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The Description of the Project
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SPECIFICATION DIVISION 23

NUMBER SECTION DESCRIPTION

DIVISION 23 HEATING, VENTILATING AND AIR CONDITIONING (HVAC)
SECTION 233600 - AIR TERMINAL UNITS

END OF CONTENTS TABLE

DIVISION 23 HEATING, VENTILATING AND AIR CONDITIONING (HVAC)
SECTION 233600 - AIR TERMINAL UNITS

REVISIONS:

6/16: ADDED CONSTANT AIRFLOW VENTURI VALVES (CVV) FOR LABORATORY FLOW APPLICATIONS. CVV VALVES ARE TO BE PROVIDED BY THE SHEET METAL TRADE TO SUPPORT CONSTANT FLOW APPLICATIONS, INCLUDING FUME HOODS, COVERED BY SPECIFICATION 230900.

6/21/13: MINOR REVISION TO CLARIFY QUALITY ASSURANCE STANDARDS AND TO SPECIFY THAT LINER EROSION RESISTANCE IS TO BE RATED AT 6000 FPM.

NOTE THAT THIS SECTION DOES NOT INCLUDE FAN-POWERED TAU'S.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

INCLUDE PARAGRAPH 1.1.A AND B IN EVERY SPECIFICATION SECTION. EDIT RELATED SECTIONS 1.1.B TO MAKE IT PROJECT SPECIFIC.

A. Drawings and general provisions of the Contract, Standard General and Supplementary General Conditions, Division 1 Specification Sections, and other applicable Specification Sections including the Related Sections listed below, apply to this Section.

CAREFULLY EDIT AND COORDINATE RELATED SECTIONS.

RETAIN THE DIVISION 16 ELECTRICAL REFERENCE IN THIS SECTION TO ASSURE THAT ELECTRICAL WORK STANDARDS ARE OBSERVED AND ENFORCED

B. Related Sections:

1. Section 230900: Mechanical Systems Controls
2. Division 26: Electrical.

1.2 SUMMARY

A. Section Includes:

1. Terminal airflow units (TAUs) of the various types, arrangements and sizes as specified in this Section and scheduled on Drawings.
2. Constant (CAV) and Variable Volume (VAV) Terminal Airflow Units.
3. Dual Duct Terminal Airflow Units.
4. Retrofit Terminal Airflow Units.
5. Terminal Airflow Unit-Mounted Sound Attenuators.
6. Terminal Airflow Unit Pneumatic Controller and Actuator.
7. Terminal Airflow Unit-Mounted Reheat Coils.
8. Airflow-sensing array(s) and dampers on TAUs to be equipped with DDC controls.

9. Pneumatic damper operator(s) and airflow-sensing array(s) on pneumatic VAV, CAV, and Dual Duct terminal box.
10. Constant Volume Venturi (CVV) Terminal Airflow Units

1.3 ADMINISTRATIVE REQUIREMENTS

A. Mechanical Systems Controls Contractor shall coordinate with the terminal airflow unit manufacturer to provide a complete operating system.

1.4 SUBMITTALS

A. Product Data: Provide performance data, rated capacities, furnished specialties, sound-power ratings, weights, operation and maintenance, and accessories for the following.

1. Terminal airflow units.
2. Liners and adhesives.
3. Sealants and gaskets.
4. Sound attenuators.
5. Pneumatic controllers.
6. Airflow sensing array, damper, pneumatic damper operator.
7. Damper and casing leakage data.
8. Hangers and supports, including methods for duct and building attachment and vibration isolation.
9. Constant Volume Venturi (CVV) Terminal Airflow Units

B. Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment.

1.5 QUALITY ASSURANCE

RETAIN PARAGRAPHS A AND B IN EVERY PROJECT SPECIFICATION.

A. Manufacturers and Products: The products and manufacturers specified in this Section establish the standard of quality for the Work. Subject to compliance with all requirements, provide specified products from the manufacturers named in Part 2.

EDIT THE REFERENCE STANDARDS FOR PROJECT REQUIREMENTS.

B. Reference Standards: Products in this section shall be built, tested, and installed in compliance with the following quality assurance standards; latest editions, unless noted otherwise.

1. AHRI 880: "Performance Rating of Air Terminals." Test in an AHRI certified laboratory. Units shall be AHRI 880 sealed.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Insulation/liner:
   a. UL 723, "UL Standard for Safety Test for Surface Burning Characteristics of Building Materials."
   b. UL 181 "UL Standard for Safety Factory-Made Air Ducts and Connectors." Limited to mold growth and humidity test and erosion test.

c. ASTM C1071 - 05e1 "Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)."
d. ASTM E84-10 "Standard Test Method for Surface Burning Characteristics of Building Materials."
e. NFPA 90a: "Standard for the Installation of Air-Conditioning and Ventilating Systems."
f. NFPA 90b: "Standard for the Installation of Warm Air Heating and Air-Conditioning Systems."

4. Coils: AHRI Standard 410 "Forced-Circulation Air-Cooling and Air-Heating Coils."
5. SMACNA "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
6. ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Mark each terminal unit before shipment to the job site with a unique identifier corresponding to its location and function in the building. Identifier nomenclature shall correspond to the Terminal Airflow Unit Detail.

REVIEW WARRANTY TERM PER PROJECT. LONGER WARRANTY PERIOD MAY BE APPROPRIATE FOR CERTAIN TYPES OF WORK. RETAIN THIS ARTICLE IN EVERY PROJECT SPECIFICATION.

1.7 WARRANTY

A. Provide a complete parts and labor warranty for a minimum of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Terminal Airflow Unit Manufacturers:

1. Titus.
2. Krueger.
3. Metalaire.
4. Nailor Industries, Inc.
5. Price Industries.
6. Tuttle and Bailey.

COORDINATE THE FOLLOWING REQUIREMENT WITH DRAWINGS.

B. Acceptable CVV Terminal Airflow Unit Manufacturers:

1. Phoenix
2. Siemens

C. Acceptable Pneumatic Controller Manufacturer:

1. KMC Controls, Inc.

2.2 ACOUSTIC PERFORMANCE

A. Provide acoustic performance, including performance supplemented by sound attenuators, as scheduled on Drawings. Acoustical performance shall be met at all damper positions with 1 inch static pressure at the TAU inlet.

2.3 FIRE AND SMOKE TEST PERFORMANCE

A. Insulation: Maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for insulation and adhesive, when tested according to ASTM E 84.

2.4 SINGLE AND DUAL DUCT TERMINAL AIRFLOW UNIT (TAU) (CAV AND VAV)

A. Provide single duct, variable or constant volume terminal units as scheduled and detailed. Pneumatic controllers shall have the minimum and maximum airflow rates preset at factory with capability of field adjustment.

B. Provide dual duct, variable or constant volume terminal units as scheduled and detailed. Pneumatic controllers shall have the minimum and maximum airflow rates preset at factory with capability of field adjustment.

1. Construct unit casings of 22 gauge, minimum, galvanized steel sheet.

C. Damper Assembly: Minimum 20 gauge construction with a mechanical stop to prevent overstroking.

D. Terminal unit: Mechanically assemble and seal to provide an airtight casing. Casing air leakage shall not exceed 10 cfm at 1 inch w.c. differential pressure.

WHERE ACOUSTICAL PERFORMANCE IS PARTICULARLY IMPORTANT, SPECIFY THE LINER'S ACOUSTICAL PERFORMANCE.

E. Line interior walls of the terminal casing with 1/2 inch minimum, 4 lbs./cu.ft. dual density fiberglass acoustical/thermal insulation with a non-porous, aluminum foil reinforced face sheet covering of the acoustical/thermal liner. Rate liner covering for a maximum air velocity of 6,000 fpm. Wrap and seal exposed foil lining edges from the airstream, and tucked and secured with metal barriers.

F. Provide a position indicator on the damper shaft marked on the end to verify damper position.

G. Screw damper blade through the shaft to prevent slippage and include a closed cell foam gasket to ensure minimum leakage.

H. Damper air leakage shall not exceed 5 cfm at 3.0 inches w.c. differential pressure.

I. Provide damper pivot with a Celcon or Delrin bearing.

J. Equip the terminal unit with a multi-axis flow sensor with amplifying pressure pick-up points connected to a center averaging chamber. The chamber shall be designed to provide a differential pressure signal at least 1.5 times the normal unit velocity pressure over the full capacity range of the unit. Pressure sensing pick-ups shall be extended to the outside of the casing and have capped TEEs to permit parallel pressure measurements. A flow curve for field balancing shall be affixed to the terminal unit casing on the controller side. Minimum accuracy shall be 90 percent, regardless of inlet conditions.

K. Provide pneumatic tubing in accordance with the requirements of the Temperature Controls Section.

2.5 CONSTANT VOLUME VENTURI (CVV) TERMINAL AIRFLOW UNITS

A. The terminal airflow unit shall be of venturi control type utilizing a cone shaped element.

B. Flow shall be pressure independent at the scheduled air flow over a pressure range of 0.3" WG to 3.0" WG static pressure drop across the valve. Valve shall respond within 1 second of a change in duct static pressure under all conditions.

C. Accomplish pressure independence by the cone/spring element continuously adjusting position relative to the venturi orifice to compensate for duct pressure fluctuations.

D. Provide CVV TAUs of the diameter and volumetric range indicated on the drawings. Provide larger, smaller, fewer, or additional valves versus that indicated when necessary to match the volumetric range specified on the drawings (this may be necessary when providing valves from a manufacturer other than the design basis).

E. Total CVV TAU error (including the combined effects of nonlinearity, hysteresis, repeatability, temperature and drift over a one year period) shall not exceed +/- 5% of flow set point. This error shall not be exceeded regardless of duct inlet or exit configurations, over the entire manufacturer’s cataloged volumetric operating range of the LTAU, and at any pressure drop across the LTAU from 0.3" WG to 3.0" WG static pressure.

F. Provide sound attenuators only when specifically indicated. Attenuator shall be properly matched to each individual CVV TAU to meet the sound performance scheduled. Provide stainless steel packless type attenuators for all fume hood and "wet" exhaust applications. Attenuator pressure drop shall not exceed 0.20 in. w.c. at the CCV TAUs maximum rated flow, unless indicated otherwise on drawings.

G. Valves shall be constructed of minimum 16 gauge aluminum. Shaft and shaft support brackets shall be 316 stainless steel. Pivot arm and internal linkage shall be aluminum or stainless steel. Springs shall be spring-grade stainless steel. Shaft bearing surfaces shall be made of Teflon, polyester, or polyphenylene sulfide composite.

H. Low Leakage Valves

1. Provide where indicated.

2. Provide low leak seal materials compatible with the severity of service indicated by the particular valve coating that has been specified.

I. Valves connected to fume hood exhaust or where indicated on drawings:

1. Coat LTAU with minimum 5.0 mil dry film thickness Heresite P403 coating material, applied and baked per coating manufacturer's recommendations.
2. Shaft, pivot arm and linkage, and other internal metal parts (nuts, bolts, rivets, etc.) shall be stainless steel.
3. Shaft shall be Teflon coated.
4. Shaft bearing surfaces shall be made of Teflon or polyphenylene sulfide composite.

J. Provide required valve accessories to support the controls contractor.

1. Phoenix fume hood CVV TAU require corrosion proof 316L stainless steel pressure taps for monitor installation.
2. Siemens fume hood CVV TAU require corrosion proof 316L stainless steel restricting orifices for monitor installation.

2.6 DUAL DUCT TERMINAL AIRFLOW UNITS

A. Units shall be constructed the same as the single duct units, but shall have separate damper assemblies for each airstream and shall include an integral sound attenuator/mixer section.

2.7 RETROFIT (SLIDE-IN) TERMINAL AIRFLOW UNITS)

A. Design the retrofit unit to slide into the side of existing ductwork, with a maximum length of duct opening of 10 inches. Gaskets shall be attached to the orifice plate and mounting plate to provide a tight seal against the inner duct walls. Formed flanges shall provide added duct stiffness at the insertion point and for fastening the terminal to the ductwork with sheet metal screws.

B. Unit casings shall be constructed of a minimum 22 gauge galvanized steel and shall be configured to mount on either the right or left side of the duct.

C. Damper assembly construction: Minimum 14 gauge.

D. Damper shall have blade seals and flexible metal compressible jamb seals. Damper leakage shall not exceed 5 cfm at 3.0 inches w.c. differential pressure

E. Provide damper shaft position indicator marked on the end to verify damper position.

F. Provide Celcon or Delrin Damper bearing pivot.

G. Equip terminal unit with a multi-axis flow sensor with amplifying pressure pick-up points connected to a center averaging chamber. Design the chamber to provide a differential pressure signal at least 1.5 times the normal unit velocity pressure over the full capacity range of the unit. Pressure sensing pick-ups shall be extended to the outside of the casing and have capped TEE's to permit parallel pressure measurements. A flow curve for field balancing shall be affixed to the terminal unit casing on the controller side. Minimum accuracy shall be 90 percent regardless of inlet conditions.

2.8 TERMINAL AIRFLOW UNIT-MOUNTED SOUND ATTENUATORS

A. Provide factory fabricated, integral-type sound attenuators with aluminum foil faced liners. Wrap, tuck and secure exposed foil lining edges with metal brackets. Attenuators shall be one-piece construction using the same materials as the attached terminal airflow unit.

B. For supply units, install attenuator at the discharge of supply air terminal units, between the terminal air flow unit damper and any air diffusion devices.

C. For exhaust/return units, install attenuator upstream of terminal airflow unit damper, but downstream of any exhaust/return connections.

D. Sound attenuator performance shall be as scheduled.

2.9 TERMINAL AIRFLOW UNIT CONTROLLER AND ACTUATOR

A. Pneumatic Controls: Provide controller, damper, damper actuator, linkage, flow sensor and interconnecting pneumatic tubing. Controller operation over an 8-13 psig control signal. Factory-set controller for direct acting control. Mount damper actuator to damper shaft in a normally open damper configuration. Damper actuator linkage shall allow easy conversion to a normally closed damper configuration without removing the actuator. Factory pipe flow sensor and damper actuator to the controller.

1. Provide KMC Controls CSC-3011 pressure independent controller.

THE SECTION BELOW IS WRITTEN ASSUMING STANDARD U-M PRACTICE WHERE, FOR DDC CONTROLS, U-M FURNISHES THE TERMINAL UNIT "TERMINAL EQUIPMENT CONTROLLER" (DDC CONTROLLER) TO THE MECHANICAL SYSTEMS CONTROLS CONTRACTOR; THE MSCC IS RESPONSIBLE FOR GETTING IT INSTALLED ON THE TERMINAL UNIT. SEE U-M MASTER SPEC 230900 FOR MORE INFORMATION. REVISE TO MAKE PROJECT SPECIFIC ONLY IF NECESSARY.

B. DDC Controls: Provide damper and flow sensor.

2.10 TERMINAL AIRFLOW UNIT-MOUNTED REHEAT COILS

A. Provide coils by the terminal airflow unit manufacturer as a complete factory-mounted assembly, with capacities and characteristics as scheduled on the Drawings. Provide slip and drive or flanged connections to allow removal and reversal of coils in field.

B. Coils: Maximum of 10 fins per inch, same side supply and return (steam/condensate) piping connections, enclosed in a sheet metal casing to match the size of the attached terminal airflow unit.

C. Water Coil: 2-rows, rated for 200 psi working pressure, 250 deg. F, with 3/8 inch copper tubing, minimum wall thickness of 0.016 inch, and mechanically bonded aluminum fins, 1/2 inch or larger solder connectors, and manual air vent on return. Hydrostatically test coils at 250 psi, or at 250 psi air pressure under water. Maximum pressure drop at design flow shall not exceed 10 feet or as scheduled. Hot water shall be equally distributed through all tubes by means of orifices or a header design.

IF FREEZING CONDITIONS EXIST, SPECIFY DISTRIBUTING TYPE STEAM COILS (TUBE - IN - TUBE). NON-DISTRIBUTING TYPE IS TYPICALLY AVAILABLE WITH OPPOSITE END CONNECTIONS. DISTRIBUTING TYPE ARE TYPICALLY AVAILABLE WITH OPPOSITE OR SAME END CONNECTIONS.

D. Steam Coil: Specifically designed for modulating control steam service, non-distributing type, rated for 200 psi working pressure, 250 deg. F, with 3/8 inch copper tubing, minimum wall thickness of 0.020 inch, and mechanically bonded aluminum fins, 1/2 inch or larger threaded, opposite end connections. Hydrostatically test coils at 250 psi or at 250 psi air pressure under water.

E. Electric Coil: Provide UL listed coils. Set coil in an attenuator section integral with the terminal unit. Recess the element grid a minimum of 5 inches from the unit discharge. Elements shall be derated nickel chrome, supported by ceramic isolators a maximum of 3-1/2 inches apart, staggered for maximum thermal transfer and element life, and balanced to ensure equal output per stage. House the integral control panel in a NEMA 1 enclosure with hinged access door. Provide an integral door interlock-type disconnect switch which will prevent the access door from being opened while power is on. Coil units shall contain a primary automatic thermal cutout, a secondary manual reset thermal cutout, airflow proof switch, and terminal block.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Review and examine conditions affecting work. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Commissioning: Review and perform required commissioning activities in the pre-construction phases.

3.2 HANGER AND SUPPORT INSTALLATION

A. Comply with applicable SMACNA HVAC Duct Construction Standards and Hanger and Support construction standards, and applicable Division 23 Sections.

B. Support TAU’s independently from adjacent ductwork. Ensure supports do not interfere with accessibility of other equipment, e.g., access to TAU DDC control enclosure. Do not hang TAUs from piping, other ducts or equipment.

3.3 TERMINAL AIRFLOW UNIT INSTALLATION

A. Install TAUs in accordance with manufacturer recommendations, Contract Drawings, and reviewed submittals.

B. Provide a minimum of 2 duct diameters rigid straight duct upstream of terminal unit with a bell-mouth or shoe-tap to minimize pressure drops.

C. Label unit according to the applicable detail.

D. Position terminal air flow unit, unit-mounted controller, reheat coil, and sound attenuators to comply with clearance requirements and for ease of maintenance.

3.4 CONSTANT VOLUME VENTURI TERMINAL AIRFLOW UNIT INSTALLATION

A. Install CVV TAUs in accordance with manufacturer recommendations, Contract Drawings, and reviewed submittals.

B. Install one straight equivalent duct diameter upstream of the inlet to the CCV TAU. Transitions connecting to the inlet or outlet of the CCV TAU shall not exceed 30 degrees.

C. Label unit according to the applicable detail.

D. Position terminal air flow unit and sound attenuators to comply with clearance requirements and for ease of maintenance.

3.5 REHEAT COIL INSTALLATION

A. Install reheat coils per applicable SMACNA Standards.

3.6 COMMISSIONING

A. Perform the commissioning activities as outlined in the Division 01 Section Commissioning and other requirements of the Contract Documents.

3.7 SYSTEM START-UP

A. After start-up and operation of the HVAC system, sensors and controllers shall be cleaned and "blown-out" before final calibration of airflows and controls.

3.8 ADJUSTING, CLEANING, PROTECTION

A. Protect open end of terminal boxes, flow sensors and controllers throughout the entire construction period, until Commissioning and Substantial Completion.

END OF SECTION 233600