

SECTION 23-0100
HVAC GENERAL PROVISIONS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Provide all labor, materials, tools, and services for a complete installation of equipment and systems contained in contract documents. Where discrepancies exist between the construction drawings and these specifications, the construction drawings shall take precedence. **All equipment shall be installed in strict accordance with manufacturer's instructions.**
- B. Principal features of work included are:
 - 1. Heating, ventilating, and air-conditioning system.
 - 2. Complete control system including low voltage wiring. All 120 volt power shall be the responsibility of the electrical contractor. All wiring less than 120 volts shall be provided and installed by the controls contractor. For any control component requiring 120V power, the control contractor shall be responsible for coordination with the electrical contractor for required scope.
 - 3. Complete equipment, ductwork, and piping systems coordination drawings developed in 3 dimensional CAD software. The composite coordination drawings shall include mechanical, plumbing, structural, electrical, communications systems, and fire sprinkler information so as to ensure an integrated installation.
- C. Provide necessary seismic hangers, vibration isolators, equipment mounts, etc. as required to accommodate all seismic protection requirements for all of the mechanical and plumbing work associated with this project per International Building Code requirements, along with any local codes or code amendments. Refer to structural documents for specific seismic parameter guidelines applicable to this project, and provide for accordingly. Provide shop drawings noting locations of all seismic devices, types of seismic required, and seismic device calculations signed and sealed by a qualified Professional Engineer, and to meet all local, and state code requirements related to seismic protection in effect on the date bids are received. Provide a certification from the manufacturer's Seismic Design Engineer that the final installed seismic devices will comply with all applicable code requirements. Equipment manufacturers shall provide certification that their equipment is capable of resisting expected seismic loads without failure. Equipment manufacturers shall provide suitable attachment points and/or instructions for attaching seismic devices. Seismic protection devices shall be as manufactured by Amber/Booth Company, Inc.; Mason industries, Inc.; or Kinetics Noise Control, Inc.

1.2 PERMITS

- A. Obtain and pay for the required permits and inspection fees.

1.3 CODES & STANDARDS

- A. The HVAC work installation shall only comply with State and local Building Codes, applicable Life Safety Code, and with State, Federal and local laws. Ductwork, insulation, and fire and/or smoke dampers shall comply with NFPA Standard 90A and 90B.

- B. Refer to architectural drawings for all applicable building codes for this project.
- C. The mechanical and plumbing work shall comply with "Reduction of Lead in Drinking Water Act" effective January 1, 2014.
- D. Equipment shall be U.L. listed. Installation work shall comply with U.L. Standards, where applicable.
- E. Arrange for, pay fees for, and accomplish the work required to pass tests required by agencies having authority. Obtain certificates of compliance where available from said authorities and transmit to the General Contractor.
- F. Complete work shall comply with existing regulatory noise and safety standards. Equipment shall comply with these standards, whether specifically so noted or not.
- G. Sheet Metal and Air-Conditioning Contractors National Association (SMACNA).
- H. Air Moving and Conditioning Association (AMCA).
- I. Air-Conditioning and Refrigeration Institute (ARI).
- J. American Society of Mechanical Engineers (ASME).
- K. AABC National Standards for Total System Balance (2002) and companion AABC TEST AND BALANCE PROCEDURES.

1.4 GUARANTEE

- A. Mechanical work and systems shall be guaranteed against improper operation, faulty material or workmanship for a period of one year from the date of final acceptance. If the project is occupied in several phases at the request of the Owner, then the guarantee of the scope included in the occupied area shall begin on the date that each system or piece of equipment was placed in satisfactory operation and accepted as such, in writing, by the Owner. Such acceptance may not be unreasonably withheld and shall not extend beyond the written substantial completion date of the project.

1.5 MAINTENANCE

- A. Equipment and material installed under this Division should be periodically lubricated, inspected, and serviced by competent mechanics in accordance with manufacturer's recommendations. This function becomes the responsibility of the Owner when the system is accepted by the Owner. The one year material and workmanship guarantee is not intended to supplant normal inspection or service and shall not be construed to mean that the Contractor will provide free service for normal maintenance items such as periodic lubrication and adjustment due to normal use, nor to correct without charge, breakage, maladjustment, and other trouble caused by improper maintenance.
- B. Equipment shall be turned over to the Owner, free from defects and in clean and in lubricated condition. Where filters are required, clean filters shall be installed immediately prior to turnover to Owner. Instructions on further lubrication shall be included in the operation instructions.

1.6 OPERATING INSTRUCTIONS

- A. Furnish to the Owner electronic sets of operation and maintenance instructions on mechanical equipment. Instructions shall also include recommended spare parts lists. This manual shall be approved in writing by the Engineer. A minimum of one (1) day of training on the operation and maintenance of the mechanical equipment shall be provided for the Owner's representatives.
- B. The O&M manuals shall include the final submitted & approved engineering performance data for all mechanical equipment, including but not limited to the following: airflows; static pressures; ΔP data; entering & leaving dry bulb & wet bulb temperatures; waterflows; total dynamic head; entering and leaving water temperatures; volts/phase; amps; power consumption (brake horsepower/kW) at full load (and part load, where applicable); sound power level; vibration level (displacement & velocity); etc. The O&M manuals shall include the engineering performance curves for all applicable mechanical and electrical equipment, including but not limited to the following: fan curves; pump curves; terminal box ΔP versus airflow curves; circuit setter / auto-flow device ΔP versus waterflow curves; AFMS ΔP versus airflow curves; motor % load versus efficiency curves; power consumption versus load curves; fuel consumption versus load curves; etc. Equipment items specifically included are all air handling unit fans, general exhaust fans, supply air fans.

1.7 RELATED WORK: The following work shall be furnished under other Divisions.

- A. The related electrical work is covered in Division 26, Electrical. Electrical power shall be provided and installed under the Electrical Division. Starters and disconnects shall be furnished and installed under Electrical Division, unless noted otherwise in specific sections of that specification or as noted on Division 23 plans.
- B. Painting including piping shall be done under the Painting Division.
- C. Flashing of ducts and pipes into roofs shall be done under Architectural Division.
- D. Holes, chases and recesses required for mechanical work, where advance notice is given the Contractor.
- E. Miscellaneous steel work, such as equipment supports and framed openings for piping and duct.
- F. Access panels and door grilles shall be installed under other Divisions.
- G. Owner-furnished equipment shall generally be installed by other Divisions unless it directly relates to the function of the mechanical system.
- H. Openings in casework shall be provided by Casework Manufacturers.

1.8 SUBMITTALS: Submit for review complete brochures and shop drawings for materials and equipment proposed in accordance with Division 1. Submit for review a list of major equipment within 25 days after award of contract.

- A. Brochures: Submit complete descriptions, illustrations and specification data for materials and equipment proposed. Clearly indicate proposed items when other items are shown on same sheet. Submit samples on request and/or set up for inspection. Samples will be returned to Contractor.
- B. Welding and press pipe fitting certifications

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT: Provide materials and equipment bearing the U.L. label when such label is available.

2.2 SUBMITTAL SUBMISSION:

- A. Submit one (1) electronic copy of certified shop drawings to the Engineer for review on material furnished under this Division. Submittal data shall be checked and stamped approved by the Engineer prior to his transmitting to the Architect. Submittals shall contain rating data, accessories, and features the same as listed in specifications and capacities shall be stated in the terms specified. The submittals are the contractor's documents, and the Architect's and Engineer's review or comments constitutes an acknowledgement that the documents have been submitted and nothing else.
- B. It is the contractor's responsibility to check their own submissions for compliance with the Contract Documents and job conditions.
- C. Substitutions of equipment other than that specified must be very clearly checked to assure that no problems will occur due to dimensional differences, connection points, weights, etc.
- D. **Any deviation from the design documents must be clearly identified so the Engineer may properly review such items.** Review of the shop drawings with no exceptions taken will not be considered acceptance of the deviation unless it has been explicitly identified. If equipment other than what is in the schedules is submitted, contractor is verifying that it will perform as the specified equipment as shown on the construction documents.
- E. Additional installation costs associated with substituted equipment requiring additional work on the part of this contractor or other subcontractors to satisfy the manufacturer's installation requirements shall be the responsibility of the submitting contractor.
- F. Submit for review complete brochures and shop drawings for materials and equipment proposed in accordance with Division 1. Submit for review, a list of major equipment within 25 days after award of contract. Submittals shall include but not be limited to the following:
 - 1. All equipment and fixtures shown or indicated on the HVAC drawings and specifications.

PART 3 - EXECUTION

3.1 AIR HANDLING UNIT STARTUP

- A. Once starting of mechanical systems begins, the mechanical contractor shall maintain an appropriate maintenance log, where applicable, of all interim maintenance tasks performed on all started-up equipment, so that manufacturer's warranties are not voided prior to the equipment being turned over to the owner. This log shall be submitted when the equipment is officially released to the owner.
- B. Heating hot water systems shall not be started-up until hydrostatic pressure testing, system leak identification and repair, cleaning, flushing, and pre-treatment has been completed and reported to the engineer of record (EOR). Additionally, do not install ductwork insulation until after ductwork air leakage testing (DALT) has been completed and the test results submitted to the EOR.

3.2 COORDINATION

- A. Coordinate locations of equipment, ductwork, and piping to eliminate conflict with other divisions.
- B. Carefully examine contract documents to be thoroughly familiar with items that require mechanical connections and coordination.
- C. Due to the small scale of the Drawings, it is not possible to indicate all offsets, fittings, changes in elevations, interferences, etc. Make necessary changes in the work, equipment locations, etc. as part of the contract to accommodate work to obstacles and interferences encountered. Before installing, verify exact location and elevation at work site.
- D. Coordinate work with other trades and determine route or location of each duct, pipe, conduit, etc., before fabrication and installation.
- E. Field verify all existing conditions prior to bidding and verify no conflicts exist. Notify engineer and architect if any discrepancies are found. Any tie in points (piping, or duct) shall be field verified for their exact location. No additional costs will be accepted due to the lack of verification prior to bidding.
- F. Provide proper chases and openings. Place sleeves and supports prior to pouring concrete or installation of masonry.
- G. Whether shown on the drawings or not, provide adequate space and provision for servicing equipment, for field test access, and for removal and reinstallation of replaceable items such as instrumentation, motors, heat transfer coils/tubes, filters, and miscellaneous replacement parts.
- H. The design team will make periodic site visits for project coordination and progress evaluation. A site report will be generated from these visits. All punch list, coordination and items listing work inconsistent with the design intent are to be responded to by the contractor in writing.

3.3 CUTTING AND PATCHING

- A. Repair or replace routine damage caused by cutting.
- B. Correct unnecessary damage caused due to installation of mechanical work.

3.4 Perform repairs with materials that match existing in accordance with the appropriate section of these specifications.

3.5 IDENTIFICATION

- A. Identify exposed or accessible piping with snap-on or strap-on type markers. Color code markers in accordance with ANSI. Indicate pipe contents and direction of flow on marker. Install markers on piping not more than 30 feet apart, at valves, at access panels, and at least once above each space.
- B. Sprinkler and buried lines need not be marked.
- C. Identify all mechanical equipment with engraved brass, aluminum, or stainless steel nameplates or tags. Use equipment names and numbers appearing in schedules on drawings. Fasten nameplates to equipment using screws. Glue or adhesive is

not acceptable. Fasten tags to equipment using brass, aluminum or stainless steel chains.

- D. Identify each valve with engraved brass, aluminum, or stainless steel identification tag indicating valve service and sequential identification number. Attach tag to valve handle with brass, aluminum or stainless steel chain. Service valves located at the equipment being served will not be tagged. Provide electronic manuals to Owner listing each valve sequentially and indicating valve manufacturer, style, size, service, normal position, and specific location for each valve.
- E. Frame and mount control diagrams and sequences in each equipment room. Use non-fading black and white prints encased in aluminum frame with plexiglass cover.
- F. No stenciling or labeling shall be performed until all painting required under architectural section has been performed.
- G. **Provide a label on the ceiling tile below access to all fire and fire/smoke dampers.**

3.6 DUCT CLEANING / EQUIPMENT PROTECTION

- A. The installing contractors must take appropriate precautions, during construction, to prevent unnecessary dust and debris from getting into air and water handling systems by covering equipment, controls and open-ended ducts and pipes while being stored on site and as the installation progresses. If this does not occur, then contractor shall be responsible to clean all ductwork and replace any affected electronic components.
- B. Duct systems shall be maintained at an Intermediate Level as defined by SMACNA's Duct Cleanliness for New Construction Guideline 3.1

3.7 PIPE CLEANING

- A. The system cleaning and testing described herein are minimum requirements. Additional tests as required by the authority having jurisdiction shall also be performed.
- B. Piping and related items such as valves, etc., shall be inspected for sharp edges or other hazardous conditions. Such conditions shall be corrected by removal, modification or covering
- C. Before final inspection, the HVAC piping systems shall be thoroughly cleaned. Equipment, pipe, valves, fixtures, and fittings shall be cleaned of grease, piping compound, metal cuttings, plaster, concrete, and other foreign material.
- D. Factory applied prime coat paints shall be touched up to cover bare places and scratches. Weld joints shall be cleaned and painted with rust inhibitive paint, Galv-con, or approved equal, where galvanized pipe has been welded.
- E. HVAC water piping shall be cleaned by flushing, draining, and refilling until system is free of construction dirt and scale, and water flows clear.
- F. After pipe cleaning is complete, strainer baskets shall be removed, cleaned, and replaced. Conical or disc type strainers shall be used during flush procedure at flanged connections upstream of pocket areas, shall be cleaned between flushes, and removed at completion of flushing procedure.

- G. Hot water heating lines shall be thoroughly flushed before installation of control valves by installing temporary flushing loops or spool pieces at valve locations.
- H. The installing contractors must take appropriate precautions, during construction, to prevent unnecessary dust and debris from getting into air and water handling systems by covering equipment, controls and open-ended ducts and pipes while being stored on site and as the installation progresses.

3.8 PIPE TESTING

- A. Testing shall be completed before insulation and concealment is started.
- B. All tests shall apply full test pressure to the piping for a minimum of twenty-four hours unless otherwise noted in specifications.
- C. All Hydronic piping shall be tested at 150 pounds per square inch. All other piping shall be tested at 1 ½ times the working pressure.
- D. When the test pressure has fallen over five percent during the twenty-four hour test period, the point of leakage shall be found, repaired and the test repeated. This procedure shall be followed until the piping system has been proven absolutely tight.
- E. The use of chemicals or so-called stop-leak compounds will not be permitted at any time.
- F. When delicate control mechanisms and other items having a rating less than the test pressure are installed in the piping system, they shall be removed during the tests to prevent shock damage. This does not apply to control valves.
- G. Leaks and other defects shall not be repaired by mastic or other temporary means. All leaks shall be repaired by removal of the valve, fitting joint, or section that is leaking and reinstalling new material with joints as specified hereinbefore.
- H. Piping may be tested a section at a time to facilitate construction. All gauges and instrumentation used shall have been recently calibrated in accordance with manufacturer's **recommendations**.

3.9 FINAL INSPECTION

- A. All final reports required by the specification (Test & Balance, etc.) shall be submitted to the engineer of record prior to the final site visit.
- B. All punch lists, deficiency lists, field reports and similar correspondence generated by the design team during construction is to be responded to in writing by the contractor.

END OF SECTION

SECTION 23-0104
HVAC BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work required under this section of the specifications consists of basic materials and methods applicable to work under Division 23.

1.2 QUALITY ASSURANCE

- A. Qualifications of manufacturer: Products used in the work of this Section shall be produced by manufacturers regularly engaged in manufacture of similar items and with a history of successful production acceptable to the Architect.
- B. Qualifications of installers: Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

PART 2 - PRODUCTS

2.1 FOUNDATIONS AND PADS

- A. Provide foundations, pads, and bases required for equipment. Concrete to be in accordance with concrete division of specifications.
- B. Coordinate proper sizes and locations of foundations, pads, bases, louvers, anchors, supports, and other items to be built into structure.

2.2 FASTENINGS TO STRUCTURES

- A. Provide structural fastening devices for equipment, materials, piping and ductwork. Devices to be concrete inserts, expansion shields and lag bolts, and through bolts-washers-nuts. All bolted devices to use jamb nuts. Inserts to be continuous type as manufactured by Unistrut or approved substitute. Install per manufacturer's published installation instructions in lengths to suit specific application, complete with spring nuts, end caps, and plastic coated filler to prevent concrete seepage.
- B. Use of power drive "shot-pins" is permitted only for ducts 20" in width and smaller and single pipes 1" and smaller.

2.3 ACCESS PANELS

- A. Provide ceiling and wall access panels for installation by other Divisions. Coordinate locations so panels will provide proper access to equipment served. Notify Designer of proposed wall or ceiling access panel locations prior to installation of such panels. Minimum size: 24" x 24".
- B. Panels shall be manufactured by Bilco or approved substitute. Provide panels with minimum 16 gauge steel construction with screwdriver operated locks and primer finish.
- C. Provide fire-rated panels for installation in fire-rated partitions.

2.4 POWER DISCONNECT SWITCHES

- A. All electrically powered mechanical equipment is to have a full line voltage

disconnect switch in site of and within 10 feet of the equipment so that power can be completely removed from the equipment for servicing.

- B. All electrically powered equipment is to be provided with properly sized and located electrical power disconnect switches. If switches are not provided with equipment from the manufacturer, they are to be provided and installed by the contractor.
- C. Refer to Section 260000 for additional information on disconnect switches.
- D. Label all disconnect switches and power feeds to equipment with engraved plastic tags mechanically attached. Lettering is to be sized appropriately, but no less than 1/4" high. Mechanically attached tag to disconnect or equipment. Coordinate color of tag with electrical. Label to include identification number of equipment served and name of panel and circuit.

PART 3 - EXECUTION

3.1 REQUIREMENTS

- A. Substitutions shall be reviewed by the Engineer as covered under "Submittals" located in specification 23 01 00 – HVAC General Provisions.
- B. The mechanical drawings are diagrammatic and show the relations of equipment and connections and shall not be construed to be complete as to the exact requirements.
- C. Installation of equipment and materials shall be performed in accordance with manufacturer's recommendations or contract documents, whichever is more stringent. Installation of equipment and routing of systems shall be coordinated with other work so as to prevent delays, conflicts or damage.
- D. Duct, piping and other suspended equipment shall be installed so as to provide the maximum possible clearance underneath except as noted.
- E. Equipment and devices, which require service, shall be installed to provide the necessary clearance as recommended by the manufacturer.
- F. Work, equipment and materials shall be protected from theft, injury, weather and other damage at all times. Open ends of duct, pipe and other work shall be protected by suitable plugs or covers during storage and construction to prevent entrances of dirt or other foreign material.
- G. The Engineer shall be notified in writing of any conflicts in contract documents. Conflicts shall be resolved by a written ruling from the Architect.
- H. Unless indicated by drawings or specifically approved, all items in the same section shall be by the same manufacturer (e.g. air handlers, pumps, etc.)
- I. All hangers, piping, welds, etc. made from ferrous metals are to be cleaned free of rust and painted with rust resistant paint equal to Rustoleum.

END OF SECTION

SECTION 23-0529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE

- A. The work covered under this section consists of furnishing all necessary labor, supervision, materials, and equipment required to completely execute the pipe hanger and supports as described in this section.

1.2 REFERENCES

- A. ASTM B 633 – Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
- B. ASTM A 123 – Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
- C. ASTM A 653 – Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip process.
- D. ASTM A 1011 – Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability.
- E. MSS SP-58 – Manufacturers Standardization Society: Pipe Hangers and Supports – Materials, Design, and Manufacture.
- F. MSS SP-69 – Manufacturers Standardization Society: Pipe Hangers and Supports – Selection and Application

1.3 QUALITY ASSURANCE

- A. Steel pipe hangers and supports shall have the manufacturer's name, part number, and applicable size stamped in the part itself for identification.
- B. Hangers and supports shall be designed and manufactured in conformance with MSS SP-58.

1.4 SUBMITTALS

- A. Submit product data on all hanger and support devices, including shields and attachment methods. Product data to include, but not limited to materials, finishes, approvals, load ratings, and dimensional information.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Cooper B-Line, Inc., Anvil International, Inc., or approved equal.

2.2 PIPE HANGERS AND SUPPORTS

- A. Hangers:
 - 1. Un-insulated steel pipes ½" to 24" with NO LONGITUDINAL MOVEMENT:
 - a. Adjustable steel clevis hanger equal to B-Line B3100.

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2. Un-insulated copper tubing and PVC pipe ½" O.D. to 4" O.D. with NO LONGITUDINAL MOVEMENT:
 - a. Plastic coated adjustable tubing ring hanger equal to B-Line B3170CTC.
 3. Un-insulated cast iron soil pipe ¾" to 8":
 - a. Adjustable swivel, split ring type equal to B-Line B3171.
 4. Un-insulated cast iron soil pipe 10" to 15":
 - a. Adjustable swivel, split ring type equal to B-Line B3100.
 5. Insulated steel piping ½" to 24", galvanized steel piping ½" to 24", copper piping ½" O.D. to 4" O.D., and PVC pipe with NO LONGITUDINAL MOVEMENT:
 - a. Adjustable clevis hanger equal to B-Line B3100.
 - b. Galvanized steel insulation protection shield sized for maximum 10' span on 4 psi compressive strength insulation equal to B-Line B3151.
- B. Pipe Clamps:
1. When flexibility in the hanger assembly is required due to horizontal movement, use pipe clamps with weldless eye nuts, B-Line B3140 or B3142 with B3200 or approved equal. For insulated lines, use double bolted pipe clamps equal to B-Line B3144 or B3146 with B3200.
- C. Multiple or trapeze hangers
1. Trapeze hangers shall be constructed from 12 gauge roll formed ASTM A1011 SS Gr. 33 structural steel channel, 1-5/8" x 1-5/8" minimum equal to B-Line B22 strut or stronger as required.
 2. Mount pipes to trapeze with two piece pipe straps sized for outside diameter of pipe equal to B-Line B2000 series.
 3. For pipes subject to axial movement:
 - a. Strut mounted roller support equal to B-Line B3126. Use pipe protection shield or saddles on insulated lines.
 - b. Strut mounted pipe guide equal to B-Line B2417.
- D. Wall Supports
1. Pipes 4" and smaller:
 - a. Carbon steel hook equal to B-Line B3191.
 - b. Carbon steel J-hanger equal to B-Line 3690.
 2. Pipes larger than 4":
 - a. Welded strut bracket and pipe straps equal to B-Line B3064 and B2000 series.
 - b. Welded steel brackets equal to B-Line B3066 or B3067, with roller chair or adjustable steel yoke pipe roll equal to B-Line B3120 or B3110. Use pipe protection shield or saddles on insulated lines.
- E. Floor Supports

1. Piping with NO LONGITUDINAL MOVEMENT and piping under 6" WITH LONGITUDINAL MOVEMENT:
 - a. Carbon steel adjustable pipe saddle and nipple attached to steel base stand sized for pipe elevation equal to B-Line B3093 and B3088T or B3090 and B3088. Pipe saddle shall be screwed or welded to appropriate base stand.
- F. Vertical Supports
1. Steel riser clamp sized to fit outside diameter of pipe equal to B-Line B3373 or B3374.

2.3 UPPER ATTACHMENTS

- A. Beam Clamps
1. Beam clamps shall be used where piping is to be suspended from building steel. Clamp type shall be selected on the basis of load to be supported, and load configuration.
 2. C-Clamps shall have locknuts and cup point set screws equal to B-Line B351L or B3036L. Top flange C-clamps shall be used when attaching a hanger rod to the top flange of structural shapes and shall be equal to B-Line B3034 or B3033. Refer to manufacturers' recommendation for setscrew torque. Retaining straps shall be used to maintain the clamp's position on the beam where required.
 3. Center loaded beam clamps shall be used where specified. Steel clamps shall be B-Line B3050 or B3055. Malleable iron or forged steel beam clamps with cross bolt shall be equal to B-Line B3054 or B3291 – B3297 series as required to fit beams.
- B. Concrete Inserts
1. Cast in place spot concrete inserts shall be used where applicable, either steel or malleable iron body equal to B-Line B2500 or B3014. Spot inserts shall allow for lateral adjustment and have means for attachment to forms. Select insert nuts to suit threaded hanger and rod sizes equal to B-Line N2500 or B3014N series.
 2. Continuous concrete inserts shall be used where applicable. Channels shall be 12 gauge, ASTM A 1011 SS Grade 33 structural quality carbon steel, complete with Styrofoam inserts and end caps with nail holes for attachment to forms. The continuous concrete inserts shall have a load rating of 2,000 lbs/ft in concrete and shall be equal to B-Line B221, B321, or B521 (B521 is limited to 1,500 lbs/ft). Select channel nuts suitable for strut and rod sizes.

2.4 ACCESSORIES

- A. Hanger rods shall be threaded on both ends and shall be equal to B-Line B3205. Continuous threaded rods of circular cross section may also be used. Use adjusting locknuts at upper attachments and hangers. No wire, chain, or perforated straps are allowed.
- B. Shields shall be 180 degree galvanized sheet metal, 12 inch minimum length, 18 gauge minimum thickness, designed to match the outside diameter of the insulated pipe and shall be equal to B-Line B3151. Pipe hangers serving all insulated piping shall be provided with suitable protection shields and/or saddles at the pipe

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hanger. Pipe hanger insulation shields shall be fabricated with a minimum metal gauge thickness in compliance with MSS SP-69, and insulation shields and/or saddles shall be properly centered inside pipe hangers to ensure that the piping insulation is not damaged. As an alternate, utilize per-fabricated hanger/insulation shield combinations, which are clevis hangers with insulation protection shields spot welded in place.

- C. Pipe protection saddles shall be formed from carbon steel, 1/8" minimum thickness, sized for insulation thickness. Saddles for pipe sizes greater than 12" shall have a center support rib.

2.5 FINISHES

- A. Hangers and strut located indoors and all hanger hardware shall be electro-plated zinc in accordance with ASTM B 633 SC1 or SC3.
- B. Hangers and strut located outdoors shall be hot dip galvanized after fabrication in accordance with ASTM A 123. All hanger hardware shall be hot dip galvanized or stainless steel.
- C. Hangers and strut located in corrosive areas shall be Type 304 stainless steel with stainless steel hardware.

PART 3 - EXECUTION

3.1 PIPE HANGERS AND SUPPORT

- A. Pipe shall be adequately supported by pipe hanger and supports specified in Part 2 - Products. Hangers for insulated pipes shall be sized to accommodate insulation thickness.
- B. Horizontal steel and copper piping shall be supported in accordance with MSS SP-69, Tables 3 and 4. The following is an excerpt from those tables:

Nominal Pipe Size	Rod Diameter	Maximum Spacing
3/8" – 1-3/4"	3/8"	7'-0"
1-1/2"	3/8"	8'-0"
2"	3/8"	10'-0"
2-1/2"	3/8"	10'-0"
3"	1/2"	12'-0"
3-1/2"	1/2"	10'-0"
4"	1/2"	10'-0"
5"	1/2"	10'-0"
6"	1/2"	10'-0"
8"	5/8"	10'-0"
10"	5/8"	15'-0"
12"	5/8"	15'-0"

14"	3/4"	15'-0"
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3.2 CONCRETE INSERTS

- A. Provide inserts for placement in formwork before concrete is poured.
- B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- C. Where concrete slabs from finished ceilings, provide inserts to be flush with slab surface.
- D. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.

3.3 GENERAL

- A. Pipe shall be suspended from the building structure in a neat and workmanlike manner. Wherever possible, parallel runs of horizontal pipe shall be grouped on trapeze type hangers utilizing angle iron or uni-strut. Excess all thread rod shall not exceed 1½" below pipe support.
- B. The use of wire or perforated metal strapping is not permitted.
- C. Hanging of pipe from other pipes, duct, etc is not permitted.
- D. Supports shall be designed and installed such that neither pipe nor supports will be subject to electrolytic action. Provide dielectric isolation between dissimilar metals of piping and supports (tape (electricians, duct, etc. is not acceptable).
- E. Provide anchors as required for proper anchorage including channels, plate etc.
- F. Insulation saddles shall be adhered to the insulation jacket with adhesive.
- G. Hangers for piping 2½" and smaller utilizing teardrop hangers, hanger and pipe shall be insulated as an assembly. Piping 3" and above shall be supported by sections of cellular glass (foam glass) insulation placed in the insulation saddle to protect against damage to the insulation caused by excessive weight. Installation of just a metal pipe saddle is not sufficient.
- H. Vertical piping shall be secured at sufficiently close intervals to keep the pipe in alignment and carry the weight of the pipe and contents. Screwed pipe shall be supported at not less than every other story height. Copper tubing shall be supported at each story for piping 3/4 inch and over and at not more than intervals of four feet for 5/8 inch and smaller.
- I. Piping may be grouped together and supported from galvanized angle iron trapeze hangers. Provide insulation saddles to protect the pipe insulation.

END OF SECTION

SECTION 23 0593

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This work shall include all HVAC, HVAC piping systems, and domestic water heating circulation loop. Contractor shall provide all equipment necessary for testing and balancing.
- B. Perform test and balance work by an independent (not contracted under the mechanical contractor) TABB, NEBB and/or AABC certified Test and Balance Agency that has experienced and trained personnel with at least 5 years experience in the type of work defined in the project scope. Coordinate with GC to ensure T&B contract is held by G.C. and not M.C.
- C. Perform test and balance in accordance with nationally accepted standards for the practice of testing and balancing of systems per the project documents.
- D. The TAB agency shall review construction plans and specifications. If any discrepancies are noted which would hinder balancing, notify the designer with copy to the contractor. Make inspections of the job during construction for proper installation of the system(s) and of balancing aids in the system(s). Any discrepancies noted shall be brought to the attention of the contractor and designer. The number of inspections may vary with the size and complexity of the job and shall be adequate for the purpose intended.
- E. Coordination with the agency at the job site shall be the responsibility of the contractor in order to ensure proper scheduling and operation of the systems. All correspondence (reports, letters and communications) between any parties shall have copies sent directly to the contractor. The TAB Agency shall work in close coordination with the Temperature Controls Contractor in calibrating all airflow and water flow stations and all duct and pipe mounted differential pressure sensor / transmitters. The tests shall be documented and included in the final TAB report. The TAB agent is to coordinate with the controls contractor to be available to manipulate controls as needed to execute the balance as described herein.

1.2 QUALITY ASSURANCE

- A. All testing and balancing fieldwork conducted on air and hydronic systems / equipment in this facility shall conform to AABC NATIONAL STANDARDS for Total System Balance, 6th edition, 2002 and the companion volume, AABC TEST AND BALANCE PROCEDURES.

1.3 SUBMITTALS

- A. The TAB agency shall submit the following information for approval: (1) Detailed outline of procedures for accomplishing total system balance. (2) Proposed project agenda and schedule of tests. (3) AABC, NEBB or TABB standard and / or special report and test forms that will be used. (4) Sample AABC NEBB, or TABB National Project Performance Guaranty. (5) Proposed equipment or systems test forms on all equipment for which standard AABC, NEBB or TABB test forms are not available. Design of test forms shall be based on TAB agency's experience and on project design documents. (6) Prior to beginning of

TAB fieldwork, TAB agency shall submit the following information: (6a) A complete set of Pre-field report and test forms indicating all applicable design data. (6b) A list of instruments that will be used, including instrument make, model and serial numbers and date of latest calibration.

PART 2 - TESTING AND BALANCING PROCEDURES

2.1 AIRSIDE

A. Supply Air:

1. Fans checked for rotation, amperage, static pressure, etc.
2. Terminal boxes set to maximum and minimum cfm and supply outlets balanced to within 10% of design cfm.
3. Main supply duct pitot tube traverse shall be used in coordination with adjustments of the fan speed to produce design cfm while maintaining minimum system static pressure for proper terminal box operation.
4. Test, calibrate with flow hood, establish K-factor and record airflow through terminal box.

B. Return Air:

1. Fans checked for rotation, amperage, static pressure, etc.
2. With supply system in the maximum mode, traverse and adjust return fan to design cfm.
3. With supply system in the maximum mode, proportion return inlets to within 10% of design cfm.

C. Outside Air:

1. Fans checked for rotation, amperage, static pressure, etc.
2. With supply system in the maximum mode, traverse and adjust minimum outside air setpoint to design cfm.

D. Exhaust Air:

1. Fans checked for rotation, amperage, static pressure, etc.
2. With supply system in the maximum mode, traverse and adjust exhaust fan to design cfm.
3. Proportion exhaust inlets to within 10% of design cfm.

E. Diffusers, Registers, and Grilles:

1. Balance each supply, return and exhaust air outlet within 10% of design cfm.
2. Check and/or adjust pressure relationships so that each positive pressure and each negative pressure area is at least 10% positive or negative as appropriate.
3. Provide a table indicating all final room pressure relationships for final verification by the Engineer of Record.

F. Variable Air Volume Boxes:

1. Calibrate all new VAV boxes and record the K factor.
2. If a VAV box has been converted from pneumatic control to DDC control, calibrate the box and record the K factor.

2.2 WATERSIDE

- A. Hot Water System
 - 1. Check system for cleanliness.
 - 2. With all hot water coils (including terminal box reheat coils) calling for full heating, test, set and record pump head and flow.
 - 3. Test, set and record pressure drop and flow through each convertor.
 - 4. Test, set and record pressure drop and flow through each flow balancing station.
 - 5. Test, set and record pressure drop and flow through each heating coil.
 - 6. Verify that piping system is vented.
- B. Capacity and Performance Test
 - 1. Terminal Box Heating Coils
 - a. Test, set and record flow through terminal box heating coil.

2.3 CONTROLS

- A. Controls
 - 1. AHU Controls
 - a. Check temperature controls for proper calibration and setpoint.
 - 2. Thermostats and Controllers
 - a. Check for proper control of valves, dampers, terminal boxes, exhaust fans, etc.
 - b. Set at design set point.
 - 3. Smoke Detectors:
 - a. Provide a differential pressure test across the sampling tubes of each smoke detector.
 - b. Log each device with its unique name and number and record the actual differential pressure as well as the manufacturers recommended value.
 - 4. Thermostat Calibration
 - a. Measure and record dry and wet bulb temperatures at each thermostat.
 - b. Report any thermostat that is not controlling with +/- 1-1/2 degrees F.
 - 5. Control Temperature Readouts
 - a. Test actual temperature next to sensor (if possible) and compare to readout.
 - b. Report any sensor that is not within +/- 1-1/2 degrees F.

2.4 GENERAL REQUIREMENTS

- A. After completion of the installation of the air conditioning, heating, ventilating and exhaust systems, and prior to acceptance by the Owners, all air handling systems and appurtenances applicable to the above system shall be adjusted and balanced

to deliver the air quantities as specified, indicated on the drawings, or as directed. Air balancing shall be done with all doors closed.

- B. Instruments required for the air balance shall have been calibrated within a period of one year prior to balancing. Types and dates of calibration of all instruments shall be listed in the final air balance reports hereinafter specified. Duct systems shall be leak tested in accordance with SMACNA Standards. Leakage rate shall not exceed maximum levels as specified in the standards.
- C. Air quantity measurements in main and branch ducts shall be performed by pitot tube traverse of the entire cross-sectional area of the duct. Ducts having velocities of 1000 or more feet per minute shall be measured by inclined manometers (draft gauge) or magnehelic gauges. Air measurements required for ducts having velocities of less than 1000 feet per minute shall be performed with micro-manometers, hood gauges or similar low-pressure instruments. Openings in ducts for pitot tube insertion shall be sealed with snap-in plugs after air balance is complete. Outlet and inlet air quantities shall be determined by direct reading velocity meters in accordance with outlet and inlet manufacturer's recommendations.
- D. Total air quantities shall be obtained by adjustment of fan speeds. **Contractor shall include an allowance to change out sheaves if necessary.** Branch duct air quantities shall be adjusted by volume or splitter dampers. Dampers shall be permanently marked after air balance is complete so that they can be restored to their correct position if disturbed at any time.
- E. Volume adjusters may be used to balance air quantities at outlets and inlets providing final adjustments do not produce sound levels in excess of heretofore specified limits, or objectionable drafts. Air quantity adjustments by outlet deflectors, grids or air scoops will not be permitted.
- F. Record and submit for evaluation and approval three (3) copies of the complete air balance report. Replacement of adjustable pulleys, addition of balancing dampers or pressure taps, required to effect proper air balance shall be furnished and installed by the Contractor at no additional cost to the Owner. If requested, any or all of the above field tests shall be conducted in the presence of the Architect's representative.
- G. In addition, the contractor shall submit to the Architect a typed, written report to include the following:
 - 1. A statement that all systems have been tested, checked out, balanced and are operating properly.
 - 2. A statement that all filters have been replaced.
- H. All reports by the Contractor shall include both the date of the test and the names of all persons performing and witnessing the tests.
- I. Prior to notifying the TAB agency that a given system is ready for TAB fieldwork to begin, the installing contractor(s) shall conduct the following final checks:
 - 1. The installing contractor shall have repaired all piping system leaks identified during hydrostatic pressure testing, and shall have taken every precaution to ensure that all hydronic systems declared ready for TAB hydronic fieldwork to begin, have had all fluid isolation valves and stop cocks verified fully open.

2. The installing contractor shall be responsible for bleeding & venting all entrained air from circulating water systems.
 3. The installing contractor shall check to ensure that all balancing dampers are locked in the fully open position for the start of the TAB fieldwork, and shall be responsible for fully opening all closed and / or partially closed MVDs.
 4. The installing contractor shall confirm that he has provided a new set of clean filters (both "pre" and "final" where applicable) during initial system startup and at the start of TAB fieldwork for all air handling units, fan coil units, fan-filter units, etc. Additionally, the installing contractor shall confirm that he has removed all temporary filter media and that final unit filters have been installed prior to final unit setup by the TAB agency (i.e. prior to final unit traverse).
 5. The installing contractor shall check to confirm, that wherever possible, ductwork routing / layouts has allowed sufficient ductwork length on both SA and RA side of air handlers, to enable the TAB agency to conduct pitot tube traverses to determine overall air flows.
- J. Copies of all TAB agency generated deficiency reports shall be submitted to the general contractor to ensure that the appropriate installing contractors have received copies of the reports, and to help ensure that immediate attention can be given to addressing and resolving the various deficiencies identified. No retesting of submitted deficiency items shall be attempted by the TAB agency until signed copies of the deficiency reports, certifying completion of the item, have been received back by the TAB agency from the applicable installing contractor.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. All work shall be complete and any openings or insulation disturbance due to the testing process shall be replaced and taped.
- B. If, after balancing to the requirements above, some room temperatures deviate more than 3 degrees F from the thermostatic set point of the respective zone, the contractor shall make minor adjustments in the airflow to minimize temperature deviations at no additional cost to the owner.
- C. Mechanical contractor shall measure the differential pressure between tubes on all duct mounted smoke detectors and verify compliance with manufacturer's range of acceptable differential pressures.
- D. Code required pressure relationships as indicated on the plans shall be maintained regardless of allowed 10% tolerances.
- E. The final TAB report shall clearly indicate the amount of final system leakage measured on all air handling and exhaust air systems. (amount of duct leakage equals difference between the summation of airflows measured at the individual SA outlets or exhaust and or RA inlets and the total air handler or exhaust fan main duct pitot tube traverse).
- F. The final TAB report will include a copy of the mechanical floor plan showing the locations and TAB agents' reference numbers of all diffusers, registers and grilles. All is to be clearly and legibly executed.

- G. To summarize the final balanced condition of the air handling units, provide a static pressure, airflow and temperature profile of each air handling unit in the following manner:
1. The unit should be set to full cooling by setting all of the VAV boxes to full capacity
 2. Get a snapshot of what the graphics are reading at this point
 3. Measure and record the static pressure across all appropriate points:
 - a. Return air duct to mixing plenum
 - b. Return fan
 - c. Pre-filters
 - d. Cooling coil
 - e. Fan
 4. Measure and record airflow entering and leaving:
 - a. Return
 - b. Outside air
 - c. Supply
 5. Measure and record temperature at all appropriate points:
 - a. Return air temperature
 - b. Outside air temperature
 - c. Mixed air temperature
 - d. Cooling coil leaving air temperature
 - e. Supply air temperature
 6. Get and record amp readings of the motors:
 - a. Supply
 - b. Return
 7. Note and record positions of all dampers
 8. Note and record visual conditions of filters
 9. Check and record the building pressure across the front, rear and side doors.
 10. Release the VAV boxes to normal operation
 11. Recheck and record the building pressure across the front, rear and side doors.

END OF SECTION

SECTION 23-0713
DUCT INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. The extent of duct insulation work as indicated on the drawings and by the requirements of this section.

1.2 QUALITY ASSURANCE

- A. Provide duct insulation products produced by one or more of the following manufacturers for each type of insulation and temperature range required:
1. Armacell LLC.
 2. CertainTeed Corp.
 3. Johns Manville
 4. Knauf Fiberglass
 5. Owens Corning
 6. Pittsburg Corning Corp.
- B. Fire/Smoke Ratings: Provide composite duct insulation (insulation, jackets, covering, sealers, mastics and adhesives) with flame-spread rating and smoke-developed rating as tested by ASTM E84 (NFPA 225) method. Composite rating shall not exceed the values shown with the physical properties for each type of insulation in this section.

PART 2 - PRODUCTS

2.1 DUCT INSULATION

- A. Fiberglass Blanket:
1. Provide flexible fiberglass blanket insulation with a foil-scrim-kraft (fsk) jacket. Insulation to conform strictly to fire resistive qualities hereinbefore specified in the "Quality Assurance" paragraph.
 - a. Medium-pressure supply duct – Wrap all duct with 2" thick, 1 lb./cu.ft. density fiberglass blanket with an R value of 6 (Absolutely no duct liner allowed). Joints shall be sealed with fiberglass fabric (RDC Corp Glasscoat or equal) and mastic (RCD Corp #6 Mastic or equal).
 - b. Low-pressure supply duct – Wrap all duct with 2" thick, 1 lb./cu.ft. density fiberglass blanket with an R value of 6 (Absolutely no duct liner allowed). Joints shall be sealed with fiberglass fabric (RDC Corp Glasscoat or equal) and mastic (RCD Corp #6 Mastic or equal).
 - c. Return duct – If return duct is not located immediately below a roof level, then duct does not have to be insulated. If duct is located directly below a roof level, wrap all duct with 2" thick, 1 lb./cu.ft. density fiberglass blanket with an R value of 6 (Absolutely no duct liner allowed). Joints shall be sealed with fiberglass fabric (RDC Corp Glasscoat or equal) and mastic (RCD Corp #6 Mastic or

- equal).
- d. Exhaust duct – If fan operation is intermittent, insulate the last five feet of duct leaving the building with minimum 2” thick, 1 lb./cu.ft. fiberglass blanket. If fan is operated continuous, no insulation is required.
 - e. Outside air duct – Wrap all duct with 2” thick, 1 lb/cu.ft. density fiberglass with an R value of 6 (Absolutely no duct liner allowed). Outside air plenums located in mechanical rooms shall be externally covered with 1-1/2” thick, 3 lb./cu.ft. density semi-rigid board type insulation. Joints shall be sealed with fiberglass fabric (RDC Corp Glasscoat or equal) and mastic (RCD Corp #6 Mastic or equal).
 - f. Duct located in attics or other extreme temperature locations – Wrap all supply, return, and outside air duct with 3” thick, 3/4 lb./cu.ft. density fiberglass blanket. Only insulate exhaust duct on entering side of energy recovery units located in attics or other high temperature areas (Absolutely no duct liner allowed). Joints shall be sealed with fiberglass fabric (RDC Corp Glasscoat or equal) and mastic (RCD Corp #6 Mastic or equal).
- B. All vapor barrier material, including the ASJ jackets and kraft-paper aluminum-foil jackets previously described shall meet the requirements of Federal Specification HN-B-100B, "Barrier Material Vapor (for pipe, duct and equipment thermal insulation) Type 1.
 - C. Staples, bands, wires and cements shall be as recommended by the insulation manufacturer for the applications indicated.
 - D. Adhesives, sealers, and protective finishes shall be as recommended by the insulation for each application.

PART 3 - EXECUTION

3.1 REQUIREMENTS

- A. Insulate all surfaces as indicated by drawings and specifications. Where more than one type of insulation is indicated for a particular application, selection shall be the contractor's option.
 - 1. Ductwork manual volume damper (MVD) handles, airflow station pressure ports, access door handles, duct-mounted instrumentation, etc. shall be left exposed and / or accessible above the insulation vapor barrier to enable the TAB agency or engineering maintenance personnel to access, adjust and / or read these devices without disturbing the integrity of the insulation vapor barrier. MVDs on insulated ductwork shall have standoff brackets and locking quadrants.
- B. Install insulation products in accordance with the manufacturer's written instructions, and in accordance with recognized industry practices.
- C. Surfaces shall be clean and dry prior to application of insulation. The piping system shall be tight with all testing and corrections complete.
- D. Install insulation materials with smooth and even surfaces. Do not use cut pieces or

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scraps abutting each other.

- E. Extend insulation without interruption through walls, floors and similar penetrations, except where otherwise indicated.
- F. Install protective metal shields and insulated inserts wherever needed to prevent compression of insulation between duct and angle or strap support. Insulation shall not be installed over duct supports.

END OF SECTION

SECTION 23-0719
HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. The extent of piping insulation work as indicated on the drawings and by the requirements of this section.

1.2 QUALITY ASSURANCE

- A. Provide piping insulation products produced by one or more of the following manufacturers for each type of insulation and temperature range required:
1. Armacell LLC.
 2. CertainTeed Corp.
 3. Johns Manville
 4. Knauf Fiberglass
 5. Owens Corning
 6. Pittsburg Corning Corp.
- B. Fire/Smoke Ratings: Provide composite pipe insulation (insulation, jackets, covering, sealers, mastics and adhesives) with flame-spread rating and smoke-developed rating as tested by ASTM E84 (NFPA 225) method. Composite rating shall not exceed the values shown with the physical properties for each type of insulation in this section.

PART 2 - PRODUCTS

2.1 PIPE INSULATION

- A. Fiberglass Tubular Elastomeric:
1. Provide fire-retardant closed-cell slip-on flexible type. Product must be guaranteed by manufacturer to have continuous operational temperature limit of not less than 220 degrees F and a minimum "R" value of 3.70. Product to be equivalent to Armacell LLC "Armaflex Shield". Applicable products manufactured by Manville and Rubatex are acceptable. Provide insulation for the following services:
 - a. Moisture condensate drains - 1/2" thick.
 - b. Refrigerant suction and hot gas lines – 1" thick
- B. Fiberglass:
1. Provide factory-formed factory-jacketed "system" type conforming strictly to fire-resistive qualities herein before specified in "Quality Assurance" section. Jacket to be vapor-barrier type when used for systems operating below 60 degrees F. "System" density shall not less than 4 pounds per cubic foot. Product must be guaranteed by manufacturer to have continuous operational temperature limit of not less than 650 degrees F and a minimum "R" value of 5.00. Product to be equivalent to Manville "Micro-Lok 650" with type AP jacketing. Product to be manufactured by Owens Corning, Manville or Knauf. Jacket to be fiberglass reinforced kraft paper with

aluminum foil and self-sealing lap joint.

2. Provide insulation of thickness for following services:
 - a. Heating hot water piping: 1-1/2" thick for 1-1/4" and smaller pipe, 2" thick for 1-1/2" and larger pipe.
- C. Hydronic piping excluding steam and condensate located in unconditioned mechanical rooms, attics shall have the thickness listed above increased by 1/2".
- D. For any service when above grade exposed-to-the-weather outside building, increase thickness 1" and cover straight pipe insulation with 0.016" thick aluminum jacket equivalent to Childers and cover valves and fittings with .024" thick aluminum factory formed covers equivalent to Childers Ell-Jacs. Provide heat trace at 10 watts per lineal foot.
- E. Refrigerant piping exposed-to-the-weather outside building shall be moisture and UV-resistant equal to Armaflex Shield or approved equal. Increase thickness to 1-1/2".

PART 3 - EXECUTION

3.1 REQUIREMENTS

- A. Pipe saddles for protection of the insulation shall be provided by the insulation sub-contractor and installed at the time the insulation is applied. Saddles shall be secured to insulation with adhesive.
- B. Insulate all surfaces as indicated by drawings and specifications. Where more than one type of insulation is indicated for a particular application, selection shall be the contractor's option.
- C. Install insulation products in accordance with the manufacturer's written instructions, and in accordance with recognized industry practices.
- D. Surfaces shall be clean and dry prior to application of insulation. The piping system shall be tight with all testing and corrections complete.
- E. Install insulation materials with smooth and even surfaces. Insulate each continuous run of pipe with full-length units of insulation, with a single cut piece to complete each run. Do not use cut pieces or scraps abutting each other.
- F. Cover valves, flanges, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, pre-cut, or job fabricated units (at installer's option), except where a specific form or type is indicated. In no case shall insulation cover gauges, plug cock indicators, or other items required for visual reference.
 1. Piping insulation on inline mounted P/T ports, pump suction / discharge flanges & suction strainer pressure port interconnecting piping [chilled water & hot water], circuit setter pressure ports, calibrated balancing valve pressure ports, etc. shall be made easily removable so that access to the ports can be readily obtained without destroying the insulation for hot & cold surfaces, or insulation vapor barrier for cold surfaces. All

chilled water & hot water recirculating pumps casings shall be insulated with readily removable insulation sections that allow easy access to all pump components, pressure gauges, P/T ports, etc. requiring testing or maintenance access.

- G. Extend insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.
- H. Install protective metal shields and insulated inserts wherever needed to prevent compression of insulation between pipe and hanger. Insulation shall not be installed over pipe hangers. Pipe hanger insulation shields shall be fabricated with a minimum metal gauge thickness in compliance with MSS SP-69, and insulation shields and / or saddles shall be properly centered inside pipe hangers to ensure that the piping insulation is not damaged. As an alternate, utilize pre-fabricated hanger / insulation shield combinations, which are clevis hangers with insulation protection shields spot welded in place.
- I. All pipe insulation exposed to weather, except as otherwise described, shall be finished with .016 inch, (standard thickness) aluminum jacket and pre-formed aluminum fitting covers, by Childers or approved equal.
- J. Fiberglass Insulation on Hot Piping:
 - 1. Insulation on concealed piping shall be finished with white paintable, fire-retardant ASJ jacket.
 - 2. Butt all joints firmly together and smoothly secure all jacket laps and joint strips with lap adhesive. Flare type staples at 4 inch spacing may be used for concealed work.
 - 3. Insulate fittings and valves with molded fiberglass fittings, segments of pipe insulation, or with firmly compressed fiberglass blanket with PVC covers. Secure in place with 20 gauge wire and finish with a coat of insulating cement. Fittings for pipe sizes under 4" may be insulated with hydraulic setting insulating cement. All thickness' to be equal to that of adjoining pipe covering. Exposed fittings and valves shall be additionally finished with open-weave glass cloth fabric adhered between two floor coats of lagging adhesive. Lap glass fabric 2" onto adjacent pipe. (In lieu of glass cloth embedded between coats of adhesive premolded fitting covers may be used. The covers shall overlap the adjoining pipe insulation and shall be mechanically secured).

END OF SECTION

SECTION 23 0963
BUILDING AUTOMATION SYSTEMS

PART 1 - GENERAL

1.1 OVERVIEW

- A. Furnish all labor, materials, and components for a complete and operating DDC based temperature control system as described herein and as shown on the controls drawings.
****If alternate equipment is submitted that varies from the specified equipment, the mechanical and controls contractor shall modify the BAS design, at their cost, to make up for any shortcomings of the submitted equipment, which might involve a protocol gateway, additional programming efforts, etc. All sequences of operation shall be provided per the controls drawings and all points and alarms shall be fully mapped through to the front end controller.****
- B. Complete control system including low voltage wiring. All 120 volt power shall be the responsibility of the electrical contractor. All wiring less than 120 volts shall be provided and installed by the controls contractor. For any control component requiring 120V power, the control contractor shall be responsible for coordination with the electrical contractor for required scope.

1.2 RELATED SECTIONS

- A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are a part of these Specifications and shall be used in conjunction with this Section as a part of the Contract Documents. Consult them for further instructions pertaining to this work.

1.3 DESCRIPTION

- A. **The Building Automation System installer shall be a factory owned branch office that is regularly engaged in the engineering, programming, installation and service of systems of similar size and complexity.**
- B. General: The control system shall be as indicated on the drawings and described in the specifications, and consist of a fully web-based peer-to-peer network of digital building control panels. The system controller shall serve web pages to the owners' Ethernet LAN system via BACnet/IP protocol and shall be provided with dynamic color graphics of building areas and systems. The system graphics shall be provided as described in this section and contained in the points list, and provided as a part of this project. All monitor and control points shown on the drawings and all alarms shall be mapped through to the front end workstation and integrated into the graphics. Any PC on the network shall be able to access the BAS network via Internet Explorer, Mozilla Firefox, Google Chrome, or Safari web browsers if the operator has the proper security clearances. The unit level shall communicate using BACnet/MSTP, LonTalk or Modbus open standard protocols. No proprietary communication protocol is acceptable.
- C. Direct Digital Control (DDC) technology shall be used to provide the functions necessary for control of mechanical systems on this project per the control drawings.
- D. The control system shall accommodate simultaneous multiple user operation. Access to the control system data should be limited only by operator password. Multiple users shall have access to all valid system data. An operator shall be able to log onto any workstation on the control system and have access to all appropriate data.
- E. The control system shall be designed such that each mechanical system will be able to operate under stand-alone control. As such, in the event of a network communication failure, or the loss of any other controller, the control system shall continue to independently operate under control.
- F. Communication between the control panels and all workstations shall be over a high-speed network. All nodes on this network shall be peers. The operator shall not have to know the panel identifier or location to view or control an object. Application Specific

Controllers shall be constantly scanned by the network controllers to update point information and alarm information.

- G. Communication between control system and onsite/offsite monitoring and control station via internal LAN and/or internet shall be provided. Access to the system from any onsite/offsite computers shall be provided through a web browser without the need for any system specific software on the accessing computer
- H. The documentation is schematic in nature. The Contractor shall provide hardware and software necessary to implement the functions and sequences shown.

1.4 APPROVED CONTROL SYSTEM

- A. Approved Control System:
 - 1. Trane Company
 - 2. Honeywell
 - 3. Automated Logic
 - 4. Alerton
 - 5. Delta
 - 6. Siemens
 - 7. Approved equal

1.5 QUALITY ASSURANCE

- A. System Installer Qualifications
 - 1. **The Building Automation System installer shall be a factory-owned branch of the controls manufacturer with at least 10 years of system installation experience on projects of this scope and type.**
 - 2. The installer shall have an office within 75 miles of the project site and provide 24-hour service response in the event of a customer support call.
 - 3. The installer shall have the capability to monitor the systems on a 24/7 basis for alarm notification and management.
 - 4. The Installer shall have successfully completed Control System Manufacturer's training on the control system. The Installer shall present for review the certification of completed training, including the hours of instruction and course outlines upon request.
 - 5. The above manufacturer applies to operator workstation software, controller software, the custom application programming language, Building Controllers, Custom Application Controllers, and Application Specific Controllers. All other products specified herein (i.e., sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturer.
- B. Codes and Standards: Meet requirements of all applicable standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section.
 - 1. Underwriters Laboratories: Products shall be UL-916-PAZX listed.
 - 2. Underwriters Laboratories: Products shall be UL-864 Smoke control equipment listed (if engineered smoke control system as required by the Building Code (atrium smoke, high-rise smoke, etc.) is employed).
 - 3. National Electrical Code -- NFPA 70.
 - 4. Federal Communications Commission -- Part J.
 - 5. ASHRAE/ANSI 135-2016 (BACnet)
 - 6. ANSI/EIA/CEA-709.1 (LonTalk)
- C. All products used in this installation shall be new, currently under manufacture, and shall be applied in similar installations. This installation shall not be used as a test site for any

new products unless explicitly approved by the Owner's representative in writing prior to installation and shall be available for at least 5 years after completion of this contract.

- D. The controls contractors shall be required to prepare and demonstrate a complete and comprehensive point-to-point systems checkout. This point-to-point checkout will be completed in a tabular spreadsheet format and submitted to the design team for review prior to the final systems check-out. The point-to-point checkout will include an additional column for the TAB agent to insert readings for each analog and digital input point for calibration and verification. After design team review of the tabular spreadsheet the design team will review the point-to-point checkout on site with the contractor.

1.6 SYSTEM PERFORMANCE

- A. Performance Standards. The system shall conform to the following:
1. Graphic Display. The system shall display a graphic with dynamic points.
 2. Graphic Refresh. The system shall update all dynamic points with current data within 30 seconds.
 3. Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be 10 seconds. Analog objects shall start to adjust within 10 seconds.
 4. Object Scan. All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or workstation will be current, within the prior 60 seconds.
 5. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 45 seconds.
 6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
 7. Performance. Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every 5 seconds. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
 8. Multiple Alarm Annunciation. All workstations on the network shall receive alarms within 5 seconds of each other.
 9. Reporting Accuracy. Table 1 lists minimum acceptable reporting accuracies for all values reported by the specified system.

Table I -- Reporting Accuracy

Measured Variable	Reported Accuracy
Space temperature	±0.5°C [±1°F]
Ducted air	±1.0°C [±2°F]
Outside air	±1.0°C [±2°F]
Water temperature	±0.5°C [±1°F]
Delta-T	±0.15°C [±0.25°F]
Relative humidity	±2% RH
Water flow	±5% of full scale
Air flow (terminal)	±10% of reading *Note 1
Air flow (measuring stations)	±5% of reading
Air pressure (ducts)	±25 Pa [±0.1 "W.G.]
Air pressure (space)	±3 Pa [±0.01 "W.G.]
Water pressure	±2% of full scale *Note 2

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Electrical Power	5% of reading *Note 3
Carbon Monoxide (CO)	± 50 PPM
Carbon Dioxide (CO ₂)	± 50 PPM

Note 1: (10%-100% of scale) (cannot read accurately below 10%)

Note 2: for both absolute and differential pressure

Note 3: * not including utility supplied meters

1.9 SUBMITTALS

- A. Contractor shall provide shop drawings and manufacturers' standard specification data sheets on all hardware and software to be provided. No work may begin on any segment of this project until the Engineer has reviewed submittals for conformity with the plan and specifications. Five (5) copies are required.
- B. Quantities of items submitted shall be reviewed by the Engineer. Such review shall not relieve the contractor from furnishing quantities required for completion.
- C. Provide the Engineer, any additional information or data that is deemed necessary to determine compliance with these specifications or which is deemed valuable in documenting the system to be installed.
- D. Submit the following within 60 days of contract award:
 - 1. A complete bill of materials of equipment to be used indicating quantity, manufacturer and model number.
 - 2. A schedule of all control valves including the valve size, model number (including pattern and connections), flow, CV, pressure rating, and location.
 - 3. A schedule of all control dampers. This shall include the damper size, pressure drop, manufacturer and model number.
 - 4. Provide manufacturers cut sheets for major system components. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is being submitted to cover. Include:
 - a) Building Controllers
 - b) Custom Application Controllers
 - c) Application Specific Controllers
 - d) Auxiliary Control Devices
 - e) Proposed control system riser diagram showing system configuration, device locations, addresses, and cabling.
 - f) Detailed termination drawings showing all required field and factory terminations. Terminal numbers shall be clearly labeled.
 - g) Points list showing all system objects and the proposed English language object names.
 - h) Sequence of operations for each system under control. This sequence shall be specific for the use of the Control System being provided for this project.
 - i) Provide a BACnet Product Implementation Conformance Statement (PICS) for each BACnet device type in the submittal if required by the project scope.
 - j) Color prints of proposed graphics with a list of points for display.

- E. Project Record Documents: Upon completion of installation submit three (3) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:
1. Project Record Drawings - These shall be as-built versions of the submittal shop drawings.
 2. Testing and Commissioning Reports and Checklists.
 3. Operating and Maintenance (O & M) Manual - These shall be as built versions of the submittal product data. In addition to that required for the submittals, the O & M manual shall include:
 - a) Names, address and 24-hour telephone numbers of Contractors installing equipment, and the control systems and service representative of each.
 - b) Operators Manual with procedures of operating the control systems including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
 - c) Programming Manual with a description of the programming language including syntax, statement descriptions including algorithms and calculations used, point database creation and modification, program creation and modification, and use of the editor.
 - d) Engineering, Installation and Maintenance Manual(s) that explains how to design and install new points, panels, and other hardware; preventative maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.
 - e) A listing and documentation of all custom software created using the programming language including the point database. One set of magnetic media containing files of the software and database shall also be provided.
 - f) One set of electronic media containing files of all color-graphic screens created for the project.
 - g) A list of recommended spare parts with part numbers and supplier.
 - h) Complete original issue documentation, installation, and maintenance information for all third party hardware provided including computer equipment and sensors.
 - i) Complete original issue media for all software provided including operating systems, programming language, operator workstation software, and graphics software.
 - j) Licenses, Guarantee, and Warrantee documents for all equipment and systems.
 - k) Recommended preventive maintenance procedures for all system components including a schedule of tasks (inspection, cleaning, calibration, etc.) time between tasks, and task descriptions.

1.10 WARRANTY

- A. Warrant all work as follows:
1. Labor & materials for control system specified shall be warranted free from defects for a period of twenty-four (24) months after final completion acceptance by the Owner. Control System failures during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in service to the Owner.
 2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the control system's operation has been tested and accepted in

accordance with the terms of this specification. The date of Owner's acceptance shall be the start of warranty.

3. The system provider shall provide a web-accessible Users Network to give the Owner access to question/answer forum, graphics library, user tips, and training schedules.

PART 2 - PRODUCTS

2.1 SECTION INCLUDES

- A. Communication
- B. Operator Interface
- C. Application and Control Software
- D. Building Controllers
- E. Custom Application Controllers
- F. Application Specific Controllers
- G. Communications
- H. Input/Output Interface
- I. Auxiliary Control Devices

2.2 COMMUNICATION

- A. This project shall comprise of a network utilizing high-speed BACnet/IP for communications between Building Controllers and PC Workstations. BACnet/MSTP, Modbus, or LonTalk sub-networks shall be used for communications between Building Controllers, Custom Application Controllers and Application Specific Controllers. Any wireless systems shall comply with the IEEE 802.15.4 standard and shall strictly utilize BACnet standard open protocol. Proprietary wireless protocol applications are prohibited.
- B. The controls Contractor shall provide all communication media, connectors, repeaters, hubs, and routers necessary for the DDC system internetwork.
- C. All Building Controllers shall have a communications port for connections with the operator interfaces. This may be either a network interface node for connection to the Ethernet network or a USB port for Point to Point connection.
- D. Communications services over the internetwork shall result in operator interface and value passing that is transparent to the internetwork architecture as follows:
 1. Connection of an operator interface device to any one building controller on the internetwork will allow the operator to interface with all other building controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all building controllers shall be available for viewing and editing from any one building controller on the internetwork.
 2. All database values (i.e., points, software variable, custom program variables) of any one building controller shall be readable by any other building controller on the internetwork. This value passing shall be automatically performed by a controller when a reference to a point name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communications services to perform internetwork value passing.
 3. The time clocks in all controllers shall be automatically synchronized daily.

2.3 APPLICATION AND CONTROL SOFTWARE

- A. 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 workstation.
- B. System Security

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1. User access shall be secured using individual security passwords and user names.
 2. Passwords shall restrict the user to only the objects, applications, and system functions as assigned by the system manager.
 3. User logon/logoff attempts shall be recorded.
 4. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
- C. 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:
1. Weekly Schedule. Provide separate schedules for each day of the week.
 2. 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.
 3. 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.
 4. Optimal Start/Stop. The scheduling application outlined above shall support an optimal start/stop 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 than and greater than 24 hours. Provide the ability to modify the start/stop 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.
- D. Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the appropriate workstations based on time and other conditions. An alarm shall be able to start programs, be logged in the event log, printed, generate custom messages graphics.
- E. Remote Communications. The system shall have the ability to dial out in the event of an alarm. Receivers shall include PC Workstations, and alphanumeric pagers. The alarm message shall include the name of the calling location, the device that generated the alarm, and the alarm message itself. The operator shall be able to remotely access and operate the system using dial up communications in the same format and method used on site under section 2.1 (Operator Interface).
- F. Demand Limiting.
1. The demand limiting program shall monitor building power consumption from signals generated by a pulse generator (provided by others) mounted at the building power meter, or from a watt transducer or current transformer attached to the building feeder lines.
 2. The demand limiting program shall be based on a predictive sliding window algorithm. The sliding window duration and sampling interval shall be set equal to that of the local Electrical Utility.
 3. Control system shall be capable of demand limiting by resetting HVAC system set-points to reduce load while maintaining Indoor Air Quality (humidity, VOC, CO₂) and comfort control in the space.

- 4. Input capability shall also be provided for an end-of-billing period indication.
- G. Maintenance Management. The system shall monitor equipment status and be capable of generating maintenance messages based upon user designated run time, starts, and/or calendar date limits.
- H. PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-wind-up shall be supplied. The algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs. The controlled variable, set-point, and PID gains shall be user-selectable. The set-point shall optionally be chosen to be a reset schedule.
- I. Staggered Start. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts shall be user-selectable.
- J. System Calculations. Provide software to allow instantaneous power (e.g. KW), flow rates (e.g. GPM) to be accumulated and converted to energy usage data. Provide an algorithm that calculates a sliding-window KW demand value. Provide an algorithm that calculates energy usage and weather data (heating and cooling degree days). These items shall all be available for daily, previous day, monthly and the previous month.
- K. Anti-Short Cycling. All binary output points shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected.
- L. Terminal Box Totalization:
 - 1. Provide a feature to allow VAV box volume totalization without having to add volumes manually. VAV boxes are to be totaled by air handling unit.

2.4 BUILDING CONTROLLERS

- A. General. Provide Building Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.
 - 1. The Building Automation System shall be composed of one or more independent, stand-alone, microprocessor based Building Controllers to manage the global strategies described in System software section.
 - 2. The Building Controller shall have sufficient memory to support its operating system, database, and programming requirements.
 - 3. The controller shall provide a communications port for connection to the inter-network.
 - 4. 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.
 - 5. Controllers that perform scheduling shall have a real time clock.
 - 6. Data shall be shared between networked Building Controllers.
 - 7. The Building 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.
- B. Each Building Controller shall also perform routing to a network of Custom Application and Application Specific Controllers.
- C. 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 0 C to 50 C [32 F to 120 F].
- D. Serviceability. Provide diagnostic LEDs for power, communications, and processor. All wiring connections shall be made to field removable, modular terminal strips or to a termination card connected by a ribbon cable.

- E. Memory. The Building Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
- F. 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

2.5 CUSTOM APPLICATION CONTROLLERS

- A. General. Provide Custom Application Controllers to provide the performance specified in section 1 of this division. Each of these panels shall meet the following requirements.
 - 1. The Building Automation System shall be composed of one or more independent, stand-alone, microprocessor based Building Controllers to manage the local strategies described in System software section.
 - 2. The Controller shall have sufficient memory to support its operating system, database, and programming requirements.
 - 3. Controllers that perform scheduling shall have a real time clock.
 - 4. 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.
 - 5. The 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.
- B. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.
 - 1. Controller used in conditioned ambient shall be mounted in NEMA 1 type enclosures, and shall be rated for operation at 0 C to 50 C [32 F to 120 F].
 - 2. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40 C to 70 C [-40 F to 158 F].
- C. Serviceability. Provide diagnostic LEDs for power, communications, and processor. All low voltage wiring connections shall be made such that the controller electronics can be removed and/or replaced without disconnection of field termination wiring.
- D. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
- E. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

2.6 APPLICATION SPECIFIC CONTROLLERS

- A. General. Application specific controllers (ASC) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user programmable, but are customized for operation within the confines of the equipment they are designed to serve.
 - 1. Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
 - 2. Each ASC will contain sufficient I/O capacity to control the target system.
- B. Environment. The hardware shall be suitable for the anticipated ambient conditions.
 - 1. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40 C to 65 C [-40 F to 150 F].

2. Controller used in conditioned ambient shall be mounted in NEMA 1 type rated enclosures. Controllers located where not to be disturbed by building activity (such as above ceiling grid), may be provided with plenum-rated enclosures and non-enclosed wiring connections for plenum cabling. All controllers shall be rated for operation at 0 C to 50 C [32 F to 120 F].
- C. Serviceability. Provide diagnostic LEDs for power and communications. All wiring connections shall be clearly labeled and made to be field removable.
- D. Memory. The Application Specific Controller shall maintain all BIOS and programming information in the event of a power loss for at least 90 days.
- E. Immunity to Power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%.
- F. Transformer. Power supply for the ASC must be rated at minimum of 125% of ASC power consumption, and shall be fused or current limiting type.
- G. All application specific controllers are to perform a self-calibration exercise to reset each controller. Controllers with floating (tri-state) valves (IE VAV, CAV boxes) are to recalibrate daily (midnight).

2.7 COMMUNICATIONS

- A. This project shall comprise a network utilizing communications between Building Controllers and PC Workstations.
- B. The controls Contractor shall provide all communication media, connectors, repeaters, hubs, and routers necessary for the inter-network.
- C. All Building Controllers shall have a communications port for connections with the operator interfaces. This may be either an RS-232 port for Point to Point connection or a network interface node for connection to the Ethernet or ARCNET network.

2.8 INPUT/OUTPUT INTERFACE

- A. Hard-wired inputs and outputs may tie into the system through Building, Custom, or Application Specific Controllers.
- B. All input points and output points shall be protected such that shorting of the point to itself, another point, or ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24V of any duration, such that contact with this voltage will cause no damage to the controller.
- C. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices.
- D. Pulse accumulation input points. This type of point shall conform to all the requirements of Binary Input points, and also accept up to 2 pulses per second for pulse accumulation, and shall be protected against effects of contact bounce and noise.
- E. Analog inputs shall allow the monitoring of low voltage (0-10 Vdc), current (4-20 ma), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.
- F. Binary outputs shall provide for on/off operation, or a pulsed low voltage signal for pulse width modulation control. Outputs shall be selectable for either normally open or normally closed operation.
- G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0-10 Vdc or a 4-20 ma signal as required to provide proper control of the output device.

2.9 AUXILIARY CONTROL DEVICES

- A. Motorized dampers, unless otherwise specified elsewhere, shall be as follows:
 1. Damper frames shall be 16 gauge galvanized sheet metal or 1/8" extruded aluminum with reinforced corner bracing.

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2. Damper blades shall not exceed 8" in width or 48" in length. Blades are to be suitable for medium velocity performance (2,000 fpm). Blades shall be not less than 16 gauge.
 3. Damper shaft bearings shall be as recommended by manufacturer for application.
 4. All blade edges and top and bottom of the frame shall be provided with compressible seals. Side seals shall be compressible stainless steel. The blade seals shall provide for a maximum leakage rate of 10 CFM per square foot at 2.5" w.c. differential pressure.
 5. All leakage testing and pressure ratings will be based on AMCA Publication 500.
 6. Individual damper sections shall not be larger than 48" x 60". Provide a minimum of one damper actuator per section.
- B. Control dampers shall be parallel or opposed blade types as scheduled on drawings.
- C. Electronic damper/valve actuators.
1. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
 2. Where shown, for power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing.
 3. All rotary spring return actuators shall be capable of both clockwise and counter clockwise spring return operation. Linear actuators shall spring return to the retracted position.
 4. Proportional actuators shall accept a 0-10 VDC or 0-20 ma control signal and provide a 2-10 VDC or 4-20 ma operating range.
 5. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 W for DC applications. Actuators operating on 120 VAC or 230 VAC shall not required more than 11 VA.
 6. All non-spring return actuators shall have an external manual gear release to allow anual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
 7. Actuators shall be provided with a conduit fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
 8. Actuators shall be Underwriters Laboratories Standard 873 listed.
 9. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.
- D. Control Valves
1. Hydronic Control Valves shall be equal to Bell and Gossett Pressure Independent Control and Balancing Valves for two-way or three-way type with field adjustability.
 2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
 - a) Water Valves:
 - (i) Two-way: 150% of total system (pump) head.
 - (ii) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.
 - b) Steam Valves: 150% of operating (inlet) pressure.
 3. Water Valves:

- a) Body and trim style and materials shall be per manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.
- b) Sizing Criteria:
 - (i) Two-position service: Line size.
 - (ii) Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.
 - (iii) Three-way Modulating Service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 5 psi maximum.
 - (iv) Valves 1/2" through 2" shall be bronze body or cast brass ANSI Class 250, spring loaded, Teflon packing, quick opening for two-position service. Two-way valves to have replaceable composition disc, or stainless steel ball.
 - (v) 2-1/2" valves and larger shall be cast iron ANSI Class 125 with guided plug and Teflon packing.
- c) Water valves shall fail normally open or closed as scheduled on plans or as follows:
 - (i) Heating coils in air handlers - normally open.
 - (ii) Chilled water control valves - normally closed.
 - (iii) Other applications - as scheduled or as required by sequence of operation.
- d) Zone valves shall be sized to meet the control application and they shall maintain their last position in the event of a power failure.

B. TEMPERATURE SENSORS

- 1. Temperature sensors shall be Resistance Temperature Device (RTD) or Thermistor.
- 2. Duct sensors shall be rigid or averaging as shown. Averaging sensors shall be a minimum of 5 feet in length.
- 3. Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed.
- 4. Space sensors shall be equipped with set-point adjustment, digital display, override switch.
- 5. Provide matched temperature sensors for differential temperature measurement. Differential accuracy shall be within 0.2 F.

C. HUMIDITY SENSORS

- 1. Duct and room sensors shall have a sensing range of 20% to 80% with accuracy of $\pm 2\%$ R.H.
- 2. Duct sensors shall be provided with a sampling chamber.
- 3. Outdoor air humidity sensors shall have a sensing range of 20% to 95% R.H. It shall be suitable for ambient conditions of -40 F to 170 F.
- 4. Humidity sensor's drift shall not exceed 1% of full scale per year.

D. STATIC PRESSURE SENSORS

- 1. Sensor shall have linear output signal. Zero and span shall be field-adjustable.
- 2. Sensor sensing elements shall withstand continuous operating conditions plus or minus 50% greater than calibrated span without damage.

3. Water pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Sensor shall be complete with 4-20 ma output, required mounting brackets, and block and bleed valves. Mount in location accessible for service.
 4. Water differential pressure sensor shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (DP) and maximum static pressure shall be 3,000 psi. Transmitter shall be complete with 4-20 ma output, required mounting brackets, and five-valve manifold. Mount in a location accessible for service.
- E. LOW LIMIT THERMOSTATS
1. Safety low limit thermostats shall be vapor pressure type with an element 6m [20 ft] minimum length. Element shall respond to the lowest temperature sensed by any one foot section.
 2. Low limit shall be manual reset only.
 3. Low limit sensors are to be installed so that a minimum of one linear foot of sensor is installed for every square foot of corresponding coil area and that each square foot of coil is protected by low limit sensor. MULTIPLE SENSORS MAY BE REQUIRED.
- F. INDOOR AIR QUALITY SENSORS
1. Indoor air quality sensors, if required, shall measure both total percentage VOCs and CO2 in PPM (see control drawings). Sensors shall be duct or space mounted.
- G. RELAYS
1. Control relays shall be UL listed plug-in type with dust cover. Contact rating, configuration, and coil voltage suitable for application.
 2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable plus or minus 200% (minimum) from set-point shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 Type enclosure when not installed in local control panel.
- H. TRANSFORMERS and POWER SUPPLIES
1. Control transformers shall be UL listed, Class 2 current-limiting type, or shall be furnished with over-current protection in both primary and secondary circuits for Class 2 service.
 2. Unit output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 3.0 mV maximum Peak-to-Peak. Regulation shall be 0.10% line and load combined, with 50 microsecond response time for 50% load changes. Unit shall have built-in over-voltage protection.
 3. Unit shall operate between 0 C and 50 C.
 4. Unit shall be UL recognized.
- I. CURRENT SWITCHES
1. Current-operated switches shall be self-powered, solid state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.
- J. LOCAL CONTROL PANELS
1. All indoor control cabinets shall be fully enclosed NEMA 1 Type construction with [hinged door], key-lock latch, and removable sub-panels. A single key shall be common to all field panels and sub-panels.

2. Interconnections between internal and face-mounted devices pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
3. Provide on/off power switch with over-current protection and main air gauge for control power sources to each local panel.
4. Outdoor control panels for rooftop air handling units are to be NEMA 4 located on the return air section of the unit. Panels are to be internally lined with 1" thick urethane board insulation. Provide (minimum 2) 1-1/2" conduit nipples through the back of the control panel and into the return plenum of the rooftop unit with lock nuts on both ends.

PART 3 - EXECUTION

3.1 SECTION INCLUDES:

- A. Examination
- B. General Workmanship
- C. Wiring
- D. Installation of Sensors
- E. Flow Switch Installation
- F. Actuators
- G. Warning Labels
- H. Identification of Hardware and Wiring
- I. Controllers
- J. Programming
- K. Cleaning
- L. Protection
- M. Training
- N. Field Quality Control
- O. Check-out, Start-up, and Testing
- P. Acceptance

3.2 EXAMINATION

- A. The project plans shall be thoroughly examined for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.
- B. The contractor shall inspect the site to verify that equipment is installable as shown, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.
- C. The controls contractor shall collaborate closely with the owner, the EOR, the mechanical contractor and the TAB agency to ensure that unique naming and numbering of rooms, equipment, valves, instrumentation, and any other item programmed into the BAS software follows the agreed upon numbering / naming convention established for the project. If no such convention is in place for an item or piece of equipment requiring one, the controls contractor shall take the lead in coordinating with the appropriate parties (i.e. owner, EOR, MC, TAB agency, etc.) to ensure that all references to that item are unique, suitable for the application and utilized in all project submittals.
- D. The Controls Contractor shall work in close cooperation with the TAB agency to ensure that all airflow and water flow stations and all duct and pipe mounted differential pressure

sensor / transmitters, have been calibrated. This cooperative calibration effort must take place prior to the start of Acceptance Phase Cx / FPT.

3.3 GENERAL WORKMANSHIP

- A. Install equipment, piping, wiring/conduit parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- C. Install all equipment in readily accessible location as defined by chapter 1 article 100 part A of the NEC. Control panels shall be attached to structural walls unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.
- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.4 WIRING

- A. All control and interlock wiring shall comply with the national and local electrical codes and Division 26 of these specifications. Where the requirements of this section differ with those in Division 26, the requirements of this section shall take precedence.
- B. All control and interlock wiring shall be in conduit except where Class 2 wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in conduit may be used provided that:
 - 1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
 - 2. All cables shall be UL listed for application, i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose.
 - 3. All wiring in mechanical or electrical rooms is to be in conduit.
- C. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).
- D. Where class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 10 ft intervals. Such bundled cable shall be fastened to the structure, using specified fasteners, at 5 ft intervals or more often to achieve a neat and workmanlike result.
- E. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- F. Maximum allowable voltage for control wiring shall be 120V. If only higher voltages are available, the Control System Contractor shall provide step down transformers.
- G. 120 volt power wiring to control panels and controllers will be hard wired.
- H. All wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.
- I. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with other sections of this specification and local codes.
- J. Size of conduit and size and type of wire shall be the design responsibility of the Control System Contractor, in keeping with the manufacturer's recommendation and NEC.

- K. Control and status relays are to be located in designated enclosures only. These relays may also be located within packaged equipment control panel enclosures. These relays shall not be located within Class 1 starter enclosures.
- L. Follow manufacturer's installation recommendations for all communication and network cabling. Network or communication cabling shall be run separately from other wiring.
- M. Adhere to Division 26 requirements for installation of raceway.
- N. This Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- O. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

3.5 INSTALLATION OF SENSORS

- A. Install sensors in accordance with the manufacturer's recommendations.
- B. Mount sensors rigidly and adequate for the environment within which the sensor operates.
- C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
- D. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor readings.
- E. Install duct static pressure tap with tube end facing directly down-stream of air flow.
- F. Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
- G. All pipe mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat conducting fluid in thermal wells.
- H. Wiring for space sensors shall be concealed in building walls. EMT conduit is acceptable within mechanical and service rooms.
- I. All controls systems sensors are to be installed with identification tags with the following information:
 - 1. Sensor Type (Temperature, Humidity, Flow, etc.)
 - 2. Output Type (0-10VDC, 4-20mA, etc.)
 - 3. HVAC Equipment Associated (IE AHU-1, HX-2, etc.)
 - 4. Control Contractor Reference Information
- J. Install outdoor air temperature sensors on north wall complete with sun shield at designated location.
- K. The BAS controls contractor shall provide Tee type connections (and associated stop cocks or caps) in the pressure sensor tubing at all differential pressure sensors, including ductwork high static pressure and airflow measuring devices, and HW, CHW and tempered CHW pump control ΔP sensors, etc. that will allow field test measurements to be taken without interrupting the BAS reading.

3.6 ACTUATORS

- A. Mount and link control damper actuators per manufacturer's instructions.
- B. All controls systems actuators are to be installed with identification tags with the following information:
 - 1. Actuator Type (Damper, Valve, etc.)
 - 2. Output Type (0-10VDC, 4-20mA, etc.)
 - 3. HVAC Equipment Associated (IE AHU-1, HX-2, etc.)

4. Control Contractor Reference Information

- C. To compress seals when spring return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
- D. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
- E. Valves - Actuators shall be mounted on valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following manufacturer's recommendations.

3.7 IDENTIFICATION OF HARDWARE AND WIRING

- A. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information.
- B. Permanently label or code each point of field terminal strips to show the instrument or item served.
- C. Identify control panels with minimum 1-cm letters on laminated plastic nameplates.
- D. Identify all other control components with permanent labels. Identifiers shall match record documents. All plug-in components shall be labeled such that removal of the component does not remove the label.

3.8 CONTROLLERS

- A. Provide a separate Controller for each major piece of HVAC equipment. Points used for control loop reset such as outside air or space temperature are exempt from this requirement.
- B. Future use of spare capacity shall require providing the field device, field wiring, point database definition, and custom software. No additional Controller boards or point modules shall be required to implement use of these spare points.

3.9 PROGRAMMING

- A. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25% of available memory free for future use.
- B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index. Point nomenclature shall match the design drawing format and shall be plain English language. Cryptic references and acronyms are prohibited. The controls contractor shall consult with the owner operator to establish nomenclature. If the system is to be tied into an existing system, the existing system nomenclature shall utilize unless requested otherwise in writing by the owner operator.
- C. Software Programming
 - 1. Provide programming for the system as per specifications and adhere to the strategy algorithms provided. All other system programming necessary for the operation of the system but not specified in this document shall also be provided by the Control System Contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operations.
- D. Operators' Interface
 - 1. Standard Graphics. Provide graphics for each major piece of equipment and floor plan in the building. This includes new heating Coils, and temperature sensors. These standard graphics shall show all points dynamically as specified in the input/output summaries and on the control graphical diagram schematics.
 - a) General System Graphic Requirements

- (i) Any "standard graphic" points that do not have sensors, etc. to be displayed shall not appear on the graphic presentation.
 - (ii) Setpoint control and adjustments shall be displayed on the graphical presentation.
- 2. All points as listed in the points list shall appear on each system graphic. Any equipment not listed above shall have points listed as per the design documents.
- 3. The controls contractor shall provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface data base, and any third party software installation and integration required for successful operation of the operator interface.
- 4. As part of this execution phase, the controls contractor will perform a complete test of the operator interface. Test duration shall be a minimum of 8 hours on-site. Tests shall be made in the presence of the Owner or Owner's representative.
- E. Demonstration: A complete demonstration and readout of the capabilities of the monitoring and control system shall be performed. The contractor shall dedicate a minimum of 16 hours on-site with the Owner and his representatives for a complete functional demonstration of all the system requirements. This demonstration constitutes a joint acceptance inspection, and permits acceptance of the delivered system for on-line operation.

3.10 CLEANING

- A. This contractor shall clean up all debris resulting from his or her activities daily. The contractor shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Construction Manager or General Contractor.
- B. At the completion of work in any area, the Contractor shall clean all of his/her work, equipment, etc., making it free from dust, dirt and debris, etc.
- C. At the completion of work, all equipment furnished under this Section shall be checked for paint damage, and any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.11 PROTECTION

- A. The Contractor shall protect all work and material from damage by his/her work or workers, and shall be liable for all damage thus caused.
- B. The Contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The Contractor shall protect his/her work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.12 TRAINING

- A. Provide a minimum of 2 classroom training sessions, 4 hours each, throughout the contract period for personnel designated by the Owner. Computer based training may be substituted for up to 4 hours of hands on training.
- B. Train the designated staff of Owner's representative and Owner to enable them to proficiently operate the system; create, modify and delete programming; add, remove and modify physical points for the system; add additional panels when required.
- C. These objectives will be divided into three logical groupings; participants may attend one or more of these, depending on level of knowledge required:
 - 1. Day-to-day Operators

2. System Troubleshooter
 3. System Manager
- D. Provide course outline and materials as per Part 1 of this Section. The instructor(s) shall provide one copy of training material per student.
- E. The instructor(s) shall be factory-trained instructors experienced in presenting this material.
- F. Classroom training shall be done using a network of working controllers at the customer's site.
- G. All training shall be videotaped and two (2) DVDs with the recorded training shall be turned over to the Owner's representative and/or Owner.

3.13 FIELD QUALITY CONTROL

- A. All work, materials and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this Section.
- B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship. All visible piping and or wiring runs shall be installed parallel to building lines and properly supported.
- C. Contractor shall arrange for field inspections by local and/or state authorities having jurisdiction over the work.

3.14 ACCEPTANCE

- A. The control systems will not be accepted as meeting the requirements of Completion until all tests described in this specification have been performed to the satisfaction of both the Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion requirements if stated as such in writing by the Owner's representative. Such tests shall then be performed as part of the warranty.
- B. The controls contractor shall provide a technician for the purpose of assisting the commissioning of the HVAC systems and demonstrating the controls aspects of the HVAC systems functions. The technician shall be made available through the commissioning process.
- C. As noted in Part 1.7, D above, the contractor shall demonstrate the point-to-point checkout of the system to the design team. In addition, the contractor shall demonstrate all major functions of the design, including, but not limited to:
1. Fan Coil Unit Control
 - a) Discharge Air Temperature control
 - b) Room Temperature Control
 - c) Occupancy/Setback
 2. VAV/Terminal Box Control
 - a) Discharge Air Temperature control
 - b) Room Temperature Control
 - c) Dehumidification Control
 - d) Occupancy/Setback

3.15 INSTALLATION INSTRUCTIONS TO OTHER SECTIONS

- A. CONTROL VALVE INSTALLATION (BY OTHER SECTIONS)
1. Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.
 2. All control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position.

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3. Valves shall be installed in accordance with the manufacturer's recommendations.
4. Control valves shall be installed so that they are accessible and serviceable, and such that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.
5. Isolation valves shall be installed such that control valve body may be serviced without draining the supply/return side piping system. {Note to designer: this must also be shown.} Unions shall be installed at all connections to screwed type control valves.
6. Provide tags for all control valves indicating service and number. Tags shall be brass, 1-1/2" in diameter, with 1/4" high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

B. DAMPER INSTALLATION (BY OTHER SECTIONS)

1. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.
2. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure 1/4" larger than damper dimensions and shall be square, straight, and level.
3. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be equal $\pm 1/8"$.
4. Follow manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
5. Install extended shaft or jackshaft per manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)
6. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to assure proper operation. On multiple section assemblies, all sections must open and close simultaneously.
7. Provide a visible and accessible indication of damper position on the drive shaft end.
8. Support duct-work in area of damper when required to prevent sagging due to damper weight.
9. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

END OF SECTION

SECTION 23-2113
HYDRONIC PIPING AND PIPE FITTINGS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Submit pipe, valves, and fittings and have approved before starting installation. Pipe, valves, and fittings to be new and marked clearly with manufacturers' name, weight, and classification or working pressure.
- B. Piping to be run approximately as shown on drawings or as structural and architectural conditions permit.

1.2 RELATED WORK

- A. Hangers and supports - Section 23 05 29
- B. Mechanical System Insulation - Section 23 07 13 and 23 07 19

1.3 QUALITY ASSURANCE

- A. Standards: All pipe and fittings shall conform to ANSI and appropriate ASTM Standards.
- B. Piping shown on drawings shall be installed complete and of the size indicated on the drawings. Pipe sizes are nominal size (inches) unless otherwise noted.
- C. Weld piping shall be installed in accordance with the latest edition of ASME Code B31.9

PART 2 - PRODUCTS

2.1 STEEL PIPES

- A. Electric resistance welded, ANSI B 36.10, ASTM A-53, Grade "B", Schedule 40, for piping 10" and smaller and standard weight for pipe sizes 12" and larger. Provide for the following services:
 - 1. Heating hot water supply and return piping 2-1/2" and larger.

2.2 STEEL PIPE FITTINGS

- A. Fittings 2-1/2" and larger and 2" and smaller for all steam pipe to be standard weight, carbon steel, buttwelded conforming to ASTM A234-WPB, ANSI B16.9, B16.28.
- B. Branch connections from mains or headers 2-1/2" or larger to be tees, or welding outlets. Outlets to be equal to weldolets or threadolets manufactured by Bonney Forge. Forged outlets to be used only if branch line is at least one pipe size smaller than main or header.
- C. Fittings 2" and smaller to be threaded, Class 150, standard, malleable iron fittings, with dimensions conforming to ANSI B16.3 and ASTM A-197.
- D. Fittings for galvanized steel pipe to be same as above except have galvanized coating. Fittings for waste, vent, and drainage piping to be drainage pattern type.
- E. Flanges to be Class 150 carbon steel conforming to ASTM A-105 and ANSI B16.5.
- F. Unions to be ASTM A47 malleable iron with bronze-to-iron ground joint rated at 150 lbs. wsp. Threads to conform to ANSI B2.1.

- G. Thread lubricant to be Crane "Formular 425" or equal. Approved Teflon tape may be used at Contractor's option.
- H. Gaskets to be 1/16" thick non-asbestos, ring type (or full face as needed), manufactured by "Klinger" or equal
- I. Fittings to be factory forged in the USA and shall not have been machined, remarked, painted, or otherwise produced domestically from non-domestic forgings.

2.3 COPPER PIPE

- A. Type "L" hard-drawn seamless copper tubing, ASTM B-88:
 - 1. HVAC hot water piping 2" and smaller.

2.4 COPPER PIPE FITTINGS

- A. Dielectric connection: Provide dielectric couplers at junction of steel pipe and equipment with copper piping systems. Use of steel or cast iron fittings in copper piping systems is prohibited.
- B. Provide sweat fittings, ASTM B-62, dimensions conforming to ANSI B16.22, wrought copper, with sweep patterns for copper tubing. Use lead free solder for piping up to 2-1/2" and silphos for piping 3" and larger.
- C. Unions to be brass ground joint, 250-pound working pressure.
- D. The use of Tee Drill connections is not acceptable.
- E. Provide copper press fitting with EPDM O-rings. Use press fittings where indicated on plans and install per manufacturer's recommendations. Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22 and performance criteria of IAPMO PS 117. Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer. Press end shall have SC (Smart Connect) feature design (leakage path). In ProPress 1/2" to 4" dimensions the Smart Connect Feature assures leakage of liquids and/or gases from inside the system past the sealing element of an unpressed connection. This provides the installer quick and easy identification of connections which have not been pressed prior to putting the system into operation.

PART 3 - EXECUTION

- 3.1** Piping shall be routed approximately as shown on drawings, or as conditions will permit, and shall be so installed as not to interfere with doors and access to equipment. All piping shall be installed so as to run parallel or perpendicular to building lines. Piping shall be installed to allow for expansion as required.
- 3.2** Press connections: Copper press fitting joints shall be made in accordance with the manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacturer.
- 3.3** Unions and flanges shall be installed to allow servicing and removal of equipment without dismantling piping. Connections for Owner furnished equipment shall be made with gate valves terminating this Contractor's work.

- 3.4 Piping shall be hung so that equipment does not bear piping load. Provide additional small piping not shown on drawings required in connection with instruments, gauges, traps, etc. not shown on drawings.
- 3.5 **FIRE-RATED PARTITIONS:** Provide permanent firestop system at all piping penetrations of fire-rated walls and floors. The firestop system shall have been tested and approved in accordance with ASTM E119 and U.L. 1479 (ASTM E814) and classified for up to 2 hours fire rating. Firestop system shall be type detailed on drawings or intumescent type capable of expanding up to 8 times its original volume. Firestop system to be 3M, Hilti, Nelson, Johns Manville, or Specified Technologies. Firestop system shall be installed in strict accordance with published U.L. approved installation instructions. Piping to pass through the fire-rated partition insulated or non-insulated as specified and detailed. Submit U.L. approved installation drawing for each type of penetration prior to construction.
- 3.6 **NON-RATED PARTITIONS:** Piping to pass through the walls insulated or non-insulated as specified. Sleeves shall be provided for all pipes penetrating masonry walls and floors, including all mechanical rooms and shall extend a minimum of 1 inch above the floor and all penetrations shall be sealed. Sleeves may be used in other walls at the discretion of the contractor. Walls should be finished to seal neatly and completely around the pipe, pipe insulation or sleeve using acoustical caulk. Firestopping is not required at non-rated partitions.
- 3.7 Install isolation valves in each pipe connection to equipment and at all connections of new branches to existing systems.
- 3.8 Balancing valves shall be installed as shown on the Drawings.
- 3.9 Tees shall be installed to prevent "bullheading". Tees in the same line shall be located a minimum 10 pipe diameters apart.
- 3.10 Pipe dependent on gravity drainage shall be sloped minimum 1/8 inch per foot of horizontal run or as called for on drawings.
- 3.11 Furnish and install dielectric couplings for piping connections of dissimilar metals.
- 3.12 See Specification 23 01 00 "Pipe Testing" for pressure testing requirements.
- 3.13 Plastic and cast-iron piping and fittings shall not be pressure tested with compressed air. Obtain and follow the manufacturer's recommendations for testing.
- 3.14 Pipes not to be hung or supported by pumps. No torque to be applied to pumps by connecting pipes. After final pipe adjustments and initial operation of the pumps, this Contractor to recheck alignment of pumps and realign as required.
- 3.15 **PIPING IN TRANSFORMER, ELECTRICAL, AND ELEVATOR EQUIPMENT ROOMS:** Refer to drawings. No water piping permitted in transformer, electrical, or elevator equipment rooms. Additionally, the routing of water or drain piping over motor control centers, electrical panels, or other electrical equipment should be strictly avoided as much as possible. However, in the event that no alternative route exists, a copper drip pan with drain outlet shall be provided underneath the piping and above the electrical equipment item.
- 3.16 **AIR VENTING:** Provide manual air vents at high points of vertical risers and at each water coil to eliminate air from HVAC water systems. Contractor shall be responsible for bleeding and venting all entrained air from circulating water systems prior to handing the systems over to the TAB agency for waterside TAB fieldwork to begin.

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- 3.17 WATER DRAINING:** Provide 3/4" hose end gate valves at low points and bottom of each riser to drain HVAC water systems.
- 3.18** Ream pipe after cutting to full bore. Remove foreign matter from inside of pipe before installing. Keep installed piping free from dirt and scale and protect open ends from foreign matter. Use temporary plugs or other approved methods of open-end closure.
- 3.19** Threads to be right-hand, pipe standard, clean cut, full depth, and tapered. Joints to be made tight without caulking. Approved pipe joint lubricant to be used, applied in thin layer to the male thread only.
- 3.20** Install copper fittings with suitable flux and 95/5 solder. Type K copper pipe to be joined by means of suitable flux and silver or phos-copper.
- 3.21 CONTROL SYSTEM CONNECTORS:** Weld 1" steel half coupling Crane No. 386 or equal, or provide 1" female pipe thread connection at points shown on drawings and at necessary points for installation of thermometers and automatic controls.
- 3.22** All automatic controls valves are to be installed with unions on both sides of the valve to allow for removal and reinstallation of valve. Provide strainer dedicated to each valve and coil assembly.

END OF SECTION

SECTION 23-2114
HYDRONIC PIPING VALVES

PART 1 - GENERAL

1.1 ACCEPTABLE MANUFACTURERS

A. Valves shall be Nibco, Crane, Apollo, or approved equal.

1.2 REQUIREMENTS

A. Provide clamp lock hand lever operators on valves less than 6 inches. Provide hand wheel and closed housing worm gear on valves 6 inches and larger unless indicated otherwise below. Provide chain operators for all equipment room and powerhouse valves 4 inch and larger which are located over 6 feet 6 inches above the finish floor. All valves shall be of the extended neck design to allow for the installation of full thickness insulation over flanges. Provide rubber end caps on all exposed valve stems under 7'-0" to prevent bump hazards. Valves shall be installed upright with no more than 45 degrees off center.

PART 2 - PRODUCTS

2.1 GATE VALVES

A. Provide gate valves per the following table:

<u>SERVICE</u>	<u>SIZE</u>	<u>NIBCO MODEL #</u>	<u>PRESSURE CLASS</u>
Heating Hot Water	2" & smaller	T134 (threaded) / S134 (soldered)	150
Heating Hot Water	2-1/2" & larger	F617-0	125

2.2 BALL VALVES

A. Provide ball valves per the following table:

<u>SERVICE</u>	<u>SIZE</u>	<u>NIBCO MODEL #</u>	<u>PRESSURE CLASS</u>
Heating Hot Water	2-1/2" & smaller	T585-70 (threaded) / S585-70 (soldered)	150# CWP

B. Where piping is insulated, ball valves shall be equipped with 2" extended handles of non-thermal conductive material. A protective sleeve shall be provided that allows operation of the valve without breaking the vapor seal or disturbing the insulation. Include fully adjustable memory stops for all ball valves.

2.3 CHECK VALVES

A. Provide check valves per the following table:

<u>SERVICE</u>	<u>SIZE</u>	<u>NIBCO MODEL #</u>	<u>PRESSURE CLASS</u>
Heating Hot Water	2" & smaller	T-433 (threaded) / S-433 (solder)	150
Heating Hot Water	2-1/2" & larger	F-918-B	125

2.4 FLOW BALANCING VALVES

- A. Flow balancing valves shall be Circuit Setter by Bell and Gossett or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The installation of butterfly valves in water piping systems shall allow for ordinary maintenance work to be performed on the equipment these butterfly valves isolate, without having to drain the system beyond the butterfly valve. For instance, a check valve, of the type which would have to be removed from the line to replace the clapper or liner, should not be bolted onto a water type butterfly valve since removal of the check valve from the line would involve removing the butterfly valve also.
- B. Valves shall be located so as to be accessible by maintenance personnel. Valves 2 1/2 and larger shall have piping supported on each side of the valve.
- C. Valves shall be installed with stem no longer than horizontal position. Prior to installation valves shall be thoroughly cleaned to remove foreign material.

END OF SECTION

SECTION 23-2300
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Division-23 HVAC Basic Mechanical Materials and Methods sections apply to work of this section.

1.2 DESCRIPTION OF WORK

- A. Extent of refrigerant piping work is indicated on drawings and schedules, and by requirements of this section.
- B. Insulation of refrigerant piping is specified in other Division-23 sections and is included as work of this section.

1.3 CODES AND STANDARDS

- A. ANSI Compliance: Fabricate and install refrigerant piping in accordance with ANSI B31.5 "Refrigeration Piping" and extend applicable lower pressure limits to pressures below 15 psig.
- B. ASHRAE Compliance: Fabricate and install refrigerant piping in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".

1.4 DESIGN

- A. Refrigerant piping shall be sized, selected, and designed either by the equipment manufacturer or in strict accordance with the manufacturer's published instructions. The schematic piping diagram shall show all accessories such as, stop valves, level indicators, liquid receivers, oil separator, gauges, thermostatic expansion valves, solenoid valves, moisture separators and driers to make a complete installation.

1.5 SUBMITTALS

- A. Shop Drawings: Complete information for components noted, including valves and refrigerant piping accessories, clearly presented, shall be included to determine compliance with drawings and specifications for components noted below:
 - a. Tubing and fittings
 - b. Valves
 - c. Strainers
 - d. Moisture-liquid indicators
 - e. Filter-driers
 - f. Flexible metal hose
 - g. Liquid-suction interchanges
 - h. Oil separators (when specified)
 - i. Gauges
 - j. Pipe and equipment supports
 - k. Refrigerant and oil

- l. Pipe/conduit roof penetration cover
 - m. Soldering and brazing materials
- B. Layout of refrigerant piping and accessories, including flow capacities, valves locations, and oil traps slopes of horizontal runs, floor/wall penetrations, and equipment connection details.

PART 2 - PRODUCTS

2.1 MATERIALS AND PRODUCTS

- A. 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 ANSI B31.5 Code for Refrigeration Piping where applicable, base pressure rating on refrigerant piping system maximum design pressures. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in refrigerant piping systems. Where more than one type of materials or products are indicated, selection is Installer's option.

2.2 BASIC PIPES AND PIPE FITTINGS

- A. General: Provide pipes and pipe fittings in accordance with the following listing:
 - 1. Tube Size 4-1/8" and Smaller: Copper tube; Type ACR, soft annealed temper fittings; cast copper-alloy fittings for flared copper tubes; flared joints.
 - 2. Soldered Joints: Solder joints using silver-lead solder, ASTM B 32, Grade 96 TS.
 - 3. Brazed Joints: Braze joints using American Welding Society (AWS) classification BCuP-4 for brazing filler metal.

2.3 BASIC PIPING SPECIALTIES

- A. General: Provide specialties complying with the following listing:
 - 1. Pipe escutcheons.
 - 2. Drip pans.
 - 3. Sleeves.
 - 4. Sleeve seals.

2.4 BASIC SUPPORTS AND ANCHORS

- A. General: Provide supports and anchors in accordance with the following listing:
 - 1. Adjustable steel clevises, adjustable roller hangers, and adjustable pipe roll stands for horizontal piping hangers and supports.
 - 2. Two-bolt riser clamps for vertical piping supports.
 - 3. Concrete inserts, C-clamps, and steel brackets for building attachments.
 - 4. Protection shields for insulated piping support in hangers.
 - 5. Copper flashings for piping penetrations.

2.5 SPECIAL REFRIGERANT VALVES

- A. General: Special valves required for refrigerant piping include the following types:

1. 2-Way Solenoid Valves: Forged brass, designed to conform to ARI 760, normally closed, teflon valve seat, NEMA 1 solenoid enclosure, 24 volt, 60 Hz., UL-listed, 1/2" conduit adapter, 250 deg. F (121 deg. C) temperature rating, 400 psi working pressure.
- B. Manufacturer: Subject to compliance with requirements, provide solenoid valves of one of the following or equal:
 1. Alco Controls Div.; Emerson Electric Co.
 2. Automatic Switch Co.
 3. Sporlan Valve Co.

2.6 REFRIGERANT SPECIALTIES

- A. Refrigerant Strainers: Brass shell and end connections, brazed joints, monel screen, 100 mesh, UL-listed, 350 psi working pressure.
- B. Moisture-Liquid Indicators: Forged brass, single port, removable cap, polished optical glass, solder connections, UL-listed, 200 deg. F (93 deg. C) temperature rating, 500 psi working pressure.
- C. Refrigerant Filter-Driers: Corrosion-resistant steel shell, steel flange ring and spring, wrought copper fittings, ductile iron cover plate with steel cap screws, replaceable filter-drier core, 500 psi working pressure.
- D. Manufacturer: Subject to compliance with requirements, provide refrigeration accessories of one of the following or equal:
 1. Alco Controls Div.; Emerson Electric Co.
 2. Henry Valve Co.
 3. Parker-Hannifin Corp.; Refrigeration & Air-Conditioning Div.
 4. Sporlan Valve Co.

PART 3 - EXECUTION

3.1 INSPECTION

- A. General: Examine areas and conditions under which refrigerant 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 REFRIGERANT PIPING

- A. General: Install refrigerant piping in full compliance with equipment manufacturer's requirements.

3.3 INSTALLATION OF SPECIAL REFRIGERANT VALVES WHERE REQUIRED

- A. General: Install refrigerant valves where indicated, and in accordance with manufacturer's instructions. Remove accessible internal parts before soldering or brazing, replace after joints are completed.
- B. Solenoid Valves: Install in refrigerant piping as indicated with stem pointing upwards.

3.4 INSTALLATION OF REFRIGERANT ACCESSORIES WHERE REQUIRED

- A. Refrigerant Strainers: Install in refrigerant lines as indicated and in accessible location for service.

- B. Moisture-Liquid Indicators: Install as indicated on refrigerant liquid lines in accessible location.
- C. Refrigerant Filter-Dryers: Install in refrigerant lines as indicated and in accessible location for service.

3.5 EQUIPMENT CONNECTIONS

- A. General: Connect refrigerant piping to mechanical equipment as indicated and comply with equipment manufacturer's instructions where not otherwise indicated.

3.6 FIELD QUALITY CONTROL

- A. Refrigerant Piping Leak Test: Prior to initial operation, clean and test refrigerant piping in accordance with ANSI B31.5, "Refrigeration Piping". Perform initial test with dry nitrogen, using soap solution to test all joints. Perform final test with 27" vacuum, and then 200 psi using halide torch. System must be entirely leak-free.
- B. Repair or replace refrigerant piping as required to eliminate leaks and retest as specified to demonstrate compliance.

3.7 DEHYDRATION AND CHARGING SYSTEM

- A. Install core in filter dryer after leak test but before evacuation.
- B. Evacuate refrigerant system with vacuum pump.
- C. During evacuation, apply heat to pockets, elbows, and low spots in piping.
- D. Maintain vacuum on system for minimum of 5 hours after closing valve between vacuum pump and system.
- E. Break vacuum with refrigerant gas.
- F. Complete charging of system using new filter dryer core in charging line. Provide full operating charge per manufacturer

3.8 STARTUP

- A. Manufacturer shall provide written approval of refrigerant piping installation and provide confirmation that it has been installed per manufacturer's requirements.

END OF SECTION

SECTION 23-3113.23
LOW PRESSURE SHEETMETAL DUCTWORK

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. All drawings are diagrammatic. Contractor is required to re-route ductwork, provide offsets, 90 and 45 degree bends, change aspect ratio of ductwork as required in coordinate with other trades at no additional cost to the project.
- B. Low pressure ductwork refers to systems operating at 2.00" w.g. total static pressure with velocities up to 2000 FPM. It is the intent of this specification to provide an installed duct system which will supply the air quantities indicated by the plans and has the lowest possible friction loss with the least possible leakage loss. Friction loss for each system shall not exceed that which is indicated in the A.C. unit schedule as external static pressure or in the fan schedule as static pressure and shall include the losses of all accessories. Friction losses shall be minimized by reduction in the number of offsets and elbows by pre-planning the duct system installation and coordination with other trades to prevent interferences. Access to all accessories requiring maintenance, service and inspection shall be maintained. Radius elbows are preferred for all turns to minimize friction, noise and vibration; and, especially, for sections having large volume or higher velocities and sections which may have turbulences.
- C. The contractor shall provide and/or construct all materials, ductwork, joints, transitions, splitters, dampers, access doors, etc., as set forth in these specifications necessary to install the Low Pressure Sheet Metal Ductwork required by the Mechanical Drawings.

1.2 QUALITY ASSURANCE

- A. Sheet metal work shall be fabricated and installed in accordance with the most recent recommendations of the SMACNA Duct Manual. When local authorities or specifications included herein are more stringent, they shall supersede the SMACNA guidelines.
- B. Dimensions for sheet metal work shown on Drawings are inside clear unless otherwise noted.
- C. Quality control involves not only the general performance requirements for all air ducts, but also quality workmanship which includes layout preplanning so that offsets, rises, falls, elbows, fittings, etc., are minimized or eliminated. General performance requirements for all ducts include:
 - 1. Dimensional stability (shape deformation and strength).
 - 2. Containment of the air being conveyed (leakage control).
 - 3. Vibration (fatigue and appearance).
 - 4. Noise (generation, transmission or attenuation).
 - 5. Exposure (to damage, weather, temperature extremes, flexure cycles, wind, corrosive atmospheres, biological contamination, flow interruption or reversal, underground or other encasement conditions, combustion, or other in service conditions).
 - 6. Support (alignment and position retention).

7. Thermal conductivity (heat gain or loss and condensation control).

1.3 SUBMITTALS AND SHOP DRAWINGS

- A. Submit material/product data to designer for approval ONLY when it deviates from products specified in Part 2 herein.
- B. The General Contractor shall be responsible for coordination between trades. Non-critical piping and conduit shall give way to ducts.

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Sheet Metal, Angles, Bar Slips, Hangers, and Straps: Galvanized steel.
- B. Screws: Cadmium plated.

2.2 FABRICATION

- A. Provide a rectangular or round duct where required on drawings of prime quality galvanized steel sheets, thickness and reinforcement as required by the following schedule, SMACNA, or local and state codes, whichever is more stringent. When fabricating low pressure ductwork, largest duct dimension governs the entire duct and complete joint.
- B. Ductwork shall be of S and drive construction (or equivalent in pocket-lock construction) or duct flange construction. Duct shall be built to 2" w.c. per SMACNA standards.
- C. Duct gauge shall conform to the current edition of SMACNA.
- D. In addition to the above, reinforcement and supplemental bracing shall be added per SMACNA standard and as necessary to prevent sagging and drumming.
- E. Duct sections and fittings shall be secured with sheet metal screws.
- F. Connections of round duct to rectangular shall be made with spin-in collars.
- G. A duct in which the larger side is less than 18 inches shall have transverse joints at least every eight feet. Ducts 18 inches or over larger side dimension shall have transverse joints, or equivalent supplemental angle reinforcing on 4 foot centers.
- H. Longitudinal joints shall be Pittsburgh lock or grooved seams closed tightly and evenly.
- I. Ductwork over ten inches dimension, either side, shall have sides cross broken.
- J. Duct dimensions shown on drawings indicate inside clear dimensions. Make allowances in sheet metal size for duct requiring internal duct liner to provide "inside clear" dimensions.
- K. Round prefabricated slip joint snaplock duct may be used on low pressure supply, exhaust and return duct 14" diameter and smaller.
- L. Connections of round ductwork to rectangular ductwork shall be made with bellmouth spin-in fittings with MVDs. MVD handles shall be supplied with a stand-off bracket and locking quadrant to ensure that the handle can be adjusted, locked down with no "drifting" of the damper blade, and permanently marked by the TAB

agency. Manual volume damper (MVD) blades shall be constructed of 24 gauge minimum thickness metal.

- M. Do not exceed 1" in 7" of slope for increase-in-area transitions.
- N. Do not exceed 1" in 4" of slope for decrease-in-area transitions; 1" in 7" is preferable.
- O. Do not exceed 30 degrees on the approaching side and 45 degrees on the leaving side for angle of transitions at connections to equipment without the use of approved vanes.
- P. Provide elbows fabricated to one of the following specifications:
 - 1. Unvaned elbow with the throat radius equal to 1-1/2 of the width of the duct and with full heel radius.
 - 2. Three inch square throat and square heel, with closed-spaced double thickness turning vanes.
- Q. Make branch connections and tees in one of the following manners:
 - 1. Converging radius elbow.
 - 2. Radius tap-in.
 - 3. Square take off with suitable vanes.

2.3 DUCT SEALING

- A. All ductwork shall be sealed (exhaust, return, supply, etc.) to SMACNA Seal Class
- B. Sealants
 - 1. Renovation Projects Use water based solvents (due to fumes spreading into occupied spaces). Hard cast tape may be used as an alternative.
- C. All duct wall penetrations shall be sealed with caulk.

2.4 DUCT PRESSURE TESTING

- A. The following ductwork shall be tested at a pressure of 2 in.wc. with a maximum allowable leakage as determined using SMACNA Leakage Class 6:
 - 1. Stairwell pressurization ductwork
- B. Prior to performing leak test all duct systems must be complete. This includes access doors, fire/smoke dampers, flexible duct, and branch run-outs exceeding 10 feet in length.
- C. The TAB agency shall be responsible for witnessing ductwork air leakage testing (DALT) procedures on the various sheet metal sections of each type of ductwork (to be conducted by the sheet metal installing contractor). The sheet metal installing contractor shall be responsible for providing the necessary DALT equipment, preparing the duct test section including sealing the ductwork ends and the air distribution taps, installing the connection tap for the DALT fan discharge hose, and for calculating the various duct test section surface areas, on the appropriate SMACNA HVAC AIR DUCT LEAKAGE TEST MANUAL form. The TAB agency shall coordinate all required DALT procedures with the sheet metal installing contractor and select the various ductwork sections to be tested. Once the test sections have been chosen, the sheet metal installing contractor

shall submit copies of shop drawings indicating the sections of ductwork to be tested, including the surface area calculations, and proceed with preparing the selected duct section for testing. Once the testing has been completed and witnessed, and repeated where necessary to ensure that all test sections have "PASSED", the sheet metal installing contractor, shall submit all DALT procedure results to the owner, EOR and the general contractor on copies of the AIR DUCT LEAKAGE TEST SUMMARY form provided in the SMACNA HVAC DALT manual."

PART 3 - EXECUTION

3.1 INSTALLATION OF DUCTWORK

- A. Ductwork shall be constructed and erected in a workmanlike manner approximately as shown on drawings. Equivalent size duct to that shown on the drawings can be installed to facilitate installation so long as aspect ratio does not exceed 4 to 1 without express consent from the engineer. Ducts shall be straight and smooth on the inside with neatly finished joints, airtight, and shall be free from vibration under all conditions of operation. The internal ends of slip joints shall be made in the direction of air flow. The ducts shall be securely attached to the building construction in an approved manner. Ductwork sizes shown are inside clear and do not include liners.
- B. Strap hangers for low pressure round ductwork 12" and smaller, when used, shall be continuous. Larger ductwork shall be supported using angle iron or unistrut supports connected to the structure using 3/8" threaded rod. The duct shall be secured to the structural portion of the building with approved anchor shields and to the steel structure by means of C-clamps or bolting. Hangers shall be spaced approximately eight feet along the duct. For ducts 60 inches and larger and heavy sections, such as welded duct and sound absorbers, hangers shall be spaced at approximately four foot intervals.
- C. Permanent pitot ports shall be installed in the ductwork on each system, as required for air balancing. Ports shall be 7/16 inch diameter holes, on maximum eight inch centers, at least three to a duct, and shall be closed up with removable plastic plugs. Insulated duct shall be provided with extension collar around port and screwed panel cover with insulation adhered to underside.
- D. Wherever ductwork is connected to fans, air handling unit or other equipment by means of a flexible connection constructed of UL listed 20-ounce fire resistant flexible canvas or other approved material. The connection shall be suitable for the pressures at the point of installation.
- E. Counterflashing: Counterflash all ducts where they pierce the roof.
- F. Insulation: Where drawings and insulating specifications indicate that ducts are to be insulated, make provisions for neat insulation finish around damper operating quadrants, splitter adjusting clamps, access doors, and similar operating devices. After system balancing is complete, devices should be covered with insulation and marked. Metal collar equivalent in depth to insulation thickness and of suitable size to which insulation may be finished shall be mounted on duct. Straps should always be on the outside of the insulation and rolled 2" larger than the round duct they support and appropriate saddles shall be installed to protect the insulation. All unistrut or angle iron supports shall be on the outside of the insulation.

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3.2 CLEANING: Clean ductwork thoroughly to assure all foreign matter, dirt, etc. is removed. The following procedures shall be followed:

- A. All duct is to be shipped to the project sealed with plastic to prevent dust/dirt accumulation during shipping and storage.
- B. All specified pre-filters will be installed prior to unit startup.
- C. All return grilles will be covered with filter media before units are started.
- D. A final set of the specified pre filters will be installed for project turnover.

END OF SECTION

SECTION 23-3113.26
MEDIUM PRESSURE SHEETMETAL DUCTWORK

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. All drawings are diagrammatic. Contractor is required to re-route ductwork, provide offsets, 90 and 45 degree bends, change aspect ratio of ductwork as required in coordinate with other trades at no additional cost to the project.
- B. The contractor shall provide and/or construct all materials, ductwork, joints, transformations, fittings, access doors, etc., as set forth in these specifications necessary to install the medium pressure sheet metal ductwork required by the drawings.
- C. Medium pressure - sheet metal ductwork with air velocity greater than 2000 feet per minute and static pressure 10" or less, but greater than 2". This specification will establish the actual pressure which will be required for the ductwork in Part 2.
- D. It is the intent of this specification to provide an installed duct system, which will supply the air quantities, indicated by the plans and has the lowest possible friction loss with the least possible leakage loss. Friction loss for each system shall not exceed that which is indicated in the A.C. unit schedule as external static pressure or in the fan schedule as static pressure and shall include the losses of all accessories. Friction losses shall be minimized by reduction in the number of offsets and elbows by pre-planning the duct system installation and coordination with other trades to prevent interferences. Access to all accessories requiring maintenance, service, and inspection shall be maintained. Elbows with a radius of 1.5 x width radius are preferred for all turns to minimize friction, noise and vibration; and, especially, for sections having large volume or higher velocities, and sections which may have turbulences.
- E. Medium pressure ductwork is required from the outlet of AHU to each variable volume terminal box.

1.2 QUALITY ASSURANCE

- A. Sheet metal work shall be fabricated and installed in accordance with the most recent recommendations of the SMACNA Duct Manual. When local authorities or specifications included herein are more stringent, they shall supersede the SMACNA guidelines.
- B. Dimensions for sheet metal work shown on Drawings are inside clear unless otherwise noted.
- C. Quality control involves not only the general performance requirements for all air ducts, but also quality workmanship which includes layout preplanning so that offsets, rises, falls, elbows, fittings, etc., are minimized or eliminated. General performance requirements for all ducts include:
 - 1. Dimensional stability (shape deformation and strength).
 - 2. Containment of the air being conveyed (leakage control).
 - 3. Vibration (fatigue and appearance).
 - 4. Noise (generation, transmission or attenuation).

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5. Exposure (to damage, weather, temperature extremes, flexure cycles, wind, corrosive atmospheres, biological contamination, flow interruption or reversal, underground or other encasement conditions, combustion, or other in-service conditions).
6. Support (alignment and position retention).
7. Thermal conductivity (heat gain or loss and condensation control).

1.3 SUBMITTALS AND SHOP DRAWINGS

- A. Submit material/product data to designer for approval ONLY when it deviates from products specified in Part 2 herein.
- B. Duct pressure test reports (test reports shall have a witness signature from a representative of the facility maintenance department).
- C. The General Contractor shall be responsible for coordination between trades. Non-critical piping and conduit shall give way to ducts.

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Sheet Metal, Angles, Bar Slips, Hangers, and Straps: Galvanized steel.
- B. Screws: Cadmium plated.
- C. Joint Sealer: Manufactured by Hardcast, Inc., Two-Stage Sealant Process.
 1. Stage 1: Apply fiber DT tape.
 2. Stage 2: Brush on RTA-50 sealant over fiber tape.

2.2 FABRICATION REQUIREMENTS

- A. Materials, including sealers (after setting), liners, pre-insulated jackets, and flexible ducts shall have a flame spread rating of not over 25 and smoke developed rating of not over 50.
- B. Single wall round ducts, shall be spiral lock seam round conduit, except that duct 21 inches diameter and larger may be 20 gauge grooved seam round duct. Spiral conduit and all round duct fittings shall be United Sheet Metal Company or approved equal by SEMCO or R.D. Herbert. Round duct and fittings shall be manufactured to close tolerances to allow tight fitting slip joints. Elbows shall be three or more piece rigid duct. Reducers shall be a maximum one inch in reduction in four inches of length. Tees shall be conical. Duct shall be built or manufactured to 6" w.c. per SMACNA standards.
- C. Double wall spiral duct shall be galvanized steel in accordance with ASTM A-653 and A-924. The inner metal wall shall be a perforated liner consisting of 1/8 inch perforations on 1/4 inch staggered centers corresponding to an overall open area of 23%. Fiber glass insulation shall have a maximum conductivity factor (K) of 0.26 BTU-in/hr o ft² o °F at 75°F mean ambient temperature. Retaining fabric shall be 0.008 inch thick, 15.6 lb/ft³ density with an air permeability rate of 9.2 ft³/ft² o s. Insulation stop shall be closed cell polyethylene foam, 1.7 lb./ft³ in accordance with ASTM E-84, ASTM E-162.
- D. Saddle taps shall be used wherever possible for branch take-offs except that they cannot exceed 2/3 the diameter of the trunk duct. Male ends of all fittings shall be at least two inches long, beyond the bead, for diameters up to nine inches and four

inches long for ten inches diameter and larger.

- E. Joints in round ducts shall be made with MMM EC800 sealer, or equal, by Benjamin Foster or General Adhesive Company. Sealer shall be fire resistive, after setting. (Reference hereinafter to "sealer" shall mean this type sealer). Male ends of joints shall be coated with sealer, the joint assembled and secured with sheetmetal screws, and sealed with two coats of sealer with a gauze strip imbedded between coats.
- F. Rectangular duct shall have appropriate thickness per SMACNA and shall be built and installed to SMACNA standards for medium pressure duct. Sealer shall be used in making joints as outlined in SMACNA standards for medium pressure duct construction or as described within these specifications. Duct shall be built or manufactured to 6" w.c. per SMACNA standards.
- G. Connections of round ductwork to rectangular ductwork shall be made with bellmouth spin-in fittings.
- H. Provide elbows fabricated to one of the following specifications:
 - 1. Unvaned elbow with the throat radius equal to 1-1/2 of the width of the duct and with full heel radius.
 - 2. Three inch square throat and square heel, with closed-spaced double thickness turning vanes.

2.3 DUCT SEALING

- A. All Projects:
 - 1. Medium-pressure supply duct - Seal all duct joints and seams to a SMACNA SEAL Class A.
- B. Sealants:
 - 1. Use water based solvents (due to fumes spreading into occupied spaces). Hard cast tape may be used as an alternative.
- C. All duct wall penetrations shall be sealed with caulk.

2.4 DUCT PRESSURE TESTING

- A. Medium-pressure duct shall be tested at a minimum static of 6 in. wc., with a maximum allowable leakage rate as determined using SMACNA Leakage Class 6 for rectangular duct and Leakage Class 3 for spiral ductwork.
- B. Prior to performing leak test all duct systems must be complete. This includes access doors, fire/smoke dampers and branch run-outs exceeding 10 feet in length.
- C. The TAB agency shall be responsible for witnessing ductwork air leakage testing (DALT) procedures on the various sheet metal sections of each type of ductwork (to be conducted by the sheet metal installing contractor). The sheet metal installing contractor shall be responsible for providing the necessary DALT equipment, preparing the duct test section including sealing the ductwork ends and the air distribution taps, installing the connection tap for the DALT fan discharge hose, and for calculating the various duct test section surface areas, on the appropriate SMACNA HVAC AIR DUCT LEAKAGE TEST MANUAL form. The TAB agency shall coordinate all required DALT procedures with the sheet

metal installing contractor and select the various ductwork sections to be tested. Once the test sections have been chosen, the sheet metal installing contractor shall submit copies of shop drawings indicating the sections of ductwork to be tested, including the surface area calculations, and proceed with preparing the selected duct section for testing. Once the testing has been completed and witnessed, and repeated where necessary to ensure that all test sections have "PASSED", the sheet metal installing contractor, shall submit all DALT procedure results to the owner, EOR and the general contractor on copies of the AIR DUCT LEAKAGE TEST SUMMARY form provided in the SMACNA HVAC DALT manual.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Ductwork shall be constructed and erected in a workmanlike manner approximately as shown on drawings. Equivalent size duct to that shown on the drawings can be installed to facilitate installation so long as aspect ratio does not exceed 4 to 1 without express consent from the engineer. Ducts shall be straight and smooth on the inside with neatly finished joints, airtight, and shall be free from vibration under all conditions of operation. The ducts shall be securely attached to the building construction in an approved manner.
- B. Support round ducts from building structure with galvanized steel angle iron or unistrut as recommended in SMACNA manual. Galvanized bands attached directly to the ductwork are not acceptable. Secure hangers to masonry portion of building by means of inserts or other acceptable anchors. Secure hangers to steel structure members by means of C-clamps. Vertical risers and other duct runs where methods of support specified above are not applicable, to be supported by angle brackets as shown in SMACNA manual.
- C. Space hangers approximately 8' along the duct for ducts under 60". For ducts 60" and larger and heavier sections, such as welded duct, space hangers at approximately 4' intervals.
- D. Hangers and bracing used with ductwork to be galvanized.
- E. Obstructions shall not be located within ducts.
- F. Provide smooth insulation finish around dampers, access doors, and similar operating devices. Provide metal collar equivalent in depth to insulation thickness.
- G. Provide pitot ports for measuring airflows in each main supply duct downstream of straightest run of main and before first branch takeoff. Form pitot ports by drilling 7/16" holes in the duct, lined up perpendicular to airflow on maximum of 8" centers. Provide minimum of 3 per duct evenly spaced. Plug holes with plastic plugs. Provide access to pitot ports for future re-balancing.
- H. Seal duct joints as follows:
 - 1. Apply sealer to male end of couplings and fittings. After joint is slipped together, place sheet metal screws 3" on center, 1/2" from joint bead. Apply sealer to the outside of the joint extending 1" on each side of the joint bead and covering screw heads. Apply tape immediately over wet sealer.

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2. Duct sealer to be specifically formulated for the sealing of medium-pressure duct systems. Sealer to be compatible with tape to ensure cure and bond. Flame spread rating of sealer to be less than 25, smoke development rating of sealer to be less than 50. Sealer to be mineral impregnated woven fiber tape and plastic type activator/adhesive as manufactured by Hardcast Inc., or approved equal. Apply joint material in strict accordance with manufacturers' published installation instructions.

I. Flanged joints to be sealed with neoprene rubber gaskets.

J. Seal off the insulation jacket at its ends, at joints and over punctures of the vapor barrier jacket with three inches wide pressure sensitive tape. Complete insulation coverage up to the terminals. Straps should always be on the outside of the insulation and rolled 2" larger than the round duct they support and appropriate saddles shall be installed to protect the insulation. All unistrut or angle iron supports shall be on the outside of the insulation.

3.2 CLEANING: Clean ductwork thoroughly to assure all foreign matter, dirt, etc. is removed.

A. All duct is to be shipped to the project sealed with plastic to prevent dust/dirt accumulation during shipping and storage.

B. All specified pre-filters will be installed prior to unit startup.

C. A final set of the specified pre filters will be installed for project turnover.

END OF SECTION

SECTION 23-3300
SHEET METAL ACCESSORIES

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Contractor shall provide and install the following equipment as specified herein and in locations shown on drawings.
 - 1. Air distribution registers, grilles, and diffusers.
 - 2. Fire dampers, smoke dampers, and combination fire/smoke dampers.
 - 3. Access doors.
 - 4. Flexible ducts.
 - 5. Air mixing devices.
 - 6. Volume control dampers.
 - 7. Backdraft dampers.
 - 8. Air turning devices.

1.2 QUALITY CONTROL

- A. Fire dampers to be UL labeled and conform to NFPA 90A and NFPA 90B.
- B. Air diffusers, grilles, and registers to have rating certified by Air Diffusion Council and tested per ADC Equipment Test Code 1062R2 and ASHRAE Standard 36B-63.
- C. Fire dampers shall meet test requirements of UL 555.
- D. Smoke dampers shall meet test requirements of UL 555S.

1.3 SUBMITTALS

- A. Submit product data to Owner for approval as required by Section 23 01 00.

PART 2 - PRODUCTS

2.1 REGISTERS, GRILLES AND DIFFUSERS

- A. Acceptable manufacturers include Price, Titus, Greenheck, Nailor and Anemostat. (Titus or Price numbers are used.)
 - 1. Sidewall Supply Registers: Price model 620, aluminum, double deflection, and powder coat white finish.
 - 2. Sidewall Return and Exhaust Registers: Price model 630, aluminum, fixed horizontal deflection, and powder coat white finish.
 - 3. Ceiling Diffusers: Price model ASPD, aluminum, square plaque face, 24x24 lay-in, and powder coat white finish.
 - a) Ceiling diffusers may be suitable for lay-in tile installation by mounting it in a factory fabricated, 24" x 24" back pan.
 - b) Do not use directional diffusers. Diffusers noted on drawings as three-way or two-way blow shall be four-way diffusers with sides blanked off with sheet metal plates installed in the diffuser necks.
 - c) Diffusers in systems with ducted return shall be insulated with 2" of 3/4 pcf fiberglass wrap.

4. Exhaust and Return Registers: Price model 80, aluminum, 1/2x1/2x1/2 egg-crate, VCS3 opposed blade volume control damper, and powder coat white finish. Screws in the face of these grilles shall match the finish for surface mount applications. **Provide square to round transition above grille equal to Flexmaster, with black coated interior.**

2.2 FIRE, SMOKE, & COMBINATION FIRE/SMOKE DAMPERS

- A. Dampers shall be UL listed and in compliance with NFPA 90A. Fire dampers for use in walls, ceilings and floors shall be Greenheck, Ruskin, or Leader Industries. See Architectural and/or Mechanical plans for hour rating of floors and/or wall at damper locations. Dampers to be compatible with hour ratings. Do not use dampers with asbestos paper or coating.
- B. Fire dampers to be UL555 dynamic rated curtain style with spring closing for both horizontal and vertical mounting. Dampers to be manufactured by Greenheck, Ruskin, or Leader Industries. All dampers shall be "C" style frames in square and rectangular low pressure supply, return, or exhaust ducts or round, oval, or medium pressure applications and may have no more than zero (0) percent obstruction to air flow. Provide dampers with integral sleeves and mounting angle frames with metal gauges as required by SMACNA and in accordance with UL and NFPA requirements.
- C. Smoke Dampers: Provide smoke dampers with airfoil blades which are classified by UL as Leakage Rated Dampers for Use in Smoke Control Systems under the latest version of U.L. Standard 555S. The leakage rating shall be no higher than leakage class II (10 cfm/sq.ft. at 1" w.g.). Dampers and their operators shall also be qualified under UL 555S to elevated temperature category B (250 degrees F). Each damper assembly shall bear a U.L. label attesting to its classification.
 1. Smoke damper operators shall be electric type, to operate on 24 Volts or 120 VAC, 60 Hz, and shall be of the spring return type such that damper will be closed upon power interruption. Operators shall be mounted outside the air stream.
 2. Operators for the smoke dampers shall be installed by the damper manufacturer at the time of damper fabrication. The damper and operator shall be supplied as a single entity, which meets all applicable UL 555S qualifications for both smoke dampers and operators.
 3. **Provide optional switch package to allow for remote indication of damper blade position.**
- D. Combination Fire/Smoke Dampers: Provide combination fire and smoke dampers with airfoil blades which are 1-1/2 hour rated under U.L. Standard 555 and also qualified under U.L. Standard 555S. Each combination damper shall bear both UL classified labels. Fire protection shall 1-1/2 hour and the leakage rating shall be no higher than Class II at elevated temperature Category B (10cfm/sq.ft.at 1" w.g. and 250 degrees F).
 1. Smoke damper operators shall be electric type, to operate on 24 Volts or 120 VAC, 60 Hz, and shall be of the spring return type such that damper will be closed upon power interruption. Operators shall be mounted outside the air stream.

2. Combination fire/smoke dampers shall be of multi-blade construction with metal-to-metal seals.
3. Except as otherwise noted, each combination fire/smoke damper shall include all the features as required for fire dampers and smoke dampers as described above, including:
 - a) 160 degrees F (minimum) fusible link;
 - b) Positive lock in closed position (when activated by melting of fusible link);
 - c) Remote resetting after being closed via smoke device;
 - d) Factory-furnished sleeve.
 - e) **Optional switch package to allow for remote indication of damper blade position.**
- E. Miscellaneous Materials: Extra fusible links shall be provided as maintenance spare parts. Furnish 5 percent, but not less than 3 of each type and operating characteristic of fusible links used in project.
- F. All dampers shall have suitable access doors in the duct for examination, testing and service of the damper. **Access doors shall be a minimum of 12"x12" for proper access.**

2.3 ACCESS DOORS

- A. Greenheck CAD-10, insulated doors, or approved equal located in ductwork, floors, walls, ceiling, or casing for equipment service such as automatic dampers, fire dampers, smoke dampers, humidifiers, entering side of duct coils (entering side only), casing mounted coils (each side), filters (each side), and elsewhere as noted on drawings.
- B. The size of all access doors at all fire, smoke, or combination dampers shall be as follows:

<u>DUCT SIZE</u>	<u>ACCESS DOOR</u>
Under 12"	12" x 12"
12" to 20"	12" x 12"
20" to 36"	18" x 18"
36" and above	24" x 24"
- C. Apparatus Casing Access Doors: Prehung door frame assemblies, Venco HF-10, or equal.
- D. Provide reinforced wire glass view windows 12" x 12" in access doors at humidifiers.
- E. Use double panel construction, two sheets of at least 24-gauge galvanized steel with 1" thick insulation between panels.
- F. Mount doors in a rigid frame of at least 22 gauge formed galvanized steel or aluminum.
- G. Use angle iron bracing as required making the door frame a rigid assembly.

- H. Provide cam lock access doors and provide positive closing, tight sealing and easily operated latches.
- I. Provide latches that permit easy removal of access door while maintaining positive closing and minimum leakage.
- J. Provide sponge rubber gaskets for all doors.
- K. Provide clear labeling indicating what is being accessed, "Fire Damper", "Fire/Smoke Damper", etc.

2.4 FLEXIBLE DUCT

- A. Acceptable manufacturers: Flexmaster Type 3 Insulated or Thermaflex Type M-KC.
- B. Characteristics of flexible duct:
 - 1. Approved as UL-181 Class 1 air duct.
 - 2. Flame spread rating less than 25 and smoke developed rating less than 50.
 - 3. Rated for 10" w.g. positive pressure, 4" w.g. negative pressure, and 4000 fpm air velocity.
 - 4. Tear and puncture resistant reinforced duct fabric mechanically locked together with a corrosive resistant galvanized steel helix.
 - 5. Insulated with minimum 1" thick, $\frac{3}{4}$ pound density fiberglass insulation with vapor barrier jacket.
- C. Flexible duct is NOT to be used for runouts where it must pass through walls or through smoke or fire partitions. Flexible duct is not to be used in exposed application. Flexible duct lengths shall not exceed 5 feet at each connection.
- D. Flexible duct is NOT to be used as medium pressure connections to variable or constant air volume or fan powered terminal boxes.
- E. No bends shall be made in flexible duct with the center line radius less than one and one-half duct diameter.

2.5 VOLUME CONTROL DAMPERS

- A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards, and as indicated. All dampers shall be a minimum of 24 ga.
- B. Fabricate splitter dampers of material same gauge as duct to 24 inches size in either direction, and two gauges heavier for sizes over 24 inches.
- C. Fabricate splitter dampers of double thickness sheet metal to streamline shape. Secure blade with continuous hinge or rod. Operate with minimum 1/4" inch diameter rod in self aligning, universal joint action flanged bushing with set screw.
- D. Fabricate single blade dampers for duct sizes to 9-1/2 x 30 inch.
- E. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
- F. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.

- G. Provide locking, indicating quadrant regulators on single and multi-blade dampers. Where rod lengths exceed 30 inches provide regulator at both ends.
- H. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases or adapters.

2.6 BACKDRAFT DAMPERS

- A. Provide multi-blade, parallel action gravity balanced backdraft dampers of 16-gauge galvanized steel, or extruded aluminum, with center pivoted blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.7 AIR TURNING DEVICES

- A. Turning vanes shall be an engineered, true airfoil design with smoothly rounded entry nose and extended trailing edge for low pressure drop, anti-dirt, and positive fastening.
- B. Generated sound power level shall not exceed 54 decibels in band 4 at 2,000 FPM-duct 24 x 24.
- C. Acceptable manufacturers: Aero-dyne Sound Control Company, High Efficiency Profile, HEP.
- D. Fabricate assemblies with the Aero-Dyne Side Rail support system. Install vanes on design centers of 2.4 inches across the full diagonal dimension of the elbow. Tabbed or slotted dimple fasteners are not acceptable.
- E. Submittals are required.

2.8 EXTRACTORS

- A. Provide volume extractors where shown on the drawings. Extractors shall be gang operated parallel blades on one inch centers, and adjustable from side open to full closed. Unless otherwise noted, extractors shall be furnished with manual operators.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Sheet metal accessories to be installed in locations shown on drawings.
- B. Installation to be in accordance with manufacturer's published recommendations as well as applicable sections of the SMACNA manual.
- C. Provide all screws, bolts, nuts, inserts, and material required for attaching sheet metal to duct, walls, floors, and ceilings.
- D. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Use splitter dampers only where indicated.
- E. Provide fire dampers, and/or smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves,

breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

- F. Demonstrate proper operation and re-setting of all fire and fire/smoke dampers to authorities having jurisdiction and Owner's Representative. Maintain a record of acceptance test results.
- G. Fire and Fire/smoke damper installation shall not require any special equipment to access the dampers for inspection or testing. All dampers shall be readily accessible through an acoustical ceiling or access door. Dampers shall not be installed at a height that is not accessible via a ground mounted ladder. This shall be taken into account during the sheet metal coordination planning phase. Do not install dampers that require access or testing more than three feet above ceiling level.
- H. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- I. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment. Cover connections to medium and high pressure fans with leaded vinyl sheet, held in place with metal straps.
- J. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, and elsewhere as indicated.

3.2 TESTING

- A. Check work for satisfactory installation and performance.
- B. Ensure that adequate access does in fact exist for fire and smoke dampers and that damper operator motors are not hindered in operation by proximity to walls or other objects.
- C. Where applicable, check duct connections, access doors, etc. for leakage and condensation and correct conditions found.

END OF SECTION

SECTION 23-3613
VARIABLE/CONSTANT VOLUME BOXES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Variable volume air terminal units to be pressure independent, single duct, DDC control type.
- B. Air terminal unit airflow and sound performance ratings to be certified in accordance with ARI Standard 880.

1.2 ACCEPTABLE MANUFACTURER

- A. Trane Model VCWF, Price, Nailor, Titus, Environmental Technologies

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Terminal units to be pressure independent, to reset air volume within plus or minus 5% of reduced air flow (as determined by the space thermostat) regardless of changes in system air static duct pressure. Devices using CFM limiters are not acceptable.
- B. Internal resistance of terminal shall not exceed that scheduled on drawings when handling maximum cataloged air volumes.
- C. Maximum room N.C. - due to discharge or radiated sound - not to exceed 30 when terminals are either in throttled or full open position and inlet static pressure ranging from 0.3 to 1.5 " w.g. Sound ratings and measurements to be derived from sound power levels measured in accordance with ASHRAE Standard with reference level of 10-12 watts. Correction of noise excesses shall not constitute additional charges.
- D. Terminals to be complete with factory provided (installed) actuators and accessory controls suitable for electronic operation. Controls to be mounted in easily accessible enclosure, completely wired requiring only thermostat connection.

2.2 CONSTRUCTION

- A. The outer casing shall be constructed of 22-gage galvanized steel with slip and drive duct connections and hanger holes or brackets.
- B. Provide boxes with factory hanger brackets at each corner.

2.3 INSULATION

- A. 1" Double-wall Insulation—The interior surface of the unit casing shall be acoustically and thermally lined with a 1-inch, 1.0 lb./ft³ composite density glass fiber with high-density facing. The insulation R-value shall be a minimum of 3.8. The insulation shall be UL listed and shall meet NFPA-90A and UL 181 standards. The insulation shall be covered by an interior liner made of 26-gage galvanized steel. All wire penetrations are covered by grommets.

2.4 PRIMARY AIR VALVE

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- A. Air Valve Round—The primary air inlet connection shall be an 18-gage galvanized steel cylinder sized to fit standard round duct. A multiple-point, averaging flow sensing ring shall be provided with balancing taps for measuring +/-5% of unit cataloged airflow. An airflow-versus-pressure differential calibration chart shall be provided. The damper blade shall be constructed of a closed-cell foam seal that is mechanically locked between two 22-gage galvanized steel disks. At 4.0 in. w.g., the air valve leakage shall not exceed 1% of cataloged airflow.
- B. Air Valve Rectangular—The inlet collar shall be constructed of 22-gage galvanized steel sized to fit standard rectangular duct. An integral multiple-point, averaging flow-sensing ring shall provide primary airflow measurement within +/- 5% of unit cataloged airflow. The damper shall be constructed of 22-gage galvanized steel. At 3.0 in. w.g., the air valve leakage shall not exceed 6% of maximum airflow.

2.5 HOT WATER COILS

- A. Provide a 1 or 2 row hot water reheat coil as scheduled that is factory-installed on the discharge outlet. The coil shall have 144 aluminum-plated fins per foot and full fin collars for accurate fin spacing and maximum fin-tube contact. The 3/8" OD minimum seamless copper tubes shall be provided with headers, have a minimum wall thickness of 0.020" and be mechanically expanded into the fin collars. Coils shall be proof tested at 450 psig and leak tested at 300 psig air pressure.

2.6 CONTROLS

- A. Temperature control contractor to provide a unit mounted DDC controller to be installed in the factory. The unit shall be complete with a 120 volt to 24-volt transformer for Division 2 power connection in the field.
- B. All controllers are to automatically perform a self-calibration exercise daily.

PART 3 - EXECUTION

3.1 CALIBRATION

- A. Calibrate flow ring using calibrated flow hood to total supply outlets or by traversing the supply duct main on the discharge side of the box. All readings shall be taken by a NEBB or AABC balance contractor.

3.2 INSTALLATION

- A. Install terminal units where shown on drawings.
- B. Unit to be installed per manufacturer's published recommendations
- C. Do not provide manual volume dampers (MVDs) on singles supply air (SA) outlet terminal boxes and DO NOT INSTALL MVDs UPSTREAM OF ANY VAV TERMINALS.
- D. Do not use flexible duct on the medium pressure inlet to VAV or CV terminal boxes.
- E. VAV Terminal boxes shall be supplied with factory mounted hanger brackets for use with 3/8" all-thread hanger rod or 1-1/2" x1/8" galvanized strap (see detail).

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Support the terminal in this manner to allow for suitable maintenance and test access.

- F. Terminal boxes shall be supported / suspended from the building structure in a horizontal plane, such that access panels are not obstructed via support channels or straps. Access panels must be provided for any terminal box installed over a hard ceiling area, in order to facilitate access to all components.
- G. Duct-take-offs for VAV devices shall be bell-mouth type. The installing contractor shall maintain 4 duct diameters of straight duct at the entrance to all terminal boxes, and ensure that the final tie-in to the box is properly aligned so as not to restrict airflow into the box. Route the branch runout ductwork to the terminal box at one diameter larger duct size than the terminal box inlet, reducing the runout duct at the terminal box inlet. This should be done to maintain the free area of the inlet connection and prevent turbulence at the airflow sensor, so that the TAB agency's minimum / maximum airflow readings are both repeatable and not skewed by a false velocity reading at the sensor. The minimum and maximum terminal box airflows shall be initially set by the Controls contractor and then field tested, verified and / or adjusted by the TAB agency.
- H. Provide sufficient access to all terminal box controllers, to ensure that TAB agency can adjust controller to specified minimum and maximum airflows.

END OF SECTION

SECTION 23-3733
EXTRUDED ALUMINUM STATIONARY LOUVERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Extruded aluminum stationary louvers with drainable blades.

1.2 REFERENCES

- A. AAMA 605.2 - High Performance Organic Coatings on Architectural Extrusions and Panels.
- B. AMCA 500 - Test Methods for Louvers, Dampers and Shutters.
- C. AMCA 511 - Certified Ratings Program for Air Control Devices.

1.3 QUALITY ASSURANCE

- A. Louvers licensed to bear AMCA Certified Ratings Seal. Ratings based on tests and procedures performed in accordance with AMCA 511 and comply with AMCA Certified Ratings Program. AMCA Certified Ratings Seal applies to air performance and water penetration ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. Ruskin Manufacturing, Greenheck or equal.

2.2 EXTRUDED ALUMINUM STATIONARY LOUVERS

- A. Fabrication:
 - 1. Performance Ratings: AMCA licensed.
 - 2. Frame:
 - (a) Material: Extruded aluminum, Alloy 6063-T5.
 - (b) Wall Thickness: 0.125 inch, nominal.
 - (c) Depth: 4 inches.
 - (d) Downspouts and caulking surfaces.
 - 3. Blades:
 - (a) Style: Drainable.
 - (b) Material: Extruded aluminum, Alloy 6063-T5.
 - (c) Wall Thickness: 0.125 inch (3.2 mm), nominal.
 - (d) Angle: 37.5 degrees.
 - (e) Centers: 5-3/32 inches (129 mm), nominal.
 - 4. Bird Screen:
 - (a) Material: Aluminum, 3/4 inch x 0.051 inches, expanded, flattened.
 - (b) Frame: Removable, rewirable.
 - 5. Gutters: Drain gutter in head frame and each blade.
 - 6. Downspouts: Downspouts in jambs to drain water from louver for minimum water cascade from blade to blade.
 - 7. Vertical Supports: Hidden vertical supports to allow continuous line appearance up to 120 inches.

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8. Sill: Steeply angled integral sill eliminating areas of standing or trapped moisture where mold or mildew may thrive and effect indoor air quality.
9. Assembly: Factory assemble louver components. All welded construction.

B. Performance Data:

1. Based on testing 48 inch x 48 inch size unit in accordance with AMCA 500.
2. Free Area: 54 percent, nominal.
3. Free Area Size: see mechanical plans.
4. Maximum Recommended Air Flow Thru Free Area: 873 feet per minute.
5. Maximum Pressure Drop: 0.15 inches w.g.
6. Water Penetration: Maximum of 0.01 ounces per square foot of free area at an air flow of 873 feet per minute free area velocity when tested for 15 minutes.

2.3 ACCESSORIES

- A. Bird Screens
- B. Extended Sills: Extruded aluminum, Alloy 6063-T5. Minimum nominal wall thickness 0.060 inch (1.5 mm).

2.4 FACTORY FINISH

- A. Standard mill finish.
- B. Prime Coat:
 1. Apply alkyd prime coat following chemical cleaning and pretreatment.
 2. Primer preparation for field painting. Color specified by architect.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Inspect areas to receive louvers. Notify the Architect of conditions that would adversely affect the installation or subsequent utilization of the louvers. Do not proceed with installation until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install louvers at locations indicated on the drawings and in accordance with manufacturer's instructions.
- B. Install louvers plumb, level, in plane of wall, and in alignment with adjacent work.

3.3 CLEANING

- A. Clean louver surfaces in accordance with manufacturer's instructions.
- B. Repair minor damaged surfaces as directed by Architect.

END OF SECTION

SECTION 23-4113
AIR FILTERS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Provide and install a complete installation of panel filters and/or high efficiency final filters, in factory-fabricated housing equipped with appropriate draft gauge.
- B. **In this section, the term “final” when applied to a filter bank, shall mean downstream of all wet air cooling coils and the supply fan.**

1.2 QUALITY ASSURANCE

- A. Filters must meet NFPA 90A requirements for flammability.

1.3 ACCEPTABLE MANUFACTURERS

- A. Camfil Farr
- B. American Air Filter
- C. Approved Equal

PART 2 - PRODUCTS

2.1 ONE-INCH THICK, DISPOSABLE, MERV-6 FILTERS

- A. Air filters shall be medium-efficiency ASHRAE pleated panels consisting of cotton and synthetic media, media support grid, and enclosing frame.
- B. Filter media shall be a cotton and synthetic blend, lofted to a uniform depth of 0.15” and formed into a uniform radial pleat.
- C. A welded wire grid, spot-welded on one-inch centers and treated for corrosion resistance, shall be bonded to the downstream side of the media to maintain the radial pleat and prevent media oscillation.
- D. An enclosing frame of no less than 28-point high wet-strength beverage board shall provide a rigid and durable enclosure. The frame shall be bonded to the media to prevent air bypass and include integral diagonal support members on the air entering and air exiting side to maintain uniform pleat spacing in varying airflows.
- E. The filter shall have an average dust spot efficiency of 20% when evaluated under ASHRAE Standard 52.1-1992. It shall have a minimum arrestance of 85% when tested under the same Standard.
- F. Initial resistance to airflow shall not exceed 0.26” w.g. at an airflow of 500 fpm.
- G. The filter shall be rated by Underwriters Laboratories as UL Class 2.

2.2 TWO-INCH THICK, DISPOSABLE, MERV-8 FILTERS

- A. Air filters shall be UL Class 1, medium efficiency, ASHRAE pleated panels consisting of microfiber glass media, all-glass closed-mesh backing, media support grid and enclosing frame.
- B. Filter media shall be microfiber glass laminated to an all-glass mesh backing and formed into uniform radial pleats.

- C. A welded wire grid, spot-welded on one-inch centers and treated for corrosion resistance, shall be bonded to the downstream side of the media to maintain the radial pleat and prevent media oscillation.
- D. An enclosing frame of non-flammable board shall provide a rigid and durable enclosure. The frame shall be bonded to the media to prevent air bypass, and include integral diagonal support members on the air entering and air exiting side to maintain uniform pleat spacing in varying airflows.
- E. The filter shall have a Minimum Efficiency Reporting Value of MERV 8 when evaluated under the guidelines of ASHRAE Standard 52.2-1999. It shall have an average dust spot efficiency of 25-30% when evaluated under ASHRAE Standard 52.1-1992.
- F. Initial resistance to airflow shall not exceed 0.38" w.g. at an airflow of 500 fpm.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide filters in locations as shown on drawings of sizes and capacities as scheduled.
- B. Install filters in accordance with manufacturer's published installation instructions.
- C. Filters shall be installed in frames or apparatus casing so as to be leak free. Verify with light test from both sides.
- D. Protect cooling and/or heating coils with media during construction.
- E. Deliver one complete change of media to the Owner.
- F. Provide insulation as required on filter housing to ensure elimination of sweating.

END OF SECTION

SECTION 23-8126
SPLIT SYSTEM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Provide unit sizes scheduled and in locations as shown on drawings and as specified herein.

1.2 SYSTEM DESCRIPTION

- A. The system shall be a direct expansion type as scheduled. Air moving and coil capacity and unit arrangement shall be as shown on drawings. Indoor and outdoor units shall be factory assembled, internally wired and shipped in one piece and shall meet existing regulatory noise standards.

1.3 QUALITY ASSURANCE

- A. Provide unit consisting of UL listed components, factory tested to conform to ASHRAE and ARI standards.

1.4 ACCEPTABLE MANUFACTURERS

- A. Trane
- B. Carrier
- C. Approved equal

PART 2 - PRODUCTS

2.1 SPLIT SYSTEM HEAT PUMP (5 TON CAPACITY AND UNDER)

- A. Indoor Unit
 1. Casing shall be fabricated of heavy gauge steel, reinforced and braced for maximum rigidity. Casings and all accessories, with exception of coil, shall be given a protective enamel finish. All metal parts of units chemically cleaned, phosphatized and coated with baked enamel finish.
 2. Refrigerant system shall be designed and tested for R-410A and shall contain sufficient charge for a complete operable system. Provide thermal expansion valve to meter flow of refrigerant through evaporator coil.
 3. Indoor fan shall be forward curved with double inlet, mounted on motor shaft, dynamically and statically balanced. The 3-speed fan shall be factory lubricated, have internal overload protection, and be resiliently mounted to minimize vibration. Fan-motor assembly shall be easily removable for service. Fan drive shall be directly driven. Motor shall be permanent split capacitor type designed for quiet operation.
 4. Fan coil unit shall be equipped with DX coil constructed of aluminum fins mechanically bonded to copper tubes. Coil shall be hydrostatically tested to 425 psig.
 5. Filter rack shall be reversible with duct connection flanges and be equipped with 1-inch fiberglass throwaway type filter.
 6. Drain pan shall be provided under the complete fan and coil section. Drain pans shall have drain connections on both sides and are completely insulated with a minimum of 1/2 inch seamless cellular, spray-in-place insulation.

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7. Removable panels in fan and coil sections shall provide access to all internal parts adequate for lubrication and maintenance. Coils shall be removable through access panels. All hanger or bolt holes in unit casing to be pre-punched at factory. Coil and fan sections to have minimum 1-1/2 pound density fiberglass insulation secured with waterproof adhesive and permanent fasteners. All insulation shall meet NFPA 90A flame spread and smoke generation standards.
- B. Outdoor Unit
1. Unit casing shall be constructed of heavy gauge, galvanized steel and painted with weather-resistant powder paint.
 2. Compressor shall be of welded-hermetic type with internal vibration isolation and be covered with a shield to muffle operating sound. Compressor shall have both thermal and current sensitive overload devices and starting capacitors where required. Compressor shall carry a 5-year warranty. Provide crankcase heaters.
 3. Fan shall be aluminum propeller-type, direct-driven, and arranged for vertical discharge with permanently lubricated fan motor having thermal overload protection. Fan motor shall be factory lubricated, weather protected, and resiliently mounted.
 4. Condenser coil shall have copper tubes and aluminum fins, or aluminum tubes and aluminum fins.
 5. Provide evaporator defrost control and TXV for operation down to 30 degrees F.
 6. Head Pressure Safety Switch-Provide a high head pressure switch to shut the unit down on loss of condensing unit fan or similar issue.
- C. Controls
1. All controls shall be factory pre-wired and located in a readily accessible location on unit for service. Control wiring terminal board shall be designed to match indoor unit and thermostat. Controls shall include manufacturer's thermostat and sub base. Low voltage pig tails, fan contactor, and plug-in module for electric heat control shall be included.
 2. Programmable Electronic Night Setback Thermostat – Provide a fully programmable 7-day electronic thermostat that shall allow heating and cooling setback operation.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install equipment in accordance with manufacturer's instructions, as by drawings, in locations shown on drawings.
- B. Coordinate electrical connections with Electrical Contractor.
- C. Coordinate controls with Control Contractor.
- D. Charge system and place in operational condition.

3.2 START-UP AND TEST

- A. Start-up unit, test for proper operation and capacity, check for proper control operation.

END OF SECTION

SECTION 23-8216
HEATING COILS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Hot Water Coils.

1.2 CERTIFICATION

- A. Certify coil capacities, pressure drops, and selection procedures in accordance with ARI Standard 410.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS: Coils shall be the product of manufacturer regularly engaged in production of coils and issues complete catalog data on such products.

2.2 HOT WATER COILS

- A. Design for minimum 200 psig at 220 degrees F.
- B. The coil shall be of extended surface, staggered tube, rippled plate fin type.
- C. The coil shall be round seamless 5/8" O.D. or 1/2" O.D. copper tube staggered in the direction of airflow.
- D. Tubes shall be on 1-1/2" or 3" centers. High pressure coils shall have cupro-nickel tubes and headers.
- E. Tube fins shall consist of rippled aluminum plate for higher capacity and structural strength. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Bare copper tube shall not be visible between fins. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates.
- F. Casings shall be constructed of continuous galvanized steel with 3/8" diameter bolt holes for mounting on 6" centers. Coil side plates shall be of reinforced flange type for greater strength and ease of stacking coils in banks.
- G. All coils over 45" fin length shall be furnished with four fin angles to properly position the coil core.
- H. Headers shall be seamless copper tubing. The headers shall have intruded tube holes to provide large brazing surface for maximum strength and inherent flexibility. Coils shall be tested with 315 pounds air under water and be suitable for operation at 250 psig and 300° F. High pressure coils shall be suitable for operation up to 400 psig and 400°F.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Mount coil in accordance with SMACNA standards including a maximum transition angle of 30 degrees on the entering air side of coil and 45 degrees on

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leaving air side. Transitions on both entering and leaving side to be 20 degrees if space permits. Provide air-tight seal between coil and duct or unit casing.

- B. Provide access door on entering air side of coil for cleaning and inspection purposes.
- C. See drawings for required piping connections to hot water coils.
- D. Externally insulate coil casing including return bends with 1" thick, blanket-type fiberglass insulation to prevent condensation.
- E. Hot water reheat coils required for variable volume boxes to be furnished factory mounted to boxes by terminal box manufacturer.

END OF SECTION