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Project Manual

Houston Methodist West Hospital

Phase IIB Backfill Renovation

ISSUE FOR CONSTRUCTION

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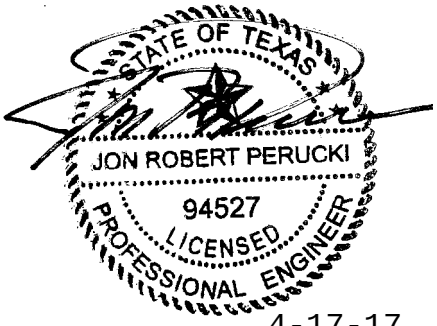

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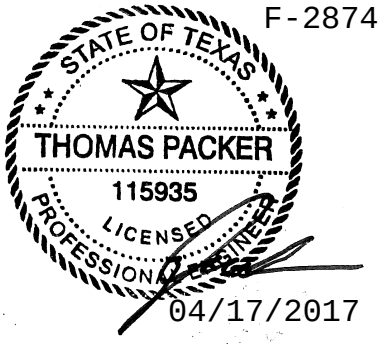

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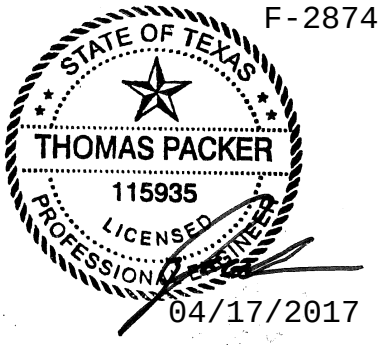

SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Common work results for requirements specifically applicable to Division 23.

B. Requirements of Division 01 Specifications, General Provisions of the Contract and General and Supplementary Conditions apply to this Division.

1.2 REGULATORY REQUIREMENTS

A. Perform Work specified in Division 23 in accordance with standards listed below of the latest applicable edition adopted by the authority having jurisdiction. Where these Specifications are more stringent, they shall take precedence. In case of conflict, obtain a decision from the Architect.
1. NFPA 70: National Electrical Code
2. NFPA 72: National Fire Alarm and Signaling Code
3. NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems
4. NFPA 90B: Standard for the Installation of Warm Air Heating and Air Conditioning Systems
5. NFPA 92A: Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences
6. NFPA 101: Life Safety Code
7. NFPA 101A: Guide on Alternative Approaches to Life Safety
8. NFPA 101B: Standard on Means of Egress for Buildings and Structures
9. NFPA 105: Standard for the Installation of Smoke Control Door Assemblies and Other Opening Protectives
10. NFPA 241: Standard for Safeguarding Building Construction, Alterations, and Demolition Operations
11. NFPA 5000: Building Construction and Safety Code
12. ANSI A17.1: Elevators, Dumbwaiters, Escalators and Moving Walks
13. ANSI Handicapped Code-A117.1
14. ASTM E814-08B: Standard Test Method for Fire Tests Penetration Firestop Systems.
15. U.L. Fire Resistance Index.
16. All applicable Occupational Safety and Health Administration (OSHA) Publications, Rules and Regulations.
17. Americans with Disabilities Act (ADA)
18. Texas Department of State Health Services, Hospital Licensing Regulations
19. Special regulations, supplement, and amendments of the State and/or local authorities having jurisdiction.

1.3 REFERENCE STANDARDS

A. AGA: American Gas Association.

B. ANSI: American National Standards Institute.

C. ARI: American Refrigeration Institute.

D. ASHRAE: American Society of Heating Refrigeration and Air Conditioning Engineers.

E. ASME: American Society for Mechanical Engineers.

F. ASTM: American Society for Testing and Materials.

G. AWWA: American Water Works Association.

H. FM: Factory Mutual

I. IRI: Industrial Risk Insurers

J. MSS: Manufacturer's Standardization Society of the Valve and Fitting Industry.

K. NEMA: National Electrical Manufacturers' Association.

L. NFPA: National Fire Protection Association.

M. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

N. UL: Underwriters' Laboratories, Inc.

O. U.L. Fire Resistance Index

1.4 SUBMITTALS

A. Submit under provisions of Division 01.

B. Incomplete submittals containing unmarked cutsheets or not providing specific detail of what is being proposed will be rejected and will not be reviewed.

C. Include Products as specified in the individual sections of Division 23.

D. Submit shop drawing and product data grouped to include complete submittals of related systems, products, and accessories in a single submittal.

E. Prepare shop drawings completely independent of the Engineer of Record's CADD files or Revit model. Should the Contractor or Vendor wish to use the Engineer of Record's CADD files or Revit model as the basis for developing their shop drawings, a release form, obtainable from the Engineer or Architect, must be signed. A nominal charge of $50.00 per sheet must be made payable to the engineering firm to cover the cost of preparing the drawings for use by others.

F. Submit copies of shop drawings in accordance with Division 01, including:
   1. Building Automation System including direct digital control drawings.
   2. Concrete pads and foundations including anchor bolt and sleeve locations.
   3. Prepare and submit coordination drawings as specified herein. Facilitate the coordination effort with all other trades, specifically Divisions 21, 22, 26 and 28 and shall include:
      a. Central Plant
      b. Boiler Room
      c. Chiller Room
      d. Electric Switchgear Rooms
      e. Arena Bowl Mechanical Rooms
      f. Mechanical Rooms
      g. Fire Pump Room
      h. Coordinated room layouts shall include:
         1) Room dimensions.
         2) Support column locations.
         3) Locations and dimensions of equipment foundations and pads required.

4) Locations and dimension of equipment and apparatus, including electrical control panels and starters, and service and coil pull areas.
5) Dimensioned floor drain locations.
6) Locations of wall mounted equipment.
7) Trench locations and sizes.
8) Sleeve locations in mechanical rooms and equipment rooms.
9) AHU (fan) and duct layouts in AHU equipment rooms.
10) Piping 3" and larger.
11) Conduit 3" and larger.

4. Roof layouts including:
   a. Air Intakes.
   b. Vents.
   c. Boiler Stacks.
   d. Vacuum Pump discharge.
   e. Clinical Air Compressor Intake.
   f. Exposed ductwork.
   g. Roof mounted equipment.

G. Brochures: Submit manufacturer's product data and brochures including:
   1. Complete descriptions.
   2. Illustrations.
   3. Rating data, accessories, dimensional data, and applicable options and features marked for the specific items scheduled on drawings and specified herein.
   4. Capacities stated in the terms specified.
   5. Performance curves for all air handling units, fans, and pumps.

1.5 FIELD CONDITIONS

A. Layouts indicated on drawings are diagrammatic and intended to show relative positions and arrangement of equipment, ductwork and piping. Coordinate mechanical work with other trades and measurements obtained at the job site, as applicable, prior to installation. Generally, install work in locations shown on Drawings, using as necessary rises, drops, offsets, transitions, and alternate routings to fit in the available space unless prevented by Project conditions.

B. If prevented by project conditions, prepare drawings showing proposed rearrangement of Work, including changes to Work specified in other sections. Obtain permission of Architect before proceeding.

C. Place anchors, sleeves, and supports prior to pouring concrete or installation of masonry work.

D. Cause as little interference or interruption of existing utilities and services as possible. Schedule work which will cause interference or interruption in advance with Owner, authorities having jurisdiction, and all affected trades.

E. Determine sizes and verify locations of existing utilities on or near site.

F. Keep roads clear of materials and debris.

G. Visit site and be informed of conditions under which Work must be performed.

H. Locate equipment requiring periodic servicing so that it is readily accessible. Provide means of service access, following appropriate manufacturer's recommended service clearance space or, as applicable, means of access using duct, wall, or ceiling access doors.

I. Install ductwork and piping to leave sufficient space for AHJ inspection of wall construction.

1.6 FEES AND PERMITS

A. Obtain and pay for all necessary permits and inspection fees required to perform Division 23 work.

1.7 COORDINATION DRAWINGS

A. Prior to commencement of installation, prepare coordination drawings for work under this division, as specified in Division 01, in full cooperation with persons performing work under other Divisions, including but not limited to mechanical, electrical, plumbing, fire protection, telecommunications, audio/visual and miscellaneous steel.

B. Drawings shall not be formally submitted but shall be kept on site for reference. Notify Architect and Construction Manager of conflicts that cannot be resolved.

C. Coordination Drawings shall be prepared to include the following:
1. Drawn to a scale of 1/4" = 1'-0".
2. Room dimensions.
3. Sheet size matching contract documents.
4. Duct sizes with bottom elevation from finished floor.
5. Show equipment, columns, and beams.
6. Duct fitting details.
7. Construction details of plenums and casings.
8. Concrete pad and foundation layouts including anchor bolt and sleeve locations.
9. Dimensioned floor drain locations.
10. Wall mounted equipment.
11. Piping 3" and larger, with elevations from finished floor to bottom of pipe.
12. Space allocation for conduits and cable trays.
13. Ceiling height.
14. Ductwork, air terminal units, and piping 3" and larger shall be shown in proper graphic scale.
15. Clearance requirements for control panels, inspections, and maintenance.
16. Coordination drawings are to indicate air terminal units, fan coil units, air handling units, control panels, and all other devices and materials to proper scale.

1.8 COMPLETENESS OF WORK

A. The Contract Documents depict HVAC systems which are intended to be complete and functioning systems. All products, materials, and labor necessary to render a fully functional system to fulfill the design intent shown on the documents shall be provided by the Contractor.

B. Catalog numbers referenced throughout the Division 23 Drawings and Specifications are intended to convey a general understanding of the type and quality of the product required. Where written descriptions differ from information conveyed by a catalog number, the written description shall govern. No extra shall be allowed because a catalog number is found to be incomplete or obsolete.

1.9 PRODUCT SUBSTITUTIONS

A. Comply with provisions of Division 01.

1.10 RECORD DRAWINGS

A. Provide record drawings that illustrate the work of Division 23 as finally constructed. Deliver record drawings to the Architect in a form suitable for reproduction.

B. Provide record drawings that illustrate the work of Division 23 as finally constructed. Deliver record drawings to the Architect electronic format and also three (3) copies marked in red ink to reflect work as constructed.

C. Record drawings shall reflect all changes made to the Contract Documents, whether generated by addenda, change orders, or field conditions. Maintain a daily record of these changes and keep current set of drawings showing these changes.

D. Deliver record drawings to Architect within 30 days of Substantial Completion.

E. Record drawings are to indicate air terminal units, fan coil units, air handling units, fans, control panels, and all other devices and materials to proper scale.

1.11 OWNING AND OPERATING MANUALS

A. Comply with the requirements of Division 01, but provide a minimum of three hard copy sets and an electronic copy.

B. Manuals shall include clear and comprehensive instructions with appropriate graphics and project specific marked data to enable owner to operate and maintain all systems specified in this Division.

C. Copies of final reviewed submittals indicating all model numbers, serial numbers, cut sheets, and all performance criteria on furnished equipment shall be included.

PART 2 - PRODUCTS

2.1 EQUIPMENT SUPPORTS

A. Structural Steel for Supports: ASTM A36.
1. Use galvanized members installed in fan plenums or areas of high humidity or condensation, and outside. All fasteners shall be stainless steel. Any damage caused by cutting, drilling, or welding or any other means to galvanized surface must be repaired by apply two coats of cold-galvanizing.
2. Use hot dipped galvanized members installed in fan plenums or areas of high humidity or condensation, in tunnels and outside. All fasteners shall be stainless steel. Any damage caused by cutting, drilling, or welding or any other means to galvanized surface must be repaired by applying two coats of cold-galvanizing.
3. Furnish other members with shop coat of primer.
4. Retouch primer after field welding.

2.2 FLASHINGS AND COUNTERFLASHINGS

A. Furnish materials and coordinate installation for flashing and counterflashing roof penetrations for ductwork and piping.

B. Materials:
1. Sheetmetal: 24 gauge minimum ASTM A525, Class G90.
2. Sheet lead: 3 pounds per square foot.
3. Stainless steel: Minimum 20 gauge.

4. Sheet copper: 24 OZ/SF.

2.3 WALL AND CEILING ACCESS PANELS

A. Style and type as required for material in which installed.

B. Size: 24"x24" minimum, as indicated, or as required to allow inspection, service and removal of items served.

C. 14 gauge minimum sheet metal for doors, 16 gauge frames of cadmium-plated or galvanized construction. Doors shall have expanded plaster rings where located in plaster walls or flanged finish where located in drywall or block construction.

D. Panels shall have spring hinges with screwdriver locks in non-public areas. Key lock, keyed alike, for panels in public areas.

E. Prime painted or rust inhibitive paint finish.

F. UL labeled when in fire-rated construction, 1-1/2 hour rating.

G. Provide in walls, floors, and ceilings to permit access to all equipment and piping requiring service or adjustment. Examples of such equipment needing access are fire and/or smoke dampers, mechanical system valves, and equipment needing periodic or replacement maintenance.

H. Furnish and locate access panels under this Division. Coordinate with trades who are responsible for building system in which panels are to be installed.

I. Acceptable manufactures: Milcor, Nystrom, Karp, J.L. Industries, or Williams Brothers.
1. For masonry and drywall construction: Milcor Style M.
2. For plastered masonry walls and ceiling: Milcor Style K.
3. For ceramic tile or glazed structural tile: Use stainless steel panels.

2.4 PIPE ENCLOSURES

A. For exposed vertical piping in kitchen: 18 gauge stainless steel (Type 302) with No. 4 finish.
1. Extend from 2" above ceiling to equipment or island partition.
2. Size covers to contain number of pipes served.

B. Minimize number of covers by enclosing maximum number of pipes in each drop.

C. Anchor to equipment or partition.

D. Fasten seams and joints with stainless steel pop rivets.

E. Provide 1-1/2" ceiling flange as closure.

2.5 SLEEVES

A. Materials:
1. Concrete floors, concrete and masonry walls: 18 gauge galvanized steel sheetmetal or Schedule 10 galvanized steel pipe.
2. Drywall partitions: 18 gauge galvanized steel sheetmetal or Schedule 10 galvanized steel pipe.

B. Sleeves shall be sized such that the annular space between outside surface of pipe or pipe insulation and the inside surface of the sleeve is not less than 1/2". Provide larger annular space if required by firestopping product installation instructions.

C. Sleeves supporting riser piping 4" and larger shall have three 6" long reinforcing rods welded radially at 120 degree spacing to the sleeve and shall be installed with the rods embedded in the concrete slab.

2.6 ESCUTCHEON PLATES

A. Provide B & C No. 10 or equal chrome plated escutcheon plates where pipes penetrate partitions or ceilings in finished areas.

PART 3 - EXECUTION

3.1 CUTTING AND PATCHING

A. Repair or replace damage caused by cutting or installation of work specified in Division 23.

B. Perform repairs with materials which match existing and install in accordance with the appropriate section of these specifications.

3.2 FLASHING AND COUNTERFLASHING

A. Counterflash ducts and pipes where penetration of roofs and outside walls occur.

3.3 CONNECTION TO EQUIPMENT FURNISHED BY OWNER

A. Connect and/or install equipment shown on mechanical drawings that requires mechanical connections.

B. Provide piping, isolation valves, unions, and other piping appurtenances required for a complete installation.

C. Provide steam strainers, steam traps, and pressure reducing valves in steam lines.

3.4 DELIVERY, STORAGE, AND PROTECTION

A. Insofar as possible, deliver items in manufacturer's original unopened packaging. Where deliver in original packaging is not practical, provide cover and shielding for all items with protective materials to keep them from being damaged. Use care in loading, transporting, unloading, and storing to keep items from being damaged.

B. Store items in a clean, dry place, and protect from damage. Mechanical equipment may not be staged or stored outdoors unless intended for outdoor use.

C. Protect nameplates on motors, pumps, and similar equipment. Do not paint or insulate over nameplate data.

D. Protect valves and piping from damage. Cover equipment during work of finishing trades.

E. Keep dirt and debris out of pipes and ducts.

F. Repair, restore, and replace damaged items.

G. Cover factory finished equipment during work of finished trades, such as fan coils, fin tubes, etc.

H. Protect cooling and/or heating coils with temporary filter media during construction.

3.5 SLEEVES

A. Floors: Sleeve all pipe penetrations. Extend sleeve 1-1/2" above finished floor, except piping within pipe chases. Sleeve shall be flush with underside of floor.

B. Masonry or concrete walls: Sleeve all pipe penetrations. Sleeves shall be flush on both sides of wall.

C. Drywall partitions: Sleeve all penetrations of piping in systems over 160 degree F.

D. Seal voids between outside surface of sleeve and wall, partition or floor. Seals shall be airtight.

E. Install piping, insulation and sleeves in strict accordance with applicable U.L. floor or partition assembly instructions. Coordinate with Division 07 Firestop manufacturer's installation instructions.

F. Clearance between sleeve and pipe: Minimum of 1/2 inch for hot piping and 1 inch for cold piping or as otherwise dictated by U.L. Fire Resistance Directory.

G. Penetrations not Sleeved or Firestopped:
1. Seal voids between pipe and partition. Seals shall be airtight.

3.6 ESCUTCHEON PLATES

A. Provide chromium plated escutcheon plates for exposed uninsulated pipes projecting through floors or walls in "finished" spaces. Mechanical rooms, store rooms, electric closets, and janitor closets are not considered "finished" spaces.

3.7 EQUIPMENT GUARDS

A. Use suitable structural frames with minimum 12 gauge, 3/4" galvanized mesh, or expanded metal mesh. Attach to equipment by removable clips and bolts with wing nuts, or other approved connectors.

B. At belts, provide opening for measuring RPM.

C. Provide at all belts, couplings, moving machinery and equipment.

D. Design for easy access to belts and other items requiring replacement.

E. Comply with OSHA Regulations.

3.8 CLEANING HVAC SYSTEMS

A. General Cleanup:
1. Upon completion of contract and progressively as work proceeds, clean up dirt, debris, old materials, etc., and remove from site, keeping premises in neat and clean condition to satisfaction of the Architect. See Division 01 of specifications for further requirements.
2. Seepage, discoloration or other damage to parts of the building, its finish, or furnishings due to Contractor's failure to properly clean piping systems or duct systems shall be repaired without cost to the Owner.

B. Factory Finishes:
1. Clean items with factory finishes. Touch up bare places, scratches and other minor damage to finishes. Use only factory supplied paint of matching color and formula. If

finishes are badly damaged or if there are many damaged, scratched or bare places, refinish the entire item.

C. Ducts and Apparatus:
   1. Thoroughly clean ducts and apparatus casings before fans and filters are operated.

D. HVAC Closed and Open Water Systems:
   1. Initial flushing:
      a. Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system components.
      b. Bypass factory equipment unless acceptable means of protection are provided, or by subsequent inspection of water boxes and other "hide-out" areas takes place.
      c. Isolate or protect "clean" system components including pumps and pressure vessels and any component that may be damaged.
      d. Open all valves, drains, vents, strainers, and the like at all system levels. Close all valves isolating piping from the existing central piping systems.
      e. Remove plugs, caps, spool pieces, and components to facilitate early discharge from the system.
      f. Sectionalized system to obtain debris carrying velocity of six feet per second.
      g. Connect dead end supply and return headers and the like as necessary, or provide drains in dead end eccentric caps.
      h. Install temporary strainers where necessary to protect downstream equipment.
      i. Supply and drain-off "flushing" water by fire hoses, garden hoses, temporary or permanent piping, Contractor's booster pumps, and the like.
      j. Flush for not less than four hours. Drain all dirt legs. If water drained is not visibly clean, repeat the above procedure until dirt legs are visibly clean.
      k. Before starting the cleaning and flushing process, confirm a thermometer has been installed on the system. During flushing and cleaning process, monitor the water temperature to ensure the water temperature does not become too hot.
   2. Cleaning (Closed Systems Only):
      a. Utilize defoamers to preclude damage to existing work, and specifically adjacent electrical equipment.
      b. Utilize heat to maximize effectiveness of compounds or use live steam injection where practical and safe. Do not raise cleaning water temperature in excess of 150 degrees F. Install a thermometer in the piping system and constantly monitor the water during cleaning to prevent over-heating.
      c. Install temporary strainers, reinforced against blowout, sized to not impair equipment performance, to preclude passing of particles larger than 60% of smallest radial and at a minimum to retain all particles larger than 1000 microns.
      d. Permanent facility pumps shall not be used for circulating cleaning water. Contractor shall supply temporary pumps for this process.
         1) If the system construction, flow rates, and pressures are such that it is impractical for the Contractor to provide temporary pumps, the permanent facility pumps may be used with the specific express permission of the Owner, provided the guarantee on the entire pump assembly is unconditionally extended for two years after date of Substantial Completion. Leakage from pump seals or other damage resulting from circulating the uncleaned water shall require immediate rectification at no additional cost to the Owner.
      e. Add 20 pounds of Garratt Callahan Formula 248, or equal, alkaline cleaner for each 1000 gallons of system water for chemical cleaning (approximate .2%

solution). Formula 248 is a dry blend of buffered phosphates, a corrosion inhibitor, a surfactant, and an iron oxide sequestrant.

f. Circulate for a period of at least 72 hours.

g. Every eight hours, blow-down the condensers and system low points for three minutes.

h. Drain and flush the system. Rapid flushing from the lowest point in the system is needed to remove debris.

i. Inspect the system and repeat first four steps.

j. Begin the corrosion control program immediately at double the normal inhibitor dosage for one week. After one week, drop to the normal dosage.

k. Chemical treatment compound: Use Garratt Callahan Company Formula 12-L closed system inhibitor strictly following manufacturer's directions.

3.9 OPERATION OF HVAC SYSTEMS DURING CONSTRUCTION

A. Install all specified filters prior to system operation. In addition to specified filters, install a roughing filter upstream of mixed air filter. Roughing filter shall consist of two layers of roll filter media clipped and sealed to entering side of filter frame. Change roughing filter as necessary to minimize dust collection on specified filters.

B. Cover return and exhaust air grilles with temporary filter media. Attach media to avoid damage to grille or ceiling. Change temporary media as required to protect against dust buildup on ductwork. Remove temporary media from grilles after flooring is installed, walls are sanded and painted and other dust generating construction has been completed.

C. During periods of excessive dust generation such as drywall sanding, seal off return and exhaust openings and grilles to prevent dust from accumulating in ductwork.

D. If outside air source contains less dust than building air, adjust A/C unit dampers to operate with as much outside air as possible without causing a freezing condition for coil or exceeding capacity of coil to adequately condition supply air.

E. Furnish and install a new set of specified filter media prior to start of system test and balance. Furnish a new, clean set of the specified media and turn over to Owner's Representative.

3.10 TESTING MECHANICAL SYSTEMS

A. Test all systems and equipment installed to demonstrate proper operation.

B. Advise Architect of scheduled systems testing and completed system demonstration/operation schedules so that he may witness, if desired.

C. Correct and retest work found defective when tested.

D. Make repairs to piping systems with new materials. Peening, doping, or caulking of joints or holes will not be acceptable.

E. HVAC Circulating Water Piping: Hydrostatically test piping at 150 psig pressure or at 1-1/2 times design pressure as indicated on drawings, whichever is greater, for a period of six hours without evidence of leaking.

F. Ductwork Pressure Testing: Refer to Section 23 31 13 for required pressure testing for ductwork.

G. Chemical Water Treatment Systems: Have equipment manufacturer field check installations of boiler water treatment systems, and cooling tower water treatment systems, including field

calibration of pumps, controllers and other operable parts. Chemical water treatment for HVAC including cleaning, testing, and treatment shall be performed in accordance with Section 23 25 00.

H. System Balance and Testing: Prepare to assist test and balance firm by assuring systems are complete and operational.

I. Test all smoke and combination fire/smoke, dampers by observing damper operation during fire alarm system commissioning.

J. Records of Testing: Maintain records of system testing and results thereof. Deliver results as part of project closing file and on an intermediate basis as requested by Architect.

3.11 INFECTION CONTROL REQUIREMENTS

A. Coordinate with the Owner the exact requirements for the infection control measures to be executed and performed during the course of this Project.

B. Prior to execution, present to the Owner for approval a written execution plan for each infection control measure.

C. Coordinate infection control measures as needed with all other trades and disciplines.

D. Provide documentation of infection control measures to the Owner, as required and specified in the ICRA.

END OF SECTION 23 05 00

SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Single phase electric motors.

B. Three phase electric motors.

1.2 RELATED REQUIREMENTS

A. Section 26 27 17 - Equipment Wiring

1.3 REFERENCE STANDARDS

A. Each motor, controller and all components shall be designed, manufactured and tested in accordance with the folling applicable standards:
1. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015.
2. IEEE 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators; 2004.
3. IEEE Standard 112, Test Method "B"; 1996.
4. IEEE Standard 444 (ANSI C34.3); 1992.
5. IEEE Standard 519; 1992.
6. NEMA MG 1 - Motors and Generators; 2014.
7. NEMA MG1, Part 31 - Definite Purpose, Inverter Fed Motors; 2012.
8. NEMA - ICS-3-303
9. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
10. Energy Policy Act of 1992

B. All equipment and material to be furnished and installed on this Project shall be UL or ETL listed, in accordance with the requirements of the authorities having jurisdiction, and suitable for it's intended use on this Project.

1.4 SUBMITTALS

A. See Division 01 for submittal procedures.

B. Submit motor information with submittals and shop drawings for Division 23 equipment.

C. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.

D. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than 1/2 horsepower.

E. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.

F. Operation Data: Include instructions for safe operating procedures.

G. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.5 QUALITY ASSURANCE

A. Conform to NFPA 70.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.7 WARRANTY

A. See Division 01 for additional warranty requirements.

B. Provide two year manufacturer warranty from the date of substantial completion for motors smaller than 20 horserpower.

C. Provide five year manufacturer warranty from the date of substantial completion for motors 20 horsepower and larger.

PART 2 PRODUCTS

2.1 ACCEPTABLE **MANUFACTURERS**

A. Baldor, General Electric, Gould, Lincoln, MagneTek/Century, Marathon, Reliance, Siemens, Toshiba, U.S. Motors, and Westinghouse.

B. Substitutions: Refer to Division 01.

2.2 GENERAL CONSTRUCTION AND REQUIREMENTS

A. Electrical Service:
1. Motors 1/2 HP and smaller: 115 volts, single phase, 60 Hz.
2. Motors larger than 1/2 Horsepower: 460 volts, three phase, 60 Hz.

B. Windings and Insulation:
1. All motors shall have copper windings.
2. Motors shall be equipped with Class B, 80 deg. C rise or Class F, 105 deg. C rise insulation suitable for use in a 40 deg. C ambient temperature.
3. Motors used for cooling tower applications shall be equipped with Class F, 105 deg. C insulation suitable for use in a 40 deg. C ambient temperature. Windings shall be treated with an epoxy varnish to inhibit the moisture absorption.

C. Bearings:
1. Single phase, fractional horsepower motors shall be equipped with quiet operating, all angle babbitt lined sleeve bearings.
2. Polyphase motors shall be equipped with deep groove type ball bearings, generously sized for the loads to which applied and for severe duty application. Provide the necessary seals on the shaft to keep the bearing system free of contamination and moisture. Lubricant shall be high temperature, nonbleeding grease.
   a. Provide inlet and outlet plugs on poly phase motors so that grease fittings can be easily inserted for bearing lubrication except as otherwise specified. The end

shields shall be carefully machined to add extra grease capacity. Lower outlet plugs shall be equipped with combination breather/drains on TEFC and TEAO motors.

D. Motors on belt driven equipment shall have slide rails with adjusting screws for belt tension adjustment.

E. Motors specified with variable frequency motor controllers shall comply with NEMA MG1, Part 31 for Definite Purpose, Inverter Fed motors including insulation meeting the requirement for 1600 Vpk at 0.1 uS rise time. In addition to compliance with MG1, Part 31, motors also shall be designed for starting across the line and specifically designed to reduce inrush current.
   1. To protect motor bearings and shafts from damage due to induced electrical currents along the motor shaft, provide Aegis shaft grounding ring (SGR), conductive microfiber motor shaft grounding ring on the driven end of all inverter fed motors. For inverter fed motors 100 HP and larger, also provide either an insulated motor bearing or a ceramic bearing on non-driven end of motor. Comply with manufacturer's installation instructions and with NEMA MG1, Part 31 for inverter fed motor bearings.

F. Sound power levels shall not be greater than recommended in NEMA M61-12.49. Inverter duty rated motors shall not increase by more than 3 dB when operating on a variable frequency motor controller.

G. Provide motors with drive shafts long enough to extend completely through belt sheaves when sheaves are properly aligned and balanced.

H. Motors exposed to the weather shall be weather protected.

I. Install premium efficiency electric motors for motors 1 horsepower and above. Premium efficiency motors shall have efficiency and losses determined in accordance with the latest revisions of IEEE Standard 112. Polyphase squirrel cage motors rated 1 through 150 horsepower shall be tested by dynamometer method B. The efficiency shall be determined using segregated losses in which stray load loss is obtained from a linear regression analysis to reduce the effect of random errors in the test measurements. Guaranteed minimum load efficiency shall be as follows:
   1. HP:3/4 Eff:80.0%
   2. HP:1 Eff:84.0%
   3. HP:1 1/2 Eff:86.5%
   4. HP:2 Eff:86.5%
   5. HP:3 Eff:89.5%
   6. HP:5 Eff:89.5%
   7. HP:7 1/2 Eff:91.7%
   8. HP:10 Eff:91.7%
   9. HP:15 Eff:93.0%
   10. HP:20 Eff:93.6%
   11. HP:25 Eff:93.6%
   12. HP:30 Eff:94.1%
   13. HP:40 Eff:94.5%
   14. HP:50 Eff:95.0%
   15. HP:60 Eff:95.4%
   16. HP:75 Eff:95.4%
   17. HP:100 Eff:95.4%
   18. HP:125 Eff:95.4%
   19. HP:150 Eff:95.4%

J. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.

K. Motors shall be specifically designed for quiet operation and for severe duty. Standard open drip proof motors shall be equipped with aluminum or stainless steel stamped nameplates. Totally enclosed fan cooled and air over motors shall be equipped with stainless steel stamped nameplates with either zinc or cadmium plated hardware. Motor nameplates shall clearly indicate manufacturer's name and model number, frame size, horsepower, frequency, voltage, RPM, starting torque class, insulation class, full load amps, locked rotor amps, service factor, power factor, efficiency and winding material.

L. Motors shall be specifically designed for quiet operation and for severe duty. Standard open drip proof motors shall be equipped with aluminum or stainless steel stamped nameplates. Totally enclosed fan cooled and air over motors shall be equipped with stainless steel stamped nameplates with either zinc or cadmium plated hardware. Motor nameplates shall clearly indicate frame size, horsepower, frequency, voltage, speed, starting torque class, insulation class, service factor and winding material.

M. Wiring Terminations:
1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.3 APPLICATIONS

A. Exception: Motors less than 250 watts, for intermittent service may be the equipment manufacturer's standard and need not conform to these specifications.

B. Single phase motors for shaft mounted fans, oil burners, and centrifugal pumps: Split phase type.

C. Single phase motors for shaft mounted fans or blowers: Permanent split capacitor type.

D. Single phase motors for fans, pumps, blowers, and air compressors: Capacitor start type.

E. Single phase motors for fans, blowers, and pumps: Capacitor start, capacitor run type.

F. Three phase motors for blowers, fans, pumps, and other HVAC equipment: Squirrel cage type.

G. Motors located in exterior locations, wet air streams downstream of sprayed coil dehumidifiers, draw through cooling towers, air cooled condensers, humidifiers, direct drive axial fans, roll filters, explosion proof environments, and dust collection systems: Totally enclosed type.

H. Motors located in outdoors, in wet air streams downstream of sprayed coil dehumidifiers, in draw through cooling towers, and in humidifiers: Totally enclosed weatherproof epoxy-treated type.

2.4 SINGLE PHASE POWER - SPLIT PHASE MOTORS

A. Starting Torque: Less than 150 percent of full load torque.

B. Starting Current: Up to seven times full load current.

C. Breakdown Torque: Approximately 200 percent of full load torque.

D. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.

E. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings, automatic reset overload protector.

2.5 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

A. Starting Torque: Exceeding one fourth of full load torque.

B. Starting Current: Up to six times full load current.

C. Multiple Speed: Through tapped windings.

D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

2.6 SINGLE PHASE POWER - CAPACITOR START MOTORS

A. Starting Torque: Three times full load torque.

B. Starting Current: Less than five times full load current.

C. Pull-up Torque: Up to 350 percent of full load torque.

D. Breakdown Torque: Approximately 250 percent of full load torque.

E. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.

F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve bearings.

G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings, automatic reset overload protector.

2.7 THREE PHASE POWER - SQUIRREL CAGE MOTORS

A. Starting Torque: Between 1 and 1-1/2 times full load torque.

B. Starting Current: Six times full load current.

C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.

D. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.

E. Insulation System: NEMA Class B or better.

F. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.

G. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.

H. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Section 26 29 13.

I. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA STD 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

J. Sound Power Levels: To NEMA MG 1.

K. Part Winding Start Where Indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.

L. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.

M. Nominal Efficiency: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

N. Nominal Power Factor: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install base mounted motors securely on firm foundation.

C. Align motors on direct drive equipment using dial type gauges.

D. Check line voltage and phase and ensure agreement with nameplate. Test motor for proper rotation under Division 26.

3.2 ADJUSTMENTS

A. Motors, together with driven equipment, shall be dynamically and statically balanced. Imbalance shall be reduced to minimum specified by equipment manufacturers.

END OF SECTION 23 05 13

SECTION 23 05 29 - HANGERS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hangers for HVAC piping

1.2 RELATED REQUIREMENTS

A. Section 23 05 23 - General Duty Valves for HVAC

B. Section 23 07 00 - HVAC Insulation

C. Section 23 21 13 - HVAC Piping

1.3 SUBMITTALS

A. Submit product data for review in accordance with Division 01 requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Anvil, B-Line, Carpenter and Patterson, Fee and Mason, Michigan, Reliable, and Viking. Anvil numbers are used for reference.

B. Substitutions: Refer to Division 01.

2.2 HANGERS

A. Anvil Figure #260 MSS Type 1, clevis hangers for:
   1. Non-insulated steel and galvanized piping 2" through 24" diameter

B. Anvil Figure #260 clevis hangers with Figure 167, MSS Type 40 galvanized insulation protection shields (sized for supporting insulation having a compressive strength of 4 psi). Support piping on outside of insulation. Size hangers so that pipe insulation passes through them without interruption.
   1. Heating water piping above 160 degrees F. 4" diameter and less.
   2. Chilled water piping
   3. All other insulated piping

C. Anvil Figure CT-69, MSS Type 10 with adjustable wrought tubing ring hanger, copper plated for:
   1. Non-insulated copper tubing with no longitudinal movement

D. Anvil Figure #CT-121, MSS Type 8, riser clamps (at floor slab penetrations) to support:
   1. Copper pipe risers

E. Anvil Figure #261, MSS Type 8, galvanized riser clamps (at floor slab penetrations) to support:
   1. Steel pipe risers

F. Anvil Powerstrut Trapeze Hangers: Where three or more lines of pipe run parallel, support them with trapeze hangers.

G. Except for copper hangers, all other hangers and supports shall be hot-dipped galvanized.

2.3 INSERTS

A. Concrete Insert: Anvil Figure #281, MSS Type 18, universal concrete inserts, adequately sized and correctly positioned to support full load operating systems.

B. Concrete Insert, Wedge Type: Anvil Figure #281, 1/4" to 7/8"

C. Lightweight Concrete Insert: Anvil Figure #285

D. Continuous Concrete Insert: Anvil Powerstrut Figure #PS-349 pre-galvanized

2.4 EXPANSION ANCHORS

A. Hilti Kwik-bolt, zinc-plated, metal expansion anchor.

B. Anchor to meet U.L., ICBO-4627 and FM listings.

2.5 HANGER RODS

A. Provide mild steel all-thread rods with maximum loads as follows:
1. 3/8" - 300 lbs
2. 1/2" - 600 lbs
3. 5/8" - 1,200 lbs
4. 3/4" - 2,000 lbs
5. 1" - 5,000 lbs

2.6 CLAMPS

A. C-Clamps: Anvil Figure #92, MSS Type 23.
1. Use these for attaching hangers to steel beams. Do not weld hanger rods to structural steel members.

B. Malleable Beam Clamps: Anvil Figure #218, MSS Type 30: Use these for attaching hangers to bar joists. Attach clamps to top chord of bar joists only. Confirm with structural engineer for maximum loading and restrictions.

PART 3 - EXECUTION

3.1 PIPE HANGERS

A. Support pipes on specified hangers so that equipment, pumps, and fittings do not bear weight or stresses from vibration and swaying of pipe. Support pipe risers at regular intervals in pipe shafts at least once at each floor level or a maximum of 12'-0" apart. Do not use perforated metal, strap iron, or band iron. Do not make offsets in hangers.

B. Maximum allowable spacing of pipe hangers is listed below. Space hangers and brackets at closer intervals where necessary to maintain levels, slopes, and drainage, or to prevent sagging or swaying of pipe.

C. Steel and Galvanized Pipe - Water
1. 1/4" to 1-1/2" - 7' 0" O.C.
2. 2" to 2-1/2" - 10' 0" O.C.
3. 3" to 4" - 12' 0" O.C.
4. 5" and above - 14'0" O.C.

D. Steel and Galvanized Pipe - Vapor

1. 1/4" to 1-1/2" - 8' 0" O.C.
2. 2" to 2-1/2" - 13' 0" O.C.
3. 3" and above - 15' 0" O.C.

E. Copper Pipe - Water
1. 1/4" to 1-1/4" - 5'0" O.C.
2. 2" to 2-1/2" - 8'0" O.C.
3. 3" and above - 10'0" O.C.

F. Copper Pipe - Vapor
1. 1/4" to 1" - 5'0" O.C.
2. 1-1/4" to 2" - 8'0" O.C.
3. 2-1/2" to 4" - 10' 0" O.C.
4. 5" and above -15' 0" O.C.

G. Sway Bracing
1. Provide sway bracing and additional supports to meet the seismic bracing requirements.

END OF SECTION 23 05 29

SECTION 23 05 48 - VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Vibration isolators, pipe supports, and equipment anchors, of appropriate sizes and weight loading to meet the specified deflection requirements, in accordance with instructions of isolator manufacturer.

B. Vibration isolation for all Division 22 and 23 systems as noted below. Provide all miscellaneous items (angle iron, bolts, rods, etc.) required for a complete system. Contractor and vendors shall thoroughly coordinate all vibration isolation systems.

C. Coordination of installation with other trades (placement of anchor bolts in concrete slabs, etc.)

1.2 RELATED REQUIREMENTS

A. Division 22: Plumbing

1.3 MANUFACTURER RESPONSIBILITIES

A. Manufacturer of vibration isolation and seismic control products shall have the following responsibilities:
   1. Manufacturer of vibration isolation shall have the following responsibilities:
      a. Determine vibration isolation and restraint sizes and locations for mechanical and plumbing equipment.
      b. Determine vibration isolation sizes and locations for mechanical and plumbing equipment.
      c. Provide isolation systems for all plumbing and mechanical of equipment (vibration isolated and non-isolated) and systems (piping and ductwork).
      d. Provide installation instructions and drawings.

B. Vibration isolation specialist shall coordinate his work with that of other trades to verify that equipment speeds, in revolution per minute (rpm), are based upon actual equipment installed at the project site.

C. Verify that equipment rpm and spring deflection selected are arranged so that resonance is avoided.

D. Exact mounting sizes, dimensions and quantity of isolators and static deflection required shall be determined by the isolator manufacturer based upon equipment that will be furnished and installed by the contractor under this Contract.

1.4 SUBMITTALS

A. Contractor's Certification: Vibration isolator submittals shall include a certification, signed by an officer representing the Contractor and stipulating that the submittal prepared by the manufacturer has been reviewed, and checked on an item by item basis against each piece of mechanical equipment, piping, ductwork and panel shown or specified in the Contract Documents, which requires vibration isolation and/or support.

B. Manufacturer's Certification: The manufacturer or manufacturers (if there are more than one) shall each certify that the selections of vibration isolation equipment are based upon the drawings and specifications, and that each piece of mechanical equipment has been examined

for rotational speed, equipment type, mounting location, and supporting span between column centers, and that an appropriate isolator has been selected.

C. Product Data: Furnish manufacturer's product data covering each isolator type for style, characteristic, and finish. Isolator quantities, dimensions, deflections, capacities and types shall remain the responsibility of the manufacturer and the contractor.

D. Shop Drawings: Provide layout drawings, drawn to a scale of not less than 1/8-inch to 1-foot, showing the proposed layout of equipment and piping systems and the location and type of each vibration isolation and restraint device. Carefully examine other sections requiring coordinated shop drawings, including but not limited to Section 23 31 13, "Sheetmetal Ductwork", Section 23 31 14, "Sheetmetal - Special Ductwork", and prepare restraint/isolation shop drawings to the same scale showing the location of each vibration isolation equipment base, pipe hanger, flexible connection, and isolator restraint device.

1.5 QUALITY ASSURANCE

A. Responsibility for Products: Select deflection for spring isolators in accordance with recommendations in the current issue of ASHRAE Handbook of Fundamentals, unless noted otherwise on drawings.

B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with not less than 10 years fo documented experience.
1. Member of Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

1.6 STORAGE AND PROTECTION

A. Storage: Store vibration isolation equipment indoors in the manufacturer's original shipping containers. Preclude the entrance of construction dirt and debris. Vibration isolation equipment and bases, which show signs of rust, cement or concrete fouling, dirt and construction debris shall be disassembled and cleaned, approved or removed from the project site and replaced with new.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Amber Booth, Kinetics Noise Control, Korfund Company, Mason Industries, Vibration Eliminator Co., or Vibration Mountings & Controls.

B. Furnish vibration isolators by single manufacturer.

C. Substitutions: Not permitted.

2.2 PRODUCTS

A. Type 1: Mason Super "W", 2 layers of 3/4" neoprene pad with 16 ga. galvanized shim.

B. Type 2: Mason BR, two neoprene elements housed in a ductile iron casting.

C. Type 3: Mason SLF, free standing spring isolator, 1/4" neoprene non-skid pad, leveling bolt, spring diameter no less than 0.8 of compressed height at rated load, minimal additional travel to solid equal to 50% or rated deflection.

D. Type 4: Mason SLR, restrained spring isolator, vertical limit stops, internal isolation pad.

E. Type 6: Mason 30N, spring and double neoprene hanger, 1-1/4" neoprene element at top of housing, spring seated in neoprene cup at bottom of housing, designed to allow 30 degrees arc from side to side of hanger rod.

F. Type 12: Mason BBS flexible stainless steel braided hose; minimum lengths as follows:
1. 1/2" - 1-1/2" : 12"
2. 2" 4" : 18"
3. 6" - 10" : 24"
4. 12" - 16" : 32"

G. Type 15: Mason SafeFlex flexible rubber pipe connection, peroxide cured EPDM with Kevlar tire cord reinforcement, raised face rubber flanges with encased solid steel rings.
1. 14" diameter and below: Mason SFDEJ twin sphere with reinforcing ring; minimum pressure rating of 250 psi at 170 degrees F. and 215 psi at 250 degrees F.
2. 16" diameter and above: Mason SFEJ single sphere; minimum pressure rating of 180 psi at 170 degrees F. and 150 psi at 250 degrees F.
3. Control rods; Mason CR with 1/2" thick Neoprene washer bushings.

2.3 MATERIALS AND EQUIPMENT

A. Materials and equipment shall conform to the respective specifications and other requirements specified below:
1. Squarehead bolts and heavy hexagon nuts, ANSI B18.2.1 and ANSI B18.2.2, and ASTM A 307 or ASTM A 576.
2. Sway Brace Material used for members shown on mechanical drawings, except for pipes, shall be structural steel conforming with ASTM A 36. Steel pipes shall conform to ASTM A 501.

PART 3 - EXECUTION

3.1 VIBRATION CONTROL

A. Size vibration control equipment in accordance with weight distribution, pull or the imposed torque as shown on equipment shop drawings. Minimum static deflections may be revised subject to prior approval.

B. Provide revised vibration control equipment to match revised or substituted equipment.

C. Install vibration control equipment in accordance with the manufacturer's installation instructions and as specified.

D. Install equipment on vibration isolation curbs to provide watertight seal.

3.2 APPLICATIONS

A. Equipment: Use the vibration and restraint types listed above on the following applications:
1. A/C units, indoor, not internally isolated
   a. Type 3
   b. Type 5
2. Fans, suspended
   a. Type 6, 14
3. Blower coil units above 1500 cfm (suspended):
   a. Type 13

B. Piping
   1. Provide Type 6 vibration isolation on following piping:
      a. Closest two hangers on piping at air handling units and blower coil units.
      b. HVAC water piping within 20 pipe diameters each side of HVAC pumps.
      c. Food service heat rejection piping within 20 pipe diameters of heat rejection equipment.
      d. Condenser water piping within 20 pipe diameters of tower. Alternate: Use Mason BBF braided stainless steel hose at connections to tower.

C. Use hold down clamps to attach multiple pipes to trapeze hangers.

3.3 ANCHORING

A. Installation: Installation shall comply with manufacturer's published recommendations and shall be installed so that isolators are plumb and are operating at a manner for which they were designed.

B. Unless otherwise specified, all equipment shall be securely bolted to isolators, steel bases or concrete inertia bases.

3.4 ANCHOR BOLTS

A. If the size and number of the anchor bolts are not shown on the drawings then anchor bolts shall conform to the schedule for the various equipment weights or the manufacturer's installation recommendations, whichever is the most stringent.

3.5 INSTALLATION

A. Set anchor bolts when concrete is placed.

B. Install isolators in accordance with recommendations of isolator manufacturer and equipment manufacturer.

C. Isolate mechanical equipment as indicated.

D. Remove all debris from under equipment, and thoroughly clean steel bases, inertia bases and check for free movement.

END OF SECTION 23 05 48

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Stencils.

D. Pipe Painting and Markers.

E. Printed Labels / Ceiling Markers / Tacks

F. Control Diagrams.

1.2 RELATED REQUIREMENTS

A. Section 09 90 00 - Painting and Coating: Identification painting.

1.3 REFERENCE STANDARDS

A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2007.

B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2013.

1.4 SUBMITTALS

A. See Division 01.

B. List: Submit list of wording, symbols, letter size, and color coding for mechanical systems identification.

C. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number. Follow existing facility standards if applicable.

D. Product Data: Provide manufacturers catalog literature for each product required.

E. Samples: Submit samples of ceiling markers/tacks, duct labels, nameplates, pipe markers, and valve tags.

F. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

G. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

A. Access Doors: Stencil painting compliant with NFPA 90A where applicable.

B. Major HVAC equipment including, but not limited to AHU's, boilers, chillers, fans, pumps, and RTU's: Nameplates.

C. Air Terminal Units: Nameplates

D. Automatic Controls: Tags. Key to control schematic.

E. Control Panels and major control components: Nameplates.

F. Automatic Control Dampers: Ceiling markers/tacks, where located above lay-in ceiling.

G. Ductwork: Stencil painting.

H. Fire, Smoke, and Combination Dampers: Labels.

I. Heat Transfer Equipment: Nameplates.

J. Major Control Components: Nameplates.

K. Piping: Pipe markers.

L. Pumps: Stencil painting.

M. Unitary Equipment: Nameplates.

N. Tanks: Stencil painting.

O. Thermostats: Printed Labels.

P. Valves: Tags and ceiling tacks where located above lay-in ceiling.

Q. Water Treatment Devices: Nameplates.

2.2 ACCEPTABLE **MANUFACTURERS**

A. Brady Corporation, Kolbi Pipe Marker Company, Marking Services, Inc., MIFAB, Inc., or Seton Identification Products

B. Substitutions: Refer to Division 01.

2.3 NAMEPLATES

A. Rigid plastic with engraved lettering.

B. Fasteners: Commercial quality, rust resisting nuts and bolts with backwashers, self-tapping screws, or rivets. If equipment surface does not allow for direct attachment, use copper or brass rings to attach tags.

C. Use names, numbers, and abbreviations appearing in schedules on Contract Drawings or as otherwise directed by the Owner.

D. Letter Color: White.

E. Letter Height: 1/2 inch.

F. Background Color: Black.

G. Plastic: Conform to ASTM D709.

2.4 TAGS

A. Tags shall be provided showing the valve service and number or equipment number.
   1. At substantial completion, submit chart showing all valve and equipment numbers to Owner and Engineer.

2. Alpha-numeric I.D. shall include floor level and buliding section as part of the identification.
3. Securely fasten tags to valves with a brass "S" hook or chain.

B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.

C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges. Provide with permanently stamped black filled letters and numbers.

D. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.5 ADHESIVE-BACKED DUCT MARKERS

A. Acceptable Manufacturers:
1. Brimar Industries, Inc.; _____: www.pipemarker.com.
2. Substitutions: Refer to Division 01.

B. Material: High gloss acrylic adhesive-backed vinyl film; printed with UV and chemical resistant inks.

C. Style: Individual Label.

D. Color: Yellow/Black.

2.6 STENCILS

A. Where stenciling is used to identify large pieces of equipment, such as boilers, chillers, and air handling units, stenciling shall be in a conspicuous place and visible from control panel area.

B. Use names, numbers, and abbreviations appearing in schedules on Contract Drawings or as otherwise directed by the Owner.

C. Piping stencils shall include flow direction arrow and identification of fluid being conveyed
1. Steam piping shall indicate operating pressure in addition to contents and flow direction

D. Stencils: With clean cut symbols and letters of following size:
1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.
4. 8 to 10 inch Outside Diameter of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.
5. Over 10 inch Outside Diameter of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.
6. Ductwork and Equipment: 2-1/2 inch high letters.

E. Stencil Paint: Semi-gloss enamel or latex. Color shall be black or white, whichever provides the highest contract to the adjacent surface. Comply with colors in ASME A13.1 where applicable.

2.7 **PIPE PAINTING AND MARKERS**

A. Painting of HVAC piping:

1. Paint piping as specified in this section and as specified in Division 09.
2. Paint all exposed piping (or exterior surface of insulation) in mechanical rooms, central energy plants, and rooms without ceilings in its entirety.
3. Colors:
    a. Chilled Water Supply: Blue
    b. Chilled Water Return: Light Blue
    c. Condenser Water Supply: Light Green
    d. Condenser Water Return: Green
    e. Heating Water Supply: Purple
    f. Heating Water Return: Light Purple
    g. Steam: Orange
    h. Steam Condensate: Light Orange
    i. Boiler Feedwater and drain piping: Dark Orange
    j. Fuel Oil Supply: Brown
    k. Fuel Oil Return: Light Brown
    l. Refrigerant Piping: Same as current ASHRAE Standard 34 container color based on refrigerant type.

B. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering. At a minimum, marker shall have flow direction arrows and identification of fluid being conveyed.

C. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service. At a minimum, marker shall have flow direction arrows and identification of fluid being conveyed.

D. Colors shall conform to ASME 13.1 where applicable.

2.8 PRINTED LABELS / **CEILING MARKERS / TACKS**

A. Printed Labels
1. Printed labels / asset tags to be coordinated with Owner and applied by Contractor.
2. Prior to Substantial Completion date, Contractor to work with owner, as required, to locate devices above the ceiling requiring a printed label / asset tag.

B. Ceiling Marker / Tack description: Steel with 3/4 inch diameter color coded head.
1. Contractor to provide an install.
2. Color code as follows:
    a. HVAC Equipment: Yellow.
    b. Fire Dampers and Smoke Dampers: Red.
    c. Valves: Blue.

2.9 CONTROL DIAGRAM FRAMES

A. Provide printed diagrams for all major HVAC equipment. Mount diagrams on walls in conspicuous, easily accessible places in each separate equipment room housing the equipment which the individual diagrams are applicable. Diagrams shall be laminated and represent as-built conditions. Lettering to be no smaller than 10 pt font.

B. The following diagrams are required:
1. Written sequences of operation.
2. Graphic control diagram indicating relative device locations and labels.

C. Provide and install mounting hardware to secure each diagram to the wall. If adequate wall space is not available adjacent to the associated equipment, coordinate an alternate mounting location with Owner.

PART 3 EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. Prepare surfaces in accordance with Division 09 for stencil painting.

3.2 INSTALLATION

A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Install tags with corrosion resistant chain.

C. Apply stencil painting in accordance with Division 09.

D. Install plastic pipe markers in accordance with manufacturer's instructions at no less than 25 foot intervals, at valves, and at least once in each separate space through which the pipe passes. Label all vent piping and pressure relief piping.

E. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

F. Use tags on piping 3/4 inch diameter and smaller.
   1. Identify service, flow direction, and pressure.
   2. Install in clear view and align with axis of piping.
   3. Locate identification not to exceed 25 feet on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction.

G. Label ductwork at no less than 25 foot intervals, on both sides of barriers and rated wall penetrations, and at all ductwork penetrations into and exiting from enclosed chases.

H. Install ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

I. Confirm with Owner or Architect prior to placing ceiling tacks or labels on surfaces other than lay-in panel ceilings.

END OF SECTION 23 05 53

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. HVAC systems testing and balancing requirements.

1.2 REFERENCE STANDARDS

A. AABC - Associated Air Balance and Control

B. NEBB - National Environmental Balancing Bureau

1.3 SCOPE OF WORK

A. Perform test and balance in accordance with AABC or NEBB Standards.

B. Water systems: Adjusted to deliver design flow rates and pressure requirements.

C. Air and water balance shall be performed by qualified personnel experienced in this field.

D. The air balance procedure followed and forms used shall agree with AABC or NEBB Standards.

E. Make changes to pulleys, belts, dampers, impellers, and similar equipment to obtain design conditions as required by TAB procedures.

F. The Architect, Engineer, Owner, or Owner's Representative may request a recheck, resetting, or verification of an air or water related item within 90 days of the completion of work. The work shall be provided at no additional cost.

PART 2 - PRODUCTS

2.1 NOT APPLICABLE

PART 3 - EXECUTION

3.1 PROCEDURES

A. On completion of work, submit three copies of the complete report to include the following:
1. Current certification documentation of all TAB equipment used.
2. Current certification of TAB personnel responsible for the work.
3. Dates, time, all personnel, and operating status of cooling and heating systems.
4. A description of the procedure used for air and water balance.

3.2 AIR SYSTEMS

A. Balance supply, return, and exhaust air outlets within outlets within 10% of design while still maintaining required pressure relationships.

B. On each fan system, measure and report:
1. Design and actual fan RPM. Fan suction and discharge pressure. Fan total static pressure, and pressure drop across components. Design and actual supply, return, exhaust, and outside air CFM.
2. Actual and motor nameplate voltage and amperage on fans.
3. Design and actual entering and leaving air temperatures, heating and cooling (dry bulb and wet bulb) of the supply, return, exhaust, and outside air.

C. For diffusers and grilles, measure, adjust, and report:
   1. Design and actual CFM at each supply, return, and exhaust outlet.

3.3 WATER SYSTEMS

A. For water systems, measure, adjust and report:
   1. Design and actual GPM.
   2. Discharge and suction head for each pump.
   3. Actual and motor nameplate voltage for each pump.
   4. Design and actual GPM and entering/leaving temperatures of heating water through each heat exchanger.
   5. Design and actual water temperature difference and water pressure drop through air tempering coils at air terminal units, air handling units, and duct mounted reheat coils.

END OF SECTION 23 05 93

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe insulation

B. HVAC equipment insulation

C. Ductwork insulation

1.2 RELATED REQUIREMENTS

A. Section 23 05 53 - Identification for HVAC Piping and Equipment

B. Section 23 21 13 - Hydronic Piping

C. Section 23 21 14 - Hydronic Specialties

D. Section 23 31 13 - Sheetmetal Ductwork

1.3 DEFINITIONS

A. Exposed - Equipment, ducts and piping in areas which will be visible without removing ceilings or opening access panels.

B. Concealed - Installed above ceiling, in walls or chases.

C. Outdoors - Exposed to the weather or ambient conditions.

D. Underground - Buried.

1.4 REFERENCE STANDARDS

A. ASTM C553 - Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013.

B. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014.

C. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2012.

D. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts; 2011.

E. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation; 2013.

F. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2013.

G. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2012.

H. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation; 2013.

I. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation; 2013.

J. SMACNA (DCS) - HVAC Duct Construction Standards; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

1.5 SUBMITTALS

A. Refer to Division 01.

B. Submit manufacturer's product data and installation procedures for review. Product data shall identify specific thermal characteristics, list of materials and thickness for each service.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001-2000 certified.

B. Fire-Test Response Characteristics: Testing in accordance with ASTM E84. Insulation and related materials, adhesives, coatings, sealers, jackets and tapes, shall have a fire-test response characteristic of: Flame spread rating of 25 or less; Smoke development of 50 or less.

C. Materials shall meet the requirements of NFPA 90A.

PART 2 - PRODUCTS

2.1 PIPE AND EQUIPMENT INSULATION

A. Materials for Pipe and Equipment: Provide factory premolded insulation for pipe, pipe fittings, and valves.

B. Fitting insulation: Same thickness and material as adjoining pipe insulation.

C. Cellular Glass (Foamglass):
1. Acceptable manufacturers: Pittsburgh Corning "Foamglas"; minimum "R" value of 2.63.
2. Mastic: Water based, Foster 30-80 or equal
   a. Inside applications: Foster Vapor Fas 30-65, Childers CP-34 or Vimasco 739. Permeance shall be 0.03 perms or less at 45 mils dry per ASTM E 96."
3. Use on the following services:
   a. Chilled water piping located in central plants and outdoors , 2" and less pipe, 1-1/2" thick; 2-1/2" and greater, 2" thick.
   b. At hanger and support points as specified herein.

D. Flexible Tubular Elastomeric:
1. Provide fire-retardant closed-cell slip-on flexible type; minimum "R" value of 2.57
2. Acceptable manufacturers: Aeroflex "Aerocel", Armacell "AP/Armaflex", or K-Flex "Insul-Tube".
3. Use on the following services:
   a. Moisture condensate drains: 1/2" thick.

E. Fiberglass Pipe Insulation:
1. Acceptable manufacturers: Johns-Manville "Micro-Lok 850, CertainTeed, Knauf, or Owens Corning.
2. Jacket: ASJ fiberglass reinforced kraft paper with aluminum foil; minimum R value of 3.6.
3. Use on the following services:
   a. Chilled water piping: 1-1/2" thick.
   b. Heating water piping:
      1) Pipe sizes 1 1/2" and less: 1" thick.

2) Pipe sizes 2" and greater: 2" thick.
3) Insulate all run outs to coil connections including valves, control valves, fittings and connections regardless of the piping size or length of the run out.

c. Quench vent piping: 1-1/2" thick.

2.2 DUCTWORK INSULATION

A. Blanket Type Duct Insulation:
1. Acceptable manufacturers: CertainTeed, Johns-Manville, Knauf, or Owens Corning.
2. Provide with Foil Reinforced Kraft (FSK) vapor barrier, providing the minimum "R" value and pound per cubic foot (PCF) density shown below.
3. Use on the following:
a. Unlined supply air ductwork in an unconditioned space, including concealed above ceiling: 2.2", 0.75 PCF, installed "R" value of 6.0.
b. Unlined supply air ductwork serving low temperature systems including operating rooms and cath labs: 3.0", 0.75 PCF, installed "R" value of 8.3. Overlapping layers with offset seams is acceptable to meet the "R" value indicated.
c. Unlined, exposed supply air ductwork: 2.2", 0.75 PCF, installed "R" value of 6.0.

2.3 MATERIALS FOR FITTINGS, VALVES, AND SPECIAL COVERINGS

A. For all services, use full thickness premolded insulation for pipe fittings, elbows, tees, valves, and couplings 2-1/2 and larger. Finish shall be as specified under Products above or as specified below. PVC fitting covers may be used over the premolded insulation for chilled water and heating water systems.

B. PVC fitting covers with full thickness fiberglass inserts may be used on piping fittings elbows and valves 2" and less for chilled water and heating water systems.

C. For tanks, heat exchangers and large pipes in systems operating over 60 degrees F. When exposed-to-view inside building or in equipment rooms, cover insulation with a smoothing coat of Keane Powerhouse cement, one layer of white colored woven glass fabric embedded and finished with Foster GPM mastic.

D. For pipe fittings, valves, strainers, and other irregular surfaces, in chilled water or refrigerant systems operating below 60 degrees F, when inside building or in equipment rooms, cover insulation with white colored woven glass fabric embedded in white vapor barrier coating, Foster 30-35 or equal.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Deliver and store insulation materials in manufacturers containers and keep free from dirt, water, chemical and mechanical damage.

B. Complete piping and ductwork pressure testing prior to applying insulation.

C. Apply insulation in workmanlike manner by experienced, qualified, workmen.

D. Surfaces shall be clean and dry when covering is applied. Covering to be dry when installed and before and during application of any finish, unless such finish specifically requires a wetted surface for application.

E. Adhesives, cements and mastics shall be compatible with materials applied and shall not attack materials in either wet or dry state.

F. Stop duct coverings, including jacket and insulation, at fire penetrations of fire or smoke rated partitions, floors above grade and roofs. "Fan-out" or extend jacketed insulation at least 2" beyond angle frames of fire dampers and secure to wall. Maintain vapor barrier.

3.2 BLANKET TYPE DUCT INSULATION

A. Apply jacketed blanket type glass fiber covering to ducts pulled snug but not so tight as to compress corners more than 1/4". Use insulation having 2" tab, or cut insulation long enough to allow for "peel-off" of insulation from jacket to effect a minimum overlap of 2". Staple lap with flare type staples on 1" centers. Cover standing seams, stiffeners, and braces with same insulation blanket, using 2" jacket lap and staple lap as herein before outlined. Cover and seal all staples with Foster 30-80 reinforced with glass cloth. Do not use pressure sensitive tape.

B. Secure jacket to covering using equivalent of Foster No. 85-20 or Childers CP-82 adhesive.

C. For ducts 24" or wider, mechanically fasten insulation to duct bottom, using weld pins having self-locking, metal discs, locating fasteners on not over 12" centers laterally and longitudinally. Seal pins as above.

D. For ducts up to 24" deep, mechanically fasten insulation to duct sides, using one row of pins, plates or discs located on not over 12" centers longitudinally and equidistant laterally between duct top and bottom. For ducts 24" deep and greater, apply fasteners as before only using minimum of two rows.

3.3 INSTALLATION OF PIPE AND EQUIPMENT COVERING

A. Where glass fiber or flexible tubular elastomeric insulation is used on piping sized 2" and larger, insert a section of foamglass or calcium silicate insulation, at hanger or support points, between pipe and metal shield for full length of shield, to prevent crushing of insulation. Where insulation passes through pipe hangers and across trapeze supports, 12" long metal saddles shall be used. Insulation thickness to be same as adjoining glass fiber insulation. On cold pipe, vapor barrier should be carried through the hanger and sealed. Saddles shall be used where rigid foamglass inserts are not acceptable. Pipe saddles shall cover 180 degrees of the pipe.

B. Foamglass insulation shall be strictly applied as follows:
   1. Both the circumferential and longitudinal joints shall be buttered with fire-resistive pliable sealer. Voids and cracks shall be filled with sealer. Mastic shall be Foster 30-80 or equal. Secure insulation with 3/4" wide x 0.010" thick aluminum bands on 8" centers.
   2. The circumferential joints shall be staggered.
   3. Fittings, valves, flanges, traps, and air vents shall be insulated with the same thickness of insulation using factory fabricated fitting sections or pre-molded insulated fittings.
   4. Block type insulation shall be adhered by stick-clips or bands, in addition to the sealer, as required to provide support for the insulation.
   5. Finish above furred ceilings and in chases shall be the bare insulation.
   6. Finish in equipment rooms and elsewhere where exposed-to-view shall be white ASJ.
   7. Finish where exposed-to-the-weather shall be Childers, or equal, .016 inch thick aluminum jacket on piping and Ell jacs, or equal, pre-formed aluminum covering on fittings.
   8. Finish on underground insulation shall be Pittsburgh Corning Pittwrap as recommended by manufacturer.

C. Apply flexible tubular elastomeric insulation to pipe and fittings with all joints tightly fitted and sealed with adhesive.

D. Apply semi-rigid high temperature, fiberglass board insulation as recommended by the manufacturer.

E. Apply flexible high temperature blanket type in two steps. First, cover fitting with 1/2" thick matt only; then apply finished envelope containing 2" thick matt material. Secure envelope using stainless steel or monel bands, hooks washers, and lacing.

F. Heat Traced Piping: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

END OF SECTION 23 07 00

SECTION 23 09 13 - INSTRUMENTATION AND CONTROL DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Provide input and output control devices to integrate with direct digital control and building automation system.

B. Furnish instrumentation control devices as an integral part of the Building Automation Section specified in Section 23 09 23.

1.2 RELATED REQUIREMENTS

A. Section 23 05 00 - Common Work Results for HVAC

B. Section 23 09 23 - Building Automation and Direct Digital Controls

C. Section 23 20 00 - HVAC Piping

D. Section 23 31 13 - Sheetmetal Ductwork

E. Section 23 36 00 - Air Terminal Units

F. Division 26: Electrical

1.3 SUBMITTALS

A. Submit product data and schedules for all input/output devices.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Provide products and components by manufacturers listed. Where manufacturers are not listed, provide component that complies with specifications.

B. Manufacturers listed must meet performance and material specifications of product or component. Listing of a manufacturer as an acceptable manufacturer does not grant permission to deviate from the specification requirements.

2.2 INPUT DEVICES

A. General Requirements
   1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

B. Temperature Sensors
   1. Acceptable Manufacturers: Automated Logic, Johnson Controls, Setra, or Siemens.
      a. Substitutions: Not permitted.
   2. General Requirements:
      a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
      b. The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.
      c. Accuracy values indicated include errors associated with the sensor, lead wire, and analog to digital conversion.

3. Room Temperature Sensors
    a. Refer to temperature sensor legend, schedules, floor plans, and control sequences for specific room temperature sensor requirements in each zone.
    b. Room sensors shall be constructed for either surface or wall box mounting.
    c. Room sensors shall have the following options when specified:
        1) Local setpoint adjustment providing a +/- 3 degree (adjustable) range.
        2) Timed override request push button with LED status for activation of after-hours operation.
        3) Flush mounting (sensor only, no local adjustment)
        4) Integral LCD display and keypad with the following capabilities:
            (a) Display room and outside air temperatures.
            (b) Display room setpoint.
            (c) Password selectable adjustment of setpoint and override modes.
4. Thermo Wells
    a. When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.
    b. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.
    c. Thermo wells and sensors shall be mounted in a threadolet or 1/2" NFT saddle and allow easy access to the sensor for repair or replacement.
    d. Thermo wells shall be constructed of 316 stainless steel.
5. Duct Mount Sensors
    a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
    b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
    c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
6. Averaging Sensors
    a. Provide at the following locations:
        1) Heating coils and cooling coils at air handling units and fan coil units.
        2) Ductwork greater in any dimension that 48 inches and/or where air temperature stratification exists.
    b. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.
    c. Capillary supports at the sides of the duct shall be provided to support the sensing string.
7. Low Limit Temperature Sensors
    a. Provide vapor charged sensing element that reacts to coldest 14" of sensor length.
    b. Sensor shall have field adjustable setpoint.

C. Differential Pressure Transmitters
1. Acceptable Manufacturers: Automated Logic, Johnson Controls, Mamac, Setra, or Siemens.
    a. Substitutions: Not permitted.
2. General Air and Water Pressure Transmitter Requirements:
    a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.

b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

3. Differential Pressure Transmitters: (chilled water and hot water systems)
a. Provide self-contained, variable capacitance type differential pressure transmitters at chillers, boilers and air handling units to measure system and equipment differential pressures.
b. Installed by the contractor where indicated on the drawings including system DPs at AHU coils and across chillers. Wiring terminals and electronics shall be in separate compartments, so the electronics remain sealed during installation. Reverse polarity protection shall be included to keep wiring mishaps from damaging the transmitter. Wiring installed by the contractor between the control system and the transmitter(s) shall be Belden 9320, two wire, shielded twisted cable, and shall not be included in conduit containing AC circuit wiring.
c. Design range shall be as required by system. External zero and span adjustments, over-pressure to 2,000 PSI, and no humidity effects.
d. Minimum accuracy shall be 0.25% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability. Stability shall be 0.25% of upper range limit for six months. No internal mechanical linkages shall be used in the transmitter(s).

D. Smoke Detectors
1. Ionization type air duct detectors shall be furnished as specified elsewhere in Division 28. for installation under Division 23. All wiring for air duct detectors shall be provided under Division 28, Fire Alarm System. Coordinate interface with BAS and Fire Alarm System.

E. Status and Safety Switches
1. General Requirements
a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BAS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

2. Current Sensing Switches
a. Acceptable manufacturers: Veris Industries.
1) Substitutions: Refer to Division 01.
b. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
c. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
d. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.

3. Differential Pressure / Water Flow Switches
a. Acceptable manufacturers: Johnson Controls (model P74).

1) Substitutions: Refer to Division 01.

b. Switch shall contain heavy duty pressure elements and be used to measure and relay the pressure difference between two sources or across the inlet/outlet of equipment.

c. Device shall be an automatic reset device and shall provide a control output at the differential pressure setpoint.

2.3 OUTPUT DEVICES

A. Actuators

1. Acceptable manufacturers: Johnson Controls or Mamac.
   a. Substitutions: Refer to Division 01.
2. General Requirements
   a. Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.
3. Electronic Damper Actuators
   a. Electronic damper actuators shall be direct shaft mount.
   b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.
   c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
   d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.
4. Electronic Valve Actuators
   a. Electronic valve actuators shall be manufactured by the valve manufacturer.
   b. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
   c. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized Based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.

d. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
e. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

B. Control Relays
1. Control Pilot Relays
a. Acceptable manufacturers: Johnson Controls or Lectro.
1) Substitutions: Refer to Division 01.
b. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
c. Mounting Bases shall be snap-mount.
d. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
e. Contacts shall be rated for 10 amps at 120VAC.
f. Relays shall have an integral indicator light and check button.
2. Lighting Control Relays
a. Lighting control relays shall be latching with integral status contacts.
b. Contacts shall be rated for 20 amps at 277 VAC.
c. The coil shall be a split low-voltage coil that moves the line voltage contact armature to the ON or OFF latched position.
d. Lighting control relays shall be controlled by:
1) Pulsed Tri-state Output - Preferred method.
2) Pulsed Paired Binary Outputs.
3) A Binary Input to the Facility Management System shall monitor integral status contacts on the lighting control relay. Relay status contacts shall be of the "dry-contact" type.
e. The relay shall be designed so that power outages do not result in a change-of-state, and so that multiple same state commands will simply maintain the commanded state. Example: Multiple OFF command pulses shall simply keep the contacts in the OFF position.

C. Control Valves
1. Acceptable manufacturers: Johnson Controls.
a. Substitutions: Refer to Division 01.
2. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Specification.
3. Chilled water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer's

recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.

4. Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.
5. Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all special applications as indicated on the valve schedule. Valve discs shall be composition type. Valve stems shall be stainless steel.
6. Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system, and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.

D. Control Valves, Segmented Ball Valves
1. Acceptable manufacturers: Fisher, Kele, Nelis-Jamesbury, or Valve Solutions, Inc.
   a. Substitutions: Refer to Division 01.
2. High performance segmented V-Ball control valve: Carbon steel body, stainless steel V-notch ball and shaft, low friction bearings and a low friction graphite ball set.; ANSI Class 150 or 300 flanges as required by application.
3. Rated ANSI Class VI leakage rate, -20 degrees F. to 450 degree F. temperature range and minimum 285 PSI allowable shutoff pressure drop at -20 to 100 F.
4. Rotation: 90 degrees; rangeability: 300 to 1 with equal percentage control characteristic; valve shall accommodate standard electric actuators.
5. Warranty: Valve and linkage, 3 year warranty from date of installation.

E. Electronic Signal Isolation Transducers
1. Acceptable manufacturers: Advanced Control Technologies.
   a. Substitutions: Refer to Division 01.
2. A signal isolation transducer shall be provided whenever an analog output signal from the BAS is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input signal from a remote system.
3. The signal isolation transducer shall provide ground plane isolation between systems.
4. Signals shall provide optical isolation between systems.

F. External Manual Override Stations
1. External manual override stations shall provide the following:
   a. An integral HAND/OFF/AUTO switch shall override the controlled device pilot relay.
   b. A status input to the Facility Management System shall indicate whenever the switch is not in the automatic position.
   c. A Status LED shall illuminate whenever the output is ON.
   d. An Override LED shall illuminate whenever the HOA switch is in either the HAND or OFF position.
   e. Contacts shall be rated for a minimum of 1 amp at 24 VAC.

G. Electronic/Pneumatic Transducers
1. Acceptable manufacturers: Johnson Controls or Mamac.
a. Substitutions: Refer to Division 01.
2. Electronic to Pneumatic transducers shall provide:
a. Output: 3-15 PSIG.
b. Input: 4-20 mA or 0-10 VDC.
c. Manual output adjustment.
d. Pressure gauge.
e. External replaceable supply air filter.

2.4 MISCELLANEOUS DEVICES

A. Local Control Panels
1. All control panels shall be factory constructed, incorporating the BAS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch. Provide common keying for all new panels and match keying when existing panels are present.
2. Control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices-such as relays, transducers, and so forth-that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.
3. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.
4. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
5. All wiring shall be neatly installed in plastic trays or tie-wrapped.
6. A 120 VAC duplex convenience receptacle and required transformers shall be provided in each enclosure.

B. Power Supplies
1. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.
2. Input: 120 VAC +10%, 60Hz.
3. Output: 24 VDC.
4. Line Regulation: +0.05% for 10% line change.
5. Load Regulation: +0.05% for 50% load change.
6. Ripple and Noise: 1 mV rms, 5 mV peak to peak.
7. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.
8. A power disconnect switch shall be provided next to each power supply.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Actuation / Control Type
1. Primary Equipment
a. Controls shall be provided by equipment manufacturer as specified herein.
b. All damper and valve actuation shall be electric.
2. Air Handling Equipment
a. All air handlers shall be controlled with a HVAC-DDC Controller

b. All damper and valve actuation shall be electric.

3. Terminal Equipment:
   a. Terminal Units (ATU, UV, etc.) shall have electric damper and valve actuation.
   b. All Terminal Units shall be controlled with HVAC-DDC Controller.

B. HVAC Input Devices - General
1. All Input devices shall be installed per the manufacturer recommendation.
2. Locate components of the BAS in accessible local control panels wherever possible.
   a. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, air flow stations, etc.
3. Flow Measuring Devices shall be installed in strict compliance with ASHRAE and ASME guidelines affecting non-standard approach conditions.
4. Outside Air Sensors
   a. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
   b. Sensors shall be installed with a rain proof, perforated cover.
5. Water Differential Pressure Sensors
   a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
      1) Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
   b. The transmitters shall be installed in an accessible location wherever possible.
6. Duct Temperature Sensors
   a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
   b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
   c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
   d. The sensor shall be mounted to suitable supports using factory approved element holders.
7. Space Sensors
   a. Mounted per ADA requirements.
8. Averaging and Low Temperature Limit Switches
   a. Install as indicated in the control diagram.
   b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by at least 1 foot of sensor.
   c. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to obtain full coverage.
9. Air Differential Pressure Status Switches
   a. Install with static pressure tips, tubing, fittings, and air filter.
10. Water Differential Pressure Status Switches
   a. Install with shut off valves for isolation.

C. HVAC Output Devices
1. All output devices shall be installed per the manufacturer's recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, air flow stations, pressure wells, etc.
2. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the

entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.

3. Control Dampers: Shall be opposed blade for modulating control of air flow. Parallel blade dampers shall be installed for two position applications.
4. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.
5. Electronic Signal Isolation Transducers: Whenever an analog output signal from the BAS is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

3.2 TRAINING

A. The BAS contractor shall provide the following training services:
   1. One day of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BAS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

3.3 COMMISSIONING

A. Fully commission all aspects of the Building Management System work.

B. Acceptance Check Sheet
   1. Prepare a check sheet that includes all points for all functions of the BAS as indicated on the point list included in this specification.
   2. Submit the check sheet to the Engineer for approval
   3. The Engineer will use the check sheet as the basis for acceptance with the BAS Contractor.

C. ATU performance verification and documentation:
   1. The BAS Contractor shall test each air terminal unit for operation and correct flow. At each step, after a settling time, box air flows and damper positions will be sampled. Following the tests, a pass/fail report indicating results shall be produced. Possible results are Pass, No change in flow between full open and full close, Reverse operation or Maximum flow not achieved. The report shall be submitted as documentation of the installation.
   2. The BAS Contractor shall issue a report based on a sampling of the ATU calculated loop performance metrics. The report shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the non-conforming boxes along with their performance data, and shall also include graphical representations of performance.

D. Promptly rectify all listed deficiencies and submit to the Engineer that this has been done.

END OF SECTION 23 09 13

SECTION 23 09 23 - DIRECT-DIGITAL CONTROL SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. The HVAC building automation system (BAS) shall consist of a BACnet communications based network of DDC controllers and a Web-based Ethernet 10BaseT operator interface. The system shall have the capability to integrate seamlessly with a BACnet system, communicating on a BACnet IP LAN at up to 10Mbps. Provide system controllers as required to achieve sequence of operation.

B. The system shall utilize on-board flash memory that is non-volatile to power cycles. Application program, graphics and controller parameters must be stored in flash in case of a power outage.

C. Installing, integrating and configuring a network of building controllers including DDC controllers furnished with ground source heat pumps, rooftop dedicated outside air units, and all other equipment shown on drawings and specified herein. Creating HMI graphic interfaces for all DDC controllers installed for the project.

1.2 RELATED WORK

A. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC.

B. Section 23 09 13 - Instrumentation and Control Devices for HVAC.

C. Division 26: Electrical

1.3 REFERENCE STANDARDS

A. All work shall conform to the following Codes and Standards, as applicable:
1. National Fire Protection Association (NFPA) Standards
2. National Electric Code (NEC) and applicable local Electric Code
3. Underwriters Laboratories (UL) listing and labels
4. International Building Code
5. UL 864 UUKL Smoke Control
6. UL 268 Smoke Detectors
7. UL 916 Energy Management
8. NFPA 70 - National Electrical Code
9. NFPA 90A - Standard For The Installation Of Air Conditioning And Ventilating Systems
10. Factory Mutual (FM)
11. American National Standards Institute (ANSI)
12. National Electric Manufacturer's Association (NEMA)
13. American Society of Mechanical Engineers (ASME)
14. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
15. Air Movement and Control Association (AMCA)
16. Institute of Electrical and Electronic Engineers (IEEE)
17. American Standard Code for Information Interchange (ASCII)
18. Electronics Industries Association (EIA)
19. Occupational Safety and Health Administration (OSHA)
20. American Society for Testing and Materials (ASTM)
21. Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices
22. Americans Disability Act (ADA)
23. ANSI/ASHRAE Standard 195-2004 (BACnet)

B. In the case of conflicts or discrepancies, the more stringent regulation shall apply.

C. All work shall meet the approval of the Authorities Having Jurisdiction at the project site.

1.4 SUBMITTALS

A. Shop Drawings, Product Data, and Samples
1. At a minimum, submit the following:
a. BAS network architecture diagrams including all nodes and interconnections.
b. Systems schematics, sequences and flow diagrams.
c. Points schedule for each point in the BAS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.
d. Project specific GUI's and all other screens proposed for the project.
e. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
f. Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type.
g. Details of all BAS interfaces and connections to the work of other trades.

1.5 WARRANTY

A. Standard Material and Labor Warranty:
1. From date of substantial completion for the BAS system, provide a one-year labor and material warranty on the BAS.
2. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BAS Supplier/Installer at the cost of the BAS Supplier/Installer.

PART 2 - PRODUCTS

2.1 GENERAL

A. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.

B. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

2.2 ACCEPTABLE MANUFACTURERS

A. Johnson Controls - Metasys.

B. Substitutions: Not permitted.

2.3 BUILDING CONTROLLER

A. General: Provide Building Controllers (BC) as required to achieve sequence of operation. Provide BCs for HVAC equipment, exhaust fans, and for integrating heat pumps and DOAS units into BAS.

B. Stand-Alone Operation. Each BC on the BAS system shall be of true stand-alone operation. All schedules, data logs, time-clock, alarms graphics and program application shall reside in the controller. BCs that require global or master controllers or devices are not acceptable. Each BC shall be able to broadcast data from one to another or globally throughout the system in a true peer-to-peer way, any data value within the controller to any other controller, specified group of controllers, or globally around the system. Controllers shall build LAN and Internetwork communications across data networks and routers and report communications loss to Operator Interface.

C. Hardware Design. BCs must be modular in design and be mounted on standard DIN Rail for ease of replacement and expansion. Every input or output shall have 2-part connectors provided to facilitate commissioning and replacement. BCs shall have a minimum of 16 IO points and be capable of expanding to a total of 128 input-output points through a series of plug in input-output modules. Input-output modules shall be connected to the BC by a CAN network bus and have the capability of being mounted up to 33 feet from controller.

D. Hardware. Controllers shall be powered by 24VAC or DC and shall be protected by a self-resetting solid state circuit breaker and bus communications shall be protected by a multifuse. Controllers shall be rated to operate at plus or minus 15%. Each BC shall have LED status indication of network, bus, power and controller failure.

E. Memory. BC must have flash memory that is non-volatile to power cycles. Application program and controller parameters must be stored in flash in case of a power outage. Controllers using batteries to store program or parameters are not acceptable. A minimum of 16MB of SDRAM and 8MB of Flash memory shall be employed at each controller.
   1. Network communication. Each BC shall have a minimum of one 10BaseT Ethernet port as its primary network communications connection and communicate directly on the buildings TCP/IP data network without the need for master control panels. Each BC shall have an on-board Web server that will allow local or remote system control, monitoring and configuration via a standard Web browser.

F. BACnet Communication. Each BC shall be native BACnet and integrate seamlessly with a BACnet system, communicating on a BACnet IP LAN at up to 10Mbps.

G. Sequencing. BC shall execute all program sequences independent of program size once per second. Controller shall execute all program and mathematical functions and PID Loops as described in Section 2.4.E.

H. Scheduling. BC controllers shall provide the following schedule options as a minimum. All schedule, exception or holiday changes shall be configurable from the Web browser interface or the Operator Interfaces.
   1. Optimized start-stop. One optimum start-stop function shall be assigned to any schedule within the controller. Optstart functions shall be self-learning and shall have operator adjustable start-stop limits.

I. Data Logs. Each BC shall be able to log any data within a controller at one second, 1 minute, 5 minute, 10 minute, 15 minute, 20 minute, 30 minute, 1 hour, 6 hour or 24 hour intervals. 1000 points of data must be held in data log until last value is overwritten. Multiple data logs with differing intervals shall have the capability of being attached to any data point. Any data log shall be viewed from the browser or Operator Interfaces. Data logs shall be viewed in graphical or text format by the operator.

J. Alarms. BCs shall generate alarms configured by the programming tool. Alarms shall be sent to the operator interface workstation. In event that operator workstation is off-line for any reason,

alarms shall be sent to the system Display Panel, via email or cell phone text message directly from the controller across the data network to any internal or external email or cell phone email address. Alarms shall have the capability of being sent to different locations depending on schedule status or operator defined alarm group. An internal alarm log shall record the last 50 alarms generated by controller. Alarm log shall be viewed from the browser or Operator Interfaces.

K. Graphics. Each BC shall be capable of containing graphics pages of the connected mechanical equipment as well as the application program. Dynamic data points shall be shown on graphical backdrops representing all hardware and software points within the controller. Graphics pages shall contain links to other graphics pages within the controller, other building controllers on the BAS system, any intranet or Internet Website and any valid email address. Controller shall have the ability to add any user defined text to any graphics page. Graphics pages shall be accessible from any standard Web browser on the intranet or Internet.

L. Controller Input-Outputs. All controller inputs and outputs may be overridden on-off or by any analog value of the operator's choice via a standard Web browser. In addition an override timer may be initiated to switch all inputs-outputs to automatic operation after user has logged out.
   1. Controller inputs shall all be Universal Inputs and be selectable by moving a jumper for the required input type. Controller shall support thermistor, 0-10vdc voltage and 0-20 or 4-20mA current inputs with 12-bit resolution. All digital inputs shall be volt free contacts capable of pulse counting up to 30 pulses per second. When input is selected for digital, LED shall indicate when contact is closed. All sensor scaling and curves shall be software configurable.
   2. Controller shall have analog or Form C relay outputs. Analog outputs shall be modulating 0-10Vdc and current limited to 20mA as required to properly control output devices. All analog outputs shall have modulating LED's to indicate output voltage. Analog outputs shall have 11-bit resolution as a minimum. Form-C relay outputs shall have common, normally-open and normally-closed contacts. All relay outputs shall have LED's to indicate relay status.
   3. Protection. All input and outputs shall have over-voltage protection built-in to protect main board from failure.

M. PID Loops. Loops shall have the capability to be sequenced once per second and switched between occupied and unoccupied setpoints. In addition, a manual override and level may be initiated and implemented in logic. PID Loops shall support drift-limit alarm and controlled input alarms. Should controlled input fail or alarm, one of the following actions shall be initiated:
   1. Maintain output at level when sensor failed and return to normal operation on alarm clear.
   2. Automatically go to pre-defined controlled input value and return to normal operation on alarm clear.
   3. Automatically go to pre-defined loop output level and return to normal operation on alarm clear.
   4. Automatically go to pre-defined loop output level and stay there until a alarm clears and a manual override is initiated by operator.

N. Runtime Totalization. Controller shall provide an algorithm that can totalize runtime for each digital input or output and calculate the number of starts. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit via the Web browser interface.

O. Staggered Start. Controller shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts via the Web browser interface.

P. Web Browser. In addition, the Web browser interface shall support the following functions on the building controller other than outlined above:
   1. Configuration and editing of any function or programming module stored within the controller.
   2. Operator override of any function module or software point within the controller in addition to the physical input-outputs.
   3. Support of navigation through logic flow diagram to support commissioning via the browser.
   4. Display lists of each type of function or programming module within the controller in numerical order and highlight any current alarm points in flashing red format.
   5. Operation will be mouse driven point and click between views, graphics and modules. Values shall be changed by drop-down menus or by clicking and typing in open fields.

2.4 BACNET UNITARY CONTROLLERS

A. Provide fully programmable BACnet VAV controllers with or without an on-board actuator. Both shall include a built-in airflow sensor and a pressure transducer. BACnet VAV controllers shall have a pre-loaded strategy and also shall be fully programmable.

B. Provide fully programmable BACnet unitary controllers with universal I/O for terminal equipment control of RTU's, HP, FCU, UV, and others.

C. Network Communication. As a BACnet controller, the unitary controllers shall integrate seamlessly with the building control system, communicating at up to 76.8Kbps on a BACnet MS/TP LAN.

D. Hardware Design. BACnet VAV controller actuator shall be left or right mountable with ability to set actuator to clockwise or counter-clockwise rotation. BACnet unitary controllers shall be DIN-rail mounted and have software-configurable inputs and outputs allowing for compatibility with a wide range of HVAC and other control and monitoring applications.

PART 3 - EXECUTION

3.1 BAS REQUIREMENTS

A. Graphic Displays
   1. Provide a color graphic system flow diagram display for each system including each ground source heat pump and DOAS unit with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library. Provide a floor graphic of each area of the building with capability to see temperature and humidity of each space or system and allow penetration to individual heat pumps, VAV boxes, etc. from the graphic floor plan.
   2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

B. Custom Reports:
   1. Provide custom reports as required for this project

C. Actuation / Control Type
   1. Primary Equipment:
      a. Controls shall be provided by equipment manufacturer as specified herein.
      b. All damper and valve actuation shall be electric.
   2. Air Handling Equipment:
      a. All air handlers shall be controlled with a HVAC-DDC Controller.

b. All damper and valve actuation shall be electric.

3. Terminal Equipment:
   a. Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation.
   b. All Terminal Units shall be controlled with HVAC-DDC Controller)

3.2 INSTALLATION

A. BAS Wiring
1. All conduit, wiring, accessories and wiring connections required for the installation of the Building Automation System, as herein specified, shall be provided by the BAS Supplier/Installer unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 and all local and national electric codes, unless specified otherwise in this section.
2. All BAS wiring materials and installation methods shall comply with BAS manufacturer recommendations.
3. The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the BAS Supplier/Installer. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BAS Supplier/Installer, the Supplier/Installer shall be responsible for all costs incurred in replacing the selected components.
4. Class 2 Wiring
   a. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
   b. Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5' from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
5. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
6. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

B. BAS Line Voltage Power Source
1. 120-volt AC circuits used for the Building Automation System shall be taken from panel boards and circuit breakers provided by Division 26.
2. Circuits used for the BAS shall be dedicated to the BAS and shall not be used for any other purposes.
3. DDC terminal unit controllers may use AC power from motor power circuits.

C. BAS Raceway
1. All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2".
2. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.
3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
4. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

D. Penetrations

1. Provide UL rated fire stopping for all penetrations used by dedicated BAS conduits and raceways.
2. All openings in fire proofed or fire stopped components shall be closed by using UL approved fire resistive sealant.
3. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

E. BAS Identification Standards
1. Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.

F. Cable types specified in Item A shall be color coded for easy identification and troubleshooting.

G. BAS Panel Installation
1. The BAS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
2. The BAS Supplier/Installer shall be responsible for coordinating panel locations with other trades including work specified under Divisions 23 and 26.

3.3 TRAINING

A. The BAS Supplier/Installer shall provide the following training services:
1. One day of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BAS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

3.4 COMMISSIONING

A. Fully commission all aspects of the Building Automation System work.

B. Acceptance Check Sheet
1. Prepare a check sheet that includes all points for all functions of the BAS as indicated on the point list included in this specification.
2. Submit the check sheet to the Engineer for approval
3. The Engineer will use the check sheet as the basis for acceptance with the BAS Supplier/Installer.

C. Promptly rectify all listed deficiencies and submit to the Engineer that this has been done.

END OF SECTION 23 09 23

SECTION 23 21 13 - HVAC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping and pipe fittings for:
   1. Chilled Water Piping
   2. Heating Water Piping

1.2 RELATED REQUIREMENTS

A. Section 23 05 00 - Common Work Results for HVAC

B. Section 23 21 16 - Hydronic Piping Specialties

C. Section 23 05 23 - General Duty Valves for HVAC

D. Section 23 07 00 - HVAC Insulation

E. Section 23 22 16 - Steam and Condensate Specialties

1.3 REFERENCE STANDARDS

A. ASME B1.1 - Unified Inch Screw Threads; 2008.

B. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2011.

C. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard; 2013.

D. ASME B16.9 - Factory Made Wrought Buttwelding Fittings; 2012.

E. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2012.

F. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; 2013.

G. ASME B18.2 - Square, Hex, Heavy Hex, and Askew Head bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws; 2013.

H. ASME B31.1 - Power Piping; 2014.

I. ASME B31.3 - Process Piping; 2012.

J. ASME B31.9 - Building Services Piping; 2014 (ANSI/ASME B31.9).

K. ASTM A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings; 2010.

L. ASTM A21.51 - American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water; 2002.

M. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2012.

N. ASTM A106/A106M - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service; 2013.

O. ASTM A193 - Standard Specification for alloy Steel and Stainless Steel Bolting Materials for High Temperature Service; 2014.

P. ASTM A194 - Standard Specification for Carbon and Alloy Steel Nuts for bolts for High Pressure or High Temperature Service, or Both; 2014.

Q. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod; 2014.

R. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts; 2014.

S. ASTM A449 - Standard Specification for Quenched and Tempered Steel bolts and Studs; 2004.

T. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2009.

U. AWWA C110/A21.10 - American National Standard for Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (75 mm Through 1200 mm), for Water and Other Liquids; American Water Works Association; 2012.

V. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast, for Water; American Water Works Association; 2009 (ANSI/AWWA C151/A21.51).

W. MSS SP-25 - Standard Marking System for Valves, Fittings, Flanges, and Unions; 2013.

1.4 SUBMITTALS

A. Submit product data for review in accordance with the requirements of Division 01 for piping and fittings. Submittal data shall include but not be limited to:
1. Manufacturer of pipe.
2. Tests or listings by recognized testing laboratory that certifies material composition is in accordance with ANSI/ASTM requirements.
3. Product data for pipe and fittings to be used on each piping system.
4. Welding procedures for steel pipe.
5. Solder and brazing product data and installation procedures for copper pipe.

PART 2 - PRODUCTS

2.1 STEEL PIPE

A. Black steel: Electric resistance welded or seamless, ASTM A53 or ASTM A106 Grade B. Mill wrap uninsulated underground steel pipe with Republic X-Tru-Coat or equal.
1. Through 10" standard weight Schedule 40
2. 12" pipe and larger: standard weight with 0.375" wall thickness

B. Provide for the following services:
1. Chilled water supply and return piping, 1-1/4" diameter and larger. (Contractor option: copper up to 2" diameter; see "COPPER PIPE" below.)
2. Chilled water supply and return piping, 2-1/2" diameter and larger.
3. Heating water supply and return piping, 1-1/4" diameter and larger. (Contractor option: copper up to 2" diameter. See "COPPER PIPE" below.)
4. Heating water supply and return piping, 2-1/2" diameter and larger.

2.2 STEEL PIPE FITTINGS

A. Flanges, Fittings, and Unions: Mark in accordance with MSS-SP-25.

B. Fittings:
1. 2-1/2" and larger: Class 150, wrought steel, butt welded fittings, ASME B16.9
2. 2" and Smaller

a. Water Service: Class 150, malleable iron, screwed.
b. Condensate: Class 150 malleable iron, A53 screwed, ASME B16.3

C. Flanges, 2-1/2" and larger: Class 150, A53 wrought forged steel, slip-on or weld neck, ASME/ANSI B16.5. Flange faces shall match equipment or mating flanges (i.e. flat-faced flanges shall be used adjacent to equipment with integral flat-faced flanges, such as pumps, control valves, etc.)

D. Gaskets:
1. Inorganic fibers, 1/16 or 1/8 inch thick, reinforced EPDM binder, 550 deg F (continuous) and 700 psig operation, Garlock 5507 or equal:
a. Chilled water
b. Heating water
2. Spiral wound "chevron" metallic gaskets, flexible graphic filler, class 150 and 300 service, Flexitallic LS, CG or equal
a. Qench Vent

E. Unions, 2" and smaller: Material as specified under fittings, screwed with brass seat.

F. Branch connections from mains or headers, 2-1/2" and larger: Welded tees or welding outlets, Bonney Forge Weldolets or Threadolets. Use forged outlets only if branch line is at least one pipe size smaller than main or header.

G. Galvanized steel pipe fittings: Same as above, except galvanized coated.
1. Provide drainage pattern type fittings for drain piping.

H. Bolting Materials: Torque all bolts to 50% of yield strength or per equipment manufacturer's recommendation, whichever is lower. Use anti-seize lubricant on all bolt threads. Same finished carbon steel bolts and hex nuts, ASTM A307. Threads and Dimensions: ASME/ANSI B1.1 and B18.2.
1. Systems 210 degrees F and less: Use ASTM A449 studs or bolts and ASTM-A563 Grade B hex nuts
2. Systems above 210 degrees F: Use ASTM-A193 Grade B7 studs or bolts and ASTM-A194 Grade 2 Heavy Hex Nuts
3. Use galvanized bolts and nuts on piping outside outide the building, inside tunnels, and inside manholes.

I. Thread Lubricant: Similar to Crane "Formula 425".

2.3 COPPER PIPE

A. Conform to ASTM B-88 specification for wrought seamless copper.

B. Type L, hard for:
1. HVAC reheat water pipe, 1" and smaller; Contractor option for copper or steel pipe 1-1/4" to 2".
2. HVAC reheat water pipe, 2" and smaller.
3. HVAC chilled water pipe, 1" and smaller. Contractor option for copper or steel pipe 1-1/4" to 2".

C. Type M, hard for:
1. For non-pressurized drain piping.
2. Fan coil unit condensate piping.
3. Cooling coil condensate piping.

2.4 COPPER PIPE FITTINGS

A. Sweat type, wrought copper, ASTM B62, with dimensions conforming to ASTM/ANSI B16.22 and sweep patterns for copper tubing.

B. Dielectric Connections:
1. Provide at junction of copper pipe and equipment with steel piping systems.
2. Central, Dielectric insulating unions, and insulating flange unions, as manufactured by Central Plastic Company or CTS Fabrication USA (1-1/2" thru 8").
3. Provide copper solder joint to plated female iron pipe for sizes 1/2" through 2".
4. Provide insulating flange unions, malleable female iron pipe thread to copper solder joint flange unions for sizes 2-1/2" through 4".
5. Brass fittings and valves may not be used for dielectric union locations.

C. Unions: Brass ground joint, 250 lb. working pressure.

D. Nipples: Brass.

2.5 STAINLESS STEEL PIPE AND FITTINGS

A. Stainless Steel Pipe: ASTM A312, Type 304/204L, Schedule 10S may be used in lieu of copper piping.

B. Fittings: Precision, cold drawn, stainless steel, suitable for working pressure to 500 psig.

2.6 MISCELLANEOUS PIPE ACCESSORIES

A. Escutcheons: Chrome pipe escutcheons, slip-on or split type where pipe passing through finished walls or ceiling may be visible.

B. Exposed Metal Pipe and Trim: Chrome plated.

C. Control System Connectors: Crane No. 386, 1" steel half couplings, or 1" female pipe thread connectors.

D. Install 18 gauge sheetmetal or galvanized steel pipe saddles to protect insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Clean inside of pipe before installation. Keep installed piping clean, and protect ends from foreign matter by capping or plugging them.

B. Install pipe so that it does not interfere with opening of doors or apparatus, access to equipment, or to electrical equipment.

C. Do not install pipes in such a way that they will apply torque to pumps. After pumps have been installed and pumps have been operated, recheck and realign pumps if necessary.

D. Run pipes in straight lines and square with building. Install risers plumb. Make offsets only where indicated and where necessary.

E. Install branch connections using separate tee or lateral fittings for each branch. Do not combine branches into "bullhead tee" arrangement.

F. Do not install water pipes in electric rooms, tele/data and IDF rooms, transformer rooms, audio/visual rooms or elevator equipment rooms. Fire protection piping runouts serving only these rooms shall be installed in these rooms.

G. Do not install piping above electrical equipment such as starters, variable frequency motor controllers, motor control centers, or disconnects. Maintain code required clearance above, below and to sides of electrical equipment.

H. Provide flanges or unions throughout the pipe systems at all equipment. Make provisions for servicing and removal of equipment without dismantling piping.

I. In so far as possible, drainage piping shall not be installed overhead, whether exposed or above ceiling, in operating rooms, delivery rooms, nurseries, food preparation or serving areas, or in rooms listed above. Where unavoidable, provide drain troughs or other means to carry away leakage.
   1. Grading Pipes for Drainage:
   2. Slope cooling coil condensate drains at 1/8" per foot.

J. Slope steam pipes and steam condensate drain pipes at 1/4" per 10 feet. Do not raise condensate pipe except at ends of main drips.

K. Branch Lines:
   1. Where possible branch lines shall come off top of mains to prevent sediment, welding slag, or pipe burrs from entering the branch lines and causing valve leakage or failure.

3.2 PIPE JOINTING

A. Preparing Pipe Ends:
   1. Machine cut pipe ends square.
   2. Ream pipe ends, after cutting, to full diameter.
   3. Where pipe is to be threaded, secure pipe in pipe stand, die cut, full depth, right hand threads. Threads to be taper type.
   4. All threaded pipe joints to have suitable pipe sealant applied to threads prior to assembly of joint. Joints shall be leak proof.
   5. Where pipe is to be welded, die-cut end of butt joints at 30 degree taper. Weld should have a full penetration with no bubbles or holes. Remove all slag.

B. Welded Steel Piping:
   1. Where welded piping is specified, make welds by oxy-acetylene process or electric process in accordance with ASME/ANSI B31.1.
      a. Welding Rods: Grade recommended for purpose by manufacturer's and identification.
   2. Line welds, single V-butt type:
      a. Mill or machine bevel pipe at 37 1/2 degrees to within 1/16" of inside wall, except that in field limited amount of pipe may be flame beveled.
      b. Pipe with a wall thickness of 3/16" or less need not be beveled but may be welded by melting down into building up over abutting ends.
      c. Separate abutting ends of joints before welding to permit complete fusion to bottom without overlapping.
      d. Tack in two or more points to maintain alignment, and fusion weld.
   3. Make all welds of sound weld metal, thoroughly fused into ends of pipe, and to bottom of vee.
      a. Build in excess of pipe wall to give reinforcement to one fourth pipe wall thickness.

b. Weld metal shall present a gradual increase in thickness from surface of pipe to center of weld.
c. Minimum weld width: Two and one half times thickness of pipe wall.

4. Use welding ells at turns in welded lines
5. Do not weld pipe couplings in place of welding fittings for any branch connections.
6. Weld-o-lets and thread-o-lets:
   a. Scribe and cut openings in main pipes for welded branches accurately taking care to remove all of plugs and cuttings from main pipe.
   b. Full weld fillet welds for full depth of fillet, with additional beads to form well rounded connection as recommended by weld-o-let manufacturer.
7. Cut openings into pipe for welded connections accurately to give matched intersections.
8. Make welded fittings of same material with same pressure and temperature rating as pipe with which they are used.
9. Make flanged connections to control valves, pump suction and specialties with ANSI standard welding neck flanges. All other flange connections may be made with slip-on flanges provided they are seal welded on inside.
10. Fuse all fillet welds for flanges or fittings into pipe and plate for minimum distance of 1-1/2 times pipe wall thickness and depth weld on 1-1/4 times pipe wall thickness.

C. Soldered and Brazed Joints:
   1. Make Type L and M copper pipe joints with suitable flux and 95/5, lead free solder.

D. Bracing Joints:
   1. Provide braces and bridle rods as required to reinforce joints.
   2. If mechanical lock type couplings are used, then prepare pipe ends and make joints in accordance with pipe coupling manufacturer's printed instructions.
   3. Where large pipes underground are subject to shock because of sudden changes in liquid flow rate, provide concrete "kicker" blocks at joints, fittings, and changes of pipe direction. Provide "kicker" blocks in accordance with applicable pipe industry trade or research organization recommendations.
      a. For example, for ductile iron pipe follow recommendations of Ductile Iron Pipe Research Association.

3.3 ESCUTCHEONS

A. Provide chrome plated escutcheons where uninsulated pipes penetrate walls or ceilings of finished spaces.

3.4 STRAINERS

A. Install strainers so the strainer basket can be removed without spilling water on motors and electrical equipment.

3.5 AIR VENTING

A. Provide manually operated air vents at high points in vertical risers and at water coils to eliminate air from systems. Air vents are not required at reheat coils.

B. Use ball valves for manual air vents.

3.6 VALVE ACCESS

A. Locate ceiling/wall access panels at shut-off and control valves for proper access and operation. Furnish and install access doors in accordance with Section 23 05 00 and other Divisions as applicable.

3.7 COOLING TOWER BLEED

A. Coordinate bleed off requirements with chemical treatment vendor. Provide piping, fittings, and valves as required.

3.8 CONTROL SYSTEM CONNECTORS

A. Weld connectors at points indicated, and at other points where necessary for installation of thermometers, sensors, and automatic controls.

3.9 TESTING

A. Before piping is concealed or insulated, recheck it for leaks.

B. Rework or replace defective and leaking joints, and joints which are otherwise unsatisfactory. Peening, caulking, and doping are not permitted.

END OF SECTION 23 21 13

SECTION 23 21 16 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section includes requirements for:
1. P.T. test plugs
2. Pressure gauges
3. Thermometers
4. Hydronic pressure reducing valves
5. Triple duty valves
6. Water to water plate/frame heat exchanger
7. Strainers

1.2 RELATED REQUIREMENTS

A. Section 23 21 13 - HVAC Piping

B. Section 23 21 23 - HVAC Pumps

1.3 SUBMITTALS

A. Submit product data for review in accordance with the requirements of Division 01 including:
1. P.T. plugs
2. Pressure gauges
3. Thermometers
4. Thermometer test wells
5. Hydronic pressure reducing valves
6. Relief valves
7. Triple duty valves
8. Flow measuring station
9. Water to water plate/frame heat exchanger
10. Strainers

B. Operation and Maintenence Data

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in the manufacture of the products specified herein for a minimum of five years of documented experience.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. As noted in the individual product paragraphs.

2.2 P.T. TEST PLUGS

A. Acceptable Manufacturers: Peterson Engineering or approved equal.

B. Provide 1/4" solid brass pressure/temperature test plugs at locations shown on drawings.

C. Provide N2 Nordel self-closing valve rated for 275 degrees F service.

D. P.T. test plugs shall be installed at the following locations and elsewhere as shown on the drawings.
   1. Entrance and exit of building when connected to the chilled water central plant.
   2. At suction and discharge of pumps.
   3. At water inlet and outlet of heat exchanger.
   4. At water inlet and outlet of air handling unit coils.
   5. Adjacent to each pressure gauge and thermometer.

2.3 PRESSURE GAUGES

A. Acceptable Manufacturers: Ashcroft, Dwyer, Trerice, or Weiss.

B. Type: Round face, dial type.

C. Trerice 800 LF, 3-1/2" face, glycerin filled, ASME B40.1 Grade A accuracy, 1% full scale, with ranges noted below:
   1. Constant flow primary chilled water 0-100 psi range
   2. Variable flow primary chilled water 0-160 psi
   3. Secondary chilled water 0-160 psi
   4. Condenser water 0-100 psi

D. Trerice P500, 4-1/2" face, ASME B40.1 Grade A accuracy, 1% full scale; stainless steel Bourdon tube for high operating Temperatures with ranges noted below:
   1. Reheat hot water - 0-100 psi
   2. Heating Hot water - 0-100 psi

E. Gauge Cocks: Trerice Model 735 needle valves.

F. For hydronic systems, provide 1/4" ball valve and install a 1/4" brass ground joint union between valve and gauge. Gauge cocks shall not be used for pressure gauge isolation.

G. Provide Trerice Model 872 snubber on all gauges.

H. For pressure gauges serving hydronic systems, pipe from the pressure gauge to the pipe.

I. Select scale range of gauges to indicate design pressure at middle 1/3 of scale.

2.4 THERMOMETERS

A. Acceptable Manufacturers: Ashcroft, Dwyer, Trerice, or Weiss.

B. Provide Trerice Model BX91403-1/2 9" scale, non-mercury, red or blue spirit filled thermometers, adjustable angle (rear, front, and side), with separable stainless steel wells at locations shown on drawings. Thermometer scales shall be capable of calibrations by sliding the scale while leaving the spirit-filled tube stationary.

C. At a minimum, provide thermometers across AHU coils, heat exchangers, and at chilled water entering and leaving the building.

D. Dial Type Thermometers: Stainless steel, 5" diameter case, adjustable angle with front calibration, bimetallic helix actuated with silicone fluid dampening, white with black markings and black pointer, stainless steel stem, 1% accuracy across full range.

E. Range:
   1. Chilled water: 30 degrees F. - 130 degrees F

2. Condenser water: 30 degrees F.- 130 degrees F
3. Reheat hot water: 30 degrees F. - 240 degrees F
4. Food Service Heat Rejection - 30 degrees F. - 130 degrees F

2.5 HYDRONIC PRESSURE REDUCING VALVES

A. Acceptable Manufacturer: Bell & Gossett, Taco, or approved equal.

B. Equip each valve with antisyphon check valve and removable strainer.

C. Select reducing valve for operation at midpoint of adjustment range.

D. Provide factory set pressure reducing valve with adjustable range.

2.6 TRIPLE DUTY VALVES

A. Acceptable Manufacturers: Bell & Gossett, Keckley, or Taco.

B. Type: Similar to Bell & Gossett No. 3DS.

C. Provide triple duty valves as shown on the plans that incorporate non-slam, vertical lift check, calibrated balance, and positive shutoff, all in one valve.

D. Provide valve weighted disc, hand lap seat and disc, and suitable for 300 degrees F operating temperature.

E. Unit to be cast iron body construction, suitable for maximum working pressure as specified on drawings.

2.7 WATER TO WATER PLATE/FRAME HEAT EXCHANGER

A. Acceptable Manufacturers: Alfa-Laval, Armstrong, Bell & Gossett, Graham, Mueller, or SPX / APV

B. Materials of Construction:
1. Plates shall be Type 304 stainless steel, with herringbone corrugations, minimum with minimum thickness of 0.5 mm.
2. Gaskets shall be one piece, molded, nitrile butadiene rubber.
3. Frame shall be epoxy coated carbon steel.
4. Tie rods, bolts, nuts and washers shall be zinc plated or stainless steel.
5. Safety shroud shall be aluminum, to meet OSHA requirements.

C. Fabrication/Assembly:
1. Unit shall be designed, manufactured and tested in accordance with ASME, Section VIII for design working pressure of 100 psig. Unit shall be tested at design pressure x 1.5. Unit shall withstand full design pressure in one circuit with zero psig in opposite circuit.
2. Unit shall be bolted together to allow field assembly. Exchanger shall have capacity for future addition of 20 plates.
3. Provide lifting lugs capable of supporting weight of flooded unit.
4. Unit shall be designed using a fouling factor of 0.001 at conditions and capacities required.
5. Connections 2-1/2" and above shall be ANSI flanged; connections 2" and less shall be IPS threaded connections.

2.8 STRAINERS

A. Acceptable Manufacturers: Elliott, Mueller, Keckley, or Wheatley.

B. Cast semi-steel body or cast iron construction for steel piping and bronze body construction for copper piping; equipped with removable, Monel or stainless steel 20 mesh, water screen; maximum pressure drop 2 psi with free area at least four times area of pipe. Provide with blow-off outlet piped to nearest floor drain.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install hydronic specialty items in locations shown on drawings.

B. Insulate any components subject to sweating or any hot or cold service in accordance with Section 23 07 00.

C. Utilize manufacturer's instructions to install specialty items. Manufacturer's instructions must be adhered to for proper operation of air removal devices and flow control valves.

D. Provide manual air vents at top of pipe risers and other locations where air can be trapped or collected.

E. Pipe relief valve outlets and drain connections from hydronic systems to nearest floor drain.

F. Support pump inlet and strainer fittings with floor mounted pipe and flange supports.

G. Locate thermometers and pressure gauges no higher than 7 feet above finished floor elevation, positioned to be read from the floor.

H. After systems are started up, placed in service and tested/adjusted to perform as designed, contractor shall provide competent representative to demonstrate proper operation and provide instruction to maintenance personnel to include performance on both cooling and heating cycles.

I. At a minimum, pressure gauges and thermometers shall be installed at the following locations:
1. Suction and discharge of pumps.
2. Water side, Inlet and outlet of heat exchangers.
3. Water side, inlet and outlet of air handling units.
4. Building entrance and exit on chilled water plant and chilled water systems.

END OF SECTION 23 21 16

SECTION 23 31 13 - SHEETMETAL DUCTWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Rectangular Metal Ducts

B. Round Ducts

C. Double Wall Round and Flat-Oval Spiral Ducts

1.2 RELATED REQUIREMENTS

A. Division 07 - Firestopping

B. Division 09 - Painting and Coating

C. Section 23 01 30.51 - HVAC Air Duct Cleaning

D. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment

E. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC

F. Section 23 07 00 - HVAC Insulation

G. Section 23 33 00 - Air Duct Accessories

H. Section 23 36 00 - Air Terminal Units

I. Section 23 37 00 - Air Outlets and Inlets

1.3 REFERENCE STANDARDS

A. ASHRAE Handbook - Fundamentals; 2013.

B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2013.

C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2014.

D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2012.

E. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems; National Fire Protection Association; 2012.

F. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; National Fire Protection Association; 2014.

G. SMACNA 1972 - HVAC Air Duct Leakage Test Manual; Sheet Metal and Air Conditioning Contractors' National Association; 2012, 2nd Edition.

H. SMACNA 1966 - HVAC Duct Construction Standards; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

I. SMACNA 1767 - Kitchen Ventilation Systems and Food Service Equipment Fabrication & Installation Guidelines; 2001.

J. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

K. UL 1978 - Grease Ducts; Current Edition, Including All Revisions.

L. UL 2221 - Tests of Fire Resistive Grease Duct Enclosure Assemblies; Current Edition, Including All Revisions.

1.4 SUBMITTALS

A. Submit material/product data as described in Division 01.

B. Shop Drawings: Provide shop drawings of sheet metal shop ductwork, as follows:
1. Draw to a scale not less than 1/4-inch to one foot
2. Provide sheet sizes equal to Contract Drawings
3. Show duct sizes
4. Show fitting details
5. Show lighting and ceiling diffusers
6. Show bottom of duct elevation above finished floor
7. Show all manual and motorized dampers and associated access doors.
8. Show HVAC equipment, all air terminal units, and air quantities.

C. Coordinated Shop Drawings: Provide coordinated shop drawings for sheet metal work in mechanical equipment rooms, and other congested areas listed.
1. Draw to a scale of 1/2 inch to 1 foot.
2. Provide sheet sizes to match Contract Drawings.
3. Show duct sizes.
4. Show bottom duct elevations from finished floor.
5. Show lighting, equipment, maintenance and operating clearances, HVAC piping, plumbing piping, medical gas piping, pneumatic tube system, conduit 3" and larger, and columns and beams with mounting heights.
6. Show construction details of all fittings and connections to equipment.
7. Show construction details of plenums and casing.

D. Coordinated Shop Drawings shall be completed for all areas prior to installation of the major trades. The coordinated shop drawings are not required to be submitted except as noted above. A coordinated shop drawing attempt shall be submitted with any request to the owner or design team to assist with overhead coordination conflicts.

E. Certifications: Provide a duct schedule, certified by an officer of the sheet metal fabrication subcontractor, that the ductwork conforms to SMACNA standards. For each sheet metal system furnished on the project include:
1. System name
2. Duct material
3. Duct gauge
4. SMACNA rectangular reinforcement number
5. SMACNA intermediate reinforcement number
6. SMACNA transverse reinforcement number
7. Rod diameter and type
8. Sealant type
9. Attachment method
10. Duct system design pressure

F. Field Conditions
   1. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturer.
   2. Maintain temperature within acceptable range during and after installation of duct sealants.

1.5 QUALITY ASSURANCE

A. Provide an installed duct system which will supply the air quantities indicated by the drawings and have the lowest possible friction loss with the least possible leakage loss. System static pressure loss for each system shall not exceed that which is indicated in the equipment 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. Maintain access to accessories requiring maintenance, service, and inspection. Radius elbows are preferred for turns to minimize friction, noise, and vibrations.

B. Provide and/or construct materials, ductwork, joints, transformations, splitters, dampers, and access doors as specified herein for the sheet metal ductwork as shown on drawings.

C. SMACNA Manual: Sheet Metal Tradesman shall have access on the construction site to "HVAC Duct Construction Standards". Comply with applicable provisions of the SMACNA Manual and more stringent requirements of this specification.

D. Quality control involves not only the general performance requirements for air ducts, but also quality workmanship which includes layout pre-planning so that offsets, rises, falls, elbows, fittings, etc., are minimized or eliminated. General performance requirements for ducts include:
   1. Dimensional stability (shape deformation and strength)
   2. Containment of the air being conveyed (leakage control). See Part 3 of this specification for leakage testing.
   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. Seismic restraint
   8. Thermal conductivity (heat gain or loss and condensation control)

E. Provide galvanized duct materials which meet applicable requirements of local and state codes, whichever is the most stringent.

F. Support ductwork in accordance with applicable requirements of local and state codes and details on drawings.

G. Emboss fittings with material gauge, manufacturer, and type material.

H. Sealers, liners, pre-insulated jackets and flexible ducts shall comply with a flame spread rating of 25 or less and a smoke developed rating of not over 50.

PART 2 - PRODUCTS

2.1 MATERIAL

A. Sheet metal ductwork, angles, bar slips, hangers, and straps: Galvanized, prime quality steel sheets.

B. Screws: Cadmium plated.

C. Joint Sealers: water resistant, mildew and mold resistant.
1. Suitable for indoor and outdoor use, fiber reinforced, with UV inhibitors.
2. Surface burning characteristics: Flame spread of zero and smoke developed of zero when tested in accordance with ASTM E84.
3. Suitable for use with flexible ducts and UL listed.
4. Acceptable Products:
   a. Substitutions: Not permitted.
5. Pressure sensitive tape is not acceptable.

D. Duct Sealing:
1. All longitudinal and transverse joints, seams and duct sidewall penetrations, regardless of pressure classification, shall be sealed with duct sealer. Follow SMANCA Table 1-2, Seal Class A for all supply, return, exhaust, relief, and make-up air ductwork.
2. See Leakage Testing of Installed Systems requirements in Part 3.

E. Sheetmetal accessories: As specified in Section 23 23 00.

2.2 PRESSURE CLASSIFICATION

A. Ductwork where maximum dimension is less than 97" shall be constructed based on applicable pressure classification in accordance with SMACNA Manual including sheetmetal gauge, reinforcement gauge and spacing.

B. Construct the following for 1" pressure classification, Table 1- 4:
1. Supply ductwork downstream of air terminal units
2. Low pressure supply ductwork to reheat coils
3. Low pressure supply, return, and outside air ductwork at fan coil units

C. Construct the following for 2" pressure classification, Table 1- 5:
1. Return ductwork
2. Exhaust ductwork
3. Make-up air ductwork

D. Construct the following for 6" w.g. pressure classification Table 1-8:
1. Supply ductwork and plenums downstream of supply fans up to air terminal units

2.3 RECTANGULAR DUCTWORK

A. Transverse Joints:
1. "S" and drive construction for 1" and 2" w.g. pressure classification.
   a. Provide duct gauge and reinforcing angles in accordance with Table 1-11
2. Duct Connection System: Connection system as manufactured by Ductmate or Nexus shall incorporate gasketed joints, metal cleats and bolted corners. Minimum metal gauge shall be 24 gauge. Connection systems may be used for all pressure classifications.

3. For pressure classifications above 2", use double "S" joint up to 30" and companion angle or manufacturer's connection system above 30".

B. Longitudinal Seams: Pittsburg Lock

C. Transitions:
1. Do not exceed 1" in 7" of slope for increase-in-area transitions.
2. Do not exceed 1" in 4" of slope for decrease-in-area transitions, 1" in 7" is preferable.
3. Do not exceed 45 degrees on the entering or leaving side for angle of transitions at connections to equipment without the use of approved turning vanes.

D. Elbows:
1. Fabricate ells using one of the following specifications: The fabrication methods are listed in order of preference. Use radius elbows where ever possible. Use square elbows only when available space prevents the use of radius elbows.
   a. Unvaned, long radius elbow with the throat radius equal to 3/4 of the width of the duct and with a full heel radius.
   b. Six inch throat radius with full radius, single thickness vanes and full heel radius. Maximum unsupported length of vanes shall be 36". Securely fasten vanes to runners. Secure vanes in stable position. Construct vane edges to project tangents parallel to duct sides.
   c. Square elbows with airfoil, double thickness turning vanes.
2. Turning vanes:
   a. Acceptable manufacturers: Aero Dyne
   b. Substitutions: Not permitted.
   c. True airfoil design; smoothly-rounded entry nose with extended trailing edge. Generated sound power level shall not exceed 54 decibels in band 4 at 2000 FPM in a 24"x24" duct.
   d. Fabricate assemblies with Aero Dyne Co. side rails; install vanes on design centers of 2.4 inches across the full diagonal dimension of the elbow.
   e. Submit Aero Dyne product and performance data for review.

E. Branch Connections:
1. Pressure classification 2" and less:
   a. Rectangular branch from rectangular main: 45 degree entry with all corners closed as shown in Figure 2-8
   b. Round branches: Spin-in fitting without scoop.
   c. Parallel flow branches: See Figure 2-7.
   d. Space duct joints to avoid cutting them for branch take offs and outlet collars.
2. Pressure classification above 2":
   a. Round branches: Conical round fittings only.
   b. Rectangular branch from rectangular main: 45 degree entry with all corners closed as shown in Figure 2-8
   c. Parallel flow branches: See Figure 2-7.
   d. Space duct joints to avoid cutting them for branch take offs and outlet collars.

2.4 ROUND DUCTWORK

A. Applicable for pressure classification above 2".

B. Round Duct (Spiral Pipe) and Fittings:
1. Manufactured from galvanized steel meeting ASTM A653/A653M. Construction shall be in accordance with SMACNA HVAC Duct Construction Standards.

2. Use appropriate seams made to eliminate leakage based on pressures for which system has been designed. Longitudinal seam duct to have fusion welded butt seam.
3. Fittings and couplings shall have minimum gauges specified by SMACNA Manual.
4. Fittings shall have continuous welds along all seams. Divided flow fittings shall be manufactured as separate fittings, not as tap collars welded into spiral duct sections.
5. Ninety degree tees (conical) and 45 degree laterals (wye) up to and including 12" diameter tap size to have radiused entrance into the tap, produced by machine or press forming. Entrances to be free of weld build-up, burrs, or irregularities.
6. Elbows in diameters 3" thru 8" shall be two section stamped elbows. Other elbows shall be gored construction with all seams continuous welded. Fabricate to center line radius of 1.5 times the cross sectional diameter. Elbows, not die-stamped, shall be fabricated as follows:
   a. Less than 30 degree angle: minimum 2 gores
   b. Between 30 thru 60 degrees: minimum 3 gores
   c. Over 60 degrees: minimum 5 gores
7. Two piece mitered elbows shall not be used.
8. Tees shall be conical. Saddle taps or straight tees shall not be used.
9. The leading edge of all vanes in ducts over 20" diameter shall be hemmed with 1/2" foldback. Turning vanes in ducts over 24"shall be reinforced by stays or sectional construction to limit unsupported length to 24". Vanes shall be a minimum of 20 gauge.
10. Reduction of divided flow fittings to conical span section in the 36 common reductions in sizes 4" thru 22".
11. Spun bellmouth connections are to be used at each round take-off from plenum.
12. Galvanized areas damaged by welding to be coated with corrosion resistant aluminum paint.

C. Couplings for Round Medium-Pressure Duct (over 2" w.g.):
1. Pipe-to-pipe joints shall be sleeve couplings, reinforced by rolled beads.
2. Pipe-to-fitting joints shall be slip-fit of projecting collar fitting into pipe.
3. Insertion length of sleeve coupling and fitting collar shall be 2" minimum.

2.5 DOUBLE WALL INSULATED ROUND AND FLAT OVAL DUCTWORK

A. Acceptable manufacturers: McGill Airflow, Semco, or Eastern Sheetmetal.

B. Provide all bowl supply ductwork and other exposed round and flat oval ductwork which complies with requirements specified herein.

C. Construction: All duct and fittings shall be a minimum G-90 galvanized sheet metal in accordance with ASTM A653 and A924 specifications.

D. Gauges: In accordance with SMACNA HVAC Duct Construction standards.

E. Insulation: Maximum thermal conductivity (k) of 0.27 Btu/hr/sq ft/°F/inch thickness at 75°F mean temperature. Provide insulation ends at all locations where internally insulated duct connects to single-wall duct or to any non-insulated component. Terminate insulation end and reduce the outer shell diameter to the nominal single-wall size.

F. Flat oval supply duct shall be McGill AirFlow Uni-Seal flat oval construction. Flat oval duct will be reinforced based on its flat span dimension and maximum operating pressure in accordance with SMACNA standards.

G. Round supply duct shall be McGill AirFlow Uni-Seal round spiral lockseam construction. Longitudinal seam duct shall be used in those sizes greater than 84 inches in diameter and

other odd sizes for which spiral duct is unavailable. Standard spiral gauges shall be in accordance with SMACNA standards.

H. Insulated duct will be constructed of a galvanized, perforated metal liner with a 2-inch layer of fiberglass insulation, and an outer pressure shell. Metal liner shall be 24 gauge up to 34"; 22 gauge to 58" and 20 gauge to 84". Outer shell gauge shall be based on actual outer shell dimensions.

I. Fittings: Uni-Seal round or flat oval fittings as determined by duct configuration. Flat oval fittings shall be same as gauges for longitudinal seam flat oval duct. Coated all welded joints with protective paint to prevent damage. Elbows shall be as follows:

J. Provide McGill AirFlow Acousti-k27 double-wall (insulated) fittings. Construct insulated fittings of a galvanized, solid metal liner, a 2-inch layer of fiberglass insulation, and an outer pressure shell.

K. Double-wall, round supply system connections shall be slip coupling to 36" diameter or Uni-Flange (T-25) to 85". When an outer shell connection is by slip coupling, a separate slip coupling will be used to connect the metal liner at duct-to-duct joints. Safe-offs may be used in lieu of a metal liner coupling. When an outer shell connection is by flanged joint, a slip coupling will be used to connect the metal liner sections at duct-to-duct joints. Safe-offs may be used in lieu of a metal liner coupling.

L. Double-wall, flat oval supply system connections shall be slip coupling to 24" minor axis and flat span to 18"; Ovalmate to minor axis to 24"; Uni-Flange (T-25) to 30" minor axis and 48" flat span in accordance with Table D and will be reinforced with guidelines established in current SMACNA standards.

M. Secure connectors to duct in accordance with manufacturer's instruction. All double-wall spiral duct and fitting will be installed in accordance with SMACNA standards.

PART 3 - EXECUTION

3.1 INSTALLATION, APPLICATION, ERECTION

A. Do not exceed 45 degrees for easement transition angle.

B. Seal all transverse and longitudinal joints and seams and duct wall penetrations with approved sealer in accordance with manufacturer's directions regardless of pressure class.

C. Counterflash ductwork penetrating roof.

D. Support round ducts from building structure with galvanized steel hangers in accordance with SMACNA. Secure hangers to masonry portion of building by means of inserts or other acceptable anchors.

E. 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, shall be supported by angle brackets as shown in SMACNA manual.

F. Where appropriate based on duct weight, support rectangular ducts by minimum, 1" x 18 gauge, galvanized band iron or minimum 3/8" galvanized rod hangers attached to reinforcing angles and spaced same as reinforcing angles. Design hangers, reinforcing angles and other components to support weight of duct and insulation. Secure hangers to concrete beam or slab by adequately sized inserts, anchor shield and bolt, toggle bolt, or expansion bold.

G. Attach hangers to ductwork using sheet metal screws.

H. Space hangers approximately 8' along the duct for ducts under 60". For ducts over 60" and larger and heavier sections, such as welded duct and sound absorbers, space hangers at approximately 4' intervals.

I. Hangers and bracing used with ductwork shall be galvanized.

J. Provide smooth insulation finish around damper operating quadrants, splitter adjusting clamps, access doors, and similar operating devices. Provide metal collar equivalent in depth to insulation thickness. Access door locks and damper handles shall be free from mastic or sealant.

K. In addition to the requirements above, add supplemental bracing as necessary to prevent sagging and drumming, and/or vibration.

3.2 CLEANING

A. Clean mechanical system thoroughly to assure all foreign matter and dirt is removed.

3.3 AIR MOVING EQUIPMENT OPERATION DURING CONSTRUCTION

A. The use of new or existing air handling units, fans, or other permanent air moving equipment during construction is prohibited unless approved by the owner in writing. If approved for use during construction, the following procedures shall be followed:
1. The contractor shall protect the interior of all ductwork, air handling units, and other equipment from the accumulation of dirt and dust and other contaminants. If the permanent equipment cannot be adequately protected, temporary air moving/ conditioning equipment and distribution systems shall be utilized as required for finishing trades.
2. Provide all specified filters in equipment to be operated as well as temporary filters on all return and exhaust air grilles, open ductwork, and transfer openings in the work area.
3. The contractor shall remove all filters used during construction and replace them with new filters prior to test and balance work and prior to substantial completion.
4. If the ductwork and/or equipment is found to be contaminated at any point during construction, an independent NADCA certified contractor shall be retained to clean the ductwork and/or equipment at the contractors expense. Refer to Section 23 01 30.51.
5. System operating temperatures shall be maintained to avoid condensation on ductwork and equipment surfaces. New or existing insulation found damaged shall be replaced.
6. Coordinate use of air handling equipment with ICRA plan, if applicable. Maintain required pressure relationships in construction areas adjacent to occupied areas.

3.4 LEAKAGE TESTING OF INSTALLED SYSTEMS

A. Test duct for leakage in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Use prescribed test kit containing test blower, two U-tube manometers and calibrated curve attached to the orifice tube assembly.

B. Pressure testing shall include taps/take-offs to air terminal units in medium pressure ductwork and taps/take-offs to air devices in supply, return, and exhaust ductwork.

C. Pressurize all installed duct systems for each pressure class to maximum pressure for fabrication classification. The leakage amount shall not exceed the allotted amount for the pressure class or the allotted amount for that portion of the system as follows:
1. 1" Pressure Class - Leakage Class 6; Max. Leakage Factor - 6.0 CFM/100 SF
2. 2" Pressure Class - Leakage Class 6; Max. Leakage Factor - 9.4 CFM/100 SF

3. 1" and 2" Pressure Class exhaust ductwork connected to or serving fume hoods, bio-safety cabinets, chemical or hazardous storage rooms, smoke removal/purge systems, laboratory spaces, isolation rooms, bronchoscopy rooms, and nuclear medicine rooms shall be construction and tested as follows:
   a. 1" Pressure Class - Leakage Class 3; Max. Leakage Factor - 3.0 CFM/100 SF
   b. 2" Pressure Class - Leakage Class 3; Max. Leakage Factor - 4.7 CFM/100 SF
4. 6" Pressure Class - Leakage Class 3; Max. Leakage Factor - 9.6 CFM/100 SF

D. All ductwork shall be leak tested first before being enclosed in a shaft or above other inaccessible areas.

E. Correct leaks found in excess of allowable limits. Retest until acceptable leakage is witnessed.

F. Have test results available for review on a progressive and final basis. Include all test results in project closing file along with name, signature, and date of independent witness to testing. Test results shall show preliminary and final test results and include all calculations used to determine system compliance with the maximum specified leakage rate.

3.5 AIR TEST AND BALANCE

A. Prepare the system for tests as specified in Section 23 05 93 and correct deficiencies found by the Test and Balance firm.

B. Duct dimensions shown on drawings indicate inside clear dimensions. Make calculation allowances for duct requiring internal sound lining, or insulation to provide "inside clear" (IC) dimensions.

END OF SECTION 23 31 13

SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Backdraft dampers - metal.

B. Duct access doors.

C. Duct test ports.

D. Fire dampers.

E. Smoke dampers.

F. Combination fire and smoke dampers.

1.2 RELATED REQUIREMENTS

A. Division 07: Firestopping.

B. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.

C. Section 23 31 13 - Sheetmetal Ductwork.

D. Section 23 36 00 - Air Terminal Units: Pressure regulating damper assemblies.

1.3 REFERENCE STANDARDS

A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2012.

B. SMACNA 1966 - HVAC Duct Construction Standards; 2005.

C. UL 181 - Factory-Made Air Ducts and Air Connectors; 2013.

D. UL 33 - Heat Responsive Links for Fire-Protection Service; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

E. UL 555 - Standard for Fire Dampers; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

F. UL 555S - Standard for Leakage Rated Dampers for Use in Smoke Control Systems; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

G. AMCA 511 - Certified Ratings Program-Product Rating Manual for Air Control Devices; Current Edition, Including All Revisions.

1.4 SUBMITTALS

A. Refer to Division 01 for submittal procedures.

B. Product Data: Submit manufacturer's product data for review. Include electrical characteristics and connection requirements where applicable.

C. Project Record Drawings: Record actual locations of volume dampers, rated dampers, access doors, and test holes.

PART 2 PRODUCTS

2.1 BACKDRAFT DAMPERS - METAL

A. Acceptable manufacturers: Louvers & Dampers, Nailor Industries, or Ruskin Company.
1. Substitutions: Refer to Division 01.

B. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: Galvanized steel, 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; counter-balance adjustment device to permit setting for varying differential static pressure.

2.2 FIRE DAMPERS

A. Acceptable manufacturers: Air Balance, Greenheck, Ruskin, or Nailor.
1. Substitutions: Not permitted.

B. Fabricate in accordance with NFPA 90A, UL 555, and as indicated.

C. Material: Galvanized steel or 304 stainless steel to match adjacent ductwork.

D. Dampers shall be curtain or multi-leaf type, 1-1/2 hour rated, suitable for horizontal or vertical mounting. Blades for curtain type dampers shall be stored out of the airstream.

E. Dampers shall meet Class 1 leakage rates and be dynamic rated for closure against airflow up to 2000 FPM in low pressure systems and up to 4000 FPM in medium pressure systems.

F. Dampers shall have a UL 555 differential pressure rating of 4 in. wg.

G. Provide damper with fusible link causing the damper to lock in the closed position at 165 degrees F.

H. Provide manufacturer's round to horizontal duct adapter as required.

I. Maximum pressure drop shall be as follows:

J. Damper pressure drop shall not exceed 0.05 in. wg. at 1500 FPM or 0.10 in wg. at 2000 FPM.

K. Dampers shall bear the AMCA Certified Ratings Seal for Air Performance in accordance with AMCA 511.

2.3 COMBINATION FIRE AND SMOKE DAMPERS

A. Acceptable manufacturers: Air Balance, Ruskin, Greenheck, or Nailor.
1. Substitutions: Not permitted.

B. Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.

C. Dampers: Single or multi-blade type, 1-1/2 hour rated, automatically operated by 120V electric actuator mounted outside the airstream unless noted otherwise. Actuator shall be adequately sized to open the damper within 15 seconds.

D. Dampers shall be meet Class 1 leakage rates and be dynamic rated for closure against airflow up to 2000 FPM and 4" w.g. in low pressure systems and up to 4000 FPM and 6" w.g. in medium pressure systems.

E. Provide two-position actuator and with resetable link with open/closed indicator causing the damper to close at 165 degrees F. Damper shall fail normally closed.

F. Provide each damper with a remote test switch installed in the wall or ceiling near the damper.

G. Provide manufacturer's round to horizontal duct adapter as required.

H. Damper pressure drop shall not exceed 0.15 in. wg. at 1500 FPM or 0.25 in. wg. at 2000 FPM.

I. Dampers shall bear the AMCA Certified Ratings Seal for Air Performance in accordance with AMCA 511.

2.4 SLEEVES FOR RATED DAMPERS

A. Unless otherwise required by the authority having jurisdiction, sleeves for fire dampers, smoke dampers and combination fire and smoke dampers shall be provided by the damper manufacturer and be of rigid type construction recommended in Schedule 2 of SMACNA Publication for "Fire Damper and Heat Stop Guide for Air Handling Systems". Use 16 gauge for ducts 24" or less in diameter or either rectangular dimension and 14 gauge for ducts over 24". Provide minimum 18" long sleeves. Coordinate required length with wall thicknesses.

B. Install 1-1/2"x1-1/2"x1/8" angle bar on four sides of sleeves and both sides of wall. Fasten angles to sleeve only. Do not fasten to the wall.

2.5 DUCT ACCESS DOORS

A. Acceptable manufacturers: Ruskin, SEMCO, Greenheck, or Ward Industries.
   1. Substitutions: Refer to Division 01.

B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards and as indicated.

C. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ducts, provide minimum 1 inch thick insulation with minimum 24 gauge sheet metal cover on each side.
   1. Less Than 12 inches Square: Secure with sash locks.
   2. Up to 18 inches Square: Provide two hinges and two sash locks.
   3. Up to 24 x 48 inches: Three hinges and two compression latches with outside and inside handles.
   4. Larger Sizes: Provide an additional hinge.
   5. Latches shall permit easy removal of access door while maintaining positive closing and minimum leakage. Provide continuous sponge rubber gaskets for all doors.

D. Provide insulated doors in ductwork for access to service equipment such as airflow measuring stations (each side), casing mounted coils (each side), control dampers, duct mounted coils (each side), duct mounted smoke detectors, humidifiers, rated dampers, and elsewhere as noted on drawings.

E. Size access doors as follows:
   1. Duct sizes under 12": Door sized sufficient to service equipment or replace fusible link.
   2. Duct sizes 12" to 20": 12"x12" door.
   3. Duct sizes 20" to 36": 18"x18" door.
   4. Duct sizes above 36": 24"x24" door.

F. Provide reinforced wire glass view windows (min. 12"x12") in access doors at humidifiers.

G. Mount doors in rigid frame of at least 22 gauge formed galvanized steel or aluminum.

H. Use angle iron bracing as required to make the door frame a rigid assembly.

I. In accordance with NFPA 90A, identify each access door with minimum 1/2" high printed or stenciled letters as 'Fire Damper', 'Smoke Damper', or 'Combination Fire/Smoke Damper'.

2.6 DUCT TEST PORTS

A. Temporary Test Port: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps. Repair insulation and vapor barrier.

B. Permanent Test Port: Factory fabricated, air tight flanged fittings with screw cap equal to Carlisle PTP-1. Provide extended neck fittings to clear insulation.

2.7 MISCELLANEOUS PRODUCTS

A. Duct Opening Closure Film: Mold-resistant, self-adhesive film to keep debris out of ducts during construction equal to Carlisle Dynair Duct Protection Film. Use to cover all open ends of stored or hung ductwork during construction.
   1. Thickness: 2 mils.
   2. High tack water based adhesive.
   3. UV stable light blue color.
   4. Elongation before break: 325 percent, minimum.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install accessories in locations specified and as shown on drawings in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards. Refer to Section 23 31 13 for duct construction and pressure class.

B. Provide insulated doors in ductwork for access to service equipment such as airflow measuring stations (each side), casing mounted coils (each side), control dampers, duct mounted coils (each side), duct mounted smoke detectors, humidifiers, rated dampers, and elsewhere as noted on drawings.

C. Provide insulated access doors in kitchen exhaust ducts for cleaning and inspection in accordance with NFPA 96.

D. Provide duct test holes where indicated and required for testing and balancing purposes.

E. Provide fire dampers, combination fire and smoke dampers, and 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. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.

G. Provide balancing dampers at all points on supply, return, and exhaust systems where branches are taken from larger ducts.

H. Where diffusers or grilles and registers are not provided with volume dampers, install spin-in fitting with balance damper in duct run-out.

I. Provide all screws, bolts, nuts, inserts, and material required for attaching sheetmetal to duct, walls, floors, and ceilings.

3.2 TESTING

A. Check work for satisfactory installation and performance.

B. Insure that adequate access does in fact exist for rated dampers, that damper blade movement is not restricted, and that damper operator motors are not hindered in operation by proximity to walls or other objects.

C. Check duct connections at access doors for air leakage or condensation. Correct deficiencies found.

END OF SECTION 23 33 00

SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Single duct terminal units.

1.2 RELATED REQUIREMENTS

A. Section 23 05 00 - Common Work Results for HVAC.

B. Section 23 05 13 - Common Motor Requirements for HVAC Equipment

C. Section 23 05 23 - General Duty Valves for HVAC

D. Section 23 05 29 - Hangers for HVAC Piping

E. Section 23 05 53 - Identification for HVAC Piping and Equipment

F. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC

G. Section 23 07 00 - HVAC Insulation

H. Section 23 09 13 - Instrumentation and Control Devices for HVAC

I. Section 23 21 13 - Hydronic Piping

J. Section 23 21 14 - Hydronic Specialties

K. Section 23 31 13 - Sheetmetal Ductwork

L. Section 23 33 00 - Air Duct Accessories

M. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.

1.3 REFERENCE STANDARDS

A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilation Systems; National Fire Protection Association; 2012.

B. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

C. Acoustical Liner: Meet requirements of NFPA 90A, UL 181, and ASTM C665 as specified.

D. Air Diffusion Council, ADC Standard 1062R2, Air Diffusing Equipment Test Code.

E. Air Moving and Conditioning Association, AMCA Standard 210, Test Code for Air Moving Devices.

F. SMACNA HVAC Duct Construction Standards; Current Edition.

1.4 SUBMITTALS

A. See Division 01 requirements.

B. Product Data: Provide data indicating configuration, general assembly, materials used in fabrication, access door location and size, insulation thickness, density, and R-value. Include

specific performance ratings that indicate unit ID, airflow setpoints, coil performance, air pressure drop, NC rating, and electrical characteristics and connection requirements.

C. Manufacturer's Installation Instructions: Indicate support and hanging details, and service clearances required.

D. Project Record Documents: Record actual locations of units.

E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists.

F. Substitutions: Refer to Division 1.

G. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.6 WARRANTY

A. See Division 1 for additional warranty requirements.

B. Provide five year manufacturer warranty for air terminal units.

1.7 GUARANTEE

A. Manufacturer guarantees resultant noise levels to be within NC rating published by manufacturer.

PART 2 PRODUCTS

2.1 SINGLE DUCT AIR TERMINAL UNITS

A. Acceptable Manufacturers:
1. Anemostat, Environmental Technologies (JCI), Kruegor, Metalaire, Nailor, Price, Titus, and Trane.

B. Basic Assembly:
1. Casings: Minimum 22 gauge galvanized steel.
2. Lining:
   a. Dual Wall: Interior liner of minimum 22 gauge phosphatized steel covering the insulation. All cut edges of insulation shall be covered with metal flange. All wire penetrations shall be covered by grommets. High density, glass fiber insulation, 1" thick, 1.9 lb/cu.ft., R-Value of 4.2.
   b. Insulation shall comply with the requirements of UL 181, NFPA 90A, and ASTM C665.
3. Provide insulated gasketed access panel on bottom of terminal unit for access to internal air valve and heating coil inspection. Adjacent duct insulation shall not block access door.
4. Leakage: Maximum 1% of maximum rated airflow at 1" wg. inlet static pressure.
5. Multi-point, multi-axis flow ring or cross sensor at box inlet.

6. Provide integral flow taps and calibration chart on each unit.
7. Factory calibrate sensor and controller for maximum, minimum, heating, and unoccupied design airflow according to the air terminal unit schedule. Terminal units scheduled for constant volume operation shall be provided with controls capable of variable volume operation.
8. Factory mount, wire, connect, calibrate, setup and test DDC controller, pressure transducer, and electronic damper actuator furnished to box manufacturer under Section 23 09 13. Damper actuators integral with terminal unit may be furnished by terminal unit manufacturer and operation coordinated with DDC controller.

C. Actuator / Controls: Electronic
1. Configuration: Air volume damper assembly inside unit casing. Locate control components inside protective metal shroud with removable cover.
2. Volume Damper: Construct of galvanized steel with peripheral gasket and self lubricating bearings; maximum damper leakage: 1 percent of design air flow at 3 inches rated inlet static pressure. Damper position shall be indicated on the end of the shaft on the outside of the casing
3. Controller to provide consistent air delivery within 5% of nominal airflow down to 25% of unit rated CFM, independent of changes in system static pressure.
4. The actuator shall be directly coupled to the damper shaft.

D. Heating Water Coil:
1. Selection criteria:
   a. Unless noted otherwise, coils shall be selected at the scheduled heating water supply temperature to meet the scheduled performance criteria in the following priority: total capacity (BTUH), leaving air temperature, heating water return temperature.
   b. Coils rows shall be be selected to obtain the performance closest to the scheduled values while meeting the scheduled capacity and without exceeding the leaving air temperature.
2. Construction:
   a. Fins: Aluminum, maximum 10 fins per inch.
   b. Tubes: 1/2 inch, 5/8 inch, or 7/8 inch seamless, copper tubes mechanically expanded into the fin collars; arranged for counter-flow of heating water.
   c. Water velocity maximum 8 feet per second with water pressure loss not greater than indicated on the drawings.
   d. Rows: Provide coil rows scheduled or as required to achieve scheduled performance.
3. Coils shall be ARI certified and leak tested at 300 PSIG under water.
4. Casing shall be minimum 22 gauge galvanized steel.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide ceiling access doors or locate units above easily removable ceiling components.

C. Support units independently from structure. Do not support from adjacent ductwork.

D. Connect to ductwork in accordance with Section 23 31 13.

E. Provide insulation and engraved equipment nameplate as specified.

F. Provide insulation in accordance with Section 23 07 13 and Section 23 07 19.

G. Verify that electric power is available and of the correct characteristics.

H. Coordinate control installations with temperature controls vendor.

3.2 CLEANING, TESTING, STARTUP, AND DEMONSTRATION

A. Clean and test units in accordance with Section 23 05 00.
   1. Include flushing of connected piping and cleaning of water control valves.

B. Start-up units, check for proper operation as a system with air handling unit, fan, and connected ductwork.

C. Check for clear access to control panel, isolation valves, control valves, balancing valves, and access panels. Verify required working clearance for control panels.

D. Prepare units for Test and Balance as required by Section 23 05 93, correct any deficiencies found and retest.

E. Demonstrate operation of units as a complete system to maintenance personnel and instruct them in the operation, adjustment and repair of the system.

F. Check connections to insure they are tight and without noticeable leakage. Correct any deficiencies found.

END OF SECTION 23 36 00

SECTION 23 37 00 - AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Diffusers.

B. Registers/grilles.

1.2 RELATED REQUIREMENTS

A. Section 23 05 00 - Common Work Results for HVAC

B. Section 23 33 00 - Air Duct Accessories

C. Section 23 31 13 - Sheetmetal Ductwork

D. Section 23 31 14 - Sheetmetal - Special Ductwork

1.3 REFERENCE STANDARDS

A. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating; Air Movement and Control Association International, Inc.; 2012.

B. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Inlets; American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.; 2006 (R2011).

C. SMACNA 1966 - HVAC Duct Construction Standards; 2005.

1.4 SUBMITTALS

A. Product Data: Submit product data for review. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

B. Samples: Submit two of each required air outlet and inlet type upon request.

C. Project Record Documents: Record actual locations of air outlets and inlets.

1.5 QUALITY ASSURANCE

A. Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.

B. Test and rate louver performance in accordance with AMCA 500-L.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Anemostat, Carnes, Krueger, Metalaire, Nailor, Price, or Titus unless noted otherwise.

B. Substitutions: Refer to Division 01.

C. Air devices shall meet these specifications and the requirements noted in the Air Distribution Device Schedule. Titus model numbers are not inclusive of all listed requirements.

2.2 SUPPLY DIFFUSERS

A. Type S4 (based on Titus Omni)
1. Plaque face diffuser with square deflection plate centered in a square housing, four way directional blow. Face panel shall not protrude more than 1/4" below the outside border of the diffuser backpan. Diffusers with a 12"x12" full face shall have no less than a 9"x9" face panel. Diffusers with a 24"x24" full face shall have no less than an 18"x18" face panel. For diffusers noted on drawings to be 2 or 3 way blow, provide blank off plates in diffuser. Provide panel, face and neck size scheduled.
2. Material: Steel with baked acrylic finish.
3. Color: White.
4. Borders and mounting: Coordinate ceiling device frame type with architectural ceiling type.
5. Dampers: Provide ceiling diffusers complete with opposed blade volume dampers where diffuser is installed in inaccessible ceiling and spin-in fitting manual volume damper at branch ductwork tap is not accessible.
6. Accessories: None

B. Type S5 (based on Titus 300R)
1. Sidewall, double deflection register with 3/4" blade spacing and front blades parallel to the long dimension. Blades shall have steel friction pivots on both ends to allow individual blade adjustment without loosening or rattling. Provide panel, face and neck size scheduled.
2. Material: Steel with baked acrylic finish.
3. Color: White.
4. Borders and mounting: 1-1/4" wide border on all sides with countersunk screw holes..
5. Dampers: Provide opposed blade manual volume damper with matching finish behind register. Damper shall be adjustable through the front blades of the diffuser.
6. Accessories: None.

2.3 RETURN AND EXHAUST GRILLES

A. Type R2 / E2 (based on Titus MLR-39)
1. Linear grille with 1" slot(s). Refer to schedule for length and slot quantity. Multiple sections of grilles shown end-to-end shall be joined together with alignment pins to form a continuous slot appearance. Provide heavy gauge aluminum end borders, end caps, and mitered corners to close off ends of grilles. Provide factory fabricated, flat black blank off plates for unused portions of continuous grille. Provide panel, face and neck size scheduled.
2. Material: Aluminum with baked acrylic finish.
3. Color: White .
4. Borders and mounting: Coordinate ceiling device frame type with architectural ceiling type. Sidewall mounted diffusers shall be installed so the fastening devices are not visible from the finished space.
5. Dampers: Refer to Construction Drawings.
6. Accessories: Plenum by the same manufacturer and meeting the performance requirements scheduled. Plenum shall be non-insulated.

B. Type R4 / E4 (based on Titus Omni)
1. Plaque face grille with square plate centered in a square housing. Face panel shall not protrude more than 1/4" below the outside border of the backpan. Grilles with a 12"x12"

full face shall have no less than a 9"x9" face panel. Grilles with a 24"x24" full face shall have no less than an 18"x18" face panel. Provide panel, face and neck size scheduled.

2. Material: Steel with baked acrylic finish.
3. Color: White.
4. Borders and mounting: Coordinate ceiling device frame type with architectural ceiling type.
5. Dampers: Provide ceiling grilles complete with opposed blade volume dampers where diffuser is installed in inaccessible ceiling and spin-in fitting manual volume damper at branch ductwork tap is not accessible.
6. Accessories: None

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install accessories in accordance with manufacturer's published recommendations as well as applicable sections of SMACNA manual and other standards set forth in Part 1.

C. Provide all screws, bolts, nuts, inserts, and material required for attaching sheet metal to duct, walls, floors, and ceilings.

D. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

E. Where diffusers or grilles and registers are not provided with volume dampers, install spin-in fitting with balancing damper in duct runout.

3.2 TESTING

A. Check work for satisfactory installation and performance.

B. Check duct connections at air inlets and outlets air leakage or condensation. Correct conditions found.

3.3 INSPECTION

A. Air inlets and outlets shall be clean and free from scratches and dents. Repair or replace damaged devices as required.

END OF SECTION 23 37 00

SECTION 23 41 00 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Panel Filters

B. Pleated Filters

C. Cartridge Filters

D. Bag Filters

E. Housing and Frames

F. Filter Pressure Gauges

1.2 RELATED REQUIREMENTS

A. Section 23 05 00 - Common Work Results for HVAC.

B. Section 23 73 13 - Modular Indoor Central-Station Air Handling Units.

1.3 REFERENCE STANDARDS

A. ASHRAE 52.2; 2012: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

B. ASHRAE 52.1; 1992: Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

C. NFPA 90A: Standard for the Installation of Air-Conditioning and Ventilating Systems.

D. UL 900: Test Performance of Air Filter Units.

E. ISO 9001-2000: Certified manufacturing facility

1.4 SUBMITTALS

A. Submit manufacturer's product data for review in accordance with the requirements of Divison 01.

B. Submit evidence of manufacturing facility certification with ISO 9001-2000.

1.5 QUALITY ASSURANCE

A. MERV Ratings: Minimum Efficiency Reporting Value of MERV when evaluated under the guidelines of ASHRAE Standard 52.2; 2012.

B. Average atmospheric dust spot and arrestance: Average dust spot efficiency of and a minimum arrestance based evaluation ASHRAE Standard 52.1; 1992.

C. Performance: Media to maintain or increase in efficiency over the life of the filter.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Airguard, American Air Filter (AAF), Camfil, or Flanders/Precisionaire.

2.2 PANEL FILTER MEDIA

A. Scheduled as AAF AmerSeal - MERV 8.

B. Construction
1. Media: Cotton and synthetic blend, self-sealing panel filter with internal wire support frame.
2. Filter shall be rated by Underwriters Laboratories as UL Class 900.

C. Performance
1. Efficiency: MERV 8; 25% average dust spot and minimum arrestance of 90% The media shall maintain or increase in efficiency over the life of the filter.
2. Initial resistance to airflow: Not to exceed 0.26" at airflow velocity of 500 feet/minute on 1" deep models.

2.3 PLEATED PANEL FILTERS

A. Scheduled as AAF AmAir 300X - MERV 7.

B. Construction
1. Media: Cotton and synthetic blend, lofted to a uniform depth of 0.18", and formed into a uniform radial pleats. There shall be at least 14 pleats per linear foot for 2" deep filters.
2. Support: Welded wire grid, spot-welded on one-inch centers, treated for corrosion resistance, bonded to the downstream side of the media to maintain the radial pleat and prevent media oscillation.
3. Frame: Minimum 28-point high wet-strength beverage board. Bond frame to media to prevent air bypass. Include integral diagonal support members on the air entering and air existing side to maintain uniform pleat spacing in varying airflow.
4. Filter shall be rated by Underwriters Laboratories as UL Class 900.

C. Performance
1. The filter shall have a Minimum Efficiency Reporting Value of MERV 7 and MERV-A of 7 when evaluated under the guidelines of ASHRAE Standard 52.2-2012 must include -B with appendix J. Minimum arrestance of 90% The media shall maintain or increase in efficiency over the life of the filter.
2. Initial resistance to airflow: Not to exceed 0.28" w.g. at airflow velocity of 500 feet/minute on 2" deep model.

2.4 PLEATED PANEL FILTERS

A. Scheduled as AAF Perfect Pleat HC M8 - MERV 8.

B. Construction
1. Media: Cotton and synthetic blend, lofted to a uniform depth of 0.18", and formed into a uniform radial pleats. There shall be at least 15 pleats per linear foot for 2" deep filters.
2. Support: Welded wire grid, spot-welded on one-inch centers, treated for corrosion resistance, bonded to the downstream side of the media to maintain the radial pleat and prevent media oscillation.

3. Frame: Minimum 28-point high wet-strength beverage board. Bond frame to media to prevent air bypass. Include integral diagonal support members on the air entering and air existing side to maintain uniform pleat spacing in varying airflow.
4. Filter shall be rated by Underwriters Laboratories as UL Class 900.

C. Performance
1. The filter shall have a Minimum Efficiency Reporting Value of MERV 8 and MERV-A of 8 when evaluated under the guidelines of ASHRAE Standard 52.2-2012 must include -B with appendix J. Minimum arrestance of 92% The media shall maintain or increase in efficiency over the life of the filter.
2. Initial resistance to airflow: Not to exceed 0.25" w.g. at airflow velocity of 500 feet/minute on 2" deep model.

2.5 CARTRIDGE TYPE FILTERS

A. Scheduled as AAF Varicel II - MERV 11.
1. Construction
a. Media: Microfine glass laminated to a reinforcing backing to form a uniform lofted media blanket.
b. Blanket: Form into uniform tapered radial pleats and bonded to a stiffened backing that is bonded to the downstream side of the media to preclude media oscillation.
c. Bonding: Mechanically and chemically bond media within the frame to prevent air bypass.
d. Frame: Constructed of corrosion resistant galvanized steel. Media support contour stabilizers shall be mechanically fastened to diagonal support members of the same construction shall create a rigid and durable filter enclosure. There shall be a minimum of four contour stabilizers on the air entering side and four on the air exiting side.
e. Filter shall be rated by Underwriters Laboratories as UL Class 900.
2. Performance
a. Performance: The filter media shall have an average efficiency of MERV 11 by ASHRAE 52.2-2012-B with Appendix J. It shall have an average arrestance of not less than 98%, 99 or 100 in accordance with that standard. The dust holding capacity shall not be less than 432 grams on the same standard.
b. Initial resistance to airflow: Not to exceed 0.45" wg at airflow velocity of 500 feet/minute.
c. Maximum pressure withstand rating: 10" w.g. without failure of the media pack.

B. Scheduled as AAF Varicel RF - MERV 14.
1. Construction
a. Media: Microfine glass laminated to a reinforcing backing to form a uniform lofted media blanket.
b. Blanket: Form into uniform tapered radial pleats and bonded to a stiffened backing that is bonded to the downstream side of the media to preclude media oscillation.
c. Bonding: Mechanically and chemically bond media within the frame to prevent air bypass.
d. Frame: Constructed of corrosion resistant galvanized steel. Media support contour stabilizers shall be mechanically fastened to diagonal support members of the same construction shall create a rigid and durable filter enclosure. There shall be a minimum of four contour stabilizers on the air entering side and four on the air exiting side.
e. Filter shall be rated by Underwriters Laboratories as UL Class 900.
2. Performance

a. Performance: The filter media shall have an average efficiency of MERV 14 by ASHRAE 52.2-2012-B with Appendix J. It shall have an average arrestance of not less than 98%, 99 or 100 in accordance with that standard. The dust holding capacity shall not be less than 142 grams on the same standard.
b. Initial resistance to airflow: Not to exceed 0.53" wg at airflow velocity of 500 feet/minute.
c. Maximum pressure withstand rating: 10" w.g. without failure of the media pack.

C. Scheduled as AAF BioCel VXL - MERV 16.
1. Construction
a. Filter media shall be of a special grade of microfine glass fibers. No charged or synthetic media shall be used.
b. Media packs shall be assembled into a v-bank configuration. Computer-optimized pleat to height ratio shall create a radial air exiting and entering design. The filter outlet shall be radial in shape with a maximum of 60% open area and the inlet shall be 30% larger than any other V-bank style filter to maintain low-pressure drop and uniform airflow.
c. The media packs shall be completely sealed and bonded to the inside periphery of a polystyrene enclosing frame with a polyurethane sealant. . The enclosing frame shall include top and bottom molded tracks as an integral part of the frame to ensure a proper seal.
d. Media packs shall be recessed at least 1” from the headered side of the enclosing frame to allow uniform airflow when a prefilter is mounted directly to the enclosing frame. The header shall include a gasket on the vertical side to create a filter-to-filter seal in side-access housing applications.
e. Filter shall be rated by Underwriters Laboratories as UL Class 900.
2. Performance
a. Performance: The filter media shall have an average efficiency of MERV 16 by ASHRAE 52.2-2012-B with Appendix J. It shall have an average arrestance of not less than 98%, 99 or 100 in accordance with that standard. The dust holding capacity shall not be less than 230 grams on the same standard.
b. Initial resistance to airflow: Not to exceed 0.60" wg at airflow velocity of 500 feet/minute.
c. Maximum pressure withstand rating: 10" w.g. without failure of the media pack.

2.6 CARTRIDGE TYPE, HEPA FILTER

A. Scheduled as AAF Astrocel I - HCX.

B. Construction
1. Media: Continuous pleating of micro fine glass fiber media. Pleats shall be uniformly separated by corrugated aluminum separators incorporating a hemmed edge to prevent damage to the media.
2. Media pack: Potted into the enclosing frame with a fire-retardant urethane sealant.
3. Frame: 16-gauge steel, with a zinc aluminum alloy finish, and shall be bonded to the media pack to form a rugged and durable enclosure. The filter shall be assembled without the use of fasteners to ensure no frame penetrations. Overall dimensional tolerance shall be correct within -1/8", +0", and square within 1/8"
4. Gasket: Include a poured-in-place seamless sealing gasket on the downstream side of the enclosing frame to form a positive seal upon installation.
5. Filter shall be rated by Underwriters Laboratories as UL Class 900.

C. Performance

1. Efficiency: Minimum tested efficiency of 99.97% when evaluated according to IEST Recommended Practice RP-CC001.
2. Initial resistance to airflow: Not exceed 1.4" w.g. at airflow velocity of 500 feet/minute.
3. Maximum pressure withstand rating: 10" w.g. without failure of the media pack.
4. Supporting Data: Label filters as to tested efficiency, rated/tested cfm, pressure drop and shall be serialized for identification. Each filter must be individually tested, no batch testing will be allowed.

2.7 HOUSING AND FRAMES FOR HEPA FILTERS

A. General
1. Side-access absolute filter housing shall be constructed of 14-guage 304 stainless steel and shall include removeable dual access doors, challenge injection port, door gasketing and swing bolt filter retainers. An appropriate number of swing bolts to match air filters shall also be included.
2. Front loading individual filter frames, sized appropriately for air flow with no spaces between filter frame and unit construction with sealing methods noted below.

B. Construction
1. Absolute filter housing: All-welded construction of 14-guage galvanized steel (304 SST); reinforced with channel bracing to withstand 8.0" w.g. positive or negative pressure.
2. Standing flanges: Provide to mate housing to other housings or ductwork.
3. Housing shall be weatherproof without modification.
4. Doors: Pin-hinged removable access doors for service from either side of the housing. Doors shall include high-memory door gasketing to prevent leaks to ± 8.0" w.g.
5. Filter securing swing bolt assemblies: Same construction as the housing, and with equip-bearing filter clamps, to secure filters into the housing. There shall be a minimum of four assemblies per filter unit.
6. Housing shall include integral challenge injection port for introduction of filter evaluation challenge.
7. Housings shall include a filter track for application of a nominal 2" deep prefilter.
8. Housing shall include knife-edge gel seal opening for sealing to filter frame. Filters edge seal method shall be coordinated with housing.

C. Performance
1. The sealing assembly shall be capable of sealing each element with 30 inch/lbs. of torque to 50% filter gasket compression. The sealing assembly shall create a scan capable filter to housing seal.

2.8 **CONTAINMENT SYSTEMS (BAG IN/BAG OUT FILTER HOUSING)**

A. Acceptable Manufacturers: AAF International, Camfil, Flanders

B. Housing Seal Type:
1. Gasket Seal
2. Gel Seal with knife edge

C. Construction:
1. Housing: 14 gage 304 Stainless Steel, fully welded, side or front access as required.
2. Standard 24" x 24" x 11-1/2" HEPA filter frames, each compartment.
3. Prefilter compartment and door.
4. Separate individual door for each filter component.
5. Designed to withstand +/- 10" w.g. and factory tested to +10" w.g. in accordance with ANSI/ASME N509 and N510.

6. Upstream filter seal.
7. Pressure ports both upstream and downstream.
8. Pressure gauges; magnehelic for indoor or outdoor mounting.
9. External predrilled flanges for duct connection.
10. Doors to have high performance extruded neoprene gasket seal with star knob hand wheels.
11. Each filter module shall have a clamping mechanism, cam-operated with one hand lever with a 6" length so it can be handled through the bag. Door shall not be able to close unless filters are properly set and sealed.
12. Bag: 8 mil thick PVC changeout bag, non sticking, matt finish with elastic nitrile O-ring or stretch cord hemmed into the opening of the bag to fit securely around the two continuous bag ring flanges. Three gloved openings shall be built into the bag to facilitate filter handling. Bag and components shall be such that all changeout operations ensure the bag is between service techniciam and filter at all times. Bags shall be independently tested to prove operability at temperature ranges of 0 degrees F to 130 degrees F.

D. Filters: Provide HEPA filters and prefilters as scheduled on drawings.

E. Clearances: A minimum of 4 feet clearance in front of filter access door shall be provided to facilitate filter charging.

2.9 FILTER PRESSURE GAUGES

A. Acceptable manufacturers: Dwyer Instruments, H.O. Trerice, or Weiss Instruments.

B. Magnehelic: Direct reading 3-1/2 inch diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, +/-3% full-scale accuracy. Range shall start at zero and have a maximum of 0.25" to 1.0" w.c. above the scheduled final resistance. Mark scheduled clean and dirty resistance on face of dial. If two filter beds are installed in tandem, provide magnehic across each filter bed.

C. Provide filter pressure gauges as specified in addition to BAS differential pressure sensor across each filter bank.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide filters in locations as shown on drawings. Provide quantity and sizes to comply with scheduled performance.

B. Upon completion of ductwork and fan system, clean systems as required in Section 23 05 00 and install specified filter media prior to placing system in operation.

C. All filters shall be installed prior to operating the HVAC system. Provide a complete change in filter media as required during construction and prior to the HVAC test and balance process. If equipment and/or ductwork is found to be contaminated at any point during construction, an independent NADCA certified contractor shall be retained to clean the ductwork and/or equipment at the contractors expense.

D. Install filters in accordance with manufacturer's published installation instructions. Provide manufacturer's recommended media change data to maintenance personnel.

E. Install filters in frames or apparatus casing so as to be leak free. Verify with light test from both sides.

F. Install and level filter gauges outside air stream for each bank of filters.

G. Protect cooling and/or heating coils with temporary media during construction.

H. Deliver one complete change of media to the maintenance personnel at Substancial Completion. Store spare media in a clean and dry place adjacent to equipment served or as coordinated with the Owner.

I. Provide insulation as required on filter housing to prevent condensation.

J. Insulate and make leak-proof filter access doors.

END OF SECTION 23 41 00

SECTION 23 82 16 - HEATING COILS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Heating Water Coils

B. Steam Coils

C. Integral Face and Bypass Coils

1.2 RELATED REQUIREMENTS

A. Section 23 05 19 - Hydronic Specialties

B. Section 23 05 23 - General Duty Valves for HVAC

C. Section 23 21 13 - HVAC Piping

D. Section 23 22 14 - Steam and Condensate Heating Specialties

1.3 REFERENCE STANDARDS

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

1.4 SUBMITTALS

A. Submit product data, coil ratings, and performance data for review.

PART 2 - PRODUCTS

2.1 HOT WATER COILS

A. ACCEPTABLE MANUFACTURERS
1. McQuay, Modine, Sterling, Trane, USA Coil & Air, or York.
2. Coils shall be the product of manufacturer regularly engaged in production of coils who issues complete catalog data on such products.

B. CONSTRUCTION
1. Tubes: Copper.
2. Fins: Aluminum or copper.
3. Headers: Heavy gauge cast iron or steel.
4. Casing: Minimum 16-gauge galvanized steel.
5. Design for minimum 200 psig at 220 degrees F.
6. Testing: Proof test and leak test each coil at minimum 300 psig and 200 psig air pressure respectively with coil submerged in water.

2.2 STEAM COILS

A. ACCEPTABLE MANUFACTURERS
1. McQuay, Trane, USA Coil & Air, or York.
2. Coils shall be the product of manufacturer regularly engaged in production of coils who issues complete catalog data on such products.

B. CONSTRUCTION

1. Tubes: Copper.
2. Fins: Aluminum or copper.
3. Headers: Heavy gauge cast iron or steel.
4. Casing: Minimum 16-gauge galvanized steel.
5. Design for minimum 100 psig at 400 degrees F.
6. Provide non-freeze type steam coils. Construct coils of double tubes consisting of inner steam distributing tubes and outer tubes for condensing steam.
7. Provide cleanable tube coils with straight tubes.
8. Testing: Proof test and leak test each coil at minimum 300 psig and 200 psig air pressure respectively with coil submerged in water.

2.3 INTEGRAL FACE AND BYPASS COILS

A. ACCEPTABLE MANUFACTURERS
1. L.J. Wing Model IFB or approved equal.

B. CONSTRUCTION
1. Tubes: Copper.
2. Fins: Aluminum or copper.
3. Headers: Schedule 40 steel or copper.
4. Casing and dampers: Minimum 16-gauge galvanized steel.
5. Testing: Proof test and leak test each coil at minimum 300 psig and 200 psig air pressure respectively with coil submerged in water.

C. Each coil to consist of built-in series of finned heating elements and bypasses with interlocked dampers furnished complete with electric damper motors and air stream thermostat, as required by the plans.

D. Each coil shall be capable of maintaining a constant discharge air temperature regardless of variations in entering air temperature with full steam pressure or hot water flow, as applicable, on the coil at all times.

E. The temperature at any point in a plane parallel to the face of the coil three feet downstream from the leaving air side shall not vary more than 5 degrees F from the average discharge temperature.

F. Pressure drop of air through the coil shall not vary more than 5% regardless of the position of the integral dampers.

G. Tubes shall be individually removable.

H. Optional accessories: electric freezestat.

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 leaving air side. Transitions on both entering and leaving side shall be 1:7 if space permits. Provide air tight seal between coil and duct or unit casing.

B. Provide access doors on entering side of coil for cleaning and inspection purposes.

C. See drawings for required piping connections to heating water coils.

D. See drawings and Section 23 22 16 for required piping connections to steam coils.

E. Externally insulate coil casing including return bends with 1" thick, blanket type fiberglass insulation to prevent condensation.

F. Heating water coils required for air terminal units shall be furnished factory mounted by air terminal unit manufacturer.

END OF SECTION 23 82 16