

SECTION 233600 VARIABLE AIR VOLUME TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Shutoff, single-duct variable air volume terminal units.
2. Shutoff, single-duct variable air volume terminal units with integral heating coils.
3. Series, fan-powered air terminal units with integral heating coils.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.

1. Variable Air Volume Terminal Units.
2. Liners and adhesives.
3. Sealants and gaskets.

- B. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Size and location of initial access modules for acoustic tile.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Instructions for resetting minimum and maximum air volumes.
 - 2. Instructions for adjusting software set points.

1.6 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated.
- C. 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.
- D. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.7 WARRANTY

- A. Provide manufacturer's standard warranty commencing at the date of substantial completion. Provide additional warranties as required by Section 01850.

1.8 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
 - 1. Series, Fan-powered Air Terminal Units - Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 SHUTOFF, SINGLE-DUCT VARIABLE AIR VOLUME TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide a comparable product by one of the following:
 - 1. Trane.
 - 2. Daikin.
 - 3. Environmental Technologies, Inc.
 - 4. Krueger.

5. Price.
 6. Nailor.
 7. Or approved equivalent.
- B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: 0.034-inch steel, single wall.
1. Casing Lining: Adhesive attached, 1-inch-thick, coated, fibrous-glass duct liner with foil facing complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 3. Air Outlet: S-slip and drive connections, size as indicated on equipment schedules.
 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Primary Air Control Damper Assembly: Galvanized steel (20 gage minimum) with peripheral gasket and self-lubricating bearings located within unit casing.
1. Maximum Damper Leakage: ARI 880 rated, 1 percent of nominal airflow at 4-inch wg inlet static pressure.
 2. Damper Position: Normally open.
 3. Integral Flow Sensor:
 - a. Flow sensor shall be provided regardless of control type.
 - b. Flow sensor shall be a multi-point, averaging ring or cross type. Bar or single point sensing type is not acceptable.
 - c. Flow sensor shall be capable of maintaining airflow to within +/- 5 percent of rated unit airflow set point when installed with 1.5 duct diameters straight duct, of the same size as the primary airflow inlet, upstream from the unit.
- E. Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:
1. Damper Actuator: 24 V, powered closed, power open.
 2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Ability to control automatic temperature control valve to maintain room set point and discharge air set point.
 - e. Communication with temperature-control system specified in Section 230900 "HVAC Instrumentation and Controls."

3. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
4. Control Transformer: Provide factory-installed 50-VA transformer in an enclosure with 7/8-inch knockouts for 24 VAC controls.

F. Control Sequence:

1. Refer to specification 230993 “Sequence of Operations for HVAC Controls.”

2.2 SHUTOFF, SINGLE-DUCT VARIABLE AIR VOLUME TERMINAL UNITS WITH INTEGRAL HEATING COIL

A. Manufacturers: Subject to compliance with requirements, provide a comparable product by one of the following:

1. Trane.
2. Environmental Technologies, Inc.
3. Krueger.
4. Price.
5. Nailor.
6. Or approved equivalent.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch steel, single wall.

1. Casing Lining: Adhesive attached, 1-inch-thick, coated, fibrous-glass duct liner with foil facing complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections, size as indicated on equipment schedules.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Primary Air Control Damper Assembly: Galvanized steel (20 gage minimum) with peripheral gasket and self-lubricating bearings located within unit casing.

1. Maximum Damper Leakage: ARI 880 rated, 1 percent of nominal airflow at 4-inch wg inlet static pressure.
2. Damper Position: Normally open.
3. Integral Flow Sensor:
 - a. Flow sensor shall be provided regardless of control type.
 - b. Flow sensor shall be a multi-point, averaging ring or cross type. Bar or single point sensing type is not acceptable.

- c. Flow sensor shall be capable of maintaining airflow to within +/- 5 percent of rated unit airflow set point when installed with 1.5 duct diameters straight duct, of the same size as the primary airflow inlet, upstream from the unit.
 - E. Integral Hydronic Coils: Hydronic Coil, as noted on equipment schedule, shall be factory installed on the discharge outlet of the variable air volume terminal unit. Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve. Supply and return water connections shall be on the same side of the coil.
 - F. Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:
 1. Damper Actuator: 24 V, powered closed, power open.
 2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Ability to control automatic temperature control valve to maintain room set point and discharge air set point.
 - e. Communication with temperature-control system specified in Section 230900 "HVAC Instrumentation and Controls."
 3. Room Sensor: Refer to specification 230900.
 4. Control Transformer: Provide factory-installed 50-VA transformer in an enclosure with 7/8-inch knockouts for 24 VAC controls.
 - G. Control Sequence:
 1. Refer to specification 230993 "Sequence of Operations for HVAC Controls."
- 2.3 SERIES FAN-POWERED AIR TERMINAL UNITS WITH INTEGRAL HEATING COILS
- A. Manufacturers: Subject to compliance with requirements, provide a comparable product by one of the following:
 1. Trane.
 2. Environmental Technologies, Inc.
 3. Krueger.
 4. Price.
 5. Nailor.
 6. Or approved equivalent.

- B. Configuration: Volume-damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud for installation above a ceiling.
 - 1. Designed for quiet operation.
 - 2. Low-profile design.
- C. Casing: 0.040-inch thick galvanized steel, single wall.
 - 1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner. Comply with UL181 and ASTM E84.
 - 2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
 - 3. Air Outlet: S-slip and drive connections.
 - 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
 - 5. Fan: Forward-curved centrifugal.
 - 6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
 - 2. Damper Position: Normally open.
 - 3. Visual position indicator etched into the end of damper shaft.
- E. Velocity Sensors: Multipoint array with velocity sensors in air inlets and air outlets.
- F. Motor:
 - 1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 2. Type: Electronically commutated motor.
 - 3. Fan-Motor Assembly Isolation: Rubber isolators.
 - 4. Enclosure: Open drip proof or Totally enclosed, fan cooled
 - 5. Enclosure Materials: Cast iron, Cast aluminum or Rolled steel.
 - 6. Efficiency: Premium efficient.
 - 7. Motor Speed: Multispeed.
 - a. Speed Control: Infinitely adjustable with electronic controls.
- G. Filters:
 - 1. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
 - 2. Material: Pleated; MERV 8 in filter plenum with return air connection.
 - 3. Thickness: 2 inches.
- H. Attenuator Section: 0.034-inch galvanized steel sheet.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- I. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.
- J. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
 2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
 3. Disconnect Switch: Factory-mounted, fuse type.
- K. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
- L. Control devices shall be compatible with temperature controls system specified in Section 230900 "HVAC Instrumentation and Controls."
1. Damper Actuator: 24 V, powered open, spring return.
 2. Thermostat: Refer to specification 230900.
 3. Terminal Unit Controller: Pressure-independent, VAV controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Division 23 Section "Instrumentation and Control for HVAC."
- M. Control Sequence:
1. Refer to specification 23 "Sequence of Operations for HVAC Controls."

2.4 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Steel Cables: Galvanized steel complying with ASTM A 603.

- D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- E. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- F. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.
- G. Vibration Isolation: For Fan-Powered Boxes, refer to Section 230548 "Vibration Isolation and Wind Load Restraints for HVAC Components."

2.5 SOURCE QUALITY CONTROL

- A. Factory Tests: Test assembled air terminal units according to ARI 880.
 - 1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install variable air volume terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
- B. Install variable air volume terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
- C. Install wall-mounted thermostats in locations as indicated on plan. Contractor is responsible to patch and paint to match existing conditions for any existing wall area that is not covered by the new thermostat.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.

5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Section 232113 "Hydronic Piping" and connect heating coils to supply with shutoff valve, strainer, and union or flange; and to return with balancing valve, control valve and union or flange. Refer to mechanical detail sheets for final valve arrangement for heating coil hook-ups.

C. Connect ducts to air terminal units according to Section 233113 "Metal Ducts."

D. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.

2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Air terminal unit will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Verify that inlet duct connections are as recommended by variable air volume terminal unit manufacturer to achieve proper performance.
 3. Verify that controls and control enclosure are accessible.
 4. Verify that control connections are complete.
 5. Verify that nameplate and identification tag are visible.
 6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units in accordance with Section 01820.

END OF SECTION 233600