

SECTION 23 36 16 – VARIABLE-AIR-VOLUME UNITS

PART 1: GENERAL

1.01 Section Includes

- A. Dual duct terminal units.
- B. Variable volume regulators.
- C. Integral damper motor operators.
- D. Integral controls.

1.02 Related Sections

- A. Section 23 00 00 – Heating, Ventilation and Air Conditioning (HVAC).
- B. Section 23 31 00 – HVAC Ducts and Casings.
- C. Section 23 09 53 – Pneumatic and Electric Control HVAC.
- D. Section 23 05 93 – System Preparation for Testing, Adjusting, and Balancing.
- E. Section 23 05 93.01 – System Testing, Adjusting, and Balancing.

1.03 References

- A. NFPA 90A – Installation of Air Conditioning and Ventilation Systems.
- B. UL 181 – Factory-Made Air Ducts and Connectors.
- C. ADC 1062 – Air Distribution and Control Device Test Code.
- D. ARI 880-89 – Standard for Air Terminals.

1.04 Submittals

- A. Submit shop drawings under provisions of Section 23 00 00.
- B. Submit product data under provisions of Section 23 00 00.
- C. Submit product data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings which indicate air flow, static pressure, and NC designation.
- D. Include schedules listing discharge and radiated sound power level for each of second through seventh octave bands at inlet static pressures of one inch wg.

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- E. Submit manufacturer's installation instructions under provisions of Section 23 00 00.
- F. A sample 8-inch inlet production run unit shall be submitted for examination and approval by the Architect and Owner's Testing and Balancing (TAB) Consultant. This submittal box shall be submitted, in addition to the required written submittal, well in advance of any requirement for installation of boxes, but absolutely no later than 60 days after the start of construction stipulated in the Work Order letter from the Owner to the General Contractor. A minimum of three weeks shall be allowed by the Contractor for the testing of the box from the time of submittal to the time of determination of project worthiness. This period shall restart if the sample box is rejected and another box is resubmitted. If rejected for any reason, the Contractor shall expedite the corrections documented, and shall resubmit a sample box as soon as possible. Any delay in the submittal of the box for approval shall not be grounds for a claim of delay of the part of the Contractor. If approved, the unit shall remain in the possession of the Owner at the job site for comparison with units as shipped to the project. The unit shall be installed in the project, at an accessible, marked location to allow access to bottom, left, and right sides of terminal unit. The unit manufacturer shall provide test from an independent agency certifying that each box used on this project has been tested as specified.

1.05 Operation and Maintenance Data

- A. Submit operation and maintenance data under provisions of Section 23 00 00.
- B. Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts list.

1.06 Qualifications

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

1.07 WARRANTY

- A. Provide one year manufacturer's warranty under provisions of Section 23 00 00.

PART 2: PRODUCTS

2.01 Variable Volume Terminal Unit

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- A. The Contractor shall furnish and install pressure independent dual duct variable air volume control assemblies with attenuator-mixers (dual duct units), of the sizes, capacities, and configurations shown on the Drawings.

- B. Casing Construction.
 - 1. The units shall be constructed of a minimum of 22 gage galvanized steel and internally lined with a minimum of 1-inch thick, three pound per cubic foot density insulation. The insulation shall be foil faced with the edges and seams sealed or “captured” using sheet metal, encapsulating all fibers of the insulation. The insulation shall be neatly installed with no rough edges to interrupt the smooth flow of air through the box. The casing shall be insulated throughout its interior.

 - 2. All interior features of the boxes (such as mixing baffles, damper housing, etc.) shall be secured within the casing to avoid excessive movements or rattling with air movement to avoid externally terminal units shall be designed not to extend beyond the ends of the unit. (For example, the actuator mounting brackets, etc., shall not extend beyond the plane of the inlet “bulkhead.”) The only exception shall be flow sensors installed in the inlet duct connections. Note that if a separate flow station is installed within the frame within the casing, then it shall be so installed not to allow air flow to bypass the flow measurement station.

 - 3. The terminal units shall be constructed with inlet and discharge ductwork connections. The inlet ductwork connections shall extend a minimum of 4 inches from the unit casing including an allowance for the installation of air flow station (s) or probe (s). The discharge connection shall include 1” extension with slip and drive connections for use by the contractor to secure the discharge ductwork or appurtenances to the unit and shall be reinforced to provide a rigid assembly.

- C. Casing Leakage. Assembled units shall be so constructed and sealed to limit air leakage to the following listed quantities at 6” static pressure. Leakage curves or tables will be required as part of the submittal data. The following is the maximum allowable casing leakage including all components:

Diameter	Maximum Allowed CFM (Area x 2000 fpm)	Maximum Allowable CFM Damper Leakage
4” – 6”	393	8.0
7” – 8”	698	14.0
9” – 10”	1091	22.0
11” – 12”	1571	30.0
13” – 14”	2138	40.0

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- D. Damper Construction. The damper blades shall be an equivalent of 18 gage galvanized steel aluminum and shall be securely riveted or bolted through the damper shafts to assure no slippage of the blades. The damper shafts shall operate in rust-proof self-lubricating bearings. Damper shafts penetrating the unit casings shall be sealed against leakage, and bearings shall be installed for protection against wear in the casing penetration. Damper shafts shall be formed of, or cut from solid stock; no hollow shafts will be allowed. The dampers shall seat against gasketed stops or the dampers shall have gasketed edges. Dampers shall be secured to the blades with adhesive and shall be so constructed to prevent “oil canning” of the damper blade. The units shall be tested for leakage in both inlets with 6” static pressure imposed on one inlet at a time. The maximum percent leakage from all tests shall be reported. Leakage curves as a function of pressure shall be supplied as part of the submittal data. The damper actuator linkage, if used, shall be constructed of material of sufficient strength to avoid bucking under extreme loads. Also, linkages shall not allow play greater than 5 degrees of damper movement. The controls for the dampers shall cause the dampers to fail in the position of last control (freeze in place) or fail to the open position.
- E. Damper Leakage. The following is the maximum damper leakage allowable for the various size diameter inlets at 6” w.g. differential pressure. The damper leakage shall not exceed the values listed in the table below at 6” S.P., following ARI 880 Testing Procedures.

Diameter	Maximum Allowed CFM (Area x 2000 fpm)	Maximum Allowable CFM Damper Leakage
4” – 6”	393	6.0
7” – 8”	698	10.5
9” – 10”	1091	16.5
11” – 12”	1571	20.0
13” – 14”	2138	30.0

- F. Unit Pressure drop. For dual duct units with an integral attenuator-mixer, but with no other accessories, the static pressure across the assembly with an equivalent 2000 fpm inlet velocity through one inlet shall not exceed 0.50 inches water gage, with the total flow through either inlet.
- G. Certification. The Unit Manufacturer shall certify that each unit used on this project will perform as specified. Each unit shall bear a tag or decal listing the following specified information:
1. Test pressure.
 2. Leakage CFM (damper).

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3. Leakage CFM (casing).
 4. Date of manufacture.
 5. Room or area served.
 6. Unit size – 6”, 8”, etc.
 7. Calibrated CFM, i.e. 800 CFM.
- H. **Mixing.** Dual duct terminal units as specified herein shall provide mixing within the units, and not rely upon the discharge ductwork to provide for the completion of the mixing process. The horizontal average temperature of the air as it leaves the terminal unit shall not vary more than 1°F for each 20°F of temperature difference between the two inlet air supplies. (For example, if the cold supply air is 55°F and the hot supply air is 95°F, the difference is 40 degrees. The allowable temperature variation of the discharge air is, thus, 2°). The temperature of the discharge air shall be measured using a pattern of four vertical, evenly spaced columns, and three horizontal, evenly spaced rows. The rows and columns shall be spaced so that the resulting 12 points shall be at the centers of equal areas. The plan of the points shall be perpendicular to the direction of air flow, within 4 inches of the discharge of the terminal unit, within the discharge ductwork. The three readings in each column shall be averaged to determine compliance with the 1°F criteria.
- I. **Flow Measurement.** Air flow through the unit shall be accomplished by the use of a multi-port sensing device with a minimum of four radially distributed pick-up points connected to a center averaging chamber with adequate internal passages to prevent restrictions that can result in control “hunting”. On VAV systems, sensors shall be mounted in the each supply duct connection. On constant volume dual duct systems, one sensor shall be mounted in the cold duct and one sensor shall be mounted in the box discharge.
- J. **Sound.** (Note that the maximum sound levels listed in this paragraph refer to raw sound levels, with no credits taken for the construction.)
1. **Discharge Sound.** Maximum discharge Sound Power Levels at 2000 fpm primary inlet velocity with 1.5 inch w.g. inlet static pressure shall not exceed that listed in the following table. No credit for lined discharge duct, branching, flow division, and reflection, room absorption or any other effects shall be allowed.

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Center Frequency Octave Band	(Hz)	Sound Power Level (dB re 10-12 Watts)
2	125	76
3	250	66
4	500	63
5	1000	58
6	2000	60
7	4000	55

2. All sound power levels shall be obtained from testing in accordance with ARI-ADC Standard 880 and shall be certified at ARI-880 certification points.

K. Testing Prior to Installation.

1. **Shipment Testing.** A minimum of ten percent (10%) of each size of the terminal units (but no less than one unit of each size used) may be tested for conformance to this Specification, at the Owner’s discretion. The Contractor shall allow sufficient time during construction and space for the Owner’s TAB Consultant to perform all testing as may be required.
2. **Unit Non-Performance.**
 - a. If the results of the Shipment Testing show that any of the units do not perform as specified, then an additional ten percent (10%) of each size (but no less than one unit of a size, unless 100% of the size has been tested) of the units shall be tested. If this testing, in the Owner’s opinion, shows that ten percent (10%) or more of the units tested do not perform as specified, and then one hundred percent (100%) of all sizes shall be tested for conformance with these Specifications. The results of that testing shall be reviewed carefully between the Contractor, manufacturer, the Owner’s Construction Administrator(s), and the Owner’s Design Engineer(s). A method of repair or replacing the units will be negotiated. The Owner, however, shall maintain the right of final approval of any proposed solution.
 - b. Should for any reason the testing described above under “Submittal” and “Shipment Testing” prove that any of the units do not perform as specified, the Contractor shall be responsible for all subsequent labor, travel, travel expenses, and incidental expenses, penalties, or other costs attendant to any additional testing as

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described under “Unit Non-Conformance”, or as required to prove that the units perform as specified. This shall include, but not be limited to the labor, travel, and reasonable incidental expenses of not only the Contractor and Owner’s TAB Consultant, but also those incurred by the Owner as may be specifically required for this purpose. The expenses to be reimbursed to the Owner shall be labor at a rate of \$300 per day or any portion of a day, plus travel and travel expenses at actual cost, plus reasonable incidental expenses at actual cost.

- L. Manufacturer. All Terminal Units shall be manufactured by Titus (Model MDV-3100-UT or MDC-3100-UT), Metal*Aire (Series 400DDUT), or Naylor-Hart 3000-UT or 3200-UT. *Note that the model and series numbers listed may differ slightly from catalogue information.* No other manufacturers or models are acceptable. Even though specific manufacturers may be named herein, the material supplied by any approved manufacturer shall meet all of the provisions of this specification without exception.
- M. General Performance. Devices using mechanical CFM limiters will not be accepted, nor shall it be necessary to change control components to make airflow rate changes. If used, DDC flow stations shall be furnished, mounted and adjusted by the terminal unit assembly manufacturer to assure their proper placement within the units. If DDC controls of another manufacturer (NOT the terminal unit manufacturer) are provided for this project, the terminal unit manufacturer shall be responsible only for the construction of the terminal unit and the installation of internal control components installed at the manufacturer’s factory, and shall not be responsible for the installation of controls not installed at the terminal unit manufacturers factory, nor shall the manufacturer be responsible for the performance of the DDC controls. The performance of DDC controls, especially in connection with the terminal units, shall be the responsibility of the DDC controls manufacturer.
- N. Control Performance. Assemblies shall be able to be reset to any airflow between minimum and the maximum cfm shown on Drawings. To allow for maximum flexibility and future changes, it shall be necessary to make only simple screwdriver or keyboard adjustments to arrange each unit for any maximum air flow within the ranges for each inlet size as scheduled on the Drawings. The control devices shall be designed to maintain the desired flow regardless of inlet flow deflection. (All terminal units shall be installed with a minimum of three diameters of straight duct directly prior to the entry into each terminal unit connection.)
- O. Control Sequences. The control sequence arrangement shall be as described on the Drawings; and the terminal units shall be shipped from the manufacturer with

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all necessary control devices to accomplish each sequence, except as may be prohibited by the controls manufacturer. The desired sequence shall be adjustable according to space usage or a change in space conditions. Separate maximum CFM values for hot and cold ducts with zero minimum flow values for both hot and cold ducts, with adjustable mixing of hot and cold air flow to allow for adjustable minimum total air flow from the terminal unit.

P. DDC Systems.

1. Electronic motors and controllers shall be furnished by temperature control contractor and installed by the terminal unit manufacturer. The controls manufacturer shall be responsible for the installation of the controls. The controls manufacturer shall be responsible for the operational performance of the entire system. The terminal unit manufacturer shall remain responsible only for the performance of the mechanical components of the unit. The box manufacturer shall provide a unit mounted 120 volt toggle switch and six foot cord with cap for each terminal unit for control power shut-down.
2. A temperature sensor will be installed on the discharge side of all VAV Boxes.

PART 3: EXECUTION

2.01 Installation

- A. Refer also to requirements included in Part 2 of this Specification.
- B. Install in accordance with manufacturer's instructions.
- C. Provide ceiling access doors or located units above easily removable ceiling components.
- D. Support units individually from structure. Do not support from ductwork.
- E. Connect to ductwork in accordance with Section 23 31 00.

END OF SECTION 23 36 16