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**THE UNIVERSITY OF TEXAS  
MEDICAL BRANCH  
Victory Lakes Town Center**

**Victory Lakes Town  
Center Clinic Expansion**

## **PROJECT MANUAL**

UTMB Project. No. 59562  
Design Team Project No. 18201

DOCUMENT NUMBER	DOCUMENT TITLE	Number of Pages	Date Last Modified
<b>DIVISION 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS</b>			
Section 00 01 01	Cover Page .....	1	02/15/19
Section 00 01 10	Table of Contents .....	4	02/15/19
Section 00 50 00	Professional Seals.....	1	02/15/19
<b>DIVISION 01 – GENERAL REQUIREMENT</b>			
Section 01 10 00	Summary .....	2	02/15/19
Section 01 10 12	Indoor Air Quality.....	5	02/15/19
Section 01 25 00	Substitution Procedures (After Contract Award) .....	2	02/15/19
Section 01 31 00	Project Management and Coordination .....	4	02/15/19
Section 01 33 00	Submittal Procedures .....	9	02/15/19
Section 01 35 23	Project Safety Requirements .....	35	02/15/19
Section 01 42 00	Reference Standards and Definitions .....	5	02/15/19
Section 01 43 00	Quality Assurance .....	3	02/15/19
Section 01 43 39	Field Constructed Mock-Ups.....	2	02/15/19
Section 01 45 29	Structural Testing and Inspections.....	25	02/15/19
Section 01 50 00	Temporary Facilities and Controls .....	8	02/15/19
Section 01 61 00	Common Product Requirements.....	8	02/15/19
Section 01 71 36	Maintenance and Protection of Utilities.....	4	02/15/19
Section 01 73 00	Execution Requirements .....	4	02/15/19
Section 01 73 29	Cutting and Patching .....	3	02/15/19
Section 01 77 00	Closeout Procedures.....	3	02/15/19
Section 01 78 32	Operation and Maintenance Data .....	5	02/15/19
Section 01 78 35	Warranties and Bonds.....	4	02/15/19
Section 01 78 39	Project Record Documents .....	3	02/15/19
Section 01 79 00	Demonstration and Training.....	4	02/15/19
<b>DIVISION 02 – EXISTING CONDITIONS</b>			
Section 02 41 19	Selective Demolition.....	7	02/15/19
<b>DIVISION 03 – CONCRETE</b>			
NOT USED			
<b>DIVISION 04 – MASONRY</b>			
NOT USED			
<b>DIVISION 05 – METALS</b>			
NOT USED			
<b>DIVISION 06 – WOOD, PLASTIC, AND COMPOSITES</b>			
Section 06 10 53	Miscellaneous Rough Carpentry .....	5	02/15/19
Section 06 41 16	Plastic Laminate Clad Cabinetry .....	9	02/15/19
Section 06 61 16	Solid Surfacing Fabrications .....	3	02/15/19
<b>DIVISION 07 – THERMAL AND MOISTURE PROTECTION</b>			
Section 07 21 00	Thermal Insulation.....	6	02/15/19
Section 07 22 00	Roof and Deck Insulation .....	8	02/15/19

DOCUMENT NUMBER	DOCUMENT TITLE	Number of Pages	Date Last Modified
Section 07 25 00	Weather Barriers .....	3	02/15/19
Section 07 51 19	Built-Up Roofing Repair .....	7	02/15/19
Section 07 62 00	Sheet Metal Flashing and Trim .....	4	02/15/19
<b>DIVISION 08 – OPENINGS</b>			
Section 08 11 13	Hollow Metal Doors and Frames.....	6	02/15/19
Section 08 14 16	Flush Wood Doors.....	5	02/15/19
Section 08 31 13	Access Doors and Frames.....	3	02/15/19
Section 08 41 13	Aluminum Entrances and Storefronts .....	8	02/15/19
Section 08 42 29	Automatic Entrances .....	12	02/15/19
Section 08 71 00	Door Hardware .....	11	02/15/19
Section 08 71 13	Automatic Door Operators .....	7	02/15/19
Section 08 80 00	Glazing .....	11	02/15/19
<b>DIVISION 09 – FINISHES</b>			
Section 09 05 61	Moisture Vapor Emission Control.....	3	02/15/19
Section 09 20 13	Light Gage Metal Framing.....	4	02/15/19
Section 09 21 13	Plaster Assemblies.....	7	02/15/19
Section 09 21 16	Gypsum Board Assemblies.....	13	02/15/19
Section 09 30 00	Tiling.....	9	02/15/19
Section 09 51 00	Acoustical Ceilings .....	7	02/15/19
Section 09 65 13	Resilient Base and Accessories.....	4	02/15/19
Section 09 65 16	Resilient Sheet Flooring .....	5	02/15/19
Section 09 65 19	Resilient Tile Flooring.....	4	02/15/19
Section 09 65 36	Static-Control Resilient Flooring.....	6	02/15/19
Section 09 68 10	Carpeting.....	4	02/15/19
Section 09 81 00	Acoustical Blanket Insulation .....	3	02/15/19
Section 09 91 00	Painting .....	10	02/15/19
<b>DIVISION 10 – SPECIALTIES</b>			
Section 10 21 13	Phenolic Toilet Compartments.....	3	02/15/19
Section 10 21 23	Cubicle Curtain and Tracks.....	3	02/15/19
Section 10 26 00	Wall and Door Protection .....	4	02/15/19
Section 10 28 13	Toilet Accessories .....	5	02/15/19
Section 10 51 13	Metal Lockers.....	6	02/15/19
<b>DIVISION 11 – EQUIPMENT</b>			
Section 11 13 00	Loading Dock Equipment.....	16	02/15/19
Section 11 24 00	Building Maintenance Equipment.....	7	02/15/19
Section 11 53 13	Laboratory Fume Hoods .....	6	02/15/19
Section 11 53 53	Biological Safety Cabinets .....	7	02/15/19
Section 11 70 10	Medical Equipment General Requirements .....	4	02/15/19
Section 11 73 10	Modular Headwall System .....	6	02/15/19
<b>DIVISION 12 – FURNISHINGS</b>			
NOT USED			
<b>DIVISION 13 – SPECIAL CONSTRUCTION</b>			
NOT USED			

DOCUMENT NUMBER	DOCUMENT TITLE	Number of Pages	Date Last Modified
DIVISION 14 – CONVEYING EQUIPMENT			
NOT USED			
DIVISION 20 – FACILITY SERVICES			
NOT USED			
DIVISION 21 – FIRE SUPPRESSION			
Section 21 00 00	Basic Fire Protection Requirements.....	21	02/15/19
Section 21 05 53	Fire Protection Piping and Equipment Identification .....	4	02/15/19
Section 21 13 13	Fire Protection Systems .....	9	02/15/19
DIVISION 22 – PLUMBING			
Section 22 05 00	Common Work Results for Plumbing .....	22	02/15/19
Section 22 05 26	Pipe and Pipe Fittings .....	7	02/15/19
Section 22 05 29	Plumbing Supports and Sleeves .....	9	02/15/19
Section 22 05 48	Plumbing Vibration Isolation .....	4	02/15/19
Section 22 05 53	Plumbing Identification .....	5	02/15/19
Section 22 05 84	Plumbing Specialties.....	5	02/15/19
Section 22 07 19	Plumbing Insulation.....	7	02/15/19
Section 22 08 00	Commissioning of Plumbing System.....	2	02/15/19
Section 22 11 16	Domestic Water Piping System .....	9	02/15/19
Section 22 11 17	Gas Piping and Appurtenances.....	5	02/15/19
Section 22 11 19	Domestic Water Piping Specialties .....	3	02/15/19
Section 22 11 23	Plumbing Equipment.....	9	02/15/19
Section 22 11 23	Domestic Water Pressure Boosting System .....	4	02/15/19
Section 22 13 16	Sanitary Waste and Vent Piping.....	7	02/15/19
Section 22 40 00	Plumbing Fixtures .....	4	02/15/19
DIVISION 23 – HEATING, VENTILATING, AND AIR CONDITIONING			
Section 23 00 00	Mechanical General Provisions .....	10	02/15/19
Section 23 05 13	Common Motor Requirements for HVAC Equipment.....	5	02/15/19
Section 23 05 29	Hangers and Supports for HVAC Piping and Equipment.....	11	02/15/19
Section 23 05 53	Identification for HVAC Piping and Equipment .....	4	02/15/19
Section 23 05 93	System Testing, Adjusting and Balancing.....	6	02/15/19
Section 23 09 23	Direct Digital Control Systems .....	16	02/15/19
Section 23 31 00	Ductwork.....	10	02/15/19
Section 23 33 00	Air Duct Accessories .....	8	02/15/19
Section 23 34 00	Fans .....	6	02/15/19
Section 23 36 00	Air Terminal Units.....	4	02/15/19
Section 23 37 00	Air Devices .....	4	02/15/19
Section 23 41 00	Particulate Air Filtration .....	3	02/15/19
Section 23 74 00	Packaged Rooftop Air Handling Units .....	8	02/15/19
DIVISION 26 – ELECTRICAL			
Section 26 00 00	Basic Electrical Requirements .....	9	02/15/19
Section 26 00 00.01	Electrical Demolition.....	5	02/15/19
Section 26 05 19	Cable, Wire and Connectors 600 Volt.....	11	02/15/19
Section 26 05 26	Grounding.....	4	02/15/19
Section 26 05 29	Securing and Supporting Methods .....	3	02/15/19

## SECTION 23 00 00 - MECHANICAL GENERAL PROVISIONS

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. Except as modified in this Section, General Conditions, Special Conditions, applicable provisions of Division 01, General Requirements, and other provisions and requirements of the contract documents apply to work of Division 23.
- B. Applicable provisions of this Section apply to all Sections of Division 23 HVAC.
- C. Contract drawings are diagrammatic only and do not give fully dimensioned locations of various elements of work. Determine exact locations from field measurements and provide coordination drawings.
- D. All work in these Sections shall be installed by craftsmen skilled in their trade.
- E. Unsightly, inadequate, or sloppy work will not be acceptable and shall be removed and replaced as necessary to achieve an acceptable installation.

- 1.3 Commissioning of a system or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel, is required in cooperation with the Owner's Representative and the Commissioning Agent. Project Closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019000, General Commissioning, for detailed commissioning requirements.

## 1.4 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, un-air-conditioned spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within un-air-conditioned shelters.

- F. Furnish: The term "furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations.
- G. Install: The term "install" is used to describe operations at project site including the actual unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.
- H. Provide: The term "provide" means to furnish and install, complete and ready for the intended use.

#### 1.5 CODE REQUIREMENTS AND PERMITS

- A. Perform work in accordance with applicable statutes, ordinances, codes, and regulations of governmental authorities having jurisdiction.
- B. Resolve any code violation discovered in contract documents with the Engineer prior to award of the contract. After award of the contract, make any correction or addition necessary for compliance with applicable codes at no additional cost to Owner.
- C. Obtain and pay for all permits and inspections.
- D. The following building codes are applicable to this project.
  - 1. 2015 International Mechanical Code
  - 2. 2015 International Building Code
  - 3. 2015 International Energy Conservation Code
  - 4. State Energy Conservation Office (SECO) mandated state building compliance with ASHRAE 90.1-2013

#### 1.6 REFERENCES

- A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, AWWA Specifications, Federal Standards or other standard specifications must comply with latest editions except where specified otherwise in individual Sections, revisions, amendments, or supplements in effect on date bids are received.
- B. Requirements in reference specifications and standards are minimums for all equipment, materials and work. In instances where capacities, size or other features of equipment, devices, or materials exceed these minimums, meet listed or shown capacities.

#### 1.7 SUBMITTALS

- A. Equipment and Materials submittals must show sufficient data to indicate complete compliance with contract documents as follows:
  - 1. Proper sizes and capacities.
  - 2. That the item will fit in the available space in a manner that will allow proper service.
  - 3. Construction methods, materials, and finishes.
- B. Material and Equipment List: Within 30 days after award of the contract and before orders are placed or shop drawings are submitted, submit a list of equipment and principal materials specified. Give names of manufacturers, catalog and model numbers, and such other supplementary information as necessary for identification.
- C. Material and Equipment Shop Drawings: Submit all detailed shop drawings, descriptive literature, physical data, and performance data for review for items of equipment and for principal materials proposed for installation. HVAC controls may be submitted separately provided the controls submittal is complete and coordinated with all other applicable trades. Include identifying symbols and equipment numbers used in plans and specifications, with reference to specification paragraphs, and drawing numbers of all equipment and material submitted.

- D. Final Submittal: In addition to number of copies of shop drawings and other data required for review submittals, maintain a separate file of final approved copies of such material. Deliver approved copies in a hard-back binder for the Owner's use. Incorporate changes and revisions made throughout construction period. Delivery of approved copies is a condition of final acceptance for the project.
- E. Contractor's Check: Shop drawings will be submitted only by the Contractor. Indicate by signed stamp that the drawings have been checked, that the work shown on the drawings is in accordance with contract requirements and that dimensions and relationship with work of other trades have been checked. If drawings are submitted for approval that have not been checked and signed by the Contractor, they will be returned for checking before being considered by the Architect/Engineer.
- F. Refer to Section 01 33 00 for additional submittal requirements

#### 1.8 COORDINATION DRAWINGS

- A. Prior to starting work, the Contractor shall provide coordination drawings for all areas of the building. The Contractor shall submit the coordination drawing for confirmation of the coordination process. The Contractor is responsible for all trade confirmation.
- B. CAD. Provide 1/4 inch scale 2D coordination drawings.
  - 1. Drawings shall show all equipment, ductwork, cable trays, fire protection system, coil pull spaces, chilled water, heating water and condensate piping and trap, electrical conduit, electrical and control panels, etc. installed in mechanical room to verify space allocation and coordination of trades.
  - 2. Provide plan and elevation views detailing installation.
  - 3. Contractor may not proceed with construction of MEP systems until trade coordination process has been demonstrated to be completed by the Contractor to the Architect, Engineer and Owner.

#### 1.9 INTERFERENCE DRAWINGS

- A. Interference drawings are drawings that indicate conflict between the various systems and other components of the building such as beams, columns, walls, etc. They shall be drawn to scale and shall include plans, elevations, sections and other details as required to clearly define the interference and to indicate the contractor's proposed solution.
- B. They shall be submitted for approval whenever job measurements and an analysis of the drawings and specifications by the contractor indicate that the various systems cannot be installed without significant deviation from the intent of the contract. When such interference is encountered, work shall cease in the general area of the conflict until a resolution to the question has been approved.

#### 1.10 GUARANTEE

- A. Guarantee work for one year from the date of final acceptance of the project. During that period make good any faults or imperfections that may have arisen due to defects or omissions in materials or workmanship.

#### 1.11 SERVICE

- A. Perform service work required during the guarantee period including lubrication of bearings. Perform manufacturer's recommended monthly service and provide Owner with written report. Cleaning of air filters and pipe strainers is not included.

#### 1.12 RESOLUTION OF CONFLICTS

- A. Where conflicts may exist between and/or within the drawings and/or specifications, the contractor shall contact the A/E to clarify. The Contractor shall notify the A/E for resolution of the issue prior to executing the work in question.

## PART 2 - PRODUCTS

## 2.1 MATERIALS AND EQUIPMENT

- A. Furnish new and unused materials, pipes, pipe fittings, and equipment of domestic manufacture, where available. Where two or more units of same type or class of equipment are required, provide units of a single manufacturer.

## 2.2 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers are listed in individual Sections of Division 23. Where two or more units of same type or class of equipment are required, provide units of a single manufacturer.
- B. Manufacturers' names and catalog numbers specified under Sections of Division 23 are used to establish standards of design, performance, quality and serviceability and not to limit competition.
- C. Equipment of similar design, equal to that specified, manufactured by a manufacturer named in the acceptable manufacturers' list will be acceptable on approval.
- D. Substitutions:
1. If the Contractor desires to substitute a material or method as an equal to the specified item, he shall request permission from the Architect/ Engineer, in writing, and shall include such literature, samples, etc., deemed necessary to establish the equal quality of his proposal.
  2. If the Architect/Engineer deems it necessary in order to establish the equality between two or more products, he may require laboratory testing at the Contractor's expense in order to obtain information upon which to base a decision.
  3. The Architect/Engineer will not give approval to material salesmen or subcontractors, and only in writing to the successful Contractor after the project has been awarded.
  4. For each proposed substitution product, clearly show how the proposed product meets the requirements of the specifications, including performance.
  5. No substitution will be considered unless it is presented in writing within that number of days after Notice to Proceed equal to 15 percent of the contract time.
  6. Proposers of substitute products shall present samples, literature, test and performance data, record of other installations, names of Owners, architects, engineers, contractors and subcontractors as references, statement of current financial condition, and other technical information applicable to their products, to aid in determining the worth of the substitute product offered in relation to the material and work specified from the standpoint of the Owner's best interest. Substitute materials and products shall be used only if approved in writing by the Architect/Engineer in advance.
  7. Approval of substitute materials offered shall not be a basis for contingent extra charges because of changes in other work or related work, such as roughing-in, electrical, structural or architectural, which may result from the substitution.
  8. For any Contractor initiated substitutions or changes, Contractor shall be responsible for achieving results equal to or better than the product or design originally specified.
- E. Basis of Design: Where a basis of design is indicated (i.e., scheduled products), that product was used for the purposes of established space requirements, structural design for the building, utility connections, etc. If the contractor elects to furnish a product other than the basis of design product (either another named acceptable manufacturer or via substitution) the contractor is responsible for any construction or design costs associated with the non-basis of design product.



### 2.3 NOISE AND VIBRATION

- A. Select equipment to operate with minimum noise and vibration. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of work, rectify such conditions without cost to the Owner. If the item of equipment is judged to produce objectionable noise or vibration, demonstrate (without cost to the Owner) that equipment performs within designated vibration limits indicated in the specifications, or as specified by manufacturer.
- B. Seal all wall and partition penetrations (the penetration opening shall be one inch larger than penetrating member) by ducts and piping by stuffing the annular void with fiberglass insulation and then caulking over fully with a non hardening acoustical caulking applied to both sides of wall or partition.

### 2.4 AIR FILTERS AND PIPE STRAINERS

- A. Immediately prior to final acceptance of project, inspect, clean and service hydronic system strainers and replace disposable type air filters.
- B. Turn over to Owner additional sets of spare filters and other spare parts as specified.

### 2.5 ACCESS DOORS

- A. Provide access doors for all walls or ceiling locations as required for access to valves, controls, regulating devices, water arresters, fire dampers, air distribution boxes, and other concealed equipment requiring maintenance adjustment or operation. Coordinate location with General Contractor.
- B. Basis-of-Design Product: Design of access doors is based on model numbers manufactured by Milcor unless otherwise indicated. Subject to compliance with requirements, provide named product or approved equal.
  - 1. Non-Fire Rated Doors:
    - a. Furnish Milcor non-fire rated doors with 16-gage frames and 14 gage door panels.
    - b. Provide continuous concealed hinges and flush screwdriver cam lock.
    - c. Use Style M for prime painted steel, and MS for stainless steel.
    - d. Use Style DW access door for drywall or gypboard construction.
    - e. Use Style CF for suspended drywall ceilings.
    - f. Use Style K for plastered walls and ceilings.
    - g. Use Style AP for acoustical plastered ceilings with all galvanized construction.
  - 2. Fire-Rated Access Doors:
    - a. Furnish Milcor, UL listed, 1-1/2 hour, "B" label for service access in walls of stairwell, corridors and all other areas where fire-rated construction occurs.
    - b. Access doors shall have a 16 gage steel frame and 20 gage insulated sandwich type insulated panel.
    - c. Use ATR for fire-rated suspended drywall ceilings.
  - 3. Provide spring-loaded door for automatic closure and exterior key lock for security.

### 2.6 FLAME SPREAD PROPERTIES OF MATERIALS

- A. Materials and adhesives incorporated in this project shall conform to NFPA Standard 255, "Method of Test of Surface Burning Characteristics of Building Materials" and NFPA 90. The classification shall not exceed a flame spread rating of 25 for all materials, adhesives, finishes, etc., specified for each system, and shall not exceed a smoke developed rating of 50.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Cooperation with Other Trades: Cooperation with trades of adjacent, related, or affected materials or operations and of trades performing continuations of work under subsequent contract is considered a part of this work in order to effect timely and accurate placement of work and to bring together in proper and correct sequence the work of such trades.
- B. Workmanship: Work must be performed by workmen skilled in their trade.
- C. Installation of all equipment and materials must be complete. Installation shall meet requirements of specifications and manufacturer's recommendations.
- D. Electrical Wiring of Motors and Equipment. The Contractor shall note that the electrical design was based upon the mechanical equipment indicated on the mechanical construction documents and specifications. If Contractor proposes any mechanical equipment that requires changes to the electrical design, the required electrical changes shall be made at no cost to the Owner.

## 3.2 SPACE REQUIREMENTS

- A. Consider space limitations imposed by contiguous work, including clearances required for service, in selection and location of equipment and material. Do not provide equipment or material which is not suitable in this respect.
- B. The following space allocation and coordination shall be followed, unless otherwise indicated on the construction drawings:
  - 1. Gravity-fed plumbing and roof drain line shall take priority over all other systems.
  - 2. Light fixtures and cable tray arrangements shall take priority in spatial layout. In areas with ceilings, other systems shall be routed above the light fixtures, and offset from above cable tray allowing for access and maintenance clearance.
  - 3. Install HVAC ductwork as close to the bottom of structural framing as possible while allowing clearance for installation of insulation wrap. Install ductwork to be accessible from the ceiling plane.
  - 4. Install HVAC chilled/hot water piping in the plane directly below HVAC ductwork unless indicated otherwise on drawings.
  - 5. Install fire sprinkler piping in the plane directly beneath the HVAC chilled/hot water piping. Do not install sprinkler piping directly below equipment requiring maintenance.
  - 6. Install domestic hot and cold water in the plane directly above the light fixtures.
  - 7. Refer to Division 26 for electrical and control wiring requirements.
  - 8. Install piping to permit removal of coils at air handling units and to permit access to all terminal unit components.

## 3.3 OBSTRUCTIONS

- A. The drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.
- B. Before any cutting or trenching operations are begun, verify with Owner's Representative, utility companies and other interested parties that all available information has been provided. Verify locations given.
- C. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.

- D. Assume total responsibility for and repair any damage to existing utilities or construction.

### 3.4 OPENINGS

- A. Framed, cast or masonry openings for ductwork, equipment and piping are specified under other divisions. However, drawings and layout work for exact size and location of all such openings are included under this division.

### 3.5 ACCESS DOORS

- A. Coordinate location of access doors for ease of operation and maintenance of concealed equipment.

### 3.6 DELIVERY, STORAGE AND HANDLING

- A. Adequately protect work, equipment, fixtures and materials from damage during storing, installation, start-up and testing.
- B. Cover all equipment stored exposed to elements with waterproof tarps, provide adequate ventilation.
- C. At work completion, all work must be clean and in like new condition.
- D. Storage of all mechanical equipment, piping materials and ductwork shall be in strict accordance with manufacturers written installation instructions.
- E. Rotate air handler fans and pump shafts on routine basis.
- F. Provide factory installed pipe caps for all pipes to be installed on the project.
- G. Provide covers over all openings in ductwork stored or installed on the project.
- H. Energize motor heaters with temporary power as soon as the motor is received on site.
- I. Air Handling Units shall not be used as storage containers

### 3.7 LUBRICATION AND OIL

- A. Provide a complete charge of correct lubricant and/or oil for each item of equipment requiring lubrication. Contractor shall lubricate per manufacturers requirements until equipment is turned over to the owner.

### 3.8 CUTTING AND PATCHING

- A. General: Cut and patch walls, floors, etc., resulting from work or by failure to provide proper openings or recesses in new construction.
- B. Methods of cutting: Openings cut through concrete and masonry shall be made with masonry saws and/or core drills and at such locations acceptable to the Architect/Engineer.
  1. Do not use impact-type equipment except where specifically acceptable to the Architect/Engineer.
  2. Core drill openings in precast concrete slabs for pipes, conduits, outlet boxes, etc., to exact size.
- C. Restoration: Restore all openings to "as-new" condition under the appropriate Specification Section for the materials involved
- D. Match remaining surrounding materials and finishes.

- E. Masonry: Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry.
- F. Provide adequate support during cutting operation to prevent any damage to the masonry occasioned by the operation. All structural members, supports, etc., shall be of the proper size and shape, and shall be installed in a manner acceptable to the Architect/Engineer.
- G. Special Note: No cutting, boring, or excavating which will weaken the structure shall be undertaken.

### 3.9 TEMPORARY CONDITIONING OF BUILDING SPACES FOR COMPLETION OF CONSTRUCTION

- A. All permanent filters for air handlers must be in place. Temporary filters must be installed on VFD drives and fan powered VAV boxes during construction. Provide temporary filter media ahead of permanent filters and replace when dirty. Do not operate exhaust devices, including fume hoods, during gypboard finishing.
- B. Factory startup of the VFD drives shall occur prior to turning on units.
- C. A preliminary air balance of the supply air shall be performed within one week of start-up by the TAB firm. All air unit and fan motors amperage ratings shall be measured and provided to the University in the preliminary Air Balance Report.
- D. All equipment utilized will be checked out by a factory representative, serviced, lubricated, checked for rotation, pressure, amp draw and vibration isolation, adjusted and certified. Record of this service must be provided monthly to the Owner. Submit appropriate reports to the University prior to submitting a written request for service.
- E. All equipment operated shall be serviced on a regular basis by the contractor.
- F. Prior to final inspection, clean all equipment inside and out to a like new condition, remove temporary filters, install new permanent filters in preparation for final inspection by Owner.
- G. All warranties will be commenced at the time of final acceptance.
- H. Refer to Division 1 requirements for a clean building.

### 3.10 OPERATING TESTS

- A. After all mechanical systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequence and operation throughout the range of operation witnessed by Owner's Representative.
- B. Prove operations of control systems and all safeties, freezestats and alarms.
- C. Make adjustments as required to ensure proper functioning of all systems.
- D. Special tests on individual systems are specified under individual Sections.

### 3.11 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. Furnish copies of commercially available standard operation and maintenance data, including operating instructions, maintenance instructions and parts listings in accordance with Specification 01 78 32. Detailed requirements for these items are as follows:
  - 1. Information required for the preparation of O&M manuals may be furnished in the form of manufacturers' standard brochures, schematics, and other printed instructions. Clearly distinguish between information which applies to the equipment and information which does not apply. Data shall include as a minimum the following items:

- a. Recommended procedures and frequencies for preventive maintenance; inspection, adjustment, lubrication, cleaning, etc.
  - b. Special tools and equipment required for testing and maintenance.
  - c. Parts lists reflecting the true manufacturer's name, part number and nomenclature.
  - d. Recommended spares by part number and nomenclature and spare stocking levels.
  - e. Integrated mechanical and electrical system schematics and diagrams to permit operation and troubleshooting after acceptance of the system.
  - f. Troubleshooting, checkout, repair and replacement procurement procedures.
  - g. Operating instructions including start up and shutdown procedures.
  - h. Safety considerations including load limits, speed, temperature and pressure.
2. Provide O&M manuals for all HVAC equipment.

3.12 PROJECT RECORD DOCUMENTS

- A. Maintain at the job site a separate set of white prints of the contract drawings for the sole purpose of recording the "as-built" changes and diagrams of those portions of work in which actual construction is significantly at variance with the contract drawings.
- B. Mark the drawings with a colored pencil.
- C. Prepare, as the work progresses and upon completion of work, drawings clearly indicating locations of various lines, valves, ductwork, traps, equipment, and other pertinent items, as installed.
- D. Record underground and underslab piping installed, dimensioning exact location and elevation of such piping.
- E. At conclusion of project, obtain without cost to Owner, reproducibles of original mechanical drawings and transfer as-built changes to these.
- F. Delivery of as-built prints and reproducibles is a condition of final acceptance.
- G. Upon completion of work, and at time designated by the Owner's Representative, provide services of a competent representative of the manufacturer/Contractor to instruct the Owner's Representative and up to 8 members of the Owner's staff in the operation and maintenance of the entire system. Record training sessions on DVDs for instructing future technicians.
- H. Provide training for the following pieces of equipment if provided for the project:

Items:	HRs of Training Pre-Substantial Completion	HRs of Training at 6 months from Substantial Completion	HRs of Training at 11 months from Substantial Completion	Video Taping Required
Pumps	4			X
DDC Controls	16	8	8	X
VFDs	4	4		X
Air Handling Units	4			X
Chillers	8	8	8	X
Cooling Towers	4			
Boilers	8	4		X
Refrigerant Monitors	4			X
Fans	4			X
Water Treatment equipment	4	4	4	X

- I. All training sessions shall be scheduled in coordination with the Owner's Representative 14 days in advance, attendance taken, and sign-in sheet and training materials included in the O&M manuals.

END OF SECTION 23 00 00

## SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. Section includes general requirements for 1-phase and 3-phase electric motors with NEMA frame machines sized through 200 horsepower and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation. Unless otherwise specified, provide motors meeting the basic requirements for general purpose alternating current motors, as defined in ANSI/NEMA MG 1-1.05.

## 1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
  - 1. Motor controllers.
  - 2. Torque, speed, and horsepower requirements of the load.
  - 3. Ratings and characteristics of supply circuit and required control sequence.
  - 4. Ambient and environmental conditions of installation location.

## 1.4 REFERENCES

- A. ANSI/IEEE 117 - Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random Wound AC Electric Machinery.
- B. ANSI/NEMA MG 1 - Motors and Generators.
- C. ANSI/NEMA MG 2 - Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors.
- D. ANSI/UL 674 - Electric Motors and Generators for Use in Hazardous (Classified) Locations.
- E. ANSI/UL 1004 - Electric Motors.
- F. Energy Conservation Design Standard for New State Buildings.

## 1.5 SUBMITTALS

- A. Provide the following information for each motor:
  - 1. Manufacturer.
  - 2. Rated full load horsepower.
  - 3. Rated volts.
  - 4. Number of phases.
  - 5. Frequency in hertz.
  - 6. Full load amperes (FLA).

7. Locked rotor amperes (LRA) at rated voltage or NEMA code letter.
  8. Nominal speed at full load (rpm).
  9. Service factor.
  10. NEMA design letter.
  11. NEMA machine type (ODP, WP-I, TEFC, etc).
  12. Motor space heater voltage, wattage and number of wires (where applicable)[Engineer to remove if space heaters not required by project]
- B. For motors 3/4 horsepower and larger, include the following additional information:
1. NEMA frame size.
  2. NEMA insulation system classification. For motors required to be installed outdoors, include information showing compliance with the intent of paragraph 2.3C.
  3. Maximum ambient temperature for which motor is designed.
  4. Time rating.
  5. Bearing type.
  6. Efficiency at full load.
- C. For motors 20 horsepower and larger, include the following additional information:
1. No load amperes.
  2. Efficiency at 1/2 and 3/4 load.
  3. Power factor at no load, 1/2, 3/4 and full load.
  4. Full load amperes.
  5. Maximum guaranteed slip at full load.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Acceptable Manufacturers: Subject to compliance with requirements for integral horsepower motors, provide products by one of the following:
1. General Electric.
  2. Baldor/Reliance.
  3. Toshiba
  4. TECO Westinghouse.

### 2.2 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.

### 2.3 MOTOR CHARACTERISTICS

- A. Speed and Size:
1. Speed and approximate horsepower ratings are specified in the driven equipment specification Sections or are indicated on the Drawings.
  2. Furnish motors sufficiently sized for the particular application and with full-load rating not less than required by the driven equipment at specified capacity.
  3. Size motors so as not to overload at any point throughout the normal operating range.
  4. Provide motors designed and rated for variable frequency drive applications where required.
- B. Voltage:
1. Single phase: 115 volts for 120-volt nominal system voltage and 277 volts (refer to mechanical schedules).
  2. Three phase: 460 volts for 480-volt nominal system voltage.



- C. Frequency: 60 hertz.
- D. Service Factor: According to NEMA MG 1-12.47 but not less than 1.15.
- E. Acceleration Time: For integral horsepower motors, the calculated acceleration time of the combined motor and driven load shall not exceed 4 seconds at 90 percent of rated voltage.
- F. Efficiency:
  - 1. Provide single-speed NEMA Design B Premium efficiency induction motors having minimal full-load motor efficiency no less than those listed in the latest edition of NEMA MG 1 Section 12.60 (EFFICIENCY LEVEL OF PREMIUM EFFICIENCY ELECTRIC MOTORS). Motors and manufacturers shall be officially listed and labeled by the NEMA Premium program.
  - 2. Base motor efficiencies on a statistically valid control procedure conforming to ANSI/IEEE 112-84, Test Method B (Dynamometer), using NEMA MG 1).
  - 3. For motors rated at a horsepower not listed in the NEMA guidelines the motors shall conform to the next higher nominal motor horsepower efficiency rating.

## 2.4 DESIGN TYPE

- A. Motors Smaller than 1/6 Horsepower: Single-phase squirrel-cage induction motors with integral thermal protectors.
- B. Motors 1/6 through 1/2 Horsepower: Single-phase NEMA Design Letter N, squirrel-cage induction motors with integral thermal protectors.
- C. Motors Larger than 1/2 Horsepower: 3-phase, NEMA Design Letter B, squirrel-cage induction motors.
- D. Motor Driven by Variable Frequency Drives (VFDs): Inverter duty motors.

## 2.5 MOTOR INSULATION

- A. Use Class F insulation system meeting the requirements of NEMA MG Part 31 and made of non-hygroscopic materials for motors 10 HP and larger.
- B. Use Class B Temperature Rise: NEMA MG 1-12.41 for fractional horsepower motors and NEMA MG 1-12.42 for integral horsepower motors.
- C. Outdoor Suitability:
  - 1. Where motors must be suitable for outdoor installation, insulation must withstand 1 full week (168 hours) of testing in a chamber maintained at 100 percent relative humidity and 104°F (40°C) ambient temperature.
  - 2. Immediately after the test period, insulation system must have a minimum resistance of 1.5 megohms.
  - 3. Coat inside circumference of the stator and the outside circumference of the rotor and shaft with the same moisture-resistant insulation system.
- D. VFD Motors: Inverter duty type and capable of withstanding repeated peaks of 1600 volts at 0.1 microsecond rise time. Comply with NEMA MG-1 Part 31.

## 2.6 LEADS

- A. Use not less than ASTM B 173, Class G, stranded copper conductors with insulation the same as or better than specified in the preceding Motor Insulation paragraph.
- B. Provide permanent identification numbers on leads according to NEMA MG 1-2.02.

- C. Use crimp-on, solderless copper terminals on leads and place heat-shrink insulation sleeves or covers between leads and terminals.

## 2.7 ENCLOSURE

- A. Indoors:
  - 1. Open drip-proof (ODP).
  - 2. Use steel frame for motors smaller than 3/4 horsepower and up to 10 HP, and cast-iron frame for motors over 10 horsepower.
- B. Outdoors: Completely enclosed, fan cooled (TEFC), with a corrosion-resistant drain plug under each bearing. Use cast-iron frame.
- C. Motors 5 HP and greater that are driven by variable frequency drives, provide motor with factory mounted AEGIS shaft grounding ring. Where factory mounting is not available, installation of shaft grounding shall be bolted in accordance with the manufacturers recommendations and shall not void the warranty. Conductive epoxy installation is not acceptable.

## 2.8 BEARINGS

- A. Motors Smaller than 1/6 Horsepower: Motor manufacturer's standard bearing is acceptable.
- B. Motors 1/6 Horsepower and Larger:
  - 1. Antifriction:
    - a. Supply motors with grease-lubricated antifriction ball bearings conservatively rated for long life under the total radial and thrust loads produced by the actual combination of motor-driven equipment.
    - b. Provide each motor with suitable lubrication fittings and pressure relief devices suitable for in-service lubrication.
  - 2. Oil Lubricated: If the driven equipment Section specifies oil-lubricated bearings for motors, include a suitable sight gauge on each bearing with maximum and minimum levels clearly indicated.

## 2.9 HARDWARE

- A. Use structural bolts, washers, nuts, pins, and similar items manufactured of high-strength steel. Use only hexagon-head bolts and hexagon nuts.
- B. Use corrosion-resistant materials or protect hardware from corrosion by hot-dip galvanizing, chrome plating, or cadmium plating.

## 2.10 NAMEPLATES

- A. Main Nameplate: Provide each motor with a stainless steel nameplate meeting the requirements of NEMA MG 1-10.38, and the National Electrical Code, Section 430-7. Identify energy-efficient motors in accordance with MG-1-12.54.2.
- B. Bearings Nameplate: When bearings are oil lubricated, include oil type information on a suitable nameplate. Indicate bearing data if nonstandard.
- C. Attachment: Attach the nameplates to the motor with stainless steel fastening pins or screws.

## 2.11 CONDUIT BOX

- A. For each motor not supplied with a cord and plug, provide a conduit box suitably sized for the motor lead terminations, in accordance with the National Electrical Code, Section 430-12. Include a grounding lug for motors 1/6 horsepower and larger. Supply a gasket suitable for the motor enclosure type and application.

## 2.12 PAINT

- A. Manufacturer's standard shop paints for prime and finish coats are acceptable.

## 2.13 NOISE

- A. Provide integral horsepower motors with overall sound power levels meeting the requirements of MG 1-12.49.

## 2.14 STARTERS

- A. Provide starters for any motor not equipped with VFD.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Properly install and align motors in the locations as shown on Drawings. Use crimp-on, solderless copper terminals on the branch circuit conductors. For motors 20 horsepower and larger, use 5300 Series 3M motor lead splicing kit or approved equivalent.
- B. Nameplate must be in full view when motor and equipment are installed.
- C. If a motor horsepower rating larger than indicated is offered as a substitute and is accepted, provide required changes in size of conductors, conduits, motor controllers, overload relays, fuses, circuit breakers, switches, and other related items at no change in contract price.

## 3.2 FIELD TESTING

- A. Provide instruments, labor and personnel required to perform motor inspection and testing.
- B. Inspect all motors for damage, moisture absorption, alignment, freedom of rotation, proper lubrication, oil leaks, phase identification, and cleanliness. Report abnormalities to Owner's Representative before energizing.
- C. Megger test all motors 20 horsepower and larger in accordance with IEEE Report No. 43, "Recommended Practices for testing Insulation Resistance of Rotating Machinery" to determine insulation resistance.
- D. Measure full load current and full load voltage.
- E. Complete and submit Motor Test Report forms to Owner's Representative.
- F. After installation has been thoroughly checked and found to be in proper condition with thermal overloads in motor controllers properly sized and all controls in place, energize the equipment at system voltage for operational testing.

END OF SECTION 23 05 13

## SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. This Section includes requirements for furnishing and installing supports, anchors, hangers, sleeves, and concrete equipment pads for all direct and isolated suspended, roof mounted, and floor mounted HVAC equipment and exterior pipe and ductwork.
- B. See Division 05 Section, Metal Fabrications, for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
- C. See Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment, for vibration isolation devices.
- D. See Section 23 31 00, Ductwork, for duct hangers and supports.

## 1.3 DEFINITIONS

- A. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

## 1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

## 1.5 SUBMITTALS

- A. Product Data: Submit manufacturer's catalog data, dimensional drawings and construction materials for the following:
  - 1. Steel pipe hangers and supports.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
  - 1. Trapeze pipe hangers. Include Product Data for components.
  - 2. Metal framing systems. Include Product Data for components.
  - 3. Equipment supports.
- C. Welding certificates.

## 1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.

## 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver all roof support material materials to project site in manufacturer's original packaging, marked with manufacturer's name, product model names and catalog numbers, identification numbers, and other related information.
- B. Store material under cover until needed for installation

## PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers as applicable:
  1. Anvil Intl., Inc.
  2. Superstrut, Mult-A-Frame, Unistrut and Power-Strut pipe support systems
  3. Specified Technologies, Inc.
  4. Pipe Shields, Inc.

- A. CONCRETE PROVIDE MINIMUM 3,000 PSI CONCRETE. REINFORCE SLAB WITH MINIMUM NO. 4 REBAR ON 12-INCH CENTERS EACH WAY, CENTERED IN SLAB UNLESS OTHERWISE INDICATED ON DRAWINGS.

## 2.2 STRUCTURAL METAL

- A. Furnish structural metal as specified in Division 05 and as shown on Drawings.

## 2.3 PIPE HANGERS AND SUPPORTS

- A. Provide hangers for insulated and non-insulated pipes, provide galvanized carbon steel adjustable clevis hangers. Anvil Fig. 260 or equal.
- B. Multiple or Trapeze Hangers: Provide Galvanized steel channels with welded spaces and hanger rods.
- C. Wall supports: Provide galvanized welded steel brackets and galvanized wrought steel clamp, galvanized adjustable steel yoke and cast iron roll. Anvil Fig. 194, 195, 199 as required by pipe size and weight. Submit to structural engineer for approval detailing method of attachment to wall.
- D. Vertical Support: Provide galvanized riser clamp with field welded shear lugs. Anvil Fig 261 or Fig 40 as required by installation and loads to be supported. Refer to mechanical details for main riser supports.
- E. Floor supports for Pipe sizes to 4 inches and all cold pipe sizes: Cast iron adjustable pipe saddle, locknut nipple, floor flange and steel support. Anvil Figures 264 or 265 as required.
- F. Floor supports for Hot pipe 6 inches and larger: Provide adjustable cast iron roll and stand, adjusting screws and steel support all galvanized. Anvil Fig. 274.
- G. Copper Piping Supports and Hangers: Provide copper plated carbon steel clevis hanger. Anvil Fig. Anvil CT-65.

- H. Provide galvanized hangers and supports for all piping and ductwork located in pipe shafts and chases and above suspended ceiling spaces.
1. Provide hanger rods, bolts and nuts and all metal parts coated with same material as hangers.
  2. Prime coat and paint exposed steel hangers and supports.

#### 2.4 PIPE SHIELDS

- A. Provide pipe shields for piping 2 inches and smaller fabricated of 20 gauge galvanized steel over insulation in 180 degree segments, minimum 12-inches long.
- B. Provide pipe shields for piping 2-1/2 inches and larger fabricated of galvanized steel over insulation in 180 degree segment as follows:

PIPE SIZE	METAL GAUGE	SHIELD LENGTH
2-1/2 to 6 inches	18	12 inches
8 to 16 inches	16	18 inches
18 inches and larger	12	24 inches

- C. Provide high density segment of insulation at shields at least two inches longer than shield. Foamglas blocks (HLB 1600) or factory made insulation shields as made by Pipe Shields, Inc. are acceptable. High density insulation segment shall be of sufficient compressive strength to prevent indentation of insulation jacket. Submit data indicating compressive strength of insulation segment. Furnish vapor barrier and sealant where used on low temperature service (below 100°F).
- D. Secure insulation shields to insulation jacket with adhesive as recommended by insulation manufacturer or 2 stainless steel bands, 1/2 inch wide by 0.015 inch thick with matching seals.

#### 2.5 HANGER RODS

- A. Provide cadmium plated or galvanized steel, threaded both ends continuous sized for supported load. If rod couplings have to be used the contractor shall seek permission from UTMB. If permitted, each end of threaded rod shall be threaded until they join in the middle of the coupler.

#### 2.6 INSERTS

- A. Provide malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded rods. Submit data to structural engineer for approval. Anvil Fig. 282.

#### 2.7 SLEEVES

- A. Fit with sleeves all pipes passing through gyp board, masonry and concrete construction. Provide sleeves in floors and walls of mechanical rooms, pump rooms, etc. constructed of schedule 40 steel with galvanized finish. Sleeves outside mechanical room type spaces shall be galvanized EMT conduit for 2 inch and less diameter sleeves. Sleeves outside mechanical room type spaces over 2 inch and thru walls shall be rolled 20 gauge galvanized steel with welded seam. All galvanizing shall be done after welding.
- B. Sleeves in floors shall be provided with a 1-1/2 inches wide center flange welded to sleeve and centered in slab. Refer to Drawings for additional requirements.
- C. Sleeves thru roofs: schedule 40 galvanized steel pipe.
- D. Caulk all sleeves water and air tight. Provide firestop compound at all penetrations of floor slabs and fire rated walls.

- E. Sleeves below grade in outside walls are detailed on drawings. Provide Link Seal casings at sleeves at all exterior walls above and below grade. Use stainless steel retainers, nuts and bolts in sleeves below grade. Size sleeves in accord with Link Seal recommendations.
- F. Size sleeves one pipe size larger than the pipe it serves including insulation thickness as appropriate.
- G. Extend each sleeve through the floor or wall. Cut the sleeve 1/2 inch beyond flush from each surface, except that in exposed locations, extend floor sleeves 2 inches above finished floor line.
- H. Refer to section 23 31 00 for sleeve requirements for ductwork.

## 2.8 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
  - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
  - 2. Design Mix: 5000-psi, 28-day compressive strength.

## PART 3 - EXECUTION

### 3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections for piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized or stainless steel, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use copper hangers with copper pipe and nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing. As an alternate, tape copper pipe at all points contacting steel hangers, structural members or sleeves. Use a dual wrap of polyvinyl tape.
- E. Use padded hangers for piping that is subject to scratching.

### 3.2 CONCRETE PADS

- A. Pour 6-inch pads on roughened floor slabs unless otherwise noted.
- B. Extend outer edges of pads minimum 2 inches beyond equipment.
- C. Chamfer edges of pads.
- D. Secure equipment with anchor bolts in accordance with equipment installation instructions.
- E. Air handling units shall be installed on concrete pads with adequately sized neoprene isolation pads at each air unit support point.
- F. Verify that housekeeping pads for air handling units are high enough to provide a condensate drain trap deep enough to override the air handler static pressure.
- G. Install equipment on 6 inch pads unless indicated otherwise on drawings.

### 3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Bolt floor stands to concrete pads or as shown on Drawings.
- C. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- D. Provide lateral bracing, to prevent swaying, for equipment supports.
- E. Hot dip galvanize after fabrication.

### 3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Hot dip galvanize after fabrication.
- D. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.
  - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

### 3.5 ROOF CURBS

- A. Provide prefabricate curbs for roof mounted equipment.
- B. Furnish curbs suitable for slope of roof to ensure equipment is set level.

### 3.6 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

### 3.7 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 23 05 29



## SECTION 23 05 48 - VIBRATION ISOLATION FOR HVAC PIPING AND EQUIPMENT

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. Section includes requirements for furnishing, installing, and adjusting vibration isolation, for mechanical equipment and piping, including bases of structural steel and concrete, with steel pouring forms and concrete reinforcing bars.
- B. Related Sections Include:
  - 1. Section 23 05 29, Hangers and Supports for HVAC Piping and Equipment.

## 1.3 PERFORMANCE REQUIREMENTS

- A. Wind-Restraint Loading:
  - 1. Basic Wind Speed: 150 miles per hour.
  - 2. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

## 1.4 SUBMITTALS

- A. Product Data: Submit product data showing type, size, load, deflection, and other required information. Include clearly outlined procedures for installing and adjusting isolators. Submit Drawings for each item of equipment with complete isolation installation information.
- B. Submit detailing of inertia bases and locations of vibration, including weight of inertia base.

## 1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

## 1.6 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 10.
- B. Include copies of approved submittals and any submittal comments.
- C. Provide tab for each major type of equipment (fan coil units, pumps, piping, fans, etc.). Provide schedule of vibration isolator type with location and load on each. Include data on each isolator type that corresponds to:
  - 1. Spring diameter.
  - 2. Deflection.
  - 3. Compressed spring height.
  - 4. Point location of each isolator.

- 5. Calculated load at each point.
- 6. Field static deflection.

D. Include copy of written certification from factory representative as required in Part 3 of this specification.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS**

- A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Amber/Booth Company, Inc.
  - 2. Kinetics Noise Control
  - 3. Korfund Dynamics
  - 4. Mason Industries.
  - 5. Metraflex
  - 6. Vibration Eliminator Co., Inc.

**2.2 ISOLATOR DESIGN**

- A. Materials:
  - 1. Design and treat vibration isolators for resistance to corrosion.
  - 2. Steel components shall be PVC coated or phosphatized and painted with industrial-grade, corrosion-resistant enamel.
  - 3. Furnish zinc-electroplated or cadmium plated nuts, bolts and washers.
  - 4. All isolators exposed to the weather shall have the steel parts hot dip galvanized and a PVC coating.
  - 5. Clean steel bases thoroughly of welding slag and prime with zinc-chromate or metal etching primer.
- B. Design:
  - 1. Unless otherwise instructed, use spring-type vibration isolators for all equipment driven by motors of 3 horsepower and larger.
  - 2. The isolator manufacturer must calculate the amount of spring deflection required for each isolator to achieve optimum performance and to prevent the transmission of objectionable vibration and noise.
  - 3. Isolators must be sized for starting torque of equipment motors.
  - 4. The following minimum spring deflections apply unless noted otherwise in the specifications:

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**BELT DRIVEN EQUIPMENT**

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<b>Motor Size Horsepower</b>	<b>Installation Above Grade</b>	<b>Installation at Grade or Below</b>
5 – 10	1"	1"
15 – 30	1-1/2"	1"
40 – 75	2"	1-1/2"

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**DIRECT DRIVEN EQUIPMENT**

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<b>Motor Size Horsepower</b>	<b>Installation Above Grade</b>	<b>Installation at Grade or Below</b>
5 – 20	1"	1"
25 – 75	1"	1"

5. All spring isolators must be completely stable in operation and must be designed for not less than 30 percent reserve deflection beyond actual operation conditions.
6. Height saving brackets used with isolators having 2-1/2 inch deflection or greater shall be of the precompression type to limit exposed bolt length.

### 2.3 ISOLATOR TYPES

- A. Design of isolator types listed is based on model numbers manufactured by Kinetics Noise Control, unless otherwise indicated. Subject to compliance with requirements provide named product.
- B. Type FDS: Adjustable, freestanding, open-spring mounting with combination leveling bolt and equipment fastening bolt. The spring mounting to base plate and compression plate must be rigid. Bond neoprene pad with a minimum thickness of 1/4 inch to the base plate. Base isolator shall have provisions for bolting the isolator to the supporting structure. A minimum horizontal-to-vertical spring rate of 1.0 is required.
- C. Type FRS: Similar to Type FDS, but with addition of bottom load plate and restraint assembly for vertical restraint for wind loads or large torqueing forces.
- D. Type SH: Spring hanger consisting of a rectangular steel box, coil spring, spring retainers, neoprene-impregnated fabric washer, and steel washer.
- E. Type SRH: Combination spring and rubber hanger consisting of a rectangular steel box, coil spring, spring retainers, and an elastomeric mounting designed for 1/2 inch deflection.
- F. Type SLP: Adjustable, open-spring isolator having one or more coil springs attached to a top compression plate and a base plate. Bond neoprene pad with a minimum thickness of 1/4 inch to the base plate. The spring assembly must fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolator includes restraining bolts for connecting the top plate and lower housing to prevent the isolated equipment from rising when drained of water.
- G. Type NGS: Pad-type mounting consisting of two layers of 3/8 inch thick ribbed or waffled neoprene pads bonded to a 16-gage galvanized steel separator plate. Size pads for approximately 20 to 40 psi load and a deflection of 0.1 inch to 0.16 inch.
- H. Type RH: Elastomeric hanger consisting of a rectangular steel box and an elastomeric isolation element of neoprene. A high-quality synthetic rubber may be used if it contains anti-ozone and antioxidant additives. Design elements for approximately 1/2 inch deflection and load so that the deflection does not exceed 15 percent of the free height of the element.
- I. Type SS: Type 321 stainless steel hose and Type 304 stainless braid sheath, with carbon steel threaded fittings for pipe sizes 2 inches and less, and carbon steel flanges for pipe sizes 2-1/2 inches and greater. Hose shall have a maximum working pressure of 200 psi at 70°F through 4", 155 psi at 70°F through 12".
- J. Type REJ: Flexible pump connectors/expansion joints shall be of the molded twin spherical type. Provide neoprene with nylon construction or EPDM. Unit shall be rated at 225 PSI and maximum temperature of 225°F. Provide 150# flanges and galvanized aircraft cable or control rods.
- K. Expansion Loop: Flexible expansion loop consisting of two Series 300 stainless steel hoses and braids, two 90 degree carbon steel elbows, and a 180 degree return. Provide drain plug and flanged connections. Rate 10 inch expansion loop for 220 psi at 70°F. Rate 6 inch expansion loop for a minimum of 200 psi at 70°F.

## 2.4 ISOLATION BASES

- A. Type CIB-L: Mount equipment on concrete inertia blocks which weigh at least twice the weight of equipment supported. Obtain equipment assembly information from the equipment manufacturer and include with submittal, including dimensional data. Vibration isolation manufacturer shall furnish steel concrete pouring forms for floating concrete bases. Size each inertia base to extend a minimum of 4 inches outside the equipment base. In the case of belt-driven equipment, extend the base 4 inches beyond the end of the drive shaft. Provide T-shaped inertia bases where necessary to conserve space. Bases for split case pumps shall be large enough to provide support for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6". The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of 1/2" bars welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom. Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor bolts while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a minimum 1" clearance below the base. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable. Install vibration isolation, as specified, between inertia blocks and equipment (housekeeping) pads.
- B. Type SFB: A structural steel fan and motor base with NEMA standard motor side rails and holes drilled to receive the fan and motor. The steel members shall be adequately sized to prevent distortion and misalignment of the drive. Suspended equipment shall be designed to spread the base area of equipment for increased stability and to permit suspension with hanger rods.
- C. Structural bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer. A finish coat of industrial grade enamel shall be applied over the primer.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Installation of vibration isolators must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.
- D. The contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.
- E. Install motor driven equipment with vibration isolators as indicated in schedule below.
- F. Isolate pumped water-piping systems with spring-type vibration isolators as indicated in schedule.
- G. All open-type spring isolators shall be restrained as recommended by the manufacturer.
- H. Install full line size flexible connectors at the suction and discharge connection of each piece of equipment as indicated in schedule below. All connectors to be suitable for use at the pressure and temperature encountered at point of operation. Do not insulate Type REJ flex pump connectors installed in heating hot water systems.
- I. Isolation Bases

1. The isolated equipment and its driving motor shall be mounted on a common inertia base and the base, in turn, shall be mounted on the scheduled vibration isolator type to prevent transmission of vibration and noise to the building structure.
2. For floor mounted equipment, provide an equipment (housekeeping) pad under the isolation base.
3. In general, all inertia bases shall be formed and poured in place onto a hard, flat surface from which the base can be separated when cured. The base shall be shimmed, using flat material, to the intended final height prior to equipment mounting and piping connection.
4. After piping connections are made and the system filled with water and ready to be put into service, the isolator adjustment bolts shall be extended until the shim blocks can be removed. Isolators may then be backed down slightly to restore the intended height. The locknuts should then be tightened on the isolators. Jack bolts shall be trimmed to a length that will allow no more than 1 inch of additional height adjustment. After final adjustment, the inertia base shall not support any piping load. All springs supporting piping that is connected to a piece of isolated equipment shall be sized for static deflection equal to that of the isolated equipment.

### 3.2 APPLICATION

- A. The following is a schedule of equipment and piping on a typical project that requires vibration isolation and base isolators of the types specified. Refer to Drawings for equipment scheduled for the Project. Any equipment, system or condition that may be altered, added, or changed; or that is not specifically described in the Contract Documents shall be isolated in a manner specified for similar equipment, system or condition in order to comply with these Specifications.
- B. Provide isolation for the following equipment:

Equipment	Isolator Type	Minimum Deflection (inches)
<u>Air Handling Units:</u>		
Floor/Roof Mounted – up to 15 HP	FDS* and NGS	1 0.1 – 0.16
Floor/Roof Mounted – 20 HP and over	FDS* and NGS	2 0.1 – 0.16
*Type FDS by AHU Manufacturer		
<u>Fan Coil Units:</u>		
Suspended	SRH	1
Belt Drive - Suspended	SRH	1
Floor Mounted	NGS	0.1 – 0.16
<u>Inline Fans:</u>		
Suspended – up to 15 HP Provide thrust restraints as required	SRH	1
Suspended – 15 HP and over Provide thrust restraints as required	SRH	2
<u>Pumps:</u>		
Up to 5 HP	FDS/CIB-L	1
5 HP, 7-1/2 HP	FDS/ CIB-L	1
10 HP and over	FDS/CIB-L	2
<u>Vent Sets:</u>		
Roof/Structure Mounted – up to 15 HP	FRS	1
Roof/Structure Mounted – 20 HP and over	FRS	2
Interior Mounted – up to 15 HP	FDS	1
Interior Mounted – 20 HP and over	FDS	2
<u>Miscellaneous:</u>		
Computer Room AHUs Suspended	SRH	1
Computer Room AHUs - Floor Mounted	NGS	0.1 – 0.16

Equipment	Isolator Type	Minimum Deflection (inches)
[Fan Powered Terminal Boxes (FCV, FVV)]	SRH	1

### 3.3 STOCK REQUIREMENTS

- A. The isolation manufacturer's representative must maintain an adequate stock of springs and isolators of type used so that changes required during construction and installation can be made.

### 3.4 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

### 3.5 FACTORY REPRESENTATION:

- A. After installation, furnish factory-trained representative of the isolation manufacturer to check various isolators and report measured versus anticipated deflection on all isolators. Have the representative submit written certification that the isolators have been installed in accordance with the specifications, manufacturer's recommendations and approved submittals

END OF SECTION 23 05 48

SECTION 23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

1.2 SUMMARY

- A. This section includes:
  - 1. Equipment labels.
  - 2. Warning signs and labels.
  - 3. Pipe labels.
  - 4. Stencils.
  - 5. Valve tags.
  - 6. Warning tags.
  - 7. Duct labels.

1.3 SUBMITTAL

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

1.5 RELATED WORK

- A. Painting. Division 09.

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 10.

- B. Valve Tags
  - 1. Provide three-ring binder including valve tag information (8-1/2 x 11 inch paper).
  - 2. Each service shall be individually tabbed in the binder.
  - 3. For each valve tag, indicate service, function, valve position (NC or NO), floor, room location and nearest column numbers.
  
- C. Equipment Labels
  - 1. Provide three ring binder including equipment label information (8-1/2 x 11 inch paper).
  - 2. Each type of equipment (pumps, AHUs, etc) shall be individually tabbed in the binder.
  - 3. For each item of equipment to be labeled, provide equipment identification number, floor, room location, and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Acceptable Manufactures: Subject to compliance with requirements, provide products by one of the following:
  - 1. Brady Corporation.
  - 2. Marking Services, Inc.
  - 3. Seton Identification Products.

### 2.2 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
  - 1. Material and Thickness: Brass, 0.032 inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
  - 2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 x 3/4 inch.
  - 3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
  - 4. Fasteners: Stainless-steel rivets or self-tapping screws.
  - 5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
  
- B. Plastic Labels for Equipment:
  - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
  - 2. Letter Color: Black.
  - 3. Background Color: Background to contrast with letter color.
  - 4. Maximum Temperature: Able to withstand temperatures up to 160°F.
  - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 inch x 3/4 inch.
  - 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
  - 7. Fasteners: Stainless-steel rivets or self-tapping screws.
  - 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
  
- C. Label Content: Include equipment's Drawing designation or unique equipment number.



### 2.3 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Black.
- C. Background Color: Background to contrast with letter color.
- D. Maximum Temperature: Able to withstand temperatures up to 160°F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 inch x 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering 2/3 to 3/4 the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

### 2.4 DUCT LABELS

- A. Identify ductwork with stencil.
- B. Letter Color: Black.
- C. Lettering Size: At least 1-1/2 inches high.
- D. Paint: Shall meet VOC requirements per Division 09 painting specification.
- E. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

### 3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment. Use fasteners for all equipment labels where possible. Where it is not possible to use fasteners, use adhesive.
- B. Locate equipment labels where accessible and visible.

### 3.3 DUCT LABEL INSTALLATION

- A. Identify ductwork with stencil.

- B. Identify exhaust fan number, air handling unit number, service and area served.
- C. Locate identification at air handling unit or fan, at each side of penetration of structure or enclosure at each obstruction, every 20 feet on long horizontal runs. Provide identification for the following ductwork:
  - 1. All exhaust (restroom, laboratory, kitchen, etc) and relief ductwork.
  - 2. All supply air ductwork served by Air Handling Units
  - 3. All outside air ductwork, including pretreated outside air ducts.
  - 4. All return air ductwork, not including return air boots and transfer ducts.

END OF SECTION 23 05 53

## SECTION 23 05 93 – SYSTEM TESTING, ADJUSTING AND BALANCING

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. Testing, adjusting and balancing (TAB) of the air conditioning systems and related ancillary equipment will be performed by an impartial technically qualified TAB firm as part of General Contractors scope of work.
- B. The firm shall be capable of performing the services specified at the location of the facility described within the time specified, of preparing and submitting the detailed report of the actual field work performed, and following up the basic work as may be required.

## 1.3 QUALIFICATIONS

- A. The Firm shall be one which is organized to provide professional services of this specified type in the State of Texas and as a minimum shall have one (1) professional engineer licensed in the State of Texas, with current registration, to perform such professional services. This engineer shall be personally responsible for developing the job site data as required in the test procedures outlined in these Specifications.
- B. The Firm shall have operated a minimum of five (5) years under it's current Firm name, and shall be in good standing with the State of Texas, Franchise Tax Board. The firm shall submit their full incorporated name, Charter Number and Taxpayer's I.D. Number for proper verification of the firm's status.
- C. The Firm shall be capable of providing a performance bond, by a bonding company licensed to do business in the State of Texas, if determined by the Owner that such a bond is required. The amount of the bond which may be required shall be equal to the cost of the proposal submitted, or in the case of more than one proposal, the sum of all such proposals and any awarded work in progress.
- D. The Firm shall maintain current insurance coverages in the minimum amounts shown below. If the Firm normally carries such insurance coverages (minimum or higher) incident to it's operation, additional insurance for the specific proposal or proposals is not required. The minimum insurance coverages required are:
  - 1. Worker's Compensation as required by law.
  - 2. General Liability for not less than \$1,000,000 aggregate refer to Division 01, General Conditions.
  - 3. Fire Damage, and Extended Coverage, Vandalism and Malicious Mischief, in the full amount of Contract. The above policies shall be carried with companies satisfactory to the Owner. Certificates of each of the above policies, together with a written statement by the issuing company, stating that said policy will not be canceled without ten (10) days prior written notice to the Board of Regents of the University of Texas system, shall be delivered to the Owner before any work is started.
- E. All personnel used on the job site shall be either professional engineers or engineering technicians, who shall have been permanent, full time employees of the firm for a minimum of six (6) months prior to the start of work for this specific project.

- F. The TAB firm shall submit biographical data on the individual proposed to directly supervise the TAB work, as well as other personnel scheduled to perform the technical work under the contract. It shall also submit a background record of at least five years of specialized experience in the field of air hydronic system balancing, and shall possess properly calibrated instrumentation. The supervisory personnel for the TAB firm shall be registered engineers in the mechanical field and all of the employees used in the TAB firm shall be permanent, full-time employees of the firm.
- G. The scope of the TAB work as defined herein is indicated in order that the Mechanical Contractor will be advised of the coordination, adjustment and system modification which will be required under the project work in order to complete the Owner's requirements for final TAB. The General Contractor shall engage one of the certified TAB firms from the approved list below:

Engineered Air Balance, Inc. - (713)873-7084

Technical Air Balance, Inc. - (281) 651-1849

Precision Air of Texas - (281) 449-0961

Air balance work shall be done by one of the above approved contractors and not by the Mechanical Contractors own forces.

#### 1.4 REFERENCES

- A. National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems, Fifth Edition 1989.
- B. ASHRAE - 1991 HVAC Applications Chapter 34: Testing, Adjusting and Balancing.
- C. ANSI/ASHRAE Standard 111-1988 - Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

#### 1.5 DOCUMENTS

- A. The TAB firm shall, as a requirement of the TAB contract, arrange with the Architect to compile one set of mechanical specifications, all pertinent change orders, and the following:
1. One complete set of Drawings less the structural sheets.
  2. One set of mechanical floor plans of the conditioned spaces. These Drawings shall be ozalid type (blue or black on light background) reproductions to facilitate marking.
- B. Approved submittal data on equipment installed, and related changes as required to accomplish the test procedures outlined in Paragraphs 1.6 through 1.10 of this Specification will be available through the Construction Inspector.

#### 1.6 RESPONSIBILITIES OF THE TAB FIRM

- A. The TAB personnel shall check, adjust, and balance the components of the air conditioning system which will result in optimal noise, temperature, and airflow conditions in the conditioned spaces of the building while the equipment of the system is operating economically. This is intended to be accomplished after the system components are installed and operating as provided for in the contract documents. It is the responsibility of the Mechanical Contractor to place the equipment into service. Variable air volume systems shall be balanced in accordance with AABC 1989 Standard, Fifth Edition.
- B. Liaison and Early Inspection:
1. The TAB firm personnel on the job shall act as liaison between the Owner, Architect and Contractor.
    - a. During construction, review all HVAC submittals such as control diagrams, air handling devices, etc., that pertain to commissioning work and balance ability.

- b. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the Construction Inspector shall be advised in writing so that the condition can be corrected by the Mechanical Contractor. The written document need not be formal, but must be understandable and legible. Data from malfunctioning equipment shall not be recorded in the final TAB report. The TAB firm shall not instruct or direct the Contractor in any of the work, but will make such reports as are necessary to the Owner.

## 1.7 FINAL AIR BALANCE

- A. General: When systems are complete and ready for operation, the TAB Consultant will perform a final air balance for all air systems and record the results. The outside, supply, exhaust and return air volume for each air handling unit, supply fan and exhaust fan and the supply, exhaust or return air volume for each distribution device shall be adjusted to within +5% of the value shown on the drawings. Air handling unit and fan volumes shall be adjusted by changing fan speed and adjusting volume dampers associated with the unit. Air distribution device volume shall be adjusted using the spin-in tap damper for flexible duct connected devices and the device OBD for duct connected devices. Air distribution devices shall be balanced with air patterns as specified. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown. The general scope of balancing by the TAB Consultant will include, but is not limited to, the following:
  1. Filters: Check air filters and filter media and balance only system with essentially clean filters and filter media. The Division 23 Contractor shall install new filters and filter media prior to the final air balance.
  2. Blower Speed: Measure RPM at each fan or blower to design requirements. Where a speed adjustment is required, the Division 23 Contractor shall make any required changes.
  3. Ampere Readings: Measure and record full load amperes for motors.
  4. Static Pressure: Static pressure gains or losses shall be measured across each supply fan, cooling coil, heating coil, return air fan, air handling unit filter and exhaust fan. These readings shall be measured and recorded for this report at the furthest air device or terminal unit from the air handler supplying that device. Static pressure readings shall also be provided for systems which do not perform as designed.
  5. Equipment Air Flow: Adjust and record exhaust, return, outside and supply air CFM (s) and temperatures, as applicable, at each fan, blower and coil.
  6. Coil Temperatures: Set controls for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb temperatures (cooling only) at each cooling coil, heating coil and HVAC terminal unit. At the time of reading record water flow and entering and leaving water temperatures (In variable flow systems adjust the water flow to design for all the above readings).
  7. Zone Air Flow: Adjust each zone of multizone units, each HVAC terminal unit and air handling unit for design CFM.
  8. Outlet Air Flow: Adjust each exhaust inlet and supply diffuser, register and grille to within +5% of design air CFM. Include all terminal points of air supply and all points of exhaust. Note: For Labs and Rooms that are negative exhaust air flow shall be set to design +10% and supply to design -5%. Positive areas will have opposite tolerances.
  9. Pitot Tube Traverses: For use in future troubleshooting by maintenance personnel, all exhaust ducts, main supply ducts and return ducts shall have air velocity and volume measured and recorded by the traverse method. Locations of these traverse test stations shall be described on the sheet containing the data.
  10. Maximum and minimum air flow on terminal boxes.

## 1.8 TESTING OF TEMPERATURE CONTROL SYSTEMS

- A. In the process of performing the TAB work, the TAB Agency shall:
  1. Work with the temperature control contractor to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.
  2. Verify that all control devices are properly connected.
  3. Verify that all dampers, valves and other controlled devices are operated by the intended controller.

4. Verify that all dampers and valves are in the position indicated by the controller (open, closed or modulating).
5. Verify the integrity of valves and dampers in terms of tightness of close-off and full-open positions. This includes dampers in multizone units, terminal boxes and fire/smoke dampers.
6. Observe that all valves are properly installed in the piping system in relation to direction of flow and location.
7. Observe the calibration of all controllers.
8. Verify the proper application of all normally opened and normally closed valves.
9. Observe the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts or cold walls.
10. Observe the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media. Control Contractor will relocate as deemed necessary by the TAB Agency.
11. Verify that the sequence of operation for any control mode is in accordance with approved shop drawings and specifications. Verify that no simultaneous heating and cooling occurs.
12. Verify that all controller set points meet the design intent.
13. Check all dampers for free travel.
14. Verify the operation of all interlock systems.
15. Perform variable volume system verification to assure the system and it's components track with changes from full flow to minimum flow.

B. A systematic listing of the above testing and verification shall be included in the final TAB report.

## 1.9 REPORTS

- A. The activities described in this section shall culminate in a report to be provided in quadruplicate (4) individually bound to the RCM. Neatly type and arrange data. Include with the data the date tested, personnel present, weather conditions, nameplate record of test instrument and list all measurements taken after all corrections are made to the system. Record all failures and corrective action taken to remedy incorrect situation. The intent of the final report is to provide a reference of actual operating conditions for the Owner's operations personnel.
- B. All measurements and recorded readings (of air, water, electricity, etc.) that appear in the reports must have been made onsite by the permanently employed technicians or engineers of the firm.
- C. At the option of the Construction Inspector, all data sheets tabulated each day by TAB personnel shall be submitted for initial by the Construction Inspector. Those work sheets so initialed, or copies thereof, shall be presented as a supplement to the final TAB report.
- D. Submit reports on forms approved by the Owner & Engineer which will include the following information as a minimum:
  1. Title Page:
    - a. Company Name.
    - b. Company Address.
    - c. Company telephone number.
    - d. Project name.
    - e. Project location.
    - f. Project Manager.
    - g. Project Engineer.
    - h. Project Contractor.
    - i. Project Identification Number.
  2. Instrument List:
    - a. Instrument.
    - b. Manufacturer.
    - c. Model.
    - d. Serial Number.
    - e. Range.
    - f. Calibration date.

- g. What test instrument was used for.
3. Fan Data (Supply and Exhaust):
  - a. Location.
  - b. Manufacturer.
  - c. Model.
  - d. Air flow, specified and actual.
  - e. Total static pressure (total external), specified and actual.
  - f. Inlet pressure.
  - g. Discharge pressure.
  - h. Fan RPM.
4. Return Air/Outside Air Data (If fans are used, same data as for 3 above):
  - a. Identification/location.
  - b. Design return air flow.
  - c. Actual return air flow.
  - d. Design outside air flow.
  - e. Return air temperature.
  - f. Outside air temperature.
  - g. Required mixed air temperature.
  - h. Actual mixed air temperature.
5. Electric Motors:
  - a. Manufacturer.
  - b. HP/BHP.
  - c. Phase, voltage, amperage, nameplate, actual.
  - d. RPM.
  - e. Service factor.
  - f. Starter size, heater elements, rating.
6. V-Belt Drive:
  - a. Identification/location.
  - b. Required driven RPM.
  - c. Driven sheave, diameter and RPM.
  - d. Belt, size and quantity.
  - e. Motor sheave, diameter and RPM.
  - f. Center-to-center distance, maximum, minimum and actual.
7. Duct Traverse:
  - a. System zone/branch.
  - b. Duct size.
  - c. Area.
  - d. Design velocity.
  - e. Design air flow.
  - f. Test velocity.
  - g. Test air flow.
  - h. Duct static pressure.
  - i. Air temperature.
  - j. Air correction factor.
8. Air Monitoring Station Data:
  - a. Identification/location.
  - b. System.
  - c. Size.
  - d. Area.
  - e. Design velocity.
  - f. Design air flow.
  - g. Test velocity.
  - h. Test air flow.
9. Air Distribution Test Sheet:
  - a. Air terminal number.
  - b. Room number/location.
  - c. Terminal type.
  - d. Terminal size.
  - e. Area factor.

- f. Design velocity.
  - g. Design air flow.
  - h. Test (final) velocity.
  - i. Test (final) air flow.
10. Sound Level Report:
- a. Location (Location established by the design engineer).
  - b. NC curve for eight (8) bands - equipment off.
  - c. NC curve for eight (8) bands - equipment on.
11. Vibration Test on equipment having 10 HP motors or above:
- a. Location of points:
    - 1) Fan bearing, drive end.
    - 2) Fan bearing, opposite end.
    - 3) Motor bearing, center (if applicable).
    - 4) Motor bearing, drive end.
    - 5) Motor bearing, opposite end.
    - 6) Casing (bottom or top).
    - 7) Casing (side).
    - 8) Duct after flexible connection (discharge).
    - 9) Duct after flexible connection (suction).
  - b. Test readings:
    - 1) Horizontal, velocity and displacement.
    - 2) Vertical, velocity and displacement.
    - 3) Axial, velocity and displacement.
  - c. Normally acceptable readings, velocity and acceleration.
  - d. Unusual conditions at time of test.
  - e. Vibration source (if non-complying).
12. Control verification indicating date performed and any abnormalities identified.
- a. Point Location/Description.
  - b. EMS Readout (Setpoint and Actual).
  - c. Actual Readout.
  - d. Interlocks.
  - e. Safeties:
    - 1) VSD Normal Operation.
    - 2) VSD Bypass Operation.
  - f. Alarms.
  - g. Sequences of Operation.

END OF SECTION 23 05 93



## SECTION 23 09 23 - DIRECT DIGITAL CONTROL SYSTEMS

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including "Uniform General Conditions and Supplementary General Conditions for the State of Texas Building Construction Contracts", and Division 01 sections apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Development, 301 University Boulevard, Galveston, Texas 77555-1116. Phone (409) 772-3500, Fax (409) 772-5199.

## 1.3 RELATED SECTIONS

- A. 23 05 19 – Meters and Gauges for HVAC Piping
- B. 23 21 00 – Hydronic Piping and Fittings
- C. 23 33 00 – Air Duct Accessories
- D. Division 26
- E. Division 27

## 1.4 REFERENCED STANDARDS

- A. ASHRAE Standard 135 Latest Edition: BACnet® – A Data Communication Protocol for Building Automation and Control Networks
- B. UL 916 – Energy Management Equipment
- C. NFPA 70 – National Electric Code

## 1.5 SYSTEM DESCRIPTION

- A. A complete automatic Building Management System (BMS) using field-programmable micro-processor based units. System shall communicate with the existing BMS. Contractor shall interface all new field controllers and devices and provide all necessary programming to establish communication with the existing Operator Stations on campus. Communication shall be established in one of two acceptable ways, by either extending existing field communications trunks to new field controllers or by tying in new open protocol controllers utilizing the existing Campus-wide Ethernet LAN via an OPC client/server data path to the Operator Stations. The Contractor shall be responsible for verifying and establishing new controls databases on the existing Operator Stations and provide for a Human/Machine interface to the new equipment including generating graphics compatible with existing, manual override for start/stops, manual override for setpoint resets, schedule changes, and displaying values of all binary and analog field points.

## 1.6 SUBMITTALS

- A. Submit under provisions of Division 01.
- B. Shop Drawings:
  - 1. Trunk cable schematic showing programmable control unit locations, and trunk data conductors.
  - 2. List of connected data points, including connected control unit and input device.
  - 3. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
  - 4. System configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
  - 5. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring and pneumatic details.
  - 6. Descriptive data and sequence of operation of operating, user, and application software.
- C. Product Data: Provide data for each system component and software module. Markup datasheet to easily reference the intended component and part number being supplied.
- D. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE Standard 135.
- E. Samples for Initial Selection: Submit one sample of each color of thermostat and/or sensor cover with factory colors. Where applicable, match the color of existing thermostats and/or sensor covers.
- F. Manufacturer's Installation Instructions: Include for all manufactured components. Markup installation instructions to easily reference the intended installation method.

## 1.7 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 01.
- B. Accurately record final location of control components, including panels, thermostats, and sensors.
- C. Revise shop drawings as necessary to reflect actual installation and operating sequences.
- D. Include data specified in "Submittals" in final "Record Documents" form.
- E. Provide final documentation in electronic and hard copy formats.

## 1.8 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 01.
- B. Include interconnection wiring diagrams of complete field installed system with identified and numbered, system components and devices.
- C. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
- D. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
- E. Product Data: Provide data for each system component and software module. Markup datasheet to easily reference the intended component and part number supplied.
- F. Manufacturer's Installation Instructions: Include for all manufactured components. Markup installation instructions to easily reference the installation method.
- G. Provide final documentation in electronic and hard copy formats.

## 1.9 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum five years documented experience. Manufacturer shall have a local Branch office staffed with Factory trained engineers and system representatives fully capable of providing instruction, routine maintenance, and emergency maintenance service on all system components.
- B. Installer: Company specializing in applying the work of this Section with minimum five years documented experience. Installer shall be a local Branch office of the Manufacturer with resident factory trained personnel. Branches shall be certified for ISO-9002 quality standards to assure adherence to quality standards adopted for their manufactured products.

## 1.10 PRE-INSTALLATION CONFERENCE

- A. Convene a conference **one** week prior to commencing work of this Section, under provisions of Division 1.
- B. Require attendance of all parties directly affecting, or responsible for coordinating with the work of this Section. Attendance shall include but not be limited to: General Contractor, Controls Contractor, HVAC Contractor, Electrical Contractor, Testing and Balancing Contractor, and Owner's Representative.
- C. Controls contractor shall provide all attendees with a meeting agenda at least two working days in advance of the scheduled meeting. The agenda shall include but not be limited to the review of: overall design, major components, component locations, and coordination with other trades.
- D. All BMS point names (Including BACNet device names) and applicable database names will be approved by the owner. The intent is to conform to the standard UTMB point naming and database naming convention.
- E. New BMS point alarming and trending shall match existing typicals and will be approved by the owner.

## 1.11 COORDINATION

- A. Coordinate work under provisions of Division 01.
- B. Ensure installation of components is complementary to installation of similar components in other systems.
- C. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.
- D. Coordinate power requirements with Division 26 contractor.

## 1.12 WARRANTY

- A. Provide two year warranty under provisions of Division 01.
- B. Provide two-year manufacturer's warranty for materials on all field-programmable, micro-processor based units.

## 1.13 MAINTENANCE SERVICE

- A. Furnish service and maintenance of energy management and control system for two years beginning on the date of acceptance of the system by the Owner.
- B. Provide two complete inspections per year, one in each season, to inspect, calibrate, and adjust controls as required. Submit written inspection and service reports.

## 1.14 EXTRA MATERIALS

- A. Submit maintenance materials under provisions of Division 01.
- B. Provide to Owner two extra units of each type of sensor under provisions of Division 01 and provisions herein.

## 1.15 PROTECTION OF SOFTWARE RIGHTS

- A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:
  - 1. Limiting use of software to equipment provided under these specifications.
  - 2. Limiting copying.
  - 3. Preserving confidentiality.
  - 4. Prohibiting transfer to a third party.
- B. Contractor shall provide all registrations and agreements with software copyright holders executed on behalf of the Owner.

## PART 2 - PRODUCTS

## 2.1 ACCEPTABLE MANUFACTURERS

- A. Siemens Building Technologies, Inc.
- B. Johnson Controls, Inc.
- C. Substitutions: Under provisions of Division 01.

## 2.2 LOCAL OPERATOR ACCESS AND DISPLAY PANEL

- A. Provide local display and adjustment panel. Panels shall be portable programmable control units. Panel shall contain a digital display and keyboard for displaying and editing the following parameters:
  - 1. Input/output point information.
  - 2. Controller set points.
  - 3. Controller tuning constants.
  - 4. Program execution times.
  - 5. High and low limit values.
  - 6. Limit differential.
  - 7. Time, date, year.

## 2.3 OPERATOR STATION

- A. Unless otherwise required in this specification, the Operator Stations and printers already exist on campus. New control system shall communicate through the campus LAN to the existing Operator Stations.
- B. Description:
  - 1. Provide one Operator Interface as described herein. Locate as shown on plans or as indicated by Owner's Agent. Operator PC shall be able to access all operator-level information in the system through the use of a standard, commercially available web browser. Access for a remote desktop shall also be made possible. The Operator Interface shall reside on the same peer-to-peer network as the building controllers.
  - 2. The Operator Interface shall connect via Ethernet to a local area network and be able to serve controller information to users connected via the LAN or via telephone through standard web browser software.
- C. Hardware:

1. Operator Interface PC shall have all hardware, peripherals, cables, interfaces, etc. necessary to optimally run the operating system and BMS software.
  2. PC shall be of speed, performance, capacity, etc., that is considered current technology and is commercially available at the time of the installation of the system. At a minimum include: 19" Monitor capable of displaying at 1024x768 resolution or better, Inkjet or Laser printer, 2.0 times the minimum system memory and hard drive capacity as recommended for the operating system, CD/DVD read and write drive, multi-button optical or laser mouse with scroll wheel.
  3. Software: Contractor shall provide all required software including the database. Provide the latest professional version of Microsoft Windows operating system. Provide a non-proprietary internet browser interface with capabilities as described herein.
- D. Graphical User Interface (GUI): Provide a comprehensive GUI using a collection of graphically-oriented pages accessed via standard web browser software or Remote Desktop session.. The GUI shall be constructed to operate like a single application, and shall provide a complete and intuitive point-and-click operator interface for access to system data.
1. Graphics shall have the ability to show animations of equipment such as fans/pumps rotating, dampers operating, etc. Provide a complete clip-art library of standard HVAC equipment (chillers, air-handling units, pumps, etc.).
    - a. Graphics have a nested or "Drill Down" structure beginning at the Campus Map level down to individual components.
    - b. Graphics shall include detailed floor drawings with device (ie, Air terminals, thermostats, discrete devices) locations clearly and accurately displayed.
  2. Custom Graphics: Custom graphic files may be created with the use of a graphics generation package. Graphics may be downloaded to the Web server to use as graphical backgrounds for Dynamic data sent to a Web browser.
  3. GUI pages shall be grouped in a logical manner.
  4. The system shall provide a search function to allow users to search for GUI pages or groups of pages by name or partial name.
  5. The system shall provide the necessary means to add, remove, and manage GUI pages.
  6. The system shall provide summary tables by equipment type per site. Room or space summary tables shall provide names, space temperatures, set points, and variance from set point. Provide a means to sort columns of data viewed by ascending or descending value for any chosen data type.
  7. An operator shall be able to access a tabular listing of the system's most recent alarms and acknowledge, print, delete, and link to trouble areas. Provide the ability to reset diagnostic messages and perform control overrides.
  8. The system default setting shall be to display data in Imperial/English units. The user shall have the option to select the display of data in SI/Metric units.
- E. Security: The system shall support state-of-the-art encryption between server and GUI, and comply with all current UTMB IS Security policies.
1. Server security shall accommodate a minimum of 1000 individually password-protected users. Each user shall be assigned a user name, password, and security level. User names and passwords shall be case sensitive and able to have up to 32 characters. User security shall be set up through the web browser as an administrative function. Each user will be assigned to a security level. Security levels shall be hierarchical in nature (i.e., the higher security levels have all rights of lower levels). There shall be at least four (4) user security levels corresponding to user roles.
  2. A system administrator shall be able to define the data view and edit capabilities for each security level. Additions to the server database shall be structured in the same manner as existing access control groups with the approval of the owner.
  3. Users shall be required to enter their user name and password to use the system. Users shall be automatically logged off of the system after a specified period of inactivity.
  4. System Applications and Software: The central server shall serve operator interface web pages and provide off-line storage of system information. Provide the following applications within the system.
  5. Automatic System Database Save and Restore. The central server shall store on the hard disk backup tables of data including trends, alarms, custom settings and user profiles. This data shall be backed up once per day. This database shall be updated whenever a change is made in the system. The storage of this data shall be automatic and not require operator intervention.

6. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to archive the database manually at any time.
7. System Configuration. The central server shall serve web pages as the interface for configuring the operator-level functions of the system. A user with proper security shall be able to configure the system to allow for future changes or additions.
8. On-Line Help and Training. Provide a context sensitive, on line help system to assist the operator in operation and editing of the system. On-line help shall be available for all system functions and shall provide the relevant data for that particular screen. Additional help shall be available through the use of hypertext links onscreen.
9. System Diagnostics. The system shall automatically monitor the operation of all workstations, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
10. Alarm Management - The central server shall provide the following alarm handling functions:
  - a. Receiving alarms from each building panel.
  - b. The central server shall store specified alarms in an alarm log database.
  - c. Displaying an alarm log.
  - d. Forward alarms to email, pager, cell phone as specified by the user.
  - e. Alarm sorting and/or filtering by alarm and/or site attribute.
  - f. Store alarm data in a standard format accessible to a user-specified peer database/server.
  - g. Storing and purging the alarm log.
  - h. Provide a means of acknowledging and deleting alarms from the viewable alarm log(s).
  - i. Provide a logical and printer-friendly format for printing alarm logs.
11. Alarm and Event Log. The operator shall be able to view all logged system alarms and events from any location in the system. An operator with the proper security level may acknowledge and clear alarms. All alarms shall be archived to the hard disk on the central server.
12. Trend Logs. The operator shall be able to define a trend log for any data in the system. This definition shall include interval, start-time, and stop-time. Change of Value (COV) trending shall also be possible to obtain from the system. Trend intervals of 1, 5, 15, 30, and 60 minutes as well as user-defined intervals shall be selectable. The system operator shall be able to determine how many samples are stored in each trend. Trend data shall be sampled and stored on the Building Controller panel, then harvested and be archived on the central server hard disk. Additionally, provide the capability to sample directly from the building controller database to the central server. Trend data shall be able to be viewed and printed from the operator interface web pages. Trends shall be viewable in both a text-based and graphical format. Trends shall also be storable in a tab delimited ASCII format for use by other industry standard word processing and spreadsheet packages, and be exportable to a file for use in other software tools, available in a non-proprietary file format to be used by another database.
13. Dynamic Graphical Trending. The system shall have the ability to display collected data in a graphical chart. Trend viewing capabilities shall include the ability to show up to 5 points on a chart. Each data point trend line shall be an individual color. Trend data shall be able to be stored indefinitely on the central server, based on server storage capacity and data archiving practices.
14. Object and Property Status and Control. Provide a method for the operator to view, and edit (if applicable) the status of any object and property in the system.
15. Data Collection. Provide a data collection module to acquire historical data for access by the GUI. Historical data shall be categorized as follows:
  - a. Consumable Data: KHW, BTU, GPM, etc., acquired in either analog or digital pulse form.
  - b. Runtime Data: Information on time and operation of equipment based on equipment status.
  - c. History Data: Trend log data on status of equipment or values such as an analog sensor. History data collection shall be initiated from either a specified time function or an event. Provide enough software capacity to accomplish the required data collection function for the total system as specified. The data collection process shall not require the BMS PC to be online. Additional Data Collection modules may be added at any time to meet increased system requirements. The system shall allow the operator the capability of configuring each additional module.
16. Reports and Logs. Operator shall be able to select, modify, create, and print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
17. Standard Reports. Furnish the following standard system reports. Reports shall be organized based upon the selected equipment.
  - a. Alarm Summary Report of current alarms.

- b. List of equipment and associated alarm conditions.
  - c. List of configured alarm actions such as pop-up, notify by email, etc.
  - d. Table of operating schedules for each equipment.
  - e. Summary of all operating schedules.
  - f. Summary of all security actions taken through user interface.
  - g. List of equipment commissioning checkout status.
18. Custom Reports. Operator shall be able to create custom reports that retrieve data, including archived trend data, organize the data, and present results in tabular or graphical format. Reports shall be launched from the operator interface.
- F. Operator Interface Applications Editors. The GUI shall support dedicated screens for the editing of control system applications. The application programs shall be executed at the appropriate controller panels.
- G. Scheduling. An editor for an enterprise-wide scheduling application shall be provided. Provide a method by which a system operator can make permanent changes to one or many building schedules without the need to repeat any steps. The system shall be able to provide temporary changes to one or more schedules at one or more building locations. The scheduling application shall have the following features:
1. Scheduling by system type, building area, zone, groups of zones, individually controlled equipment and groups of individually controlled equipment.
  2. Schedules may be entered for up to nine years in advance.
  3. Schedules shall automatically adjust for leap year and Daylight Savings Time.
  4. Schedules shall be self-deleting when effective dates have passed.
- H. Optimum Start/Stop. The scheduling application shall provide and support an optimal start algorithm. This algorithm shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less than and greater than 24 hours. Provide the ability to modify the algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit.
- I. Timed Local Override. A standard application shall be utilized to enable/disable temperature control when a user selects on/cancel at the zone sensor, workstation, or the operator display. The amount of time that the override takes precedence shall be defined by the operator from the workstation. The system shall allow the operator to define a maximum number of overrides allowed in a given time period.
- J. Day/Night Setback. The system shall allow the space temperature to drift within an adjustable, user-defined temperature range when the building or zones are in unoccupied mode. The heating/cooling shall be activated if the space temperature leaves the setback range and shall remain active until the space temperature reaches the setback range.
- K. Staggered Start/Stop. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started and the time delay between starts shall be user-selectable. This application shall also prevent all major controlled equipment from simultaneously stopping during normal shut down. The order in which equipment (or groups of equipment) is stopped and the time delay between stops shall be user-selectable.
- L. Demand Limiting. The demand limiting program shall monitor building power consumption from signals generated by a pulse generator (provided by others) mounted at the building power meter, or from a watt transducer or current transformer attached to the building feeder lines. The system shall be capable of handling no less than six separate time of day KW demand billing rate periods. The system shall be capable of measuring electrical usage from multiple meters serving one building and each piece of equipment being controlled on the LAN shall be programmable to respond to the peak demand information from its respective meter.

1. The demand limiting program shall be based on a predictive sliding window algorithm. The sliding window interval shall be operator selectable in increments of one minute, up to 60 minutes. The operator shall be able to establish the kilowatt threshold for a minimum of three adjustable demand levels.
  2. Control system shall be capable of demand limiting by resetting HVAC system set points to reduce load while maintaining a widened band of comfort control in the space. The system shall allow the operator to set the individual equipment temperature set points for each operator defined demand level. If these reset set points are not satisfied, the set point shall be revised for the different established demand levels.
  3. The system shall have failed meter protection, such that when a KW pulse is not received from the utility within an operator adjustable time period, an alarm will be generated. The system software will automatically default to a predetermined fail-safe shed level.
  4. Information Archiving. The system shall have the ability to archive demand and usage information for use at a later time. System shall permit the operator access to this information on a current day, month-to-date, and a year-to-date basis. Input capability shall be provided for an end-of-billing period indication.
- M. Maintenance Management. The system shall monitor equipment status and generate maintenance messages based upon user designated run time, starts, and/or calendar date limits.
- N. Online Help. Operator Interface shall have a context-sensitive online help tool to provide help with operating and editing the system.

## 2.4 CONTROL UNITS

- A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
  2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
  3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
- B. Provide the following functions:
1. Mathematical: Absolute value, calculate, square root, power, sign, average, totalize.
  2. Logic: OR, AND, compare negate.
  3. Fixed Formula: High and low select, span, rate, ramp, enthalpy, wet bulb, dew point, relative humidity, humidity ratio, filter differential pressure.
  4. Data Manipulation: Store, file and set.
  5. Control Routines: Proportional, integral, lead lag, hysteresis correction and incremental control.
  6. Energy Management: Duty cycling, load shed, optimal run time, economizer, holiday and daylight savings time correction.
- C. Provide self-test procedure for checking digital display and computer. Display advisories for maintenance, performance, or software problems. Identify variables as reliable or unreliable. Variables identified as unreliable will flash when displayed and calculation will use default.
- D. Indicate alarms and deviations. Alarm scan shows alarms and identification. Continue alarm indication until acknowledged and alarm condition is corrected.
- E. BACnet Compliance: Control units shall be compatible with BACnet.



## 2.5 BUILDING SYSTEMS INTEGRATION

- A. Protocol Translator Module (PTM): The BMS System shall establish a seamless interconnection with other building, electrical and/or mechanical subsystems as well as other manufacturers control systems using a Protocol Translator as specified below and related equipment sections of the specification. These systems shall be controlled, monitored and graphically programmed with the same Graphical Programming Language (GPL) used for all other control modules.
1. System Information. All system information specified in the I/O Point Summary and related documents shall be available to the BMS server.
  2. OEM Cooperation. Full cooperation by the Original Equipment Manufacturer (OEM) in this open protocol effort shall be a requirement for bidding this project. OEM manufacturers shall bid BACnet® compliant devices. OEM manufacturers that utilize other protocols shall include the cost of a PTM in their bid.
  3. Necessary Equipment Included Price. If the equipment manufacturer does not have this capability, they shall contact the authorized representative of the BMS for assistance and shall include in their equipment price any necessary equipment obtained from the BMS manufacturer to comply with this section.
  4. PTM Specification:
    - a. The PTM shall be a microprocessor based communication device designed to provide seamless, two-way translation between two or more standard or non-standard protocols.
    - b. The PTM shall be available for a variety of Data Link\Physical Layer configurations including PTP (point-to-point) via EIA-232, MS/TP via EIA-485 and Ethernet.
    - c. In addition to BACnet®, the PTM shall also support other protocols including Modbus, J-Bus and other protocols as specified herein for electrical/mechanical subsystems.
    - d. The PTM shall have at least three communication ports. One shall be for communication between native BACnet® controllers residing on the controller network. The other two ports shall have the ability to be configured for different protocols.
    - e. The PTM shall provide full custom programmability of the data flowing between the networks using the same graphical programming as specified herein. The system shall have the ability to create custom building control strategies using global data between networks.

## 2.6 INPUT/OUTPUT SENSORS [ENGINEER TO REVISE SENSORS AS APPLICABLE TO PROJECT]

- A. Temperature:
1. Resistance temperature detectors (RTD's) with resistance tolerance of plus or minus 0.1 percent at 70 degrees F, interchangeability less than plus or minus 0.2 percent, time constant of 13 seconds maximum for fluids and 200 seconds maximum for air, 1800 ohm or 10,000 ohm thermistor sensors are also acceptable.
  2. Use insertion elements in ducts not affected by temperature stratification or smaller than nine square feet. Use averaging elements where larger or where prone to stratification. Sensor length as recommended by manufacturer for given installation conditions.
  3. Insertion elements for liquids shall be with brass socket with minimum insertion length of 2-1/2 inches (60 mm). Chilled water and condenser water sensors shall have an accuracy of  $\pm 0.25^{\circ}$  F at calibration point. Hot water temperature sensors shall have an accuracy of  $\pm 0.75^{\circ}$  F at calibration point.
  4. Provide room sensors with locking mechanism (physical or software; intent is to restrict access to local adjustment). Unless otherwise noted, public areas (ie, Rest rooms, corridors, hallways, etc) shall use Flush Mount Room Temperature sensors of Stainless Steel or white blank cover plate construction without local display or adjustments. All room sensors shall be locally labeled with it's point name for easy identification. Room sensors shall have an accuracy of  $\pm 1.0^{\circ}$ F at calibration point.
  5. Provide outside air sensors with watertight inlet fitting and shielding from direct sunlight. OA sensors shall have an accuracy of  $\pm 0.5^{\circ}$ F at calibration point.
- B. Humidity Sensors:
1. Elements: Accurate within  $\pm 2$  percent 10-90%RH @ 25°C with linear output.
  2. Room Sensors: With locking mechanism (physical or software; intent is to restrict access to local adjustment), range of 0 - 100 percent relative humidity.

3. Duct and Outside Air Sensors: With element guard and mounting plate, range of 0 - 100 percent relative humidity.
- C. Pressure Sensors:
1. Differential Pressure and Pressure Sensors: Sensors shall have a 4-20mA output proportional signal with provisions for field checking. Sensors shall withstand up to 150% of rated working pressure without damaging the device. Accuracy shall be  $\pm 2\%$  of full scale.
  2. Water Differential Pressure Switches: Pressure switches shall have a repetitive accuracy of  $\pm 2\%$  of range and withstand up to 150% of rated pressure. Sensors shall be diaphragm or bourbon tube design. Switch operation shall be adjustable over the operating pressure range. The switch shall have an application rated Form C, snap-acting, self-wiping contact of platinum alloy, silver alloy, or gold plating.
  3. High static limit switch: Switches shall be diaphragm operated with 3-1/2" diaphragm to actuate a single pole double throw snap switch. Motion of the diaphragm shall be transmitted to the switch button by means of a direct mechanical linkage. It should include a 1.4 – 5.5" WG range pressure switch with manual reset snap switch.
  4. Static pressure sensor: Provide a differential pressure transmitter with a 4-20mA output to the BMS. It shall operate on the capacitance principle and be capable of sensing very low positive, negative or differential pressures. Sensor shall be accurate within  $\pm 1\%$  of range. Range shall be from 0.1 to 5.0 inches WG over a temperature range of 32 to 125°F and humidity range of 20 – 90% RH; additional sensor ranges may be necessary to accommodate the system being monitored or controlled.
- D. Flow Switches: Flow Switches shall be either paddle or differential pressure type and have a repetitive accuracy of  $\pm 1\%$  of their operating range.
1. Paddle Paddle type switches (water service only) shall be UL listed, SPDT snap-acting with pilot duty rating (125 VA minimum). Adjustable sensitivity with NEMA 1 Type enclosure unless otherwise specified.
  2. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 Type enclosure, with scale range and differential suitable for intended application, or as specified.
- E. Water Flow Meters:
1. Turbine Meter: Provide inline turbine type flow meter with bronze or stainless steel body, plastic turbine (stainless steel above 150 deg. F), and sensor and indicator as appropriate for the application for which it is installed. Flow meter shall be rated for minimum working pressure and temperature as appropriate for the application for which it is installed. Accuracy shall be  $\pm 1.5\%$  or better with at least 1% repeatability.
  2. Vortex Shedding Meter. Provide inline vortex shedding type flow meter with stainless steel body, stainless steel shredder bar, and sensor and indicator as appropriate for the application in which it is installed. Flow meter shall be rated for minimum working pressure and temperature as appropriate for the application for which it is installed. Accuracy shall be  $\pm 1.5\%$  or better.
- F. BTU Meters:
1. BTU Meter: [Provide inline turbine type flow meter with bronze or stainless steel body, plastic turbine, (stainless steel above 150 deg. F). and sensor and indicator as appropriate for the application for which it is installed. Flow meter shall be rated for minimum working pressure and temperature as appropriate for the application for which it is installed. Accuracy shall be  $\pm 1.5\%$  or better with at least 1% repeatability. Flow meter shall be similar to Onicon F-3500 or equivalent] [Water flow sensors shall be inline magnetic flowmeter flow tubes similar to Rosemont 8705. Each sensor shall be sized specifically for the pipe in which it is to be installed. Sensor shall have  $\pm 0.5\%$  accuracy from 1 to 30 feet/second, with Class 150 carbon steel flanges, exterior painted with polyurethane, grounding electrode, Teflon (PTFE) lining, and Type 316L stainless steel electrodes. Contractor shall furnish remote mounted magnetic flowmeter transmitters, similar to Rosemount Model 8712E, with 115Vac/1ph/60hz power supply, NEMA 4X enclosure, 4 – 20 ma output, battery-backup totalizer, and local operator interface]. Temperature sensors shall be matched for accuracy within  $\pm 1\%$ . Power shall be 24 VAC and be supplied by Division 23. Meter shall communicate with the server via Modbus or BACNet protocols.

- G. Equipment Operation Sensors:
1. Status Inputs for Fans: Differential pressure switch with adjustable range of 0.1 to 5.0 inches WG (0 to 1250 Pa); additional sensor ranges may be necessary to accommodate the system being monitored or controlled.
  2. Status Inputs for Pumps: Differential pressure switch piped across pump with adjustable pressure differential range of 8 to 60 PSI (50 to 400 kPa).
  3. Status Inputs Where Differential Pressure Sensing is Impractical: Current sensitive relay with current transformers, adjustable and set to 175 percent of rated motor current.
  4. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
  5. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
  6. Water-Flow Switches: Bellows-actuated or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.
- H. Watt-hour Transducers shall have an accuracy of  $\pm 0.25\%$  for KW and KWH outputs from full lag to full lead power factor. Input ranges for KW and KWH transducers shall be selectable without requiring the changing of current or potential transformers, and shall communicate with the server via Modbus or BACNet or BMS specific protocols.
- I. Digital to Pneumatic Transducers: Convert plus or minus 12 vdc pulse width modulation outputs and/or continuous proportional current or voltage to 0 to 20 psi (0 to 138 kPa).
- J. Voltage-to-Digital Alarm Relays shall monitor status of equipment safeties and overloads and shall be sized and connected so as not to impede the function of the monitored contacts. Switch shall have self-wiping, snap-acting Form C contacts rated for the application.
- K. Damper Position Indication: Potentiometer mounted in handbox enclosure with adjustable crankarm assembly connected to damper to transmit 0 - 100 percent damper travel.
- L. Photocells shall have transmitters for 4-20mA output signal. Sensor shall be mounted in a waterproof enclosure. Unit shall be calibrated for 4mA at greater than 100 foot-candles and 20mA at less than 0.1 foot-candles.
- M. Airflow Measuring Devices:
1. Airflow/temperature measurement device (ATMD). Each ATMD shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor nodes contained in one or more probe assemblies per measurement location. Provide transmitter with appropriate communications interface with the Building Control System. Sensor probe shall be constructed of aluminum alloy or Stainless Steel with Stainless Steel mounting brackets. Sensor shall utilize bead-in-glass thermistor probes. Airflow sensing shall be accurate within  $\pm 2\%$  over a temperature range of  $-20^{\circ}\text{F}$  to  $120^{\circ}\text{F}$ .
  2. Air Monitoring Station with multi-point, self-averaging Pitot traverse and aluminum "honeycomb" air straightener section in one assembly (Honeycomb air straightener section shall have access doors installed before and after per Section "23 33 00 – 3.3 A. Access Doors" for cleaning of Honeycomb). Aluminum **or** stainless steel frame with mounting flanges on both sides. Unit shall be capable of operating over a temperature range of  $-20^{\circ}\text{F}$  to  $120^{\circ}\text{F}$  and an airflow velocity range of 400 to 5,000 FPM with an accuracy of 2% of total flow and a pressure drop of no more than .085" WC at 2000 FPM. AMS model submitted shall require owner review and approval.
- N. Motorized Dampers:
1. Control dampers shall be AMCA-rated opposed [parallel] blade design and rated for leakage less than 10 CFM/SF of damper area at a differential pressure of 4"WC. Modulating dampers shall have linear flow output characteristics.
  2. Frame shall be 16 gauge galvanized steel, or 1/8" extruded aluminum with reinforced corner bracing.

3. Damper blades shall be a maximum of 8" wide and a maximum of 48" long. Applications requiring longer dampers shall have multiple sections with multiple linkages to prevent binding.
  4. Blade material shall be galvanized steel, not less than 16 GA, formed for extra strength. Secure blades to 1/2-inch diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
  5. Dampers used for outside air intake shall have frames, blades, and other internal parts exposed to outside air constructed of 316 stainless steel.
  6. Edge seals shall be inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless steel side seals rated for leakage of less than 10 CFM/SF of damper area at a differential pressure of 4"WC when damper is held by a torque of 50 IN-LB.
- O. Damper Actuators:
1. Provide UL-listed electronic damper actuators designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.
  2. Actuators shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
  3. All rotary spring return actuators shall be capable of both clockwise and counter clockwise spring return operation. Linear actuators shall spring return to the retracted position.
  4. Proportional actuators shall accept a 0-10 VDC or 0-20 mA control signal and provide a 2-10 VDC or 4-20 mA operating range.
  5. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
  6. Modulating damper operators shall be sized with sufficient reserve power to provide smooth modulating action.
- P. Valve Actuators:
1. Provide UL-listed electronic valve actuators designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.
  2. Actuators shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
  3. Proportional valve actuators shall accept a 0-10 VDC or 0-20 mA control signal and provide a 2-10 VDC or 4-20 mA operating range.
  4. Rotary spring return actuators shall be capable of both clockwise and counter clockwise spring return operation. Linear actuators shall spring return to the retracted position
  5. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the valve when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
- Q. Control Valves:
1. Pressure ratings shall be 125 psig or 1.25 times the maximum system operating pressure.
  2. 2" and smaller:
    - a. ANSI class 250, spring loaded, Teflon packing. Two-way valves shall have replaceable composition disc or stainless steel ball and shall be quick acting for two-position service unless otherwise indicated.
    - b. Screwed.
    - c. Bodies and internal parts shall be bronze, cast brass, stainless steel or other approved corrosion-resistant metal as required for the application.
  3. 2-1/2" and larger:
    - a. ANSI class 125, guided plug, Teflon packing.
    - b. Flanged.
    - c. Bodies shall be cast iron or cast steel.
    - d. Seats and parts exposed to fluid shall be bronze, stainless steel or other approved corrosion resistant metal as required for the application.
  4. Three-way valves: linear throttling plugs allowing total flow through valve to remain constant regardless of position.
  5. Sizes shall be by the control system manufacturer based on the following minimum criteria:
    - a. Valves for two-position service shall be line size unless indicated otherwise.

- b. Valves for modulating service shall have a pressure drop equal to twice the pressure drop through the coil/exchanger, 50% of the pressure difference between supply and return mains, or 5 PSI, whichever is greater.
  - c. Valves for three-way modulating service shall have a Pressure drop equal to twice the pressure drop through the coil/exchanger load, 5 PSI maximum.
  - d. Relief and bypass valves shall be sized according to pressure available and/or flow required.
- R. Steam System Globe Valves:
- 1. Pressure ratings shall be 125 psig or 1.25 times the maximum system operating pressure.
  - 2. 2" and smaller:
    - a. ANSI Class 250.
    - b. Screwed.
    - c. Body shall be bronze.
    - d. Trim shall be bronze with a stainless steel rising stem, renewable composition disc, and backseating capacity repackable under pressure.
  - 3. 2-1/2" and larger:
    - a. ANSI Class 125.
    - b. Flanged.
    - c. Body shall be cast iron.
    - d. Trim shall be bronze with stainless steel rising stem, plug type disc, and renewable seat and disc.
  - 4. Sizes shall be by the control system manufacturer based on the following minimum criteria:
    - a. Two position service valves shall be sized for 20% of inlet pressure.
    - b. Modulating service valves for 15 PSI and lower shall be sized for 80% of inlet pressure.
    - c. Modulating service valves for 16-50 PSI shall be sized for 50% of inlet pressure.
    - d. Modulating service valves for >50 PSI shall be sized for the given pressure and application.
  - 5. Control valves for steam service shall be equal percentage type unless otherwise indicated.
- S. Gas Detection Equipment:
- 1. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of -4 to 122°F; with 2 factory-calibrated alarm levels at 50 and 100PPM. Maximum response time to 100 PPM CO calibration gas shall be two minutes.
  - 2. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors suitable over a temperature range of 32 to 130°F and calibrated for 0 to 2 percent, with continuous or averaged reading 4-20 mA output, for wall mounting.
  - 3. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing suitable over a temperature range of 4 to 122°F and calibrated for 0 to 5 percent with continuous or averaged reading 4-20 mA output, for wall mounting.
  - 4. Nitrogen Dioxide Sensor and Transmitter: Single detectors using electro-chemical sensors suitable over a temperature range of 25 to 104°F and calibrated for 0-20 PPM with continuous or averaged reading 4-20 mA output, a 2-year minimum life, for wall mounting.
  - 5. Storage Tank Level Sensor. Pulse radar transmitter that provides a continuous level measurement up to 98 feet with a 4-20 mA signal output and is configurable via an integral push button display module. The antenna and mount shall be 316L stainless steel. The sensor shall have auto-temperature compensation and fail-safe diagnostics. The sensor shall be housed in an IP67 aluminum enclosure with polycarbonate window.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install electrical work in accordance with Division 26. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

- C. Each Programmable Control Unit shall be provided a 120V AC, 15 amp dedicated emergency power circuit provided by Division 26. Mission critical PCU's shall have appropriately sized UPS's to ride out a power event while emergency power is being restored.
  - 1. 120 V AC Circuits shall be the responsibility of and coordinated with Division 26 and shown on Division 26 Drawings.
  - 2. Each PCU unit will include a local copy of its wiring diagram as well as pertinent sequences of operations.
- D. Each Air Terminal Unit shall be provided a 120V AC, circuit provided by Division 26.
  - 1. 120 V AC Circuits shall be the responsibility of and coordinated with Division 26 and shown on Division 26 Drawings.
  - 2. The number of ATU's per circuit shall not exceed the 120 V circuits 15 Amp rating.
  - 3. Each ATU unit will include a local copy of its wiring diagram as well as pertinent sequences of operations.
- E.
- F. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Generally, install devices 48 inches above the floor in alignment with light switches.
  - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- G. Install raceways, boxes, and cabinets according to Division 26 Section "Raceways, Conduit and Boxes ."
- H. Install building wire and cable according to Division 26 Section " Cable, Wire, and Connectors ."
  - 1. All input-output, communications, and low voltage control wiring shall have each end labeled with the appropriate identification information, ie Point name and termination location info, etc.
- I. Data communications (Ethernet) shall be the responsibility of and coordinated with Division 27
  - 1. In addition to any data connections required for each PCU, a spare data connection shall be provided by Division 27 within 15 feet of the PCU for technician use.
- J. Connect manual-reset limit controls independently of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- K. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

### 3.2 MANUFACTURER'S FIELD SERVICES

- A. Prepare and start systems under provisions of Division 01
- B. Start-up, calibrate, and adjust systems. Allow sufficient time for start-up, calibration, and adjusting prior to placing control systems in permanent operation.
- C. Provide basic operator training for four persons as designated by the Owner. Include a minimum of 24 hours dedicated instructor time. Training shall consist of instruction in the operation of the BMS including but not limited to: Logging in and navigation through all parts and pages of the graphical user interface, Sequences of control (viewing, creating and adjusting), Set points (viewing, adjusting), Alarm capabilities and management, Trending capabilities (viewing, creating, editing, reporting, and storing data), Scheduling (viewing, creating, and editing) Troubleshooting communication errors, Troubleshooting hardware errors, other capabilities as designated by the Owner's Agent.
- D. Provide each attendee with a bound set of printed training materials to be used during training and to become property of the Owner.
- E. Provide service engineer to instruct Owner's representative in the operation of systems and equipment for a period of three working days.

- F. Provide Owner with video recordings on DVD of all training sessions. DVD shall have a sequentially indexed menu for easy, individual access to each session/topic.

### 3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
  2. Test and adjust controls and safeties.
  3. Test each point through its full operating range to verify that safety and operating control set points are as required.
  4. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
  5. Test each system for compliance with sequences of operation.
  6. Test software and hardware interlocks.
- B. DDC VERIFICATION:
  1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
  2. Check instruments for proper location and accessibility.
  3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
  4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
  5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
  6. Check temperature instruments and material and length of sensing elements.
  7. Check control valves. Verify that they are installed in the correct orientation.
  8. Check DDC system as follows:
    - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    - c. Verify that spare I/O capacity has been provided.
    - d. Verify that DDC controllers are protected from power supply surges.
- C. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

### 3.4 ADJUSTING

- A. Calibrating and Adjusting:
  1. Calibrate instruments.
  2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
  3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
  4. Control System Inputs and Outputs:
    - a. Check analog inputs at 0, 50, and 100 percent of span.
    - b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    - c. Check digital inputs using jumper wire.
    - d. Check digital outputs using ohmmeter to test for contact making or breaking.
    - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
  5. Flow:
    - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    - b. Manually operate flow switches to verify that they make or break contact.
  6. Pressure:
    - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:
  - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
  - b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

### 3.5 DEMONSTRATION

A. Provide systems demonstration under provisions of Division 01.

### 3.6 INPUT/OUTPUT SCHEDULE

A. Contractor shall provide a complete points list/matrix describing all system inputs, outputs, and functions as necessary to accomplish specified sequences of control.

END OF SECTION 23 09 23



## SECTION 23 31 00 - DUCTWORK

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. Perform Work required to provide and install ductwork, flexible duct, hangers, supports, sleeves, flashings, vent flues, and all necessary accessories as indicated in the Contract Documents. Provide any supplementary items necessary for proper installation
- B. Section Includes:
1. Rectangular ducts and fittings.
  2. Round ducts and fittings.
  3. Sheet metal materials.
  4. Sealants and gaskets.
  5. Hangers and supports.
- C. Related Sections:
1. Division 09 Section, Painting, for interior painting of metal ductwork exposed to view through grilles, registers, and other openings.
  2. Section 23 05 93, System Testing, Adjusting, and Balancing.
  3. Section 23 33 00, Air Duct Accessories.
  4. Section 23 34 00, Fans.
  5. Section 23 36 00 Air Terminal Units.
  6. Section 23 37 00, Air Devices.

## 1.3 DEFINITIONS

- A. Low Pressure: Up to 2 inches w.g. positive or negative static pressure and velocity equal to 1500 fpm. Constructed and tested for +2 inches W.G.
- B. Medium Pressure: Over 2 inches w.g. through 6 inches w.g. positive or negative static pressure and velocity greater than 1500 fpm. All medium pressure ductwork shall be constructed and tested for +6 inches w.g.
- C. High Pressure: Over than 6 inches w.g. positive static pressure and velocity greater than 2500 fpm.
- D. Duct Size. The supply, return and exhaust duct sizes shown on drawings are clear inside sheet metal dimensions. Include proper allowances for acoustical lining, where indicated in plans or specifications. For acoustical return air boots, refer to additional information on detail.

## 1.4 GUARANTEE

- A. Guarantee all ductwork for 1 year from the date of final acceptance. The guarantee will cover workmanship, noise, chatter, whistling or vibration. Ductwork shall be free from pulsation under all conditions of operation.

## 1.5 CONTRACTOR COORDINATION

- A. Erect all ducts in the general locations shown on the drawing(s), but conform to all structural and finish conditions of the building. Before fabricating any ductwork, Contractor to check the physical conditions at the job site and make all necessary changes in cross sections, offsets and similar items, whether they are specifically indicated on drawing(s) or not. Do not obstruct the induced air plenum opening at VAV boxes and service access spaces for VAV boxes and other equipment.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

## 1.6 STANDARDS AND CODES

- A. Except as otherwise indicated, sheet metal ductwork material, fabrication and installation shall comply with second edition of SMACNA HVAC Construction Standards Metal and Flexible, except where indicated otherwise. All air distribution devices (such as dampers) included in this Section shall comply with the third edition of SMACNA HVAC Construction Standards Metal and Flexible.
- B. In addition, construct ductwork and all air distribution devices to the following:
  - 1. IMC International Mechanical Code
  - 2. NFPA 90A Installation of Air Conditioning and Ventilating Systems.
  - 3. NFPA 90B Installation of Warm Air Heating and Air Conditioning Systems
  - 4. SMACNA Round Industrial Duct Construction Standards
  - 5. SMACNA The Managers' Guide for Welding

## 1.7 SUBMITTALS

- A. Product Data
  - 1. Submit product data for each product. Refer to Section 23 00 10.
  - 2. Provide acoustical data on insulated flexible ductwork as indicated in Part 2.
- B. Delegated-Design Submittal. Include the following for each system furnished on the project.
  - 1. System name and type
  - 2. Duct system design pressure.
  - 3. Sheet metal thicknesses and materials.
  - 4. Reinforcement details and spacing.
  - 5. Seam and joint construction and sealing.
  - 6. Fittings, construction and details.
  - 7. Hangers and supports, including materials, fabrication, methods for duct and building attachment.
- C. Ductwork shop drawings. Provide CAD-generated shop drawings of mechanical rooms and building ductwork drawn at a minimum scale of 1/4 inch per foot. Include the following as a minimum:
  - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
  - 2. Factory and shop fabricated duct and fittings.
  - 3. Duct layout indicating sizes, configuration and pressure classes.
  - 4. Elevations of top and bottom of ducts.
  - 5. Dimensions of main duct runs from building grid lines.
  - 6. Reinforcement and spacing.
  - 7. Penetrations through fire-rated and other partitions.
  - 8. Equipment installation based on equipment being used on Project.
  - 9. Duct accessories, including access doors and panels, fire dampers and smoke dampers.
- D. Welding certificates. For duct welders including procedures and standards of acceptance

## PART 2 - PRODUCTS

## 2.1 ACCEPTABLE MANUFACTURERS

- A. Spiral Ductwork. Gowco, McCorvey, United McGill.
- B. Sheet Metal Products. McCorvey Sheet Metal Works, Gowco, United McGill, Flexmaster, Ductmate, Ward.
- C. Insulated Flexible Duct. Pepertree Air Solutions, Thermaflex, Flexmaster.
- D. Double-Wall Flue – Schebler, Selkirk, Metal-Fab, Van Packer
- E. Double-Wall Ductwork (supply) - United McGill, Semco

## 2.2 APPLICATION

- A. Ductwork shall be constructed in accordance with the following as a minimum. Refer to drawings for any deviations from this table.

SYSTEM	MATERIAL	MINIMUM PRESSURE CLASSIFICATION <sup>(1)</sup>
<b>Supply Systems:</b>		
All ductwork downstream of terminal boxes	Galvanized Steel	Low Pressure
All fan coil unit supply ductwork	Galvanized Steel	Low Pressure
Supply ductwork downstream of constant volume single and multi-zone AHUs.	Galvanized Steel	Low Pressure
Supply ductwork downstream of single zone VAV AHUs <sup>(2)</sup>	Galvanized Steel	Medium Pressure
Treated outside air to AHU <sup>(3)</sup>	Galvanized Steel	Medium Pressure
Inlet connection to terminal box	Flexible Duct	As Specified
Connection to Air Device	Flexible Duct	As Specified
<b>Return Systems:</b>		
Return air boot/transfer duct	Galvanized Steel	Low Pressure
Return air device to return distribution <sup>(4)</sup>	Galvanized Steel	Low Pressure <sup>(5)</sup>
Return Air Distribution	Galvanized Steel	Medium Pressure <sup>(5)</sup>
<b>General Exhaust/Relief Systems:</b>		
Exhaust air device to exhaust distribution <sup>(4)</sup>	Galvanized Steel	Low Pressure <sup>(5)</sup>
Exhaust Air Distribution	Galvanized Steel	Medium Pressure <sup>(5)</sup>
<b>Miscellaneous Exhaust Systems:</b>		
Gas-Fired Unit Heaters Flue	Type IPS Double Wall	Refer to Specs

- B. Notes to Table:
  1. Positive pressure unless noted otherwise in Table.
  2. From air handling unit (AHU) to terminal boxes.
  3. From pretreatment AHU to AHU.
  4. Runout from air device to return/exhaust air trunk duct
  5. Negative pressure SMACNA table.
  6. Applies to exhaust system for general laboratory exhaust, fume hoods, and biosafety cabinets. Refer to Drawings for construction of any additional exhaust systems.

### 2.3 DUCT MATERIAL AND CONSTRUCTION

- A. General. Noncombustible or conforming to requirements for Class I air duct materials or UL 181. All ductwork indicated on the Drawings, specified or required for the air conditioning and ventilating systems shall be of materials as hereinafter specified unless indicated otherwise on Drawings. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein
- B. Galvanized Steel Ducts. Constructed of G-60 coated galvanized steel meeting requirements of ASTM A 653 or ASTM A 527. Stencil coils of sheet steel throughout on 10 foot centers with gage and manufacturer's name. All materials associated with the duct system shall be galvanized steel including stiffeners, fasteners, etc.
- C. Stainless Steel Ducts. Type 304 or 316L as indicated in application schedule. For round ductwork, butt-welded (solid welded) longitudinal seam only. Spiral lockseam and Spiral lockseam with standing rib is not acceptable.
- D. Fasteners. Rivets, bolts or sheet metal screws.
- E. Sealant.
  - 1. Sealant shall be water based, latex UL 181B-M sealant with flame spread of 0 and smoke developed of 0. Sealants shall be similar to Foster 32-19, Childers CP-146, Hard Cast Iron Grip 601, Ductmate Pro Seal or Design Polymeric DP 1010.
  - 2. Scrim tape shall be fiberglass open weave tape, 3 inches wide, with maximum 20/10 thread count.
- F. Hangers and Supports.
  - 1. Support ductwork with continuously threaded hanger rods of galvanized steel or 20 gauge straps as indicated in these specifications.

### 2.4 RECTANGULAR DUCTS AND FITTINGS GENERAL REQUIREMENTS

- A. General Fabrication Requirements: Comply with SMACNA based on indicated static-pressure class unless otherwise indicated. In no case shall the ductwork be less than 26 gage for low pressure ductwork, 24 gage for medium pressure ductwork.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA.
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Snaplock longitudinal seams (L2) are not acceptable.
- D. Fittings:
  - 1. Select types and fabricate according to SMACNA Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA.
  - 2. Construct bends and elbows per SMACNA Figure 2-2, "Rectangular Elbows", Type RE1 with radius of not less than 1-1/2 times width of duct on centerline. Where not possible or where indicated on construction documents, construct Type RE2 rectangular elbows with welded-in-place double wall airfoil turning vanes (whether specifically shown on drawings or not), or short radius type RE1 radius elbows.
  - 3. Construct tees per SMACNA Figure 2-5, "Divided Flow Branches", Type 2, Type 3, Type 4A or 4.

4. Construct branch connections per SMACNA Figure 2-6, "Branch Connection". Use 45 degree entry, 45 degree lead in, conical or bellmouth connections only.
5. Unless indicated on construction document details, transform duct sizes gradually, not exceeding 15 degrees divergence and 30 degrees convergence. Divergence upstream of equipment shall not exceed 30 degrees. Convergence downstream of equipment shall not exceed 45 degrees.
6. Bullhead tees are not permitted.

## 2.5 ROUND AND OVAL DUCTS AND FITTINGS GENERAL REQUIREMENTS

- A. General Fabrication Requirements: Comply with SMACNA Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated. In no case shall the ductwork be less than 26 gage.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Use flanged joints for ducts larger than 48 inches in diameter.
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Utilize spiral seam or butt weld seams only. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
- D. Fittings:
  1. Fittings shall have a wall thickness not less than that specified for longitudinal-seam straight duct or 26 gage, whichever is more stringent.
  2. Tees and Laterals: Select types and fabricate according to SMACNA Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA. Utilize 90 degree tee with oval to round tap, 45 degree lateral tap, or conical fitting only. Wye fittings may be utilized where specifically indicated on drawings and details.
  3. Elbows: Construct elbows with radius of not less than 1-1/2 times width of duct on centerline. Provide minimum 5 gore elbows on all 90 deg elbows, 3 gore elbows on 45 degree elbows. Continuously welded stamped long radius elbows may be utilized on ductwork up to and including 12-inches in diameter.
  4. Bullhead tees are not permitted.

## 2.6 INSULATED FLEXIBLE DUCTWORK

- A. Use for connection to diffusers, grilles and terminal boxes as indicated in specifications and details.
- B. Construct the inner liner of coated steel helix and a PE or CPE liner substantially bonded together to prevent the duct from collapsing or kinking in short radius bends. Provide fiberglass insulation providing minimum R-4.2 thermal conductance and 3 pound minimum density around inner jacket consisting of fiberglass reinforcement and aluminum foil vapor barrier outer jacket. Use duct rated at minimum working pressure of 10 inches of water positive and 1 inches of water maximum negative pressure (4-12 in I.D.), and 6 inches of water positive and 1/2 inch of water maximum negative pressure (14- 16 I.D.),. Provide duct listed by U.L. at flame spread rate of not over 25 and smoke developed rate of not over 50, and complying with NFPA Standard 90A and 90B. The entire assembly shall be listed by Underwriters Laboratories under U.L. Standard 181 as a Class I flexible air duct. Supplier shall submit laboratory test results indicating acoustical performance comparable to that of "Flexmaster Type 1M-Insulated".
- C. Submit upon request by owner or A/E, certification of welder's qualifications to perform the required welding operations and all project WPS for TIG welding sheet metal. All welder certifications shall be maximum 2 years prior to project notice to proceed date.

## 2.7 FLUE VENT

- A. Provide for all gas fired equipment. Provide all accessories such as flue caps, support plates, ventilated roof thimble, storm collar, etc. by the same manufacturer.
- B. Type AL 29-4C Double Wall Flue. Provide UL listed pressure rated, double pipe with Type AL 29-4C stainless steel inner liner, 1-inches of space (air gap), and Type 430 stainless steel outer jacket, similar to Heat-Fab Saf T-Vent Cl..
- C. Type IPS Double Wall Flue. Provide UL listed pressure rated, double pipe with Type 304 stainless steel inner liner, 2 inches of fiber insulation, and Type 304 stainless steel outer jacket, similar to Metalbestos Model IPS. The vent system shall be UL tested and listed to 50"W.G and 1000°F continuous operating conditions.

## 2.8 INTERNAL ACOUSTIC DUCT LINING

- A. Internal insulation with JohnsManville Permacote Linacoustic standard fiberglass duct liner with factory-applied edge coating. Insulation shall have a composite, abrasion resistant airstream surface with EPA-registered, anti-microbial coating that will not support microbial growth.
- B. Duct Lining used on the project must have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50 as determined by test procedures ASTM E 84, NFPA 255 and UL 723. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics and cements must meet the same individual ratings as the minimum requirements. The liner shall meet the Life Safety Standards as established by NFPA 90A and 90B.
- C. Provide insulation thicknesses as follows:
  - 1. Provide 1/2 inch insulation on all return air transfer ductwork as shown on detail.
  - 2. Additional areas specifically noted on drawings.
- D. Flexible connector:
  - 1. Provide flex connectors as shown in details on the Drawings and Part 3. Flex connectors shall be flanged, constructed of materials of similar chemical resistance as duct system, and provided by the ductwork Vendor.
- E. Hangers and Supports:
  - 1. Support FRP ductwork using details and methods described in the SMACNA Industrial Duct Construction Manual.
  - 2. Protect the duct from clamping force of strap hangers with a 1/8-inch-thick layer of neoprene pad.
  - 3. Maximum spacing of supports shall not exceed 10 feet for sizes 8 inches and under or 15 feet for ducts over 20 inches.
  - 4. Provide supports which are independent of equipment and walls.

## PART 3 - EXECUTION

### 3.1 GENERAL INSTALLATION

- A. Construction Standards. Use construction methods which follow the requirements outlined SMACNA publications, as well as SMACNA Balancing and Adjusting publications, unless indicated otherwise in these specifications or accompanying drawings.
- B. Reinforcement. Reinforce ducts having one side equal to 25 inches or more in accordance with recommended construction practice of SMACNA.
- C. Plenum Construction. Construct plenum chambers of not less than No. 20 U.S. gage metal reinforced with galvanized structural angles.

- D. Cross Breaking or Beading. Cross break or bead sheet metal for rigidity, except ducts which are 12 inches or less in the longest dimension.
- E. Wall and Floor Penetrations.
  - 1. Install fire, smoke and combination fire smoke dampers in floor penetrations and in one and two-hour rated walls where indicated in drawings and in accordance with code requirements.
  - 2. Where ducts pass through walls in exposed areas, install suitable escutcheons made of galvanized sheet metal angles as closers.
  - 3. At all locations where ductwork passes through floors, provide watertight sleeves projecting 3 inches above finished floor and flush with bottom of floor slab. Fabricate sleeves of 1/8 inch thick steel, galvanized after fabrication. Anchor into adjacent floor slab as required.
  - 4. Sleeves are required inside as well as outside chases.
  - 5. Provide 24 gage sheet metal sleeves for insulated ducts penetrating gyp board walls. Seal openings between ducts and sleeves with fireproofing sealants.
- F. Interior Painting. Interior painting of metal ductwork exposed to view through grilles, registers, and other openings is specified in the Section on painting. Do not install grilles, registers, or similar items until painting is complete.
- G. Ductwork Openings. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- H. Ductwork Location. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities, including access to electrical and control panels.
- I. Instrument Test Hole Fitting. Provide Duro Dyne Model TH-1 instrument test ports with heavy-duty zinc-plated heavy-gage cap, instant-release wing nut, neoprene expansion plug, flat neoprene mounting bracket and mounting holes. Provide fittings to air balance contractor.
- J. Provide transitions at equipment and air device connections as per SMACNA standards. Where equipment requires an oval inlet and a round flex duct is routed to the equipment, provide insulated round to oval transition.
- K. Install duct mounted electric and hot water coils, provided in other specification sections, if required.
- L. Refer to mechanical details for information on terminal box connections, diffuser connections, fume hood connections, lab-trac equipment, etc.

### 3.2 SEAM AND JOINT SEALING

- A. All duct systems (except welded exhaust ductwork and double wall flue) shall be sealed. Duct shall be thoroughly cleaned prior to application of sealant. All transverse joints, longitudinal seams and duct wall penetrations shall be sealed. All ductwork shall be sealed as per seal Class A of SMACNA Standards irrespective of the duct pressure classifications.

### 3.3 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports." Unless indicated otherwise in specifications.
- B. Hanger Spacing. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing. Install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection. Do not use wire to support ductwork.

- C. Horizontal Ducts Up to 40 Inches. Support horizontal ducts up to and including 40 inches in their greater dimension by means of No. 20 U.S. gage band iron hangers attached to the ducts by means of screws, rivets or clamps, and fastened to inserts with toggle bolts, beam clamps or other approved means. Use clamps to fasten hangers to reinforcing on sealed ducts.
- D. Horizontal Ducts Larger Than 40 Inches. Support horizontal ducts larger than 40 inches in their greatest dimension by means of hanger rods bolted to angle iron (or equivalent unistrut) trapeze hangers. Place supports on at least 8'-0" centers according to the following:

Angle Length	Angle	Rod Diameter
4'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
6'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
8'-0"	2" x 2" x 1/8"	5/16"
10'-0"	3" x 3" x 1/8"	3/8"

The trapeze is to be placed on the exterior of non-compressible insulation between hanger and ductwork.

- E. Vertical Ducts. Support ducts to ensure rigid installation. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Fig. 4-7, Fig 4-8, Fig 4-9 "Riser Supports – From Floor". Support vertical ducts where they pass through the floor lines with 1-1/2 inches x 1-1/2 inches x 1/4 inch angles for ducts up to 60 inches. Above 60 inches, the angles must be increased in strength and sized on an individual basis considering space requirements. Support vertical duct drops more than 6 feet in length with angle iron frames attached to ducts.
- F. Refer to drawings for additional hanger details and requirements. Note that not all hangers are shown on the drawings are in the BIM model. The Contractor shall coordinate all hangers with the structure and other trades.

### 3.4 FLEXIBLE DUCTWORK

- A. Low Pressure Flexible Ductwork
- Do not exceed 6 feet in length with any flexible duct.
  - Flexible duct shall be limited to a maximum of a single 90 degree change in direction between the duct and the neck of the air device. This does not include the final turn into the neck of the air device.
  - Support ductwork independently of lights, ceiling and piping. Provide harness at connection to ceiling diffuser as indicated on details.
  - Provide two stainless steel work clamps on inner core and seal connection with duct sealant. The insulation and outer jacket shall be slipped over inner core connection to point where insulation abuts insulation on duct or diffuser. The insulation connections shall be sealed by embedding scrim tap and sealant to form a vapor barrier.
- B. Medium Pressure Flexible Ductwork
- Refer to details for maximum length of flexible ductwork upstream of terminal box.
  - Do not use flexible ductwork for changes in direction of airflow.
  - Provide two stainless steel work clamps on inner core and seal connection with duct sealant. The insulation and outer jacket shall be slipped over inner core connection to point where insulation abuts insulation on duct or terminal box. The insulation connections shall be sealed by embedding scrim tap and sealant to form a vapor barrier.

### 3.5 FLUE VENTS

- A. General. Install ductwork in accordance with manufacturer's recommendations and International Building Code and Mechanical Code requirements. Maintain minimum clearances from combustible materials. Provide ventilated roof thimble, storm collar, flashing and cap. Maintain necessary



## 3.6 FLASHING

- A. Where ducts pass through roofs or exterior walls, provide suitable flashing to prevent rain or air currents from entering the building. Provide flashing not less than No. 26 gage 316L stainless steel or 16 ounce copper.

## 3.7 DUCT LINING

- A. Fiberglass acoustical lining is not permitted to be installed on this project except as indicated in this specification or specifically shown on drawings.
- B. Install per manufacturer's recommendations. Keep internal lining clean during construction by keeping ends of ductwork sealed during storage and construction.

## 3.8 TESTS

- A. Allowable Leakage. Test ductwork for leaks in accordance with SMACNA before concealing or insulating as indicated below. Arrange for the Owner's Representative to witness the test.
  - 1. Low pressure ductwork. Test low pressure ductwork at +2 inches W.G. Maximum allowable leakage (Lmax) per 100 ft<sup>2</sup> of ductwork shall be equal to  $C_L \times P^{0.65}$ , where  $C_L = 6$  for rectangular ducts and round flexible ducts,  $C_L = 3$  for round/flat oval ducts, and  $P = 2$ " for low pressure ducts.
  - 2. Medium pressure ductwork. Test medium pressure ductwork at +6 inches W.G. Maximum allowable leakage (Lmax) per 100 ft<sup>2</sup> of ductwork shall be equal to  $C_L \times P^{0.65}$ , where  $C_L = 6$  for rectangular ducts and round flexible ducts,  $C_L = 3$  for round/flat oval ducts, and  $P = 6$ " for medium pressure ducts.
  - 3. Lab exhaust ductwork. Test laboratory exhaust ductwork at +6 inches w.g. Maximum allowable leakage is 1/2% of the total system air flow rate. Where partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
  - 4. Test the following ductwork:
    - a. Low pressure ductwork:
      - 1) All ductwork served by terminal boxes.
      - 2) All ductwork served by fan coil units.
    - b. Medium pressure ductwork:
      - 1) Ductwork served by individual air handling units.
      - 2) Ductwork served pretreatment outside air handling units.
      - 3) Ductwork served by exhaust fans.
    - c. Other
      - 1) Do not test Double Wall Flue Piping or Dryer Exhaust Ductwork.
- B. Equipment. Provide equipment necessary for performing tests, including rotary blower, orifice section and U-tube gage board complete with cocks and rubber tubing.

## 3.9 CLEANING

- A. Protect all ductwork and equipment from dirt during storage, installation and prior to grille, diffuser installation with protective covering at each end. Ductwork exposed to dirt and dust due to inadequate protection will have to be removed, cleaned and reinstalled.
- B. Do not operate any air handling units or fan coil units during construction without filters.
- C. Provide temporary filters on return air ductwork during construction to protect ductwork from dust.
- D. Provide temporary filters on exhaust grilles during construction to protect ductwork from dust.

February 15, 2019

DUCTWORK  
23 31 00 - 10

END OF SECTION 23 31 00

## SECTION 23 33 00 - AIR DUCT ACCESSORIES

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. Section Includes:
  - 1. Fire dampers.
  - 2. Combination fire and smoke dampers.
  - 3. Smoke dampers.
  - 4. Volume control dampers.
  - 5. Duct access doors.
  - 6. Conical spin-in fittings and taps
  - 7. Duct accessory hardware.
  - 8. Flexible Connection

## 1.3 RELATED WORK

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specification 23 31 00, Ductwork

## 1.4 SUBMITTALS

- A. Product Data: Submit product data for each product. Refer to Section 23 00 00.
- B. Fire and Combination Fire/Smoke Damper. Include manufacturer's literature to include performance data and installation requirements. Include any wiring diagrams.
- C. Access Doors. Include type of material, installation guidelines, leakage rates and maximum pressure data.
- D. Volume Control Dampers. Include type of material, installation guidelines, pressure drop and maximum pressure data.
- E. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
  - 1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
    - a. Special fittings.
    - b. Manual volume damper installations.
    - c. Control damper installations.
    - d. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors.
    - e. Wiring Diagrams: For power, signal, and control wiring.

## 1.5 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 10.
- B. Fire dampers, smoke dampers and combination fire/smoke dampers.
  - 1. Include operation and maintenance information, including recommended testing requirements.
  - 2. Assign identification numbers (FD – Fire Damper, FSD – Fire/smoke Damper, SD – Smoke Damper) for each damper. Include table in O&M manual that indicates identification number, room location, duct system and size.

## 1.6 QUALITY ASSURANCE

- A. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references
  - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
  - 2. AMCA 500-D, "Laboratory Method of Testing Dampers for Rating"
  - 3. NFPA 101 - Life Safety Code.
  - 4. SMACNA - HVAC Duct Construction Standards Metal and Flexible – Second Edition
  - 5. UL 555 – Standard for Fire Dampers.
  - 6. UL 555C – Standard for Ceiling Radiation Dampers.
  - 7. UL 555S – Standard for Smoke Dampers

## PART 2 - PRODUCTS

## 2.1 ACCEPTABLE MANUFACTURERS

- A. Fire, Smoke and Fire/Smoke Dampers. Greenheck, Pottorff, Ruskin, Nailor.
- B. Flexible Connections. Ductmate, Ventfabrics Ventglass.
- C. Duct Access Doors. Ductmate, DuraSystems, Flexmaster, Greenheck, Ruskin, United McGill.
- D. Conical Spin-in Fittings. Flexmaster, Buckley
- E. Volume Control Dampers. Flexmaster, Greenheck, Prefco, Ruskin.

## 2.2 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - 1. Galvanized Coating Designation: G60.
  - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316L, and having a No. 2 finish for concealed ducts and finish for exposed ducts.
- D. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

## 2.3 FIRE DAMPERS (FD)

- A. Quality Standards. Furnish and construct fire dampers according to NFPA 90A and UL 555 (Dynamic). Dampers must bear UL label and suitable for dynamic application. Dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the architectural Drawings) protection rating 165 degrees F fusible link.
- B. Construct fire dampers such that damper frame material and curtain material are galvanized.
- C. Use Curtain Type Fire Dampers for fire dampers where possible. Use Multiple Blade Fire Dampers for fire damper sizes that exceed manufacturer's allowable Curtain Type Fire Damper sizes, or where velocities or pressures exceed Curtain Type Fire Dampers.
- D. Curtain Type Fire Dampers (Type B)
1. Damper shall be classified for dynamic closure to 2000 fpm and 4 inches w.g. static pressure.
  2. Damper shall have 5" frame constructed from minimum 20 gage galvanized steel.
  3. Blades shall be minimum 24 gage galvanized steel.
  4. Closure springs shall be Type 301 stainless steel, constant force or spring clip type.
  5. Provide Grille, Grille Access Type or Out of Wall Type of frame where indicated on drawings.
- E. Multiple Blade Fire Damper
1. Dampers shall be suitable for dynamic closure to 3000 fpm and 6 inches w.g. static pressure at 90"x64" for vertical installation and 60"x48" for horizontal installation.
  2. Damper shall have 5" frame constructed from minimum 16 gage galvanized steel channel and reinforced at the corners.
  3. Blades shall be 6" wide airfoil type and constructed from minimum 14 gage galvanized steel.
  4. Bearings shall be self-lubricating stainless steel sleeve, turning in extruded hole in frame.
  5. Blade seals shall be galvanized steel for flame seal to 1,900 degrees F and mechanically attached to blade edge.
  6. Linkage shall be concealed in frame.
  7. Provide 1/2-inch diameter plated steel hex shaped axle attached to blade.
  8. Pressure drop shall be a maximum of 0.07 inches w.g. at 1,500 feet per minute through 24 x 24 inch damper.

## 2.4 COMBINATION FIRE AND SMOKE DAMPERS (FSD)

- A. Quality Standards. Furnish and construct combination fire/smoke dampers according to NFPA 90A and UL 555 (Dynamic). Dampers must bear UL label and suitable for dynamic application and a Leakage Class 1 Smoke Rating in accordance with UL 555S. Dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the architectural Drawings) protection rating 165 degrees F. Dampers shall have a minimum 5 year warranty.
1. Dampers shall be suitable for dynamic closure to 3000 fpm and 6 inches w.g. static pressure at 120"x96" for vertical installation and 144"x96" for horizontal installation.
  2. Damper shall have 5" frame constructed from minimum 16 gage galvanized steel channel and reinforced at the corners.
  3. Blades shall be 6" wide airfoil type and constructed from minimum 14 gage (equivalent) galvanized steel.
  4. Bearings shall be self-lubricating stainless steel sleeve, turning in extruded hole in frame.
  5. Blade seals shall be inflatable silicone fiberglass material, rated for maintaining smoke leakage at a minimum of 450°F and galvanized steel for flame seal to 1,900 degrees F. Seals shall be mechanically attached to blade edge. Provide stainless steel flexible metal compression jamb.
  6. Linkage shall be concealed in frame.
  7. Provide 1/2-inch diameter plated steel hex shaped axle attached to blade.

8. Temperature Release Device. Close in a controlled manner and lock damper during test, smoke detection, power failure, or fire conditions through actuator closure spring. At no time shall actuator disengage from damper blades. Allow damper to be automatically and remotely reset after test or power failure conditions. After exposure to high temperature or fire, inspect damper before reset to ensure proper operation. Controlled closing and locking of damper in 7 to 15 seconds to allow duct pressure to equalize. Instantaneous closure is not acceptable.
9. Actuator. Provide electric 120V [24V], 60 Hz, two-position, fail close actuator. Operators shall be UL listed and labeled.
10. Pressure drop shall be a maximum of 0.07 inches w.g. at 2,000 feet per minute through 24 x 24 inch damper.

## 2.5 SMOKE DAMPERS (SD)

- A. Quality Standards. Furnish and construct smoke dampers according to NFPA 90A and UL 555 (Dynamic). Dampers must bear UL label and suitable for dynamic application and a Leakage Class 1 Smoke Rating in accordance with UL 555S. Dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the architectural Drawings) protection rating 165 degrees F. Dampers shall have a minimum 5 year warranty.
  1. Dampers shall be suitable for dynamic closure to 3000 fpm and 6 inches w.g. static pressure at 120"x96" for vertical installation and 144"x96" for horizontal installation.
  2. Damper shall have 5" frame constructed from minimum 16 gage galvanized steel channel and reinforced at the corners.
  3. Blades shall be 6" wide airfoil type and constructed from minimum 14 gage (equivalent) galvanized steel.
  4. Bearings shall be self-lubricating stainless steel sleeve, turning in extruded hole in frame.
  5. Blade seals shall be inflatable silicone fiberglass material, rated for maintaining smoke leakage at a minimum of 450°F. Seals shall be mechanically attached to blade edge. Provide stainless steel flexible metal compression jamb.
  6. Linkage shall be concealed in frame.
  7. Provide 1/2-inch diameter plated steel hex shaped axle attached to blade.
  8. Actuator. Provide electric 120V [24V], 60 Hz, two-position, fail close actuator. Operators shall be UL listed and labeled.
  9. Pressure drop shall be a maximum of 0.07 inches w.g. at 2,000 feet per minute through 24 x 24 inch damper.

## 2.6 VOLUME CONTROL DAMPERS

- A. Provide volume dampers in round and rectangular ductwork where indicated on drawings.
- B. General Fabrication Requirements:
  1. Comply with SMACNA Chapter 2, "Volume Dampers" unless more stringent requirements are indicated. Provide single blade dampers on round dampers and for rectangular dampers not exceeding 36-inches in width or 12-inches in height. Provide multiblade rectangular dampers for dampers exceeding 36-inches in width or 12-inches in height or where required due to velocity or pressure requirements.
  2. Refer to Specification 23 31 13 Ductwork for application table that defines Low and Medium Pressure ductwork.
  3. Provide a locking hand quadrant on all dampers. Mount quadrant regulators on stand-off mounting brackets, bases, or adapters on insulated ducts.
  4. For stainless steel ductwork, provide stainless steel finish to match ductwork material.
  5. Shop fabricated dampers are not acceptable.
- C. Round Dampers.

1. Low Pressure. Provide single blade damper with minimum 20 gage galvanized steel frame, minimum 20 gage galvanized steel blade, continuous 3/8" square plated steel axle mechanically attached to blade, and bronze or oilite bearings. Dampers shall be suitable for 1500 feet per minute velocity and a maximum pressure of 2"W.G. when closed, and a maximum pressure drop of 0.03"W.G at 1500 feet per minute through a 20-inch damper when tested in accordance with AMCA Fig. 5.3.
2. Medium Pressure. Provide single blade damper with minimum 20 gage galvanized steel frame, minimum 14 gage (equivalent) galvanized steel blade, continuous 1/2" square plated steel axle mechanically attached to blade, and bronze or oilite bearings. Dampers shall be suitable for 3000 feet per minute velocity and a maximum pressure of 4"W.G. when closed, and a maximum pressure drop of 0.06"W.G at 2000 feet per minute through a 24-inch damper when tested in accordance with AMCA Fig. 5.3.

D. Rectangular Dampers.

1. Low Pressure Single Blade Damper (Fans systems with less than 1"W.G. Static Pressure). Provide single blade damper with minimum 3-inch x 20 gage galvanized steel frame, minimum 20 gage galvanized steel blade on dampers up to 18-inches wide, 16 gage on dampers over 18-inches wide. Provide a continuous 3/8" square plated steel axle mechanically attached to blade, and synthetic flanged sleeve type bearing. Dampers shall be suitable for 1500 feet per minute velocity and a maximum pressure of 1"W.G. when closed.
2. Low Pressure Multi-Blade Damper. Provide opposed multi-blade damper with minimum 5-inch x 16 gage galvanized steel frame, minimum 16 gage triple V galvanized steel blade. Provide a continuous 1/2" square plated steel axle mechanically attached to blade and external (out of airstream) blade-to-blade linkage. Provide bronze or oilite bearings. Dampers shall be suitable for 1500 feet per minute velocity and a maximum pressure of 3"W.G. for up to a 24-inch wide damper when closed. Damper shall have a maximum pressure drop of 0.1"W.G. at 1500 feet per minute through a 24-inch x 24-inch damper.
3. Medium Pressure Damper. Provide opposed multi-blade damper with minimum 5-inch x 1-inch 16 gage galvanized steel channel frame. Blades shall be minimum 16 gage triple V galvanized steel blade. Provide a continuous 1/2" square plated steel axle mechanically attached to blade and external (out of airstream) blade-to-blade linkage. Provide bronze or oilite bearings. Dampers shall be suitable for 3000 feet per minute velocity and a maximum pressure of 5"W.G. for up to a 24-inch wide damper when closed. Damper shall have a maximum pressure drop of 0.16"W.G. at 2000 feet per minute through a 24-inch x 24-inch damper when tested in accordance with AMCA Fig. 5.3.
4. Low Pressure Drop Medium Pressure Damper. Provide opposed multi-blade damper with minimum 4-inch x 1-inch 0.125-inch thick aluminum channel frame. Blades shall be extruded aluminum airfoil type, minimum 0.125-inch thick. Provide a continuous 1/2" square plated steel axle mechanically attached to blade and linkage concealed in jamb. Provide bronze or oilite bearings. Dampers shall be suitable for 5000 feet per minute velocity and a maximum pressure of 5"W.G. for up to a 24-inch wide damper when closed. Damper shall have a maximum pressure drop of 0.1"W.G. at 2000 feet per minute through a 24-inch x 24-inch damper when tested in accordance with AMCA Fig. 5.3.

- E. Splitter Dampers. Fabricate splitter dampers of minimum 16 gauge thickness sheet metal to streamline shape. Secure blade with continuous hinge or rod. Operate with minimum 1/4" diameter rod in self-aligning, universal joint action flanged bushing with set screw. Control splitter with locking quadrants on exposed externally insulated ductwork.

## 2.7 DUCT ACCESS DOORS

A. Square Frame Access Doors

1. Low Pressure Ductwork
  - a. Construct outer frame of minimum 22 gage roll formed galvanized steel with installation tabs. Door shall be removable double wall door constructed of 24 gage galvanized steel and insulated with 1-inch of insulation (R-4). Provide minimum 2 manually operated cam locks on access doors 16-inches and under, 4 cam locks for doors greater than 16-inches. Provide foam gasket seal between door and frame and between frame and duct.

- b. Performance. 24"x24" access door shall be suitable for up to 2"W.G. and have a maximum leakage of 0.15 CFM/sq.ft. at 1"W.G. pressure.
    - 2. Medium Pressure Ductwork
      - a. Construct outer frame of minimum 22 gage roll formed galvanized steel with installation tabs. Door shall be removable double wall door constructed of 24 gage galvanized steel and insulated with 1-inch of insulation (R-4). Provide minimum 4 manually operated cam locks on access doors 16-inches and under, 8 cam locks for doors greater than 16-inches. Provide foam gasket seal between door and frame and between frame and duct.
      - b. Performance. 24"x24" access door shall be suitable for up to 10"W.G. and have a maximum leakage of 0.15 CFM/sq.ft. at 1"W.G. pressure.
  - B. Round "Spin" Access Doors
    - 1. Construct outer frame of minimum 22 gage roll formed, double hemmed galvanized steel. Door shall be removable double wall door constructed of 24 gage galvanized steel and insulated with 1-inch of insulation (R-4). Provide minimum 3 manually operated cam locks on access door. Provide continuous foam gasket between door and frame.
  - C. For stainless steel ductwork, provide stainless steel finish to match ductwork material.
  - D. Where duct size permits, access door size shall be 18-inches in diameter or 18" x 16" for oval and rectangular doors. For duct sizes under 20-inches, provide access door 2-inches smaller than duct size. For ducts 12-inches wide, provide minimum 10" x 12".

2.8 CONICAL SPIN-IN FITTINGS AND TAPS

- A. General Construction. For stainless steel ductwork, provide stainless steel finish to match ductwork material.
- B. Furnish conical spin-in fittings with quadrant dampers at all round runout ducts serving diffusers and grilles. Fabricate conical fitting of 26-gage galvanized sheet metal with 2-inch build out, continuous 3/8" square shaft, air tight nylon bushings and locking quadrant handle. Connect damper plate to shaft with a minimum 2 u-bolts on dampers 12-inches and greater.

2.9 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Drill temporary test holes for balancing in ducts as required. Cap with neoprene plugs, threaded plugs, or threaded or twist-on metal caps. Provide neat patch on external duct insulation and label as "Test Plug".
- C. Provide permanent test holes in ductwork upstream and downstream of all coils, fans, and locations as indicated on drawings. Test holes shall be factory fabricated, airtight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.10 FLEXIBLE CONNECTIONS

- A. Provide air-tight flexible connections where ductwork connects to fans, air handling units and fan coil units with fabric as specified below:

Application	Fabric	Coating	Gauge
HVAC (Indoor)	Fiberglass	Neoprene	28
HVAC (Outdoor & Lab)	Fiberglass	Hypalon	28



- B. The fabric shall be UL listed, fire retardant, waterproof and mildew resistant, crimped into metal edging strip.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
  - 1. Install steel volume dampers in steel ducts.
  - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.

#### 3.2 ACCESS DOORS

- A. Install duct access doors on sides or bottom of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
  - 1. Upstream and downstream of duct mounted duct coils.
  - 2. Downstream from manual volume dampers (not spin-in fittings).
  - 3. Downstream of control dampers.
  - 4. Upstream of airflow measuring stations.
  - 5. Adjacent to and close enough to fire, smoke and combination fire/smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors; and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
  - 6. At duct mounted smoke detectors.
  - 7. Upstream or Downstream of turning vanes.
  - 8. In internally lined ductwork, provide access doors for duct liner inspection at 50 foot intervals and downstream of each elbow or branch fitting. Access doors are not required in return air boots.
  - 9. Elsewhere as indicated on drawings, details or specifications.
- B. Label access doors according to Section 23 05 53 - Identification for HVAC Piping and Equipment to indicate the purpose of access door.

#### 3.3 FIRE, SMOKE AND COMBINATION FIRE/SMOKE DAMPERS

- A. Install dampers at locations indicated on the drawings and in accordance with manufacturer's UL approved installation instructions.
- B. Install dampers square and free from racking with blades running horizontally.

- C. Do not compress or stretch damper frame into duct or opening.
- D. Handle damper using sleeve or frame. Do not lift damper using blades, actuator, or jackshaft.
- E. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.
- F. Provide access doors for all fire, smoke and combination fire/smoke dampers. Refer to details for additional requirements.

#### 3.4 CONICAL SPIN-IN FITTINGS AND TAPS

- A. Install conical spin-in fittings with quadrant dampers to serve diffusers as indicated on drawings.
- B. After installation of spin-in fitting, seal all around connection to meet leakage class indicated in Specification 23 31 13.

#### 3.5 VOLUME CONTROL DAMPER

- A. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
- B. Set dampers to fully open position before testing, adjusting, and balancing

#### 3.6 FLEXIBLE CONNECTIONS

- A. Install at connections between ductwork and motor driven equipment as shown. Provide a minimum of 1 inch slack in the connections, and a minimum of 2-1/2 inches distance between the edges of the ducts and equipment. Also provide a minimum of 1 inch slack for each inch of static pressure on the fan system. Securely fasten flexible connections to equipment and to adjacent ductwork by means of sealant with sheet metal screws. Where flex ductwork is connected to oval collars in diffusers and plenums, provide a metal transition fitting from oval to round.

#### 3.7 FIELD QUALITY CONTROL

- A. Tests and Inspections:
  - 1. Operate all volume dampers to verify full range of movement.
  - 2. Inspect locations of access doors and verify that purpose of access door can be performed.
  - 3. Operate fire, smoke and combination fire/smoke dampers to verify full range of movement per NFPA and verify that proper heat-response device is installed.

END OF SECTION 23 33 00

## SECTION 23 34 00 - FANS

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. This Section includes requirements for furnishing and installing fans and supplemental equipment including the following:
  - 1. Centrifugal fans.

## 1.3 PERFORMANCE

- A. Provide fan type, arrangement, rotation, capacity, size, motor horsepower, and motor voltage as shown. Fan capacities and characteristics are scheduled on the drawings.
- B. Rate fans according to appropriate Air Moving and Conditioning Association, Inc. (AMCA), approved test codes and procedures. Supply fans with sound ratings below the maximums permitted by AMCA standards. All fans provided must be licensed to bear the Certified Ratings Seal.
- C. Statically and dynamically balance all fans.

## 1.4 SUBMITTALS

- A. General:
  - 1. Submit shop drawings and product data.
  - 2. Shop drawings shall indicate assembly, unit dimensions, weight, required clearances, construction details and field connection details.
  - 3. Product data shall indicate capacities, ratings, fan performance, motor electrical characteristics, and gages and finishes of materials.
  - 4. Provide fan curves with specified operating point clearly plotted.
  - 5. Provide the fan's fan efficiency grade, peak total efficiency and operating efficiency as defined by AMCA 205.
  - 6. Include backdraft damper information for each fan, including the size of the backdraft damper.
  - 7. Submit sound power levels.
  - 8. Submittals shall show compliance with Section 23 05 13, Common Motor Requirements for HVAC Equipment.

## 1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

- D. Fan Efficiency. For fans greater than 5 HP, the fans shall have a fan efficiency grade (FEG) of 67 or higher based on manufacturers' certified data, as defined by AMCA 205. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.

## 1.6 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 10.
- B. Include installation instructions, assembly views, lubrication instructions and replacement parts list.
- C. Include copy of approved submittals (with all comments corrected).
- D. Include copy of vibration test reports.
- E. Include copy of airflow measuring station calibration curves.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Fans:
    - a. Acme Engineering & Mfg. Corp.
    - b. Greenheck.
    - c. Loren Cook Company.
    - d. Twin City Fan & Blower
  - 2. High Dilution Lab Exhaust Fans:
    - a. Loren Cook Variplume.
    - b. Greenheck Vektor
    - c. Twin City Fan & Blower

### 2.2 PROTECTIVE COATINGS

- A. Manufacturer's Standard: Apply manufacturer's standard prime coat and finish to fans, motors and accessories, except on aluminum surfaces or where special coatings are required.
- B. Galvanizing:
  - 1. After fabrication of the parts, hot-dip coat all surfaces which require galvanizing.
  - 2. Where galvanizing is specified, a zinc coating may be used.
  - 3. After fabrication, apply the zinc coating and air-dry the coating to 95 percent pure zinc.
  - 4. Acceptable zinc coatings include Zincilate, Sealube, Amercoat, Diametcoat, or an approved equal.
- C. Roof Mounted Fans. Coat surfaces, inside and out, with minimum of 4 mils of Hi-Pro-Z. Coating shall withstand a minimum 4,000 hour salt spray per ASTM B117. Have the product factory applied to fan wheels, interior and exterior surfaces of casings, fan isolation base and motor covers. No uncoated metal fan parts shall be acceptable. Any fans found to have insufficient coating during construction shall be touched up per manufacturers recommendation to prevent corrosion.
- D. Fasteners for all fans and relief hoods mounted outside of building and in crawl space shall be stainless steel.

### 2.3 SUPPLEMENTAL EQUIPMENT

- A. Motor Covers: Provide weatherproof motor covers for installations out of doors. Apply the same finish as used on the fan.

- B. Belt Drives:
1. Unless otherwise specified for belt-driven fans, equip the fan motors with variable pitch sheaves. Select the sheave size for the approximate midpoint of adjustment and to provide not less than 20 percent speed variation from full open to full closed. Size drives for 150 percent of rated horsepower. Key the fan sheave to the fan shaft.
  2. Nonadjustable motor sheaves may be used for motor sizes over 15 horsepower, at the Contractor's option. However, if changing a nonadjustable sheave becomes necessary to produce the specified capacity, the change must be made at no additional cost.
  3. Provide belt guards and apply the same finish as used for the fan.
- C. Safety Disconnect Switch: Provide a factory-wired, safety disconnect switch on each unit equipped with a 115/1/60 motor. Division 26 will provide safety disconnect switches for all motors that are not 115/1/60, such as three phase motors, unless noted otherwise in specifications or fan schedule.
- D. Relief Vents and Air Inlets: Provide vents and inlets with aluminum frames and 1/2-inch mesh, galvanized bird screens. Include dampers, motorized dampers on inlets and adjustable counter balanced dampers for relief vents as indicated on fan schedule and in specifications.
- E. Prefabricated Roof Curbs: Furnish prefabricated roof curbs with built-in cant strips and lined with glass fiber insulation. Curbs may be made of No. 18 U.S. standard gage galvanized steel or 0.063 inch aluminum. The minimum height is 8 inches. Include on each roof curb a resilient pad for equipment mounting on the top flange. Include damper tray where indicated on schedule or specifications. Refer to Kitchen Exhaust Fan specification for additional requirements roof curbs serving grease exhaust fans.
- F. Motors. All 115/1/60 motors shall be provided with thermal overload protection.
- G. Nameplates. Provide an aluminum or stainless steel nameplate secured with screws to the equipment in a location that is readable when the equipment is installed and in operation. The following information shall be included on the nameplate: manufacturer, model number, serial number, date of manufacture, Motor HP, Motor enclosure, motor volts/ph/hz and rpm, design CFM, design SP, Fan Class, Fan RPM, Max RPM.
- 2.4 ROOF-MOUNTED DOWNBLAST EXHAUST FANS
- A. General. Fan shall be a spun aluminum, roof mounted, belt or direct driven as indicated on schedule, downblast centrifugal exhaust ventilator.
- B. Construction. The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16 gauge marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. The discharge baffle shall have a rolled bead for added strength. A two piece top cap shall have stainless steel quick release latches to provide access into the motor compartment without the use of tools. An integral conduit chase shall be provided through the curb cap and into the motor compartment to facilitate wiring connections. The motor, bearings and drives shall be mounted on a minimum 14 gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream. Unit shall have integral conduit chase provide through curb cap and into the motor compartment.
- C. Wheel. Wheel shall be centrifugal backward inclined, constructed of 100 percent aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-05.

- D. Fan Motor, Bearings and Drives. Motor shall be NEMA design B with class B insulation rated for continuous duty and furnished at the specified voltage, phase and enclosure. Bearings shall be ball type selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed. Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150% of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM.
- E. Supply a disconnect switch on all 120V/1ph and 277/1ph fans and have the switch and motor factory wired to the junction box.
- F. Options.
  - 1. Dampers.
    - a. Motorized Dampers. Provide 120V motorized backdraft dampers with curb flanges where indicated on schedule. Damper size shall be full size of duct connection or full size of curb opening if curb opening is smaller than the ductwork.
    - b. Gravity Dampers. Provide gravity backdraft dampers with curb flanges where indicated on schedule. Damper size shall be full size of duct connection or full size of curb opening if curb opening is smaller than the ductwork
  - 2. Provide speed controllers on all direct drive fans.
  - 3. Auto Belt Tensioner. Provide an automatic tensioning device that adjusts for the correct belt tension, only for single belt drives.
  - 4. Pressure Probe: Provide a ¼ inch diameter tube in the fan venturi that allows hook up to manometer

## 2.5 INLINE EXHAUST

- A. General: Fan shall be a duct mounted centrifugal square inline fan.
- B. Construction: The fan shall be of bolted construction utilizing corrosion resistant fasteners. Housing shall be minimum 18 gauge galvanized steel with integral duct collars. Bolted access doors shall be provided on three sides, sealed with closed cell neoprene gasketing. Pivoting motor plate shall utilize threaded L-bolt design for positive belt tensioning. Housing shall be pre-drilled to accommodate universal mounting feet for vertical or horizontal installation.
- C. Wheel: Wheel shall be centrifugal backward inclined, constructed of 100% aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-05.
- D. Fan Motor, Bearing and Drives. Motor shall be Nema design B with class B insulation rated for continuous duty and furnished at the specified voltage, phase and enclosure. Bearings shall be ball type selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed. Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150% of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM.

## 2.6 GRAVITY RELIEF HOOD AND AIR INTAKES

- A. Reference Supplemental Equipment above for additional information.
- B. Shall be constructed of heavy gauge aluminum, with precision formed, arched panels with interlocking seams. The hood shall be bolted to a minimum 8 gauge aluminum or 12 gauge galvanized steel support structure. A radius throat must be provided for optimum performance. Lifting lugs shall be provided to help prevent damage from improper lifting. The base shall have continuously welded curb cap corners for maximum leak protection. Provide four tie-down points on relief hoods.

## 2.7 CABINET EXHAUST FANS

- A. Cabinet. Ceiling mounted exhaust fans shall be of the centrifugal direct drive type. The fan housing shall be constructed of heavy gauge galvanized steel. The housing interior shall be lined with 0.5 in acoustical insulation. The outlet duct collar shall be adaptable for horizontal or vertical discharge. The grille shall be constructed of high impact polystyrene or aluminum. Grilles shall be non-yellowing. The access for wiring shall be external. The motor disconnect shall be internal and of the plug in type. The motor shall be mounted on vibration isolators. The fan wheel(s) shall be of the forward curved centrifugal type, constructed of galvanized steel and dynamically balanced. All fans shall bear the AMCA Certified Ratings Seals for sound and air performance and shall be U.L. Listed.
- B. In-line. Duct mounted exhaust fans shall be of the centrifugal, direct drive type. The fan housing shall be constructed of heavy gauge galvanized steel and shall include prepunched mounting brackets. The housing interior shall be lined with 0.5 in acoustical insulation. The outlet duct collar shall be adaptable for horizontal or vertical discharge. The access for wiring shall be external. The motor disconnect shall be internal and of the plug in type. The motor shall be mounted on vibration isolators. The fan wheel(s) shall be of the forward curved centrifugal type, constructed of either galvanized steel or plastic and dynamically balanced. Fans shall be licensed to bear the AMCA Certified Ratings Seal for air performance and shall be U.L. Listed.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install fans level and plumb.
- B. Support floor-mounting units using spring isolators having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.
  - 1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
- C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section, Cast-in-Place Concrete.
- D. Support suspended units from structure using threaded steel rods and spring hangers. Vibration-control devices are specified in Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.
- E. Install units with clearances for service and maintenance.
- F. Label fans according to requirements specified in Section 23 05 53, Identification for HVAC Piping and Equipment.

### 3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 33 00, Air Duct Accessories.
- B. Ground equipment according to Division 26 requirements.
- C. Connect wiring according to Section 26 05 19, Insulated Conductors.

### 3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 34 00



## SECTION 23 36 00 - AIR TERMINAL UNITS

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. Section includes air distribution devices including the following:
  - 1. Single Duct Terminal Units.
  - 2. Fan Powered Terminal Units.

## 1.3 COOPERATION WITH OTHER TRADES

- A. Coordinate work with Division 26 Electrical Sections to ensure intended functions of lighting and air systems are achieved.

## 1.4 SUBMITTALS

- A. Product Data: Submit schedule for each box indicating size, capacity, sound data and other data to show compliance with the specifications and schedule on drawings. Submit product data indicating materials, finishes and options provided that clearly indicate compliance with Part 2 of this Section. For all types of terminal boxes, provide documents proving that the box performance as submitted has been certified by an independent laboratory
- B. Samples: At the request of the Owner and/or A/E team, submit one terminal unit of each specified for review.

## 1.5 TERMINAL UNIT TESTING:

- A. Two terminal units of each type will be selected by the Owner for testing by the TAB firm. After the terminal units have been shipped to the job site, the Owner and TAB firm will select which terminal units will be tested. The Contractor will then ship the terminal units from the job site to the TAB firm's testing facility.
- B. The boxes will be tested for casing and damper leakage at the TAB firm's testing facility. The TAB firm will ship the terminal units back to the job site at Contractor's expense for installation after testing is complete.
- C. If a terminal box fails testing, the manufacturer shall visit the TAB firm's testing facility and modify the terminal unit to meet the leakage requirements. The TAB firm will then retest the terminal unit to verify it meets the leakage requirements. If the terminal unit passes the test, the manufacturer shall provide a written procedure for repair and modifications of the terminal units for review and approval by the Owner. If approved by the Owner, the manufacturer shall implement the repairs and modifications to all the terminal units at the job site. If the required repairs and modifications can not be made at the job site, the contractor shall ship all of the applicable terminal units back to the factory for repair and modifications.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Products meeting all requirements of this specification Section of the following manufacturers are acceptable:
  1. Price
  2. Krueger
  3. Metalaire
  4. Titus

2.2 TERMINAL BOX CROSS-FLOW AVERAGING SENSOR (APPLIES TO ALL TYPES OF TERMINAL BOXES)

- A. Units shall be provided with a grid of multipoint velocity sensors. Each flow cross shall include a minimum of 8 pickup points of amplified sensing for each 16 inches of duct diameter. The pickup points shall be divided evenly in each of the four quadrants of the duct. Ducts larger than 16 inches in diameter shall be divided into sections which are each averaged to its respective center and then cascaded so that the entire cross-sectional area is traversed.
- B. Center tapped averaging sensors shall provide a differential pressure signal that represents actual airflow within an accuracy of +5 percent of maximum rated flow. This accuracy shall be maintained when inlet duct varies from straight to 90 degrees entrance approach angle.

2.3 SINGLE DUCT TERMINAL BOXES (TYPE CV AND VV)

- A. Furnish boxes with performance certified as per ARI Standard 880, for installation above the ceiling with capacities as scheduled. Boxes shall be listed in the latest ARI directory. Provide boxes supplied by the manufacturer fully assembled with air dampers, heating coil, self-contained volume regulator, and disconnect switch. Select boxes with maximum scheduled CFM within mid to 80 percent of box listed capacity range. All controls components including HVAC controller shall be supplied by the ATC Contractor to the box manufacturer for factory installation. Controls shall be electronic for DDC application.
- B. The damper actuator must be factory installed by box manufacturer. All required linkages must be furnished and factory-installed and performance tested by the box manufacturer. Provide control transformer, disconnect switch, etc., as required.
- C. Box maximum volumes shall be adjustable through DDC over the entire range of operation. Contractor shall verify all maximum and minimum volumes in the field.
- D. Provide a self-contained, pressure-independent volume regulator to vary discharge CFM up to 3 inches W.G. duct static pressure. The box controls will be factory installed to satisfy specified control sequence.
- E. Set the damper linkages so that primary air delivered to the box varies from 100 percent to scheduled minimum, depending upon the cooling load.
- F. Casing shall be single wall 20-gage galvanized steel, internally lined with at least 1 inch thick, 1-1/2 lb dual density insulation of fiberglass complying with NFPA 90A and UL 181. All exposed insulation edges shall be coated with NFPA 90A approved sealant to prevent entrainment of fibers in the air stream. Leakage not to exceed the following at 1 inch water gage. Tapes and sealants on the exterior of the casing are not acceptable. Provide gasketed access door with ¼ turn metal cam lock in bottom of terminal box.

Box Inlet Size (in)	Casing Leakage CFM
4 - 14	10
16	14

- G. Limit installed unit discharge sound levels to NC-30 and radiated to NC-30, based upon 1"W.G. static pressure drop across the unit. NC shall be reported calculated using the acoustical reductions indicated in latest version of AHRI 885, appendix E.
- H. Electric Heating Coil (where scheduled). Provided the capacity scheduled on the drawings. The heating coils shall be factory mounted at the discharge outlet of the terminal unit. The entire assembly shall be constructed of heavy gauge galvanized steel. Heaters shall be UL listed for zero clearance and meet all applicable requirements of the NEC. Resistance wire shall be 80 percent nickel and 20 percent chromium. Furnish heater with airflow switch, SCR power to heating elements or magnetic contactors, fan relay, control voltage transformer, high limit thermal cut-out, and a NEMA 1 electrical enclosure. No magnetic contactors are allowed. Provide a fused main power disconnect as an integral component of the unit (for both fan and heater.)

#### 2.4 FAN-POWERED TERMINAL BOXES (TYPE FVV):

- A. Provide side pocket (parallel) type fan-powered variable air volume units sized as scheduled and consisting of air valve to modulate cooling, a recirculating fan and a heating water coil.
- B. Furnish boxes with performance certified as per ARI Standard 880 and which are listed in ARI directory. Select boxes with maximum scheduled CFM within mid to 80 percent of box listed capacity range. All controls including HVAC shall be supplied by the ATC Contractor to the box manufacturer for factory installation. Controls shall be electronic for DDC application.
- C. Casing shall be single wall 20-gage galvanized steel, internally lined with at least 1 inch thick, 1-1/2 lb dual density insulation of fiberglass complying with NFPA 90A and UL 181. All exposed insulation edges shall be coated with NFPA 90A approved sealant to prevent entrainment of fibers in the air stream. Leakage not to exceed 2 percent at 1-1/2 inches water gage. Tapes and sealants on the exterior of the casing are not acceptable. Provide access to all internal components. Access doors shall be gasketed. Mastics or liquid sealant are not considered equivalent of gasket. Provide a factory-mounted filter rack with 1-inch throwaway filter and an insulated sound boot on box inlet. Provide gasketed access door with ¼ turn metal cam lock in bottom of terminal box.
- D. Air valve shall be pressure independent and designed for tight shutoff with maximum 6 CFM of leakage at 3.0 inches s.p. Valve shall maintain desired flow within 5 percent when inlet pressure varies between 1/2 and 3 inches water gage. The damper actuator and all the necessary linkages shall be installed and performance tested by box manufacturer. Box maximum and minimum volumes shall be adjustable through DDC over the entire range of operations.
- E. Fans.
  - 1. Fans shall be forward curved centrifugal type fan of metal construction. Motor shall be Electronically Commutated Motor (ECM) and brushless; no exceptions. Motor must be complete with and operated by a single phase integrated controller/inverter that operates the wound stator and senses rotor position to electrically commutate the stator. All motors must be designed for synchronous rotation. Motor rotor must be permanent magnet type with near zero rotor losses. Motor must have built in soft start and soft speed change ramps. Motor must be able to be mounted with shaft in horizontal or vertical orientation. Motor must be permanently lubricated with ball bearings. Sleeve bearings will not be acceptable. Motor shall be direct coupled to the blower. Motor must maintain a minimum of 70 percent efficiency over its entire operating range. Terminal unit manufacturer must set the fan CFM at the factory. Fan CFM must be constant within +/-5 percent regardless of changes in static whether upstream or downstream of the terminal unit after it is installed. Fan CFM shall be set with a potentiometer. Neither SCRs nor rheostats are acceptable means of setting fan CFM. A speed adjustment device must be included with the motor for field adjustment should construction or design changes become necessary.

2. Provide backdraft damper. Motor and fan to be isolated from casing to remove vibration. Provide blower disconnect switch, control transformers, and motor fuses. Unit shall have a single point electrical connection. The mechanical contractor shall provide at no additional cost to the owner all modifications including but not limited to wiring, conduit, circuit breakers, starters, etc. all in accord with the NEC and specifications as required to serve unit motors which are larger than the motor horsepower as scheduled.
- F. Fans shall be direct drive with galvanized forward-curved wheel, PSC type motor with integral thermal overload protection and designed for SCR control. Provide backdraft damper. Provide manual SCR control with minimum voltage stop to prevent stall and to adjust fan speed. Motor and fan to be isolated from casing to remove vibration. Provide blower disconnect switches, control transformers, motor fuses and a starter. Unit shall have a single point electrical connection.
  - G. Limit installed unit discharge sound levels to NC-35 and radiated to NC-30, based upon 1"W.G. static pressure drop across the unit. NC shall be reported calculated using the acoustical reductions indicated in latest version of AHRI 885, appendix E.
  - H. Electric Heating Coil (where scheduled). Provided the capacity scheduled on the drawings. The heating coils shall be factory mounted at the discharge outlet of the terminal unit. The entire assembly shall be constructed of heavy gauge galvanized steel. Heaters shall be UL listed for zero clearance and meet all applicable requirements of the NEC. Resistance wire shall be 80 percent nickel and 20 percent chromium. Furnish heater with airflow switch, SCR power to heating elements or magnetic contactors, fan relay, control voltage transformer, high limit thermal cut-out, and a NEMA 1 electrical enclosure. No magnetic contactors are allowed. Provide a fused main power disconnect as an integral component of the unit (for both fan and heater.).

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Seal connection at box, as required, to comply with system maximum leakage. Install ductwork at inlet of boxes so that the maximum straight run of duct is achieved at the box inlet. Install boxes so that minimum 3'-0" clearance is maintained in front of box-mounted control and electrical panels. Refer to detail for additional requirements.
- B. For fan powered terminal box, install filter during construction phase. Change out filter just before final field observation by the Engineer. Provide one set of spare filters per terminal to the Owner.
- C. Store units under protective tarps and in accordance with manufacturer's installation instructions.
- D. Provide clear access to unit mounted access doors on bottom of units.
- E. Field insulate all exposed heating coil bends, headers and coil casing with specified duct insulation.
- F. Seal the connection between the hot water coil and the terminal box with duct sealant.

END OF SECTION 23 36 00

## SECTION 23 37 00 - AIR DEVICES

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. Section includes air distribution devices including the following:
  - 1. Diffusers.
  - 2. Grilles.
  - 3. Registers.

## 1.3 COOPERATION WITH OTHER TRADES

- A. Coordinate work with Division 26 Electrical Sections to ensure intended functions of lighting and air systems are achieved.

## 1.4 SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
  - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
  - 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- B. Samples: At the request of the Owner and/or A/E team, submit each exposed product for each color and texture specified.
- C. Sound Attenuators. Submit schedule for each sound attenuator indicating size, airflow and static pressure. Submit product data indicating materials, acoustical performance and options provided that clearly indicate compliance with Part 2 of this Section. For all sound attenuators, provide documents proving that the acoustical performance as submitted has been certified by an independent laboratory in accordance with ASTM Specification E477-2013.

## PART 2 - PRODUCTS

## 2.1 ACCEPTABLE MANUFACTURERS

- A. Products meeting all requirements of this specification Section of the following manufacturers are acceptable:
  - 1. Diffusers, Grilles and Registers. Krueger, Price, Metalaire, Titus.

## 2.2 DIFFUSERS

- A. Square Plaque Diffuser (MARK A – E):

1. Provide aluminum plaque diffuser, precision formed back cone of one piece seamless construction which incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct. An inner plaque assembly shall be incorporated that drops no more than 1/4 inch below the ceiling plane to assure proper air distribution performance. The inner plaque assembly shall be completely removable from the diffuser face to allow full access to any dampers or other ductwork components located near the diffuser neck.
2. Finish shall be White Powder Coat.
3. Provide transitions for rectangular duct connections if required.

B. Perforated:

1. Provide steel frame construction with aluminum perforated face and white factory finish. Frame the diffuser face with a mitered and welded frame.
2. Face shall have no less than 51% free area.

### 2.3 DIFFUSERS - PART OF A RATED CEILING ASSEMBLY

- A. Provide UL fire rated ceiling diffuser with louver face, radiation fire damper and thermal blank radiation barrier.

### 2.4 GRILLES

A. Supply:

1. Use double-deflection supply grilles made of aluminum.
2. Install vertical face blades and horizontal rear blades. Provide solid, extruded aluminum blades which are individually adjustable. Space at not more than 3/4 inch centers for rear blades and 1/2 inch centers for face blades and not less than 5/8 inch deep.
3. Employ grille frames of extruded aluminum with welded and mitered corners and mounting gaskets.
4. Provide white finish on all grilles unless indicated otherwise on drawings.
5. Provide integral steel opposed blade damper with mill finish.

B. Return and Exhaust:

1. For ceiling return, provide scheduled diffuser with white factory finish. Use construction and frame styles as specified for ceiling diffusers, but without pattern controllers. Use neck sizes as shown.
2. For wall return and exhaust, provide a 45 degree fixed-blade aluminum grille. Provide 3/4 inch blade spacing as scheduled, with front blades parallel to long dimension. Provide solid, extruded frames and aluminum blades which are individually adjustable on sizes larger than 24 inches x 24 inches, roll-formed aluminum blades for smaller grilles. Include mounting gaskets. Provide white finish unless noted otherwise on drawings.
3. Provide steel opposed blade damper with mill finish for all air devices used for exhaust.

C. Spiral Duct Grille:

1. Shall be a double deflection type with two sets of fully adjustable deflection blades, spaced 3/4" on center. Grille shall be mounted on spiral ductwork without use of transitions. Grille shall be curved to match the radius of the duct.
2. Front blades shall run parallel to the short dimension.
3. Provide air-scoop adjusted via operator on the side frame for balancing.
4. Provide finish that can be painted in field.
5. Provide closed cell foam gasket attached to the border to provide a tight seal around opening of the ductwork.

D. Heavy Duty Return:

1. Provide a 0 degree fixed-blade 14 gauge steel grille. Provide 3/8 inch blade spacing as scheduled, with front blades parallel to long dimension. Include mounting gaskets. Provide white finish unless noted otherwise on drawings. Provide key operated opposed blade damper for all air devices.

## 2.5 SLOT DIFFUSERS

## A. Supply:

1. The linear slot diffuser shall utilize heavy wall extruded aluminum air deflector frames. These frames shall be designed to accommodate notched compressible space bars, complete with integral hanger, spaced approximately 24 inches on center. The steel air pattern controllers are fully adjustable and can be moved from side to side to create various air pattern configurations. These dual pattern controllers shall be fully adjustable to allow shut-off without adding any blank-off devices. The spacer bars and pattern controllers shall be removable for on-site modification and trimming.
2. Provide minimum 10 inch high plenum with 1/4 inch thick, 2lb density insulation. Plenum shall have tabs for supporting from structure. Provide hard ceiling clips for installing unit in gypboard, end caps and other accessories required for complete installation. Confirm border type with Architect prior to submittal.

## B. Return:

1. Similar in construction to supply slot diffuser but without plenum. Provide perforated black galvanized steel light shield. Where installed in a vertical wall (sidewall installation), do not provide light shield where light shield would conflict with studs.

C. Provide blank-off plates on unused sections of slot diffusers where indicated on the drawings.

D. Provide end caps at ends of slot diffusers.

## 2.6 ACCESSORIES

A. Supply Grille Extractors. Provide each supply grille with an air control device capable of positively regulating the volume of air extracted from the supply duct.

1. Select extractors similar to Price Model AE1, tight-closing in the minimum position. Include a key-operated or worm-gear adjusting mechanism to facilitate positioning from the grille opening. Where adjustment is not accessible at the grille opening, provide a control rod equipped with a locking quadrant.
2. For ductwork control, use Young regulators. Provide extractors 30 inches and longer with a support rail inside of the duct at the outboard quarter point of the extractor. Construct the support rail of angle or channel members formed of sheet metal fastened securely to the duct. Make the rails 18 inches long, except where duct width prevents the extractor from sagging when moved toward its maximum position.
3. Check extractors thoroughly for freedom of operation. If necessary, oil bearing points before installing.

B. Mounting Frames. Provide each grille or register not equipped with a removable core with a companion, all-purpose mounting frame constructed like a grille frame to facilitate installation and removal of the grille or register without marring adjacent mounting surfaces.

1. Furnish frames with 1/2 inch thick sponge rubber gasket to prevent air leakage.
2. Provide a frame that neatly fits the grille. Mounting frames will not be required for grilles or registers mounted directly on exposed ductwork.

## 2.7 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

## 2.8 SOUND ATTENUATORS

A. Construct casings of not less than 22-gage galvanized steel for diameters up to 36 inches, and 18 gage for diameters up to 48 inches. Furnish perforated face sheets over acoustical material of not less than 5.0 pounds per cubic foot of compressed density glass fiber or mineral wool.

- B. Airtight construction shall be provided by use of a duct sealing compound on the job site by the Contractor. Silencers shall not fail structurally when subjected to a differential air pressure of 8 inches w.c. inside to outside of casing.
- C. Provide acoustical liners of the same density around the outside perimeter and in the center baffle of the silencer. Attenuation shall be within 5% of that listed below at 2000 feet per minute face velocity:
1. Five foot attenuator (based upon a 24x24 attenuator, 2000 feet per minute in forward direction):

Octave Band	2	3	4	5	6	7	8
Insertion loss, dB	10	17	32	30	22	17	13

2. Three foot attenuator (based upon a 24x24 attenuator, 2000 feet per minute in reverse direction):

Octave Band	2	3	4	5	6	7	8
Insertion loss, dB	7	11	20	20	16	13	10

- D. For five foot attenuator, the maximum pressure drop shall be 0.30-inch W.G. at 2000 feet per minute face velocity. For three foot attenuators, the maximum pressure drop shall be 0.20 inch W.G. at 2000 feet per minute face velocity.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Do not install ceilings adjacent to fixtures until installation of fixtures, air supply assemblies, return-air blank-off strips and flexible duct have been properly approved. Remove and reinstall any part of the installation found incorrect.
- B. Diffusers. Louvered diffuser outlets mount tight against the ceiling. Fasten outlets securely to ductwork with sheet metal screws. For perforated diffusers, attach the frame assembly by a concealed hinge assembly to an outer frame compatible with the type of ceiling on which the diffuser is installed.

#### 3.2 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 00



## SECTION 23 41 00 - PARTICULATE AIR FILTRATION

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
  - 1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  - 2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. This Section includes factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

## 1.3 REFERENCES

- A. AMCA 99 – Standards Handbook.
- B. ARI 850 – Commercial and Industrial Air Filter Equipment.
- C. ASHRAE 52.1 – Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices used in General Ventilation for Removing Particulate Matter.
- D. ASHRAE 52.2 – Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size.
- E. ASHRAE 62 – Ventilation for Acceptable Indoor Air Quality.
- F. IEST RP-CC—1 – HEPA Filters.
- G. NFPA 70 – National Electrical Code.
- H. SMACNA – HVAC Duct Construction Standards – Metal and Flexible.
- I. UL 586 – High Efficiency, Particulate Air Filter Units.
- J. UL 900 – Test Performance of Air Filter Units.

## 1.4 DEFINITIONS

- A. IEST – Institute of Environmental Sciences and Technology.
- B. MERV – Minimum Efficiency Reporting Value.

## 1.5 SUBMITTALS

- A. Product Data: Include dimensions; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; MERV rating, efficiency and test method; fire classification; furnished specialties; and accessories for each unit indicated.
- B. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
  2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
  3. Include wiring diagrams.
- C. Operation and Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
- 1.6 QUALITY ASSURANCE
- A. Manufacturer Qualifications: Company specializing in manufacturing the specified products with minimum three years documented experience, who issues complete catalog data on total product.
  - B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - C. Comply with ARI 850.
  - D. Comply with ASHRAE 52.1 and ASHRAE 52.2 for method of testing and rating air-filter units.
  - E. Comply with NFPA 90A and NFPA 90B.
- 1.7 DELIVERY, STORAGE, AND HANDLING
- A. Deliver, store, protect, and handle products to site in accordance with Section 23 00 10, Mechanical General Provisions.
  - B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
  - C. Store in clean, dry space and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
  - D. Ship equipment to jobsite with not less than a prime coat of paint or as specified.
- 1.8 PROJECT CONDITIONS
- A. Environmental Requirements: Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fans have been test run under observation.
- 1.9 SCHEDULING
- A. Capacities and characteristics are generally shown on schedules on Drawings. Reference shall be made to schedules for such information.
  - B. Capacities shown are minimum capacities. Variations in capacities of scheduled equipment supplied under contract will be permitted only with written direction from Owner.
- 1.10 MAINTENANCE
- A. Extra Materials: Provide two complete sets of filters for each unit. Tag to identify associated unit.

## PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AAF International.
  2. Cambridge.
  3. Camfil
  4. Flanders
  5. Koch
  6. Dwyer Instruments, Inc.

## 2.2 FILTERS

- A. Filters shall be listed as Class 2 in accordance with UL 900 and shall be tested and reported in accordance with ASHRAE Test Standards 52.1 and 52.2. Dust spot efficiencies listed are results when tested by ASHRAE Standard 52.1. MERV and MERV-A values listed are results when tested by ASHRAE Standard 52.2. and ASHRAE Standard 52.2 Appendix J.
- B. Medium Efficiency Panel Filter (Disposable, Dry Type)
1. MERV 8-A Filters:
    - a. Media: 0.18-inch nonwoven cotton and synthetic blend media, formed into a uniform radial pleat. Provide industry standard sizes as required for installation. The minimum media area shall be 17.3 square feet for a 24X24 filter.
    - b. Frame: Provide filter media in permanent removable frames with corrosion resistant welded wire grid bonded to the downstream side of the media. Media shall be fully bonded to frame to prevent air leakage.
    - c. Rating: Initial resistance no greater than 0.31-inches w.g. at 500 FPM face velocity. Minimum Efficiency Reporting Value shall be MERV 8, dust spot efficiency of 25-30 percent.
    - d. Thickness: 2-inches or 4-inches. Pre-filters shall be 2-inches unless otherwise noted on the Drawings or Specifications.

## 2.3 FILTER GAUGES

- A. Direct Reading Dial: 3-1/2 inch diameter diaphragm actuated dial in metal case. Provide vent valves, black figures on white background, front calibration adjustment. The range of the scale shall be no greater than 1" w.g. above the filter manufacturer's recommended final resistance for the type of filter to which the gauge is being applied, 2 percent of full-scale accuracy. Provide with adjustable signal flag.
- B. Accessories: Static pressure tips with integral compression fittings, 1/4-inch aluminum or polymer tubing.

## PART 3 - INSTALLATION

- A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
- B. Install filters in position to prevent passage of unfiltered air.
- C. Coordinate filter installations with duct and air-handling unit installations.
- D. Electrical wiring and connections are specified in Division 26 Electrical Sections.

END OF SECTION 23 41 00

## SECTION 23 74 00 - PACKAGED ROOFTOP AIR HANDLING UNITS

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including "Uniform General Conditions and Supplementary General Conditions For The State Of Texas Building Construction Contracts" and Division 01 Specification Sections, apply to the work of this Section.
1. Where the term "Owner's Designated Representative" is used, it shall mean a member of the project's capital team as defined by UTMB, Facilities Design and Construction, 1302 Mechanic, Galveston, Texas 77555-1116
  2. Phone (409) 772-3500-, Fax (409) 772-5199.

## 1.2 SUMMARY

- A. Perform all Work required to provide a fully packaged air-cooled, direct expansion (DX) air conditioning (AC) unit with gas heat (if scheduled), as scheduled on the drawings. The packaged AC unit shall perform to manufacturer's product data, installation instructions, Start-up instructions and maintenance information indicated by all Specification Sections, and Contract Documents with supplementary items necessary for proper operation.
- B. Packaged air-cooled AC unit shall consist of the following as a minimum: hermetic scroll compressor(s) component utilizing R-410A, evaporator coil, air-cooled condenser coil, condenser fans, supply fan, heating coil, vibration isolation assemblies, and microprocessor control center.

## 1.3 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- B. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
1. ARI - 1060 Rating Air-to-Air Energy Recovery Equipment.
  2. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
  3. ARI 340/360 - Commercial Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
  4. ARI 410 - Standard for Forced-Circulation Air-Cooling and Air-Heating Coils.
  5. ANSI/ASHRAE 15 - Safety Standard for Refrigeration Systems.
  6. ASHRAE 90.1 or IECC – Latest adopted edition.
  7. ASHRAE 52.2 - Method of Testing General Ventilation Air-Cleaning Devices Used for Removal Efficiency.
  8. ANSI/AMCA Standard 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
  9. AMCA Publication 211 - Certified Ratings Program - Product Rating Manual for Fan Air Performance.
  10. AMCA Standard 300 - Reverberant Room Method for Sound Testing of Fans.
  11. AMCA Publication 311 - Certified Ratings Program.
  12. AMBA Method of Evaluating Load Ratings of Bearings ANSI-11.
  13. ANSI/AMCA Standard 204 - Balance Quality and Vibration Levels for Fans.
  14. ASTM B-117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
  15. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
  16. AMCA/ANSI 500 – Standard for testing dampers.

#### 1.4 QUALITY ASSURANCE

- A. The design of the unit shall be AGA and ARI certified as combination heating-cooling units for rooftop installation.
- B. Unit construction shall comply with ASHRAE 15 safety code, NEC, and UL applicable codes.
- C. Cooling capacity ratings shall be in accordance with ARI standard 210/240, most recent edition.
- D. Insulation and adhesive shall meet NFPA 90A requirements.

#### 1.5 SUBMITTALS

- A. Product Data:
  - 1. Statement of compliance with these specifications.
  - 2. Provide literature that indicates dimensions, weight, loading, clearances, capacities, gauges, thickness, and finishes of materials, electrical characteristics and connections.
  - 3. Rigging, installation, testing, Start-up and operating instructions, maintenance data including type and quantity of oil and refrigerant change (pounds), parts lists, and troubleshooting guide.
  - 4. Data on energy input versus cooling load output from 100 percent to 20 percent of full load with constant entering condenser air temperature.
  - 5. Information about control and wiring diagrams.
  - 6. Product test data on sound power levels for both fan inlet and outlet at the rated design capacity.
  - 7. Operating data such as fans speeds, compressor LRA and RA, sound levels
  - 8. Product data on special condenser coating.
  - 9. Product data on all condenser fan accessories such as controls.

#### 1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to the Project Site under provisions of Division 01 and Division 23.
- B. Accept products on Site in factory-fabricated protective containers or coverings, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish. Shall the unit be damaged at any time during construction, the unit will be deemed unacceptable and a new unit shall be provided.
- D. Check and maintain equipment on monthly basis to ensure equipment is being stored in accordance with manufacturer's recommended practices. Storage record shall be maintained that indicates above requirements have been met.

#### 1.7 EXTRA MATERIALS

- A. Provide two sets of additional replacement filters at substantial completion for each unit.

#### 1.8 WARRANTY

- A. Units shall be furnished with full coverage warranty against defects in materials. Warranty on the complete unit shall be for one year from the Substantial Completion date. On the compressors, warranty shall be for five (5) years from the Substantial Completion date.

## PART 2 - PRODUCTS

- 2.1 ACCEPTABLE MANUFACTURERS: Base bid shall match existing clinic RTU manufacturer. Contractor may also propose an alternate from the following list in addition to the base bid manufacturer.
- A. Trane
  - B. Carrier
  - C. JCI
  - D. Daikin
- 2.2 GENERAL
- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.
  - B. Factory assembled air-cooled packaged DX air conditioning unit using a refrigerant charge (R410A) with the following construction:
    - 1. Cabinet.
      - a. single wall access doors with steel hinges and zinc cast lockable handles.
      - b. Compressors and unit controls contained within single isolated compartment.
    - 2. Scroll compressors installed on sheet metal deck with rubber isolation mounts for quiet efficient operation.
    - 3. DX coil(s).
    - 4. Stainless steel evaporator coil support.
    - 5. Stainless steel drain pan.
    - 6. Blower motor(s) installed on rubber isolation mounts for quiet efficient operation.
    - 7. Direct drive condenser fan(s).
    - 8. Bottom or side access return, as indicated on drawings.
    - 9. Bottom or Side supply air discharge, as indicated on drawings.
    - 10. Return air damper and actuator.
    - 11. Outside air damper and actuator.
    - 12. Air filters with multiple options, efficiencies and monitoring devices.
    - 13. RTU Roof sloped for proper drainage.
    - 14. Single point power connection.
    - 15. Thermostatic expansion valves on DX coils.
    - 16. Manual reset high pressure cutoffs.
    - 17. Automatic reset low pressure cutoffs.
    - 18. Run test report, wiring diagram, installation manual and Start-up form in control access compartment.
    - 19. GFI convenience outlets.
    - 20. Weather-resistant finish paint coating which passes a salt spray test at a minimum of 672 hour duration.
    - 21. Roof mounting curb
  - C. Compressor shall have load capacity ratings per the requirements ARI 210/240.
  - D. Unit efficiency shall be in compliance with the requirements of the latest adopted version of the energy code.
  - E. Unit dampers shall have a maximum leakage rate of 4 cfm per square foot of damper area at 1" w.g. when tested according to AMCA/ANSI standard 500.

## 2.3 CABINET AND INSULATION

- A. All cabinet walls, access doors, floor and roof shall be fabricated of single wall, impact resistant panels.
- B. All exposed vertical panels and top covers in the indoor air section shall be insulated with a ½" 1-pound density foil-faced, fire resistant, permanent, odorless, glass fiber material. The base of the unit shall be insulated with ½" 1-pound density foil-faced closed cell insulation.
- C. Unit construction shall be single wall with G90 galvanized steel on both sides.
- D. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.
- E. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.
- F. Access to filters, dampers, cooling coils, reheat coil, heaters, exhaust fans, energy recovery wheels, compressors, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles.
- G. Exterior paint finish shall be capable of withstanding at least 672 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
- H. Units with cooling coils shall include double sloped 430 stainless steel drain pans.
- I. Unit shall be provided with base discharge and return air openings as indicated on drawings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.
- J. Unit shall include lifting lugs on the top of the unit.
- K. Unit shall include factory installed, painted galvanized steel condenser coil guards on the face of the condenser coil.

## 2.4 COMPRESSORS

- A. Unit shall be factory charged with R-410A refrigerant.
- B. Compressors shall be scroll type with thermal overload protection, independently circuited and carry a 5 year non-prorated warranty, from the date of project substantial completion.
- C. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation.
- D. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.
- E. Each refrigeration circuit shall be equipped with thermostatic expansion valve type refrigerant flow control.
- F. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides and a factory installed replaceable core liquid line filter driers.

- G. Unit shall include hermetic scroll compressors that are capable of staging on and off to modulate capacity. Refer to drawings special compressor requirements.

## 2.5 FANS, MOTORS, AND DRIVES

- A. Indoor airflow and external static pressure capabilities shall be no less than the values indicated on the Drawings. Supply air fans shall be direct drive fans.
- B. All fan(s) and motor(s) shall be in compliance with the fan power limitations and efficiency requirements of the latest adopted edition of the energy code.
- C. All fans shall be AMCA certified.
- D. Outdoor fans shall be direct drive, shaft mounted propeller type, statically and dynamically balanced. Outdoor fan motor(s) shall be TEFC weather resistant with permanently lubricated bearings.
- E. Indoor fans shall be direct drive, shaft mounted centrifugal or plenum type, statically and dynamically balanced. Indoor fan motor(s) shall be premium efficiency ODP with sealed lubricated bearings. The motor and fan bearings shall have L10 200,000 service life.
- F. Variable frequency drives shall be factory wired and mounted in the unit.
- G. The unit shall be equipped with phase and brown out protection.

## 2.6 COILS AND CAPACITY CONTROL

- A. Coils shall be standard construction copper tubes with aluminum fins. All copper work shall be brazed. Coils shall be factory pressure tested.
- B. Indoor coils shall be capable of the performance indicated on the Drawings with no "blow-off" of condensate.
- C. Indoor coils shall be equipped with a sloped stainless steel, corrosion resistant condensate pan terminating at a stainless-steel condensate drain located outside the unit cabinet. Condensate drain pan shall be formed sections of stainless-steel sheet, a minimum of 2 inches deep, and complying with ASHRAE 62.1.
- D. Units with rated capacity smaller than 65,000 BTUH shall not be required to have part-load refrigeration capability. Units with a rated capacity greater than or equal to 65,000 BTUH shall have minimum two (2) stages of cooling per the latest edition of adopted energy code. The refrigeration system shall be equipped with filter dryers on the liquid lines and service valves with gauge port connections on the discharge and suction lines.

## 2.7 CONDENSERS

- A. Condenser fans shall be a vertical discharge, axial flow, direct drive fans.
- B. Coils shall be designed for use with R-410A refrigerant. Coils shall be multi-pass and fabricated from anti-corrosion coated aluminum microchannel tubes or coils shall be constructed of copper tubes with copper fins mechanically bonded to the tubes and aluminum end casings. Fin design of copper tube coils shall be sine wave rippled.
- C. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.
- D. Coils shall be leak tested.



- E. Condenser fans shall be VFD driven variable speed for condenser head pressure control. Factory provided and factory programmed VFDs shall continuously modulate the fan air flow to maintain head pressure at acceptable levels. Cooling operation shall be allowed down to 35°F with adjustable compressor lockouts.

## 2.8 GAS HEATING (AS SCHEDULED)

- A. Stainless steel heat exchanger furnace shall carry a 25 year non-prorated warranty, from the date of original equipment shipment from the factory.
- B. Gas furnace shall consist of stainless steel heat exchangers with multiple concavities, an induced draft blower and an electronic pressure switch to lockout the gas valve until the combustion chamber is purged and combustion airflow is established.
- C. Furnace shall include a gas ignition system consisting of an electronic igniter to a pilot system, which will be continuous when the heater is operating, but will shut off the pilot when heating is not required.
- D. Unit shall include a single gas connection and have gas supply piping entrances in the unit base for through-the-curb gas piping and in the outside cabinet wall for across the roof gas piping.
- E. Natural gas furnace shall be equipped with modulating gas valves, adjustable speed combustion blowers, stainless steel tubular heat exchangers, and electronic controller. Combustion blowers and gas valves shall be capable of modulation. Electronic controller includes a factory wired, field installed supply air temperature sensor. Sensor shall be field installed in the supply air ductwork. Supply air temperature setpoint shall be adjustable on the electronic controller within the controls compartment. Gas heating assemblies shall be capable of operating at any firing rate between 100% and 40% of their rated capacity.

## 2.9 OUTSIDE AIR ENTHALPY- BASED ECONOMIZER

- A. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge and end seals. Damper blades shall be gear driven and designed to meet the low leakage requirements of energy code. Damper assembly shall be controlled by spring return dry bulb activated fully modulating actuator. Unit shall include outside air opening bird screen, outside air hood, and barometric relief dampers.
- B. Economizer dampers shall meet the low leakage requirements of latest adopted version of energy code.

## 2.10 FILTERS

- A. Each unit shall include 4-inch-thick, pleated panel filters with an ASHRAE MERV rating of 8, upstream of the cooling coil. Front frame loaded filters shall be easily accessible for removal through access panels or doors. The MERV 8 filter shall have a clean air pressure drop of 0.25" w.g. at 500 fpm.
  - 1. Acceptable filter manufacturers:
    - a. Flanders
    - b. 3M
    - c. American Air Filter
    - d. Camfil Farr
- B. Unit shall include a clogged filter switch.
- C. Units shall include a differential pressure switch across filter bank.

## 2.11 ELECTRICAL REQUIREMENTS

- A. The unit shall be designed for the electrical service designated on the Drawings.
- B. Arrange electrical cabinet for connecting electrical service at one point only.
- C. Power and control wiring of the unit shall be factory installed complete within the unit. Provide correctly identified suitable lugs and terminal strips for field connection to electrical power and external controls.
- D. Factory equip unit with motor starters for each of the motor driven components that are not driven by VFD.
- E. Factory equip unit with supply air fan VFD.
- F. Units shall be provided with a factory installed and factory wired 115V, 13 amp GFI outlet disconnect switch in the unit control panel

## 2.12 CONTROLS

- A. Provide each rooftop unit with dedicated BACNET interface.
- B. Integral Unit Controls: As a minimum, the packaged AC unit's components shall be protected with high pressure-stat, loss-of-charge protection, current and temperature sensitive overload devices, and anti-short cycle timer control circuit to prevent the compressor from restarting for five (5) minutes after stopping.
- C. The microprocessor controller provided by the equipment manufacturer shall be capable of receiving signals from a variety of control sources, which are not mutually exclusive.
  - 1. The controller shall interface with the building automation system (BAS) via the BACNet interface panel.
  - 2. All variables listed in the points list shall be passed to the BAS via the BACnet gateway. Variables shall include:
    - a. Unit Status
    - b. Compressor Status
    - c. Stages of Cooling
    - d. All Alarms
  - 3. The controller shall also receive start/stop, discharge temperature setpoint, and VFD fan speed command from the BAS through a BACNet interface.
  - 4. Application specific controllers (ASC) shall communicate using BACNet.
  - 5. BACnet controllers shall conform to ASHRAE Standard 135 and communicate to a TCP/IP Ethernet physical layer.
- D. Equipment manufacturer shall include on-site programming assistance to both the Owner and BAS Provider to:
  - 1. Assure that data from their respective interface is available.
  - 2. Assist the BAS Provider to establish proper communication.
  - 3. Confirm that the interface and controller are operating in accordance with sequence of operation.
  - 4. Provide software or hardware tools as required to operate and checkout the controller interface.

## 2.13 ACCESSORIES

- A. Curb: Provide roof curb.
- B. UV lighting shall be located on the downstream airside of the cooling coil. UV light density shall have the intensity to preclude algae growth in the drip pan and dirt build-up on coil tubes and fins.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Packaged air conditioning units shall be installed according to manufacturer's recommendations to be completely weatherproof. Protect the roof from damage during installation. Secure factory touch-up paint to repair scratches and minor damage to equipment prior to Start-up.
- D. Power wiring to the units, including externally mounted service disconnect switch, shall be furnished and installed under Division 26. Installing Contractor shall be provided with the manufacturer's Shop Drawings as required for power wiring installation.
- E. Secure unit to roof to withstand local wind speed/gust regulations

3.2 TESTING

- A. Equipment shall be cycled through all heating, cooling, and ventilation cycles to ensure proper operation of all components and controls prior to test and balance.
- B. At time of Start-up, manufacturer's representative shall visit the Project Site and verify that unit installation and performance is satisfactory, and to make any adjustments or settings to unit operating and safety controls that may be required.
- C. Include Start-up checkout service of at least one working day for one service technician, including a written report of operational check provided to the Owner. Owner's Representative may require that the Start-up service be performed with Owner's attendance and on-site review.
- D. Clean filters shall be placed within the unit at the time of Substantial Completion. Provide two sets of additional clean filters to the owner at project completion.

END OF SECTION 23 74 00