**SECTION 23 36 00**

**AIR TERMINAL UNITS**

**BASED ON DFD MASTER SPECIFICATION DATED 7/11/2023**

***This section has been written to cover most (but not all) situations that you will encounter. Depending on the requirements of your specific project, you may have to add material, delete items, or modify what is currently written. The Division of Facilities Development expects changes and comments from you.***

**PART 1 - GENERAL**

**SCOPE**

This section includes specifications for air terminal equipment. Included are the following topics:

PART 1 - GENERAL

Scope

Related Work

Reference

Reference Standards

Quality Assurance

Shop Drawings

Operation and Maintenance Data

Design Criteria

PART 2 - PRODUCTS

Supply Air Terminal Boxes

Exhaust/Return Air Terminals

Venturi Air Valves

Terminal Air Box/Venturi Air Valve Controls

Access Doors

Insulation

Control Enclosures

PART 3 - EXECUTION

Installation

Adjusting

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Agency Training

**RELATED WORK**

Section 01 91 01 or 01 91 02 – Commissioning Process

Section 23 08 00 – Commissioning of HVAC

Section 23 09 14 - Pneumatic and Electric Instrumentation and Control Devices for HVAC

Section 23 09 93 – Sequence of Operation for HVAC Controls

Section 23 31 00 - HVAC Ducts and Casings

Section 23 33 00 - Air Duct Accessories

Section 23 82 00 - Convection Heating and Cooling Units

**REFERENCE**

Applicable provisions of Division 1 govern work under this section.

**REFERENCE STANDARDS**

NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

UL 181 - Factory-Made Air Ducts and Connectors.

ARI-ADC Standard 880

ASTM E84 – Surface Burning Characteristics of Building Materials

UL 723 – Surface Burning Characteristics of Building Materials

**QUALITY ASSURANCE**

Refer to division 1, General Conditions, Equals and Substitutions.

**SHOP DRAWINGS**

Refer to division 1, General Conditions, Submittals.

Contractor shall submit air terminal unit data including materials of construction, dimensions, scheduled flow rates, pressure drops, radiated and discharge sound power levels, reset volume controller data, actuator spring range and torque data.

# **OPERATION AND MAINTENANCE DATA**

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

***Delete the following if there are no additional requirements.***

In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. ***[A/E and commissioning provider to define detailed operation and maintenance data requirements for equipment specifications added to this section.]***

**DESIGN CRITERIA**

Select sizes, capacities, configuration, and operating characteristics as shown on the plans and/or as scheduled.

**PART 2 - PRODUCTS**

**SUPPLY AIR TERMINAL BOXES**

Units shall be single duct and pressure independent.

MANUFACTURERS:

Carnes, Envirotec, Greenheck, Metal-Aire, Nailor, Price, Titus, Trane, or equal.

CONSTRUCTION:

Unit casing shall be minimum 22 gauge steel and internally insulated with 13/16” rigid fiberglass insulation with a foil scrim face or ¾” thick polyolefin closed cell insulation. Construction to meet UL 181 and NFPA 90A. Casing shall be sealed to limit leakage to a maximum of 15 cfm at 6.0 inches of static pressure. Casing outlet shall have slip and drive joint for connection to discharge ductwork.

Metal damper blade shall be mounted to shaft having self-lubricated bearings. Shaft end shall be marked to indicate damper position and shall have a built-in stop to prevent overstroking. Damper blade shall close off against gasket to limit leakage to 10 cfm at 6.0 inches of differential static pressure. Damper linkage shall be sized to accept at least 40 inch-pounds of torque to the damper shaft. Damper shaft shall be provided with a marking indicating damper position.

Round inlet collar shall be equipped with a multi-point flow sensor that shall amplify the measured velocity pressure. Pneumatic tubing from flow sensor to differential pressure transducer shall be UL listed, fire retardant (FR) type.

HOT WATER REHEAT COIL**:**

Reference section 23 82 00 for hot water reheat coil specifications.

For hot water coils factory mounted, provide a 12” to 18” casing extension, complete with access panel as specified below between the manufacturer’s standard casing termination and the hot water reheat coil

**EXHAUST/RETURN AIR TERMINALS (BUTTERFLY TYPE)**

***List the required type (Butterfly/Venturi) on the Lab Air Terminal Devices Schedule.***

Units shall be single duct and pressure independent.

MANUFACTURERS:

Carnes, Envirotec, Greenheck, Metal-Aire, Nailor, Price, Titus, Trane, or equal.

CONSTRUCTION:

EXHAUST/RETURN AIR TERMINALS

Round duct assembly and damper shall be constructed from a minimum of 22 gauge galvanized steel. Construction to meet UL 181 and NFPA 90A. Casing shall be sealed to limit leakage to a maximum of 15 cfm at 6.0 inches of static pressure.

Galvanized steel damper blade shall be mounted to shaft having self-lubricated bearings. Shaft end shall be marked to indicate damper position and shall have a built-in stop to prevent overstroking. Damper blade shall close off against a gasket to limit leakage to 10 cfm at 6.0 inches of differential static pressure. Damper linkage shall be sized to accept at least 40 inch-pounds of torque to the damper shaft. Damper shaft shall be provided with a marking indicating damper position.

The round duct assembly shall be equipped with a multi-point flow sensor that shall amplify the measured velocity pressure. Pneumatic tubing from flow sensor to differential pressure transducer shall be UL listed, fire retardant (FR) type. The multi-point flow sensor shall be able to be readily removed for servicing and replacement from the upstream access door.

FUME EXHAUST

Round duct assembly shall be constructed from a minimum of 24 gauge stainless steel and damper blade constructed from a minimum of 22 gauge stainless steel. Construction to meet UL 181 and NFPA 90A. Casing shall be sealed to limit leakage to a maximum of 15 cfm at 6.0 inches of static pressure.

Stainless steel damper blade shall be mounted to a stainless steel shaft having self-lubricated bearings. Shaft end shall be marked to indicate damper position and shall have a built-in stop to prevent over stroking. Damper blade shall close off against a butyl gasket to limit leakage to 10 cfm at 6.0 inches of differential static pressure. Damper linkage shall be sized to accept at least 40 inch-pounds of torque to the damper shaft. Damper shaft shall be provided with a marking indicating damper position.

The round duct assembly shall be equipped with a stainless steel multi-point flow sensor that shall amplify the measured velocity pressure. Pneumatic tubing from flow sensor to differential pressure transducer shall be UL listed, fire retardant (FR) type. The multi-point flow sensor shall be able to be readily removed for servicing and replacement from the upstream access door.

***List the required construction on the Lab Air Terminal Devices Schedule. Each butterfly valve’s construction must be clearly labeled.***

**VENTURI AIR VALVES**

***List the required type (Butterfly/Venturi) on the Lab Air Terminal Devices Schedule.***

Factory calibrated, pressure independent venture type valve for constant volume or variable volume applications.

MANUFACTURERS:

Phoenix Corp., Price Critical Controls, Rosemax, Siemens – Landis, TSI, or equal

CONSTRUCTION:

SUPPLY AND GENERAL EXHAUST CONSTRUCTION

Valve body and cone shall be 16 gauge spun aluminum or 316 stainless steel with internal components of aluminum or stainless steel. Valve body ends shall have slip connections. Control valve shall be mounted to a 316 stainless steel shaft on Teflon bearings.

The pressure independent spring shall be stainless steel.

FUME EXHAUST CONSTRUCTION

Valve body and cone shall be 16 gauge, 316 stainless steel. Valve body ends shall have slip connections. Control valve shall be mounted to a 316 stainless steel shaft on Teflon bearings. The pressure independent spring shall be stainless steel. The shaft support brackets, pivot arm, internal mounting link, nuts, bolts, and rivets shall be constructed from 316 stainless steel. As an option the valve body may be constructed from 16 gauge spun aluminum and be completely coated with factory applied baked Heresite.

ACID EXHAUST CONSTRUCTION

Valve body and cone shall be 16 gauge spun aluminum or 316 stainless steel. Valve body ends shall have flanged connections. Control valve shall be mounted to a 316 stainless steel shaft on Teflon bearings. The pressure independent spring shall be stainless steel. The shaft support brackets, pivot arm, internal mounting link, nuts, bolts, and rivets shall be constructed from 316 stainless steel.

The valve body, valve cone, internal components and housing shall be completely coated with factory applied baked Heresite. Exposed aluminum or stainless steel shall be completely covered with Heresite. Exposed aluminum or stainless steel valve body, valve cone, internal components and housing are not allowed.

***List the required construction on the Lab Air Terminal Devices Schedule. Each venturi air valve’s construction must be clearly labeled.***

PEFORMANCE:

Valve shall be pressure independent without means of external control devices. Calibrated spring shall maintain a cfm setting within +/- 5% over a calibrated range of [0.6 – 3.0 inches w.c.] or [.3 – 3.0 inches w.c.] duct pressure range. Valve shall be capable of 16:1 turndown ratio. Valve shall be capable of 100% shutoff where noted on the drawings.

**TERMINAL AIR BOX/VENTURI AIR VALVE CONTROLS**

DDC CONTROLS:

BUTTERFLY DAMPER TERMINAL AIR BOX

Damper actuator and differential pressure sensor for flow measurement shall be provided with the DDC controller provided for the terminal air box as specified under Section 23 09 23, 23 09 24, or 23 09 25.

VENTURI AIR VALVE

***Select one or more of the following specifications for actuators to meet the performance requirements for the application the venturi air valve will be used in. Indicate in the terminal unit schedule the type of actuation required.***

Fume Hood Actuation (High Speed): Provide a damper actuator and all required linkages provided and mounted by the manufacturer. Actuator shall be high speed with a maximum of a 2.5 second response time for a 90º rotation. Size operators for smooth and positive operation of devices served, and with sufficient torque capacity to provide tight shutoff against system temperatures and pressure encountered. All electric actuators will be provided with overload protection to prevent motor from damage when stall condition is encountered. Actuator shall use 24VAC power.

For modulating applications, signal input to the actuator shall be 0-10VDC, 2-10VDC, or 4-20mA to match requirements of the DDC controller. Provide a factory mounted feedback device that measures the valve position and provides an electronic signal that is linear to the flow of the valve. The actuator shall be directly controlled by the DDC controller provided under Section 23 09 23 or 23 09 24.

Low Speed Actuation: Provide a damper actuator and all required linkages provided and mounted by the manufacturer. Actuator shall be low speed with a maximum of a 110 second response time for a 90º rotation. Size operators for smooth and positive operation of devices served, and with sufficient torque capacity to provide tight shutoff against system temperatures and pressure encountered. All electric actuators will be provided with overload protection to prevent motor from damage when stall condition is encountered. Actuator shall use 24VAC power.

For modulating applications, signal input shall be 0-10VDC, 2-10VDC, or 4-20mA to match requirements of the DDC controller. Provide a factory mounted feedback device that measures the valve position and provides an electronic signal that is linear to the flow of the valve. The actuator shall be directly controlled by the DDC controller provided under Section 23 09 23 or 23 09 24.

PNEUMATIC CONTROLS:

BUTTERFLY DAMPER TERMINAL AIR BOX

Actuator shall be furnished with a spring range meeting requirements of the sequence of operation specified in section 23 09 93. The damper actuator shall be arranged so on loss of supply air pressure the damper shall fail open.

Factory furnished pneumatic reset controller shall have a five psi reset span regardless of cfm adjustments. Air consumption of the controller shall not exceed 1.0 scfh at 20 psi. Controller shall be field selectable for direct/reverse acting operation and maximum/ minimum cfm setpoints. Controller shall have taps for high and low pressure inputs from flow sensor, 20 psi main air, thermostat input, branch output to damper actuator and gauge taps for calibration of unit.

 ***Note that the reset controller specification is based around the Krueter CSC-3011 or Titus III type controller. The Krueter series 2000 type controllers are not acceptable.***

VENTURI AIR VALVE

***Use where two-position pneumatic actuation is desired.***

Two-position Actuation (High Speed): Provide a damper actuator and all required linkages provided and mounted by the manufacturer. Actuator shall be pneumatic high speed with a maximum of a 1.5 second response time for transition from minimum to maximum valve flow positions.

**ACCESS DOORS**

STANDARD ACCESS DOORS:

Access door to be designed and constructed for the pressure class of the duct in which the door is to be installed. Doors in exposed areas shall be hinged type with cam sash lock not requiring a tool for opening and closing.  Hinges shall be steel full length continuous piano type.  Doors in concealed spaces may be secured in place with cam sash latches.  For both hinged and non hinged doors provide sufficient number of camp sash latches to provide air tight seal when door is closed. Do not use hinged doors in concealed spaces if this will restrict access.  Use minimum 1” deep 24 gauge galvanized steel double wall access doors with minimum 24 gauge galvanized steel frames.  For non-galvanized ductwork, use minimum 1” deep double wall access door with frame that shall use materials of construction identical to adjacent ductwork.  Provide double neoprene gasket that shall provide seals from the frame to the door and frame to the duct.  When access doors are installed in insulated ductwork or equipment provide insulated doors with insulation equivalent to what is provided for adjacent ductwork or equipment.  Access doors constructed with sheet metal screw fasteners or requiring a tool or object for access will not be accepted. Minimum access door size shall be 9” x 9”.

ROUND DUCT ACCESS DOORS:

For duct pressure class positive or negative up to 6 in. wg. Access doors shall be constructed from 16 gauge stainless steel for fume exhaust ducts and 16 gauge galvanized steel for general exhaust or return ducts. Hinges shall be continuous piano style constructed from the same material as the access door. Access doors shall be sealed with ¼” closed cell butyl gasketing permanently bonded on all four sides and no fewer than two draw latches with strike plates. The strike plates shall match the duct/access door material.

For duct pressure class positive or negative up to 10 in. wg. Access doors shall be the sandwich type and constructed from two layers of stamped 22 gauge stainless steel for fume exhaust ducts and 22 gauge galvanized steel for general or return ducts. Access doors shall be sealed with ¼” butyl gasketing permanently bonded to all four sides of the inside door. The bolts and springs shall be constructed from the same material as the access door. The knobs shall be constructed from polypropylene with threaded metal inserts and able to be fastened without the use of wrenches.

**INSULATION**

Materials or accessories containing asbestos will not be accepted.

Use composite insulation systems (insulation, jackets, sealants, and adhesives) that have a flame spread rating of 25 or less and smoke developed rating of 50 or less.

The following two internal insulation options may be utilized.

RIGID FIBERGLASS INSULATION:

Minimum nominal density of 3 lbs. per cu. ft., and thermal conductivity of not more than 0.23 at 75 degrees F, minimum compressive strength of 25 PSF at 10% deformation, rated for service to 450 degrees F.

Foil-scrim-kraft vapor barrier jacket, factory applied to insulation, maximum permeance of .02 perms. All exposed insulation edges shall be covered with metal nosing.

POLYOLEFIN INSULATION:

Flexible closed cell, minimum nominal density of 1.5 lbs. per cu. ft., thermal conductivity of not more than 0.24 at 75 degrees F, minimum compressive strength of 5 psi at 25% deformation, maximum water vapor permeability of 0.0 perm inch, maximum water absorption of 0% by weight and volume, rated for service range of -165 degrees F to 210 degrees F.

CONTROL ENCLOSURES

Do not provide a controls enclosure for air terminal units installed above accessible lay-in tile ceilings.

Provide a control enclosure for air terminal units installed in mechanicall rooms and all other exposed locations where not concealed by a suspended ceiling. Completely enclose the DDC controller and allow for condiut terminations. Coordinate with the Section 23 09 23 or 23 09 24 control contractor to ensure the enclosure is of sufficient size to house the controller required to control the terminal unit.

Do not conceal unit name tag information and coapacity data within the controls enclosure. Adhere such information data to the surface of the air terminal unit casing so that the information is easily visible without opening the enclosure.

**PART 3 - EXECUTION**

**INSTALLATION**

Install air terminal units as indicated on project drawings and in accordance with the manufacturer’s installation instructions.

Mount air terminal boxes with a minimum 3 feet of straight ductwork upstream of inlet flow sensor for sizes 12” diameter and below. Provide a minimum of 3X the inlet diameter of straight duct upstream of the inlet flow sensor for inlet sizes above 12” diameter.

Where hot water reheat coils are provided with air terminal boxes the following two options may be used.

Field mount coil separate from box with a 12-18” section of duct between the air terminal box and reheat coil. The reheat coil and 12-18” section of duct shall be wrapped with external insulation as indicated in specification section 23 07 00 – HVAC Insulation.

Factory mount coil in extended supply air terminal unit. The supply air terminal unit shall be extended at the factory 12-18” and internally insulated to match the insulation used for the supply air terminal unit

Provide a minimum of 36” of clearance on the controller side of the air terminal unit in front of the controller. The minimum clearance area shall extend 30” wide.

Provide 24” of clearance in front of all access doors.

Support air terminal units from building structure using sheet metal straps or trapeze hanger with rods. Do not mount air terminal units off adjacent ductwork or piping.

**ACCESS DOORS**

DUCT ACCESS DOORS – SQUARE DUCT:

Provide duct access doors in duct or extended supply air terminal unit upstream and downstream of the reheat coil. Duct access doors shall be as large as duct allows with a maximum size of 18”x18”. Install heating coils in accordance with Section 23 73 12 - Air Handling Unit Coils.

DUCT ACCESS DOORS – ROUND DUCT:

Install round duct access doors on the side of the duct upstream of the return/exhaust terminal unit. At no time shall the access door be installed in the bottom of the duct. Piano hinged style access doors shall be installed with the piano hinges located ½ above the bottom of the duct to allow the access door to swing down toward the floor.

**INSULATION**

RIGID FIBERGLASS INSULATION:

 All rigid duct insulation edges shall be covered with metal nosing. Foil scrim face must completely separate the rigid fiberglass duct material from the air stream.

POLYOLEFIN INSULATION:

Apply full cover coat of adhesive to surface to be insulated, insulation and edge butt joints. Place insulation with edge joints firmly butted pressing to surface for full adhesion. Seal seams and joints vapor tight.

For supply air terminal units, provide five feet of 1” thick lining immediately downstream from air terminal unit discharge. Where hot water reheat coils are field or factory installed, provide five feet of 1” thick lining in ductwork immediately downstream of reheat coil. Refer to specification section 23 33 00 – Air Duct Accessories for liner specification.

**LABELING**

For terminal units and venturi air valves above accessible ceilings, that is accessed above acoustical lay in ceilings or access doors, label the ceiling tile grid at the ceiling tile that is to be removed for access to the terminal unit or the access door. The label shall be pre-printed using clear polyester tape with black bold 28 size font for ceilings under 12 feet. For ceilings over 12 feet high, use bold 40 size font. For accessible ceilings, use an arrow to point at ceiling tile to be removed for access. Label shall match terminal unit and venturi air valve tag designation used on mechanical plans

**ADJUSTING**

Coordinate adjustment of air terminal units with section 23 05 93 - Testing, Adjusting and Balancing.

**CONSTRUCTION VERIFICATION**

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

**FUNCTIONAL PERFORMANCE TESTING**

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01 or 01 91 02.

# **AGENCY TRAINING**

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01 or 01 91 02.

END OF SECTION