STANDARD

ASHRAE®

ANSI/ASHRAE Standard 130-2016
(Supersedes ANSI/ASHRAE Standard 130-2008)

Laboratory Methods of Testing Air Terminal Units

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ANSI/ASHRAE Standard 130-2016,
Laboratory Methods of Testing Air Terminal Units

NOTE

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FOREWORD

First published in 1996 and reaffirmed in 2006, Standard 130 specifies instrumentation, test installation methods, and procedures for determining the capacity and related performance in a laboratory controlled environment of constant-volume and variable-volume air terminal units. The standard is classified as an ASHRAE standard method of measurement. This standard is required for compliance with AHRI Standard 880.

The 2016 revision of the standard includes updates and revisions to all parts of the standard, including its title, purpose, and scope. It updates definitions, redefines airflow sensor performance testing, and adds a method to determine terminal-unit total pressure loss coefficients and the relationship between terminal-unit casing leakage and pressure.

1. PURPOSE

The standard specifies instrumentation, test installation methods, and procedures for measuring the capacity and related performance of constant-volume, variable-volume, and modulating integral diffuser air terminals.

2. SCOPE

2.1 The methods of test in this standard apply to air control devices used in air distribution systems. These devices provide control of air volume with or without temperature by one or more of the following means and may or may not include a fan:

a. Fixed or adjustable directional vanes (i.e., bypass terminal)
b. Pressure-dependent volume dampers or valves (including air induction nozzles and dampers)
c. Pressure-independent volume dampers or valves (including air induction nozzles and dampers)
d. Integral heat exchanger
e. On/off fan control
f. Variable-speed fan control
g. Modulating integral diffuser terminals

2.2 This standard covers test methods for use in determining the following performance characteristics:

a. Sound power
b. Temperature mixing and stratification
c. Minimum operating pressure
d. Air leakage
e. Induced airflow
f. Fan airflow
g. Fan motor electrical power
h. Condensation
i. Airflow sensor performance

2.3 This standard shall not be used for field testing.

3. DEFINITIONS AND SYMBOLS

3.1 Definitions

accuracy: degree of conformity of an indicated value to an accepted standard value, or true value. The degree of inaccuracy is known as "total measurement error" and is the sum of bias error and precision error.

acoustically isolated duct: ductwork for which, in all frequency bands of interest, the breakout sound level is at least 10 dB less than the transmitted sound level of the terminal unit under test. Refer to Informative Appendix G for a detail of an acoustically isolated duct.

air terminal unit: device that automatically modulates the volume of air delivered to or removed from a defined space.

amplification factor (F): ratio of sensor output (p_{sensor}) to velocity pressure (p_v) as defined by Equation 1:

$$F = \frac{p_{sensor}}{p_v} \tag{1}$$

where

F = amplification factor, dimensionless

P_{sensor} = sensor output, in. of water (Pa)

p_v = velocity pressure at sensor location, in. of water (Pa)

Example: a sensor with a reading of 1.0 in. of water (250 Pa) pressure at a velocity pressure of 0.43 in. of water (108 Pa) has an amplification factor of 2.3.

bias error: difference between the true value to be measured and the indicated value from the measuring system that persists and is usually due to the particular instrument or technique of measurement.

bypass terminal unit: a terminal unit, typically having more than one outlet, that uses a method of volume modulation whereby airflow is varied by distributing the volume required to meet the space requirements, the balance of supply/exhaust air being diverted away from the space.

discharge sound power level: sound power that is transmitted from the terminal outlet.

dual-duct terminal unit: air terminal that mixes varying portions of two independent sources of primary air.

equivalent diameter: diameter of a circular-duct equivalent that has a cross-sectional area equal to a particular rectangular duct. Equivalent diameter is calculated by the following equation:

$$D_e = \left(\frac{4A}{\pi}\right)^{0.5} \tag{2}$$

exhaust sound power level: sound power that is transmitted from an exhaust terminal inlet back to the room (counter to the airflow).

exhaust terminal unit: terminal unit for regulating exhaust or return airflow.

exhaust terminal-unit total leakage: total amount of the air in cubic feet per minute (litres per second) drawn through the casing and a fully closed damper/valve into the airstream of an exhaust terminal unit at a given outlet pressure.

fan-powered terminal unit

> ***parallel-flow fan-powered terminal unit:*** a type of induction terminal unit in which the primary air inlet is in parallel to an integral fan, thus allowing the supply air to bypass the fan. The fan induces air from the induction port.
>
> ***series-flow fan-powered terminal unit:*** a type of induction terminal unit where the primary air inlet is in series with an integral fan, and where all air flows through the fan.

fan-powered terminal unit efficiency: ratio of the total power consumed to delivered fan air volume.

flow coefficient (K): the flow coefficient of terminal units is calculated from test data by Equation 3.

$$K = \frac{Q}{p_{sensor}^{0.5}} \tag{3}$$

where

K = flow coefficient, cfm per (in. of water)$^{0.5}$ [L/s per Pa$^{0.5}$]

Q = actual terminal-unit airflow, cfm (L/s)

p_{sensor} = sensor output, in. of water (Pa)

induced airflow: air that is drawn into a terminal by means of induction and discharged through the terminal outlet

induction terminal unit: a terminal unit, typically having more than one inlet, that supplies varying proportions of primary and induced air. This type of terminal excludes fan-powered terminal units.

integral diffuser air terminal: diffuser with the features of an air terminal. Air is modulated by outlet or inlet dampers.

loss coefficient: a dimensionless fluid resistance coefficient having the same value in dynamically similar streams (i.e., streams with geometrically similar stretches, equal Reynolds numbers, and equal values of other criteria necessary for dynamic similarity). The loss coefficient represents the ratio of total pressure loss to velocity pressure at the referenced cross section:

$$C = \frac{\Delta p_t}{p_{vi}} \tag{4}$$

where

C = total pressure loss coefficient, dimensionless

Δp_t = total pressure loss, in. of water (Pa)

p_{vi} = velocity pressure at referenced cross section i, in. of water (Pa)

minimum operating pressure: the static or total pressure drop through a terminal at a given airflow rate with the damper/valve placed in its full-open position by its actuator while the terminal is operating under steady-state control.

TABLE 1 Upper, Lower, and Center Frequencies for the Preferred Series Of Octave and One-Third Octave Bands

Octave Band	Octave Bands, Hz	One-Third Octave Bands, Hz		
		Lower	Center (f)	Upper
1	63	45	50	56
		56	63	71
		71	80	90
2	125	90	100	112
		112	125	140
		140	160	180
3	250	180	200	224
		224	250	280
		280	315	355
4	500	355	400	450
		450	500	560
		560	630	710
5	1000	710	800	900
		900	1000	1200
		1200	1250	1400
6	2000	1400	1600	1800
		1800	2000	2240
		2240	2500	2800
7	4000	2800	3150	3550
		3550	4000	4500
		4500	5000	5600
8	8000	5600	6300	7100
		7100	8000	9000
		9000	10,000	11,200

modulating diffuser terminal unit: diffuser with features of an air terminal unit and with an integral airflow control device.

octave band: a frequency band with an upper frequency limit twice that of its lower frequency limit. Octave and one-third octave bands are identified by their center frequencies, which are the geometric means of the upper and lower band limits: $f_c = \sqrt{f_{upper} \times f_{lower}}$. Three one-third octave bands make up one octave band. Table 1 lists the upper, lower, and center frequencies for the preferred series of octave and one-third octave bands.

precision**:** the closeness of agreement among repeated measurements of the same characteristic by the same method under the same conditions.

pressure-compensating control system: see *pressure-independent control system*.

pressure-dependent control system: a control system in which the airflow through the air terminal varies with system pressure.

pressure-independent control system: control system in which the airflow through the air terminal is independent of system pressure. Also known as "pressure-compensated."

primary air: treated supply air to a terminal unit.

quiet air: condition in which the sound power level introduced in the frequency band of interest by the air supply alone is at least 10 dB lower than the measured sound power level generated by the air supply and the air terminal under test.

radiated sound power level: sound power that radiates from terminal casings and induction ports for induction terminal units.

reheat: the application of sensible heat to supply air that has been previously cooled below the temperature desired for maintaining the temperature of the conditioned space.

resolution: smallest change in input that produces a detectable change in instrument output.

single-duct terminal unit: a terminal unit supplied with one source of supply/exhaust air. This type of terminal excludes fan-powered terminal units.

sound power level (L_w): a level of sound power that is ten times the logarithm to the base 10 of the ratio of the sound power generated by the source to a reference sound power. The reference sound power is 10^{-12} W.

standard air: air that has a mass density of 0.075 lb_m/ft^3 (1.204 kg/m^3).

static pressure: in fluid flow, the actual pressure of the fluid, which is associated not with its motion but with its state. The pressure is exerted uniformly throughout the entire fluid. The portion of fluid pressure that exists by virtue of the degree of compression only. If expressed as gage pressure, it may be negative or positive. In a dynamic system, static pressure is the difference between total and velocity pressures in inches of water (kilopascals).

terminal-unit casing leakage: air in cubic feet per minute (litres per second) leaking from a terminal unit at a given inlet pressure with the outlets and inlets blocked and with the damper/valve fully opened.

terminal-unit damper leakage: air in cubic feet per minute (litres per second) leaking through a fully closed damper/valve of a supply/exhaust terminal unit at a given inlet/discharge pressure.

thermal equilibrium: less than 1°F (0.5°C) change over a five-minute period.

total pressure: in fluid flow, the pressure that exists by virtue of the degree of compression and the rate of motion. It is the algebraic sum of the velocity pressure and the static pressure at a point (Equation 5). Thus, if the fluid is at rest, the total pressure will equal the static pressure.

$$p_t = p_s + p_v \quad (5)$$

uncertainty: measure of potential error in a measurement that reflects the lack of confidence in the result to a specified level.

velocity pressure: the kinetic energy per unit volume of a fluid particle. Static pressure is the actual thermodynamic pressure (force/area) that would be sensed if a probe moved along with the fluid flow, and is equal in all directions if the fluid is not moving. The velocity pressure (also called "dynamic pressure") is the additional pressure that would be sensed if the flow was brought to rest isentropically, i.e., without friction or heat transfer. In that sense, the dynamic pressure is equal to the difference between the stagnation pressure and the static pressure. Velocity pressure is a function of air density and velocity, expressed as follows:

$$p_v = \rho\left(\frac{V}{1097}\right)^2 \quad \text{(6 I-P)}$$

$$p_v = \frac{\rho V^2}{2} \quad \text{(6 SI)}$$

3.2 Symbols and Subscripts

3.2.1 Symbols

Symbol	Description	Units
A	Duct area	f^2 (m^2)
A_n	Orifice area	ft^2 (m^2)
C	Total pressure loss coefficient	Dimensionless
C_n	Nozzle discharge coefficient	Dimensionless
D_e	Equivalent diameter	ft (mm)
f	One-third octave band center frequency	Hz
$\dot{m}$	Mass flow rate	lb_m/s (kg/s)
p_b	Barometric pressure	in. Hg (kPa)
p_e	Saturated vapor pressure at wet-bulb temperature (t')	in. Hg (kPa)
p_p	Partial vapor pressure	in. Hg (kPa)
p_s	Static pressure	in. of water (Pa)
p_t	Total pressure	in. of water (Pa)
p_v	Velocity pressure	in. of water (Pa)
Q	Volume flow rate	cfm (L/s)
Q_{leak}	Damper or casing leakage	cfm (L/s)
t	Dry-bulb temperature	°F (°C)
t'	Wet-bulb temperature	°F (°C)
V	Velocity	ft/min (m/s)
Y_n	Nozzle expansion factor	Dimensionless
Δp_s	Static pressure loss	in. of water (Pa)
Δp_t	Total pressure loss	in. of water (Pa)
$\Delta p_{s,5-6}$	Static pressure differential across nozzle	in. of water (Pa)
β	Ratio of nozzle exit diameter to approach diameter	dimensionless
ρ	Air density	lb_m/ft^2 (kg/m^3)

3.2.2 Subscripts

Subscript	Description
o	Ambient
c	Cold-deck
h	Hot-deck
d	Downstream
u	Upstream
Plane 1: terminal-unit inlet	
Plane 2: terminal-unit outlet	
Plane 5: upstream of airflow measuring station nozzle	
Plane 6: downstream of airflow measuring station nozzle	
Plane 7: upstream of terminal unit	
Plane 8: downstream of terminal unit	

4. INSTRUMENTATION

4.1 Accuracy. Measurements from the instruments shall be traceable to primary or secondary standards calibrated by the National Institute of Standards and Technology (NIST) or to the Bureau International des Poids et Mesures (BIPM) if a National Metrology Institute (NMI) other than NIST is used. The indicated corrections shall be applied to meet the accuracy and precision stated in this standard. Instruments shall be calibrated on a regular schedule that is appropriate for each instrument, but in no case less than annually. Calibration records shall be maintained. Instrument accuracy and precision shall be as follows:

a. Volumetric airflows shall be measured with an instrument accuracy equal to or better than 2 cfm (1 L/s) or 3% of measured flow, whichever is larger, and with an instrument precision equal to or better than ±0.5 cfm (±0.25 L/s).
b. Temperature measurements shall be made using devices with an accuracy equal to or better than 1°F (0.5°C) and with a precision equal to or better than ±0.2°F (±0.5°C)
c. Pressures shall be measured with accuracy equal to or better than 0.004 in. of water (1 Pa) and a precision equal to or better than 0.001 in. of water (0.25 Pa).
d. Barometric pressures shall be measured with accuracy equal to or better than 0.007 in. Hg (0.25 kPa).

4.2 Airflow Measurement

4.2.1 The airflow measuring means shall meet the accuracy requirements of Section 4.1(a) and be in conformance with the single-duct nozzle in ASHRAE Standard 120[1], the multiple nozzle chamber in ASHRAE Standard 41.2[2], or the rotating vane anemometer flow measuring system shown in Normative Appendix A. Fans shall be located as shown by the test setups for each test method.

4.2.2 The single-duct nozzle in compliance with ASHRAE Standard 120[1] is considered a reference flow measuring device and therefore does not need calibration.

4.2.3 The multiple-nozzle chamber in compliance with AMCA Standard 210[3] does not need calibration. Note that the flow-settling screens' effectiveness must meet the requirements of Standard 210[3] (Normative Appendix A).

4.2.4 Leakage between the airflow measuring means and the test device shall meet the requirement of AMCA Standard 210[3], Section 5.1.3. A leakage test shall be performed prior to initial use and annually thereafter. For recommended leakage rate test procedures, consult Standard 210[2] (Informative Appendix B).

4.3 Temperature Measurement. Temperature measuring instruments shall meet the requirements of ASHRAE Standard 41.1[4] and 41.6[5].

4.3.1 Thermometers and temperature measurements shall be calibrated to traceable standards per Section 4.1.

4.4 Pressure Measurement

4.4.1 Pressure measuring instruments shall meet the requirements of ASHRAE Standard 41.3[6] and the requirements of Sections 4.4.2 and 4.4.3.

4.4.2 The minimum resolution of pressure instruments shall be 0.001 in. of water (0.25 Pa).

4.4.3 Each pressure measurement shall be calibrated to traceable standards per Section 4.1.

4.4.4 Piezometer rings in compliance with Standard 120[1] (Figure 4) shall be used to measure static pressure.

4.4.5 The barometric pressure shall be obtained by means of a barometer located in the test area.

4.5 Electrical Measurement. Electrical instruments shall have the following characteristics and accuracy:

a. Voltmeters shall be true root-mean-square (RMS), high-impedance meters with an accuracy within ±2% of reading.
b. Ammeters shall have accuracy within ±2% of reading.
c. Wattmeters shall be true RMS, high-impedance meters with an accuracy within ±2% of reading.

4.6 Acoustical Measurement. Acoustical instruments shall be in compliance with AHRI Standard 220[7].

4.6.1 Acoustical instruments shall be calibrated to traceable standards per Section 4.1.

5. TEST METHODS

5.1 Table 2 identifies tests applicable for various types of air terminals.

5.2 Terminal-Unit Minimum Operating Pressure Differential and Loss Coefficient

5.2.1 Test Purpose. This test determines the minimum operating pressure differential and total pressure loss coefficient for terminal units.

5.2.2 Test Setup

5.2.2.1 The single-duct terminal unit shall be set up as shown in Figures 1 (supply) and 2 (return/exhaust).

TABLE 2 Tests Applicable for Various Types of Air Terminals

Section	Test	Single-Duct	Induction	Bypass	Dual-Duct	Fan-Powered Series-Flow	Fan-Powered Parallel-Flow	Integral Diffuser	Modulating Diffuser	Mechanically Regulated
5.2	Terminal-Unit Minimum Operating Pressure Differential and Loss Coefficient	× Supply × Exhaust	×	×	×	×	×	×	×	—
5.3	Mechanically Regulated Terminal-Unit Minimum Operating Pressure Differential	—	—	—	—	—	—	—	—	× Supply × Exhaust
5.4	Pressure-Compensating Volume Controller Performance	×	×	×	×	×	×	×	×	×
5.5	Terminal-Unit Casing Leakage	× Supply × Exhaust	×	×	×	×	×	×	×	× Supply × Exhaust
5.6	Supply Terminal-Unit Damper/Valve Leakage	×	—	—	×	×	×	—	—	×
5.7	Exhaust Terminal-Unit Total Leakage	× exhaust	—	—	—	—	—	—	—	× Exhaust
5.8	Dynamic Leakage for Parallel-Flow Fan-Powered Terminal Units	—	—	—	—	—	×	—	—	—
5.9	Terminal-Unit Airflow Sensor Amplification Factor	×	×	×	×	×	×	—	—	—
5.10	Airflow Sensor Performance—Inlet Variations from Straight	×	×	×	×	×	×	—	—	×
5.11	Temperature Mixing	—	×	—	×	×	×	—	—	—
5.12	Temperature Stratification	×	×	×	×	×	×	—	—	×
5.13	Condensation Determination	×	×	×	×	×	×	×	×	×
5.14	Sound	×	×	×	×	×	×	×	×	×