

Project Manual

HMSL MOST PT Expansion

**Houston Methodist
Sugar Land Hospital
Sugar Land, Texas**



P&W Project No. 218-048

Issue:

Permit and Bid

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**HMSL MOST
PT Expansion
Sugar Land, TX**
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PART 1 - GENERAL

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- 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.

1.02 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 30: Flammable and Combustible Liquids Code
 - 2. NFPA 54: National Fuel Gas Code
 - 3. NFPA 70: National Electrical Code
 - 4. NFPA 72: National Fire Alarm and Signaling Code
 - 5. NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems
 - 6. NFPA 90B: Standard for the Installation of Warm Air Heating and Air Conditioning Systems
 - 7. NFPA 92A: Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences
 - 8. NFPA 96: Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
 - 9. NFPA 101: Life Safety Code
 - 10. NFPA 101A: Guide on Alternative Approaches to Life Safety
 - 11. NFPA 101B: Standard on Means of Egress for Buildings and Structures
 - 12. NFPA 105: Standard for the Installation of Smoke Control Door Assemblies and Other Opening Protectives
 - 13. NFPA 241: Standard for Safeguarding Building Construction, Alterations, and Demolition Operations
 - 14. NFPA 5000: Building Construction and Safety Code
 - 15. ANSI A17.1: Elevators, Dumbwaiters, Escalators and Moving Walks
 - 16. ANSI Handicapped Code-A117.1
 - 17. ASTM E814-08B: Standard Test Method for Fire Tests Penetration Firestop Systems.
 - 18. U.L. Fire Resistance Index.
 - 19. All applicable Occupational Safety and Health Administration (OSHA) Publications, Rules and Regulations.
 - 20. Americans with Disabilities Act (ADA)

21. Special regulations, supplement, and amendments of the State and/or local authorities having jurisdiction.

1.03 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

1.04 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.

- 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.

1.05 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.

1.06 FEES AND PERMITS

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

1.07 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.

1.08 PRODUCT SUBSTITUTIONS

- A. Comply with provisions of Division 01.

1.09 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.

1.10 OWNING AND OPERATING MANUALS

- A. 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.
- B. 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

2.01 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.

2.02 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.

2.03 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.

2.04 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.

PART 3 - EXECUTION

3.01 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.

3.02 FLASHING AND COUNTERFLASHING

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

3.03 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.

3.04 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.

3.05 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.

3.06 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.

3.07 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.

3.08 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.

3.09 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. Ductwork Pressure Testing: Refer to Section 23 31 13 for required pressure testing for ductwork.
- E. System Balance and Testing: Prepare to assist test and balance firm by assuring systems are complete and operational.
- F. Test all smoke and combination fire/smoke, dampers by observing damper operation during fire alarm system commissioning.
- G. 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.

END OF SECTION 23 05 00

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

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. HVAC systems testing and balancing requirements.

1.02 REFERENCE STANDARDS

- A. AABC - Associated Air Balance and Control
- B. NEBB - National Environmental Balancing Bureau

1.03 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.
- G. The following Contractors are approved:
 - 1. Engineering Air Balance (EAB).
 - 2. Technical Air Balance
 - 3. Systems Commissioning In (SCI)

PART 2 - PRODUCTS

2.01 NOT APPLICABLE

PART 3 - EXECUTION

3.01 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.

3.02 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.

END OF SECTION 23 05 93

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Pipe insulation
- B. HVAC equipment insulation
- C. Ductwork insulation

1.02 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

1.03 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.

1.04 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.

1.05 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.

1.06 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

2.01 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.
 - d. Unlined make-up air ductwork: 1.5", 0.75 PCF, installed "R" value of 4.2.
 - e. Unlined ductwork supplying outside air: 2.2", 0.75 PCF, installed "R" value of 6.0.
 - f. Unlined return air ductwork installed in an unconditioned space, including concealed above ceiling: 2.2", 0.75 PCF, installed "R" value of 6.0.
 - 1) Insulation may be omitted from exposed low pressure return air ductwork in area served by the ductwork, except where the exposed ductwork is in rooms with doors/openings to the exterior.
 - g. Unlined exhaust air ductwork installed in an unconditioned space, including concealed above ceiling: 1.5", 0.75 PCF, installed "R" value of 4.2.
 - 1) Insulation may be omitted from exposed low pressure return air ductwork in area served by the ductwork, except where the exposed ductwork is in rooms with doors/openings to the exterior.

- 2) Insulation may be omitted except where exhaust ductwork is installed in a plenum directly below the roof.
 - h. Unlined relief air ductwork within equipment rooms: 1-1/2" thick.
 - i. Reheat coils, including reheat coils at terminal boxes: 2.2", 0.75 PCF, installed "R" value of 6.0.
- B. Board Type Duct Insulation:
1. Acceptable manufacturers: CertainTeed IB-300, Johns-Manville, Knauf, or Owens Corning.
 2. Provide semi-rigid glass fiber board type insulation with Foil Reinforced Kraft (FSK) vapor barrier having a minimum "R" value and pound per cubic foot (PCF) density shown below.
 3. Use on the following services:
 - a. Unlined supply ductwork within equipment rooms **below 6' AFF (utilize blanket type above 6' as described in 2.2A)**: 1.5", 3.00 PCF, "R" value of 6.5.
 - b. Unlined return air ductwork within equipment rooms **below 6' AFF (utilize blanket type above 6' as described in 2.2A)**: 1.5", 3.00 PCF, "R" value of 6.5.
 - c. Unlined relief air ductwork within equipment rooms **below 6' AFF (utilize blanket type above 6' as described in 2.2A)**: 1.5", 3.00 PCF, "R" value of 6.5.
 - d. Exterior ductwork: 2.0", 3.00 PCF, "R" value of 8.7.
 - e. Outside air intake plenums: 1.5", 3.00 PCF, "R" value of 6.5.
- C. Aluminum Jacketed Insulation:
1. Provide aluminum jacketed insulation for all exterior ductwork.
 2. Break jacket as required to prevent water ponding.

PART 3 - EXECUTION

3.01 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.

3.02 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.

3.03 BOARD TYPE DUCT INSULATION

- A. Apply jacketed board type glass fiber covering to ducts using weld pins having self-locking coated metal or nylon discs; locate fasteners on not over 12" centers laterally and longitudinally. If insulation is grooved to fit around corners, in order to eliminate as many joints as possible, pin as required to hold insulation tight to duct, especially on bottom of duct. Seal pins and joints with Foster 30-80 reinforced with glass cloth.
- B. Cover all joints, rips, tears, punctures, disc heads, staples, or breaks in vapor barrier jacket with 4" wide woven glass fabric tape embedded in equivalent of Foster 30-80 vapor barrier, fire resistant adhesive. Do not use pressure sensitive tape.

END OF SECTION 23 07 00

SECTION 23 09 13 - INSTRUMENTATION AND CONTROL DEVICES

PART 1 - GENERAL

1.01 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.

1.02 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

1.03 SUBMITTALS

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

PART 2 - PRODUCTS

2.01 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.

2.02 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: Siemens or Vaisala.
 - 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. 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.
- 4. 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.
- 5. 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.

D. Air Flow Measuring Stations

1. Piezo Ring Air Flow Measuring Stations

- a. Acceptable manufacturers: Air Monitor Corporation, Dietrich Standard, Paragon Controls, or Tek-Air.
 - 1) Substitutions: Not permitted.
- b. At the inlet of each fan and near the exit of the inlet sound trap, flow measurement device shall be provided that shall continuously monitor the fan air volumes and system velocity pressure.
- c. Flow measurement device shall consist of a Piezo ring mounted on the circumference of the fan inlet throat and an inlet tap mounted on the face of the inlet cone.
- d. For multiple fans in parallel, provide Piezo ring/pressure tap at each fan inlet and provide an air flow totalizing panel equal to Paragon FAATS-1000 Fan Array Air Flow Totalizing system. The panel shall communicate the air flow of each individual fan and the total fan array air flow to the BAS. Air flow discrepancies and fan failures shall be alarmed from the panel to the BAS.
- e. Station shall have an accuracy within +/- 5% of actual air flow and be rated for operation from 200 to 8,000 feet/minute velocity at up to 350 deg. F.
- f. Station shall not induce a pressure drop greater than 0.15" w.c. at 4,000 feet/minute regardless of fan inlet size.
- g. Station shall be anodized aluminum unless noted otherwise and built in accordance with ASHRAE Standard #111 and AMCA Publication #203.

2. Static Pressure Traverse Probe

- a. Acceptable manufacturers: Air Monitor Corp., Cleveland Controls, or Paragon Controls.
 - 1) Substitutions: Refer to Division 01.
- b. Duct static traverse probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple static pressure sensors located along exterior surface of the cylindrical probe.
- c. Shielded Static Air Probe
 - 1) A shielded static pressure probe shall be provided at each end of the building. The probe shall have multiple sensing ports, an impulse suppression chamber, and air flow shielding. A suitable probe for indoor and outdoor locations shall be provided.

E. 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.
2. Any fire alarm relays necessary for Building Automation & Fire Alarm interface shall be installed by the fire alarm contractor and shall be located at the BAS field panel.

F. 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. Air Flow Switches
 - a. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.
 4. Air Pressure Safety Switches
 - a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.
 - b. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.
 5. Differential Pressure / Water Flow Switches
 - a. 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.
 - b. Device shall be an automatic reset device and shall provide a control output at the differential pressure setpoint.

2.03 OUTPUT DEVICES

A. Actuators

1. General Requirements
 - a. Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.
2. 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.

B. Control Dampers

1. The BAS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BAS Contractor or as specifically indicated on the Drawings.
2. All dampers used for throttling air flow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.
3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.
4. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak in excess of 8.0 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.
5. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5" w.g., but no more than 4000 FPM or 6" w.g. Acceptable manufacturers are Johnson Controls D-7250 D-1250 or D-1300, Ruskin CD50, and Vent Products 5650.
6. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below. Acceptable manufacturers are: Johnson Controls D-1600, Ruskin CD36, and Vent Products 5800, or Siemens.
7. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

C. Control Relays

1. Control Pilot Relays

- a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
- b. Mounting Bases shall be snap-mount.
- c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
- d. Contacts shall be rated for 10 amps at 120VAC.
- e. 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.

D. 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.

E. 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.

F. 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.

2.04 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

3.01 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. Building Differential Air Pressure Applications (-1" to +1" w.c.)
 - a. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
 - b. The interior tip shall be inconspicuous and located as shown on the drawings.
 6. Air Flow Measuring Stations
 - a. Install air flow measuring stations in accordance with manufacturer's instructions at the locations indicated on the plans including clear distances to adjacent fittings, elbows, inlets, or other interference. A written report shall be submitted to the Engineer if any discrepancies exist or if installation cannot be completed per the manufacturer's recommendations.

- b. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.
- 7. 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.
- 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.
- 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

3.02 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.

3.03 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

1.01 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.

1.02 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

1.03 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 195-2008 (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.

1.04 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.

1.05 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

2.01 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.

2.02 ACCEPTABLE MANUFACTURERS

- A. Siemens
- B. Substitutions: Not permitted.

2.03 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.

2.04 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

3.01 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)

3.02 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.

3.03 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.

3.04 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 31 13 - SHEETMETAL DUCTWORK

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Rectangular Metal Ducts
- B. Round Ducts
- C. Double Wall Round and Flat-Oval Spiral Ducts

1.02 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 93 - Testing, Adjusting, and Balancing for HVAC
- E. Section 23 07 00 - HVAC Insulation
- F. Section 23 33 00 - Air Duct Accessories
- G. Section 23 33 19 - Duct Silencers
- H. Section 23 3600 - Air Terminal Units
- I. Section 23 3700 - Air Outlets and Inlets

1.03 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.

1.04 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.

1.05 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

2.01 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 33 00.

2.02 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

2.03 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.

2.04 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.

PART 3 - EXECUTION

3.01 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 bolt.
- 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.

3.02 CLEANING

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

3.03 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.

3.04 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 isolation rooms and bronchoscopy 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.

3.05 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

1.01 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.
- G. Flexible duct
- H. Flexible duct connections.
- I. Volume control dampers.

1.02 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.

1.03 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.

1.04 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

2.01 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.

2.02 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.

2.03 SMOKE DAMPERS

- A. Acceptable manufacturers: Air Balance, Greenheck, Ruskin, or Nailor

1. Substitutions: Not permitted.
- B. Fabricate in accordance with NFPA 90A, 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 in low pressure systems and up to 4000 FPM in medium pressure systems.
- E. Provide two-position actuator. Damper shall fail normally closed.
- F. Provide manufacturer's round to horizontal duct adapter as required.
- G. Damper pressure drop shall not exceed 0.15 in. wg. at 1500 FPM or 0.25 in. wg. at 2000 FPM.
- H. Dampers shall bear the AMCA Certified Ratings Seal for Air Performance in accordance with AMCA 511.

2.04 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 manufacturer's round to horizontal duct adapter as required.
- G. Damper pressure drop shall not exceed 0.15 in. wg. at 1500 FPM or 0.25 in. wg. at 2000 FPM.
- H. Dampers shall bear the AMCA Certified Ratings Seal for Air Performance in accordance with AMCA 511.

2.05 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.

2.06 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'.

2.07 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.

2.08 FLEXIBLE DUCT

- A. Acceptable manufacturers: Atco, Flexmaster USA, Hart & Cooley, J.P. Lanburn, or Thermaflex.
 - 1. Substitutions: Refer to Division 01.
- B. Characteristics of flexible duct to air terminals:
 - 1. Approved as UL 181, Class 1 air duct.
 - 2. Meet requirements of ASTM C1071.
 - 3. Flame spread less than 25; smoke developed rating less than 50.
 - 4. Thermal conductance: minimum R-6.
 - 5. Perm rating: 0.05 perms per ASTM E96, Method A.
 - 6. Provide a minimum of three feet of flexible duct upstream of diffusers. Do not exceed six feet of length.
 - 7. Flexible duct shall meet standards of local building code.
- C. Seal off the insulation jacket at its ends and at joints with mastic, hardcast, or similar material. Replace flex if jacket is punctured.
- D. Complete insulation coverage up to the diffuser neck connection.
- E. Do not route flexible duct through corridor walls or fire or smoke rated partitions, barriers, or walls.
- F. No bends shall be made in flexible duct with the center line radius less than one and one-half duct diameter and only one bend may occur per four foot length of duct material.

2.09 FLEXIBLE DUCT CONNECTIONS

- A. Acceptable manufacturers: Carlisle, Durodyne, or Elgen.
 - 1. Substitutions: Refer to Division 01.
- B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards and as indicated.
- C. Flexible Duct Connections: Fabric crimped into metal edging strip.
 - 1. Fabric: NFPA 90A compliant, UL listed fire-retardant neoprene coated woven glass fiber fabric, minimum 28 oz. density.
 - a. Net Fabric Width: Approximately 3 inches wide.
 - 2. Metal: 3 inches wide, 24 gauge, 0.0239 inch thick galvanized steel. Provide aluminum or stainless steel metal as required to match ductwork material.

2.10 VOLUME CONTROL DAMPERS

- A. Acceptable manufacturers: Louvers & Dampers, Greenheck, McGill Airflow, Ruskin, or SEMCO.
 - 1. Substitutions: Refer to Division 01.
- B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards and as indicated.

C. Splitter Dampers:

1. Material: Same gauge as duct to 24 inches size in either direction, and two gauges heavier for sizes over 24 inches.
2. Blade: Fabricate of single thickness sheet metal to streamline shape, secured with continuous hinge or rod.
3. Operator: Minimum 1/4 inch diameter rod in self aligning, universal joint action, flanged bushing with set screw .

D. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.

1. Fabricate for duct sizes up to 6 x 30 inch.
2. Blade: 22 gauge, minimum.
3. Frame: 18 gauge, minimum.

E. Multi-Blade Damper: Fabricate of opposed blade pattern with 3V or airflow shaped blades and maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

1. Blade: 18 gauge, 0.0478 inch, minimum.

F. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.

G. Quadrants:

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

2.11 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

3.01 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), control dampers, duct mounted smoke detectors, 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. Use splitter dampers only where indicated.
- I. Where diffusers or grilles and registers are not provided with volume dampers, install spin-in fitting with balance damper in duct run-out.
- J. Provide all screws, bolts, nuts, inserts, and material required for attaching sheetmetal to duct, walls, floors, and ceilings.

3.02 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

1.01 SECTION INCLUDES

- A. Single duct terminal units.
- B. Fan powered terminal units.

1.02 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 93 - Testing, Adjusting, and Balancing for HVAC
- D. Section 23 07 00 - HVAC Insulation
- E. Section 23 09 13 - Instrumentation and Control Devices for HVAC
- F. Section 23 31 13 - Sheetmetal Ductwork
- G. Section 23 33 00 - Air Duct Accessories
- H. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.

1.03 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.

1.04 SUBMITTALS

- A. Submit product data and required information in accordance with the provisions of Division 01.
- 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.

1.05 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.

1.06 WARRANTY

- A. See Division 01 for additional warranty requirements.
- B. Provide five year manufacturer warranty for air terminal units.

1.07 GUARANTEE

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

PART 2 PRODUCTS

2.01 SINGLE DUCT AIR TERMINAL UNITS

- A. Acceptable Manufacturers:
 - 1. Anemostat, Environmental Technologies (JCI), Krueger, 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 - by Controls Contractor

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. Attenuator:

1. Where indicated, attenuators shall be provided as required to reduce the discharge and radiated NC levels to 35 or less based on selections made at 3.0" w.c. inlet static pressure.
2. The attenuator lining shall match the specified air terminal unit lining.
3. Provide attenuator on all air terminal units in the following spaces: patient rooms, offices, and procedure rooms or any additional space noted on drawings or schedules..

E. Electric Heating Coil:

1. Construction: UL listed, slip-in type, open coil design, integral control box factory wired and installed, with:
 - a. Disconnect type automatic thermal primary safety device.
 - b. Manual reset thermal secondary safety device.
 - c. Minimum airflow switch.
 - d. Nickel-chromium element.
 - e. Magnetic contactor for each step of control.
 - f. Include contactors as an integral part of the control panel.
2. Heater accessories:
 - a. Interlocking door handle on heater control box.
 - b. Control disconnect.
 - c. Control fuses on primary voltage hot line.
 - d. Heater fuses on all sizes.

2.02 FAN POWERED SINGLE DUCT UNITS

A. Acceptable Manufacturers:

1. Anemostat, Environmental Technologies (JCI), Krueger, Metalaire, Nailor, Price, Titus, and Trane.

B. Basic Assembly:

1. Casings: Minimum 20 gauge galvanized steel.
2. Fan powered, single duct units, parallel fan configuration inside unit casing, pressure independent, with multi-axis flow ring and heating coil. Locate control components inside protective metal shroud.
3. 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.
4. Fan: Forward-curved centrifugal.
5. Filter: 1" thick, glass fiber having 80 percent arrestance and a MERV 5 rating.
 - a. Change filter prior to Test and Balance and again at substantial completion.
6. Motor:
 - a. Permanently lubricated, SCR controlled, direct drive, PSC type with thermal overload protection. Motor and fan assembly shall be isolated from casing using rubber isolators.
 - b. Provide speed adjustment knob outside of control panel.
 - c. Provide fan disconnect switch.
7. Provide backdraft damper at plenum air inlet to prevent backflow of primary air into plenum.
8. Provide insulated gasketed access panel on bottom of terminal unit for internal access and inspection of air valve, motor, and heating coil. Adjacent duct insulation shall not block access door(s).
9. Leakage: Maximum 1% of maximum rated airflow at 1" wg. inlet static pressure.
10. Multi-point, multi-axis flow ring or cross sensor at box inlet.
11. Provide integral flow taps and calibration chart on each unit.
12. 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.
13. 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.

14. Control transformer: Provide and factory mount 120V / 24V control circuit transformer for each terminal unit sized to handle all box controls. Provide safety devices including toggle disconnect switch and primary and secondary fusing.

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. Attenuator:

1. Where indicated, attenuators shall be provided as required to reduce the discharge and radiated NC levels to 35 or less based on selections made at 3.0" w.c. inlet static pressure.
2. The attenuator lining shall match the specified air terminal unit lining.
3. Provide attenuator on all air terminal units in the following spaces: _____.

E. Electric Heating Coil:

1. Construction: UL listed, slip-in type, open coil design, integral control box factory wired and installed, with:
 - a. Disconnect type automatic thermal primary safety device.
 - b. Manual reset thermal secondary safety device.
 - c. Minimum airflow switch.
 - d. Nickel-chromium element.
 - e. Pneumatic/electric switches and relays.
 - f. Include contactors as an integral part of the control panel.
2. Heater accessories:
 - a. Interlocking door handle on heater control box.
 - b. Control disconnect.
 - c. Control fuses on primary voltage hot line.
 - d. Heater fuses on all sizes.

PART 3 EXECUTION

3.01 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.

3.02 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

1.01 SECTION INCLUDES

- A. Diffusers.
- B. Registers/grilles.

1.02 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

1.03 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.

1.04 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.

1.05 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

2.01 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.

2.02 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: Insulated back panel

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.

- C. Provide concealed balancing damper regulator equal to Young Regulator Model 5020-CC where specified herein or indicated on drawings. Regulator shall contain a Bowden cable control assembly and be adjustable from the finished ceiling using a socket wrench. Adjustment fitting shall not protrude below the finished ceiling.

2.03 RETURN AND EXHAUST GRILLES

A. 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
- B. Type R5 / E5 (based on Titus 355RL)
1. Sidewall grille with 35 degree fixed deflection blades spaced 1/2" apart. Refer to schedule for blade orientation. Provide 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 grille.
 6. Accessories: Provide with piano hinged 1" filter frame and quarter turn fastener when noted on drawings. Hinge shall be located on right or left side of grille as required to allow frame door to fully open.

PART 3 - EXECUTION

3.01 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.

3.02 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.

3.03 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