



STANDARD

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(Supersedes ANSI/ASHRAE Standard 79-2002)

Method of Test for Fan-Coil Units

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NOTE

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FOREWORD

ASHRAE Standard 79 prescribes laboratory methods of testing the capacity of fan-coil units.

The 2015 edition of the standard includes updates to purpose, scope, and definitions. Updates to the traceability for calibration of test instruments were brought in alignment with other related standards, and test instruments in Section 4 were updated to current models. References to an alternative method of airflow in Normative Annex B were added to Section 5. New material was added to Section 9 to update and clarify methods for testing exposed and concealed fan coils for total sound, as well as methods to measure sound paths for discharge and radiated sound. An alternate method of airflow measurement was added to Normative Annex B. Two new annexes, Informative Annex C, "Alternate Mixing-Tube Reference Dimensions," and Informative Annex D, "Examples of Various Types of Exposed and Concealed Fan Coils" were included. Figures were updated to improve resolution and clarity, and new figures were added. In addition, minor editorial changes were made, along with updates to normative references.

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1. PURPOSE AND SCOPE

1.1 Purpose. The purpose of this standard is to prescribe laboratory methods of testing fan-coil units to ensure uniform performance data for establishing ratings.

1.2 Scope. This standard includes procedures that

- describe and specify test instruments and apparatus,
- describe and specify laboratory test methods and procedures,
- describe and specify test data to be recorded,
- describe and specify calculations to be made from test data,
- define terms used in testing, and
- specify standard thermodynamic properties.

2. DEFINITIONS

equilibrium: for the purposes of this standard, a steady-state condition during which the fluctuations of variables being measured remain within the test tolerances given in Table 1 for 30 minutes.

evaporative equilibrium: the condition attained on a humidity measuring instrument when the humidity measurement has reached a stable and constant temperature.

external static pressure: the sum of the absolute values of the discharge static gage pressure and the inlet static gage pressure.

fan-coil unit: a factory-made assembly that provides air circulation caused by a difference in static pressure produced by an air-moving device, cooling or cooling and heating, and filtering of air, but does not include the source of cooling or heating.

fpm: feet per minute expressed in terms of velocity

instrument accuracy: ability of an instrument to indicate or record the true value of a measured quantity.

instrument precision: statistical error of an instrument subjected to repeated measurements over a range of input values.

latent cooling capacity: the rate, expressed in Btu/h (W), at which the fan coil under test reduces the moisture content of the air passing through it.

sensible capacity: the rate, expressed in Btu/h (W), at which the fan coil under test reduces or increases the dry-bulb temperature of the air passing through it.

TABLE 1 Test Tolerances

Symbol	Item	Units, I-P (SI)	Test-Run Operating Tolerance ±	Test Condition Tolerance ±
t_{a1}	Dry-bulb temperature of air entering test unit	°F (°C)	1.0 (0.5)	0.5 (0.25)
t'_{a1}	Wet-bulb temperature of air entering test unit	°F (°C)	0.3 (0.16)	0.3 (0.16)
Q_{an}	Airflow	%	1.0	—
t_{w1}	Temperature of water entering test unit for cooling capacity test	°F (°C)	0.2 (0.1)	0.2 (0.1)
Δt_w	Water temperature rise (cooling)	°F (°C)	0.2 (0.1)	0.2 (0.1)
Δt_w	Water temperature drop (heating)	°F (°C)	1.0 (0.5)	1.0 (0.5)
Q_w	Water flow rate	%	1.0	1.0
	Air pressure difference between the test room and the unit outlet connection or between the unit inlet and unit outlet connection	in. wc (Pa)	0.01 (2.5)	0.005 (1.25)
	Voltage applied to test unit	V	2.0	1.0

standard air: air weighing 0.075 lb/ft³ (1.2 kg/m³), which approximates dry air at 70°F (21.1°C) and at standard barometric pressure.

standard barometric pressure: a barometric pressure of 29.92 in. Hg (101 kPa).

test: the recorded group of readings of required test data taken while equilibrium is maintained and used in the computation of results, including

- those observed or recorded during a sufficient period to indicate that equilibrium was attained prior to the actual test and
- those recorded during the period of the test.

test run: the complete group of readings of required test data (Table 2).

test-run operating tolerance: the maximum permissible variation of any observation during the capacity test

test condition tolerance: the maximum permissible deviations of the averages of the test observations from the standard or desired test conditions

total cooling capacity: the sum of the sensible and latent cooling capacity.

3. TEST CONDITIONS

3.1 Variations. The methods provided in this standard shall be used to determine fan-coil performance at various test conditions that may be prescribed in other standards or specifications.

3.2 Tolerances. In all cases, the test conditions shall be maintained within the tolerances specified in Section 8.6 during the prescribed test period.

TABLE 2 Required Test Data

Symbol	Item	Units, I-P (SI)	Air Delivery	Cooling Capacity Water	Heating Capacity Water	Water-Pressure Drop	Electric Heat
—	Date and time	—	×	×	×	×	×
—	Observers	—	×	×	×	×	×
—	Fan coil under test nameplate data	—	×	×	×	×	×
P_b	Barometric pressure	in. Hg (kPa)	×	×	×		
—	Voltage applied to unit	V	×	×	×		
—	Frequency	Hz	×	×	×		
—	Fan speed	rpm	×	×	×		
P_e	Power input to fan motor	W	×	×	×		
P_{ee}	Power input to electric elements	W					×
A_n	Throat area of nozzle	ft ² (m ²)	×	×	×		
t_{a1}	Dry-bulb temperature of air entering test unit	°F (°C)	×	×	×		
t'_{a1}	Wet-bulb temperature of air entering test unit	°F (°C)	×	×	×		
t_{a2}	Dry-bulb temperature of air leaving test unit	°F (°C)	×	×	×		
t'_{a2}	Wet-bulb temperature of air leaving test unit	°F (°C)	×	×	×		
t_{an}	Dry-bulb temperature of air entering nozzle	°F (°C)	×	×	×		
t_{a3}	Dry-bulb temperature of air surrounding the plenum and mixing chamber	°F (°C)		×	×		
p_v	Velocity pressure at nozzle throat or static pressure across nozzle	in. wc (Pa)	×	×	×		
P_n	Pressure at nozzle throat	in. Hg (kPa)	×	×	×		
Q_w	Water flow rate	gpm (L/s)		×	×	×	
w_w		lb/h (kg/s)					
t_{w1}	Temperature of water entering test unit	°F (°C)		×	×		
t_{w2}	Temperature of water leaving test unit	°F (°C)		×	×		
p_w	Water pressure drop between piezometer rings	in. Hg (kPa) under water		×	×	×	
X	Rate of condensate collection	lb/h (kg/s)		×			

TABLE 3 Accuracy and Precision of Temperature Measuring Instruments

	Instrument Accuracy		Instrument Precision	
1. Wet- and dry-bulb temperatures	±0.2°F	±0.1°C	±0.1°F	±0.05°C
2. Water temperatures	±0.15°F	±0.08°C	±0.1°F	±0.05°C
3. Temperature at the airflow measuring point	±1.0°F	±0.5°C	±1.0°F	±0.5°C
4. All other temperatures	±0.5°F	±0.3°C	±0.5°F	±0.3°C

3.3 Measurements from the instruments shall be traceable to primary 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. Instruments shall be recalibrated on a regular schedule that is appropriate for each instrument, and calibration records shall be maintained. All instruments shall be applied in a manner that ensures compliance with the accuracy specified for the test.

4. TEST INSTRUMENTS

4.1 Temperature Measuring Instruments. Temperature measuring instruments shall meet the requirements of ASHRAE Standard 41.1¹.

4.1.1 Accuracy and precision of the temperature measuring instruments shall be within the limits shown in Table 3.

4.1.2 Scale Division. In no case shall the smallest scale division of the temperature measuring instrument exceed twice the specified precision.

4.1.3 Air Temperature

4.1.3.1 Dry Bulb and Wet Bulb. Dry-bulb and wet-bulb temperatures shall be read only under conditions that ensure an air velocity between 700 fpm (3.5 m/s) and 1000 fpm (5 m/s) over the wet bulb and only after sufficient time has been allowed for equilibrium to be attained. The wick on the wet-bulb thermometer shall be clean, fit the thermometer tightly, and be moistened by distilled water. Wet-bulb thermometers shall always be downstream of dry-bulb thermometers.

4.1.3.2 Water Temperature. Water temperature within pipes may be measured by inserting the temperature measuring instrument directly into the water parallel to and against the flow. An acceptable alternate method of water temperature measurement is with a liquid-filled well inserted into the pipe.

4.1.3.3 Interchangeability of Instruments. Wherever possible, temperature measuring instruments used to measure the change in temperature of water or air shall be arranged so that they can readily be interchanged between inlet and outlet positions after every reading, so as to improve accuracy.

4.2 Pressure Measurement

4.2.1 Pressure measuring instruments shall meet the requirements of ASHRAE Standard 41.3² and the following subsections.

4.2.2 Accuracy and precision of the air-pressure measuring instruments shall be at least or better than 1% of full scale.

4.2.2.1 Scale Division. In no case shall the smallest-scale division of the pressure measuring instrument exceed the specified precision.

4.2.3 Accuracy and precision of the water-pressure measuring instruments shall not be greater than 1% of full scale.

4.2.3.1 Scale Division. In no case shall the smallest scale division of the pressure measuring instrument exceed the specified precision.

4.2.4 Pressure sensors shall provide an output resolution of at least ±0.10% of reading for ambient operating temperatures between 59°F and 104°F (15°C and 40°C).

4.3 Airflow Measurement

4.3.1 The airflow measuring system shall be calibrated as a unit. The airflow measuring system includes all independently calibrated sensing components and the data acquisition system. Airflow measuring instruments shall meet the requirements of ASHRAE Standard 41.2³ or the method described in Normative Annex A.

4.3.2 Type of Instrument. Airflow measurements shall be made with one of the following types of instruments:

- Laboratory pitot-static tube array with high-accuracy pressure sensors
- Orifice plate or nozzles using high-accuracy differential pressure sensors
- Volumetric airflow or velocity measuring means

4.3.3 Measurements to Determine Air Density. The requirements in this section apply if the airflow reference depends on calculation of air density. Density shall be calculated according to *ASHRAE Handbook—Fundamentals*, Chapter 6⁴.

Sensing instruments that support the density calculation shall meet the following specifications. Uncertainty in the measured reference airflow due to uncertainty in measurements related to air density shall be calculated and reported.

4.3.3.1 Barometric Pressure. Barometric pressure shall be obtained by means of a barometer located adjacent to the inlet within the conditioned test area.

4.3.3.2 Humidity. The moisture content of the air shall be determined by measuring one of the following properties:

- Wet-bulb temperature:* Measurement shall be made according to the specifications of Section 4.1.3.1 of this standard and calculated per the specifications of *ASHRAE Handbook—Fundamentals*, Chapter 6⁴.
- Relative humidity or dew-point temperature:* A direct-reading electronic relative humidity or dew-point meter shall be employed if it has been shown to provide relative humidity readings to within ±5% or dew-point readings to within ±1.0°F (0.5°C), or a hygrometer shall be employed that measures either relative humidity or dew point at appropriate airflow conditions for the sensor that is being used.

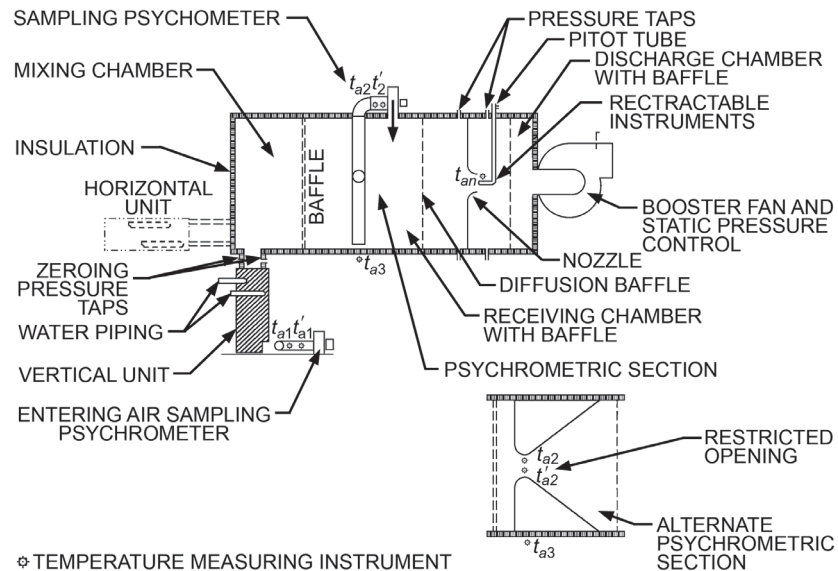


FIGURE 1 Airflow and temperature measuring apparatus.

4.4 Water Flow Measurement

4.4.1 The water flow measuring system, as a unit, shall be calibrated and certified as to accuracy by comparison with and uncertainties traceable to an agency as defined in Section 3.3.

The water flow measuring system includes all sensing components and the data acquisition system.

Water flow measurement shall be made with instruments having an accuracy of at least $\pm 2.0\%$ of reading. Typical instruments include, but are not limited to the following:

- Venturi flowmeter:** An in-line fitting that includes pressure measurement. A venturi meter incorporates an engineered tapered-throat section to minimize permanent pressure losses.
- Orifice plate:** An in-line fitting installed between flanges with pressure taps for a differential pressure measurement. An orifice plate incorporates a sharp-edged restriction to generate pressure differential with subsequent high permanent pressure losses.
- Turbine meter:** A mechanical device that uses a wheel placed in the path of liquid flow. The velocity of the liquid flow causes the wheel to turn at speeds relative to the flow rate and generates an electronic signal giving the flow directly in design units (gpm, L/s, etc.) or as a 4 to 20 mA output.
- Ultrasonic flowmeter:** A device that by the use of acoustic signals determines the flow directly in design units (gpm, L/s, etc.). The ultrasonic flowmetering station can be either a part of the piping system or a strap-on meter. There is no intrusion into the liquid flow and therefore no pressure loss. There are two distinct types of ultrasonic meters, the transit-time type for HVAC or clear water measurements and the Doppler type for flows containing a required volume of particulate in the liquid.
- Velocity-impact meter:** In this type of meter, the impact velocity of the flow moves a calibrated spring to read flow on an integral scale

- Coriolis mass flowmeters:** This type meter measures the mass per unit time (e.g., kilograms per second) flowing through the device using the principle of the Coriolis effect. Volumetric flow rate of water is the mass flow rate divided by density of water. The Coriolis effect is a deflection of moving objects when they are viewed in a rotating reference frame.

4.5 Other Measurement

4.5.1 Time. Time shall be measured with an instrument whose accuracy is within $\pm 0.5\%$ of the value being observed.

4.5.2 Weight. Weight shall be measured with an instrument whose accuracy is within $\pm 0.5\%$ of the value being observed.

4.5.3 Electrical. Electrical measurements shall be made with indicating instruments whose accuracy is within $\pm 1.0\%$ of the value being observed.

4.5.4 Fan Speed. Fan-speed measurements shall be made with instruments whose accuracy is within $\pm 2.0\%$ of the value being observed.

5. TEST APPARATUS

5.1 Airflow and Temperature Measuring Facilities

5.1.1 Airflow and Temperature Measuring Apparatus

5.1.2 General Description. Airflow rate, static pressure, and wet- and dry-bulb temperatures leaving the fan coil under test shall be measured with the apparatus illustrated in Figure 1. Alternate methods for airflow measurement are shown in Normative Annex B. The airflow through this apparatus is described as follows:

- Air flows into a plenum chamber attached to output of the fan coil under test. A manometer shall be connected to the plenum chamber to indicate the static pressure within the plenum chamber.
- The air then enters the mixing chamber. Upon leaving the mixing chamber, the air passes through the mixing device and enters the receiving chamber.

- c. The air then flows through the receiving chamber where wet- and dry-bulb temperatures are measured with an air-sampling psychrometer.
- d. Upon leaving the receiving chamber, the air enters the airflow measuring device. The air flows through the airflow measuring device and into the discharge chamber. In the discharge chamber, the air passes through a diffusion baffle when required.
- e. The air leaves the discharge chamber and enters the exhaust fan.

5.1.2.1 Plenum Chamber. Plenum chamber manometers shall have a minimum of four static pressure taps 90 degrees apart and located flush with the inner walls of the plenum chamber. The individual reading of static pressure shall be checked to ensure that the pressure difference between the pressure taps does not exceed 0.005 in. wc (1.25 Pa).

5.1.2.2 Mixing Chamber. The mixing chamber shall contain deflectors, vanes, or other means for mixing the air to the extent that air temperatures measured across the cross section at the plane of measurement do not differ more than 1.0°F (0.5°C).

5.1.2.3 Receiving Chamber

- a. Wet- and dry-bulb temperatures shall be measured by one of the following methods:
 - 1. Temperatures shall be measured by the use of an air-sampling psychrometer in the outlet opening of the mixing chamber.
 - 2. The temperatures shall be measured by temperature measuring instruments inserted directly in an opening or openings, located at the outlet of the mixing chamber, so restricted that air velocities stipulated in Section 4.1.4.1 are met.
- b. The receiving chamber shall provide uniform approach velocity to the airflow measuring device. The maximum velocity shall not exceed 600 fpm (3 m/s), and the maximum average velocity shall not exceed 400 fpm (2 m/s). The receiving chamber shall be provided with a well-gasketed door or removable side panel.

5.1.2.4 Nozzle Arrangement. Nozzles (if utilized for airflow measurement) shall be constructed in accordance with Normative Annex A and shall be fitted into one wall of the receiving chamber discharging into the discharge chamber. Center-to-center distances between nozzles in use shall be not less than three throat diameters, and the distance from the center of any nozzles to any adjacent side wall shall be not less than 1.5 throat diameters. If the nozzles are of different diameters, the distance between axes shall be based on the diameter of the largest nozzle.

Other methods are described in Normative Annex B for measuring airflow and can be substituted for the nozzle arrangement.

5.1.2.5 Discharge Chamber Construction. Walls shall be smooth and direct continuations of those of the receiving chamber, and the distance from the airflow measuring device to the nearest obstruction shall be not less than 5 equivalent

diameters. If diffusion baffles are used, this distance shall be 2.5 equivalent diameters.

5.1.2.6 Diffusion Baffles. Diffusion baffles, where used, shall cover the entire cross section of the chamber in which they are installed. Perforated metal sheets are recommended with either one sheet having 40% free area or two separate sheets each having 65% free area. Where more than one perforated sheet is used, they shall be separated by at least four times the center distance between holes.

5.1.2.7 Exhaust Fan. The exhaust fan connected to the discharge chamber shall be capable of maintaining a maximum of 0.005 in. wc (1.25 Pa) static pressure difference between the inlet and outlet of the test unit.

5.1.2.8 Airflow Measurements. Airflow measurements shall be made by one of the three following methods: Methods 1 and 2 are utilizing nozzles.

- a. A set of four static pressure taps, located flush with the inner walls of the receiving chamber 90 degrees apart and upstream from the nozzle plate, shall be required. Similarly, a set of four static pressure taps shall be located flush with the inner walls of the discharge chamber, 90° apart and downstream from the nozzle plate. The pressure drop across the nozzle or nozzles shall be measured with a manometer having one side connected to a manifold of the four upstream static pressure taps and the other side similarly connected to a manifold of the four downstream pressure taps. Individual static pressure readings shall be checked to ensure that no pressure difference greater than 2% exists across the cross section at the plane of the pressure taps.
- b. If the velocity pressure of the airstream leaving a nozzle is measured instead of the pressure drop across the nozzle, the velocity pressure shall be measured at the center of the exit of the nozzle by a pitot tube, but when more than one nozzle is in use, the velocity pressure shall be determined for each nozzle.
- c. Any alternative airflow measuring method in Normative Annex B may also be utilized.

5.1.2.9 Air Density Determination. The dry-bulb temperature and the static pressure shall be measured at the airflow measuring device.

5.1.2.10 Air Leakage of Test Apparatus. The plenum chamber, mixing chamber, and receiving chamber shall be sealed so that air leakage at places that would influence capacity measurements does not exceed 1% of the test airflow rate.

5.1.2.11 Heat Leakage. The plenum, mixing, and receiving chambers shall be insulated so that calculated heat leakage through the walls of the chambers does not exceed 2% of the capacity of the test unit.

5.1.3 Air-Sampling Psychrometer. This device shall consist of sampling tubes provided with sufficient sampling stations equally distributed across the area of the duct or test opening so as to obtain a representative sample of air to be tested. The sampling tubes shall be so located as to have no adverse effect on the air entering or passing through the test opening or device. At the point in a sampling tube where the temperature measuring instruments are inserted, the inside

diameter shall not be less than 3 in. (75 mm). The psychrometer fan motors shall be so located that their heat will not cause stratification of air passing into the fan coil under test. The fans shall draw the air over the temperature measuring instruments and discharge the air in a manner that will not affect air temperature measurement, static pressure, or circulation of air to the fan coil under test.

5.1.4 Test Room

5.1.4.1 General. A single interior test room is required for the test of a fan-coil unit. The test room shall be of sufficient volume and shall circulate air in a manner such that it does not change the normal return air circulating pattern of the test unit. Dimensions shall be such that the distance from any room surface to the equipment discharge or intake is not less than 6 ft (1.83 m) and the distance from any room surface to any other equipment surface is not less than 3 ft (0.91 m), except for floor or wall relationships required for normal installation.

5.1.4.2 Test Room Reconditioning Equipment. The room reconditioning equipment shall be mounted either within or external to the conditioned space and must have the capability to maintain the wet- and dry-bulb temperatures within the tolerances stipulated for the test. The room reconditioning equipment should handle air at a rate not less than the airflow rate of the fan coil under test, and the air distribution system shall be so designed that the air velocity within 3 ft (0.91 m) of the fan coil under test does not exceed 150 fpm (0.75 m/s).

5.2 Test Methods, Air Side

5.2.1 Tunnel Air-Enthalpy Test Method Arrangement

5.2.1.1 General. See Figure 2(a). Install the fan coil under test in the test room and connect the cooling and/or heating source thereto.

5.2.1.2 Connect Airflow and Temperature Measuring Apparatus. Connect this apparatus to the discharge of the fan coil under test.

5.2.1.3 Install an Air-Sampling Psychrometer. Install an air-sampling psychrometer to sample air entering the return air inlet openings. Construct the air-sampling tube so as to provide not less than six air-sampling stations equally distributed across the area of the air inlet openings of the fan coil under test and not more than 6 in. (150 mm) in front of the opening.

5.2.2 Loop Air-Enthalpy Test Method Arrangement

5.2.2.1 General. See Figure 2(b). Install the fan coil under test in the appropriate test room and connect the cooling and/or heating source thereto.

5.2.2.2 Connect Airflow and Temperature Measuring Apparatus. Connect this apparatus to the discharge of the fan coil under test.

5.2.2.3 Connect the Discharge of the Reconditioning Equipment. Connect the discharge of reconditioning equipment (Section 5.2.2.2) fan through ductwork to the intake of the fan coil under test. Make the inlet connection so as not to interfere with the normal functioning of the fan coil under test. The reconditioning equipment shall contain a means for

extracting or adding heat to the air and adding moisture to the air at the same rate as heat is added to and heat and moisture are extracted from the air when it passes through the test unit. The equipment fan shall be capable of moving air through the airflow and temperature measuring apparatus and reconditioning equipment at a rate that will maintain a maximum of 0.005 in. wc (1.25 Pa) static pressure differential between the inlet and outlet of the fan coil under test.

5.2.2.4 Connect Pressure Measuring Apparatus. Connect this apparatus to the discharge and inlet for the fan coil under test. See Section 6.2.

5.2.2.5 Install an Air-Sampling Psychrometer. Install an air-sampling psychrometer in the duct as close as possible to the inlet of the fan coil under test. Arrange the construction of the sampling tube so as to provide the number and distribution of air-sampling stations sufficient to obtain an accurate total air sample.

5.2.2.6 Seal the Loop Ductwork and Reconditioning Equipment. Seal this equipment so that air leakage at places that would influence capacity measurements does not exceed 1.0% of the test airflow rate.

5.2.2.7 Maintain the Dry-Bulb Temperature. Maintain the dry-bulb temperature of the air surrounding the fan coil under test within 5°F (3°C) of the desired test inlet dry bulb temperature.

5.2.3 Calorimeter Air-Enthalpy Test Method Arrangement

5.2.3.1 General. See Figure 2(c). Install the fan coil under test in appropriate test room and connect the source of cooling and/or heating thereto.

5.2.3.2 Connect Airflow and Temperature Measuring Apparatus. Connect this apparatus to the discharge of the fan coil under test.

5.2.3.3 Install Air-Sampling Psychrometer. Install air-sampling psychrometer with sampling stations in front of the return air inlet opening of the fan coil under test and in front of the air inlet opening of the calorimeter enclosure. Construct the air-sampling tube so as to provide not less than six air-sampling stations equally distributed across the area of the air inlet openings of the fan coil under test and calorimeter enclosure and not more than 6 in. (150 mm) in front of the opening.

5.2.3.4 Calorimeter Enclosure. Place an enclosure as described herein over the fan coil under test. This enclosure shall be constructed of any suitable material but it shall be essentially airtight. It shall be large enough to permit inlet air to circulate freely between the fan coil under test and the enclosure, and in no case shall the enclosure be closer than 6 in. (150 mm) to any of the fan coil under test. Locate the inlet to the enclosure remotely from the inlet of the fan coil under test so as to cause circulation throughout the entire enclosed space. The inlet opening shall be of a size to keep the air velocity through the opening at less than 500 fpm (2.5 m/s). The enclosure shall be insulated so as to limit heat transfer to 2% of the test unit capacity.

5.2.3.5 Install Pressure Measuring Apparatus. Install the pressure measuring apparatus with connections to the plenum of the fan coil under test and to the calorimeter enclosure.

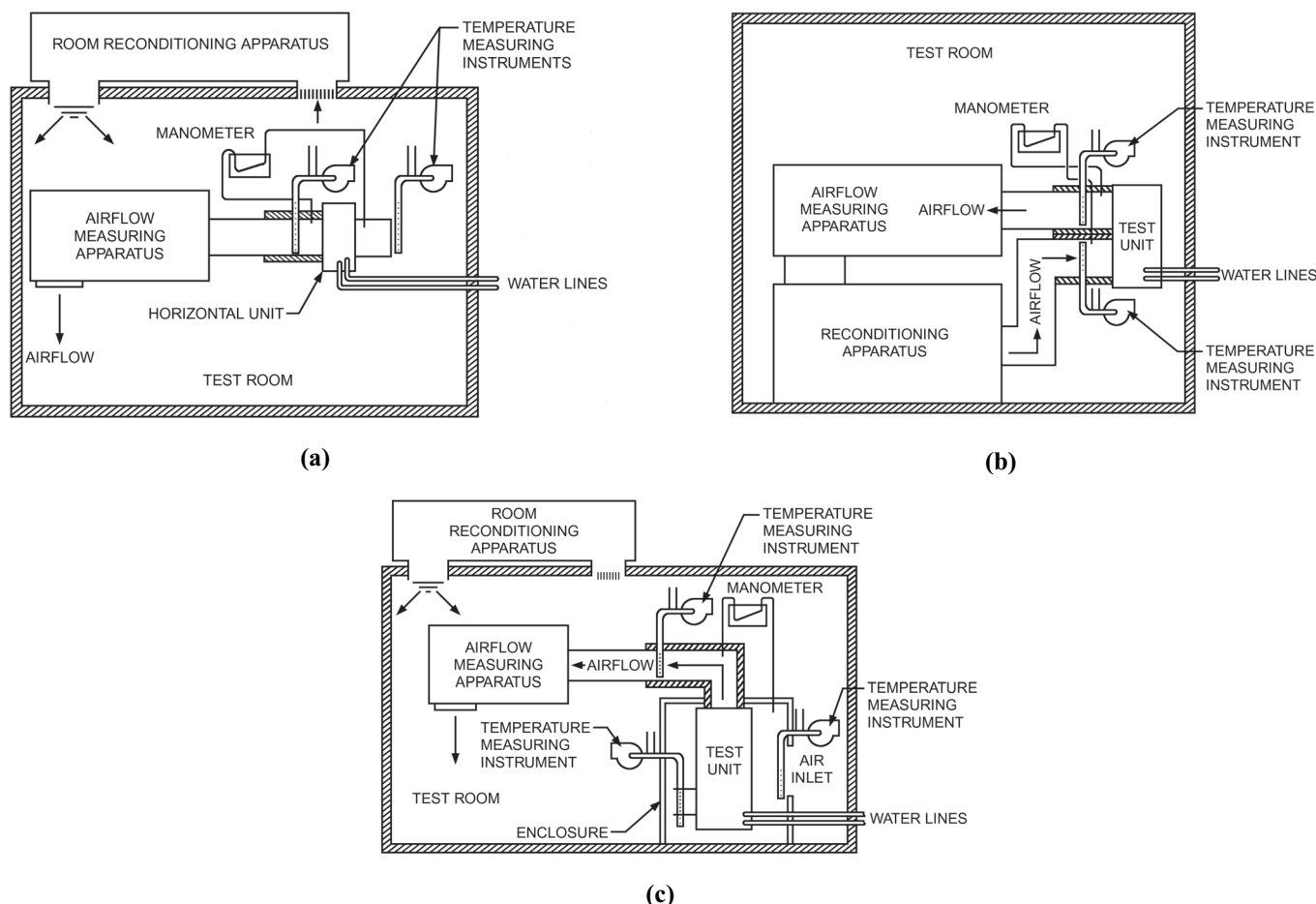


FIGURE 2 (a) Tunnel air-enthalpy test method arrangement, (b) loop air-enthalpy test method arrangement, and (c) calorimeter air-enthalpy test method arrangement.

sure. The airflow and temperature measuring apparatus fan shall maintain an airflow such that zero static pressure differential will exist between the test unit outlet and the interior of the calorimeter enclosure.

5.3 Reconditioning Equipment

5.3.1 Air-Conditioning and Heating Equipment. This equipment shall be provided for the test room to maintain the quality of the air entering the fan coil under test within the tolerances prescribed in Table 1.

5.4 Water Measuring Apparatus

5.4.1 Liquid Quantity Measurement. Rate shall be determined by a liquid quantity meter measuring either weight or volume of the following types:

- Provide a *calibrated tank* having sufficient capacity to accumulate the flow for at least two minutes and so located that the water leaving the fan coil under test can be diverted into it.
- A *liquid flowmeter* shall be used that will measure water flow rate through the test unit coil.

5.4.2 Temperature Measuring Instruments. These instruments shall be placed so as to measure accurately the temperature of water entering and leaving the coil of the fan coil under test. The water lines shall be insulated at least

between the fan coil under test and the water temperature measuring instruments and 6 in. (150 mm) beyond the water temperature measuring instruments. To minimize possible temperature stratification, mixers shall be inserted in the inlet and the outlet water lines upstream of the temperature measuring instruments. Figure 3 shows one suggested piping arrangement to ensure thorough mixing employing a liquid-filled well. Figure 4 shows the thermometer well to be screwed into the mixing piping arrangement of Figure 3. Figures 5 and 6 also show a suggested configuration of the alternate temperature-measurement arrangement.

5.4.3 Water Pressure Drop. Water pressure drop through the coil of the fan coil under test from inlet to outlet shall be measured. Figure 7 shows the suggested test apparatus. The piezometer rings shall be located in accordance with the dimensions shown in Figure 7 and constructed as shown in Figure 8. Pressure-drop reading shall be with a differential pressure gage.

5.5 Electrical Power Measurement

5.5.1 Test Procedure. Electrical measurements shall be made with instruments conforming to the requirements listed in Section 4.5.3. Readings should be taken after the test has reached thermal equilibrium. The electrical power measurements shall be taken as close to the terminal load as possible

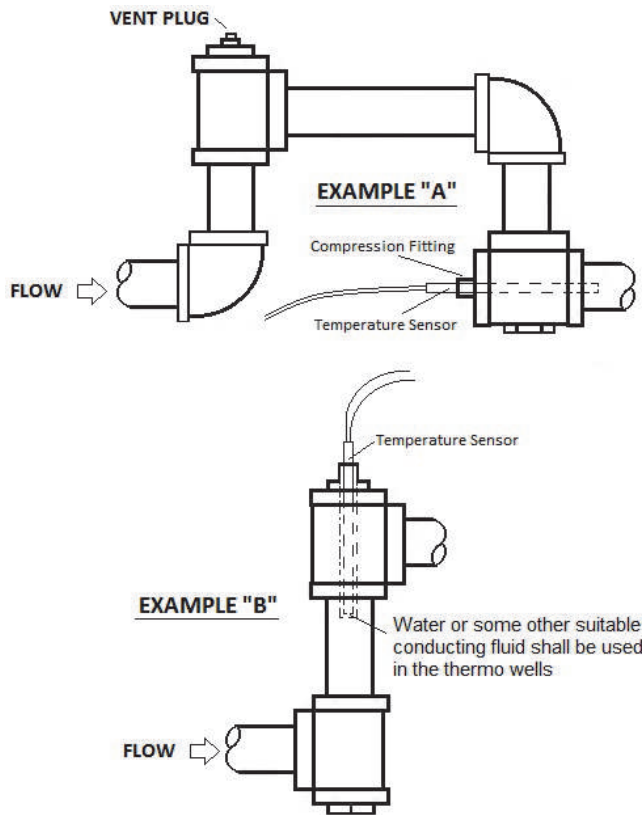


FIGURE 3 Suggested piping arrangement for ensuring thorough mixing.

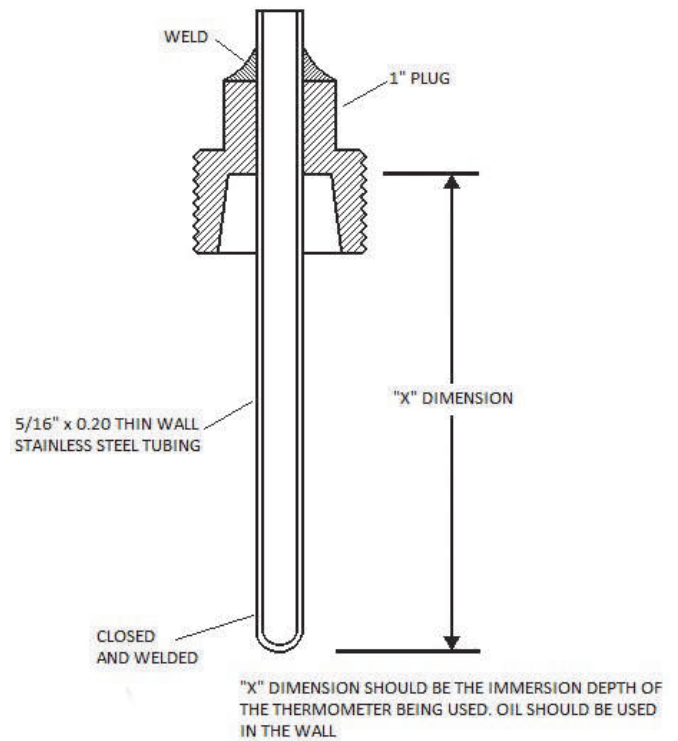


FIGURE 4 Thermometer well to be screwed into mixing piping arrangement of Figure 3.

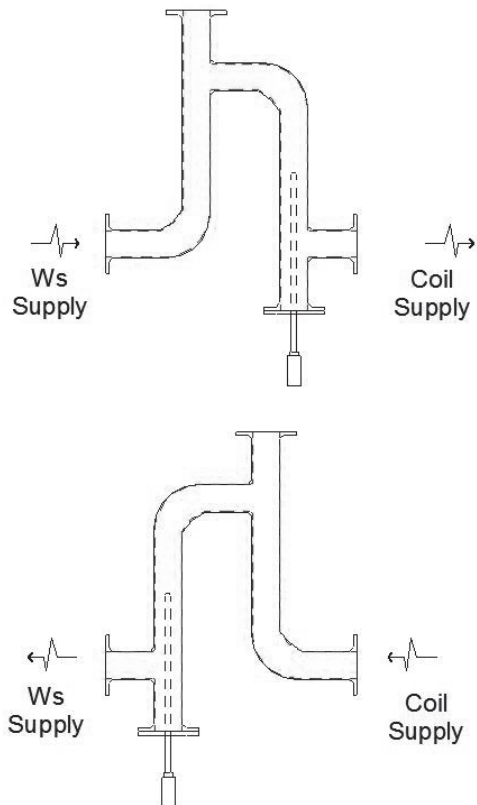


FIGURE 5 Suggested method for ensuring thorough mixing for a 1/2 in. (12.5 mm) manifold application. (See Informative Annex C for reference dimensions.)

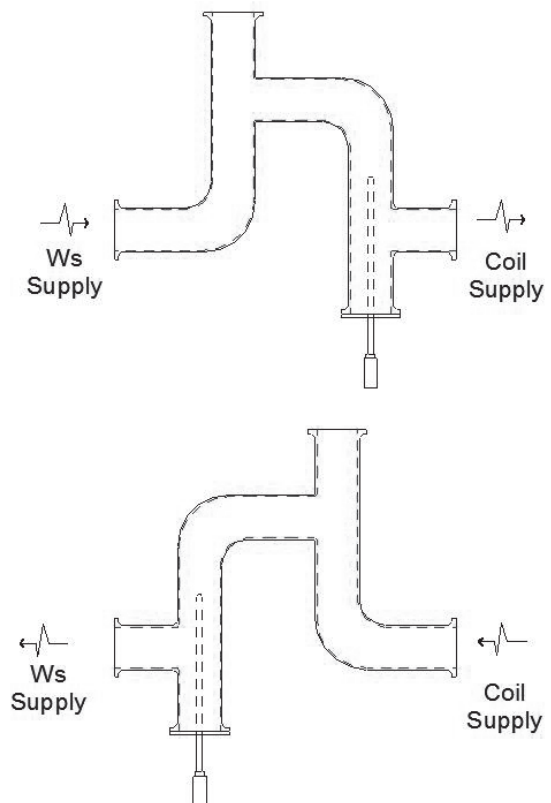


FIGURE 6 Suggested method for ensuring thorough mixing for a 3/4 in. (18.8 mm) manifold application. (See Informative Annex C for reference dimensions.)

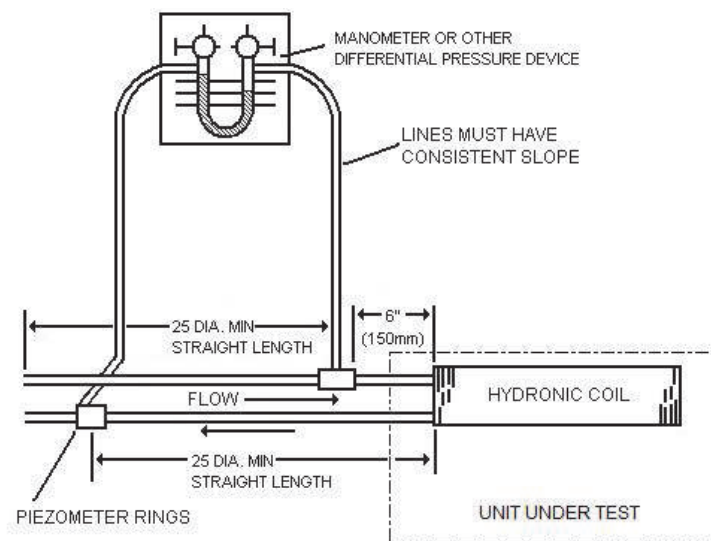


FIGURE 7 Apparatus for determining water pressure drop through test unit water coil.

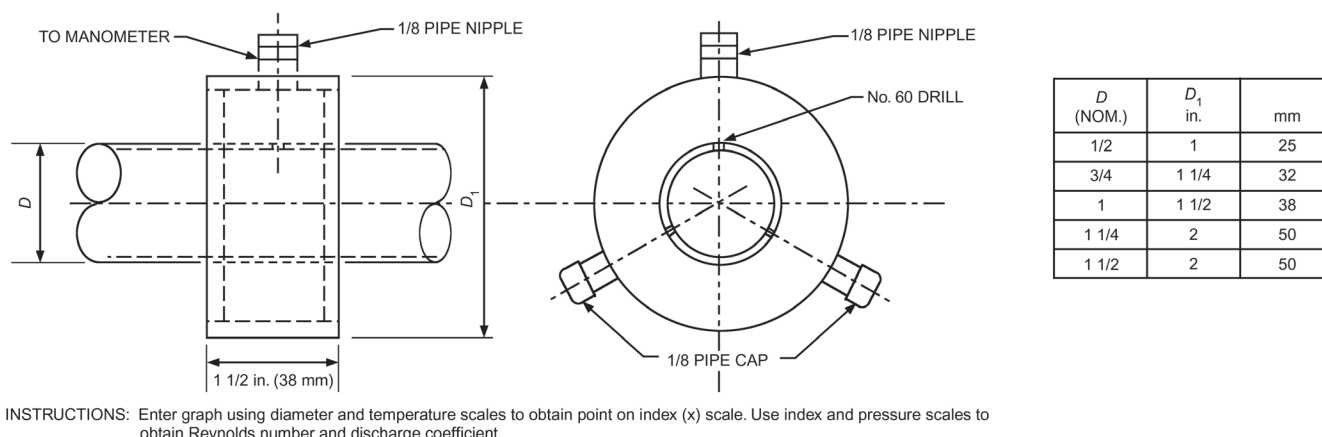


FIGURE 8 Piezometer ring details.

to reduce line losses. On units with electric heating elements, separate power measurements shall be made for the fan motor circuit and the electric heating element.

6. INSTALLATION OF FAN COIL UNDER TEST

6.1 Fan Coil. Install the fan coil under test in the test room in accordance with the manufacturer's illustrations, particularly with respect to distances to adjacent walls and ceilings.

6.2 External Static Pressure Measurement

6.2.1 External static pressure taps should be installed on a short plenum chamber attached to the outlet of the discharge side of the equipment. This plenum should have cross-sectional dimensions equal to the dimensions of the equipment outlet and shall discharge into an air measuring device. One side of the pressure measuring device shall be connected to four manifold pressure taps in the discharge plenum. These taps shall be positioned a distance of twice the mean geometric cross-sectional dimension from the equipment outlet, as shown in Figure 9.

Informative Note: For circular ducts, substitute $P_{ie}D_i/4$ for $C \times D$ and $P_{ie}D_o^2/4$ for $A \times B$. The length of the inlet duct, $1.5(C \times D)^{1/2}$, is a minimum dimension. For more precise results, use $4(C \times D)^{1/2}$.

6.2.2 Each static pressure tap should be located at the center of each face of each plenum, if rectangular, or at four evenly distributed locations along the perimeter of an oval or round plenum.

6.2.3 It is recommended that the pressure taps consist of 6.25 mm (0.25 in.) diameter nipples attached to the outer plenum surface (soldered or gasketed) and centered over 1 mm (0.040 in.) diameter holes through the plenum. The edges of these holes should be free of burrs and other surface irregularities.

6.2.4 Static pressure taps should be manifolded using one of the two recommended connection options shown in Figure 10.

6.3 Measurement of Fan RPM. A means of measuring the fan speed shall be provided. If a stroboscopic device is used, provide a sight hole in the fan coil under test that shall be sealed with transparent material. This sight hole shall be

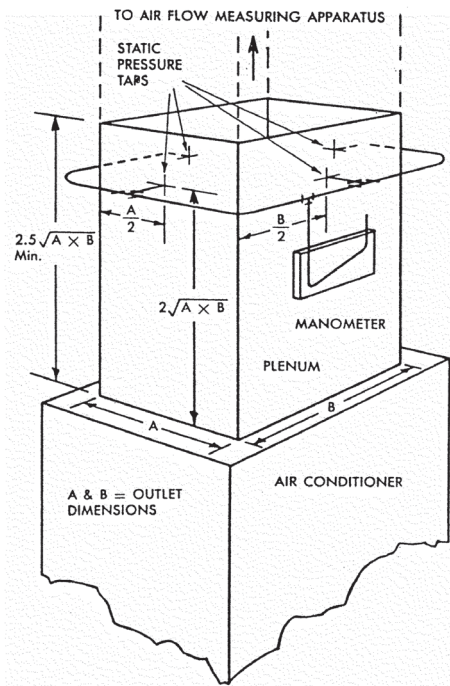


FIGURE 9 Position of manifold pressure taps in relation to equipment outlet.

located so as not to interfere in any way with normal operation of the fan coil under test.

6.4 Water Pressure-Drop Test Connection Location. All water pressure-drop tests shall be conducted using connecting pipes of the same size as recommended by the manufacturer. If headers or special fittings are required, they shall be included in the pressure-drop measurements.

6.5 Alterations to the Fan Coil Under Test. No alterations to the fan coil under test shall be made except attachment of required test apparatus and instruments in the prescribed manner. Such alterations made to the fan coil under test shall not in any way affect its normal operation.

6.6 Remote Pressure Sensors. When required to be remotely mounted, pressure sensors shall be connected to the equipment so that the readings are not influenced by fluid heat in the tubing or by the length and diameter of the tubing itself.

6.7 Barometric Pressure Variations. No changes shall be made in fan speed or system resistance to correct for barometric variations.

7. TEST METHODS AND PROCEDURES

7.1 General

7.1.1 Tolerances. All test observations shall be within the tolerances specified in Table 1 as appropriate to the type of test. The maximum permissible variation of any observation during a test run is listed under “Test-Run Operating Tolerance” in Table 1. This represents, for each variable, the greatest difference between any individual observation and the specified test condition or, where the test condition is not

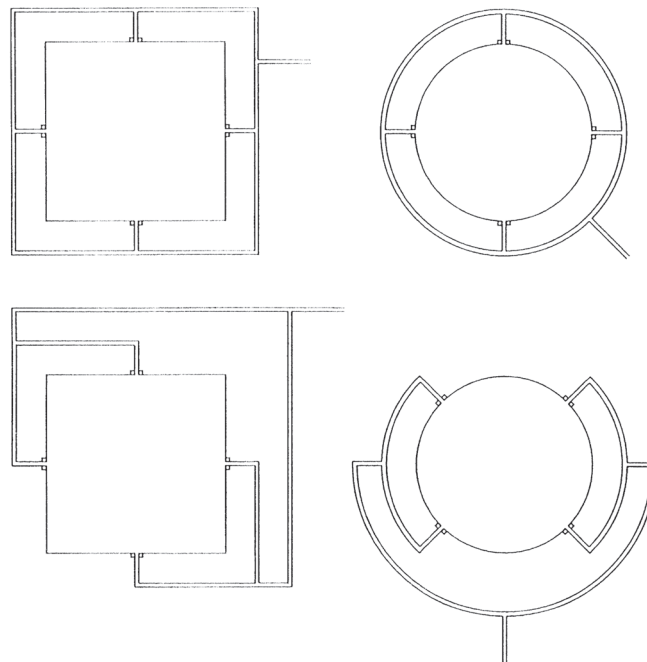


FIGURE 10 Recommended connection options for pressure-tap manifolding.

specified, between any individual observation and the average of test observations. The maximum permissible variation of the average of the test observations from the specified test conditions is shown under “Test Condition Tolerance” in Table 1.

7.1.2 Average of Readings. In any test where more than one set of readings are recorded, the arithmetical average of the readings shall be used in the test calculations.

7.2 Isothermal Air Delivery Tests

7.2.1 Apparatus. The isothermal air delivery rate of the fan coil under test shall be determined by means of the apparatus described in Section 5.1.

7.2.2 Fan Coil Under Test Adjustment. The fan coil under test fan speed selection shall be adjusted to the desired position. The voltage applied to the fan coil under test shall be adjusted to that established by IEC Standard 60038⁵ for the ranges specified by the manufacturer. The temperatures of the air entering the fan coil under test and the pressure difference between the test room and the plenum chamber shall be adjusted to the desired values. No heating or cooling medium shall be supplied to the coil of the fan coil under test.

7.3 Cooling and Heating Capacity Tests

7.3.1 Input-Output Test Average. To fulfill the requirements of this standard, two simultaneous methods shall be used in determining the fan coil under test total cooling or total heating capacity. One method shall measure the fan coil under test output cooling or heating capacity on the air delivery side; the other method shall measure the input cooling or heating capacity for the water side. The capacities measured on the output side and the input side shall agree within 5%. The aver-

age of the two determinations shall be used as the total cooling or total heating capacity of the fan coil under test.

7.3.2 Air-Side Cooling and Heating Effects. The air-side capacity shall be determined by means of the apparatus and methods described in Sections 5.1 and 5.2. The heat leakage of the plenum, mixing, and receiving chamber shall be calculated and a correction of test capacity made accordingly per Section 8.2.2.2.

7.3.3 Cooling Capacity Input. The cooling capacity on the cooling-medium side shall be determined by means of applicable apparatus described in Section 5.4.

7.3.4 Heating Capacity Input. The heating capacity on the heating-medium side shall be determined by means of applicable apparatus described in Sections 5.4 and 5.5.

7.3.5 Test Duration. Data shall be sampled at equal intervals that span 1 minute or less for a period of 1 half hour. The barometric pressure shall be recorded at least once during each test.

7.3.6 Air-Side Adjustments. The fan-coil-under-test fan speed selection device shall be adjusted to the desired position. The voltage applied to the fan coil under test shall be adjusted to that established for the isothermal air delivery tests specified in Section 7.2.2. The pressure difference between the test room and the plenum chamber and the temperatures of the air entering the fan coil under test shall be adjusted to the desired values.

7.3.7 Water-Side Adjustments. For hydronic capacity tests, entering and leaving water temperatures shall be adjusted to the desired values.

7.3.8 Electric Heating Test. For heating capacity tests when the heating is via electric resistance elements, the voltage applied to the elements shall be adjusted to that established by IEC Standard 60038⁵ for the ranges specified by the manufacturer.

8. CALCULATIONS

8.1 Isothermal Air Delivery Tests

Informative Note: See Section 8.5 for symbol designations.

8.1.1 The specific volume of the air-vapor mixture at the nozzle shall be calculated as follows:

$$v'_n = \frac{v_1}{1 + W_1} \times \frac{29.92}{P_b + (p_v/13.62)} \times \frac{460 + t_{an}}{460 + t_{a1}}$$

$$\text{or} = \frac{29.92 v_n}{P_n(1 + W_n)}$$

$$v'_n = \frac{v_1}{1 + W_1} \times \frac{101}{P_b + (p_v/1000)} \times \frac{273 + t_{an}}{273 + t_{a1}}$$

$$\text{or} = \frac{101 v_n}{P_n(1 + W_n)}$$

8.1.1.1 The humidity ratio shall be calculated as follows:

$$W_1 = \frac{(1093 - 0.556 t'_{a1}) W_{s1} - 0.240(t_{a1} - t'_{a1})}{1093 + 0.444 t_{a1} - t'_{a1}}$$

$$= \left(\frac{(2.5 \times 10^6 - 3155 t'_{a1}) W_{s1} - 1005(t_{a1} - t'_{a1})}{2.5 \times 10^6 + 1035 t_{a1} - 4190 t'_{a1}} \right)$$

$$W_n = \frac{(1093 - 0.556 t'_{a2}) W_{sn} - 0.240(t_{a2} - t'_{a2})}{1093 + 0.444 t_{a2} - t'_{a2}}$$

$$= \left(\frac{(2.5 \times 10^6 - 3155 t'_{a2}) W_{sn} - 1005(t_{a2} - t'_{a2})}{2.5 \times 10^6 + 1035 t_{a2} - 4190 t'_{a2}} \right)$$

8.1.1.2 The specific volume shall be calculated as follows:

$$v_1 = \frac{53.352(460 + t_{a1})}{70.726 P_b} (1 + 1.6078 W_1)$$

$$= \left(\frac{0.287(273 + t_{a1})}{P_b} (1 + 1.6078 W_1) \right)$$

$$v_n = \frac{53.352(460 + t_{an})}{70.726 P_n} (1 + 1.6078 W_n)$$

$$= \left(\frac{0.287(273 + t_{an})}{P_n} (1 + 1.6078 W_n) \right)$$

8.1.2 The volume flow rate through a single nozzle shall be calculated as follows:

$$Q_{an} = 1096 A_n C_n (p_v v'_n)^{0.5}$$

$$= (1414 A_n C_n (p_v v'_n)^{0.5})$$

8.1.3 The total airflow rate through multiple nozzles is the sum of the flow rates for each nozzle used.

8.1.4 The specific volume of the air-vapor mixture entering the fan coil under test shall be calculated as follows:

$$v'_1 = \frac{v_1}{1 + W_1}$$

8.1.5 The air delivery rate for the fan coil under test shall be calculated as follows:

$$Q_a = Q_{an} \frac{(v'_1)}{(v'_n)}$$

8.1.6 To correct the air delivery rate to standard airflow, the following equation shall be used:

$$Q_s = \frac{Q_a}{0.075(v'_1)} - \left(\frac{Q_a}{1.2(v'_1)} \right)$$

8.2 Cooling and Heating Capacity Tests

8.2.1 Airflow Calculations

8.2.1.1 The specific volume of the air-vapor mixture at the nozzle shall be calculated as follows:

$$v'_n = \frac{29.92 v_n}{P_n(1 + W_n)} = \left(\frac{101 v_n}{P_n(1 + W_n)} \right)$$

Informative Note: See Sections 8.1.1.1 and 8.1.1.2 for equations for W_n and v_n .

8.2.1.2 The mass flow rate of air in lb/h (kg/s) through a single nozzle shall be calculated as follows:

$$w_a = 4.5Q_s = (0.0012 \times Q_s)$$

8.2.1.3 The total mass flow rate of air through multiple nozzles is the sum of the flow rates for each nozzle used.

8.2.2 Heat Leakage Calculation

8.2.2.1 The heat leakage for the plenum, receiving, and mixing chambers is calculated as the product of square feet (square meters) of total exposed area of the chambers and the heat transmission coefficient corresponding to the construction and the insulation used and the temperature difference. The coefficient of heat transmission may be determined by testing or calculation. The value of t_{a3} , the dry-bulb temperature of the air surrounding the plenum, mixing, and receiving chambers, used in this calculation, shall be the average of the measurements at not less than two locations.

8.2.2.2 Heat leakage shall be calculated as follows:

a. Cooling Capacity Tests

$$q_k = A_k U_k (t_{a3} - t_{a2})$$

b. Heating Capacity Tests

$$q_k = A_k U_k (t_{a2} - t_{a3})$$

8.2.3 Fan Motor Heat Calculation. The heat of the electric power input to the fan motor shall be calculated as follows:

$$q_e = 3.41 P_e = (P_e)$$

8.2.4 Air-Side Cooling Capacity Calculation

8.2.4.1 The air-side total cooling capacity shall be calculated as follows:

$$q_{tca} = \frac{w_a [(h_{a1} - h_{a2}) - (W_1 - W_n)(t'_{a2} - 32)]}{(1 + W_n)} + q_k$$

$$(q_{tca} = \frac{1000 w_a [(h_{a1} - h_{a2}) - (W_1 - W_n)(4.2 t'_{a2})]}{(1 + W_n)} + q_k)$$

The enthalpy of the air-water vapor mixture shall be corrected for the barometric pressure and wet-bulb depression (see Figures 11 and 12).

8.2.4.2 The air-side sensible cooling capacity shall be calculated as follows:

$$q_s = \frac{w_a c_{pa} (t_{a1} - t_{a2})}{(1 + W_n)} + q_k$$

$$c_{pa} = 0.24 + 0.444 W_n = (1.0056 + 1.86 W_n)$$

8.2.5 Air-Side Heating Capacity Calculation. The air-side heating capacity shall be calculated as follows:

$$q_{tha} = \frac{w_a c_{pa} (t_{a2} - t_{a1})}{(1 + W_n)} + q_k$$

8.2.6 Water Flow Calculation. Where the water flow rate is measured in volume rather than mass, the calculation for the conversion to mass flow rate units of measure shall be as follows:

$$w_w = 8.02 \rho_w Q_w = \left(\frac{\rho_w Q_w}{1000} \right)$$

8.2.7 Water-Side Cooling Capacity Calculation. The total water-side cooling capacity shall be calculated as follows:

$$q_{tcw} = w_w c_{pw} (t_{w2} - t_{w1}) = (1000 w_w c_{pw} (t_{w2} - t_{w1}))$$

8.2.8 Water-Side Heating Capacity Calculation. The total water-side heating capacity shall be calculated as follows:

$$q_{thw} = w_w c_{pw} (t_{w1} - t_{w2}) = (1000 w_w c_{pw} (t_{w1} - t_{w2}))$$

8.2.9 Electric Element Heating Capacity Calculation. The element-side heating capacity shall be calculated as follows:

$$q_{ee} = 3.41 \times P_{ee} = (P_{ee})$$

8.3 Average Capacities and Heat Balance Calculations

8.3.1 The average cooling capacities of the air and water side shall be calculated as follows:

$$q_c = 0.5(q_{tca} + q_{tcw} - q_e)$$

The heat balance between the air- and water-side capacities shall be calculated as follows:

$$HB = \frac{100(q_{tca} - q_{tcw} + q_e)}{q_c}$$

The heat balance shall fall within the limits specified in Section 7.3.1.

8.3.2 The average heating capacities shall be calculated as shown in the following subsections.

8.3.2.1 Water Coils

$$q_h = 0.5(q_{tha} + q_{thw} + q_e)$$

The heat balance between the air- and water-side capacities shall be calculated as follows:

$$HB = \frac{100(q_{tha} - q_{thw} - q_e)}{q_h}$$

8.3.2.2 Electric Coils

$$q_h = 0.5(q_{tha} + q_{ee} + q_e)$$

The heat balance between the air and electric coil capacities shall be calculated as follows:

$$HB = \frac{100(q_{tha} - q_{ee} - q_e)}{q_h}$$

8.4 Water Pressure-Drop Tests. The water-pressure-drop test shall be performed separately from the thermal performance testing. The airflow across the coil shall be zero. Each water flow rate tested in the thermal performance test shall require a water-pressure-drop test. The water temperature mixing chambers shall be removed and replaced by the pressure testing apparatus. The entering water temperature shall be the mean of the entering and leaving water temperatures from the thermal performance test.

Each water-pressure-drop test shall be run for a minimum of 10 minutes after achieving stability. The reported

Wet-bulb depression corrections to enthalpy of air-water vapor mixture (IP)

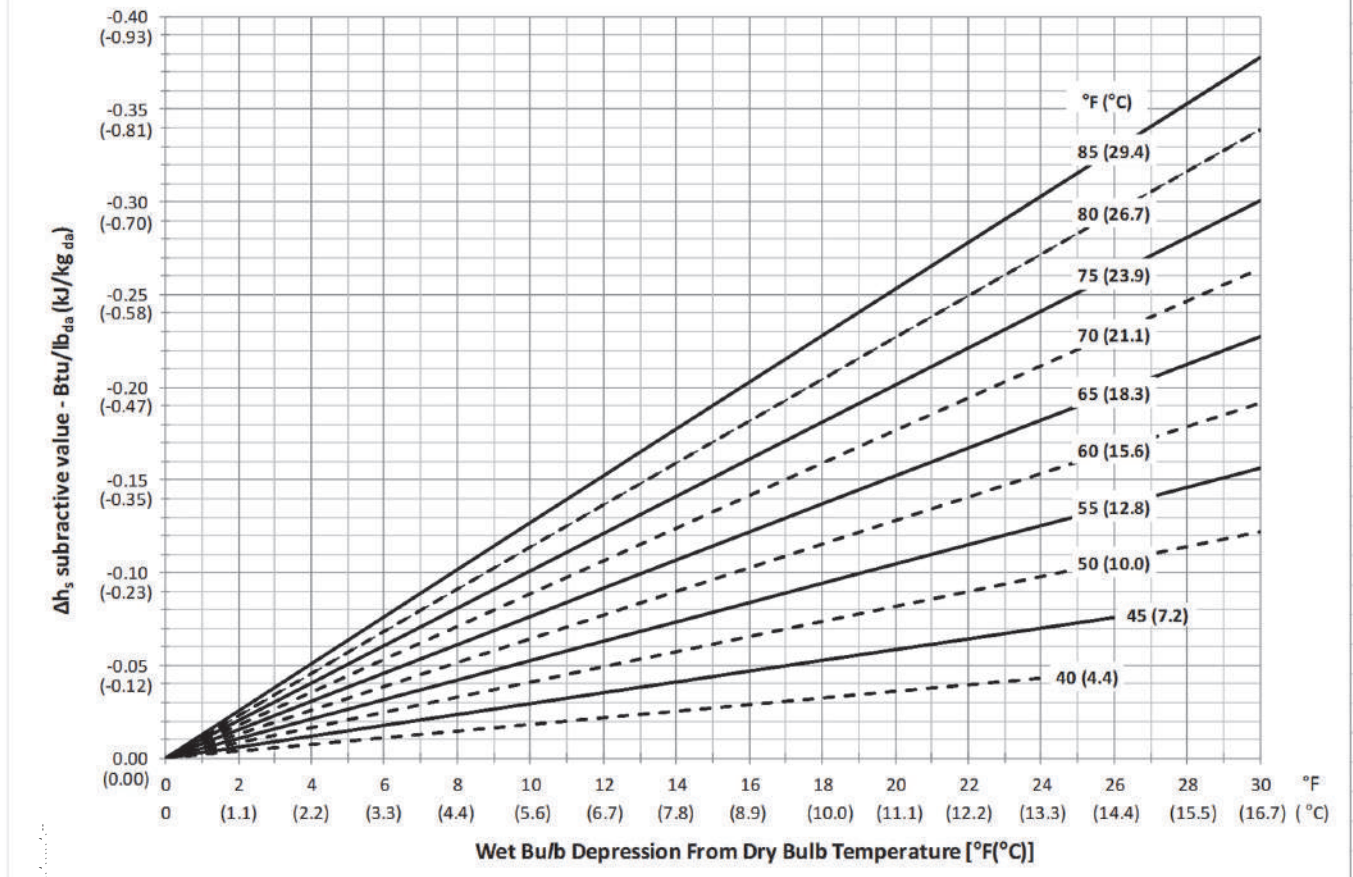


FIGURE 11 Wet-bulb depression corrections to enthalpy of air-water vapor mixture.

(Applicable when no ice is formed on wet-bulb wick)

- t = dry-bulb temperature of mixture
- t' = wet-bulb temperature of mixture
- h' = enthalpy of saturated air at t' ; corrected for actual barometric pressure
- h = enthalpy of mixture at t and t' ; corrected for actual barometric pressure
- Δh_1 = enthalpy correction for wet-bulb depression
- $h = h' - \Delta h_1$

pressure drop shall be the average of the data recorded evenly during the test time.

The test measurement of water pressure drop is intended to only include the pressure of the unit inlet connection to the unit outlet connection. Therefore, the unit pressure drop shall be the total measure pressure drop minus the pressure drop of the piping leading to the pressure measurement device. This piping loss shall be determined by calibration of the test apparatus or by calculation of pressure based on type of material used in the setup. Refer to Figure 7.

8.5 Symbols

- A_k = area, exposed walls of plenum, mixing, and receiving chambers, ft^2 (m^2)
- A_n = area, nozzle throat, ft^2 (m^2)
- C_n = coefficient of discharge, nozzle
- c_{pa} = specific heat of air, $\text{Btu/lb} \cdot ^\circ\text{F}$ ($\text{kJ/kg} \cdot ^\circ\text{C}$) of dry air
- c_{pw} = specific heat of water, $\text{Btu/lb} \cdot ^\circ\text{F}$ ($\text{kJ/kg} \cdot ^\circ\text{C}$)

- h_{a1} = enthalpy, air entering unit, Btu/lb (kJ/kg)
- h_{a2} = enthalpy, air leaving unit, Btu/lb (kJ/kg)
- HB = heat balance tolerance, percent
- P_b = pressure, barometric, in. Hg (kPa)
- P_e = power input to fan motor, W
- P_{ee} = power input to electrical resistance element, W
- P_n = pressure at nozzle throat, in. Hg absolute (kPa)
- p_v = velocity pressure at nozzle throat or static pressure difference across nozzle, in. wc (Pa)
- q_c = average cooling capacity of air and water side, Btu/h (W)
- q_e = equivalent heat input due to fan motor, Btu/h (W)
- q_{ee} = equivalent heat input to electrical resistance element, Btu/h (W)
- q_h = average heating capacity of air and water (or electric element) sides, Btu/h (W)

Change in Enthalpy [$\Delta h/\text{lb}_{\text{da}}(\text{kg}_{\text{da}})$] At Various Air Pressures from Enthalpy at Standard Air Pressure [29.921 in.Hg (kPa)] By Wet Bulb Temperature

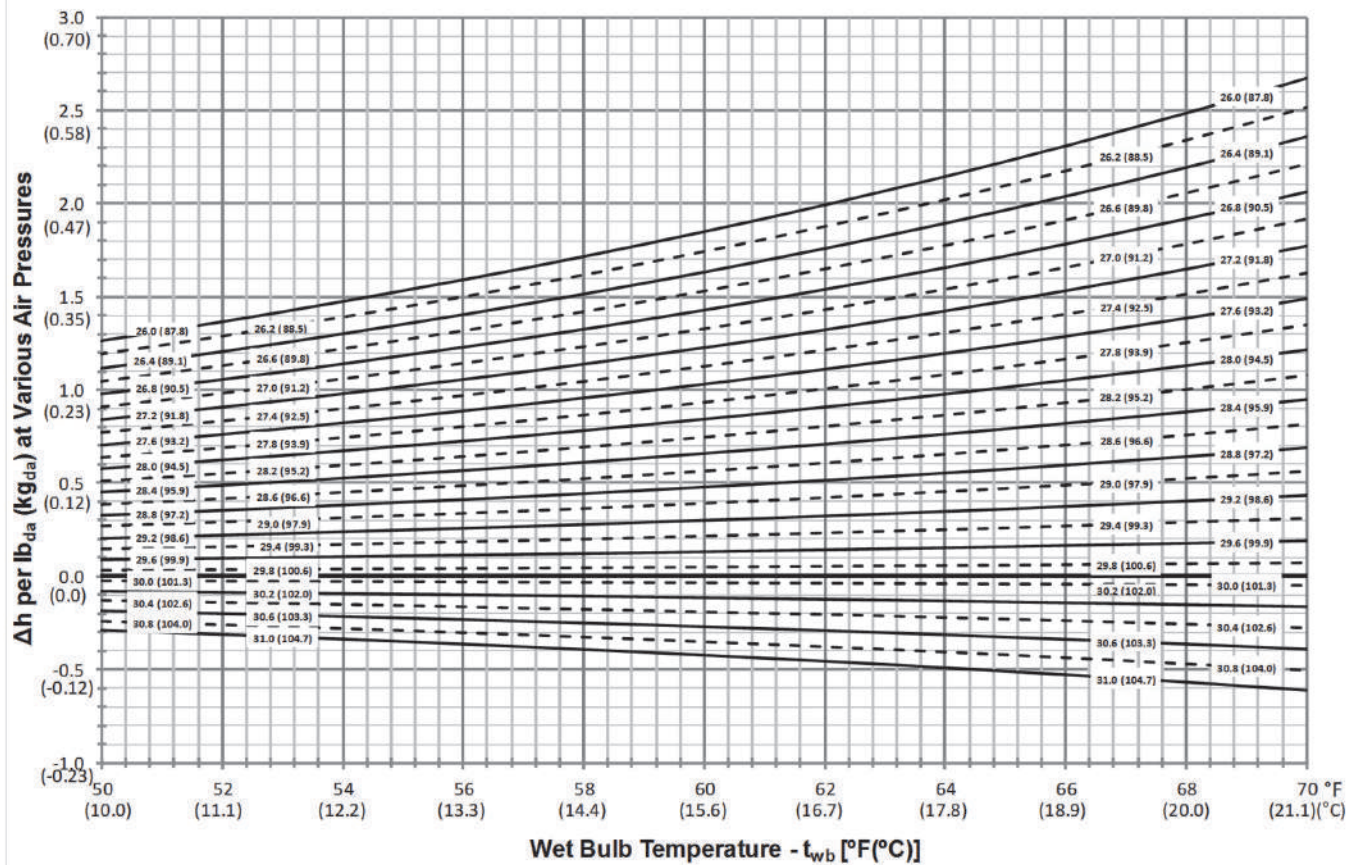


FIGURE 12 Barometric pressure corrections to enthalpy of saturated air-water vapor mixtures.

h'_0 = enthalpy of saturated air at wet-bulb temperature and standard barometer, 29.92 in. Hg

h' = enthalpy of saturated air at wet-bulb temperature and actual barometric pressure

Δh_0 = barometric pressure correction

$h' = h'_0 + \Delta h_0$

Informative Note: This chart is to be used in conjunction with Figure 11 to correct for wet-bulb depression.

q_k = heat leakage of plenum and/or ductwork ahead of temperature measuring apparatus, Btu/h (W)

q_s = sensible capacity, Btu/h (W)

q_{tca} = total cooling capacity, air side, Btu/h (W)

q_{iha} = total heating capacity, air side, Btu/h (W)

q_{tcw} = total cooling capacity, water side, Btu/h (W)

q_{ihw} = total heating capacity, water side, Btu/h (W)

Q_{an} = airflow, measured, cfm (L/s)

Q_a = airflow at test unit, cfm (L/s)

Q_s = airflow, standard air, cfm (L/s)

Q_w = water flow, gpm (L/s)

t_{a1} = temperature, air entering unit, dry bulb, °F (°C)

t'_{a1} = temperature, air entering unit, wet bulb, °F (°C)

t_{a2} = temperature, air leaving unit, dry bulb, °F (°C)

t'_{a2} = temperature, air leaving unit, wet bulb, °F (°C)

t_{a3} = temperature, ambient air surrounding plenum and mixing chamber, dry bulb, °F (°C)

t_{w1} = temperature, water entering unit, °F (°C)

t_{w2} = temperature, water leaving unit, °F (°C)

U_k = coefficient, heat leakage, Btu/h·ft²·°F (W/m²·°C)

v_1 = specific volume of air, entering unit, ft³/lb (m³/kg)

v_n = specific volume of air at dry- and wet-bulb temperature conditions existing at nozzle but at standard barometric pressure, ft³/lb (m³/kg)

v'_n = specific volume of air at nozzle, ft³/lb (m³/kg) of air-water vapor mixture

w_a = mass flow rate of air, lb/h (kg/s)

w_w = mass flow rate of water, lb/h (kg/s)

W_1 = humidity ratio, at inlet, lbs water vapor per lb (kg/kg) dry air

W_n = humidity ratio, at nozzle, lbs water vapor per lb (kg/kg) dry air

W_{s1} = humidity ratio at saturation at wet-bulb temperature at inlet, lbs water vapor per lb dry air (kg/kg)

W_{sn} = humidity ratio at saturation at wet-bulb temperature at nozzle, lbs water vapor per lb dry air (kg/kg)

ρ_w = density, of water, lb/ft³ (kg/m³)

8.6 Test Tolerances

8.6.1 All test observations shall be within the tolerances specified in Table 1, as appropriate to the test methods. See Section 7.1.1.

8.6.2 The maximum permissible variation of any observation during the capacity test is listed under “Test-Run Operating Tolerance” in Table 1. This represents the greatest permissible difference between maximum and minimum instrument observations during the test. When expressed in percentage, the maximum allowable variation is the specified percentage of the arithmetical average of the observations.

8.6.3 The maximum permissible deviations of the averages of the test observations from the standard or desired test conditions are shown in Table 1 under “Test Condition Tolerance.”

8.6.4 Variations and/or deviations greater than those prescribed shall invalidate the test.

8.7 Data to Be Recorded. Table 2 shows, generally, the data to be recorded during a test. Items indicated by an “x” are required for the test being conducted.

9. SOUND MEASUREMENT METHODS AND PROCEDURES

9.1 Test Conditions. The thermal conditions are not critical to an accurate measurement of sound; therefore, the unit under test is not required to be in a conditioned space, nor does the unit need to have the water in the coil.

9.2 Ducted Fan Coils. For any fan coil that has provisions for a duct on the inlet or discharge, follow the method of test in AHRI Standard 260⁶, except the sound data shall be recorded for the octave band range from 125 to 8000 Hz (63 Hz is optional).

For the purposes of this standard, a duct is an enclosed airway with a length greater than 1 effective diameter according to the following equation:

$$D = \left(\frac{4A}{\pi} \right)^{1/2}$$

where

A = cross-sectional area of the duct, m²

D = effective diameter, m

9.3 Nonducted Fan Coils. For any fan coil with no provision for a duct to be attached and/or that has free inlet(s) and free discharge, follow the method of test in Section 9.4.

9.4 Sound Measurement Methods for Fan-Coil Units with Free Inlets and Free Discharge. The sound test for the octave band range 125 to 8000 Hz shall be conducted using either ANSI/ASA S12.58⁷ (ANSI/AHRI 220-2014) reverberation room comparison method or the sound intensity method described in AHRI 230-2013.

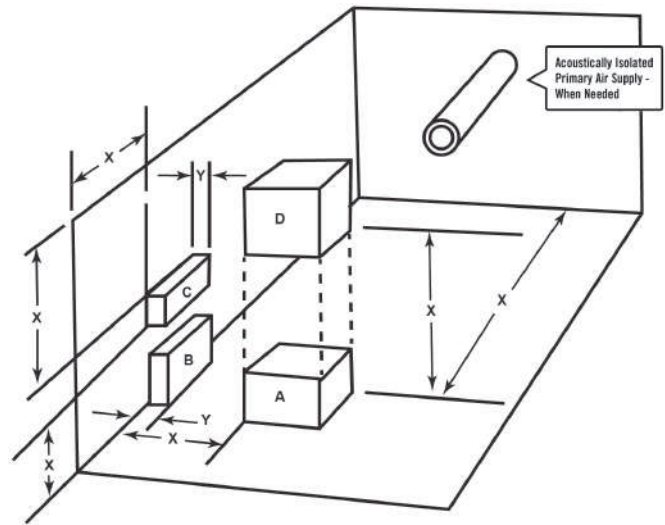


FIGURE 13 Location of equipment in the test room.

- A = location for equipment used away from a wall
- B = location for equipment used against or through the wall on the floor
- C = location for equipment mounted against or through a wall
- D = location for equipment suspended or fastened to ceiling
- X = 5.0 ft (1.5 m) minimum to adjoining room surfaces other than mounting plane
- Y = manufacturers recommended minimum

9.4.1 The tests setups can be divided into two basic types, exposed and concealed models.

9.4.1.1 Units designed to be exposed within the occupied space shall be set up without enclosures or ductwork for free delivery. For units located within the occupied space, this test setup combines the inlet, discharge, and casing radiated sound measurement (Figure 13).

9.4.1.2 Room fan-coil air conditioners designed to be located outside of the occupied space (concealed or furred-in application) shall be installed with the casing radiated noise acoustically isolated from the measured combined inlet and discharge sound and operated at free-delivery conditions. Acoustic isolation shall be achieved with either of the methods described in the following subsections.

9.4.1.2.1 A stud construction enclosure with a minimum of 0.5 in. (13 mm) and a minimum density of 1.6 lb/ft² (7.8 kg/m²) drywall or equivalent. The enclosure shall not be in contact with the equipment under test except at the inlet and outlet.

9.4.1.2.2 Direct attachment of 0.5 in. (13 mm) and a minimum density of 1.6 lb/ft² (7.8 kg/m²) drywall to the equipment with sheet metal screws or adhesive.

The laboratory shall record the construction enclosure with the following characteristics: stud type, orientation and spacing, drywall thickness, spacing between the equipment and drywall, and sound absorptive material if present. If directly attached, the attachment method shall be noted.

A description of any grills, diffusers, or acoustic panels used in the test setup shall be recorded.

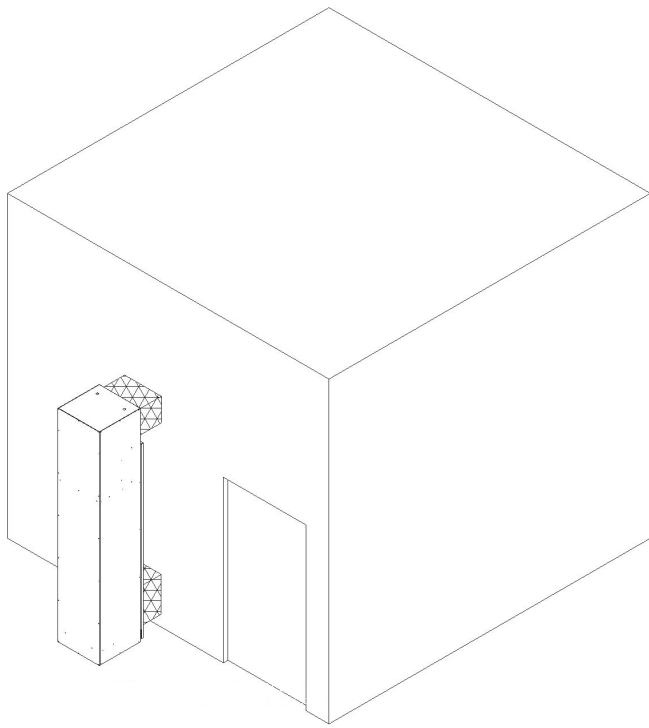


FIGURE 14 Vertical fan coil has inlet and discharge on same side of cabinet—discharge setup.

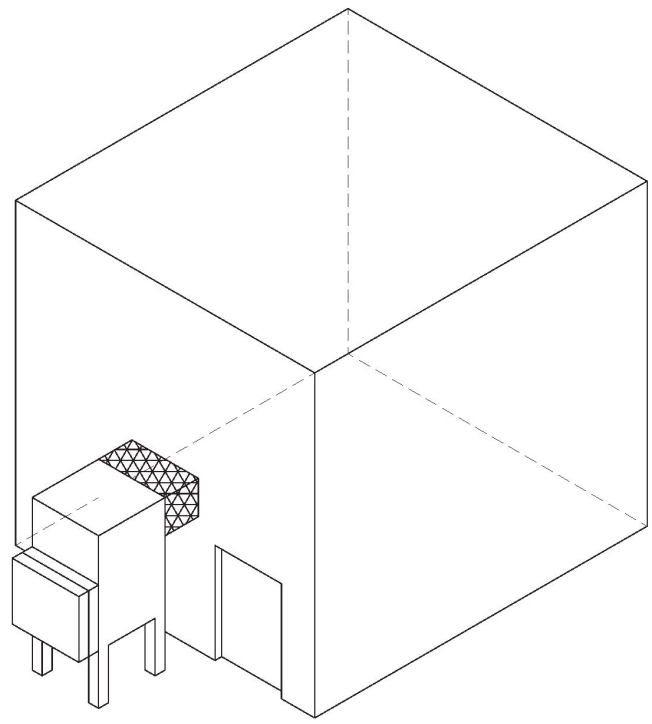


FIGURE 15 Horizontal fan coil with free discharge setup.

9.4.1.3 An alternate method to that in Section 9.4.1.2 is to record sound components that include discharge, casing radiated, or inlet sound.

For these units, the discharge sound shall be measured per Figure 14 (vertical units) and Figure 15 (horizontal units). The hatched duct length dimension is defined as 1 effective duct diameter or less.

For the purposes of this standard, a duct is an enclosed airway with a length greater than 1 effective diameter according to the equation in Section 9.2.

The casing radiated and free inlet (or discharge) combined shall be measured per Figure 16 (vertical units) and Figure 17 (horizontal units). For free inlet, only measure sound per Figure 18.

9.5 Sound Data Recorded and Calculations. The information to be recorded shall be as shown in ANSI/AHRI 260, Section 4.9⁶. Sound level calculation shall be made as shown in ANSI/AHRI 260 Section 5⁶.

10. REFERENCE PROPERTIES AND DATA

10.1 Thermodynamic Properties of Air. The thermodynamic properties of air-water vapor mixture shall be obtained from *ASHRAE Handbook—Fundamentals*⁴.

10.2 Thermodynamic Properties of Water. The thermodynamic properties of water shall be obtained from *ASHRAE Handbook—Fundamentals*⁴.

10.3 Heat Transmission Coefficients. The heat transmission coefficients for various materials shall be obtained from *ASHRAE Handbook—Fundamentals*⁴.

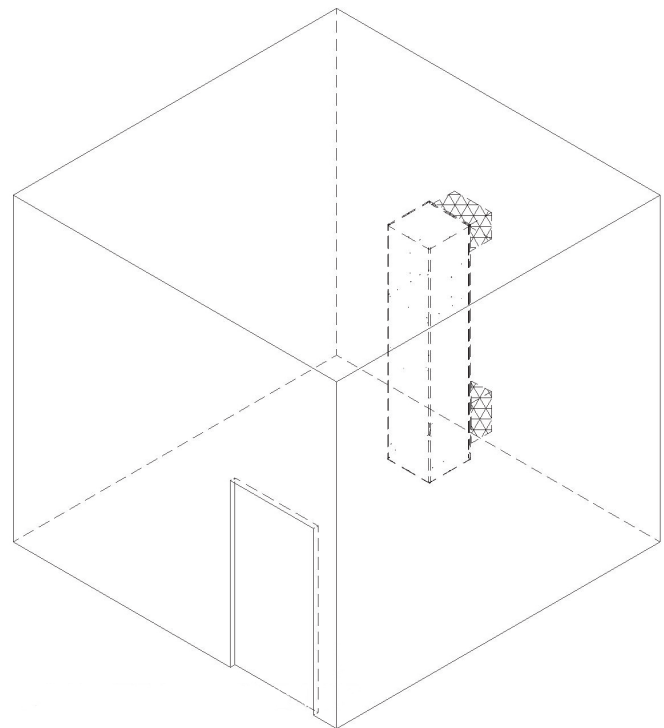


FIGURE 16 Vertical fan coil has inlet and discharge on same side of cabinet—radiated setup.

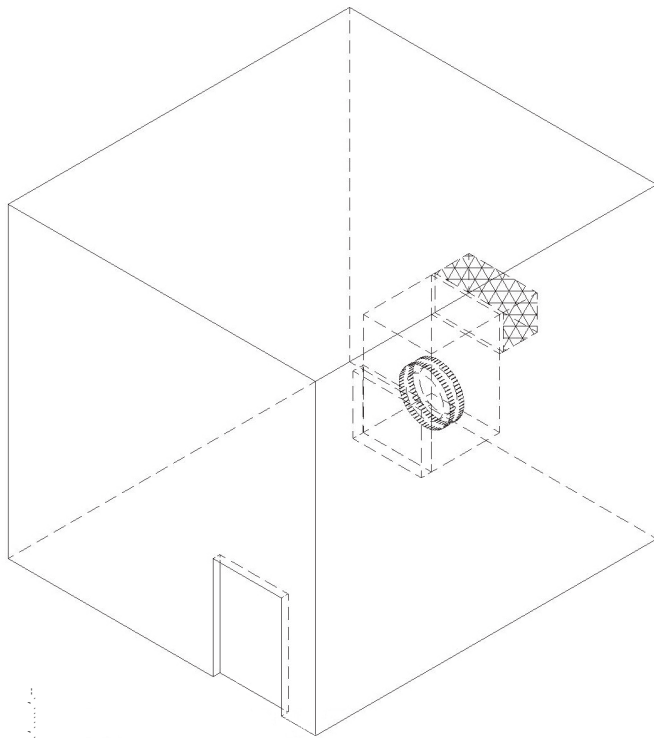


FIGURE 17 Horizontal fan coil with free discharge (or inlet) for casing radiated setup.

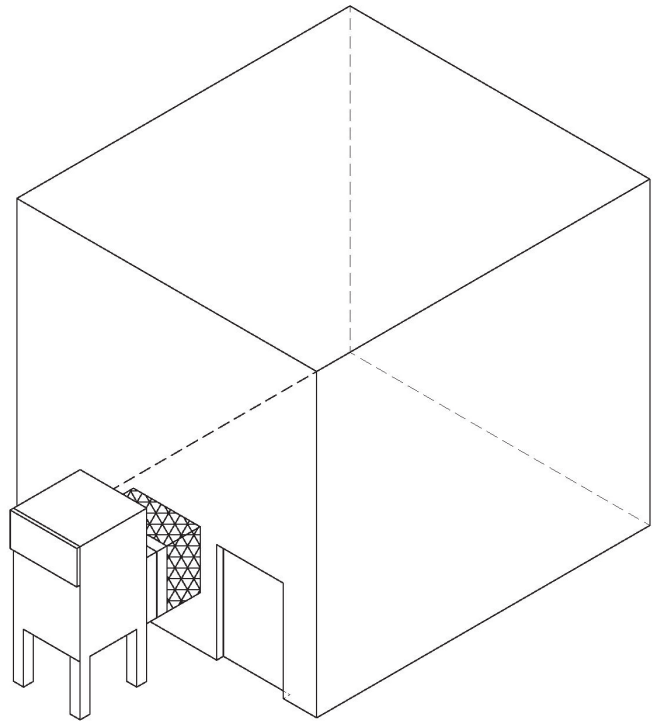


FIGURE 18 Horizontal fan coil with free inlet setup.

11. REFERENCES

1. ASHRAE. 2013. ANSI/ASHRAE Standard 41.1, *Standard Method for Temperature Measurement*. Atlanta: ASHRAE.
2. ASHRAE. 1989. ASHRAE Standard 41.3, *Standard Method for Pressure Measurement*. Atlanta: ASHRAE.
3. ASHRAE. 1992. ASHRAE Standard 41.2-1987 (RA 92), *Standard Methods for Laboratory Airflow Measurement*. Atlanta: ASHRAE.
4. ASHRAE. 2013. *ASHRAE Handbook—Fundamentals*. Atlanta: ASHRAE.
5. IEC. 2000. IEC Standard 60038, *Standard Voltages*. Geneva: International Electrotechnical Commission.
6. AHRI. 2012. ANSI/AHRI Standard 260, *Standard for Sound Rating of Ducted Air Moving and Conditioning Equipment*. Arlington, VA: Air-Conditioning, Heating, and Refrigeration Institute.
7. ASA. 2012. ANSI/ASA S12.58, *American National Standard Sound Power Level Determination for Sources Using a Single-Source Position*. Melville, NY: Acoustical Society of America.
8. ASHRAE. 2006. ANSI/ASHRAE Standard 41.6-1994 (RA 2006), *Method for Measurement of Moist Air Properties*. Atlanta: ASHRAE.
9. ASHRAE. 2015. *ASHRAE Terminology*. Atlanta: ASHRAE. wiki.ashrae.org.

(This is a normative annex and is part of this standard).

NORMATIVE ANNEX A
PRIMARY AIRFLOW MEASUREMENT

A1. NOZZLES

A1.1 Construction. Construction of nozzles shall be in accordance with Figure A-1. Nozzles shall be of a size such that the throat velocity is not less than 3000 fpm (15 m/s) or more than 7000 fpm (36 m/s). When nozzles are constructed in accordance with Figure A-1 and installed in accordance with Section 5.1.1, they may be used without calibration. If the throat diameter is 5 in. (125 mm) or larger, the coefficient may be assumed to be 0.99. For nozzles smaller than 5 in. (125 mm) in diameter, or where a more precise coefficient is desired, the value shown in Figure A-1 or as determined using the nomograph of Figure A-2 may be used.

Reynolds Number, N_{Re}	Coefficient of Discharge, C
50,000	0.97
100,000	0.98
150,000	0.98
200,000	0.99
250,000	0.99
300,000	0.99
400,000	0.99
500,000	0.99

Reynolds number is calculated as follows:

$$N_{Re} = fV_a D \tag{A-1}$$

where

V_a = velocity of air at nozzle, fpm (m/s)

D = diameter, nozzle throat, in. (mm)

The temperature factor f is as follows:

Temperature		
°F	°C	Factor f
20	-6.7	10.1 (78.2)
40	4.4	9.3 (72.0)
60	15.6	8.7 (67.4)
80	26.7	8.1 (62.8)
100	37.8	7.5 (58.1)
120	48.9	7.1 (55.0)
140	60.0	6.7 (51.9)
160	71.1	6.3 (48.8)

A1.2 Areas. Areas of a nozzle shall be computed from the average of diameter measurements made to an accuracy of $\pm 0.20\%$ in four places approximately 45 degrees apart around the nozzle in each of two planes through the nozzle throat, one at the outlet and the other in the straight section near the radius.

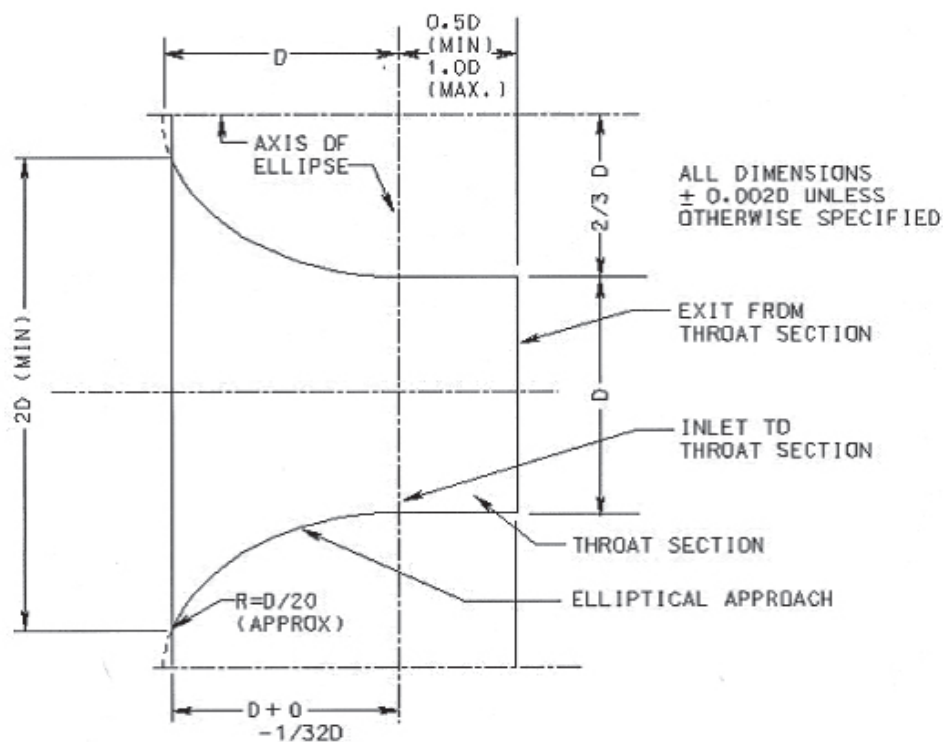


FIGURE A-1 Airflow measuring nozzle.

INSTRUCTIONS: ENTER GRAPH USING DIAMETER AND TEMPERATURE SCALES TO OBTAIN POINT ON INDEX (X) SCALE. USE INDEX AND PRESSURE SCALES TO OBTAIN REYNOLDS NUMBER AND DISCHARGE COEFFICIENT.

THIS NOMOGRAPH IS THE SOLUTION OF THE FOLLOWING EQUATIONS:

$$C_n = f(R_o); R_o = VD \rho / \mu$$

C_n – DISCHARGE COEFFICIENT
 R_o – REYNOLDS NUMBER

WHERE: V =VELOCITY
 D =DIAMETER
 ρ =DENSITY
 μ =DYNAMIC VISCOSITY

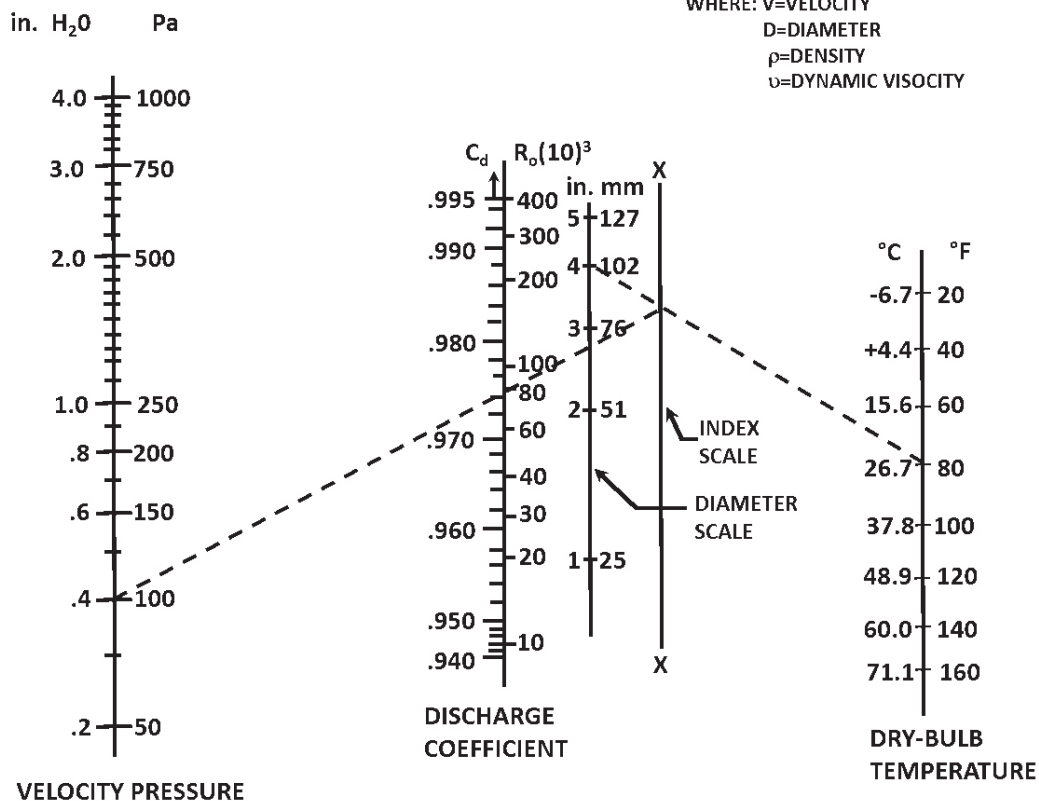


FIGURE A-2 Determination of nozzle discharge coefficient.

(This is a normative annex and is part of this standard).

NORMATIVE ANNEX B ALTERNATE AIRFLOW MEASUREMENT

B1. VANE ANEMOMETER FLOW MEASURING SYSTEM

B1.1 One method of accurately measuring airflow rates with low pressure drop is to use a vane anemometer that has been calibrated in situ against a certified standard to the required accuracy.

B1.2 The vane anemometer flow measuring system consists of a straight length of duct with a propeller anemometer, humidity measuring instruments, and a temperature probe inside (see Figure B-1). The duct has five diameters of inlet length, a flow straightener, and three diameters of discharge length. Optionally, a backpressure regulating device can be installed in the discharge of the precision flow station. A properly calibrated vane anemometer flowmeter can be accurate to $\pm 2\%$ over an extremely wide flow range. Following is a numbered list of components for a vane anemometer flow measuring system (see Figure B-1):

- a. Item 1 is a section of straight duct to allow the airflow to stabilize in the duct.
- b. Item 2 is the propeller anemometer.
- c. Item 3 is the center section of duct where all of the instruments are mounted.
- d. Item 4 is the wet-bulb temperature sensor.
- e. Item 5 is the dry-bulb temperature sensor.
- f. Item 6 is the discharge duct.
- g. Item 7 is the discharge transition.
- h. Item 8 is the optional backpressure damper.
- i. Item 9 is a flow straightener consisting of a least grid of 0.5 in. (12.5 mm) squares deeper than two times the grid size.
- j. Item 10 is an in-duct static pressure probe, mounted 1 diameter behind the front of the propeller.
- k. Not shown is an atmospheric pressure transducer.

B1.3 Vane Anemometer Flowmeter Calibration Procedure

B1.3.1 Since the propeller anemometer is most commonly used for outdoor wind-speed measurement, and since in this measurement approach the anemometer is mounted in a duct, the factory calibration will not be valid. The most convenient and accurate method to calibrate it is in place using a flow standard such as a NIST-traceable venturi flowmeter. Following is a partial numbered list of components for a vane anemometer flowmeter calibration procedure (see Figure B-2).

- a. Item 1 is the NIST traceable venturi flowmeter.
- b. Item 2 is the temperature probe (must be upstream of the venturi).
- c. Item 3 is the inlet transition.

B1.3.2 Depending on the purpose of the propeller flow station, several flow ranges will be needed to fully calibrate the unit.

B1.3.3 The anemometer flow station must be constructed solidly to minimize the potential for leakage at high static pressures. Verify that the flowmeter and calibrating venturi are concentric, straight, and level. (This is important because misalignment will result in lower than anticipated accuracy.)

B1.3.4 When constructing the anemometer flowmeter, take care to locate the anemometer within 0.16 equivalent diameters of the center of the duct as shown in Figure B-3.

B1.3.5 The target of the calibration is to create an empirical mathematic equation that relates frequency output from the anemometer to flow rate (cfm [L/s]). The finished anemometer will have an extremely wide flow range, 8 to 3400 cfm (3.7 to 1604 L/s) for a 12-in. (300 mm) $\varnothing$ duct. Several venturi will be needed to cover the entire range. Larger ducts will have a higher minimum and higher maximum and, similarly, smaller ducts will have a lower minimum and lower maximum.

- a. Start with the smallest venturi first and calibrate through its range. Gradually increase and then decrease the flow rate from the lowest practical value for that size venturi to the highest practical value in small steps recording the flow rate and frequency every few seconds.
- b. Repeat with the next-size larger venturi until the required flow range is covered. Ensure that the range of each venturi overlaps the range of adjacent sizes.
- c. Use standard statistical analysis to determine the relationship between flow and frequency.

B1.3.6 Venturi flowmeters automatically correct for atmospheric density but anemometer flowmeters will not. The solution to this is to use the barometric pressure transducer and the static pressure transducer along with the humidity and temperature probes to correct for atmospheric density changes. The anemometer flowmeter will then give readings in standard cubic feet per minute (litres per second).

Informative Note: The anemometer flowmeter can be inside any size or shape duct and still be very accurate over an extremely wide flow range because of the calibrate-in-place procedure.

NOTES:

1. THE BACKPRESSURE DAMPER (ITEM 8) WILL BE USED TO ADJUST THE STATIC PRESSURE DOWNSTREAM OF THE FPTU UNDER TEST TO .25" W.C. ALL TESTS WILL BE CONDUCTED UNDER THESE CONDITIONS.
2. ALL DUCTS MUST BE ASSEMBLED CONCENTRICALLY AND ALONG A STRAIGHT LINE.

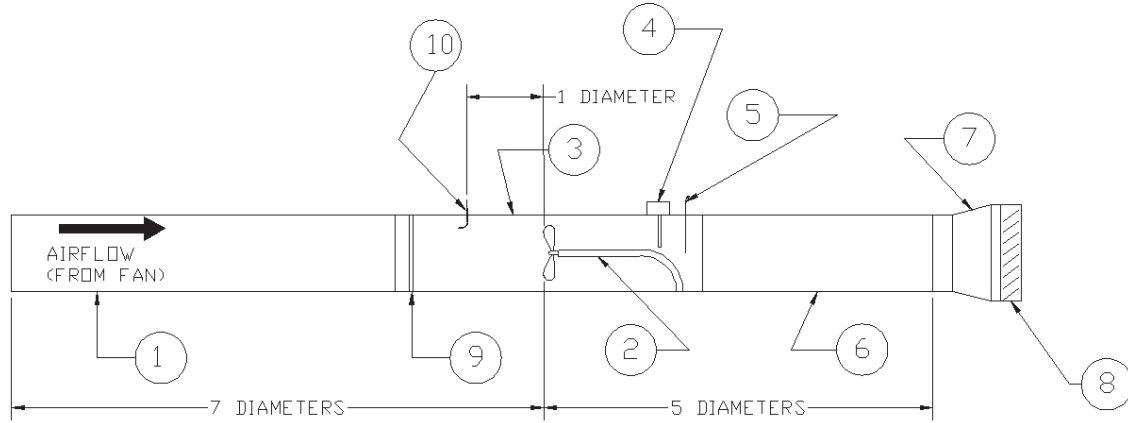


FIGURE B-1 Vane anemometer flow measuring system.

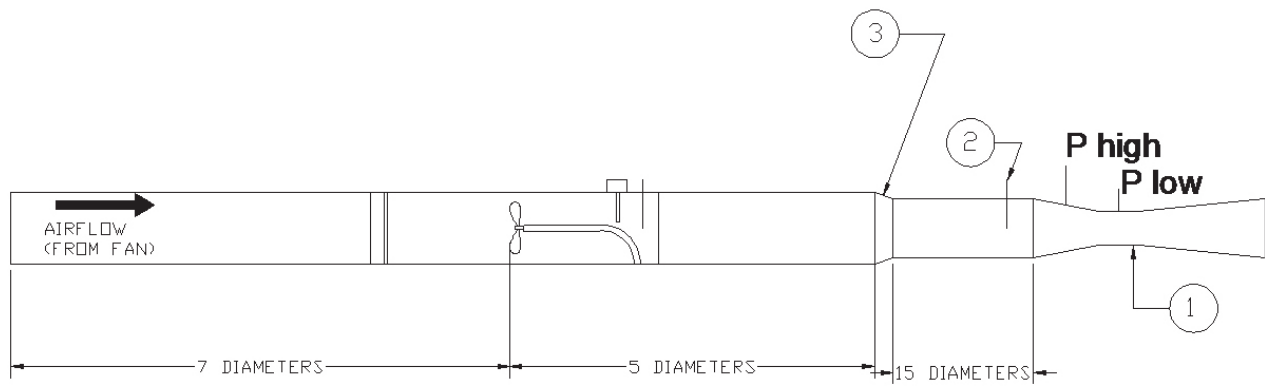


FIGURE B-2 Vane anemometer flowmeter calibration procedure.

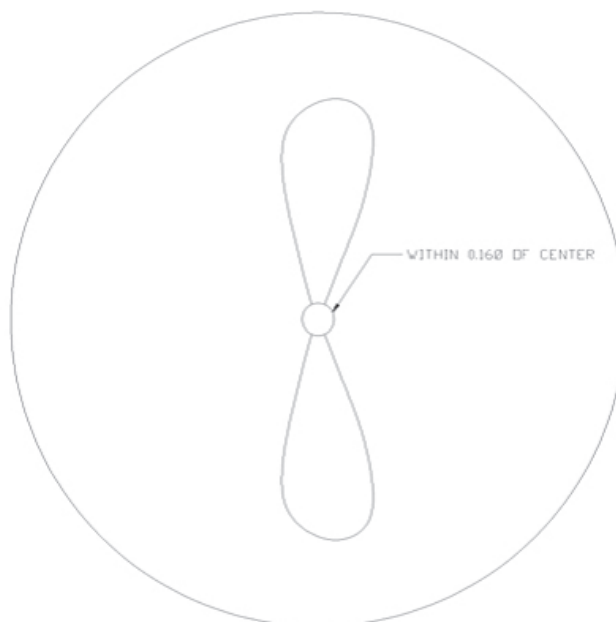


FIGURE B-3 Vane anemometer flowmeter calibration procedure.

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INFORMATIVE ANNEX C
ALTERNATE MIXING-TUBE REFERENCE DIMENSIONS

Figures C-1 and C-2 show reference dimensions when using sanitary tubing for the mixing tubes for supply and return water. These dimensions could vary depending on brand of sanitary tubing used and resistance temperature sensor used. Material is 304 stainless steel.

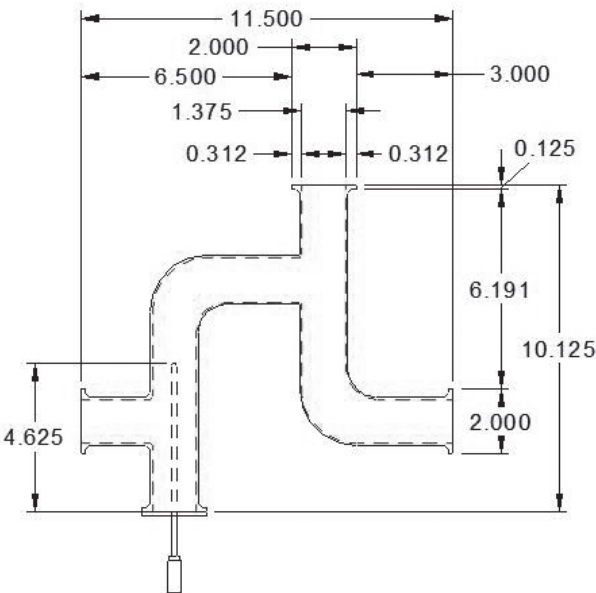


FIGURE C-1 Reference dimensions when using sanitary tubing for the mixing tubes for supply and return water (1/2 in. [12.5 mm] manifold application).

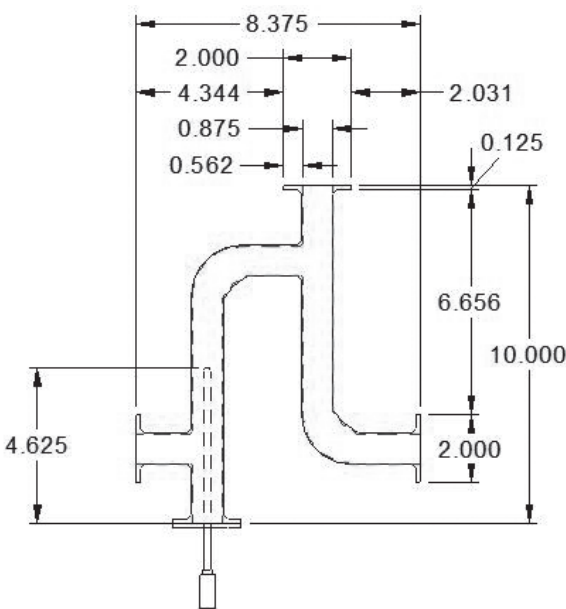


FIGURE C-2 Reference dimensions when using sanitary tubing for the mixing tubes for supply and return water (3/4 in. [18.8 mm] manifold application).

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INFORMATIVE ANNEX D EXAMPLES OF VARIOUS TYPES OF EXPOSED AND CONCEALED FAN COILS

Figure D-1 shows examples of typical free inlet and discharge fan coils exposed in the conditioned space. Figure D-2 shows examples of typical free inlet and discharge fan coils concealed near the conditioned space.

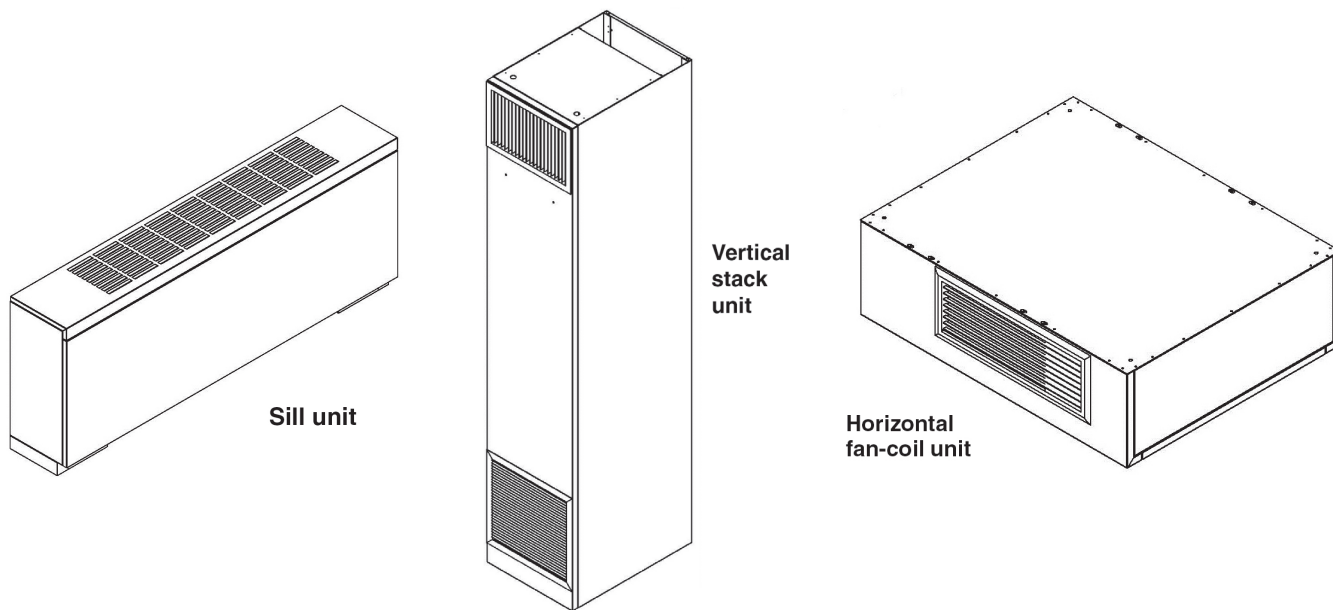


FIGURE D-1 Examples of typical free inlet and discharge fan coils exposed in the conditioned space.

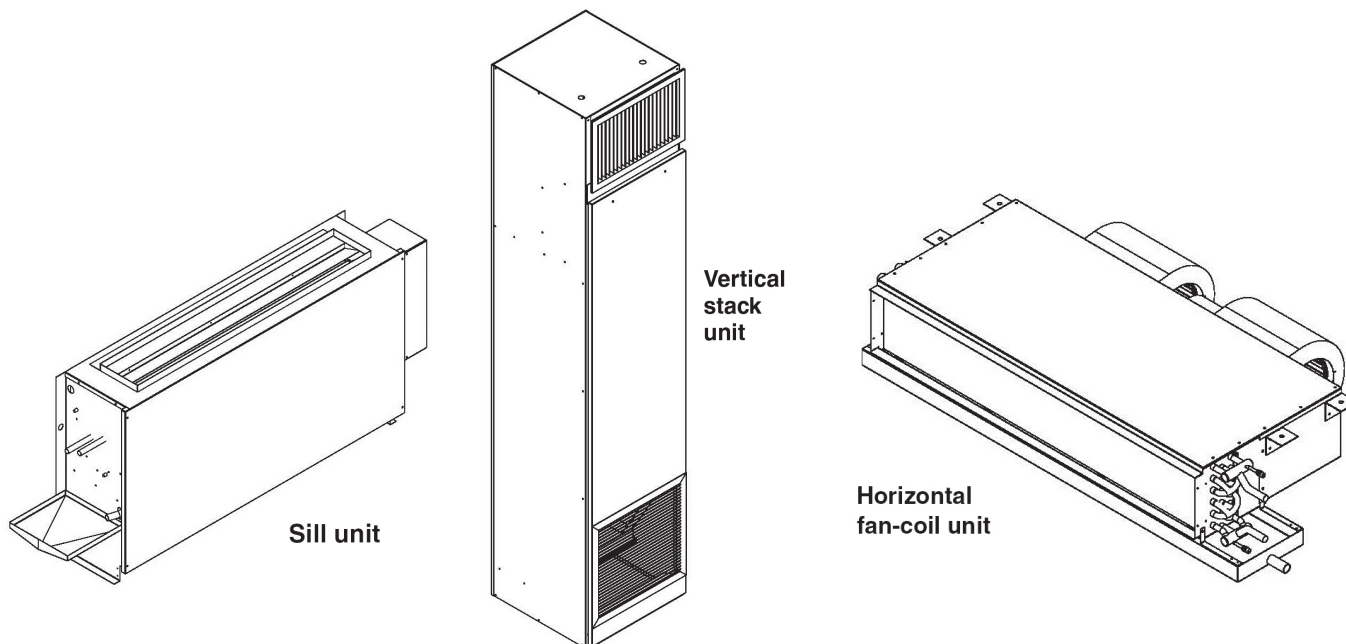


FIGURE D-2 Examples of typical free inlet and discharge fan coils concealed near the conditioned space.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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