part of each Division-23 section making reference to vibration isolation equipment.

1.3 Extent of vibration isolation required by this section is indicated on drawings and/or specified in other Division-23 sections.

1.4 Approval Submittals: When required by other Division-23 sections, submit product data sheets for each type of vibration isolation equipment including configuration and rating data. Submit with Division-23 section using vibration isolation, not as a separate submittal. Provide calculations showing supported weight, deflection, and isolator size and type for each item of supported equipment. Submit for:

Equipment Mountings. Type EM.
Hangers. Type HA.
Bases and Frames. Type BF.
Pipe Flexible Connections. Type PF.

1.5 O&M Data Submittals: Submit a copy of approval submittals for each type of vibration isolation equipment. Include this data in O&M Manual.

2 PRODUCTS

2.1 General: Provide factory-fabricated products recommended by manufacturer for use in service indicated. Provide products of types and deflections indicated; provide proper selection as determined by Installer to comply with specifications and installation requirements. Provide sizes which properly fit with equipment. All metal parts installed outside shall be hot dipped galvanized after fabrication.

2.2 Acceptable Manufacturers: Subject to compliance with requirements, provide vibration isolation equipment of: Mason Industries, Keflex, Consolidated Kinetics, Vibration Mountings & Controls, Wheatley or approved equal. All vibration isolators shall be supplied by a single approved manufacturer.

2.3 Equipment Mountings:

2.3.1 Select mountings with the required deflection and fastening means. Provide steel rails or bases as required to compensate for equipment rigidity and overhang.

2.3.2 Types of equipment mountings (EM):

1 Spring Mountings (EM1): Spring isolators shall be free-standing and laterally stable

without any housing. All mounts shall have leveling bolts. Spring diameter shall be not less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately one. Provide a nominal static deflection of at least 1.0". Basis of Design: Mason Industries SLFH.

2 Spring Mountings with Housings (EM2): Spring isolators shall consist of open, stable steel springs and include vertical travel limit stops to control extension when weight is removed. The housing of the spring unit shall serve as blocking during erection of equipment. Provide a nominal static deflection of at least 1.0". All mountings used outside shall be hot dipped galvanized. Basis of Design: Mason Industries SLR.

3 Spring Mountings with Housings (EM3): Spring isolators shall consist of open, stable steel springs with neoprene inserts to limit movement between upper and lower housing on start and stop. Provide a nominal static deflection of at least 1.0". Mountings shall be specifically designed for critical areas on light-weight floors. Basis of Design: Mason Industries C.

4 Neoprene Mountings (EM4): Double deflection neoprene-in-shear mountings shall have a minimum static deflection of 0.35". All metal surfaces shall be neoprene covered. The top and bottom surfaces shall be neoprene ribbed and bolt holes shall be provided in the base. Basis of design: Mason Industries ND.

5 Pads (EM5): Waffle or ribbed pattern neoprene pads shall be fabricated from 40-50 durometer neoprene. Provide rigid steel plate and mounting angles as required. Basis of design: Mason Industries Super W.

2.4 Hangers:

2.4.1 Select hangers with the required deflection. Provide all required hanger rods and fasteners.

2.4.2 Types of hangers (HA):

1 Hangers (HA1): Vibration hangers shall contain a steel spring set in a neoprene cup manufactured with a grommet to prevent short-circuiting of the hanger rod. The cup shall contain a steel washer designed to properly distribute the load on the neoprene and prevent its extrusion. Spring diameters and hanger box lower-hole sizes shall be large enough to permit the hanger rod to swing through a 30-degree arc before contacting the hole and short circuiting the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Basis of Design: Mason Industries 30.

2 Hangers (HA2): Vibration hangers shall contain a laterally stable steel spring and 0.3" deflection neoprene or fiberglass element in series. A neoprene neck shall be provided where the hanger rod passes through the steel box supporting the isolator mount to prevent metal to metal contact. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 degree arc before contacting the hole and short circuiting the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Basis of Design: Mason Industries 30N.

3 Hangers (HA3): Double deflection neoprene-in-sheer or EPDM hangers. Units shall be complete with projected neoprene bushing to prevent steel-to-steel contact between hanger box and hanger rod. Average static deflection shall be not less than 0.4 inches.

Basis of Design: Mason Industries HD.

2.5 Bases and Frames (BF):

2.5.1 Select mounting bases and frames as required for equipment dimensions, service access and fastening means. Provide all fasteners. Coordinate and provide required vibration isolators to match mounting bases and frames.

2.5.2 Types of bases and frames (BF):

1 Steel Base Frame for Floor-Mounted Equipment (BF1): Provide frames consisting of structural steel sections sized, spaced and connected to form a rigid base which will not twist, rack, deform or deflect in any manner that will negatively affect the operation of the supported equipment or the performance of the vibration-isolation mounts. Frames shall be of adequate size and plan form to support basic equipment units and motors plus any associated pipe elbow or duct elbow supports and electrical control elements or other components closely related and requiring resilient support in order to prevent vibration transfer from equipment to the building structure. Frames shall include side mounting brackets for attachment to vibration isolation floor mounts. The clearance between the underside of any frame or mounted equipment unit and the top of the building structure below shall be at least 2 inches. Basis of Design: Mason Industries WFSL.

2 Concrete Inertia Block for Floor-Mounted Equipment (BF2): Provide concrete inertia blocks formed of stone-aggregate concrete (150 lbs./cu.ft.) cast between appropriate steel reinforcing perimeter structural steel channels. Inertia block thickness shall be not less than 1/12 the longest dimension of the mounted equipment or equipment assembly. Inertia blocks shall be built to form a rigid base which will not twist, rack, deform, deflect or crack in any manner that will negatively affect the operation of the supported equipment or the performance of the vibration-isolation mounts. Inertia blocks shall be of adequate size and plan form to support basic equipment units and motors plus any associated pipe or duct elbow supports, electrical control elements or other components closely related and requiring resilient support in order to prevent vibration transfer from equipment to the building structure. Inertia blocks shall include side mounting bracket pockets for spring mounting. The clearance between the underside of any inertia block and the top of the building structure below shall be at least 2 inches. The vibration isolator supplier may furnish the structural steel perimeter frame, including reinforcing and anchor bolts. Basis of Design: Mason Industries KSL/BMK.

3 Steel Rails (BF3): Provide steel rails of channels or angles with vibration isolators as required. Basis of Design: Mason Industries, RND or RC.

4 Vibration Isolation Base for Rooftop Equipment (BF4): Provide aluminum vibration isolation bases that fit over roof curb and under the equipment. Provide spring isolators having a 1" minimum static deflection, resilient snubbers for wind resistance, closed cell weather seal at top and bottom, and EDPM flexible connection around entire perimeter. The unit shall provide a water-tight system. Basis of Design: Mason Industries CMAB.

5 Vibration Isolation Curb for Rooftop Equipment (BF5): Provide steel spring isolation curb with cadmium or zinc electroplated steel springs on ¼" thick neoprene pads to support the upper frame. The upper frame must provide continuous support for the equipment and must be held captive by ¼" thick neoprene snubber bushings. Minimum spring deflection is 1½" . Provide galvanized steel counter-flashing and EPDM bellows for the corners. Provide access covers for all springs. The entire assembly shall be waterproof. Curbs shall be a minimum of 12" high and shall include 2" thick insulation.

Provide curbs designed to accommodate for roof pitch so that equipment is set level.

Provide perimeter angle and cross members with two layers of 5/8" waterproof sheetrock at the floating member of the curb. Stagger sheetrock joints. Sheetrock must completely surround all ducts and shall be caulked. Where the mechanical arrangement prevents attaching to the floating member, the barrier shall be attached as high as possible on the fixed curb with 1" thick closed cell neoprene flexible seals around the ducts. A 4" layer of 1.5 pcf fiberglass shall cover the entire solid roof surface under the unit. Basis of Design: Mason Industries RSC-dB.

2.6 Pipe Flexible Connections:

2.6.1 Select pipe flexible connections suitable for duty indicated with ends to match piping system.

2.6. Types of pipe flexible connections (PF):

1 Pump Connections (PF1): Provide EPDM and dacron or neoprene and nylon flexible connectors rated at 200 psi and 250ºF. Connectors shall have the number of spheres required and ductile iron floating flanges with baked enamel finish. Provide control rods or cables as required for each application. Basis of Design: Mason Industries SFDEJ with reinforcing rings.

2 Chiller Connections (PF2): Provide EPDM and dacron or neoprene and nylon flexible connectors rated at 200 psi and 250ºF. Connectors shall have the number of spheres required and ductile iron floating flanges with baked enamel finish. Provide control rods or cables as required for each application. Basis of Design: Mason Industries SFEJ.

3 Coil Connections (PF3): Provide EPDM and dacron or neoprene and nylon flexible connectors rated at 200 psi at 250ºF. Connectors shall have the number of spheres required and ductile iron floating flanged or threaded ends with baked enamel finish. Provide control rods or cables as required for each application. Basis of Design: Mason Industries SFU or SFEJ as required.

4 Stainless Steel Flexible Hoses (PF4): Provide 300 psi working pressure flexible hoses with corrugated seamless hose body and braided cover. Basis of Design: Mason Industries BSS threaded or RF flanged, as required.

5 Bronze Flexible Hoses (PF5): Provide 300 psi working pressure flexible hoses with corrugated bronze hose body and braided cover. Basis of Design: Mason Industries BBF with sweat ends.

3 EXECUTION

3.1 Install vibration isolation devices for the duty indicated and for ease of inspection, adjustment, and proper operation. Install in accordance with the manufacturer's written instructions and coordinate with shop drawings of supported equipment.

3.2 All connections to fixtures and equipment shown on the drawings shall be considered diagrammatic unless otherwise indicated by detail. The actual connections shall be made to fully suit the requirements of each case and adequately provide for expansion and servicing.

3.3 Piping, ductwork and conduit shall not be suspended from one another or physically contact one another. Vibrating systems shall be kept free from non-vibrating systems.

3.4 Equipment Mountings:

3.4.1 Unless otherwise shown or specified, all floor-mounted equipment shall be set on housekeeping equipment bases. Refer to Division-23 section “Supports, Anchors, and Seals”.

3.4.2 No equipment unit shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators, and such direct support is approved by the equipment manufacturer. All support frames shall be sufficiently stiff and rigid so as to prevent distortion and misalignment of components installed thereon.

3.4.3 Align equipment mountings for a free, plumb installation. Isolators that are binding, offset or fully compressed will not be accepted.

3.5 Hangers:

3.5.1 Position vibration isolation hangers so that hanger housing may rotate a full 360 degrees without contacting any object.

3.5.2 Install steel angles, channels, rods and fasteners to level equipment, piping or ductwork and to evenly distribute the supported weight.

3.6 Bases and Frames:

3.6.1 Unless otherwise indicated, all equipment mounted on vibration-isolated bases shall have a minimum operating clearance of 2 inches between the structural steel frame and the concrete housekeeping pad or floor beneath the equipment. The clearance space shall be checked to ensure that no construction debris has been left to short-circuit or restrict the proper operation of the vibration isolation system.

3.7 Pipe Flexible Connections:

3.7.1 Piping connected to vibration isolated equipment shall be installed so that it does not strain or force out of alignment the vibration isolators supporting the basic equipment, nor shall pipes restrict such equipment from "floating" freely on its respective vibration isolation system. Flexible connections shall be used to eliminate transferring vibration along piping.

3.7.2 Flexible connections and hoses shall not be used to compensate for pipe misalignment. Units shall be aligned so that the flexible connection is not distorted perpendicular to the axis of the piping.

3.7.3 Install flexible connections in pump suction and discharge, chiller inlet and outlet, water coil inlet and outlet and where shown on the drawings or required by equipment specifications.

3.7.4 Drain piping connected to vibrating equipment shall not physically contact any building construction or non-isolated systems or components.

3.8 Connections of Ducts: Ducts shall be connected to fan intakes and discharges by means of flexible connectors in accordance with Division-23 section "Ductwork Accessories" so that all vibrating equipment is fully isolated.

END OF SECTION 23 05 48

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SECTION 23 05 53 - MECHANICAL IDENTIFICATION

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 This section is a Division-23 Basic Mechanical Materials and Methods section, and is part of each Division-23 section making reference to or requiring identification devices specified herein.

1.3 Extent of mechanical identification work required by this section is indicated on drawings and/or specified in other Division-23 sections.

1.4 Refer to Division-26 sections for identification requirements of electrical work; not work of this section. Refer to other Division-23 sections for identification requirements for controls; not work of this section.

1.5 Codes and Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

2 PRODUCTS

2.1 General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division-23 sections. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

2.2 Painted Identification Materials

2.2.1 Stencils: Standard fiberboard stencils, prepared for required applications with letter sizes generally complying with recommendations of ANSI A13.1 for piping and similar applications, but not less than 1-¼" high letters for ductwork and not less than ¾" high letters for access door signs and similar operational instructions.

2.2.2 Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.

2.2.3 Identification Paint: Standard identification enamel.

2.3 Plastic Pipe Markers

2.3.1 Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers.

2.3.1.1 Lettering: Manufacturer's standard pre-printed nomenclature which best describes piping system in each instance, as selected by Architect/Engineer in cases of variance with name as shown or specified.

2.3.1.2 Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

2.4 Valve Tags:

2.4.1 Brass Valve Tags: Provide 19-gage polished brass valve tags with stamp-engraved piping system abbreviation in ¼" high letters and sequenced valve numbers ½" high, and with 5/32" hole for fastener. Provide 1-½" diameter tags, except as otherwise indicated.

2.4.2 Plastic Laminate Valve Tags: Provide manufacturer's standard 3/32" thick engraved plastic laminate valve tags, with piping system abbreviation in ¼" high letters and sequenced valve numbers ½" high, and with 5/32" hole for fastener. Provide 1-½" square black tags with white lettering, except as otherwise indicated.

2.5 Engraved Plastic-Laminate Signs:

2.5.1 General: Provide engraving stock melamine plastic laminate, in the sizes and thicknesses indicated, engraved with engraver's standard letter style a minimum of 3/4" tall and wording indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.

2.5.2 Thickness: 1/16" for units up to 20 sq. in. or 8" length; 1/8” for larger units.

2.5.3 Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

2.5.4 Ceiling Grid Mounted Tags: White ½” lettering engraved in a ¾” black background, screwed parallel to the ceiling grid.

2.6 Stamped Nameplates: Provide equipment manufacturer's standard stamped nameplates for motors, AHUs, pumps, etc.

3 EXECUTION

3.1 Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 Ductwork Identification:

3.2.1 General: Identify air supply, return, exhaust, intake and relief ductwork with stenciled signs and arrows, showing ductwork service and direction of flow, in black or white. Example: **AHU-1 Supply ➔**

3.2.2 Location: In each space where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures, and at 50' spacings along exposed runs.

3.2.3 Access Doors: Provide stenciled signs on each access door in ductwork and housings, indicating purpose of access (to what equipment) and other maintenance and operating instructions, and appropriate and procedural information.

3.3 Piping System Identification:

3.3.1 General: Install pipe markers of one of the following types on each system indicated to receive identification, and include arrows to show normal direction of flow:

3.3.1.1 Plastic pipe markers.

3.3.1.2 Stenciled markers, black or white for best contrast.

3.3.2 Locate pipe markers as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces and exterior non-concealed locations.

3.3.2.1 Near each valve and control device.

3.3.2.2 Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.

3.3.2.3 Near locations where pipes pass through walls, floors, ceilings, or enter non-accessible enclosures.

3.3.2.4 At access doors, manholes and similar access points which permit view of concealed piping.

3.3.2.5 Near major equipment items and other points of origination and termination.

3.3.2.6 Spaced intermediately at maximum spacing of 50' along each piping run, except reduce spacing to 25' in congested areas of piping and equipment.

3.3.2.7 On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.3.3 The following piping shall be color-coded where exposed in mechanical and electrical rooms by completely painting the piping with the indicated color. Use standard colors where exposed in finished spaces. Use standard identification methods in concealed areas.

Fire protection piping - Red
Gas piping – Yellow

3.4 Valve Identification: Provide coded valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, plumbing fixture faucets, convenience and lawn-watering hose bibs, and shut-off valves at plumbing fixtures, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. Coordinate code with operating instructions. For valves located above acoustical lay in ceilings, provide an additional engraved plastic valve tag, mechanically affixed to the ceiling grid below the valve (white letters on black background). When multiple equipment and/or valve tags are installed in a room, orient all tags the same direction.

3.5 Valve Charts: Provide framed, glass covered valve charts in each mechanical room. Identify coded valve number, valve function, and valve location for each valve. Provide floor plan with approximate location of each valve identified.

3.6 Mechanical Equipment Identification: Install engraved plastic laminate sign on a vertical surface on or near each major item of mechanical equipment and each operational device. Label shall indicate type of system and area served. For equipment located above acoustical lay in ceilings, provide an additional engraved plastic valve tag, mechanically affixed to the ceiling grid below the valve (white letters on black background). When multiple equipment

and/or valve tags are installed in a room, orient all tags the same direction. Provide signs for the following general categories of equipment and operational devices:

3.6.1 Main control and operating valves, including safety devices.

3.6.2 Meters, gauges, thermometers and similar units.

3.6.3 Fuel-burning units including boilers, furnaces, and heaters.

3.6.4 Pumps, compressors, chillers, condensers, and similar equipment.

3.6.5 Heat exchangers, coils, evaporators, cooling towers, heat recovery units and similar equipment.

3.6.6 Fans, blowers, primary balancing dampers and VAV boxes.

3.6.7 HVAC air handlers and fan coil units.

3.6.8 Air conditioning indoor and outdoor units.

3.7 Stamped Nameplates: Equipment manufacturers to provide standard stamped nameplates on all major equipment items such as motors, pumps, AHUs, etc. Where motors are hidden from view (within equipment casing, or otherwise not easily accessible, etc.), the equipment supplier shall furnish a duplicate motor data nameplate to be affixed to the equipment casing in an easily visible location, unless data is already included on the equipment nameplate.]

3.8 Adjusting and Cleaning:

3.8.1 Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.

3.8.2 Cleaning: Clean face of identification devices, and glass frames of valve charts.

END OF SECTION 23 05 53

SECTION 23 05 56 - ACCESS DOORS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 This section is a Division-23 Basic Mechanical Materials and Methods section, and is part of each Division-23 section making reference to or requiring access panels specified herein.

1.3 Approval Submittals:

1.3.1 Product Data: When required by other Division-23 sections, submit product data for access doors. Submit with Division-23 section using access doors, not as a separate submittal. Include rating data.

1.4 O&M Data Submittals: Submit a copy of approval submittal. Include this data in O&M Manuals.

2 PRODUCTS

2.1 Acceptable Manufacturers: Subject to compliance with requirements, provide access doors by Milcor, Jay R. Smith, Zurn, BOICO, Elmdor, or approved equal.

2.2 General: Where floors, walls and ceilings must be penetrated for access to plumbing work, provide types of access doors indicated. Furnish sizes indicated or, where not otherwise indicated, furnish adequate size for intended and necessary access. Furnish manufacturer's complete units, of type recommended for application in indicated substrate construction, in each case, complete with anchorages and hardware.

2.3 Access Door Construction: Except as otherwise indicated, fabricate wall/ceiling door units of welded stainless steel construction with welds ground smooth and brushed finish; 16-gauge frames and 14-gauge flush panel doors; 175° swing with concealed spring hinges; flush screw-driver-operated cam locks.

3 EXECUTION

3.1 Access doors shall be installed to operate and service all plumbing equipment including valves, dampers, duct access panels, and other items requiring maintenance that are concealed above or behind finished construction. Access doors shall be installed in walls, chase and floors as necessary, but are not required in accessible suspended ceiling systems.

3.2 Access doors shall be installed by the Division installing the substrate construction. However, responsibility for furnishing and determining location of access doors is part of this Division's work. The style of access door shall be suitable for construction into which installed.

3.3 Access doors shall be sized and located as required to provide proper maintenance and service access in accordance with the manufacturer's recommendations and code authority requirements for all devices and equipment.

END OF SECTION 23 05 56

SECTION 23 05 73 - EXCAVATION & BACKFILL

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 This section is a Division-23 Basic Mechanical Materials and Methods section, and is part of each Division-23 section making reference to or requiring excavation and backfill specified herein.

1.3 Existing Utilities: Underground utilities shown were taken from old drawings. The exact location of these utilities and irrigation branches and abandoned services are not known. Use extreme caution when excavating.

1.4 Refer to other Division-23 sections and/or drawings for specific requirements of the particular piping system being installed. Where another Division-23 section or the drawings conflict with requirements of this section, the other Division-23 section or the drawings shall take precedence over the general requirements herein.

1.5 OSHA: Contractor employee worker protection for all trenching and excavation operations shall comply with 29 CFR 1926.650 Subpart P and all current OSHA requirements.

1.6 Trench Safety Act: Contractor shall comply with all requirements of Florida Statutes Chapter 553, including the requirement to provide a separate line item to identify the cost to comply on a per lineal foot of trench and per square foot of shoring.

2 PRODUCTS

2.1 Sand: Clean, hard, uncoated grains free from organic matter or other deleterious substances. Sand for backfill shall be of a grade equal to mortar sand.

2.2 Gravel: Clean, well graded hard stone or gravel, free from organic material. Size range to be from No. 4 screen retentions to 1".

2.3 Earth: Fill free of clay, muck, stones, wood, roots or rubbish.

2.4 Identification Tape: Polyethylene 6 inches wide, 0.004 inches thick, continuously printed with "CAUTION" in large letters and type of pipe below.

2.5 Copper Identification Wire: 14-gauge.

3 EXECUTION

3.1 Ditching and Excavation: Shall be performed by hand wherever there is a possibility of encountering obstacles or any existing utility lines of any nature whatsoever. Where clear and unobstructed areas are to be excavated, appropriate machine excavation methods may be employed. Avoid use of machine excavators within the limits of the building lines.

3.2 Bedding: Excavate to bottom grade of pipe to be installed, and shape bed of undisturbed earth to contour of pipe for a width of at least 50% of pipe diameter. If earth conditions necessitate excavation below grade of the pipe, such as due to the presence of clay, muck, or roots, subcut and bring bed up to proper elevation with clean, new sand (as described in paragraph 2.1), deposited in 6" layers and tamped. Notify Architect/Engineer if subcut exceeds 12", or if bed is of an unstable nature. In this case a 6" minimum layer of gravel will be required before sand bedding begins. Submit cost proposal if the earth conditions require subcut in excess of 12" or if gravel is required to achieve proper bedding.

3.3 Placing: Pipe shall be carefully handled into place. Avoid knocking loose soil from the banks of the trench into the pipe bed. Rig heavier sections with nylon slings in lieu of wire rope to avoid crushing or chipping. Pipe which is handled with insulation in place, coated pipe, and jacketed pipe shall have special handling slings as required to prevent damage to the material.

3.4 Backfilling: Deposit clean new sand (as described in paragraph 2.1) to 6" above the pipe and tamp. Then deposit sand or earth carefully in 6" layers, maintaining adequate side support, especially on nonferrous piping materials. Compact fill in 6" layers, using mechanical means, up to the top elevation of the pipe, and in 12" layers to rough or finish grade as required. Fine grade and restore surface to original condition.

3.5 Special: Excavations shall be installed and maintained in satisfactory condition during the progress of the work. Subsurface structures are to be constructed in adequately sized excavations. De-watering equipment shall be installed and properly maintained where required. Shoring shall be employed in the event of unstable soil condition, and in all cases where required by OSHA regulations and necessary to protect materials and personnel from injury.

3.6 Identification: Install identification tape directly above all underground piping, one tape for each pipe where multiple pipes are installed. Depth of tape shall be at least 6 inches below finished grade and 24" above buried pipe. Install copper wire above non-metallic pipes.

3.7 Depth of Cover: Minimum cover for underground piping is two feet unless indicated otherwise.

END OF SECTION 23 05 73

SECTION 23 05 90 - START-UP REQUIREMENTS FOR HVAC SYSTEMS

1 GENERAL

1.1 Intent: It is the intent of this section to require that the startup requirements and report noted herein be performed prior to starting TAB work on each system. Work can be phased with permission of the Engineer.

1.2 Coordination:

1.2.1 The Contractor shall furnish to the TAB Contractor a complete set of plans, specifications, addenda, shop drawings, equipment performance data sheets, change orders, etc. as requested by the TAB Contractor.

1.2.2 The Contractor shall participate in a TAB coordination meeting to discuss interface requirements with the TAB Contractor and to establish a schedule for TAB work prior to start of TAB work. The TAB will be performed by an independent company contracted by the owner.

1.3 Test Reports and Verification Submittals:

1.3.1 Submit Startup Report as described herein for each system. Attach Factory Startup Report for equipment as required by other Division-23 sections.

2 PRODUCTS: None

3 EXECUTION:

3.1 The TAB work shall not commence until the Engineer has received written notice from the Contractor that HVAC systems are 100% complete and are fully operational. Submit Startup Report as described herein.

3.2 The Contractor shall place all HVAC systems and equipment into complete operation during each working day of TAB work.

3.3 The Contractor shall provide access to HVAC systems and equipment by supplying ladders and/or scaffolding, and opening access panels and equipment room doors.

3.4 The TAB Contractor will provide to the Contractor TAB punch lists of non-complying HVAC work as they are discovered. The Contractor shall replace or repair non-complying work as soon as possible in order not to delay completion of TAB work.

3.5 Airside Systems: The Contractor shall provide the following information to the Engineer to substantiate proper start-up and preliminary adjustments of air handler units, belt driven fans, and duct systems.

3.5.1 Verify that air grilles (supply, return, exhaust, transfer, outdoor, etc.) are installed and connected to the duct system.

3.5.2 Verify that duct systems are clean of debris.

3.5.3 Verify that ducts attached with flexible connectors are aligned within ½" and have a uniform gap between ducts of 1"-1.5". Flexible connectors shall not leak and shall be insulated.

3.5.4 Verify that filters are clean and filter spacers are installed.

3.5.5 Verify that balancing dampers at grilles and branch ducts are operational and are fully opened.

3.5.6 Verify that fire and smoke dampers are correctly installed and are fully opened.

3.5.7 Verify that fan discharges are appropriate for the outlet ductwork with regards to the "system effect" per AMCA Publication 201. Inappropriate fan discharges will not be accepted.

3.5.8 Verify proper fan rotation.

3.5.9 Verify proper belt drive alignment.

3.5.10 Verify fan motor overload elements are correctly sized.

3.5.11 Adjust fan sheave until CFM is at or above design CFM. Provide additional sheaves and belts as required. Verify that motor is not overloaded.

3.5.12 Verify that HVAC control systems are fully operational.

3.6 Hydronic Systems: The Contractor shall provide the following information to the Engineer to substantiate proper start-up and preliminary adjustments of HVAC pumps and piping systems.

3.6.1 Verify that the hydronic systems are properly flushed, filled, vented, purged and chemically treated and that all leaks are repaired. Verify proper air venting.

3.6.2 Verify that the correct strainer screens are clean and installed.

3.6.3 Verify that pump/motor shafts are correctly aligned.

3.6.4 Verify proper pump rotation and flow direction.

3.6.5 Verify that all balancing valves and circuit setters are fully opened.

3.6.6 Verify that test ports, pressure gauges and thermometers are properly installed and are accessible at coils, boilers, pumps, and chillers. Extensions to allow for pipe insulation are required. Pressure gauges at pumps must utilize pump taps in order for head measurements to correlate with the pump performance curves.

3.6.7 Verify pump motor overload elements are correctly sized.

3.6.8 Adjust balancing valve at pump discharge until GPM is at or greater than design GPM. Verify motor is not overloaded.

3.6.9 Provide flow meter data (IN WC and GPM), pump performance chart with flow data plotted, actual motor volts/amps, rated motor volts/amps and motor overload element capacity.

3.6.10 Verify that HVAC control systems for coils, boilers, and chillers are fully operational.

3.7 VAV Systems: The Contractor shall provide the following information to the Engineer to substantiate the proper start-up and preliminary adjustments of variable air volume boxes and control systems.

3.7.1 Verify that the inlet duct to the box is straight for a minimum of five (5) inlet duct diameters.

3.7.2 Verify that the discharge duct from the box has no branch takeoffs within five (5) feet of the box discharge.

3.7.3 Set the box thermostat to 85ºF. Verify that the box modulates to minimum cooling, and the heating activates.

3.7.4 Set the box thermostat to 55ºF. Verify that the reverse operation occurs and the box modulates to maximum cooling.

3.7.5 Set box thermostat to 75ºF. Deadband shall not exceed 2ºF.

3.7.6 Set minimum and maximum CFM based on manufacturer's calibration curves.

3.7.7 Verify that the static pressure probe is located 75% of the distance down the longest duct run. Mark the location of the probe on the as-builts and notify the TAB Contractor of same.

3.7.8 Verify that the static pressure control properly modulates the AHU fan's variable frequency drive. Set static pressure controller to maintain 1 in. w.g. as the initial setting.

3.7.9 Verify that the supply air temperature controller properly modulates the chilled water control valve. Set controller to maintain 55ºF. Verify that all heating coil control valves are properly modulated.

3.8 Startup Report: The Contractor shall submit the startup information required by this section to the Engineer in a typed report organized as outlined herein. The Startup Report is required to meet the written notice described herein prior to starting TAB work. TAB work will not start until the Startup Report has been submitted and approved.

END OF SECTION 23 05 90

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SECTION 23 05 91 - TESTING, CLEANING, AND STERILIZATION OF PIPING SYSTEMS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 This section is a Division-23 Basic Mechanical Materials and Methods section, and is part of each Division-23 section making reference to or requiring the testing and other procedures specified herein.

1.3 Notify the Architect/Engineer when system tests are ready to be witnessed at least 24 hours prior to the test.

1.4 All materials, test equipment, and devices required for cleaning, testing, sterilizing or purging shall be provided by the Contractor.

2 PRESSURE TESTS

2.1 General: Provide temporary equipment for testing, including pump and gauges. Test piping systems before insulation is installed wherever feasible, and remove control devices before testing. Test each natural section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with indicated medium and pressurize for indicated pressure and time.

2.2 Required test period is four hours.

2.3 No piping, fixtures, or equipment shall be concealed or covered until they have been tested. The contractor shall apply each test and ensure that it is satisfactory for the period specified before calling the Architect/Engineer to observe the test. Test shall be repeated upon request to the satisfaction of those making the inspection.

2.4 Observe each test section for leakage at the end of the test period. Test fails if leakage is observed or if pressure drop exceeds 5% of the test pressure.

2.5 Check of systems during application of test pressures should include visual check for water leakage and soap bubble or similar check for air and nitrogen leakage.

2.6 During heating and cooling cycles, linear expansion shall be checked at all elbows and expansion joints for proper clearance.

2.7 Repair piping systems sections which fail required piping test. Disassemble and re-install using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

2.8 Pressure Test Requirements:

2.8.1 Soil, Waste, and Vent Test all piping within the building with a 10 foot head of water. Test piping in sections so that all joints are tested. Provide test tees as required.

2.8.2 Domestic Water: Perform hydrostatic test on all piping within the building at twice the normal static pressure at service point, but not less than 100 psig. Once tested, flush out piping and leave under pressure of the supply main or 40 psig for the balance of the construction period.

2.8.3 Chilled Water and Heating Hot Water Perform hydrostatic test at 150% of the normal operating pressure, but not less than 100 psig.

2.8.4 Fire Sprinkler System: Perform hydrostatic test at 200 psig.

2.8.5 Gas: Test with air or nitrogen at 150% of normal working pressure, but not less than 25 psig. The test and check for leaks shall be in accordance with NFPA-54.

3 CLEANING AND STERILIZATION

3.1 General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush out piping systems with clean water or blowdown with air before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.

3.2 Flush and drain all water systems at least three times. Reverse flush systems from smallest piping to largest piping. Replace startup strainers with operating strainers.

3.3 Blowdown all gas systems with air or nitrogen (at a rate of flow exceeding design) at least three times or until no residue shows at each outlet. Reverse blowdown systems from smallest piping to largest piping.

3.4 Sterilization of Domestic Water Systems:

3.4.1 Prerequisites: All new hot and cold water piping installed (complete), all fixtures connected, system flushed out, and system filled with water.

3.4.2 The shut off valve at the water main shall be closed, all fixture outlets opened slightly, and a sterilizing solution shall be introduced at a manifold connection installed by the Contractor at the meter.

3.4.3 The solution shall contain 50 parts per million of available chlorine. The chlorinating material shall be either liquid chlorine or calcium hypochlorite. The solution shall be allowed to stand in the system for at least eight hours after which the entire system shall be flushed.

3.4.4 After final flushing, all aerators shall be removed, cleaned, and reinstalled. After final flush the residual chlorine shall not exceed 0.2 parts per million.

3.4.5 The Architect/Engineer shall be notified 24 hours prior to the procedure so that it can be witnessed.

3.4.6 Provide sampling and certified report by an independent testing lab. Provide written Health Department approval of disinfection samples.

3.5 Chilled Water and Heating Hot Water Pipe Cleaning: After completion of all work and operational check out of the HVAC installations and prior to acceptance of the project by the

Owner, the following shall be accomplished. The completed piping systems shall be thoroughly flushed (reversed flushing) as needed to remove all dirt, debris, and any foreign matter that may have been trapped in the piping systems during construction. After flushing of systems is complete, the Contractor shall clean all main strainers and all strainers at air handlers, fan coil units, VAV boxes, reheat coils. A second cleaning of all strainers will be required if requested by the Engineer. Contractor shall furnish and install all valves and piping stub outs in the piping systems as needed to accommodate this flushing operation. Install the valves and stub outs at a location and in a manner that will allow them to remain in place for future flushing operations. The flushing and strainer cleaning operations shall be witnessed and approved by the Engineer and Owner's representative.

3.6 Fuel Gas: Purge all fuel gas systems in accordance with NFPA 54.

END OF SECTION 23 05 91

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SECTION 23 05 93 - TESTING AND BALANCING OF MECHANICAL SYSTEMS

1 GENERAL

1.1 The work of this section is intended to be performed by a test and balance contractor under a separate, stand-alone contract.

1.2 Description of Work:

1.2.1 Extent of testing, adjusting, and balancing work (TAB) is indicated by requirements of this section, and also by drawings and schedules, and is defined to include, but is not necessarily limited to, air distribution systems, hydronic distribution systems and associated equipment and apparatus of mechanical work. The work consists of setting speed and volume (flow) adjusting facilities provided for systems, recording data, conducting tests, preparing and submitting reports, and recommending modifications to work as required.

1.2.2 Coordination: Coordinate with the General Contractor and Mechanical Contractor responsible for the HVAC system installation as required to complete the TAB work.

1.3 The intent of this specification is to balance HVAC systems within the tolerances listed, maintaining the pressure relationships indicated, with a minimum of noise.

1.3.1 Airflow Tolerances:

1.3.1.1 Air Handling: The supply air, return air and outdoor air quantities shall be balanced within 5% of design values.

1.3.1.2 Exhaust Fans: The exhaust fan quantities shall be set as required to maintain the design exhaust terminal flows within 5% of design values. If no exhaust terminals exist, exhaust fan air quantities shall be balanced within 10% of design values.

1.3.1.3 Terminal Units: The air quantities associated with VAV boxes, fan coil units, self-regulating air valves, unit heaters and other similar devices shall be balanced within 5% of design values.

1.3.1.4 Ceiling Diffusers, Supply Registers, Return and Exhaust Inlets: Balance to an air quantity within 10% of the design values.

1.3.2 Temperature Tolerances:

1.3.2.1 Air Handling Temperatures: The controlled temperatures at AHUs shall be verified to be under control within 1ºF of design values.

1.3.2.2 Hot Water Temperatures: The heating hot water controlled temperatures from boilers and heat exchangers and other similar devices shall be under control within 5ºF.

1.3.2.3 Chilled Water Temperatures: The chilled water controlled temperature from chillers shall be under control within 1ºF.

1.3.2.4 Room Temperatures: Balance systems and controls within 2ºF of indicated settings.

1.3.3 Hydronic Flow: Balance hydronic flow rates to within 10% of design values.

1.4 Quality Assurance: The TAB Contractor shall be located within 125 miles of the job site and certified as one of the following:

1.4.1 Tester: A firm certified by National Environmental Balancing Bureau (NEBB) in those testing and balancing disciplines required for this project, who is not the Installer of the systems to be tested and is otherwise independent of the project. Comply with NEBB's "Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems" as applicable to this work.

1.4.2 Tester: A firm certified by Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project. AABC-certified firms are independent by definition. Comply with AABC's Manual MN-1 "AABC National Standards", as applicable to this work.

1.4.3 Industry Standards: Comply with American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) recommendations pertaining to measurements, instruments and testing, adjusting and balancing, except as otherwise indicated.

1.5 Job Conditions:

1.5.1 Do not proceed with testing, adjusting, and balancing work until HVAC work (including Controls) has been completed and is operable. Ensure that there is no residual work still to be completed.

1.5.2 Do not proceed until work scheduled for testing, adjusting, and balancing is clean and free from debris, dirt and discarded building materials.

1.5.3 Do not proceed until architectural work that would affect balancing (walls, ceiling, windows, doors) have been installed.

1.5.4 Testing may proceed system by system, but each HVAC system must be complete as describe herein.

1.5.5 The mechanical contractor shall make any changes in pulleys, belts, and dampers, and/or add dampers as required for correct balancing.

1.6 Approval Submittals

1.6.1 Submit the name of the proposed test and balance company for the Engineer's approval within thirty (30) days after awarding of contract.

1.7 Test Reports and Verification Submittals:

1.7.1 Submit four (4) copies of the dated test and balance report upon completion of TAB work. The report shall include a list of instruments used for the work. The report shall be signed by the supervisor who performed the TAB work.

2 PRODUCTS

2.1 Patching Materials: Except as otherwise indicated, use same products as used by original

Installer for patching holes in insulation, ductwork and housings which have been cut or drilled for test purposes, including access for test instruments, attaching jigs, and similar purposes.

2.2 Test Instruments: Utilize test instruments and equipment of the type, precision, and capacity as recommended in the referenced standard. All instruments shall be in good condition and shall have been calibrated within the previous six (6) months (or more recently if required by standard).

3 EXECUTION

3.1 General:

3.1.1 Examine installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned and is operable. Do not proceed with TAB work until unsatisfactory conditions have been corrected in manner acceptable to Tester.

3.1.2 Test, adjust and balance environmental systems and components, as indicated, in accordance with procedures outlined in applicable standards, and as modified or detailed herein.

3.1.3 Test, adjust and balance systems during summer season for air conditioning systems and during winter season for heating systems, including at least a period of operation at outside conditions within 5ºF wet bulb temperature of maximum summer design condition, and within 10ºF dry bulb temperature of minimum winter design condition. When seasonal operation does not permit measuring final temperatures, then take final temperature readings when seasonal operation does permit. The Contractor shall return for a change of seasons test at no additional cost to the Owner and submit the revised TAB report.

3.1.4 Punch List: Prepare a deficiency (punch)list for the Contractor with a copy of the Engineer that lists all items that are incorrectly installed or are functioning improperly. Provide a retest after all items are corrected.

3.1.5 Prepare TAB report of test results, including instrumentation calibration reports, in format recommended by applicable standards, modified as required to include all data listed herein.

3.1.6 Patch holes in insulation, ductwork and housings, which have been cut or drilled for test purposes, in manner recommended by original Installer.

3.1.7 Permanently Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings at completion of TAB work. Provide markings with paint or other suitable permanent identification materials.

3.1.8 Include in the TAB report recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced.

3.1.9 Include an extended warranty of ninety (90) days after completion of test and balance work, during which time the Engineer, at his discretion, may request a recheck, or resetting of any component as listed in test report. The TAB company shall provide technicians and instruments and make any tests required by the Engineer during this time period.

3.2 Controls

3.2.1 Check all HVAC controls for proper location, calibration and sequence of operation.

3.2.2 Check operation of all controllers and controlled devices to verify proper action and direction. Check the operation of all interlocks.

3.2.3 Check all zone damper motors for leakage when in closed position. If leakage is more that 5%, mechanical contractor shall reset damper linkages.

3.2.4 Check all control valves for complete closure and correct action under all operating conditions.

3.3 Air Balancing

3.3.1 Leakage tests on ductwork must have been completed before air balancing.

3.3.2 Set dampers, volume controls and fan speeds to obtain specified air delivery with minimum noise level. Rebalance as required to accomplish this. Simulate fully loaded filters during test.

3.3.3 Set grille deflections as noted on plans. Modify deflections if required to eliminate drafts or objectionable air movement.

3.3.4 Record air terminal velocity after completion of balance work.

3.3.5 Record final grille and register deflection settings if different from that specified on contract drawings.

3.3.6 Record all fan speeds.

3.3.7 Variable Volume Systems: Measure static pressure at all major branches. Adjust fan controllers for minimum required static pressure at the end of each branch. Report the value of the minimum static pressure that will provide proper air flow in the TAB Report and set the static pressure controller for this value. Balance outlets. Check at both modulated and full cooling condition. Traverse main supply and return ducts. Balance the return system. All branches must be above the minimum required static pressure. The supply fan must track and deliver the proper air quantity with no objectionable noise. The system must be stable and operate properly at 30% load.

3.4 Water Balancing:

3.4.1 Verify proper operation of all hydronic system devices to ensure the proper flowrate, flow direction and pressure are maintained.

3.4.2 Set balancing cocks and flow control devices to obtain specified water flow rates to all terminal units, coils, chillers, cooling towers, boilers, and heat exchangers. Coordinate set point for variable speed drives to achieve balance with minimum pump speed. Report the value of the minimum differential pressure that will provide proper flow in the TAB Report and set the differential pressure controller for this value. Pump balancing cocks (if present) shall be fully open. Set maximum speed control for variable speed pumps.

3.4.3 Variable Speed Pumps: Verify proper operation of variable speed pumps and the associated distribution system at 30% and 100% flow.

3.5 Data Collection:

3.5.1 In addition to the data required for any specified performance tests, measure and record the temperatures, pressures, flow rates, and nameplate data for all components listed herein.

3.5.2 It is the intent of this section to record data on balanced systems, under normal operating or design conditions.

3.5.3 Temperatures:

1. Outside dry and wet bulb temperatures.
2. Dry bulb temperature in each room and at least one wet bulb temperature in each zone.
3. Inlet and outlet temperature of each heat exchange device - both fluids.

3.5.4 Pressures:

1. Suction and discharge static pressure of each fan.
2. Suction and discharge pressure of each pump.
3. Water pressure drop through each heat exchanger.

3.5.5 Flow rates:

1. Flow rate through each fan.
2. Flow rate through each pump.
3. Flow rate through each coil or heat exchange device.

3.5.6 Nameplate Data:

1. Complete nameplate data for all equipment.
2. Motor data to include horsepower, phase, voltage, RPM, full load nameplate current, fuse rating in disconnect switch, number or manufacturer's size designation, and ampere rating of overcurrent and low voltage protection devices in starters.

3.6 All test openings in ductwork and ductwork insulation shall be resealed in an approved manner.

END OF SECTION 23 05 93

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SECTION 23 07 13 - EXTERIOR INSULATION FOR DUCTWORK

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Approval Submittals:

1.3.1 Product Data: Submit producer's data sheets and installation instructions on each insulation system including insulation, coverings, adhesives, sealers, protective finishes, and other material recommended by the manufacturer for applications indicated. Submit for:

Rigid duct insulation
Flexible duct insulation

1.4 O&M Data Submittals: Submit a copy of all approval submittals. Include in O&M Manual.

2 PRODUCTS

2.1 Acceptable Manufacturers: Subject to compliance with requirements, provide insulation products by Knauf, Owens-Corning, Johns Manville, Certainteed.

2.2 Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, coverings, sealers, mastic, and adhesive) with a flame spread rating of 25 or less, and a smoke-developed rating of 50 or less as tested by ANSI/ASTM 84.

2.3 Rigid Fiberglass Insulation Board: ASTM C612, Class 1 (non load bearing). Boards shall be 3 pcf density with UL rated aluminum foil vapor barrier (FSK).

2.4 Flexible Fiberglass Insulation: ASTM C553, Type I, Class B-3 (temperature less than 350ºF). Duct wrap shall be 1 pcf density with UL rated aluminum foil vapor barrier (FSK).

2.5 General Purpose Mastic: Benjamin Foster 35-00 Series, Insulcoustic VIAC Mastic, Childers CP-10, or approved equal. The final selection of this product for the specific application indicated is the responsibility of the insulation supplier. The insulation system must meet the specified application.

2.6 Vapor Barrier Sealant: Benjamin Foster 30-35, Insulcoustic IC-501, 3M EC-1378, Childers CP-30, or approved equal. Provide "Low Odor" type. The final selection of this product for the specific application indicated is the responsibility of the insulation supplier. The insulation system must meet the specified application.

2.7 Adhesive: Benjamin Foster 85-20, Insulcoustic IC-205, 3M EC-35, Childers CP-82, Childers CP-89, or approved equal. The final selection of this product for the specific application

indicated is the responsibility of the insulation supplier. The insulation system must meet the specified application.

2.8 Fiber-Glas Mesh: 10x10 Mesh. Foster Mastafab or equal.

3 EXECUTION

3.1 Insulate all rectangular supply, return and outdoor air ductwork exposed in mechanical rooms, mezzanines, fan lofts or in any finished spaces with 1½" thick rigid fiberglass insulation with vapor barrier.

3.2 Installation of Rigid Insulation:

3.2.1 Clean and dry ductwork prior to insulating. Butt insulation firmly together to ensure complete and tight fit over surfaces to be covered. Install insulation materials with smooth and even surfaces. Maintain integrity of aluminum vapor barrier wherever possible. Extend insulation without interruption through walls, floors and similar ductwork penetrations except where otherwise indicated.

3.2.2 Install with facing to the outside with a maximum of 25% compression. Butt all insulation joints firmly together. Longitudinal seam of the vapor retarder must be overlapped a minimum of 2". Staples shall be outward clinch and placed approximately 6" on center. All penetrations, joints, seams, and damage to the facing shall be sealed with glass fabric and mastic prior to system startup. For rectangular ducts over 24" wide, secure the insulation to the bottom of the duct with mechanical fasteners spaced on 12" centers to reduce sag. Do not overcompress the insulation with the retainer. Larger ducts shall be secured with fasteners on 12-inch centers and 3 inches from all edges.

3.2.3 Apply open mesh glass fabric embedded in vapor barrier mastic. Then apply a second coat of general purpose mastic with aluminum grey color. This finish shall be complete over all rigid insulation.

3.3 Insulate all supply, return and outdoor air ductwork concealed above ceilings, in chases, or elsewhere, and the backs of all ceiling supply outlets with 2" thick fiberglass blanket insulation with vapor barrier.

3.4 Installation of Flexible Insulation:

3.4.1 Insulate round elbows and fittings with wrap such that thickness is equal to adjoining duct covering. Clean and dry ductwork prior to insulating.

3.4.2 Adhere insulation to duct with 50 percent coverage using approved insulation adhesive applied in 6-inch wide swaths with 6-inch spaces between swaths. Additionally secure insulation with perforated pins and Tuff-Bond or by self-sticking pins with a 3/8" self-tapping screw. Space on 12-inch centers and 3 inches from all edges. Ducts up through 24" wide only require one row of pins. Ducts over 24" wide shall have pins spaced as described herein.

3.4.3 Lap all joints 2 inches and seal joints with 4-inch wide strips of open mesh glass fabric embedded in two coats of general purpose mastic.

3.4.4 Seal all punctures and breaks in aluminum vapor barrier with open mesh glass fabric and vapor barrier sealant.

END OF SECTION 23 07 13

SECTION 23 07 16 - INSULATION FOR HVAC EQUIPMENT AND PIPING

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods Sections apply to work of this section.

1.3 Approval Submittals:

1.3.1 Product Data: Submit producer's data sheets and installation instructions on each insulation system including insulation, coverings, adhesives, sealers, protective finishes, and other material recommended by the manufacturer for applications indicated. Submit for:

Fiberglass pipe insulation
Cellular glass pipe above ground insulation
Cellular glass equipment insulation
Flexible unicellular piping insulation
Fiberglass equipment insulation

1.4 O&M Data Submittals: Submit a copy of all approval submittals. Include in O&M Manual.

2 PRODUCTS

2.1 Acceptable Manufacturers: Subject to compliance with requirements, provide insulation products by Armstrong, Johns Manville, Knauf, Owens Corning, Pittsburgh Corning, U.S. Rubber, or approved equal. All products shall be asbestos-free.

2.2 Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics, and adhesive) with a flame-spread rating of 25 or less, and a smoke-developed rating of 50 or less, as tested by ANSI/ASTM E84.

2.3 Pipe Insulation Materials:

2.3.1 Fiberglass Pipe Insulation: ASTM C547, Class 1 unless otherwise indicated. (Preformed sleeving with white all-service jacket, suitable for temperatures up to 450°F)

2.3.2 Cellular Glass Pipe Insulation: ASTM C552, Type II, Class 1. (Uncovered.)

2.3.3 Flexible Unicellular Pipe Insulation: ASTM C534, Type I. (Tubular, suitable for use to 200□F.)

2.3.4 Staples, Bands, Wires, and Cement: As recommended by the insulation manufacturer for applications indicated.

2.3.5 Adhesives, Sealers, Protective Finishes: Products recommended by the insulation manufacturer for the application indicated.

2.3.6 Bedding Compound for CHW Systems: Provide products to completely cover the piping or equipment being insulated. Products shall be low odor type. Foster 30-45 or Foster 95-50.

2.3.7 Jackets: ASTM C921, Type I (vapor barrier) for piping below ambient temperature, Type II (vapor permeable) for piping above ambient temperature. Type I may be used for all piping at Installer's option. Provide color coded PVC jacket for all insulated piping exposed inside mechanical rooms. CHW = white; HW = grey; domestic water = light green;

2.4 Equipment Insulation Materials:

2.4.1 Rigid Fiberglass Equipment Insulation: ASTM C612, Class 1. (Boards, non-loading bearing, suitable for use to 400°F.)

2.4.2 Flexible Fiberglass Equipment Insulation: ASTM C553, Type I, Class B-3. (Flexible blankets suitable for use to 350°F, 1 pcf).

2.4.3 Cellular Glass Equipment Insulation: ASTM C552, Type I (Flat, uncovered blocks.)

2.4.4 Jacketing Material for Equipment Insulation: Provide 8 ounce canvas jacket, except as otherwise indicated.

2.4.5 Equipment Insulation Compounds: Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.

2.4.6 Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape corner angles, anchors, stud pins and metal covers as recommended by insulation manufacturer for applications indicated.

3 EXECUTION

3.1 General:

3.1.1 Install thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose.

3.1.2 Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.

3.1.3 Maintain integrity of vapor-barrier on insulation and protect it to prevent puncture and other damage. Label all insulation "ASBESTOS FREE".

3.1.4 Do not apply insulation to surfaces while they are hot or wet.

3.1.5 Do not install insulation until systems have been checked and found free of leaks. Surfaces shall be clean and dry before attempting to apply insulation. A professional insulator with adequate experience and ability shall install insulation.

3.1.6 Do not install insulation on pipe systems until acceptance tests have been completed except for flexible unicellular insulation. Do not install insulation until the building is "dried-in".

3.2 Fiberglass Pipe Insulation:

3.2.1 Insulate the following piping systems (indoor locations):

3.2.1.1 Heating hot water: up to 1-1/4" pipe - 1½" thick, 1-1/2" thick and over pipe - 2" thick.

3.2.2 Indoor Concealed Locations: Apply insulation to pipe with all side and end joints butted tightly. Seal longitudinal lap by pressurizing with plastic sealing tool. Apply 3 inch wide self sealing butt strips to joints between insulation sections. Insulate all fittings, flanges, valves and strainers with premolded insulation. Apply coat of insulating cement to fittings and wrap with glass cloth overlapping each wrap 1" and adjacent pipe 2". Finish with heavy coat of general purpose mastic. Premolded PVC covers may also be used, but no flexible inserts are allowed.

3.2.3 Indoor Exposed and Mechanical Rooms: Apply insulation to pipe with all side and end joints butted tightly. Seal longitudinal lap by pressurizing with plastic sealing tool. Apply 3 inch wide self sealing butt strips to joints between insulation sections. Insulate all fittings, flanges, valves and strainers with premolded insulation. Apply coat of insulating cement to fittings and wrap with glass cloth overlapping each wrap 1" and adjacent pipe 2". Finish with heavy coat of general purpose mastic. Cover straight piping with smooth, gloss finished, color coded PVC jacket. Use matching factory-made PVC covers for fittings and valves. Provide removable end caps for strainers. Jacketing shall be applied with the longitudinal seam positioned to shed water.

3.2.4 Provide hanger or pipe support shields of 16 gauge (minimum) galvanized steel over the insulation which extends halfway up the pipe insulation cover and at least 6" on each side of the hanger.

3.2.5 Omit insulation on unions, flanges, strainer blowoffs, flexible connections and expansion joints.

3.3 Cellular Glass Pipe Insulation (Above Ground):

3.3.1 Insulate the following piping systems:

3.3.1.1 Chilled water: smaller than 6" pipe - 1½" thick, 6" and larger pipe - 2" thick.

3.3.2 Indoor Concealed Locations: Cut insulation in sections at fittings and carefully fit to the pipe and fittings. No stovepipe or single miter insulation is allowed. Apply cellular glass bedding compound to the pipe surface to achieve 100% coverage (chilled water piping only). Apply vapor barrier mastic to all edges of the cellular insulation and between joints in the insulation. Wire the cellular glass in place with stainless steel wire 9 inches on center. Provide hanger or pipe support shields of 16 gauge (minimum) galvanized steel over or embedded in the insulation which extend halfway up the pipe insulation cover and at least 4" on each side of the hanger. Insulate anchors adequately to prevent moisture condensation problems. Finish cellular glass insulation in concealed locations by applying a white fire rated jacket with self sealing lap. Finish elbows and fittings with weather barrier sealant reinforced with white glass fabric.

3.3.3 Indoor Exposed and Mechanical Rooms: Cut insulation in sections at fittings and carefully fit to the pipe and fittings. No stovepipe or single miter insulation is allowed. Apply cellular glass bedding compound to the pipe surface to achieve 100% coverage (chilled water piping only). Apply vapor barrier mastic to all edges of the cellular insulation and between joints in the insulation. Wire the cellular glass in place with stainless steel wire 9 inches on center.

Provide hanger or pipe support shields of 16 gauge (minimum) galvanized steel over or embedded in the insulation which extend halfway up the pipe insulation cover and at least 4" on each side of the hanger. Insulate anchors adequately to prevent moisture condensation problems. Finish cellular glass by applying a heavy coat of weather barrier sealant reinforced with white glass fabric to the exterior of the cellular glass. Cover straight piping with smooth, gloss finished, color coded PVC jacket. Use matching factory-made PVC covers for fittings and valves. Provide removable end caps for strainers. Jacketing shall be applied with the longitudinal seam positioned to shed water.

3.4 Flexible Unicellular Pipe Insulation:

3.4.1 Insulate the following piping systems:

3.4.1.1 Condensate drains from air conditioning units - ½" thick.

3.4.1.2 Refrigerant piping - ¾" thick.

3.4.2 Apply insulation in accordance with the manufacturer's recommendations and instructions. Mitre cut insulation to fit pipe fittings. Use approved cement to seal all joints and ends in the insulation.

3.4.3 Insulation outside the building shall be protected by a smooth 0.016" thickness aluminum jacket secured with aluminum bands on 12" centers.

3.5 Fiberglass Equipment Insulation:

3.5.1 Insulate the following equipment:

3.5.1.1 Hot water expansion tank - 1" thick.

3.5.2 Coat insulated surfaces with a layer of insulating cement, troweled in a workmanlike manner, leaving a smooth continuous surface. Fill in scored block, seams, chipped edges, and depressions, and cover over joints with cement of sufficient thickness to remove surface irregularities. Cover insulated surface with glass cloth jacketing neatly fitted and firmly secured. Lap seams at least 2 inches. Apply over vapor barrier where applicable.

END OF SECTION 23 07 16

SECTION 23 08 00 – HVAC SYSTEMS COMMISSIONING

1 GENERAL

1.1 Intent: This section describes the work performed by the HVAC Commissioning Authority and the supporting work required by the Contractor. The Commissioning Authority will be provided by the Owner. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.

1.2 Intent of Commissioning Process:

1.2.1 Verify operation and functional performance of HVAC systems for compliance with "Design Intent". "Design Intent" is used to indicate the detailed requirements for the HVAC system, comprised of:

1.2.1.1 Design criteria and assumptions

1.2.1.2 HVAC system description and contract documentation

1.2.1.3 Intended methods of system operation and maintenance

1.2.2 Document HVAC tests and inspections.

1.2.3 Verify application of operation and maintenance manuals, as-built (record) documents, spare parts listing, special tools listing, and other items as may be specified herein for support of HVAC systems and equipment.

1.2.4 Coordinate and direct training to personnel for operation and maintenance of HVAC equipment and systems.

1.3 Contractor Scope of Work: Contractor shall perform all testing and demonstrate system operation to support the Commissioning Authority. Furnish labor and materials to support complete HVAC commissioning as specified herein. Support interim commissioning of HVAC systems during initial season operation and follow-up commissioning of required HVAC systems during additional season operation.

1.4 Quality Assurance:

1.4.1 Reference: ASHRAE Guideline 1-1996, *Guideline for Commissioning of HVAC Systems*.

1.4.2 Qualifications: The HVAC Commissioning Authority has been selected and contracted separately by the owner.

1.5 Documentation:

1.5.1 Provide the following to the Commissioning Authority:

1.5.1.1 Project plans and specification (contract documents), authorized revisions, approved HVAC

shop drawings and submittals, Startup Reports, Test and Balance Reports, factory start-up and certification reports, etc.

1.5.1.2 Records of required code authority inspections, documentation sign-offs, etc.

1.6 Submittals:

1.6.1 HVAC Commissioning Authority will provide the following to the Contractor prior to starting the commissioning process.

1.6.1.1 Commissioning Plan consisting of specific equipment and system checklists.

1.6.1.2 Training Plan outlining required training and documentation.

1.6.2 Contractor shall submit the following prior to starting the commissioning process.

1.6.2.1 O & M Manuals.

1.6.2.2 Startup Reports per Division-23 section 23 05 90.

1.6.2.3 Test and Balance Report per Division-23 section 23 05 93.

1.6.2.4 List of tools and spare parts required by other Division-23 sections.

1.7 Responsibilities:

1.7.1 Contractor:

1.7.1.1 Contractor shall verify completeness of the building envelope, perimeter and interior items which effect proper operation and control of HVAC equipment and systems.

1.7.1.2 The Contractor shall assure participation and cooperation of trade subcontractors (electrical, Test and Balance, controls/energy management, IAQ, and HVAC) under his contract as required for the commissioning process.

1.7.1.3 The Contractor shall secure the services of a professional video service to record all training sessions provided by the subcontractors. All training sessions shall be professionally videotaped and two copies provided to the Owner.

1.7.2 Subcontractors:

1.7.2.1 The subcontractors shall be responsible for providing labor, material, equipment, etc., required within the scope of their specialty to facilitate the commissioning process. The subcontractors shall perform tests and verification procedures required by the commissioning process when requested by the Commissioning Authority and directed by the Contractor.

1.7.3 Owner:

1.7.3.1 Owner will schedule their personnel to participate in the HVAC Commissioning process. This may include building security personnel, HVAC operation personnel and maintenance personnel. Personnel operating and maintaining equipment and systems will attend training sessions., factory schools, and educational institutions where indicated.

1.7.3.2 Owner shall advise HVAC Commissioning Authority regarding changes in building

occupancy and/or usage.

2 PRODUCTS

2.1 Instrumentation: Instrumentation shall be provided by agency performing prior tests. Instruments shall be operated by the individual agency requested by the HVAC Commissioning Authority, as specified elsewhere herein.

3 EXECUTION

3.1 General: The HVAC Commissioning Authority will actively participate in construction phase of the project to assure compliance with HVAC Commissioning requirements.

3.2 Procedure:

3.3 The Contractor and designated subcontractors shall attend a pre-commissioning meeting and establish requirements for HVAC Commissioning. The meeting shall outline:

3.3.1 Responsibility of each trade affected by HVAC Commissioning, as required by appropriate section of the specification and indicated on equipment and system checklists provided by the Commissioning Authority.

3.3.2 Requirements for documentation as listed elsewhere herein.

3.3.3 Requirements for documentation of HVAC test and inspections required by code authorities.

3.3.4 Requirements for the HVAC Commissioning program during specified operational seasons, part and full loads and as further delineated in Paragraph 3.4.

3.3.5 Format for training program for operation and maintenance personnel.

3.4 HVAC Commissioning:

3.4.1 To assist in the commissioning process, Operation and Maintenance manuals shall be completed and turned over to the Commissioning Authority as soon as possible during the course of the project, but in no case later than one month prior to the initial date scheduled for substantial completion.

3.4.2 The Commissioning Authority will develop and submit a specific start-up, check-out and sign-off form for every piece of major equipment and system, as well as other equipment hereinafter listed. These forms and lists do not necessarily indicate all the activities, tests and procedures which will be required for the commissioning and start-up of each piece of equipment and system.

3.4.3 The Contractor shall develop a work plan to demonstrate system and equipment operation. Systems shall be operated under actual or simulated full load conditions. Identify the operating conditions in the work plan. Where appropriate, systems shall be operated, tested, and started up, to assure operation for each of their seasonal or different characteristics, (for example heating and cooling).

3.4.4 After all components and every system has been completely commissioned, provide a 2-week, 24-hour per day fully functional automatic operation period of all systems simultaneously. This shall be successfully concluded before systems are accepted by the Owner.

3.4.5 Execute the final approved start-up and commissioning plan.

3.4.6 HVAC Commissioning shall begin only after HVAC equipment and systems, along with related equipment, systems, structures and areas are complete. Systems may be commissioned individually if requested by the Contractor and approved by the Commissioning Authority.

3.4.6.1 Verify Test and Balance readings, such as:

Supply and return air volumes
Fan performance
Hydronic performance
Branch duct readings

3.4.6.2 Verify calibration of thermostats and related controls, such as:
VAV boxes
Damper settings
Valve positions

3.4.6.3 Verify readings of remote data and control systems (Energy Management Control System), such as:

Temperatures
Air Flows
Damper positions
Differential pressures
Water temperatures

3.4.6.4 Verify that the total HVAC system is performing to provide conditions as outlined in "Design Intent", for seasonal full load and part load conditions, as follows:

Temperature
Humidity
Air movement
Air quality
Zone control
Energy Management
Pressurization
Control response

3.5 HVAC Start-Up Procedures:

3.5.1 Prior to start-up of any air handling equipment, the Commissioning Authority and the Contractor shall inspect the installation and verify that:

3.5.1.1 Ductwork is complete, clean and pressure-tested per specifications.

3.5.1.2 Prefilters and final filters are installed by the Contractor per design specifications; prefilters are to be replaced by the Contractor as required during this start-up period. The final filters shall be replaced by the Contractor any time that the static pressure drop across the filter exceeds 1.0". The filters installed shall meet design specifications and shall be dated with a felt-tip marker upon installation.

3.5.1.3 All electrical work is complete.

3.5.1.4 Safety devices are in place and operational.

3.5.1.5 Energy Management controls are installed and have been verified to be operational by the controls contractor.

3.5.1.6 All piping has been installed and insulated per specifications.

3.5.2 Prior to Occupancy:

3.5.2.1 No less than two weeks prior to substantial completion, the HVAC system for the space to be occupied shall be approved by the Commissioning Authority to be operational under the start-up procedures and shall be set up by the Contractor to operate continuously on a 24-hour basis. The following requirements shall be established by the Commissioning Authority and adhered by to the contractors during this period:

3.5.2.1.2 The Energy Management Control System is completely installed, and the EMCS Contractor has submitted a statement verifying that the system is complete and operational.

3.5.2.1.3 The HVAC air side and water systems shall be balanced at design levels by the Contractor, all systems and devices shall be operating according to specifications, and the Contractor's TAB report has been submitted to an approved by the HVAC system Design Engineer.

3.5.2.1.4 Outdoor air shall be set at maximum design levels and maintained at those levels continuously during the two-week ventilation period.

3.5.2.1.5 Chilled water temperature (where applicable) shall be operating at design levels. Supply air off-coil temperatures shall be at design levels.

3.5.2.1.6 All exhaust systems are operational and functioning according to design CFM and specifications.

3.5.2.1.7 All electric heaters and hydronic reheat systems are installed and operational.

3.5.2.1.8 Prefilters shall continue to be replaced by the Contractor as required per the start-up schedule. The final filter shall be replaced by the Contractor at any time that the static pressure drop across the filter exceeds 1.0".

3.5.2.1.9 All interior spaces are secured with doors and windows normally closed.

3.5.2.1.10 Interior air quality shall be maintained at 75ºF and relative humidity less than 60%.

3.5.3 At Occupancy: Following the date of final completion and prior to occupancy, the Commissioning Authority shall verify all prefilters and final filters have been replaced with new, approved, specified filters.

END OF SECTION 23 08 00

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SECTION 23 09 13 - VARIABLE FREQUENCY DRIVES

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Extent of variable frequency drive work required by this section is indicated on drawings and schedules, and by requirements of this section. Motor characteristics are specified in Division-23 section “Electric Motors”. Control sequences are specified in the mechanical drawings.

1.4 Refer to other Division-23 sections for installation of pumps, AHUs, pressure taps, and flow stations in mechanical systems; not work of this section. Coordinate with pump and air handling unit suppliers.

1.5 Refer to Division-26 sections for the following work; not work of this section.

1.5.1 Power supply wiring for power source to power connection on pumps, air handling units, drives, controls and/or unit control panels.

1.6 Provide the following electrical work as work of this section, complying with requirements of Division-26 sections: Control wiring and signal wiring between field-installed controls, indicating devices, and unit control panels.

1.7 Codes and Standards:

1.7.1 Electrical Standards: Provide electrical products which have been tested, listed and labeled by UL and comply with NEMA standards.

1.7.2 NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electric control systems.

1.7.3 NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

1.7.4 NEC Compliance: Comply with NFPA 70 National Electric Code.

1.8 Approval Submittals:

1.8.1 Product Data: Submit manufacturer's technical product data for each type of drive furnished, indicating dimensions, capacities, performance characteristics including harmonic contributions, electrical characteristics, finishes of materials, and including installation instructions and start-up instructions.

1.9 Test Reports and Verification Submittals:

1.9.1 Submit manufacturer's representative startup report.

1.10 O&M Data: Submit maintenance instructions and spare parts lists. Include this data, a copy of approval data in O&M manual.

2 PRODUCTS

2.1 General: Provide products in sizes and capacities indicated, consisting of variable frequency drives, bypass devices, disconnects, controllers, sensors, transmitters, and other components as required for a complete installation. Except as otherwise indicated, provide manufacturer's standard system components as indicated by published product information, designed and constructed as recommended by manufacturer.

2.2 Variable Frequency Drives: Provide UL or ETL approved, variable torque, variable frequency drives capable of being used with AC induction motors without causing overheating or excessive noises. Drives shall be housed in NEMA 1 enclosures. The supplier shall perform all necessary electric power analyses as required to ensure the drives operate properly in the service indicated. Provide the following performance and construction features:

2.2.1 The drive may be either voltage or current source, but current source drives must incorporate a voltage clamping circuit. Drives must be able to be tested under no-load conditions.

2.2.2 The controller shall accept power as indicated on the drawings and provide a variable frequency output for speed control from 10% to 100% of base speed (1,800 rpm nominal). Provide fused input.

2.2.3 The drive shall produce a variable frequency, adjustable voltage output with a constant input power factor of at least 0.95 and a variable-torque constant volts/Hz ratio. The input stage shall use a full wave diode bridge. Provide DC switching power supply.

2.2.4 The drive shall maintain an overall efficiency from input to output of at least 95% over the full range of operation.

2.2.5 The output stages shall not generate unacceptable line noise, motor noise, or radio frequency interference. Any isolation transformers, filters, or other devices required to prevent these problems, or to enable the drive to function properly with the available utility power shall be provided by the manufacturer.

2.2.6 All units shall be warranted for a period of 18 months. All drives shall be pretested before shipment.

2.2.7 Drive features:

2.2.7.1 Minimum and maximum speed adjustment.

2.2.7.2 Separately adjustable acceleration and deceleration.

2.2.7.3 Adjustable current limit.

2.2.7.4 Short circuit protection and ground fault protection. Over current protection for driven load shall comply with NEC.

2.2.7.5 4-20 mA current follower circuitry.

2.2.7.6 Under voltage and over voltage protection.

2.2.7.7 Over temperature protection.

2.2.7.8 Automatic restarting of the drive after a power outage or power dip.

2.2.7.9 Drive status indicator lights and digital display.

2.2.7.10 Mode selector switch (manual, off, automatic).

2.2.7.11 Manual speed potentiometer.

2.2.7.12 Speed indicator and ammeter to indicate full range of operation.

2.2.7.13 Motor starter circuit and drive input disconnect switch complying with NEC Article 430.

2.2.7.14 Phase loss protection (input and output) and surge suppression.

2.2.7.15 Start/stop control in any mode from a remote signal or contact closure.

2.2.7.16 Auxiliary contact indicating run status.

2.2.7.17 BACnet MS/TP interface.

2.2.7.18 Internal diagnostics displayed on unit panel.

2.2.7.19 Drives shall be able to catch and drive into a spinning load.

2.2.8 Acceptable Manufacturers: Subject to compliance with requirements, provide drives of one of the following:

Toshiba
Magnetek
Asea Brown Boveri
Yaskawa

3 EXECUTION

3.1 Examine areas and conditions under which variable volume systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 Install the variable frequency drives where shown on the drawings in accordance with the manufacturer's printed instructions. If the drive is not located within sight of the motor, provide additional line side disconnect switch complying with the requirements of Division 21 and NEC Article 430.

3.3 Mounting: Provide slotted angles or channel bars with mounting hardware for securing drives to the wall. Combustible materials are not permitted.

3.4 Refer to Division-26 sections for motor connections and testing requirements.

3.5 Variable Volume Pumping Systems:

3.5.1 System Adjustment: The drive supplier shall coordinate the setting of all adjustments and setpoints for initial operation. The system and all pumps and control valves shall be monitored for proper operation. It shall be recognized that final settings will be obtained by trial-and-error by necessity. Call backs to achieve proper settings shall be included in the base bid.

3.6 Variable Air Volume Systems:

3.6.1 Verify that the drives control the air handling unit speeds properly over the full range of operation in response to control signals. Coordinate drive operation with final sheave selection.

3.6.2 System Adjustment: The drive supplier shall coordinate the setting of all adjustments and setpoints for initial operation. Monitor system boxes and AHUs for proper operation. It shall be recognized that final settings and locations of static pressure transmitters will be obtained by trial-and-error by necessity. Call backs to achieve proper settings shall be included in the base bid.

3.7 Start-up: Start-up, test, and adjust variable volume systems in conjunction with DDC contractor and manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning equipment.

3.8 Owner's Instructions: Provide services of manufacturer's technical representative for one 4-hour day to instruct Owner's personnel in operation and maintenance of variable frequency drives. Schedule instruction with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

3.9 System Verification: The manufacturer's authorized representative shall state in writing to the Engineer that the variable volume system is operating properly, final adjustments and calibrations are complete, and Owner training has been accomplished.

END OF SECTION 23 09 13

SECTION 23 09 23 - DIRECT DIGITAL CONTROLS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Extent of Energy Management Control and DDC Systems (EMCS/DDC) work required by this section is indicated on drawings and input/output schedules, and by requirements of this section.

1.4 Refer to other Division-23 sections for installation of instrument wells, valve bodies and dampers in mechanical systems; not work of this section.

1.5 Refer to Division-26 sections for the following work; not work of this section. Power supply wiring for power source to power connection on controls and/or EMCS panels. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

1.6 Provide the following electrical work as work of this section, complying with requirements of Division-26 sections: Control wiring between field-installed controls, equipment, indicating devices, and EMCS/DDC panels.

1.7 Codes and Standards:

1.7.1 Electrical Standards: Provide electrical products which have been tested, listed and labeled by UL and comply with NEMA standards.

1.7.2 NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electric control systems.

1.7.3 NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

1.7.4 Federal Communication Commission (FCC) as required.

1.8 Approval Submittals:

1.8.1 Product Data: Submit manufacturer's technical product data for each EMCS/DDC panel and control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials. Include installation instructions and start-up instructions. Provide technical specification data for each component and software module.

1.8.2 Shop Drawings: Submit shop drawings for the EMCS/DDC containing the following information:

1.8.2.1 Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, and control devices.

1.8.2.2 Label each control device with setting or adjustable range of control.

1.8.2.3 Indicate all required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed. The point-to-point wiring diagram shall show all interconnections.

1.8.2.4 Provide details of faces of EMCS/DDC panels, including controls instruments and labeling.

1.8.2.5 Include written description of sequence of operation.

1.8.2.6 Provide a scaled floor plan drawing showing location of all conduit, control cabling, junction boxes, control devices, and surge suppression devices.

1.9 Test Reports and Verification Submittals:

1.9.1 Submit system verification letter from manufacturers representative stating that all HVAC controls have been checked, calibrated, started up and verified for proper operation. State that the Owner training has been completed and provide a roster of attendees.

1.10 O&M Data Submittals:

1.10.1 Maintenance Data: Submit maintenance instructions and spare parts lists for each type of control device. Include that type data, and a copy of all approval submittals in O&M Manual.

1.10.2 System Manual: In addition to the maintenance data requirements, provide an EMCS/DDC Owner's Manual in a separate binder specifically for this project. This manual shall provide a description of the information flow to and from panels and devices and shall describe the overall communications network. The manual shall also include operating instructions, block diagrams, schematics, schedules, and system descriptions. Instruct Owner's personnel with this manual during the required training periods.

1.10.3 Software: Submit a copy of all software.

1.10.4 Service: Submit name, address, and telephone number of company that will provide service and training for the system.

1.10.5 As-Built Drawings: Provide a scaled floor plan drawing showing location of all conduit, control cabling, junction boxes, control devices, and surge suppression devices.

2 PRODUCTS

2.1 Acceptable Manufacturers: Subject to compliance with requirements, provide EMCS/DDC control systems of one of the following:

Schneider Electric I/A Series
Trane

2.2 General: Provide EMCS/DDC control products in sizes and capacities indicated, consisting of valves, dampers, sensors, controllers and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard control system components as indicated by published product information, designed and constructed as

recommended by manufacturer. Provide an EMCS/DDC controls system with the following functional and construction features as indicated. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall utilize BACnet MSTP (RS485) communications.

2.3 Provide new stand-alone direct digital controllers for new chilled water/hot water plant, pumps, air handlers, and related terminal units and equipment.

2.3.1 Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet/MSTP (RS485) as prescribed by the BACnet standard. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system.

2.3.2 The Controls Contractor shall provide all communication media, connectors, repeaters and network switches routers necessary for the high speed Ethernet communications network.

2.3.3 All values within the system (i.e. schedules, datalogs, points, software variables, custom program variables) shall be readable and controllable (where appropriate) by any System Controller or BACnet Workstation on the communications network via BACnet.

2.4 Quality Assurance:

2.4.1 Provide equipment of firms regularly engaged in manufacture of EMCS/DDC equipment, of types required, whose products have been in satisfactory use in similar service for not less than three years. Provide evidence that software has been in use satisfactorily for at least one year.

2.4.2 Contractor shall have at least three years experience in the installation and servicing of EMCS/DDC equipment similar to that being installed. Contractor shall have an office within 100 miles of the project and shall maintain a remote terminal capable of communication with the EMCS/DDC during the year warranty period.

2.5 Control Valves: Provide factory-fabricated pressure independent electric control valves with constant differential pressure across the control valve for 100% valve authority. The valve shall accurately control the flow with an operating pressure differential range of 4 to 60 psi. Provide pressure regulation with EDPM diaphragm, stainless steel spring, and pressure control disc. Pressure control seats shall be brass construction with vulcanized EPDM. The valve shall be adjustable to indicate percentage of valve flow range, utilizing an adjustment collar and lock mechanism. Where type or body material is not indicated, provided selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature rating of piping system. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve. Except as otherwise indicated, provide valves which mate and match material of connecting piping. Equip control valves with control valve motors with proper shutoff ratings for each individual application.

2.5.1 Acceptable Manufacturers: Danfoss, Belimo, Griswold, Bell & Gossett, Flow Design Inc.

2.6 Dampers: Refer to Division-23 Section “Ductwork Accessories” for dampers. Actuators are work of this section.

2.7 Actuator Motors: Size each motor to operate dampers or valves with sufficient reserve power to provide smooth modulating action or two position action as specified.

2.7.1 Provide permanent split-capacitor or shaded pole type motors with gear trains completely oil-immersed and sealed. Equip spring-return motors, where indicated on drawings or in operational sequence, with integral spiral-spring mechanism. Furnish entire mechanism in housing designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

2.7.2 Equip motors for outdoor locations and for outside air intakes with "O-ring" gaskets designed to make motors completely weatherproof, and equip with internal heaters to permit normal operation at 10ºF.

2.7.3 Furnish non-spring return motors for dampers larger than 25 sq. ft. and for valves larger than 2½". Size for running torque rating of 150 inch-pounds and breakaway torque rating of 300 inch-pounds. Size spring-return motors for running torque rating of 150 inch-pounds and breakaway torque rating of 150 inch-pounds.

2.8 EMCS/DDC Associated Components:

2.8.1 Provide field-programmable microprocessor-based, stand-alone EMCS/DDC panels as specified herein. The EMCS/DDC panel manufacturer shall be responsible for the complete engineering of the panel. The panel shall be UL listed and housed in a key locked metal cabinet. Parts shall be plug in (modular) for easy repair or expansion. Power input shall be 24V or 120 V. Relays and contacts shall be rated at 24 VA at 24 VAC or 125 VA at 120 and 230 VAC, as required.

1. The System Controller shall have sufficient memory to support its operating system, database, and programming requirements.
2. The controller shall provide a USB communications port for connection to a PC
3. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
4. All System Controllers shall have a real time clock.
5. Data shall be shared between networked System Controllers.
6. The System Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
   a. Assume a predetermined failure mode.
   b. Generate an alarm notification.
   c. Create a retrievable file of the state of all applicable memory locations at the time of the failure.
   d. Automatically reset the System Controller to return to a normal operating mode.
7. Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at -40 F to 122 F.
8. Clock Synchronization.
   a. All System Controllers shall be able to synchronize with a NTP server for automatic time synchronization.
   b. All System Controllers shall be able to accept a BACnet time synchronization command for automatic time synchronization.
   c. All System Controllers shall automatically adjust for daylight savings time if applicable.
9. Serviceability
   a. Provide diagnostic LEDs for power, communications, and processor.
   b. The System Controller shall have a display on the main board that indicates the current operating mode of the controller.

c. All wiring connections shall be made to field removable, modular terminal connectors.
d. The System controller shall utilize standard DIN mounting methods for installation and replacement.

10. Memory. The System Controller shall maintain all BIOS and programming information indefinitely without power to the System controller
11. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shut-down below 80% nominal voltage
12. BACnet Test Labs (BTL) Listing. Each System Controller shall be listed as a Building Controller (B-BC) by the BACnet Test Labs.

2.9 EMCS/DDC Functions: Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the operator interface.

1. Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, optimal start, optimal stop, and night economizer actions. Each schedule may consist of up to [10] events. When a group of objects are scheduled together, provide the capability to define advances and delays for each member. Each schedule shall consist of the following:
   a. Weekly Schedule. Provide separate schedules for each day of the week.
   b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. This exception schedule shall override the standard schedule for that day. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed it will be discarded and replaced by the standard schedule for that day of the week.
   c. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
   d. Optimal Start. The scheduling application outlined above shall support an optimal start algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less then and greater than 24 hours. Provide the ability to modify the start algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit.
2. Trend Log Application
   a. Trend log data shall be sampled and stored on the System Controller panel and shall capable of being archived to a BACnet Workstation for longer term storage.
      1) Trend logs shall include interval, start-time, and stop-time.
      2) Trend log intervals shall be configurable as frequently as 1 minute and as infrequently as 1 year.
   b. Automated Trend Logs.
      1) The system controller shall automatically create trend logs for defined key measurements for each controlled HVAC device and HVAC application.
      2) The automatic trend logs shall monitor these parameters for a minimum of 7 days at 15 minute intervals. The automatic trend logs shall be user adjustable.
3. Alarm/Event Log
   a. Any object in the system shall be configurable to generate an alarm when transitioning in and out of a normal or fault state.

b. Any object in the system shall allow the alarm limits, warning limits, states, and reactions to be configured for each object in the system.
c. An alarm/event shall be capable of triggering any of the following actions:
1) Route the alarm/event to one or more alarm log. The alarm message shall include the name of the alarm location, the device that generated the alarm, and the alarm message itself.
2) Route an e-mail message to an operator(s)
3) Log a data point(s) for a period of time
4) Run a custom control program

4. VAV System Coordination. Provide applications software to properly coordinate and control the VAV system to ensure equipment safety and minimize energy use. This application shall perform the following functions:
a. Startup and shutdown the air handler safely. Ensure the VAV boxes are open sufficiently when the air handler is running, to prevent damage to the ductwork and VAV boxes due to high air pressure.
b. Calibrate VAV boxes.
c. Fan Pressure Optimization (ASHRAE 90.1) - Minimize energy usage by controlling system static pressure to the lowest level while maintaining zone airflow requirements. System static pressure controlled to keep the "most open" zone damper between 65% and 75% open.
1) The Fan Pressure Optimization application shall have the ability to identify and display the discharge air setpoint of the air-handler and the VAV box that serves the critical zone (e.g., the zone with the most open VAV box damper). This information shall dynamically update with changes in the location of the critical zone.
2) During commissioning, and with the engineer/owner, the controls contractor shall confirm the performance of Fan Pressure Optimization by conducting a field functional test that demonstrates critical zone reset.
5. Point Control. User shall have the option to set the update interval, minimum on/off time, event notification, custom programming on change of events.
6. Timed Override. A standard application shall be utilized to enable/disable temperature control when a user selects on/cancel at the zone sensor, operator interface, or the local operator display. The amount of time that the override takes precedence will be selectable from the operator interface.
7. Anti-Short Cycling. All binary output points shall be protected from short cycling

2.10 Operator Interface:

1. Operator Interface
a. The operator interface shall be accessible via a web browser.
b. The operator interface shall support the following Internet web browsers:
1) Internet Explorer 8.0+
c. The operator interface shall support the following mobile web browsers:
1) iOS (iPad/iPhone) V4.0+
2) Android (Phone) V2.3+
2. Mobile App Operator Interface
a. Mobile App Operator Interface shall support the following Operating systems
1) Apple iOS 5
2) Apple iOS 6
3) Android V2.3
4) Android V4.0
5) Android V4.1
b. The operator interface shall support system access on a mobile device via a mobile app to:

1) Alarm log
2) System Status
3) Equipment status
4) Space Status
5) Standard Equipment graphics

c. The operator interface shall support actions on a mobile device via a mobile app to:
   1) Override set points
   2) Override occupancy
   3) Acknowledge Alarms
   4) Comment on Alarms

d. System Security
   1) Each operator shall be required to login to the system with a user name and password in order to view, edit, add, or delete data.
   2) User Profiles shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator.
   3) Each operator shall be allowed to change their user password
   4) The System Administrator shall be able to manage the security for all other users
   5) The system shall include pre-defined “roles” that allow a system administrator to quickly assign permissions to a user.
   6) User logon/logoff attempts shall be recorded.
   7) The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
   8) All system security data shall be stored in an encrypted format.

e. Database
   1) Database Save. A system operator with the proper password clearance shall be able to archive the database on the designated operator interface PC.
   2) Database Restore. The system operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.

f. On-Line Help and Training
   1) Provide a context sensitive, on line help system to assist the operator in operation and configuration of the system.
   2) On-line help shall be available for all system functions and shall provide the relevant data for each particular screen.

g. System Diagnostics
   1) The system shall automatically monitor the operation of all network connections, building management panels, and controllers.
   2) The failure of any device shall be annunciated to the operators.

h. Equipment & Application Pages
   1) The operator interface shall include standard pages for all equipment and applications. These pages shall allow an operator to obtain information relevant to the operation of the equipment and/or application, including:
      a) Animated Equipment Graphics for each major piece of equipment and floor plan in the System. This includes:
         (1) Each Chiller, Air Handler, VAV Terminal, Fan Coil, Boiler, and Cooling Tower. These graphics shall show all points dynamically as specified in the points list.
         (2) Animation capabilities shall include the ability to show a sequence of images reflecting the position of analog outputs, such as valve or damper positions. Graphics shall be capable of launching other web pages.
      b) Alarms relevant to the equipment or application without requiring a user to navigate to an alarm page and perform a filter.

c) Historical Data (As defined in Automatic Trend Log section below) for the equipment or application without requiring a user to navigate to a data log page and perform a filter.

i. System Graphics. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using colors to represent zone temperature relative to zone set point.
   1) Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point and-click navigation between zones or equipment, and to edit set points and other specified parameters.
   2) Graphic imagery – graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.
   3) Animation. Graphics shall be able to animate by displaying different Image lies for changed object status.
   4) Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
   5) Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).

j. Custom Graphics
   1) The operator interface shall be capable of displaying custom graphics in order to convey the status of the facility to its operators.
   2) Graphical Navigation. The operator interface shall provide dynamic color graphics of building areas, systems and equipment.
   3) Graphical Data Visualization. The operator interface shall support dynamic points including analog and binary values, dynamic text, static text, and animation files.
   4) Custom background images. Custom background images shall be created with the use of commonly available graphics packages such as Adobe Photoshop. The graphics generation package shall create and modify graphics that are saved in industry standard formats such as GIF and JPEG.

k. Graphics Library. Furnish a library of standard HVAC equipment such as chillers, air handlers, terminals, fan coils, unit ventilators, rooftop units, and VAV boxes, in 3-dimensional graphic depictions. The library shall be furnished in a file format compatible with the graphics generation package program.

l. Manual Control and Override.
   1) Point Control. Provide a method for a user to view, override, and edit if applicable, the status of any object and property in the system. The point status shall be available by menu, on graphics or through custom programs.
   2) Temporary Overrides. The user shall be able to perform a temporary override wherever an override is allowed, automatically removing the override after a specified period of time.
   3) Override Owners. The system shall convey to the user the owner of each override for all priorities that an override exists.
   4) Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.

m. Engineering Units

1) Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system.
2) Unit selection shall be able to be customized by locality to select the desired units for each measurement.
3) Engineering units on this project shall be IP.

3. Scheduling. A user shall be able to perform the following tasks utilizing the operator interface:
   a. Create a new schedule, defining the default values, events and membership.
   b. Create exceptions to a schedule for any given day.
   c. Apply an exception that spans a single day or multiple days.
   d. View a schedule by day, week and month.
   e. Exception schedules and holidays shall be shown clearly on the calendar.
   f. Modify the schedule events, members and exceptions.
4. Trend Logs
   a. Trend Logs Definition.
      1) The operator interface shall allow a user with the appropriate security permissions to define a trend log for any data in the system.
      2) The operator interface shall allow a user to define any trend log options as described in the Application and Control Software section.
   b. Trend Log Viewer.
      1) The operator interface shall allow Trend Log data to be viewed and printed.
      2) The operator interface shall allow a user to view trend log data in text-based (time –stamp/value).
      3) The operator shall be able to view the data collected by a trend log in a graphical chart in the operator interface.
      4) Trend log viewing capabilities shall include the ability to show a minimum of 5 points on a chart.
      5) Each data point trend line shall be displayed as a unique color.
      6) The operator shall be able to specify the duration of historical data to view by scrolling and zooming.
      7) The system shall provide a graphical trace display of the associated time stamp and value for any selected point along the x-axis.
   c. Export Trend Logs.
      1) The operator interface shall allow a user to export trend log data in CSV or PDF format for use by other industry standard word processing and spreadsheet packages.
5. Alarm/Event Notification
   a. An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon.
   b. Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any operator interface.
      1) The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity.
      2) Alarm/event messages shall use full language, easily recognized descriptors.
      3) An operator with the proper security level may acknowledge and clear alarms/events.
      4) All alarms/events that have not been cleared by the operator shall be stored by the building controller.
      5) The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.
   c. Alarm Processing.
      1) The operator shall be able to configure any object in the system to generate an alarm when transitioning in and out of a normal state.

2) The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.

6. Reports and Logs.
   a. The operator interface shall provide a reporting package that allows the operator to select reports.
   b. The operator interface shall provide the ability to schedule reports to run at specified intervals of time.
   c. The operator interface shall allow a user to export reports and logs from the building controller in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Acceptable formats include:
      1) CSV, HTML, XML, PDF
   d. Reports and logs shall be readily printed to the system printer.
   e. Provide a means to list and access the last 10 reports viewed by the user.
   f. The following standard reports shall be available without requiring a user to manually configure the report:
      1) All Points in Alarm Report: Provide an on demand report showing all current alarms.
      2) All Points in Override Report: Provide an on demand report showing all overrides in effect.
      3) Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.
      4) Points report: Provide a report that lists the current value of all points
7. VAV Air System. An operator shall be able to view and control (where applicable) the following parameters via the operator interface:
   a. System Mode
   b. System Occupancy
   c. Ventilation (Outdoor air flow) setpoint
   d. Ventilation (Outdoor air flow) status
   e. Air Handler Static pressure setpoint
   f. Air Handler Static pressure status
   g. Air Handler occupancy status
   h. Air Handler Supply air cooling and heating set points
   i. Air Handler minimum, maximum and nominal static pressure setpoints
   j. VAV box minimum and maximum flow
   k. VAV box drive open and close overrides
   l. VAV box occupancy status
   m. VAV box Airflow to space
   n. Average space temperature
   o. Minimum space temperature
   p. Maximum space temperature
8. Custom Application Programming. Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded.
9. Custom Graphic Editor. Provide the tools to create, modify, and debug custom graphics. The operator shall be able to create, edit, and download custom graphics at the same time that all other system applications are operating. The system shall be fully operable while custom graphics are edited, compiled, and downloaded.

2.11 Associated Hardware: Provide actuators, relays, and other interface devices as required to execute the indicated control functions.

2.12 EMCS/DDC Input Devices:

2.12.1 Temperature Sensors: Provide nickel resistance temperature detector (RTD) type sensors for duct, well or room mounting as required by duty indicated. Accuracy: plus or minus 0.5ºF.

2.12.2 Temperature Transmitters: Provide 3 or 4 wire resistance temperature detector (RTD) type transmitters for duct, well or room mounting as required by duty indicated. Provide metal enclosure sealed against moisture. Accuracy: plus or minus 0.25ºF. Install wells to accommodate sensors. Wells must be of sufficient size to allow insertion of an electronic probe with the sensor for calibration. Accutech AI-1000 or approved equal.

2.12.3 Current Transformers: Provide current transformers (and potential transformers if required) and all associated interface equipment for sensing kW demand.

2.12.4 Hydronic Differential Pressure Transmitter: Provide self-contained, variable capacitance type differential pressure transmitters with the following features. Subject to compliance with requirements, provide transmitters of one of the following: Rosemont, Foxboro, Leslie, Yokagawa.

a. Sealed electronics compartment, suitable for duty at 90ºF, 100% RH. Provide NEMA 4 enclosure.
b. Output 4-20 ma DC, isolated linear signal.
c. Design pressure: 2000 psi, design overrange differential: 2000 psi with minimal adverse affect on output.
d. Accuracy: plus or minus 0.25% of span.
e. Stability: plus or minus 0.25% of range limit.
f. Provide zero and span adjustments. Set span for each transmitter based on duty, not at maximum unless required.

2.12.5 Differential and Static Pressure Sensors (Air): Provide 0-6" w.g. adjustable in 2" w.g. span pressure sensors with ±0.5% full scale accuracy. Provide zero and span adjustments. Provide over-pressure protection to 10 psig positive or negative.

2.12.6 Differential Pressure Switches (Air): Provide 0.05 to 5" w.g. differential pressure switches with adjustable setpoint and SPDT contact rated for duty indicated. Provide over-pressure protection to 1 psig positive or negative.

2.12.7 Humidity Sensors:

2.13 Guarantee:

2.13.1 All components, parts, and assemblies shall be guaranteed against defects in material and workmanship for a period of one year after acceptance. Expressed warranties are conditionally based on the requirement that the items covered within the guarantee are used and maintained in accordance with the manufacturer's recommendations. Guarantee commences at time of acceptance and continues for one year. Acceptance shall not occur until the Owner's operators are able to use the EMCS/DDC and receive reliable information from inputs and outputs.

2.13.2 The first year guarantee shall, as part of the base bid for the EMCS/DDC, include full service and maintenance of the EMCS/DDC. This service and maintenance shall include all necessary repair, reprogramming, calibration, cleaning, minimum (4) quarterly inspections, call back service, etc. This first year service, maintenance and guarantee shall be included in the base bid of the EMCS/DDC.

3 EXECUTION

3.1 Examine areas and conditions under which EMCS/DDC work is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.2 Installation of EMCS/DDC:

3.2.1 General: Install systems and materials in accordance with manufacturer's instructions, shop drawings, and details on drawings. Install electrical components and use electrical products complying with requirements of applicable Division-26 sections of these specifications. Mount panels at convenient locations and heights.

3.2.2 Control Wiring: The term "control wiring" is defined to include wire, conduit and miscellaneous materials as required for mounting and connecting electric control devices. Install all control wiring in conduit. All low voltage control wiring shall be installed in conduit.

3.2.3 Wiring System: Install complete control wiring system for the EMCS/DDC. Conceal wiring, except in mechanical rooms and areas where other conduit and piping are exposed. Provide multi-conductor instrument harness (bundle) in place of single conductors where number of conductors can be run along common path. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.

3.2.4 Install control wiring in accordance with the National Electric Code and Division 26 requirements.

3.2.5 Number-code or color-code conductors, excluding those used for local individual room controls, appropriately for future identification and servicing of control system. Tag all sensor wiring to identify zone number and room number where sensor is located.

3.2.6 Label all sensors, valves, dampers, safety devices and controllers with engraved tags matching the shop drawings.

3.3 Programming of EMCS/DDC:

3.3.1 The Contractor shall obtain operational schedules for the controlled equipment from the Engineer. Submittal data relevant to operational schedules shall be forwarded from the Contractor to the Engineer. Upon receipt of approval, the Contractor shall proceed with installation, setup, calibration and check out of the various control and monitoring systems.

Having completed component and system installation, the Contractor shall submit a written request to the Engineer to inspect and approve their satisfactory operation.

3.3.2 The EMCS/DDC shall perform all functions on the equipment as describes in Division-23 section “HVAC Sequence of Operation and as called for in the input/output schedule on the drawings. This, in conjunction with the drawings, defines the scope and extent of the project with regard to the required number of panels, control point relays, and devices. Field verify voltages at point-of-interface and provide relays as required.

3.3.3 Channel numbers may be reassigned by the Contractor during shop drawing submittal.

3.3.4 Model numbers, horsepowers, voltages, and other information equipment where listed on the

drawings are for Contractor's convenience. Verify all information in the field as necessary for preparation of shop drawings.

3.4 Functional Requirements of EMCS/DDC:

3.4.1 Provide all necessary relays, sensors, wiring and contacts to achieve proper operation.

3.4.2 Connect EMCS/DDC panels to remote panels where shown.

3.4.3 Coordinate EMCS/DDC work with pneumatic control work. Provide compatible equipment.

3.5 Adjusting and Cleaning:

3.5.1 Startup: Startup, test, and adjust the EMCS/DDC in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

3.5.2 Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.5.3 Final Adjustment: After completion of installation, adjust the program, relays, interface devices, and similar equipment provided as work of this section for optimum operation.

3.6 VFD System Adjustment: The drive/controller supplier shall set all adjustments and setpoints for initial operation. The hydronic system and all pumps and control valves shall be monitored for proper operation. The ductwork and all fans and terminal units shall be monitored for proper operation . It shall be recognized that final settings will be obtained by trial-and-error by necessity. Call backs to achieve proper settings shall be included in the base bid.

3.7 Owner's Instructions:

3.7.1 During system startup and at such time acceptable performance of the EMCS/DDC hardware and software has been established, the Contractor shall provide on-site operator instruction. This instruction shall be performed during normal working hours and shall be conducted by a competent representative of the Contractor familiar with the system's software, hardware and accessories. The Contractor shall maintain a roster of all attendees at all training sessions.

3.7.2 At a time mutually agreed upon during system training as stated above, the Contractor shall give up to 40 hours (as needed) of instruction to the Owner's designated personnel on the operation of all equipment within the EMCS/DDC and describe its intended use with respect to the programmed functions specified.

3.7.3 Operator orientation of the EMCS/DDC shall include, but not be limited to, the overall operational program, equipment functions both individually and as part of the total integrated system, commands, advisories, and appropriate operator intervention required in responding to the EMCS/DDC operation.

3.7.4 Provide at least 14-day notice to Owner and Engineer of training dates.

3.8 System Verification: The manufacturer's authorized representative shall state in writing to the Engineer that the EMCS/DDC system is operating properly, final adjustments and calibrations are complete, and Owner training has been accomplished.

END OF SECTION 23 09 23

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SECTION 23 21 13 - HEATING HOT WATER AND CHILLED WATER SYSTEMS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Refer to other Division-23 sections for insulation of hydronic piping; not work of this section.

1.4 Refer to other Division-23 sections for hydronic specialties; not work of this section.

1.5 Refer to other Division-23 sections for HVAC pumps, chillers, and boilers; not work of this section.

1.6 Refer to other Division-23 sections for testing, adjusting, and balancing of hydronic piping systems; not work of this section.

1.7 Codes and Standards: Fabricate and install hydronic piping in accordance with ASME B31.9 "Building Services Piping."

1.8 Approval Submittals:

1.8.1 Product Data: Submit manufacturer's product data for:

Valves
Meters and Gauges
Vibration Control
Access doors

1.8.2 Shop Drawings: Submit scaled layout drawings of piping systems in mechanical rooms including, but not necessarily limited to, pipe sizes, location, offsets, connections, elevations, and hydronic specialties. Indicate interface and spatial relationship between piping and equipment. Coordinate with all other trades work and existing conditions. Field verify final location of pipe prior to submittal of layout drawings and fabrication.

1.9 Test Reports and Verification Submittals:

Submit welder's certificates.
Submit water treatment test report.

1.10 O&M Manual Submittals: Submit a copy of approval submittals. Include this data in O&M manual.

2 PRODUCTS

2.1 General: Provide piping materials and factory-fabricated piping products of sizes, types,

pressure ratings, temperature ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide materials and products complying with ASME B31.9 Code for Building Services Piping where applicable, base pressure rating on hydronic piping systems maximum design pressures. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in hydronic piping systems. Where more than one type of materials or products are indicated, selection is Installer's option.

2.2 Basic Identification: Provide identification complying with Division-23 Basic Mechanical Materials and Methods section "Mechanical Identification."

2.3 Basic Pipes and Pipe Fittings: Provide pipes and pipe fittings complying with Division-23 Basic Mechanical Materials and Methods section "Pipes and Pipe Fittings", in accordance with the following listing:

2.3.1 Pipe Size 2" and Smaller: Black steel pipe; Schedule 40; Class 125 cast-iron fittings with threaded joints.

2.3.2 Tube Size 3" and Smaller: Copper tube; Type L, hard-drawn temper; wrought-copper fittings with soldered joints.

2.3.3 Pipe Size 2½" and Larger: Black steel pipe; Schedule 40; wrought-steel buttwelding fittings with welded joints.

2.3.4 Underground Piping: All underground piping regardless of size shall be welded.

2.4 Basic Piping Specialties: Provide piping specialties complying with Division-23 Basic Mechanical Materials and Methods section "Piping Specialties."

2.5 Basic Supports and Anchors: Provide supports and anchors complying with Division-23 Basic Mechanical Materials and Methods section "Supports and Anchors."

2.6 Basic Valves: Provide valves complying with Division-23 Basic Materials and Methods section “Valves” and the following list:

2.6.1 Standard Service Sectional Valves: Type GA1, GA3, BF1, BF2, BF3, BF4.

2.6.2 Standard Service Shutoff Valves: Type GA1, GA3, BA1, BF2, BF4.

2.6.3 Standard Service Check Valves: Type CK1, CK3.

2.6.4 Standard Service Drain Valves: Type GA1, BA1.

2.6.5 Standard Service Terminal Runout Valves (Steel Runouts): Type GA1, GA3, BA1.

2.6.6 Standard Service Terminal Runout Valves (Copper Runouts): Type GA2, BA2.

2.7 Basic Meters and Gauges: Provide meters and gauges complying with Division-23 Basic Mechanical Materials and Methods section "Meters and Gauges", in accordance with the following listing:

2.7.1 Temperature gauges and fittings.

2.7.2 Pressure gauges and fittings.

2.7.3 Flow measuring meters.

2.8 Access Doors: Provide access doors to service all valves and other devices as required in accordance with Division-23 Basic Materials and Methods Section “Access Doors”.

3 EXECUTION

3.1 General: Examine areas and conditions under which hydronic piping systems materials and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 Installation of Hydronic Piping:

3.2.1 General: Install hydronic piping in accordance with Division-23 Basic Mechanical Materials and Methods section "Pipes and Pipe Fittings".

3.2.2 Install eccentric reducers where pipe is reduced in size in direction of flow, with tops of both pipes and reducer flush. Do not use bushings.

3.2.3 Install piping with 1/32" per foot (¼%) upward slope in direction of flow, or as indicated on the drawings. The intent is to install piping sloped to drains at low points in the system for a drainable system.

3.2.4 Connect branch-feed piping to mains at horizontal center line of mains, connect run-out piping to branches at horizontal center line of branches.

3.2.5 Locate groups of pipes parallel to each other, spaced to permit applying full insulation and servicing of valves.

3.3 Install piping specialties in accordance with Division-23 Basic Mechanical Materials and Methods section "Piping Specialties".

3.4 Install supports and anchors in accordance with Division-23 Basic Mechanical Materials and Methods section "Supports and Anchors".

3.5 Install valves in accordance with Division-23 Basic Mechanical Materials and Methods section "Valves".

3.5.1 Sectional Valves: Install on each branch and riser, close to main, where branch or riser serves 2 or more hydronic terminals or equipment connections, and elsewhere as indicated.

3.5.2 Shutoff Valves: Install on inlet and outlet of each mechanical equipment item, and on inlet and outlet of each hydronic terminal, and elsewhere as indicated.

3.5.3 Drain Valves: Install on each mechanical equipment item located to completely drain equipment for service or repair. Install at base of each riser, at base of each rise or drop in piping system, and elsewhere where indicated or required to completely drain hydronic piping system.

3.5.4 Check Valves: Install on discharge side of each pump, and elsewhere as indicated.

3.6 Install meters and gauges in accordance with Division-23 Basic Materials and Methods section "Meters and Gauges".

3.7 Equipment Connections:

3.7.1 General: Connect hydronic piping system to mechanical equipment as indicated on the drawings, and comply with equipment manufacturer's instructions where not otherwise indicated. Install shutoff valve and union on supply and return and a drain valve on the drain connection. Connections between dissimilar metals shall be made with dielectric devices.

3.7.2 Hydronic Terminals: Install hydronic terminals with shutoff valves, unions and related devices as shown on the drawings. Install manual air vent valve on element in accordance with manufacturer's instructions. Locate valves and balancing cocks for ease of maintenance. Where indicated, install automatic temperature control valve with unions on return line between coil and shutoff valve.

3.8 Provide sufficient swing joints, expansion loops and devices necessary for a flexible piping system. Install drain valves at all low points of each system to enable complete drainage, and air vents at all high points in the piping system to enable complete air venting.

3.9 Pipe drains from pump glands, relief valves, strainers, etc., to spill over an open sight drain, floor drain or other acceptable discharge point, and terminate with a plain end (unthreaded pipe) 6" above the drain. Rigidly support all drains.

3.10 Locate and coordinate installation of access doors for all valves and devices in accordance with Division-23 Basic Mechanical Materials and Methods section “Access Doors”.

3.11 Testing, Cleaning, Flushing, and Inspecting: Test, clean, flush, and inspect hydronic piping systems in accordance with requirements of Division-23 Basic Mechanical Materials and Methods section "Testing, Cleaning, and Sterilization of Piping Systems."

3.12 Chemical Treatment: Fill l hydronic piping systems, adding a nitriteborate, MBT based treatment for corrosion protection. Add to establish the levels recommended by the water treatment company, but no less than 500 ppm nitrite and a minimum pH of 8.5. Repeat measurements daily with system under full circulation and apply chemicals to adjust levels until no change is apparent. The contractor shall maintain the chemical treatment throughout construction and the warranty period.

END OF SECTION 23 21 13

SECTION 23 21 14 - HEATING HOT WATER AND CHILLED WATER PREINSULATED PIPING

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Extent of underground preinsulated piping system work, is indicated on drawings and by requirements of this section.

1.4 Verify all existing conditions prior to bidding. The Contractor shall include in his price for the underground preinsulated system sufficient elbows, offsets, and pipe to provide for unforeseen conditions. The drawings do not show the exact location or inverts of all existing utilities, conditions, etc. However, the contractor's bid shall include sufficient labor and material costs to allow for these conditions without causing additional cost for the Owner or delays in the project schedule.

1.5 Refer to other Division-23 sections for field-applied insulation, manholes, valves, hydronic specialties, and expansion compensation.

1.6 Codes and Standards: Fabricate and install piping in accordance with ASME B31.9 "Building Services Piping".

1.7 Approval Submittals:

1.7.1 Product Data: Submit manufacturer's technical product data and installation instructions for systems, including: carrier pipe, jacket, insulation, materials and products.

1.7.2 Shop Drawings: Submit scaled layout drawings of underground preinsulated piping system including, but not necessarily limited to, pipe sizes, location, offsets, connections, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Indicate interface and spatial relationship between piping and manholes. Coordinate with all other site utilities and all existing conditions. Field verify final location of pipe prior to submittal of layout drawings and fabrication. Shop drawings shall indicate the existing conditions. Probe or excavate as required.

1.8 O&M Data Submittals: Submit a copy of approval submittals for jacket and piping materials and products. Include this data in O&M manual.

2 PRODUCTS

2.1 General: Provide factory-fabricated preinsulated piping and insulation products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by manufacturer to comply with installation requirements. Provide materials and products complying with ASME B31.9 Code for Building Services Piping where applicable, base pressure rating on piping systems maximum design pressures.

Provide fittings and materials which match pipe materials used in piping systems.

2.2 Carrier Pipe and Fittings: Provide pipes and pipe fittings complying with Division-23 Basic Mechanical Materials and Methods section "Pipes and Pipe Fittings".

2.2.1 Chilled Water Piping: A-53 black steel pipe, Grade B; Schedule 40; ERW, wrought-steel buttwelding fittings, welded joints.

2.2.2 Heating Hot Water Piping: A-53 black steel pipe, Grade B; Schedule 40; ERW, wrought-steel buttwelding fittings, welded joints.

2.3 Outer Jacket:

2.3.1 Jacket: The outer casing shall be high density polyethylene (HDPE) conforming to ASTM D1248 and D3350, Type III, Category 5, Class C and Grade P23/P24. With a minimum of 2% by weight of carbon black. Minimum thickness is 150 mils.

2.3.2 Provide straight lengths of pre-insulated pipe and fittings for field installation. Jackets for fittings shall be of the same construction as the jacket material.

2.3.3 End Seals: Seal each length of pre-insulated pipe with a watertight mastic end seal at the jacket and pipe surfaces. Any field cuts shall be sealed with a field applied end seal per the manufacturer's standard practice.

2.3.4 Anchors: Provide prefabricated 1/2" plate steel anchors attached to the carrier pipe and sealed to the pipe jacketing per manufacturer's standard practice.

2.3.5 Pipe Support Guides: Provide standard manufacturer's full round guides.

2.4 Insulation:

2.4.1 Chilled Water Pipe Insulation: polyurethane foam with minimum K = 0.16 and a density of 2 lb/ft^3: smaller than 6" pipe -1½" thick, 6" and larger pipe -2" thick

2.4.2 Heating Hot Water Pipe Insulation: polyurethane foam with minimum K = 0.16 and a density of 2 lb/ft^3: smaller than 6" pipe -1½" thick, 6" and larger pipe -2" thick

2.4.3 Insulation shall be complete through all piping, expansion loops and fittings.

2.5 Acceptable Manufacturers: Subject to compliance with requirements, provide preinsulated piping systems of one of the following: Ricwil, Rovanco, Perma Pipe, Thermacor, Energy Taskforce.

3 EXECUTION

3.1 Inspection: Examine areas and conditions under which products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 Installation of Underground Piping: Install in accordance with Division-23 Basic Mechanical Materials and Methods section "Pipes and Pipe Fittings" and "Excavation and Backfill".

3.2.1 Expansion loops and ells: Provide sufficient loops for a flexible piping system in accordance with ASME Code for pressure piping and the manufacturer's standard practice.

3.2.2 Anchors: Provide anchors where shown on the plans or as determined by the manufacturer's recommendations.

3.2.3 End seals: Terminate ends of pre-insulated pipe inside building walls and manholes with end seals.

3.2.4 After welding and pressure testing, all joints shall be insulated and sealed in accordance with the manufacturer's published methods.

3.3 Testing: Carrier pipe shall be pressure tested hydrostatically in accordance with Division-23 Basic Mechanical Materials and Methods section "Testing, Cleaning and Sterilization of Piping Systems" after welding and prior to closure of jacket. All jacket closures shall be field tested with air before backfilling. The Contractor shall provide all necessary equipment for the testing.

END OF SECTION 23 21 14

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SECTION 23 21 16 - HYDRONIC SPECIALTIES

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Refer to other Division-23 sections for insulation of hydronic specialties; not work of this section.

1.4 Codes and Standards:

1.4.1 ASME Compliance: Manufacture and install hydronic specialties in accordance with ASME B31.9 "Building Services Piping".

1.5 Approval Submittals:

1.5.1 Product Data: Submit manufacturer's technical product data and installation instructions for each type of hydronic specialty. Include pressure drop curve or chart for each type and size of hydronic specialty. Submit schedule indicating manufacturer's figure number, size, location, rated capacities, and features for each required hydronic specialty.

Balancing Cocks
Vent Valves
Air Separators
Diaphragm Type Compression Tanks
Shot Feeders
Liquid Flow Switches
Water Relief Valves
Pressure-Reducing Valves
Pump Discharge Valves
Pump Suction Diffusers
Flow Control Valves
Differential Pressure Relief Valves

1.6 O&M Data Submittals:

1.6.1 Maintenance Data: Submit a copy of approval submittals. Submit maintenance data and spare parts lists for liquid flow switches, pressure-reducing valves, pump differential relief valves . Include these data in the O&M manual.

2 PRODUCTS

2.1 General: Provide factory-fabricated hydronic specialties recommended by manufacturer for use in service indicated. Provide hydronic specialties of types and pressure ratings indicated for each service, or if not indicated, provide proper selection as determined by Installer to

comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is installer's option but more than one type cannot be used on project.

2.2 Vent Valves:

2.2.1 Manual Vent Valves: Provide manual vent valves designed to be operated manually with screwdriver or thumbscrew, 1/8" N.P.T. connection.

2.2.2 Automatic Vent Valves: Provide automatic vent valves designed to vent automatically with float principle, stainless steel float and mechanisms, brass cast iron body, pressure rated for 150 psi, ¾" NPS inlet connection. Hoffman No. 792. Use for central plant equipment.

2.2.3 Automatic Vent Valves: Provide automatic vent valves designed to vent automatically with float principle, stamped brass body, pressure rated for 150 psi, ½" NPS inlet connection. Bell & Gossett No. 87. Use for all distribution piping.

2.2.4 Acceptable Manufacturers: Subject to compliance with requirements, provide vent valves of one of the following:

Crane
Bell & Gossett
Hoffman
NuTech
Sarco
Wheatley
Taco, Inc.

2.3 Air Separators: Provide air separators pressure rated for 125 psi. Select capacity based on total system gpm.

2.3.1 In-Line Air Separators: Provide in-line air separators with tangential nozzles and stainless steel air collector tube as indicated. Construct sizes 1½" and smaller of cast iron; and sizes 2" and larger of steel complying with ASME Boiler and Pressure Vessel Code and stamped with "U" symbol. Furnish National Board Form U-1 denoting compliance.

2.3.2 Acceptable Manufacturers: Subject to compliance with requirements, provide air separators of one of the following:

Amtrol, Inc.
Bell & Gossett
Flo-Fab
John Wood Co.
Wheatley
Taco, Inc.

2.4 Diaphragm-Type Compression Tanks: Provide diaphragm compression tanks of size and number as indicated. Construct tank of welded steel, constructed, tested, and stamped in accordance with Section VIII of ASME Boiler and Pressure Vessel Code for a working pressure of 125 psi. Furnish National Board Form U-1 denoting compliance. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Provide specially compounded flexible diaphragm securely sealed into tank to permanently separate air charge from system water, to maintain design expansion capacity. Provide pressure gauge and air-charging fitting, and drain fitting.

2.4.1 Acceptable Manufacturers: Subject to compliance with requirements, provide diaphragm-type compression tanks of one of the following:

Amtrol, Inc.
Bell & Gossett
Flo-Fab
Taco, Inc.
Wheatley

2.5 Shot Feeders: Provide shot feeders of 5 gallon capacity or otherwise as indicated, construction of cast iron or steel, for introducing chemicals in hydronic system. Provide 3-1/2" screwed on top with o ring seal for loading, drain valve in bottom, and recirculating valves on side. Construct for pressure rating of 125 psi.

2.6 Liquid Flow Switches: Provide liquid flow switches as indicated to sense flow and non-flow. Construct of brass for all wetted parts, provide packless construction. Provide paddle with removable segments for pipe size and flow velocity. Provide vapor proof electrical compartment for switches mounted on cold hydronic piping systems. Coordinate switch electrical requirements with chiller and HVAC control requirements. McDonald & Miller or equal.

2.7 Water Relief Valves: Provide water relief valves as indicated, of size and capacity as selected by Installer for proper relieving capacity, in accordance with ASME Boiler and Pressure Vessel Code.

2.7.1 Combined Pressure-Temperature Relief Valves: Bronze body, test lever, thermostat, complying with ANSI Z21.22 Listing Requirements for temperature discharge capacity. Provide temperature relief at 210ºF and pressure relief at 125 psi.

2.7.2 Pressure Relief Valves: Provide ASME pressure relief valves, bronze or iron body as required with test. The set point shall be at or below the maximum allowable working pressure of the most limiting device in the system being protected. Valves shall have enclosed spindles with gland seals to minimize leakage. Coordinate pressure relief setting to protect all equipment.

2.7.3 Acceptable Manufacturers: Subject to compliance with requirements, provide water relief valves of one of the following:

Amtrol, Inc.
Bell & Gossett
Watts Regulator Co.
McDonald & Miller
Kunkle
Manning, Maxwell & Moore
Wheatley

2.8 Pressure Reducing Valves: Provide pressure reducing valves as indicated, of size and capacity as selected by Installer to maintain operating pressure on boiler system.

2.8.1 Construction: Cast iron or brass body, low inlet pressure check valve, inlet strainer removable without system shut-down, noncorrosive valve seat and stem, factory set at operating pressure.

2.8.2 Acceptable Manufacturers: Subject to compliance with requirements, provide pressure reducing valves of one of the following:

Amtrol, Inc.
Bell & Gossett
Taco, Inc.
Watts Regulator Co.
Wheatley

2.9 Pump Discharge Valves: Provide triple duty pump discharge valves as indicated. Provide non-slam check valve with spring-loaded disc and calibrated adjustment feature permitting regulation of pump discharge flow and shutoff. Design valves to permit repacking under full line pressure, and with bolt-on bonnet. Provide flanged cast-iron valve body, pressure rated for 175 psi, maximum operating temperature of 300°F. Provide straight or angle pattern as indicated.

2.9.1 Acceptable Manufacturers: Subject to compliance with requirements, provide pump discharge valves of one of the following:

Amtrol, Inc.
Bell & Gossett
Flo-Fab
Taco, Inc.
Wheatley

2.10 Pump Suction Diffusers: Provide pump suction diffusers as indicated. Construct unit with angle pattern cast-iron body, threaded for 2" and smaller, flanged for 2½" and larger, pressure rated for 175 psi. Provide inlet vanes with length 2½ times pump suction diameter or greater. Provide cylinder strainer with 3/16" diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head. Provide disposable fine mesh strainer to fit over cylinder strainer. Provide permanent magnet located in flow stream, removable for cleaning. Provide adjustable foot support designed to carry weight of suction piping. Provide blowdown tapping in bottom, gauge tapping in side.

2.10.1 Acceptable Manufacturers: Subject to compliance with requirements, provide pump suction diffusers of one of the following:

Amtrol, Inc.
Bell & Gossett
Flo-Fab
Taco, Inc.
Wheatley

3 EXECUTION

3.1 General: Examine areas and conditions under which hydronic specialties are to be installed. Do not proceed with work until satisfactory conditions have been corrected in manner acceptable to Installer.

3.2 Vent Valves:

3.2.1 Manual Vent Valves: Install manual vent valves on each hydronic terminal at highest point, and on each hydronic piping drop in direction of flow for mains, branches, and runouts, and elsewhere as indicated.

3.2.2 Automatic Vent Valves: Install automatic vent valves at top of each hydronic riser and elsewhere as indicated. Install shut-off valve between riser and vent valve, pipe outlet to suitable plumbing drain, or as indicated.

3.3 Air Separators:

3.3.1 In-Line Air Separators: Install in-line air separators in pump suction lines. Connect inlet and outlet piping. Run piping to compression tank with ¼" per foot (2%) upward slope towards tank. Install drain valve on units 2" and over.

3.4 Diaphragm-Type Compression Tanks: Install diaphragm-type compression tanks on floor as indicated, in accordance with manufacturer's instructions. Vent and purge air from hydronic system, charge tank with proper air charge as recommended by manufacturer.

3.5 Shot Feeders: Install shot feeders on each hydronic system at pump discharge and elsewhere as indicated. Install in upright position with top of funnel not more than 48" above floor. Install globe valve in pump discharge line between recirculating lines. Pipe drain to nearest plumbing drain or as indicated.

3.6 Liquid Flow Switches: Install liquid flow switches on inlet to water chiller inlet to water condenser and elsewhere as indicated. Install in horizontal pipe with switch mounted in tee on top of pipe with minimum of 24" of straight pipe with no fittings both upstream and downstream of switch. Remove segments of paddle to fit pipe in accordance with manufacturer's instructions.

3.7 Water Relief Valves: Install where indicated on the drawings. Pipe discharge to drain. Rigidly support discharge piping and route in the most direct manner possible. Turn down relief piping so as not to injure personnel. Comply with ASME Boiler and Pressure Vessel Code.

3.7.1 Pipe discharge from relief valve full size, sloping downward to a floor drain or outside the building. Cut the end of the pipe at a 45º angle and terminate the pipe six inches above the floor or grade.

3.8 Pressure Reducing Valves: Install for each piece of hydronic equipment requiring makeup water in accordance with manufacturer's installation instructions.

3.9 Pump Discharge Valves: Install pump discharge valves on each pump discharge line in lieu of separate shutoff valve, check valve, and balance cock. Install in horizontal or vertical position with stem in upward position; allow clearance above stem for check mechanism removal. Do not use for final balancing of the hydronic pumps. Final balancing shall be achieved by the maximum speed setting of the variable speed drive.

3.10 Pump Suction Diffusers: Install pump suction diffusers on each pump suction line in lieu of separate strainer, reducing elbow, entrance pipe, and pressure gauge outlet. Install on pump suction inlet, adjust foot support to carry weight of suction piping. Install nipple and shutoff valve in blowdown connection. After cleaning and flushing hydronic piping system, but before balancing of hydronic piping system, remove disposable fine mesh strainer.

END OF SECTION 23 21 16

SECTION 23 21 23 - HVAC PUMPS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Extent of HVAC pumps work required by this section is indicated on drawings and schedules, and by requirements of this section.

1.4 Pumps furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-23 sections.

1.5 Refer to Division-26 sections for the following work; not work of this section.

1.5.1 Power supply wiring from power source to power connection on pumps. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

1.5.2 Interlock wiring between pumps; and between pumps and field-installed control devices.

1.6 Codes and Standards: UL and NEMA Compliance: Provide electric motors and components which are listed and labeled by Underwriters Laboratories and comply with NEMA standards.

1.7 Submittals:

1.7.1 Product Data: Submit manufacturer's pump specifications, installation and start-up instructions, and current accurate pump characteristic performance curves with selection points clearly indicated.

1.7.2 Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

1.7.3 Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to HVAC pumps. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

1.7.4 Maintenance Data: Submit maintenance data and parts lists for each type of pump, control, and accessory; including "trouble-shooting" maintenance guide. Include these data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 1.

1.8 Manufacturer: Subject to compliance with requirements, provide pumps of one of the following:

Aurora
Bell and Gossett
Flo-Fab
Taco
Patterson

2 PRODUCTS

2.1 General: Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size, and capacity of each pump is listed in pump schedule. Provide pumps of same type by same manufacturer. Select pumps to be non-overloading over full range of curve.

2.2 Frame-Mounted End Suction Pumps:

2.2.1 General: Provide frame-mounted end suction pumps where indicated, and of capacities and having characteristics as scheduled.

2.2.2 Type: Horizontal mount, single stage, vertical split case, flexible coupling, base mounted, designed for 175 psi working pressure. Provide true back pull-out, capable of being serviced without disturbing piping connections for end suction pumps.

2.2.3 Casing: Cast iron, bronze fitted, 125 psi ANSI flanges, tappings for gauge and drain connections. Provide pump volute with integrally-cast pedestal support.

2.2.4 Shaft: Steel with replaceable shaft sleeve.

2.2.5 Bearings: Regreasable ball bearings.

2.2.6 Seal: Mechanical, with carbon seal ring and ceramic seat.

2.2.7 Motor: Open drip-proof, non-overloading at any point on pump curve, with regreasable 50,000 hour life ball bearings, high efficiency, as per Division 20, Basic Materials and Methods section, "Motors".

2.2.8 Impeller: Bronze, enclosed type, hydraulically and dynamically balanced, keyed to shaft and secured with locking screw.

2.2.9 Baseplate: Structural steel with welded cross members, and open grouting area.

2.2.10 Coupling: Flexible, capable of absorbing torsional vibration, equipped with coupling guard.

3 EXECUTION

3.1 Examine areas and conditions under which HVAC pumps are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 Installation of Pumps: Install HVAC pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized industry practices to ensure that HVAC pumps comply with requirements and serve intended purposes.

3.3 Access: Provide access space around HVAC pumps for service as indicated, but in no case less than that recommended by manufacturer.

3.4 Support: Install base-mounted pumps on minimum of 4" high concrete inertia base equal or greater than 3 times total weight of pump and motor, and anchor bolts poured in place. Set and level pump, grout under pump base with non-shrink grout. Refer to Division-23 section "Vibration Isolation" for support and mounting requirements of HVAC pumps.

3.5 Piping Connections: Refer to Division-23 HVAC piping sections. Provide piping, valves, accessories, gages, supports, and flexible connections as indicated. Provide 10 gage black steel drip pan under chilled water pumps with 3/4" drain line to floor drain.

3.6 Alignment: Check alignment, and where necessary, realign shafts of motors and pumps within recommended tolerances by manufacturer, and in presence of manufacturer's service representative.

3.7 Start-Up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.

3.8 Refer to Division-23 section "HVAC Test-Adjust-Balance" for pump system balancing; not work of this section.

3.9 Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 23 21 23

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SECTION 23 31 13 - HVAC METAL DUCTWORK

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods Sections apply to work of this section.

1.3 Extent of HVAC metal ductwork is indicated on drawings and in schedules, and by requirements of this section.

1.4 Refer to other Division-23 sections for exterior insulation of metal ductwork.

1.5 Refer to other Division-23 sections for ductwork accessories.

1.6 Codes and Standards:

1.6.1 SMACNA Standards: Comply with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible" 1985 Edition for fabrication and installation of metal ductwork, unless otherwise noted.

1.6.2 NFPA 90A Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.6.3 NFPA 96 Compliance: Comply with NFPA 96 "Standard for Installation of Equipment for Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment".

1.7 Approval Submittals:

1.7.1 Product Data: Submit manufacturer's technical product data and installation instructions for the following.

Factory-fabricated ductwork
Sealants
Duct liner
Adhesive
Flexible duct
Spin-in fittings
Side take-off fittings

1.7.2 Shop Drawings: Submit scaled layout drawings of HVAC metal ductwork and fittings including, but not limited to, duct sizes, locations, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between ductwork and proximate equipment. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that free area, materials, and rigidity are not reduced.

2 PRODUCTS

2.1 Ductwork Materials:

2.1.1 Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains and discolorations, and other imperfections, including those which would impair painting.

2.1.2 Galvanized Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A 527, lockforming quality; with G 90 zinc coating in accordance with ASTM A 525; and mill phosphatized for exposed locations. Stamp gauge and manufacturer's identification on each sheet. Break sheets so that identification is exposed.

2.1.3 Stainless Steel Sheet: Where indicated, provide 18-gauge stainless steel complying with ASTM A 167; Type 316; with No. 4 finish where exposed to view in occupied spaces. Provide No. 1 finish elsewhere. Protect finished surfaces with mill-applied adhesive protective paper, maintained through fabrication and installation.

2.2 Miscellaneous Ductwork Materials:

2.2.1 General: Provide miscellaneous materials and products of types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

2.2.2 Duct Liner: Fibrous glass, 1½ pcf minimum density, complying with Thermal Insulation Manufacturers Association (TIMA) AHC-101; of thickness indicated. Certainteed "Coated Ultralite", Owens Corning "Aeroflex", PPG "Textrafine", or Manville "Linacoustic".

2.2.3 Duct Liner Adhesive: Comply with ASTM C 916 "Specifications for Adhesives for Duct Thermal Insulation".

2.2.4 Duct Liner Fasteners: Comply with SMACNA HVAC Duct Construction Standards, Article S2.11.

2.2.5 Duct Sealant: Provide non-hardening, non-migrating mastic or liquid elastic sealant, type applicable for fabrication/installation detail, as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork.

2.2.6 Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork. For exposed stainless steel ductwork, provide matching stainless steel support materials.

2.2.7 Flexible Ducts: Provide flexible ductwork with an R-value of R-6unless the ductwork is in a ceiling return plenum. The use of flexible ductwork for connection of supply air including terminal units and return air devices is acceptable only where shown on the drawings.

2.2.7.1 Construction: Provide reinforced metalized polyester jacket that is tear and puncture resistant, air tight inner core with no fiberglass erosion in the air stream and an encapsulated wire helix. Flexible ductwork shall have a recommended operating pressure of 6" w.g. for sizes 4" through 12" diameter and 4" w.g. for sizes 14" through 20" diameter. All diameters shall be suitable for a negative operating pressure of 0.75" w.g. Flexible ductwork shall meet the requirements of UL-181, the Florida Energy Code, Florida Building Code, NFPA 90A and NFPA 90B.

2.2.7.2 Acceptable Manufacturers: Subject to compliance with requirements, provide R-6 flexible ductwork by: Atco 36, Flexmaster 8M-R6 or Thermaflex M-KE R6.

2.2.8 Spin-in and Side Take-off Fittings: Provide round branch run-outs as follows.

2.2.8.1 Spin in air device connections shall be straight sided spin in with damper and two inch high insulation stand-off equal to Crown 3720-DS.

2.2.8.2 Where duct height does not permit the use of spin-in fittings, use low profile side take-off fittings equal to Crown 3300-DS or Flexmaster STOD-BO.

2.2.9 Fittings: Provide radius type fittings fabricated of multiple sections with maximum 15° change of direction per section. Unless specifically detailed otherwise, use 45° laterals and 45° elbows for branch takeoff connections. Where 90° branches are indicated, provide conical type tees.

2.3 Fabrication:

2.3.1 Shop fabricate ductwork in 4, 8, 10 or 12-ft lengths, unless otherwise indicated or required to complete runs. Preassemble work in shop to greatest extent possible, so as to minimize field assembly of systems. Disassemble systems only to extent necessary for shipping and handling. Match-mark sections for reassembly and coordinated installation.

2.3.2 Shop fabricate ductwork of gauges and reinforcement complying with SMACNA "HVAC Duct Construction Standards", except provide sealant at all joints. Supply duct between AHU discharge and terminal units shall be minimum 4" pressure class. Duct downstream of terminal units, supply duct from low pressure air conditioning units, and all return and exhaust duct shall be minimum 2" pressure class unless otherwise noted.

2.3.3 Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with center-line radius equal to 1½ times associated duct width; and fabricate to include turning vanes in elbows where shorter radius is necessary. Limit angular tapers to 30° for contracting tapers and 20° for expanding tapers.

2.3.4 Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Division-23 section "Ductwork Accessories" for accessory requirements.

2.3.5 Fabricate duct plenums with duct liner where indicated. Laminate liner to internal surfaces of duct (100% coverage) in accordance with instructions by manufacturers of lining and adhesive, and fasten with mechanical fasteners (Grip Nails or Stic Klips) on 16 centers. On horizontal runs install top and bottom first and wedge sides between top and bottom. Apply a brush coat of fire retardant over all joints, visible cut edges, and leading edges to prevent erosion.

2.4 Factory-Fabricated Low Pressure Ductwork (Maximum 2" W.G.):

2.4.1 Material: Galvanized sheet steel complying with ASTM A 527, lockforming quality, with ASTM A 525, G90 zinc coating, mill phosphatized.

2.4.2 Gauge: 28-gauge minimum for round ducts and fittings, 4" through 8" diameter. 26-gauge minimum 9" through 14", 24-gauge minimum 15" through 26".

2.4.3 Elbows: One piece construction for 90° and 45° elbows 14" and smaller. Provide multiple gore construction for larger diameters with standing seam circumferential joint.

2.4.4 Divided Flow Fittings: 90° tees, constructed with saddle tap spot welded and bonded to duct fitting body.

2.4.5 Acceptable Manufacturers: Subject to compliance with requirements, provide factory-fabricated ductwork by Semco Mfg., Inc. or United Sheet Metal Div., United McGill Corp, or approved equal.

2.5 Factory-Fabricated High Pressure Ductwork (3" W.G. and Higher):

2.5.1 Round Ductwork: Construct of galvanized sheet steel complying with ASTM A 527 by the following methods and in minimum gauges listed.

Diameter	Minimum Gauge	Method of Manufacture
3" to 14"	26	Spiral Lockseam
15" to 26"	24	Spiral Lockseam
27" to 36"	22	Spiral Lockseam
37" to 50"	20	Spiral Lockseam
51" to 60"	18	Spiral Lockseam
Over 60"	16	Longitudinal Seam

Provide locked seams for spiral duct; fusion-welded butt seam for longitudinal seam duct.

Fittings and Couplings: Construct of minimum gauges listed. Provide continuous welds along seams.

Diameter	Minimum Gauge
3" to 36"	20
38" to 50"	18
Over 50"	16

2.5.2 Flat-Oval Ductwork: Construct of galvanized sheet steel complying with ASTM A 527, of spiral lockseam construction, in minimum gauges listed.

Maximum Width	Minimum Gauge
Under 25"	24
25" to 48"	22
49" to 70"	20
Over 70"	18

Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams.

Maximum Width	Minimum Gauge
Under 37"	20
37" to 50"	18
Over 50"	16

2.5.3 Internally Insulated Duct and Fittings: Construct with outer pressure shell, 2" thick insulation layer, and perforated inner liner. Construct shell and liner of galvanized sheet steel complying

with ASTM A 527, of spiral lockseam construction, use longitudinal seam for over 59", in minimum gauges listed.

Nominal Duct Diameter	Outer Shell	Inner Liner
3" to 12"	26 ga.	24 ga.
13" to 24"	24 ga.	24 ga.
25" to 34"	22 ga.	24 ga.
35" to 48"	20 ga.	24 ga.
49" to 58"	18 ga.	24 ga.
Over 59"	16 ga.	20 ga.

Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams of outer shell.

Nominal Duct Diameter	Outer Shell	Inner Liner
3" to 34"	20 ga.	20 ga.
36" to 48"	18 ga.	20 ga.
Over 48"	16 ga.	20 ga.

Inner Liner for Straight Duct: Perforate with 3/32" holes for 22% open area. Provide metal spacers welded in position to maintain spacing and concentricity. Provide a plastic film between the perforated liner and insulation to act as a vapor barrier.

Inner Liner for Fittings: Solid sheet metal. Provide metal spacers welded in position to maintain spacing and concentricity.

2.5.4 Optional Ducts and Fittings: At Installer's option, provided that certified tests by Manufacturer show that rigidity and performance is equivalent to SMACNA standard gauge ductwork, provide ducts and fittings as follows:

Ducts: Construct of Manufacturer's standard gauge, with spiral lock seam and intermediate standing rib.

Fittings: Construct by fabricating with spot welding and bonding with neoprene-base cement in lieu of continuous weld seams.

2.5.5 Acceptable Manufacturers: Subject to compliance with requirements, provide factory-fabricated ductwork Semco Mfg., Inc. or United Sheet Metal Div., United McGill Corp., or approved equal.

3 EXECUTION

3.1 General: Examine areas and conditions under which HVAC metal ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 Installation of Metal Ductwork:

3.2.1 General: Assemble and install ductwork in accordance with recognized industry practices which will achieve air-tight (5% leakage for systems rated 3" and under; 1% for systems rated over 3") and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support

ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling. Support vertical ducts at every floor.

3.2.2 Supports: Install concrete inserts for support of ductwork in coordination with formwork, as required to avoid delays in work. Install self-drilling screw anchors in prestressed concrete or existing work.

3.2.3 Field Fabrication: Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements. Seal joints in round or oval ductwork with hard cast or shrink bands, and sheet metal screws, or by welding. High velocity rectangular ducts shall have approved joints and be made airtight with sealer or welding.

3.2.4 Routing: Locate ductwork runs, except as otherwise indicated, vertically and horizontally. Avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct useable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Limit clearance to ½" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" clearance outside of insulation. In finished and occupied spaces, conceal ductwork from view by locating in mechanical shafts, hollow wall construction or above suspended ceilings, unless specifically noted as "Exposed". Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

3.2.5 Internally Lined Ductwork: Cover leading and trailing edge of duct liner with sheet metal nosing zee.

3.2.6 Electrical Equipment Spaces: Do not route ductwork through transformer vaults or other electrical equipment spaces and enclosures.

3.2.7 Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on 4 sides by at least 1½". Fasten to duct and substrate. Where ducts pass through fire-rated floors, walls, or partitions, provide firestopping between duct and substrate.

3.2.8 Coordination: Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.

3.2.9 Installation: Install metal ductwork in accordance with SMACNA HVAC Duct Construction Standards. Fan discharge outlet ducts shall be installed correctly with regard to "system effect" per AMCA Publication 201.

3.3 Installation of Flexible Ducts:

3.3.1 Maximum Length: For any duct run using flexible ductwork, do not exceed 5'-0" extended length. Flexible duct shall only be allowed as detailed on the drawings.

3.3.2 Installation: Install in accordance with Section III of SMACNA's "HVAC Duct Construction Standards, Metal and Flexible". Support flexible ducts to eliminate pinching and kinking which would restrict flow.

3.3.3 Downstream of VAV Boxes: Peel back insulation and slide the inner core over the spin-in or

diffuser neck, seal with duct sealant and install Panduit strap tightly. Slide insulation back over the inner core and install another Panduit strap over the insulation outer jacket. Tape is not acceptable.

3.3.4 Upstream of VAV Boxes: Install same as downstream, except use stainless steel worm-gear clamps instead of Panduit straps.

3.3.5 Seal all exposed edges of fiberglass insulation with glassfab and mastic.

3.4 Leakage Tests: After each duct system is completed, test for duct leakage in accordance with Sections 3 and 5 of the SMACNA HVAC Air Duct Leakage Test Manual. Test pressure shall be equal to pressure class of duct, less 0.5" static pressure. Repair leaks and repeat tests until total leakage is less than 5% of system design air flow for low pressure systems and less than 1% for systems rated over 3".

3.5 Equipment Connections: Connect metal ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery. Provide access doors as indicated.

3.6 Clean ductwork internally free of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration. Keep ducts closed with poly during construction to prevent contamination by construction dust and debris.

3.7 Balancing: Refer to Division-23 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork; not work of this section. Seal any leaks in ductwork that become apparent in balancing process.

3.8 System Adjustment: Adjust the system to provide functional operation to the extent possible, and leave ready for Testing and Balancing work. It is not the intent of this section to provide final testing and balancing, but to leave the system operational with a minimum of noise.

END OF SECTION 23 31 13

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SECTION 23 33 00 - DUCTWORK ACCESSORIES

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Extent of ductwork accessories work is indicated on drawings and in schedules, and by requirements of this section.

1.4 Refer to other Division-23 sections for testing, adjusting, and balancing of ductwork accessories; not work of this section.

1.5 Codes and Standards:

1.5.1 SMACNA Compliance: Comply with applicable portions of both SMACNA "HVAC Duct Construction Standards, Metal and Flexible" and "Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems".

1.5.2 UL Compliance: Construct, test, and label fire dampers in accordance with UL Standard 555 "Fire Dampers and Ceiling Dampers". Construct, test and label smoke dampers in accordance with UL Standard 555S "Leakage Rated Dampers for use in Smoke Control Systems" .

1.5.3 NFPA Compliance: Comply with applicable provisions of NFPA 90A "Air Conditioning and Ventilating Systems" pertaining to installation of ductwork accessories.

1.6 Approval Submittals:

1.6.1 Product Data: Submit manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction; and installation instructions as follows:

Low pressure manual dampers
Control dampers
Fire dampers
Duct access doors
Flexible connections

1.6.2 O&M Data Submittals: Submit manufacturer's maintenance data including parts lists for smoke dampers. Include this data, product data, and a copy of approval submittals in O&M manual.

2 PRODUCTS

2.1 Dampers:

2.1.1 Low Pressure Manual Dampers: Provide 16 gauge dampers of single-blade type (12" maximum blade width) or multiblade type. Damper blades to be gang-operated from a single shaft with nylon or ball bearings on each end. Provide indexed locking quadrant. Parallel or opposed blade style is acceptable. Provide 2" standoff on locking quadrant for externally insulated duct.

2.1.2 Control Dampers: Extruded aluminum (6063-T5) damper frame shall not be less than 0.080" in thickness. Damper frame shall be 4" deep x 1", with duct mounting flanges on both sides of frame. Damper frame shall have a 2" mounting flange on the rear of the damper when installed as Extended Rear Flange install type. Aluminum frame shall be clear anodized to a minimum thickness of 0.7 mil deep. Frame shall be assembled using stainless steel screws. Welded frames shall not be acceptable. Actuators (motors) are provided by control contractor.

2.1.2.1 Blades shall be maximum 6.4" deep extruded aluminum (6063-T5) air-foil profiles with a minimum wall thickness of 0.06", clear anodized to a minimum thickness of 0.7 mil deep.

2.1.2.2 Blade seals shall be extruded silicone, secured in an integral slot within the aluminum blade extrusions and shall be mechanically fastened to prevent shrinkage and movement over the life of the damper. Adhesive or clip-on type blade seals will not be approved.

2.1.2.3 Hexagonal control shaft shall be $^{7}/_{16}$". It shall have an adjustable length and shall be an integral part of the blade axle. A field-applied control shaft shall not be acceptable. All parts shall be stainless steel.

2.1.2.4 Linkage hardware shall be aluminum and stainless steel, installed in the frame side, out of the airstream, and accessible after installation. Linkage hardware shall be complete with stainless steel cup-point trunnion screws to prevent linkage slippage. Linkage that consists of metal rubbing metal will not be approved.

2.1.2.5 Dampers shall be designed for operation in temperatures ranging from -40°F to 212°F.

2.1.2.6 Dampers shall be AMCA rated for Leakage Class 1A at 1 in w.g. static pressure differential. Standard air leakage data to be certified under the AMCA Certified Ratings Program.

2.1.2.7 Dampers shall be custom made to required size, with blade stops not exceeding 1¼" in height.

2.1.2.8 Dampers shall be opposed blade for modulating dampers or parallel blade action for open/shut dampers.

2.1.2.9 Dampers shall be installed in the following manner: Installed in Duct

2.1.2.10 Installation of dampers must be in accordance with manufacturer's current installation guidelines, provided with each damper shipment.

2.1.2.11 Field supplied intermediate structural support is required to resist applied pressure loads for dampers that consist of two or more sections in both height and width.

2.1.2.12 Acceptable Manufacturers: Subject to compliance with requirements, provide access doors by TAMCO (T.A. Morrison & Co, Inc), Pottorff, Ruskin, or approved equal.

2.1.3 Acceptable Manufacturers: Subject to compliance with requirements, provide dampers by Air Balance, American Warming & Ventilating, Arrow Louver and Damper, Penn Ventilator Co., or Ruskin Mfg. Co.

2.2 Fire Dampers:

2.2.1 Smoke Dampers: Provide curtain type fire dampers, UL classified and labeled per UL 555, of types and sizes indicated. Construct casings and blades of galvanized steel. Damper shall not restrict duct free area when open. Dampers shall be rated for dynamic closure under flow and pressure. Provide sleeves and mounting angles. Provide fusible link rated at 160 to 165° F unless otherwise indicated. Provide damper with positive lock in closed position. All dampers shall be spring activated. Basis of design:

1-1/2 HR: Ruskin IBD2 - Style B for rectangular, Style CR for round, Style CO for oval.

1-1/2 HR: Ruskin IBDT for transfer grilles in narrow partitions.

HR: Ruskin IBD23 - Style B for rectangular, Style CR for round, Style CO for oval

2.2.2 Acceptable Manufacturers: Subject to compliance with requirements, provide fire dampers by Air Balance, Inc., American Warning & Ventilating, Arrow Louver and Damper, Penn Ventilator Co., or Ruskin Mfg. Co.

2.3 Turning Vanes: Provide manufactured or fabricated single wall turning vanes and vane runners, constructed in accordance with SMACNA "HVAC Duct Construction Standards".

2.4 Duct Access Doors:

2.4.1 General: Provide duct access doors of size indicated, or as required for duty indicated.

2.4.2 Construction: Construct of same or greater gauge as ductwork served. Provide insulated doors for insulated ductwork. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. Provide one side hinged, other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors.

2.4.3 Acceptable Manufacturers: Subject to compliance with requirements, provide access doors by Air Balance, Inc., Duro Dyne Corp., Ruskin Mfg. Co., or Ventfabrics, Inc.

2.5 Flexible Connections:

2.5.1 General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment.

2.5.2 Acceptable Manufacturers: Subject to compliance with requirments, provide products by one of the following: Duro Dyne Corp., Flexaust (The) Co., or Ventfabrics, Inc.

3 EXECUTION

3.1 Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 Installation of Ductwork Accessories:

3.2.1 Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.

3.2.2 Install balancing dampers at all main ducts adjacent to units in return air, outside air and where indicated.

3.2.3 Install control dampers in the outside air duct and return air duct for each air handler. Damper operator provided by control contractor.

3.2.4 Install turning vanes in square or rectangular 90º elbows in supply, return, and exhaust air systems, and elsewhere as indicated.

3.2.5 Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter. Install on entering air side of reheat coils. Install at fire dampers and smoke dampers. Opening size shall be per NFPA 90A for servicing fire and smoke dampers. Provide label with 1-1/2" letters to indicate location of fire protection devices—FIRE DAMPER ACCESS or SMOKE DAMPER ACCESS.

3.2.6 Install flexible connections in ductwork such that the clear length of the connector is approximately two inches. Provide thrust restraints as required. Flexible material shall not be so slack as to take a definite concave or convex shape during fan operation.

3.2.7 Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

3.2.8 Install fire dampers within fire walls and at locations shown on the mechanical drawings. Install in strict accordance with the manufacturer's printed instructions, NFPA 90A, and UL 555. Basis of design installation is detailed on the drawings.

3.3 Fire Dampers: Notify Engineer at least 24 hours in advance of ceiling installation or chase closure so that complete fire damper installation can be observed. A copy of the manufacturer’s printed installation instructions shall be available at the site.

3.4 Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories as required to obtain proper operation and leakproof performance.

3.5 Adjusting and Cleaning:

3.5.1 Adjusting: Adjust ductwork accessories for proper settings.

3.5.2 Final positioning of manual dampers is specified in Division-23 section "Testing, Adjusting, and Balancing". However, the system shall be left functional with all dampers open or throttled.

3.5.3 Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 23 33 00

SECTION 23 34 00 - FANS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Extent of fan work required by this section as indicated on drawings and schedules, and by requirements of this section.

1.4 Coordination:

1.4.1 Refer to Division-7 sections for installation of prefabricated roof curbs; not work of this section. Furnishing prefabricated roof curbs is part of this section's work.

1.4.2 Refer to Division-23 section "Testing, Adjusting, and Balancing" for balancing of fans.

1.4.3 Refer to Division-23 HVAC control systems sections for control work required in conjunction with fans.

1.4.4 Refer to Division-26 sections for power supply wiring from power source to power connection on fans. Division-26 work will include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

1.5 Codes and Standards:

1.5.1 AMCA Compliance: Provide fans which have been tested and rated in accordance with AMCA standards, and bear AMCA Certified Ratings Seal.

1.5.2 UL Compliance: Provide fans which are listed by UL and have UL label affixed.

1.6 Approval Submittals:

1.6.1 Product Data: Submit manufacturer's technical data for fans, including specifications, capacity ratings, dimensions, weights, materials, accessories furnished, and installation instructions. Submit assembly-type drawings showing unit dimensions, construction details, methods of assembly of components, and field connection details.

Fans
Vibration Control

1.7 O&M Data Submittals: Submit maintenance data and parts list for each type of fan, accessory, and control. Include these data, a copy of approved submittals, and wiring diagrams in O&M Manual.

2 PRODUCTS

2.1 General: Except as otherwise indicated, provide standard prefabricated fans of type and size indicated, modified as necessary to comply with requirements, and as required for complete installation. Provide accessories as listed in the schedule on the drawings and as described herein. Motors shall be high efficiency per Division-23 section "Motors".

2.2 Acceptable Manufacturers: Subject to compliance with requirements provide fans manufactured by Acme, Greenheck, Loren Cook, Penn or approved equal unless otherwise noted herein.

2.3 In-Line Centrifugal Fans:

2.3.1 Housing: Provide square weather tight housing constructed of aluminum or steel and painted inside and out with an epoxy finish. Provide venturi type inlet. Provide heavy duty duct collars. Housing and bearing supports shall be constructed of heavy gauge bolted and welded steel construction. Provide two sided access panels, located perpendicular to the motor mounting plane. Provide ½" insulated housing. Provide motor and drive cover for belt drive units.

2.3.2 Fan Wheels: Provide aluminum air foil type, backward curved, statically and dynamically balanced.

2.3.3 Drive: Provide direct or belt drive as scheduled with pre-lubricated, ball bearing, continuous duty type motors. Provide vibration isolation equipment for the entire drive.

2.3.4 Isolation and Support: Provide spring type vibration isolators and fan support brackets.

2.4 Vibration Isolation: Mount fans on vibration isolators in accordance with the requirements of Division-23 section "Vibration Isolation" and the following list.

2.4.1 Hangers: Type HA2.

2.5 Centrifugal Ceiling Exhausters:

2.5.1 Fan Assembly: Provide steel housing, plastic or aluminum grille, backdraft damper, statically and dynamically balanced fan wheel, permanently lubricated motor with internal thermal overloads, vibration isolation and all required mounting hardware and brackets. Provide acoustically treated housing for all fans larger than 60 cfm. Mounting type shall be as indicated on the drawings or on the schedule.

2.5.2 Connectors: Provide adaptors, connectors, and eave elbows as required to connect fan discharges to outlets.

2.5.3 Outlets: Provide where shown on the drawings (or required by the installation) wall caps, vent caps, or louvers, each with birdscreen, to match fans and surrounding construction.

3 EXECUTION

3.1 General: Except as otherwise indicated or specified, install fans in accordance with manufacturer's installation instructions and recognized industry practices to insure that fans serve their intended function.

3.2 Coordinate fan work with work of roofing, walls, and ceilings as necessary for proper interfacing. Framing of openings, caulking, and curb installation is not work of this section.

3.3 Ductwork: Refer to Division-23 section "Ductwork". Connect ducts to fans in accordance

with manufacturer's installation instructions. Provide flexible connections in ductwork at fans.

3.4 Install fans on vibration isolation equipment as required. Set level and plumb.

3.5 Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical Installer. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Verify proper rotation direction of fan wheels. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

3.6 Remove shipping bolts and temporary supports within fans. Adjust dampers for free operation.

3.7 Testing: After installation of fans has been completed, test each fan to demonstrate proper operation of units at performance requirements specified. When possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.

3.8 Cleaning: Clean factory-finished surfaces. Remove all tar and soil. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION 23 34 00

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SECTION 23 36 16 – VARIABLE AIR VOLUME TERMINAL UNITS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Extent of air terminals work required by this section is indicated on drawings and schedules, and by requirements of this section.

1.4 Refer to other Division-23 sections for external insulation of air terminals; not work of this section.

1.5 Refer to other Division-23 sections for testing, adjusting and balancing of air terminals; not work of this section.

1.6 Refer to other Division-23 sections for temperature controls which are to be furnished by others but installed as work of this section.

1.7 Refer to Division-26 sections for the following work; not work of this section. Power supply wiring from power source to power connection on air terminals. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

1.8 Codes and Standards:

1.8.1 ADC Compliance: Provide air terminals which have been tested and rated in accordance with ADC standards.

1.8.2 NFPA Compliance: Construct air terminals using acoustical and thermal insulations complying with NFPA 90A "Air Conditioning and Ventilating Systems".

1.9 Approval Submittals:

1.9.1 Product Data: Submit manufacturer's technical product data, including performance data for each size and type of air terminal furnished; schedule showing drawing designation, room location, number furnished, model number, size, and accessories furnished; and installation and start-up instructions. Submit manufacturer's assembly-type drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

Shutoff single duct VAV boxes

1.10 O&M Data Submittals:

1.10.1 Wiring Diagrams: Submit ladder-type wiring diagrams for electric power and control components, clearly indicating required field electrical connections. Include in O&M manual.

1.10.2 Maintenance Data: Submit maintenance data and parts list for each type of air terminal; including "trouble-shooting" maintenance guide. Include this data and a copy of approval submittals in O&M manual.

2 PRODUCTS

2.1 Acceptable Manufacturers: Subject to compliance with requirements, provide air terminals of one of the following (unless otherwise noted): Trane, Titus, Enviro-Tec, Price, or approved equal.

2.2 General: Provide factory-fabricated and tested air terminals as indicated, selected with performance characteristics which match or exceed those indicated on schedule.

2.3 Shutoff Single Duct: Provide pressure independent single duct, shut-off variable volume terminal units with the following characteristics, features and accessories and as indicated on drawings and schedule.

2.3.1 Casings: The unit casing shall be minimum 22 gauge galvanized steel, internally lined with engineered polymer foam insulation which complies with UL 181 and NFPA 90A. Insulation shall be 1.5 pound density, closed cell foam. Exposed fiberglass is not acceptable. The insulation shall be mechanically fastened to the unit casing. All exposed insulation edges shall be coated with NFPA 90A approved sealant to prevent erosion. Provide air valve access panel in the casing Casing and panel shall be sealed to hold leakage to 2% of rated airflow at 3.0" w.g.

2.3.2 Air Dampers: Damper shall be heavy gauge metal, with shaft rotating in self-lubricating nylon or equal bearings. Shaft shall be marked on the end to indicate the damper blade position. Unit shall be designed for field conversion from normally open to normally closed, or vice versa, without relocating the actuator, changing parts or adding relays. The damper shall seal against a closed-cell foam gasket, to limit close-off leakage to 10 cfm at 4.0" w.g. The damper shall not unseat at 6.0" w.g.

2.3.3 Provide hanger brackets for attachment of supports.

2.3.4 Access: Provide removable panels in casings to permit access to air dampers and other parts requiring service, adjustment, or maintenance.

2.3.5 Controls: Units shall have pressure independent DDC controls provided by the DDC contractor.

The unit inlet shall be equipped with a flow sensor with amplifying pressure pickup points connected to central averaging chambers. The sensor shall maintain control accuracy with the same size inlet duct in any configuration. The flow sensor shall have a minimum of three sensor points.

The terminal unit manufacturer shall supply a metal enclosure with access panel sealed from air flow and mounted on the side of the terminal unit to house field mounted digital controls. The terminal unit manufacturer shall provide a 120V to 24V controls transformer.

The DDC contractor shall provide an actuator. The damper shall move in a smooth, steady progression without dead spots. Refer to controls drawings for sequence of operations.

2.3.6 Hot Water Reheat Coils: Provide factory mounted heating coils constructed of copper tubes

and aluminum fins with galvanized steel casing.

2.3.7 Noise Ratings: Provide terminals with the NC performance data scheduled.

3 EXECUTION

3.1 Examine areas and conditions under which air terminals are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 General: Install air terminals as indicated, and in accordance with manufacturer's installation instructions.

3.3 Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.

3.4 Duct Connections: Connect ductwork to air terminals in accordance with Division-23 ductwork sections.

3.5 Upon completion of installation and prior to initial operation, test and demonstrate that air terminals, and duct connections to air terminals, are leak-tight.

3.6 Repair or replace air terminals and duct connections as required to eliminate leaks, and retest to demonstrate compliance. Leave operational and ready for Testing and Balancing work.

3.7 Clean exposed factory-finished surfaces. Repair any marred or scratched surfaces with manufacturers touch-up paint.

END OF SECTION 23 36 16

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SECTION 23 37 13 - GRILLES, REGISTERS, AND CEILING DIFFUSERS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Extent of air outlets and inlets work is indicated by drawings and schedules, and by requirements of this section.

1.4 Refer to other Division-23 sections for ductwork and duct accessories required in conjunction with air outlets and inlets and for balancing of air outlets and inlets; not work of this section.

1.5 Codes and Standards:

1.5.1 ADC Compliance: Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual". Provide air outlets and inlets bearing ADC Certified Rating Seal.

1.5.2 NFPA Compliance: Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.6 Approval Submittals:

1.6.1 Product Data: Submit manufacturer's technical product data for air outlets and inlets indicating construction, finish, and mounting details.

1.6.2 Performance Data: For each type of air outlet and inlet furnished, provide aspiration ability, temperature and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections and data as required.

1.7 O&M Data Submittals: Submit cleaning instructions for finishes and spare parts lists. Include this data and a copy of approval submittals in O&M manual.

2 PRODUCTS

2.1 General:

2.1.1 Except as otherwise indicated, provide manufacturer's standard grilles, registers, and ceiling diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

2.1.2 Manufacturers not listed in the following specification will not be considered for approval unless accepted by addendum prior to bid.

2.1.3 Performance: Provide grilles, registers and ceiling diffusers that have, as minimum,

temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device equal to the basis of design.

2.1.4 Ceiling and Wall Compatibility: Provide grilles, registers and diffusers with border styles that are compatible with adjacent wall and ceiling systems, and that are specifically manufactured to fit into ceiling module or wall with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems and walls which will contain each type of ceiling diffuser, grille, or register.

2.1.5 Appearance: All grilles and registers shall be aluminum construction and all diffusers shall be steel or aluminum construction, unless otherwise noted, with uniform matching appearance for each type of outlet. Ceiling mounted grilles and registers shall be set to be sight tight from the predominant exposure.

2.1.6 Finish: All ceiling mounted grilles, registers, and diffusers shall be finished with manufacturer's standard color to be selected by the architect. Wall and door mounted grilles and registers shall be finished with clear anodized finish .

2.2 Acceptable Manufacturers: Subject to compliance with requirements, provide products by Titus, Price, Krueger, or Metal Aire.

2.3 Rectangular Ceiling Diffusers: Provide rectangular face, adjustable diffuser with removable inner core, no corner joints. If square or rectangular neck is provided, provide square to round adaptor as required. Provide lay-in panel as required. Provide beveled trim ring for diffusers in hard ceilings.

2.4 Square Ceiling Diffusers: Provide square face, adjustable, 360 degree pattern diffusers with one-piece stamped cones, no corner joints, round necks. Provide lay-in panel as required.

2.5 Return Grilles : Provide return grilles with one set of 45 degree fixed louvers, parallel to the long dimension. Provide mounting frame for all wall and plaster ceiling installations.

3 EXECUTION

3.1 Coordinate installation with ceiling and light fixture installation. Locate ceiling outlets as indicated on architectural Reflected Ceiling Plans. Unless otherwise indicated, locate ceiling outlets in the center of acoustical ceiling modules with sides parallel to the grid.

3.2 Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended functions.

3.3 Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air outlets and inlets with other work.

3.4 Set air volumes to values shown on the drawings so that the system is functional. Leave ready for test and balance contractor.

3.5 Furnish to Owner three operating keys for each type of outlet and inlet that require them; obtain receipt.

END OF SECTION 23 37 13

SECTION 23 37 26 - WALL LOUVERS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Extent of wall louver work is indicated by drawings and schedules, and by the requirements of this section.

1.4 Refer to other Division-23 sections for ductwork, duct accessories and controls work.

1.5 AMCA Compliance: Test and rate louvers in accordance with AMCA Standard 500. Provide AMCA certified rating seal. Ratings based on tests and procedures performed in accordance with AMCA 500-L and complying with the AMCA 511 Certified Ratings Program. AMCA Certified Ratings Seal applies to air performance, water penetration and wind driven rain ratings.

1.6 Product Qualifications:

1.6.1 Florida Product Approved Louvers:

1. Miami-Dade County, Florida Notice of Acceptance (NOA).
2. Florida Building Code Approval.
3. Louver shall be certified to Florida Building Code Testing Application Standards TAS 100(A) (Wind Driven Rain Resistance), TAS 201 (Large Missile Impact), TAS 202 (Uniform Static Air Pressure) and TAS 203 (Cyclic Wind Loading).
4. AMCA Listed for compliance to AMCA 540 Level E and AMCA 550 standards.

1.6.2 ICC 500 Approved Louvers:

1. FEMA 361
2. ICC 500
3. Louver shall be UL classified wind-storm rated assembly to static and cyclical design pressures of positive/negative 250 psf and debris impact of a 15 lb 2x4 travelling at 100 mph.

1.7 Approval Submittals:

1.7.1 Product data: Submit manufacturer's technical product data for louvers including: model number, accessories furnished, construction, finish, mounting details, performance data.

1.8 O&M Data Submittals: Submit maintenance data, including cleaning of finishes and a copy of approval submittals. Include in O&M manual.

2 PRODUCTS

2.1 Acceptable Manufacturers: Subject to compliance with requirements, submit products by Ruskin, Greenheck, Arrow, American Warming and Ventilating, or AMCA labeled approved equal.

2.2 General: Except as otherwise indicated, provide manufacturer's standard louvers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation. Provide Kynar 500 coated, corrosion resistant finish and 5 year warranty; color to be selected by the Owner.

2.3 Substrate Compatibility: Provide Florida Product approved louvers with 9 inch frame and FEMA louvers with 5-1/2 inch frame, each with flange and sill extension piece that are compatible with adjacent substrate, and that are specifically manufactured to fit into construction openings with accurate fit and adequate support, for weatherproof installation. Refer to general construction drawings and specifications for types of substrate which will contain each type of louver.

2.4 Materials:

2.4.1 Florida Product Approved Louvers: Construct of aluminum extrusions, Alloy 6063-T6 0.081" thick for frame and 0.081" thick for front blades and 0.060" thick for back blades. Weld units or use stainless steel fasteners.

2.4.2 FEMA Louvers: Frame shall be constructed of ¼" thick aluminum. Blades shall be 3"x3"x1/4" thick inverted V style extruded aluminum.

2.5 Sill Flashing: Formed aluminum, 0.080" thick, upturned sides to prevent water leakage.

2.6 Installation Angles: Material: 1.375 x 2.25 inch x 0.125 inch thick continuous aluminum angles around louver perimeter for installation in concrete, deep CMU, steel and wood substrate wall systems.

2.7 Installation Plates: Material: 0.250 inch (6.4 mm) thick continuous aluminum flat or zee plates for installation in thin CMU substrate wall systems.

2.8 Louver Screens: On inside face of exterior louvers, provide 1/2" square mesh anodized aluminum wire bird screens mounted in removable extruded aluminum frames.

2.9 Stationary Florida Product Approved Louvers: Hurricane and impact rated louvers, basis of design is Greenheck EHV-901D.

2.10 FEMA Louvers: Wind-storm rated louvers, basis of design is Greenheck AFL-501.

2.11 Performance Data

2.11.1 EHV-901D:

1. Performance Ratings: AMCA licensed.
   a. Based on testing 48 inches x 48 inches size unit in accordance with AMCA 500-L.
2. Free Area: 42 percent, nominal.
3. Free Area Size: 6.66 square feet.
4. Maximum Recommended Air Flow through Free Area: 2,155 feet per minute.
5. Air Flow: 10,431 cubic feet per minute.

6. Maximum Pressure Drop (Intake): 0.60 inches w.g..
7. Water Penetration: Beginning point of water penetration of 0.01 ounce per ft² of free area shall be above 1,250 feet per minute free area velocity.
8. Wind Load Rating: Maximum wind load of ±150 PSF.
9. AMCA 500-L Wind Driven Rain Performance: 99.9 percent effective at preventing water penetration through louver when tested at 50 miles per hour wind with 8 inches per hour rainfall and 2,155 feet per minute airflow through the free area. Penetration Class 'A' with Discharge Class (Intake) '3' in accordance with AMCA 500-L Wind Driven Rain Test.

2.11.2 AFL-501:

1. Performance Ratings: AMCA licensed.
   a. Based on testing 48 inches x 48 inches size unit in accordance with AMCA 500-L.
2. Free Area: 47.5 percent, nominal.
3. Free Area Size: 7.60 square feet.
4. Maximum Recommended Air Flow through Free Area: 2,000 feet per minute.
5. Air Flow: 15,200 cubic feet per minute.
6. Maximum Pressure Drop (Intake): 1.0 inches w.g..
7. Water Penetration: Beginning point of water penetration of 0.01 ounce per ft² of free area shall be above 552.5 feet per minute free area velocity.
8. Wind Load Rating: Maximum wind load of ±250 PSF.

3 EXECUTION

3.1 Install where shown on the drawings in accordance with the manufacturer's printed instruction and Florida Product Approval. Exercise care to prevent scratches.

3.2 Isolate dissimilar metals per the manufacturer's recommendations.

3.3 Verify size of louvers shown on drawings prior to fabrication. Coordinate with wall openings. Sizes may be altered subject to approval by Engineer provided free area remains approximately the same as indicated.

END OF SECTION 23 37 26

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SECTION 23 43 18 - BI POLAR IONIZATION AIR CLEANING EQUIPMENT

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Extent of air cleaning work required by this section is indicated on drawings and schedules, and by requirements of this section.

1.4 Refer to Division-23 air handling units section for filter boxes associated with air handling units; not work of this section.

1.5 Refer to Division-23 duct accessories section for duct access door work required in conjunction with air filters; not work of this section.

1.6 Refer to Division-26 sections for power supply wiring from power source to power connection on air filter units. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed by manufacturer.

1.7 Control wiring specified as work of Division 23 for Automatic Temperature Controls is work of that section.

1.8 Codes and Standards:

1.8.1 NFPA Compliance: Comply with applicable portions of NFPA 90A pertaining to installation of air filters.

1.8.2 UL Compliance: Comply with UL Standards pertaining to safety and performance of air filter units.

1.8.3 ASHRAE Compliance: Comply with provisions of ASHRAE Standard 52 for method of testing, and for recording and calculating air flow rates.

1.9 Approval Submittals:

1.9.1 Product Data: Submit manufacturer's technical product data including dimensions, weights, required clearances and access, flow capacity including initial and final pressure drop at rated air flow, efficiency and test method, fire classification, and installation instructions.

BiPolar Ionization

1.9.2 Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, materials, and methods of assembly of components.

BiPolar Ionization

1.10 Test Reports and Verification Submittals:

1.10.1 Submit HEPA filter test reports.

1.11 O&M Data Submittals:

1.11.1 Maintenance Data: Submit maintenance data and spare parts lists for each type of filter and rack required. Include this data, product data and a copy of approval submittals in O&M manual.

1.11.2 Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to air filter units. Submit manufacturer's ladder-type wiring diagram for control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed. Include in O&M manual.

2 PRODUCTS

2.1 BIPOLAR IONIZATION SYSTEM

2.1.1 The Air Purification System shall be a product of an established manufacturer within the USA.

2.1.2 A qualified representative from the manufacturer shall be available to inspect the installation of the air purification system to ensure installation in accordance with manufacturer's recommendation.

2.1.3 Technologies that do not address gas disassociation such as UV Lights, Powered Particulate Filters and/or polarized media filters shall not be considered. Uni-polar ion generators shall not be acceptable. “Plasma” particulate filters shall not be acceptable.

2.1.4 Projects designed using ASHRAE Standard 62, IAQ Procedure shall require the manufacturer to provide Indoor Air Quality calculations using the formulas within ASHRAE Standard 62.1-2016 to validate acceptable indoor air quality at the quantity of outside air scheduled with the technology submitted. The manufacturer shall provide independent test data on a previous installation performed within the last two years and in a similar application, that proves compliance to ASHRAE 62 and the accuracy of the calculations.

2.1.5 The Air Purification System have been tested by UL or Intertek/ETL to prove conformance to UL 867-2007 including the ozone chamber testing and peak ozone test for electronic devices. Manufacturers that achieved UL 867 prior to December 21, 2007 and have not been tested in accordance with the newest UL 867 standard with the ozone amendment shall not be acceptable. All manufacturers shall submit their independent UL 867 test data with ozone results to the engineer during the submittal process. All manufacturers shall submit a copy with their quotation. Contractors shall not accept any proposal without the proper ozone testing documentation.

2.1.6 The maximum allowable ozone concentration per the UL 867-2007 chamber test shall be 0.007 PPM. The maximum peak ozone concentration per the UL 867-2007 peak test as measured 2 inches away from the electronic air cleaner’s output shall be no more than 0.0042 PPM. Manufacturers with ozone output exceeding these ozone values shall not be acceptable.

2.1.7 Equipment shall be warranted by the manufacturer against defects in material and workmanship for a period of twelve months after shipment or eighteen months from owner acceptance, whichever occurs first. Labor to replace equipment under warranty shall be provided by the

owner or installing contractor.

2.1.8 General

The air purification system(s) shall be of the size, type, arrangement and capacity indicated and required by the unit furnished and shall be of the manufacturer specified.

Basis of Design: Global Plasma Solutions

Approved equals by Airgenics, Active Air Solutions, and Plasma Air subject to specification compliance. All other Suppliers of comparable products requesting prior approval shall:

Submit for prior approval in accordance with the requirements of Mechanical General.

In addition, manufacturers submitting for prior approval for Bi-Polar Ionization must as part of the prior approval request provide their ASHRAE 62.1-2016 calculations that prove conformance to the ASHRAE Standard with the reduction of outside air to the scheduled values. A letter on the manufacturer's letterhead requesting prior approval must accompany the request for prior approval stating their calculations are ASHRAE compliant. A third party validation study performed on a previous installation of the same application shall also be included.

Submit independent test data from ETL or UL showing ozone levels produced during the UL 867 ozone chamber test. Manufacturers without this test data shall not be acceptable.

2.1.9 Bi-Polar Ionization Design & Performance Criteria: Each piece of air handling equipment, so designated on the plans, details, equipment schedules and/or specifications shall contain a Plasma Generator with Bi-polar Ionization output as described here within.

2.1.10 The Bi-polar Ionization system shall be capable of:

Effectively killing microorganisms downstream of the bi-polar ionization equipment (mold, bacteria, virus, etc.).

Controlling gas phase contaminants generated from human occupants, building structure and furnishings.

Capable of reducing static space charges.

Increasing the interior ion levels, both positive and negative, to a minimum of 800 ions/cm^3 measured 5 feet from the floor.

2.1.11 The bi-polar ionization system shall operate in a manner such that equal amounts of positive and negative ions are produced. Uni-polar ion devices shall not be acceptable.

Air exchange rates may vary through the full operating range of a constant volume or VAV system. The quantity of air exchange shall not be increased due to requirements of the air purification system.

Velocity Profile: The air purification device shall not have maximum velocity profile.

2.1.12 Humidity: Plasma Generators shall not require preheat protection when the relative humidity of the entering air exceeds 85%. Relative humidity from 0 - 100%, condensing, shall not cause damage, deterioration or dangerous conditions within the air purification system. Air purification system shall be capable of wash down duty.

2.1.13 Equipment Requirements:

Electrode Specifications (Bi-polar Ionization):

Each Plasma Generator with Bi-polar Ionization output shall include the required number of electrodes and power generators sized to the air handling equipment capacity. A minimum of one electrode pair per 2400 CFM of air flow shall be provided. Bi-polar ionization tubes manufactured of glass and steel mesh shall not be acceptable due to replacement requirements, maintenance, performance output reduction over time, ozone production and corrosion.

Electrodes shall be energized when the main unit disconnect is turned on and the fan is operating. Internal circuitry shall be provided to sense air flow across the electrode output. Ionization systems requiring the use of a mechanical air pressure switch to cycle the electrodes only when the fan is operating shall not be acceptable due to high failure rates and pressure sensitivity.

2.1.14 Air Handler Mounted Units: Plasma Generator(s) shall be supplied and installed. The plasma generator shall accept 120V power and the plasma generator company shall provide a 12V DC power supply to the control panel. The unit shall be designed with a stainless steel casing, integral illuminated on/off switch, two 2.5mm DC power jacks, high voltage output indication light and dry contacts to prove ion output is operating properly. The dry contacts shall close to prove the ion generator is working properly and may be daisy chained in series such that only one dry contact per AHU is required to interface to the BAS or the optional DDC controller. Dry contacts proving power has been applied in lieu of the ion output is actually operating, are not acceptable.

2.1.15 Ionization Requirements: Plasma Generators with Bi-polar ionization output shall be capable of controlling gas phase contaminants and shall be provided for all equipment listed above. The Bi-polar ionization system shall consist of Bi-Polar Plasma Generator and power supply. The Bi-polar system shall be installed where indicated on the plans or specified to be installed. The device shall be capable of being powered by DC power or 24VAC or 110VAC to 240VAC without the use of an external transformer. Ionization systems requiring isolation transformers shall not be acceptable.

Ionization Output: The ionization output shall be controlled such that an equal number of positive and negative ions are produced. Imbalanced levels shall not be acceptable.

Ionization output from each electrode shall be a minimum of 15 million ions/cc when tested at 2” from the ionization generator.

All manufacturers shall provide documentation by an independent NELEC accredited laboratory that proves the product has minimum kill rates for the following pathogens given the allotted time and in a space condition:

MRSA - >96% in 30 minutes or less
E.coli - > 99% in 15 minutes or less
TB - > 69% in 60 minutes or less

Manufacturers not providing the equivalent space kill rates shall not be acceptable. All manufactures requesting prior approval shall provide to the engineer independent test data from a NELEC accredited independent lab confirming kill rates and time meeting the minimum requirements stated in section 2.2 B, points 6A, 6B and 6C. Products tested only on Petri dishes to prove kill rates shall not be acceptable.

2.1.16 Ozone Generation: The operation of the electrodes or Bi-polar ionization units shall conform to UL 867-2007 with respect to ozone generation. There shall be no ozone generation during any operating condition, with or without airflow.

2.1.17 Electrical Requirements: Wiring, conduit and junction boxes shall be installed within housing plenums in accordance with NEC NFPA 70. Plasma Generator shall accept an electrical service of 24 VAC or 100 VAC to 240VAC, 1 phase, 50/60 Hz.

2.1.18 The contractor shall coordinate electrical requirements with air purification manufacturer during submittals.

2.1.19 Control Requirements:

All Plasma Generators shall have internal short circuit protection, overload protection, and automatic fault reset.

Integral airflow sensing shall modulate the Plasma output as the air flow varies or stops.

A mechanical air flow switch shall not be acceptable as a means to activate the Plasma device due to high failure rates and possible pressure reversal.

The installing contractor shall mount and wire the Plasma device within the air handling unit specified or as shown or the plans. The contractor shall follow all manufacturer IOM instructions during installation.

3 EXECUTION

3.1 General: Comply with installation requirements as specified elsewhere in these specifications pertaining to air filters housing/casings, and associated supporting devices.

3.2 AIR PURIFICATION SYSTEM

3.2.1 General: The Contractor shall be responsible for maintaining all air systems until the owner accepts the building (Owner Acceptance).

3.2.2 Assembly & Erection: Plasma Generator with Bi-Polar Ionization

All equipment shall be assembled and installed in a workman like manner to the satisfaction of the owner, architect, and engineer.

Any material damaged by handling, water or moisture shall be replaced, by the mechanical contractor, at no cost to the owner.

All equipment shall be protected from dust and damage on a daily basis throughout construction.

3.2.3 Testing: Provide the manufacturers recommended electrical tests.

3.2.4 Commissioning & Training: A manufacturer's authorized representative shall provide start-up supervision and training of owner's personnel in the proper operation and maintenance of all equipment.

3.3 Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical installer. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation

requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

END OF SECTION 23 43 18

SECTION 23 52 16 – CONDENSING BOILERS

1. GENERAL

1.1. SUMMARY

1.1.1. This Section includes packaged, factory-fabricated and -assembled, gas-fired, firetube stainless steel ultra-high efficiency condensing boilers, trim and accessories for generating hot water.

1.2. REFERENCES

1.2.1. ASME Section IV

1.2.2. CAN-1.3.1-77, Industrial and Commercial Gas Fired Packaged Boilers

1.2.3. CSD-1, Controls and Safety Devices

1.2.4. XL GAPS

1.2.5. NEC, National Electric Code

1.2.6. UL-795 7th Edition

1.2.7. AHRI, BTS-2000

1.2.8. ASHRAE 90.1

1.3. SUBMITTALS

1.3.1. Product Data: Include performance data, operating characteristics, technical product data, rated capacities of selected model, weights (shipping, installed and operating), installation and start-up instructions, and furnished accessory information.

1.3.2. Shop Drawings: For boiler, standard boiler trim and accessories.

1.3.3. End Assembly Drawing: Detail overall dimensions, connection sizes, connection locations, and clearance requirements.

1.3.4. Wiring Diagrams: Detail electrical requirements for the boiler including ladder type wiring diagrams for power, interlock and control wiring. Clearly differentiate between portions of wiring that are factory installed and portions to be field installed.

1.3.5. Certificate of Product Rating: Submit AHRI Certificate indicating Thermal Efficiency, Combustion Efficiency, Materials of Construction, Input, and Gross Output conform to the design basis.

1.3.6. Thermal efficiency curves: Submit thermal efficiency curves for a minimum of 5 input rates between and including minimum and maximum rated capacities, for return water temperatures ranging from 80°F to 180°F.

1.3.7. Water side pressure drop curve.

1.3.8. Flue gas temperature curves: Submit flue gas temperature curves for minimum and maximum boiler capacity, for return water temperatures ranging from 80°F to 160°F.

1.3.8.1. If submitted flue gas temperatures, minimum or maximum inputs are different from that of the basis of design manufacturer and model, the manufacturer shall be responsible for draft calculations and reselection of the flue gas exhaust system.

1.3.9. Source quality-control test reports.

1.3.10. Field quality-control test reports: Start-up by a factory authorized service company.

1.3.11. Operation and Maintenance Data: Data to be included in Installation and Operation Manual.

1.3.12. Warranty: Standard warranty specified in this Section.

1.4. QUALITY ASSURANCE

1.4.1. Manufacturer Qualifications: Firms regularly engaged in the manufacture of condensing hydronic boilers with welded steel pressure vessels, whose products have been in satisfactory use in service for not less than twenty-five (25) years. The manufacturer must be headquartered in North America.

1.4.2. Aftermarket Support and Service: The manufacturer shall have a factory authorized service training program, where boiler technicians can attend a training class and obtain certification to perform start-up, maintenance and basic troubleshooting specific to the product line.

1.4.3. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.4.4. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code, Section IV “Heating Boilers”, for a maximum allowable working pressure of 160 PSIG.

1.4.5. CSD-1 Compliance: The boiler shall comply with ASME Controls and Safety Devices for Automatically Fired Boilers (CSD-1).

1.4.6. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to “Gas and Oil Fired Boilers - Minimum Efficiency Requirements.”

1.4.7. UL Compliance: Boilers must be tested for compliance with UL 795, “Commercial-Industrial Gas Heating Equipment.” Boilers shall be listed and labeled by ETL.

1.4.8. AHRI Compliance: Boilers shall be tested and rated according to the BTS-2000 test standard and verified by AHRI.

1.4.9. NOx Emissions Compliance: Boiler shall be tested for compliance with SCAQMD and TCEQ.

1.4.10. The equipment shall be of the type, design, and size that the manufacturer currently offers for sale and appears in the manufacturer’s current catalog.

1.4.11. The equipment shall fit within the allocated space, leaving ample allowance for maintenance and inspection.

1.4.12. The equipment shall be new and fabricated from new materials. The equipment shall be free from defects in materials and workmanship.

1.4.13. All units of the same classification shall be identical to the extent necessary to ensure interchangeability of parts, assemblies, accessories, and spare parts wherever possible.

1.4.14. In order to provide unit responsibility for the specified capacities, efficiencies, and performance, the boiler manufacturer shall certify in writing that the equipment being submitted shall perform as specified.

1.5. COORDINATION

1.5.1. Mechanical contractor shall coordinate the size and location of concrete bases. Provide anchor bolts for existing concrete base.

1.6. WARRANTY

1.6.1. Standard Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1.6.1.1. Warranty Period for the Pressure Vessel and Heat Exchanger: The boiler manufacturer shall warranty against failure due to thermal shock, flue gas condensate corrosion, and/or defective material or workmanship for a period of 10 years, non-prorated, from the date of shipment from the factory provided the boiler is installed, controlled, operated and maintained in accordance with the Installation, Operation and Maintenance Manual.

1.6.1.2. Warranty Period for all other components: The boiler manufacturer will repair or replace any part of the boiler that is found to be defective in workmanship or material within eighteen (18) months of shipment from the factory or twelve (12) months from start-up, whichever comes first.

2. PRODUCTS

2.1. MANUFACTURERS

2.1.1. This specification is based on the Endura series boilers as manufactured by Fulton Heating Solutions, Inc. Equivalent units by Viessman, Aerco, or Raypack must meet all performance criteria.

2.1.2. Basis-of-Design Product: Fulton Heating Solutions, Inc.; Endura model **EDR-750** stainless steel firetube condensing boiler.

2.1.3. The boiler shall be a product of a single manufacturer.

2.2. CONSTRUCTION

2.2.1. Description: Factory-fabricated, -assembled, and -pressure tested, stainless steel firetube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including flue gas vent; combustion air intake connections, water supply, water return, condensate drain,

and controls. The boiler, burner and controls shall be completely factory assembled as a self-contained unit. Each boiler shall be neatly finished, thoroughly tested, and properly packaged for shipping. Closed-loop water heating service only.

2.2.2. Heat Exchanger: The heat exchanger is defined as the surfaces of the pressure vessel where flue gases transfer sensible and latent heat to the hydronic fluid. The heat exchanger shall be a three-pass firetube design constructed using only stainless steel.

2.2.2.1. The boiler shall be a firetube design, such that all combustion chamber components are within water-backed areas. Watertube boilers will not be accepted.

2.2.2.2. Furnace: First pass of the combustion chamber shall be constructed of stainless steel with a minimum wall thickness of 0.25" and a minimum bottom head thickness of 0.625".

2.2.2.3. Firetubes: Second and third passes of the combustion chamber shall be constructed of stainless steel having a minimum wall thickness of 0.083".

2.2.2.4. Furnace to tube connections shall be constructed with low weld intensity, a tube to tube minimum spacing of 2" center to center, minimum 5/8" tube to tube ligament, and shall not contain any overlapping welds.

2.2.2.5. Heat exchange capability shall be maximized within the heat exchanger via the use of corrugated firetube technology. The corrugation process shall not remove any material from the tubes. Aluminum heat transfer enhancements are dissimilar metals and are unacceptable.

2.2.2.6. Material: The heat exchanger shall have the following material characteristics and properties:

2.2.2.6.1. The metallic crystalline lattice microstructure shall contain approximately equal amounts of body center cubic (BCC) and face centered cubic (FCC) structures to offer high resistance to intergranular corrosion.

2.2.2.6.2. A minimum Pitting Resistance Equivalent Number (PREN) of 26.

2.2.2.6.3. A minimum Yield Strength of 65 ksi at 0.2% plastic strain.

2.2.2.6.4. A minimum Ultimate Tensile Strength of 94 ksi.

2.2.2.6.5. To minimize stresses caused by uneven expansion and contraction, the Coefficient of Thermal Expansion at 212°F shall not be less than 7.0 in/in °F 10-6 and shall not be greater than 7.5 in/in °F 10-6.

2.2.2.6.6. To increase resistance to pitting and crevice corrosion, the Chromium content shall not be less than 21% by mass.

2.2.2.6.7. For high mechanical strength, the Nitrogen content shall not be less than 0.17% by mass.

2.2.2.6.8. Boilers with heat exchangers constructed of austenitic stainless steels, such as 316L or 304, and ferritic stainless steels, such as 439, are unacceptable.

2.2.2.6.9. Boilers with heat exchangers constructed of cast aluminum, mild steel, cast iron or copper finned tube materials are unacceptable.

2.2.3. Pressure Vessel: Design and construction shall be in accordance with Section IV of the ASME Code for heating boilers.

2.2.3.1. The shell shall be minimum 0.25" thick steel, SA-790 or SA-516 Grade 70.

2.2.3.2. The top head shall be a minimum 0.375" thick steel, SA-790 or SA-516 Grade 70.

2.2.3.3. The water side of the pressure vessel shall be a counter-flow design with internal water-baffling plates.

2.2.3.4. The boiler return and supply water connections shall be 2" threaded mail NPT. The water connections shall not be designed to support an external structural load from the piping system.

2.2.3.5. The water volume of the boiler shall not be less than 50 Gallons.

2.2.3.6. For boilers with a lower water volume, the boiler manufacturer shall provide a buffer tank and all associated buffer tank ancillaries to make equivalent to the total volume of the design basis.

2.2.3.7. The maximum water pressure drop across the boiler inlet and outlet connections, shall not exceed 0.5 PSID at 75 GPM.

2.2.4. Burner: Standard natural gas, forced draft.

2.2.4.1. Burner Head: Shall be a woven fiber premix design.

2.2.4.2. Excess Air: The burner shall operate at no greater than 7.0% excess O2 over the entire turndown range. Due to significant reductions in combustion efficiency at high levels of excess O2, boilers exceeding 7.0% excess O2 at any operating condition shall not be accepted.

2.2.4.3. Emissions: When operating on natural gas, the boiler shall maintain a NOx level of <20 ppm, and CO emissions less than 50 ppm, over the complete combustion range at a 3% O_2 correction.

2.2.5. Blower: Variable speed, non sparking, hardened aluminum impeller centrifugal fan to operate during each burner firing sequence and to pre-purge and post-purge the combustion chamber.

2.2.5.1. Motor: Brushless DC variable speed motor with hall effect sensor feedback; internal electronic commutation controller with built in speed control and protection features; long life, sealed, ball bearing with high temperature grease.

2.2.5.2. Variable speed blower: PWM signal input with tachometer output.

2.2.6. Main Fuel Train:

2.2.6.1. The boiler shall have a pre-mix combustion system, capable of operating at a minimum 4" W.C. incoming propane gas pressure while simultaneously achieving emissions performance, full modulation, and full rated input capacity. Maximum natural gas pressure allowed to the inlet of the fuel train shall be no less than 28" W.C.

2.2.6.2. A factory mounted main fuel train shall be supplied. The fuel train shall be fully assembled complete with high and low gas pressure switches, wired, and installed on the boiler and shall comply with CSD-1 code. The fuel train components shall be enclosed within the boiler cabinet.

2.2.6.3. A lock up regulator upstream of the fuel train shall be furnished by the boiler manufacturer as a standard component integral to the boiler cabinet. Factory test fire of the boiler with the provided lock up regulator is required.

2.2.6.4. Standard CSD-1 fuel train shall comply with IRI, which has been replaced by XL GAPS.

2.2.7. Ignition: Direct spark ignition with transformer. Pilot assemblies are not accepted. A UV scanner shall be utilized to ensure precise communication of flame status back to the flame programmer. Flame rods are not accepted.

2.2.8. Boiler Enclosure:

2.2.8.1. Sealed Cabinet: Jacketed steel enclosure with left hinged full height front access door, fully removable latching access panels, gasketed seams to maintain sealed combustion, mounted on a steel skid with steel plate decking.

2.2.8.2. Control Enclosure: NEMA 250, Type 1.

2.2.8.3. Finish: Internally and externally primed and painted finish.

2.2.8.4. Combustion Air: Drawn from the inside of the sealed cabinet, preheating the combustion air.

2.2.9. Rigging and Placement: The boiler shall come with lifting eyes and fork hole accessibility for rigging.

2.2.10. Exhaust Manifold: Shall be constructed of stainless steel, with an area for the collection and disposal of flue gas condensate. The exhaust outlet connection shall allow for immediate vertical rise off the boiler without requiring an elbow or tee.

2.2.11. Characteristics and Capacities:

2.2.11.1. Heating Medium: Closed loop hot water with up to 50% propylene or ethylene glycol by volume. Standard capacities shall be based on 100% water.

2.2.11.2. Design Water Pressure Rating: 160 psig.

2.2.11.3. Safety Relief Valve Setting: 60 psig.

2.2.11.4. Minimum Return Water Temperature: No minimum temperature required.

2.2.11.5. Maximum Allowable Water Temperature: 210°F.

2.2.11.6. Minimum Water Flow Rate: No minimum flow rate required to protect the heat exchanger.

2.2.11.7. Maximum Water Flow Rate: No maximum flow rate requirement.

2.2.11.8. Minimum Delta-T: No minimum delta-T required.

2.2.11.9. Maximum Delta-T: 100°F

2.2.11.10. Minimum Side Clearance: Shall not exceed 1” between any number of boilers.

2.2.11.11. Jacket Losses: External convection and radiation heat losses to the boiler room from the boiler shall comply with IAW ASHRAE 103-2007, and shall not exceed 0.2% of the rated boiler input at maximum capacity.

2.2.12. The boiler shall have its efficiency witnessed and certified by an independent third party, and the efficiency must be listed on the AHRI directory (www.ahridirectory.org) for natural gas operation. The test parameters for efficiency certification shall be the BTS-2000 standard. The certified thermal efficiency for natural gas firing shall not be less than 97.1%

2.2.13. A zero flow or low flow condition shall not cause any harm to the pressure vessel or heat exchanger of the boiler. Flow switches, dedicated circulator pumps, or primary-secondary arrangements shall not be required to protect the boiler from thermal shock. Boilers requiring the use of flow switches or primary-secondary piping arrangements are unacceptable.

2.2.14. The equipment shall be in strict compliance with the requirements of this specification and shall be the manufacturer's standard commercial product unless specified otherwise. Additional equipment features, details, accessories, etc. which are not specifically identified but which are a part of the manufacturer's standard commercial product, shall be included in the equipment being furnished.

2.3. TRIM

2.3.1. Safety Relief Valve: ASME Rated.

2.3.1.1. Pressure and Temperature Gauge: Minimum 3-1/2" diameter, combination pressure and -temperature gauge. Gauges shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.

2.3.1.2. Mounted in the field in the boiler supply water piping prior to the first isolation valve by the boiler installer.

2.3.2. Combustion Air Inlet Filter: 50 Micron.

2.3.3. Flue Gas Condensate Drain Trap: A flue gas condensate drain trap including a cast aluminum condensate tank with makeup water line to prevent positive pressure exhaust gases from entering the boiler room.

2.3.4. Flue Gas Condensate Neutralization: Provide pH neutralization kit to handle a maximum combined boiler capacity of 12,000,000 BTU/hr with a year supply of neutralizing medium. Polyethylene housing with MgO neutralizing medium. accommodations available upon request.

2.4. CONTROLS

2.4.1. The boiler electrical control panel shall include the following devices and features:

2.4.1.1. 7" color touch screen control display factory mounted on the front cabinet panel door.

2.4.1.1.1. The control display shall serve as a user interface for programming parameters, boiler control and monitoring; and shall feature a screen saver, screen disable for cleaning, contrast control, volume control for alarm features, boiler status, configuration, history and diagnostics.

2.4.1.2. The boiler control panel shall be constructed in a UL 508 approved panel shop.

2.4.1.3. 24 VAC control transformer.

2.4.1.4. Control relay for 120 VAC motorized pump control.

2.4.1.5. The flame safeguard control on the boiler shall be integrated with temperature control and lead/lag sequencing modular boiler plant functionality.

2.4.1.6. All controls are to be cabinet, vessel or panel mounted and so located on the boiler as to provide ease of servicing the boiler without disturbing the controls. All controls shall be mounted and wired according to UL requirements.

2.4.2. Burner Operating Controls: To maintain safe operating conditions, factory mounted and wired burner safety controls limit burner operation:

2.4.2.1. High Limit: A single UL 353 temperature probe shall function as a dual-element outlet temperature sensor and shall comply with CSD-1 CW-400 requirements for 2 independent temperature control devices.

2.4.2.1.1. High limit sensor shall be NTC resistive 10KOhm +/- 1% at 77°F. Sensor shall have brass material bulb with 1.181 +/- 0.015" insertion and 0.370 +/- 0.005" bulb diameter.

2.4.2.1.2. Manual reset stops burner if operating conditions rise above maximum boiler design temperature.

2.4.2.2. Low-Water Cut Off: Electronic probe type mounted in the pressure vessel shall prevent burner operation on low water alarm.

2.4.2.3. Air Safety Switch: Prevent operation unless sufficient combustion air is proven.

2.4.2.4. High Condensate Probe: Prevent operation in the event of a blocked condensate drain.

2.4.2.5. Blocked Exhaust: Prevent operation in the event of a blocked flue gas exhaust stack.

2.4.3. Boiler Operating Controls and Features:

2.4.3.1. Proportional Integral Derivative (PID) temperature load control capability for up to two loops, central heat and domestic hot water.

2.4.3.2. Operating temperature limit for automatic start and stop.

2.4.3.3. Flue gas exhaust temperature monitoring.

2.4.3.4. Return water temperature monitoring.

2.4.3.5. Time of day display.

2.4.3.6. Customizable boiler name display.

2.4.3.7. Alarm history for 15 most recent alarms including equipment status at time of lockout.

2.4.3.8. Password protection options.

2.4.3.9. Indirect domestic hot water priority.

2.4.4. Sequencing Control of Modular Boiler Plants: Sequencing capabilities (lead/lag) shall be integral to the boiler controller for up to 8 boilers installed in the same hydronic loop and shall not require an external panel.

2.4.4.1. The boiler manufacturer shall provide a supply water header temperature sensor.

2.4.4.1.1. The sensor shall be NTC resistive 10KOhm +/- 1% at 77°F, field installed in the common supply water piping, and field wired to the master boiler.

2.4.4.2. One (1) boiler in the system shall be field programmed as the master and subsequent boilers will be programmed as lag units.

2.4.4.3. Sequence of Operation:

2.4.4.3.1. Upon call for heat and demand in the system, a boiler will be enabled at low fire and will modulate according to demand and PID settings up to the base load common value. The base load common shall be field adjustable with a default setting of 40%.

2.4.4.3.2. If the heating load exceeds the output at the base load common firing rate, the next boiler in the sequence will be enabled at low fire. Modular boilers will modulate up and down in parallel as a cohesive unit with infinite modulation points to meet heating load requirements.

2.4.4.3.3. This process continues until all available boilers are enabled, at which point they are released to modulate up to full fire if required.

2.4.4.3.4. As the load decreases, the boilers will be sequentially disabled.

2.4.4.3.5. Boiler sequence order shall be rotated on a programmable number of run hours.

2.4.4.3.6. A boiler in lockout alarm shall be automatically removed from the sequence order.

2.4.4.3.7. Lag boilers shall default to local control if the master boiler is fully powered off or removed.

2.4.4.3.8. Each individual boiler shall enable and disable a water circulation control device. The enable of the device, for example a motorized isolation valve or boiler circulator, will be simultaneous with the heat demand for that boiler. The disable of each device will be based on a programmable time delay when the heat demand is no longer present. In variable primary arrangements, the control shall hold the lead boiler isolation valve open at all times.

2.4.5. Building Automation System Interface: Hardware and software to enable building automation system (BAS) to monitor, control, and display boiler status and alarms and adjust setpoints through BACnet interface.

2.4.5.1. Hardwired Contacts:

2.4.5.1.1. Monitoring: Boiler Status, Burner Demand, General Alarm, Firing Rate.

2.4.5.1.2. Control with Factory Installed Jumper: Safety Interlock for External Device, Remote Boiler Enable, Remote Lead/Lag Enable, Emergency Stop (E-Stop

2.5. ELECTRICAL POWER

2.5.1. Single-Point Field Power Connection: Factory-installed and factory-wired switches, transformers, control and safety devices and other devices shall provide a single-point field power connection to the boiler.

2.5.2. Electrical Characteristics:

2.5.2.1. Voltage: 120 V.

2.5.2.2. Phase: Single.

2.5.2.3. Frequency: 60 Hz.

2.6. VENTING

2.6.1. The boiler shall be capable of operating with a stack effect not exceeding -0.04" W.C. and a combined air intake and exhaust venting pressure drop not exceeding +1.50" W.C.

2.6.2. Combustion Air Intake: Combustion air shall be direct vented to the boiler using sealed combustion by drawing combustion air in from the outdoors.

2.6.2.1. Sealed Combustion: Schedule 40 PVC pipe, vent termination with 1/4" x 1/4" mesh bird screen.

2.6.3. Flue Gas Exhaust: The flue gas exhaust stack shall be AL 29-4C or 316L stainless steel, listed and labeled to UL-1738 / C-UL S636 for use with Category II/IV appliances, guaranteed appropriate for the application by the manufacturer and supplier of the venting.

2.6.4. The boiler shall be capable of common exhaust and intake venting. The draft system shall be designed to prevent the backflow of exhaust gases through idle boilers.

2.6.5. Condensate drain piping shall be stainless steel.

2.7. SOURCE QUALITY CONTROL

2.7.1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

2.7.2. Each boiler shall be installed and operated in a functioning hydronic system, inclusive of venting, as part of the manufacturing process. A factory test fire report corresponding to the boiler configuration shall be included with each boiler.

3. EXECUTION

3.1. EXAMINATION

3.1.1. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

3.1.1.1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

3.1.2. Examine mechanical spaces for suitable conditions where boilers will be installed.

3.1.3. Proceed with installation only after satisfactory conditions have been verified.

3.2. BOILER INSTALLATION

3.2.1. Install boilers level on existing concrete base.

3.2.2. Install gas-fired boilers according to NFPA 54. Equipment and materials shall be installed in an approved manner and in accordance with the boiler manufacturer's installation requirements.

3.2.3. Assemble and install boiler trim.

3.2.4. Install electrical devices furnished with the boiler but not specified to be factory mounted.

3.2.5. Install control wiring to field-mounted electrical devices.

3.2.6. Connect to existing digital controls enable signal.

3.3. CONNECTIONS

3.3.1. Piping installation requirements are specified in other Division-15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

3.3.2. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

3.3.3. Connect gas piping to boiler gas train inlet with isolation valve and union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

3.3.4. Connect hot water supply and return water connections with shutoff valve and union or flange at each connection.

3.3.5. Install piping from safety relief valves to the nearest floor drain.

3.3.6. Install piping from flue gas condensate drain connection to the condensate drain trap and to the nearest floor drain.

3.3.7. Boiler Venting:

3.3.7.1. Install flue venting and combustion air-intake.

3.3.7.2. Connect to boiler connections, flue size and type as recommended by the manufacturer.

3.3.8. Ground equipment according to Division-16 Specifications.

3.3.9. Connect wiring according to Division-16 Specifications.

3.4. FIELD QUALITY CONTROL

3.4.1. Perform tests and inspections and prepare test reports.

3.4.1.1. After boiler installation is completed, the manufacturer shall provide the services of a field representative to inspect components, assemblies, and equipment installations, including connections and provide startup of the boiler and training to the operator.

3.4.1.2. Arrange with National Board of Boiler and Pressure Vessel Inspectors for inspection of boilers and piping. Obtain certification for completed boiler units, deliver to Owner, and obtain receipt.

3.4.2. Tests and inspections:

3.4.2.1. Perform installation and startup checks according to manufacturer's written instructions.

3.4.2.2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.

3.4.2.3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

3.4.2.3.1. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.

3.4.2.3.2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.4.3. Remove and replace malfunctioning units and retest as specified above.

3.4.4. Occupancy Adjustments: When requested within 12 months of startup, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to 2 visits to Project during other than normal occupancy hours for this purpose.

END OF SECTION 23 52 16

SECTION 23 64 30 - PACKAGED AIR-COOLED CHILLERS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work specified in this section.

1.3 Extent of chiller work required by this section is indicated on drawings and schedules, and by requirements of this section.

1.4 Refer to other Division-23 sections for concrete pads, piping, piping specialties, water temperature and pressure gauges, pumps, and valves which are required external to chillers for installation; not work of this section.

1.5 Refer to other Division-23 sections for field-installed automatic temperature controls required in conjunction with chillers; not work of this section.

1.6 Refer to Division-26 sections for electrical wiring work including wires/cables, raceways, and project required electrical devices; not work of this section.

1.7 Codes and Standards:

1.7.1 ARI Compliance: Test and rate chillers in accordance with ARI Std 550/590, "Standard for Water-Chilling Packages using Vapor Compression Cycle".

1.7.2 NEC Compliance: Comply with applicable NEC requirements pertaining to electrical power and control wiring for construction and installation of chillers.

1.7.3 ANSI Compliance: Comply with ANSI B9.1 safety code requirements pertaining to unit construction of chillers.

Stamp cooler with ASME mark when cooler has been successfully tested in accordance with ASME Code. Pressure test cooler for refrigerant working side pressure of not less than 235 psig and water side pressure of not less than 150 psig. Leak test condenser coils at 150 psig and pressure test coils at 450 psig.

1.8 Approval Submittals:

1.8.1 Product Data: Submit manufacturer's technical product data, including rated capacities for chillers indicated, weights (shipping, installed, and operating), furnished specialties and accessories; and rigging, installation, and start-up instructions.

1.8.2 Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, and required clearances, methods of assembly of components, and location and size of each field-connection.

1.9 O&M Data Submittals:

1.9.1 Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

1.9.2 Maintenance Data: Submit a copy of approval submittals. Submit maintenance data and parts list for each chiller, control, and accessory; including "trouble-shooting" maintenance guide. Include these data in O&M manual.

2 PRODUCTS

2.1 Acceptable Manufacturers: Subject to compliance with requirements, provide chillers of one of the following:

Daikin
Trane
York
Carrier

2.2 General: Provide factory-assembled and tested packaged air-cooled screw compressor liquid chillers as indicated, consisting of compressors, evaporator, condensers, thermal expansion valves, and control panels. Provide capacity and electrical characteristics as scheduled.

2.2.1 Specified capacity shall be met without overloading compressor motors when operating at a scale factor of 0.00010 at the temperatures scheduled.

2.2.2 Unit shall be capable of operation at all conditions between 0ºF and 125ºF ambient.

2.2.3 Chiller EER shall meet the requirements of Florida Energy Efficiency Code and schedules.

2.3 Refrigerant: Provide full operating charge or refrigerant and oil.

2.4 Housing: Provide manufacturer's standard equipment housing construction, corrosion protection coating, and exterior finish. Provide removable panels and/or access doors for inspection and access to internal parts and components. Provide louvered coil guards.

2.5 Evaporator: The evaporator shall be a tube in shell heat exchanger with internally and externally finned copper tubes roller expanded into the tube sheet. The water-side working pressure shall be a minimum of 150 psig. Vent and drain connections shall be provided in the inlet and outlet chilled water piping by the installing contractor. Evaporators shall be designed and constructed according to, and listed by, Underwriters Laboratories (UL). The evaporator shall be protected with an external, electric resistance heater plate and insulated with 3/4" thick closed-cell polyurethane insulation. This combination shall provide freeze protection down to -20°F ambient air temperature. The heat exchanger shall be protected from freeze damage by electric heat trace tape, served with a separate 120V, 20 amp circuit and controlled by the chiller control panel.

2.6 Condenser: Condenser fans shall be propeller type arranged for vertical air discharge and individually driven by direct-drive fan motors. The fans shall be equipped with a heavy-gauge vinyl-coated fan guard. Fan motors shall be TEAO type with permanently lubricated ball bearings, inherent overload protection, three-phase, direct-drive, 1140 rpm. Each fan section

shall be partitioned to avoid cross circulation. Coil shall have lanced aluminum fins mechanically bonded to internally finned copper tubes. Coils shall consist of a two-pass arrangement. Each condenser coil shall be factory leak tested with high-pressure air under water. Condenser coils shall include baked epoxy coating providing 6000+ hour salt spray resistance (ASTM B117-90) applied to both the coil and the coil frames.

2.6.1 Condenser Coil Coating: The condenser box shall be submerged in an epoxy polymer bath where an electrostatic charge to uniformly deposit the epoxy onto the coil. The coating shall resist bi-metallic corrosion and allow for operation in coastal environments.

2.7 Compressors and Motors: The compressors shall be semi hermetic, screw type with crankcase oil heater and suction strainer. The compressor motor shall be refrigerant gas cooled, high torque, hermetic induction type, two-pole, with inherent thermal protection on all three phases and shall be mounted on RIS vibration isolator pads. The compressors shall be equipped with an internal module providing compressor protection and communication capability.

2.7.1 Provide 5 year warranty to cover parts, labor, and refrigerant to cover the entire unit.

2.8 Refrigerant Circuits and Capacity Modulation: Provide dual independent refrigerant circuits. Each refrigerant circuit shall have scew compressors piped in parallel with a passive oil management system. A passive oil management system shall maintain proper oil levels within compressors and have no moving parts. Each refrigerant circuit shall include filter drier, electronic expansion valve, and liquid line and discharge service valves. Capacity modulation shall be achieved by staging compressors on and off.

2.9 Refrigerant Circuit: Dual refrigerant circuits shall be completely independent of each other. Provide for each refrigerant circuit the following:

Relief valve.
Liquid line solenoid valve.
Liquid line sight glass/moisture indicator.
Insulated suction line.
Purge valve.

2.10 Unit Controls: The microprocessor-based control panel shall be factory-installed and factory-tested. The control system shall be powered by a pre-wired control power transformer, and shall turn on and off compressors to meet the load. Provide microprocessor-based chilled water reset based on return water. The microprocessor shall automatically act to prevent unit shutdown due to abnormal operating conditions associated with low evaporator refrigerant temperature and high condensing temperature. If an abnormal operating condition continues and the protective limit is reached, the machine shall shut down. The panel shall include machine protection for the following conditions:

- Low evaporator refrigerant temperature and pressure
- High condenser refrigerant pressure
- Critical sensor or detection circuit faults
- High compressor discharge temperature (with low temp evaporator)
- Lost communication between modules
- Electrical distribution faults: phase loss, phase reversal or over temperature protection
- External and local emergency stop
- Loss of evaporator water flow

When a fault is detected, the control system shall conduct diagnostic checks and displays results. The display will identify the fault, indicate date, time, and operating mode at time of occurrence, and provide type of reset required and a help message.

Clear Language Display Panel Factory-mounted to the control panel door, the operator interface shall have an LCD touch-screen display for operator input and information output. This interface shall provide access to the following information: evaporator report, condenser report, compressor report, ASHRAE Guideline 3 report, operator settings, service settings, service tests, and diagnostics. All diagnostics and messages are displayed in “clear language.” Data contained in available reports shall include:

- Water and air temperatures
- Refrigerant pressures and temperatures
- Flow switch status
- EXV position
- Compressor starts and run-time

All necessary settings and setpoints shall be programmed into the microprocessor-based controller via the operator interface. The controller shall be capable of receiving signals simultaneously from a variety of control sources, in any combination, and priority order of control sources can be programmed. The control source with priority determines active setpoints via the signal it sends to the control panel.

- Local operator interface
- Hard-wired 4-20mA or 2-10V dc signal from an external source
- Time of day scheduling(optional capability available from local operator interface)
- BACnet Interface

2.11 Accessories: Provide the following accessories:

Suction and discharge gauges.
Vapor-proof chilled water flow switch.

3 EXECUTION

3.1 Installer must examine areas and conditions under which chillers are to be installed and notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 General: Install chillers in accordance with manufacturer's written instructions. Install units plumb and level, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.

3.3 Support: Install ground-mounted units on existing concrete pad. Secure to pad as recommended by manufacturer.

3.4 Chilled Water Piping: Refer to Division-23 section "Chilled Water Piping". Connect inlet to evaporator with controller bulb well, shutoff valve, thermometer, strainer, flow switch, flexible pipe connection, pressure gauge, and union or flange. Connect outlet to evaporator with shutoff valve, balancing cock, thermometer, flexible pipe connection, pressure gauge, and union or flange. Align piping to eliminate strain on chiller heads. Arrange piping to permit

removal of chiller heads with minimal pipe removal. Thermometers and gauges shall be located in the equipment room.

3.5 Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted, including electric strip cable for chiller and piping to prevent freezing due to low ambient temperature. Heater cable shall be powered by a separate 120V circuit that may be energized when the unit is not. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to manufacturer and equipment installer.

3.6 Control: Furnish field-installed automatic temperature control requirements to Control Installer. Field-installed automatic temperature controls are not work of this section.

3.7 Provide services of manufacturer's factory-trained service representative for at least two days to start-up chillers. Include in start-up procedures, testing controls, checking all wiring connections, demonstration of compliance with requirements, demonstration of performance, and replacement of damaged or malfunctioning controls and equipment. Submit complete operating logs and service report following chiller startup.

3.8 Provide services of manufacturer's technical representative for two 8-hour days to instruct Owner's personnel in operation and maintenance of chillers. Schedule training with Owner. Provide at least 7-day notice to Contractor and Engineer of training date.

3.9 The chiller supplier shall employ servicemen qualified to repair the chillers and shall have an office and stock parts within 100 miles of the project. All service mechanics must be factory trained with a State of Florida Class A license. Servicemen shall maintain 24 hour per day emergency service.

END OF SECTION 23 64 30

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SECTION 23 73 23 - CUSTOM AIR HANDLING UNITS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Extent of air handling unit work is indicated on drawings, and schedules, and by requirements of this section.

1.4 Refer to other Division-23 sections for field-applied insulation to air handling units.

1.5 Refer to other Division-23 sections for condensate, hot and chilled water piping required in conjunction with air handling units.

1.6 Refer to other Division-23 Sections for HVAC equipment to be included as part of the penthouse units or air handling units such as DDC Controls, Variable Frequency Drives, and Hydronic Specialties.

1.7 Refer to Division-26 sections for the following work; not work of this section.

1.7.1 Power supply wiring from power source to power connection on unit. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory installed by manufacturer.

1.8 Codes and Standards:

1.8.1 AMCA Compliance: Test and rate air handling units in accordance with AMCA standards.

1.8.2 ARI Compliance: Test and rate air handling units in accordance with ARI 430 "Standard for Central-Station Air Handling Units", and ARI 410 for coils, display certification symbol on units of certified models.

1.8.3 NFPA Compliance: Provide air handling unit internal insulation, adhesives, and coatings having flame spread rating not over 25 and smoke developed rating no higher than 50; and complying with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.8.4 UL and NEMA Compliance: Provide electrical components required as part of air handling units, which have been listed and labeled by UL and comply with NEMA Standards.

1.8.5 NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation and electrical connections of ancillary electrical components of air handling units.

1.9 Approval Submittals:

1.9.1 Product Data: Submit manufacturer's technical product data as follows showing dimensions, weights, capacities, certified ratings, fan performance with operating point clearly indicated, motor electrical characteristics, gauges and finishes of materials, and installation instructions. Submit assembly-type drawings showing unit dimensions, weight loadings, required clearances, construction details, and field connection details.

Air handling unit components including casings, fans, coils and all related equipment.
Vibration Isolation

1.9.2 Shop Drawings: Submit shop drawings showing the actual installation of each air handling unit, in plan and section. Show coil access, filter access, motor access, controls access and access to any other components requiring service. Show coordination with all related structural components of the building and show all unit supports. Show relationship to drains and other equipment. Show every electrical device and control panel with code-required service clearance clearly marked.

Units mounted in mechanical rooms.

1.10 O&M Data Submittals:

1.10.1 Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to air handling units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field installed.

1.10.2 Maintenance Data: Submit a copy of approval submittals. Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include these data and wiring diagrams in O&M manuals.

2 PRODUCTS

2.1 Acceptable Manufacturers: Subject to compliance with requirements, provide air handling units of one of the following:

Daikin
Trane
Thermal
Carrier

2.2 General:

2.2.1 Factory fabricated air handling units shall be constructed of solid steel, formed outer panels secured to an integral steel frame or to a bolted steel frame. Outer panels shall be removable without affecting the structural integrity of the units. All units shall come complete with a structural steel base around the entire perimeter. Construction shall result in a leakage rate of less than 1% of rated flow at maximum operating pressure.

2.2.2 Multiple sectioned units shall be as a single factory assembled piece (except where shipping limitations prevent) demounted into modular sections in the field by Contractor. Units shall be furnished with sufficient gasket and bolts for reassembly in the field by Contractor.

2.2.3 All units shall be UL or ETL listed.

2.2.4 All coil connections, access doors and drains shall be coordinated with field piping and

electrical connections.

2.2.5 Unit exterior dimensions shall be the size as shown on the drawings.

2.3 Testing:

2.3.1 The unit manufacturer shall provide a factory leak test on all units at 8 inches static pressure. Cabinet leakage shall not exceed leak class 6 per ASHRAE 111 at 8 inches w.g. Specified air leakage shall be obtained without the use of caulk at normally removed access panels. Total estimated air leakage shall be reported for each unit in CFM, as a percentage of supply air, and as an ASHRAE 111 Leakage Class.

2.3.2 Fan shall be factory balanced to limit vibration at operating speed to the values shown in the following table. Measure vibration in all three planes. AHU manufacturer shall provide vibration test results.

2.4 Unit Base / Framework::

2.4.1 Unit base frame shall be structural steel cross members. The base shall include “Double Bottom” insulate floor. Base frames shall be fitted with lifting lugs at the corners of the unit or section (if demounted). Floor panels shall be double-wall construction and designed to support a 250 lb load during maintenance activities and shall deflect no more than 0.0042” per inch of panel span (L/240).

2.5 Exterior Casing:

2.5.1 The air handling unit casing shall be 2” thick double wall construction of the “no-through-metal” design. The casing structure shall incorporate insulating thermal breaks as required so that, when fully assembled, there exists no path of continuous unbroken metal to metal conduction from inner to outer surfaces. Provide required structural frame and casing to withstand 8" static pressure. Panels shall be gasketed and secured to the frame with screws. Outer panels shall be constructed from 16 gauge G-90 galvanized steel. Provide support system for architectural finish panels. Architectural finish panels are not a part of Division-23 work. The exterior panels shall be coated with a painting system designed for long term corrosion.

The paint shall meet or exceed the following criteria:

(ASTM B-117) salt spray resistance 5% fog at 95 degrees F. Passes 750 hr.
(ASTM D-2247) humidity resistance 100% salt at 95 degrees F. Passes 1,000 hr.

2.6 Unit Casing Insulation: Insulation shall not be disturbed if panels are removed. Insulation shall be secured to the entire panel with mechanical and adhesive over the entire panel surface. Entire unit to be insulated with 2" thick insulation. The insulation shall have an effective thermal the resistance value of R13, minimum. Insulation shall fill panels and external structural frame members completely in all direction such that no voids exist. Panel insulation shall comply with NFPA 90A.

2.7 Liners: The units shall be double wall construction and include a 20 gauge solid galvanized liner (unless otherwise noted) in the entire unit except for supply fan section. The liner in the supply fan section shall be perforated galvanized steel construction. Insulation facing perforated inner wall shall be covered by a Mylar or Tedlar film with spacers to preserve the acoustical properties of the assembly.

2.8 Condensate Pan: Condensate drain pan shall be 16 gauge Type 304 stainless steel. All pans shall be insulated “Double Bottom” construction with welded corners. The drain shall be sloped in two planes for complete drainage with no standing water in the unit. Drain

connections shall be standard 1¼" NPT connection. Drain pans shall be provided under all cooling unit sections.

2.9 Access Doors: The unit shall be equipped with 2" double wall insulated, hinged access doors of the same construction as the interior and exterior wall panels. Doors shall be located upstream and downstream of all coils and in all filter, access plenum and fan sections and access to major components. The fan section door shall be large enough to allow the removal of the fan wheel and motor without disassembly of the unit casing. The door frame shall incorporate a built in thermal break barrier along with a gasket around the entire perimeter of the door. The door shall be hinged using a minimum of three heavy duty butt hinges. There shall be two heavy duty Ventlok (260/310) handles (or equal) per door. Provide an ETL, UL 1995, and CAL-OSHA approved tool operated safety latch on all fan section access doors. Operating tool shall be chained to each unit with tamper resistant fasteners within reach of the safety latch. All doors to have windows where shown. All doors to be 60" high when sufficient unit height is available, or maximum height allowed by the unit height.

2.10 Fans: Provide direct drive fans of type and class as specified on the schedule. Fan shafts shall be solid steel, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans controlled by variable frequency drives shall be statically and dynamically tested for vibration and alignment at speeds between 25% and 100% of design RPM. If fans are not factory-tested for vibration and alignment, the contractor shall be responsible for cost and labor associated with field balancing and certified vibration performance. Fan wheels shall be keyed to fan shafts to prevent slipping.

2.11 Motors: Provide high efficiency motor. Provide motors suitable for inverter use.

2.11.1 Variable Frequency Drives shall be furnished by the Digital Controls Contractor.

2.12 Coils:

2.12.1 Coil sections shall be double wall with 304 stainless steel inner liner.

2.12.2 All coil assemblies shall be tested under water at 315 psig and performance shall be certified under ARI Standard 410. Coils exceeding the range of ARI standard rating conditions shall be as noted on a coil computer printout.

2.12.3 Type WC (water coils) shall be constructed of seamless copper tubing mechanically expanded into fin collars. Fins shall be the die formed plate type. Headers shall be seamless copper with die formed tube holes. Connections shall be male pipe thread (MPT) Schedule 40 red brass.

Vents and drains (1/8)" shall be provided for complete coil drainage. Coils shall be suitable for 250 psig working pressure. Intermediate tube supports shall be supplied on coils over 44" fin length with an additional support every 42" multiple thereafter. Coils shall have 5/8" o.d. x .035" wall copper tubes, .010" aluminum fins and 16 gauge Type 304 stainless steel casing. Coil tracks and supports shall be fabricated of Type stainless steel.

2.12.4 Provide multiple sections of coils split vertically and horizontally as required for coil removal. Safe off all spaces between coils to prevent air from bypassing coils.

2.12.5 Provide intermediate stainless steel drain pans beneath each section of cooling coil above bottom section. Provide a drain tube from each intermediate pan down to the base drain pan. Intermediate drain pans shall extend a minimum of 8" past the downstream face of coil.

2.12.6 Insulate all piping within the AHU in accordance with Division-23 section "Insulation for

HVAC Equipment and Piping". Repair all cracks in insulation or covering at site after unit has been set. Piping and hydronic devices as well as piping insulation for all units shall be completed in the field.

2.13 Filter Boxes: Provide boxes to accommodate filters of the type indicated on the schedule. Factory fabricated filter sections shall be of the same construction and finish as the units. Side service filter sections shall include hinged access doors. Internal safing shall be provided by the manufacturer as required to prevent air bypass around the filters.

2.13.1 Filter Gauge: Each filter bank shall be furnished with one (1) Magnehelic filter gauge (Dwyer Series 2000).

2.14 Ducted connection: Provide ductwork connection of sizes shown on the drawings.

2.15 Lighting: Provide vapor-proof light fixtures in all accessible sections. Factory mounted and wired to an external service switch.

2.16 Drains: Provide a capped washdown drain in each coil section.

2.17 Vibration Isolation: Provide Type EM5 Vibration Isolation.

3 EXECUTION

3.1 Examine areas and conditions under which air handling units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 General: Install air handling units where indicated, in accordance with equipment manufacturer's published installation instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposes. The work of this section includes all equipment necessary for a complete, packaged system, including work and equipment specified in other Division-23 sections.

3.3 Coordination: Coordinate with other work, including architectural panels, ductwork, floor construction and piping, as necessary to interface installation of air handling units with other work.

3.4 Access: Provide access space around air handling units for service as indicated, but in no case less than that recommended by manufacturer.

3.5 Support:

3.5.1 Install floor-mounted air handling units on reinforced concrete housekeeping pads of sufficient height to properly trap condensate, but in no case less than 4".

3.6 Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical Installer. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

3.7 Piping Connections: Refer to Division-23 HVAC sections. Provide piping, valves, accessories, gauges and supports as indicated. Eliminate strain on coil headers. Provide trapped, insulated, DWV copper condensate drain piping full size from the drain connection as shown and extend independently to disposal point as part of this section's work. Provide individual trap from each drain.

3.8 Duct Connections: Refer to Division-23 Air Distribution sections. Provide ductwork, accessories, and flexible connections as indicated.

3.9 Vibration Isolation: Install in accordance with requirements of Division-23 Vibration Isolation.

3.10 Brush out fins on all coils.

3.11 Testing: Upon completion of installation, start-up and operate equipment to demonstrate capability and compliance with requirements. Install final, fixed sheave package. Field correct malfunctioning units, then retest to demonstrate compliance.

3.12 Provide one spare set of belts for each belt-driven fan, obtain receipt from Owner that belts have been received

3.13 Install new filters (prefilters and final filters as applicable) at final completion. Provide two spare sets of filters to owner at final completion

END OF SECTION 23 73 23

SECTION 23 81 28 - DUCTLESS SPLIT SYSTEM AIR CONDITIONING UNITS

1 GENERAL

1.1 Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

1.2 Division-23 Basic Mechanical Materials and Methods sections apply to work of this section.

1.3 Refer to other Division-23 sections for testing, adjusting, and balancing of units; not work of this section.

1.4 Approval Submittals:

1.4.1 Product Data: Submit manufacturer's technical product data, including dimensions, ratings, electrical characteristics, weight, capacities, materials of construction, and installation instructions. Submit assembly-type drawings showing all piping and electrical connections and all mounting requirements. Show methods of fastening and assembly of components. Provide wiring diagrams.

1.5 O&M Data Submittals: Submit manufacturer's maintenance data including parts lists. Include these data, product data, and a copy of approval submittals in O&M manual.

2 PRODUCTS

2.1 Quality Assurance:

2.1.1 Test and rate split system air conditioning units in accordance with ARI Standard 210, 240 or 360 as applicable, and provide certified rating seal.

2.1.2 Construct refrigeration system of split system air conditioning units in accordance with ASHRAE 15 (ANSI B 9.1) "Safety Code for Mechanical Refrigeration".

2.1.3 Provide split system air conditioning units with an SEER that meets the Florida Energy Efficiency Code and the schedule on the drawings.

2.1.4 Provide split system air conditioning units that are designed, manufactured, and tested in accordance with UL or ETL requirements.

2.1.5 Acceptable Manufacturers: Submit to compliance with requirements, provide units by Daikin, Carrier, Freidrich Mitsubishi, Trane, or approved equal.

2.2 General:

2.2.1 Casings: Construct of painted mill galvanized steel (or aluminum) formed panels rigidly reinforced and braced. Each unit shall be provided with removable panels to permit the unit (including fans and compressors) to be properly maintained and serviced.

2.3 Condensing Unit:

2.3.1 Condenser Fans and Drives: Fan shall be of rustproof construction, hot dipped galvanized steel, stainless steel or aluminum. Unit shall have weather protected totally enclosed motor. Provide a close fretwork galvanized steel or non-ferrous fan guard. Motors shall be the permanently lubricated type, resiliently mounted.

2.3.2 Condenser Coil: Construct of non-ferrous tubes and aluminum fins. Provide inlet guard to protect condenser fins.

2.3.3 Compressor: Shall be twin rotary invertor driven with vibration isolation. Compressor shall not produce objectionable noise or vibration inside the building. Compressors shall have seven (7) year warranty.

2.3.4 Service Valves: Provide for high and low pressure readings.

2.3.5 Seacoast Protection: Provide phosphate coating and acrylic enamel coating for external outer panels. Provide epoxy resin coating for fan motor support, separator assembly, and valve bed. Provide zinc-nickel coated and polyvinylidene chloride coating on fasteners. Provide anti-corrosion treatment to condenser coil to protect from airborne contaminants.

2.4 Evaporator Unit:

2.4.1 Interior of unit shall be thermally and acoustically insulated with 1 inch fiberglass duct liner insulation. Provide removable panels to permit the unit to be properly serviced and maintained.

2.4.2 The evaporator section shall include centrifugal fan, two-speed fan motor, and direct drive. Provide cooling coil, snap out washable filters, refrigerant drier, controls and other necessary devices for a completely automatic unit. Coils shall have copper tubes and aluminum fins. Provide automatic oscillating louver action to facilitate air distribution.

2.5 Controls:

2.5.1 All safety and operational controls shall be factory wired.

2.5.2 Provide remote microprocessor-based controls with room thermostat, timer and fan speed switch.

2.6 Refrigerant Piping:

2.6.1 Copper tubing 3/4" and smaller: Type ACR, soft annealed temper; cast copper-alloy fittings for flared copper tubes; flared joints.

2.6.2 Brazing material: Silver solder bearing at least 15% silver; Sil Fos.

3 EXECUTION

3.1 Installation: Install in accordance with producer's printed instructions.

3.2 Refrigerant Piping: Comply with ANSI B31.5, "Refrigerant Piping," (extend lower pressure limits below 15 psig), and ASHRAE 15 (ANSI B9.1). Make all joints carefully and neatly. Clean pipe and fittings before fluxing. Remove burrs. Braze by the sweat method using Sil Fos.

3.3 Testing: After job erection, pressure test for leaks at 150 psig using a nominal amount of a suitable tracer refrigerant and dry nitrogen or a suitable refrigerant. Perform leak tests with an electronic halide leak detector having a sensitivity of at least 1/2 ounce R-12 per year. Refrigeration piping will not be accepted unless it is gas tight.

3.4 Evacuation: After completing the successful pressure test, multiple-evacuate the system. Leave the compressor isolation valves shut and connect the vacuum pump to both the high and low sides. Evacuate the system to an absolute pressure of 1,500 microns. Then break vacuum to 2 psig with dry nitrogen. Repeat this process. Install the proper biflow drier in the liquid line and evacuate the system to 500 microns. Leave vacuum pump running for at least two hours without interruption. Break vacuum with the refrigerant to be used and raise pressure to 2 psig. Do not operate compressors during the evacuation procedure.

3.5 Charging: After completing the successful evacuation procedure, charge refrigerant directly to the system from the original containers through a filter drier. Charge to the manufacturer's stated conditions of pressure for required temperature. Weigh the refrigerant added and record on the startup report.

3.6 Cleaning: Clean tar and all other soil from housing exterior. Leave ready for Division 7, Caulking Work. Caulk around pipe sleeves.

3.7 Condensate Drain: Pipe trapped copper condensate drain to outside the building or to a point of disposal as shown on the drawings. Pipe shall be full size of unit outlet. Refer to Division-23 section "Insulation" for pipe insulation.

3.8 Startup: Check entire assembly for correctness of installation, alignment, and control sequencing. Start all component parts in proper sequence. Make all adjustments required to insure proper smooth quiet operation.

END OF SECTION 23 81 28

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