



BSR/ASHRAE Standard 198P

Public Review Draft

Method of Test for Direct Expansion-Dedicated Outdoor Air System (DX-DOAS) Units

**First Public Review (October 2026)
(Draft Shows Complete Proposed Standard)**

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website at <https://www.ashrae.org/technical-resources/standards-and-guidelines/public-review-drafts> and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the standard (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any standard may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

This document may not be distributed in whole or in part in either paper or electronic form outside of the PC without the express permission of the MOS and shall include a statement indicating such.

The appearance of any technical data or editorial material in this public review document does not constitute endorsement, warranty, or guaranty by ASHRAE of any product, service, process, procedure, or design, and ASHRAE expressly disclaims such.

© 2026 ASHRAE. This draft is covered under ASHRAE copyright. Permission to reproduce or redistribute all or any part of this document must be obtained from the ASHRAE Manager of Standards, 180 Technology Parkway NW, Peachtree Corners, GA 30092. Phone: 404-636-8400, Ext. 1125. Fax: 404-321-5478. E-mail: standards.section@ashrae.org.

ASHRAE, 180 Technology Parkway NW, Peachtree Corners, GA 30092

(This foreword is not part of this standard. It is merely informative material and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This proposed standard is a Method of Test (MOT) standard for use in factory performance testing of dedicated outdoor system units that contain a vapor compression cycle refrigeration system. It was developed primarily as a method of test to be used in conjunction with rating procedures such as AHRI 920. Rated airflow rates, air temperature and humidity, and other conditions to be tested are indicated in such rating standards.

Dedicated outdoor air system (DOAS) units are used for conditioning 100% outdoor air for space ventilation. A wide variety of designs are possible. In addition to the vapor compression cycle refrigeration system, the units that this standard applies to may include other types of technology that increase the moisture removal, cooling, and heating capacity of the device through heat exchange in the primary air or through recovery of exhaust air energy. The method of test intends to allow for measurement of the critical inputs and outputs of the machine without regard for the configuration or components included.

There are a variety of modes that the targeted systems may be operated in. Additionally, control algorithms employed to determine these modes vary greatly as well. This MOT can be applied to any of these modes, although each should be considered as a separate and distinct test. It is the intention that system be set for fully automatic operation at each test condition with adjustments only where the standard controls allow for user adjustment of parameters, such as supply air or zone temperature control. These adjustments are expected to be made before the start of each distinct test based on the parameters to be tested. Minimal intervention is expected during the testing as to best simulate the typical operating conditions in the field during year-round operation of the equipment.

1. PURPOSE

This standard provides methods of testing and calculations for moisture removal and heating by direct expansion dedicated outdoor air system (DX-DOAS) units.

2. SCOPE

- 2.1 This method of test applies to factory assembled DX-DOAS units that condition 100% outdoor air and can include factory assembled preconditioning devices. This includes the following:
 - a. Air-cooled, evaporatively-cooled, and water-cooled DX-DOAS units.
 - b. Air-source or water-source DX-DOAS heat pump units.
- 2.2 This standard does not cover:
 - a. Units containing water coils requiring a supply of water supplied by a liquid chiller located outside of the unit.
 - b. Testing of stand-alone preconditioning or energy recovery devices.
 - c. Units that incorporate heat sources other than electricity or electrically driven vapor compression cycle for regeneration of desiccant heat exchangers.

3. DEFINITIONS

conditioned space: a part of a building that is either humidified, dehumidified, heated, and/or cooled for the comfort of occupants.

conditioning coil: a coil that uses refrigerant to cool and dehumidify or heat the outdoor ventilation air. This may include coils that are part of a reheat refrigeration circuit.

desiccant DX-DOAS system: a system that used liquid or solid desiccant to dehumidify air. It includes a regeneration system to reject moisture to the outdoors.

DX-Dedicated Outdoor Air System (DX-DOAS) unit: A type of air-cooled, evaporatively-cooled, or water-cooled

air-conditioner, or an air-source or water-source heat pump, factory assembled product which is capable of dehumidifying 100% outdoor air to a low dew-point and can be capable of controlling the dry-bulb temperature of the dehumidified air to the designed supply air temperature. This conditioned outdoor air can be delivered directly or indirectly to the conditioned space(s). It can incorporate a VERS or desiccant. The product can also include a supplementary heat system for use when outdoor air requires heating beyond the capability of the refrigeration system, other heat transfer apparatus, or both.

exhaust air: air removed from the DX-DOAS unit after use for preconditioning outdoor air in a VERS and/or for use as a heat sink or source for an outdoor coil, and discharged outside the building by means of mechanical ventilation systems. This is only applicable to DX-DOAS units with VERS and relief-air-cooled DX-DOAS units.

manufacturer's installation instructions (MII): manufacturer's documents that come packaged with or appear in the labels applied to the unit(s). Online manuals are acceptable if referenced on the unit label or in the documents that come packaged with the unit. May also be referred to as "manufacturer's instructions," "manufacturer's published instructions," "manufacturer's published recommendations," "manufacturer installation and operation manuals," "installation instructions" and other similar references, including a test plan.

moisture removal capacity (MRC): the capacity of a unit to remove moisture from the outdoor air. Expressed in pounds or kilograms of moisture removed per hour (lb moisture/h [kg moisture/h]).

outdoor air: unconditioned air from outside a building that passes through the conditioning coil.

outdoor ventilation air: unconditioned air from outside a building before passing through the conditioning coil. After passing through the conditioning coil, the outdoor ventilation air becomes supply air.

reheat refrigerant circuit: a refrigerant-to-air exchange circuit that utilizes heat from a compression cycle to heat air previously cooled during the humidification cycle to achieve a lower relative humidity and/or improve comfort. The layout and coil are often referred to as Hot Gas Reheat (HGRH).

relief-air-cooled DX-DOAS unit: an air-cooled DX-DOAS unit which cools or heats the outdoor coil using either 100% return air or the air leaving a VERS after preconditioning the entering outdoor air.

return air: air removed from the conditioned space and delivered to the DX-DOAS unit by means of mechanical ventilation systems. This air is used to precondition outdoor air in a VERS or act as a heat sink or source for an outdoor coil.

shall: "shall" or "shall not" are used in this standard where a provision is mandatory for compliance with the standard.

should: "should" is used in this standard to indicate provisions that are not mandatory for compliance but represent desirable or good practice.

simulated ventilation air: air that is representative of the preconditioned air leaving the ventilation energy recovery system (VERS) when using VERS Test Option 2 as specified in Section 8.3.1.2.

supplementary heat: all heat required to increase the dry-bulb temperature of dehumidified or heat pump heated supply air that is not provided by the following sources: the vapor compression cycle; a system that transfers heat from one part of the unit to the other, such as a wrap-around heat pipe or wrap-around vapor compression cycle; or a system that transfers heat from the outdoor air to the supply air. Supplementary heat is expressed in Btu/h (W).

supply air: conditioned air discharged from the DX-DOAS unit and delivered to the conditioned space.

unit total heat capacity: the amount of heat in Btu/h (W) that the unit can transfer to the supply air when operating in heating mode. It can include heat from the vapor compression cycle, supplementary heat, and/or air-to-air heat exchanger(s).

ventilation energy recovery system (VERS): a device used to transfer energy between the outdoor ventilation air and exhaust air in a DX-DOAS unit. Examples include enthalpy wheels, sensible wheels, plate heat exchangers, heat pipes, or other heat or mass transfer apparatuses.

4. MEASUREMENTS AND INSTRUMENTS

4.1 Instrument accuracy shall be as indicated in Table 1.

Table 1 Instrument Accuracy

Type of Measurement	Purpose	Required Accuracy
Temperature	Wet-bulb for water vapor content	$\pm 0.20^{\circ}\text{F}$ ($\pm 0.11^{\circ}\text{C}$)
	Air dry-bulb steady	$\pm 0.20^{\circ}\text{F}$ ($\pm 0.11^{\circ}\text{C}$)
	Volatile refrigerant	$\pm 1.00^{\circ}\text{F}$ ($\pm 0.56^{\circ}\text{C}$)
	Water or nonvolatile refrigerant	$\pm 0.20^{\circ}\text{F}$ ($\pm 0.11^{\circ}\text{C}$)
Dew-Point Hygrometer	Water vapor content	$\pm 0.40^{\circ}\text{F}$ ($\pm 0.22^{\circ}\text{C}$) ^a
Relative Humidity	Water vapor content	$\pm 0.7\%$ rh ^a
Pressure	Barometric pressure	± 0.030 in. Hg (± 100 Pa)
	Refrigerant and liquid	$\pm 1.0\%$ of reading or 0.5 psig (3.4 kPa), whichever is greater
	Nozzle pressure difference and nozzle exit velocity pressure	$\pm 1.0\%$ of reading
	Duct static pressure	± 0.010 in. H ₂ O (± 2.5 Pa)
Electric Power Input	System components ^b	$\pm 1.0\%$ of reading
	Standby power for measurements less than 50 W	± 0.5 W
Electric Energy Input (Wh) or Average Electric Power Input (W)	Total system energy/power input	$\pm 0.5\%$ of reading
Voltage	Equipment input voltage	$\pm 1.0\%$ of reading
Flow	Volatile refrigerant	$\pm 1.0\%$ of reading
	Liquid	$\pm 1.0\%$ of reading
Rotational speed	Fan speed	$\pm 1.0\%$ of reading
Time	Any	± 2 seconds
Mass	Condensate	$\pm 1.0\%$ of reading or 0.050 lb (23 g), whichever is greater

a. Accuracy at 80.00°F DB/67.00°F WB (26.67°C DB/19.44°C WB).

b. E.g., fan motors, compressor motors, or other equipment accessories.

- 4.2 Airflow Measurement.** Instrumentation and calculations to determine airflow shall be in accordance with one or more of the methods described in ANSI/ASHRAE Standard 37, *Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment*.
- 4.3 Pressure Measurement.** Instrumentation and calculations to determine pressure measurements shall be in accordance with ANSI/ASHRAE Standard 37.
- 4.4 Air-Enthalpy.** Instrumentation and calculations to determine moist air properties shall be in accordance with ANSI/ASHRAE Standard 37.
- 4.5 Temperature Measuring Instruments.** Instrumentation for all temperatures shall be in accordance with ANSI/ASHRAE Standard 37. All air temperature measurements shall be taken upstream of the static pressure taps on the inlet and downstream of the static pressure taps on the outlet.
- 4.6 Electrical Instruments.** Electrical measurements shall be made in accordance with ANSI/ASHRAE Standard 37.
- 4.7 Liquid Flow Measurement.** Water flow rates shall be measured with a liquid flow meter or quantity meter having an accuracy of $\pm 1.0\%$ of the indicated value in accordance with ANSI/ASHRAE Standard 37.
- 4.8 Time and Mass Measurements.** Time interval measurements shall be made in accordance with Table 1.

- 4.9 Sensors.** In-duct measurements shall be taken at not less than three locations at the centers of equal segments of the cross-sectional area, or suitable sampling or mixing devices giving equivalent results shall be provided. Mixing and sampling devices are illustrated in ANSI/ASHRAE Standard 37.
- 4.9.1** Inlet temperature shall be measured at a minimum of three locations equally spaced over the equipment inlet area, or equivalent sampling means provided.
- 4.9.2** Air velocities over the wet-bulb temperature measuring instruments shall be approximately 1000 fpm (5 m/s). It is recommended that the same air velocity be used for inlet and outlet measurements. Wet-bulb measurements above or below must be corrected in accordance with ANSI/ASHRAE Standard 37.

5. INSTRUMENTS AND MEASUREMENT APPARATUS

- 5.1** Instrumentation and measurement apparatus shall be in accordance with ANSI/ASHRAE Standard 37.

5.2 Airflow Rate Measuring Apparatus

- 5.2.1 Outlet Test Chamber (Code Tester).** Where airflow is to be measured during testing, all measurement apparatus and procedures shall be made in accordance with ANSI/ASHRAE Standard 37.

- 5.3 Plenum Static Pressure Measurements.** Where static pressure is to be measured during testing, all measurement apparatus shall be in accordance with ANSI/ASHRAE Standard 41.2, *Standard Methods for Air Velocity and Airflow Measurement*.

- 5.3.1** For all ducted outlets, the duct shall extend for a distance of at least 2.5 times the square root of the cross-sectional area of the DX-DOAS outlet prior to any duct transitions, elbows, or air samplers used for air condition measurement. The static pressure taps shall be located 2.0 times the square root of the cross-sectional area of the outlet from the DX-DOAS.
- 5.3.2** For all ducted inlets connected to laboratory booster fans or to the fan of an airflow measurement apparatus, the duct shall extend for a distance of at least 1.5 times the square root of the cross-sectional area of the DX-DOAS inlet prior to any duct transitions, elbows, or air samplers used for air condition measurement. The static pressure taps shall be located 0.50 times the square root of the cross-sectional area of the inlet from the DX-DOAS.
- 5.3.3** For all other inlets not covered by Section 5.3.2, the plenum shall extend for a distance of at least 2.1 times the square root of the cross-sectional area of the DX-DOES inlet prior to any duct transitions, elbows, or air samplers used for air condition measurement. Refer to Figure 1.
- 5.3.4** If used, elbows connected to the end of the plenum shall have a centerline radius equal to at least 1.5 times the duct width in the radial direction or have turning vanes. Air velocities calculated as measured volume flow divided by duct or plenum cross-sectional area shall not exceed 250 ft/min (1.27 m/s) inside the plenum and 500 ft/min (2.54 m/s) in the connecting duct at its connection to the plenum.
- 5.3.5** When a plenum is attached to an unducted inlet or outlet employing a hood, louvered damper, or mist eliminator, these components shall be installed during the test. The inlet or outlet area shall be the smallest cross-sectional open area in the inlet or outlet airflow path that is outboard of any louvers, mist eliminators, or pre-filters. If multiple inlet/outlet openings are used, plenum size shall be based on the sum of the open areas. To avoid restriction of airflow between the hood of downward-facing inlets and outlets and the plenum walls, the plenum shall be sized sufficiently such that the velocity calculated at the measured volume flow divided by the restricted flow area shall be no more than 200 ft/min (1.02 m/s). Refer to Figures 1 and 2 for the plenum dimensional requirements.
- 5.3.6** Manifolded static pressure taps shall be installed in the plenum in at least four locations spaced uniformly around the plenum per ANSI/ASHRAE Standard 37, Section 6.4. For an outlet, the static pressure taps shall be 2.8 times the square root of the cross-sectional area of the outlet from the DX-DOAS. For an inlet, the static pressure taps shall be 1.0 times the square root of the cross-sectional area of the inlet from the DX-DOAS. Static pressure in the plenum shall be maintained within 0.050 in. H₂O (12 Pa) of ambient pressure.
- 5.3.7** If the duct pressure drop causes the plenum pressure to differ from ambient pressure by more than 0.050 in. H₂O (12 Pa), an auxiliary adjustable fan shall be installed in the duct to maintain the required plenum pressure. Air samplers used for temperature measurement shall be placed in the duct between the fan and the minimum required plenum length.

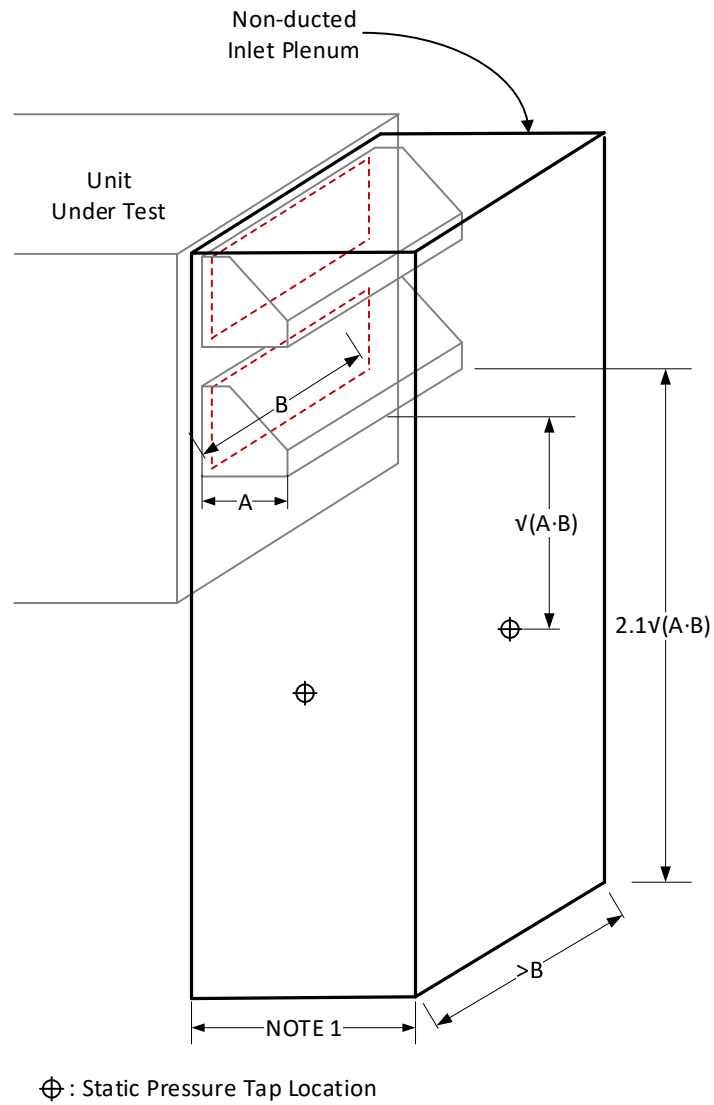


Figure 1. Non-Ducted Inlet Plenum (without Ducting to Booster Fan) (Note 1: Refer to Section 5.3.3)

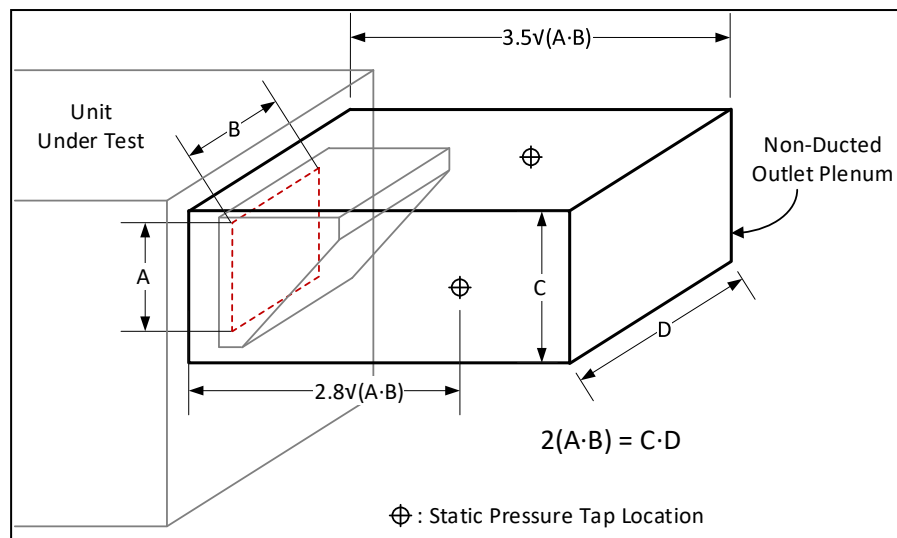


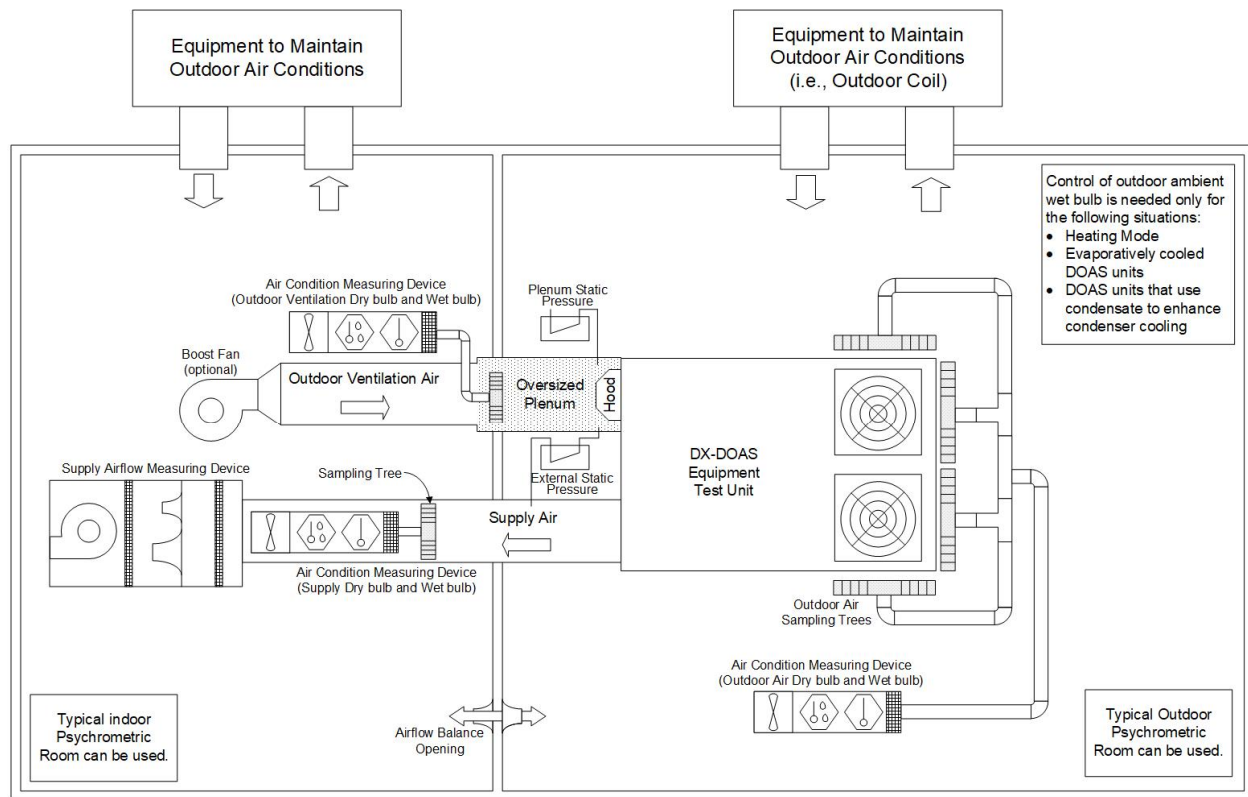
Figure 2. Non-Ducted Outlet Plenum

6. TEST FACILITY ARRANGEMENTS

6.1 Test Room Requirements. Test rooms shall be provided with suitable means to maintain prescribed conditions of temperature, humidity, and static pressure of the air entering the test section.

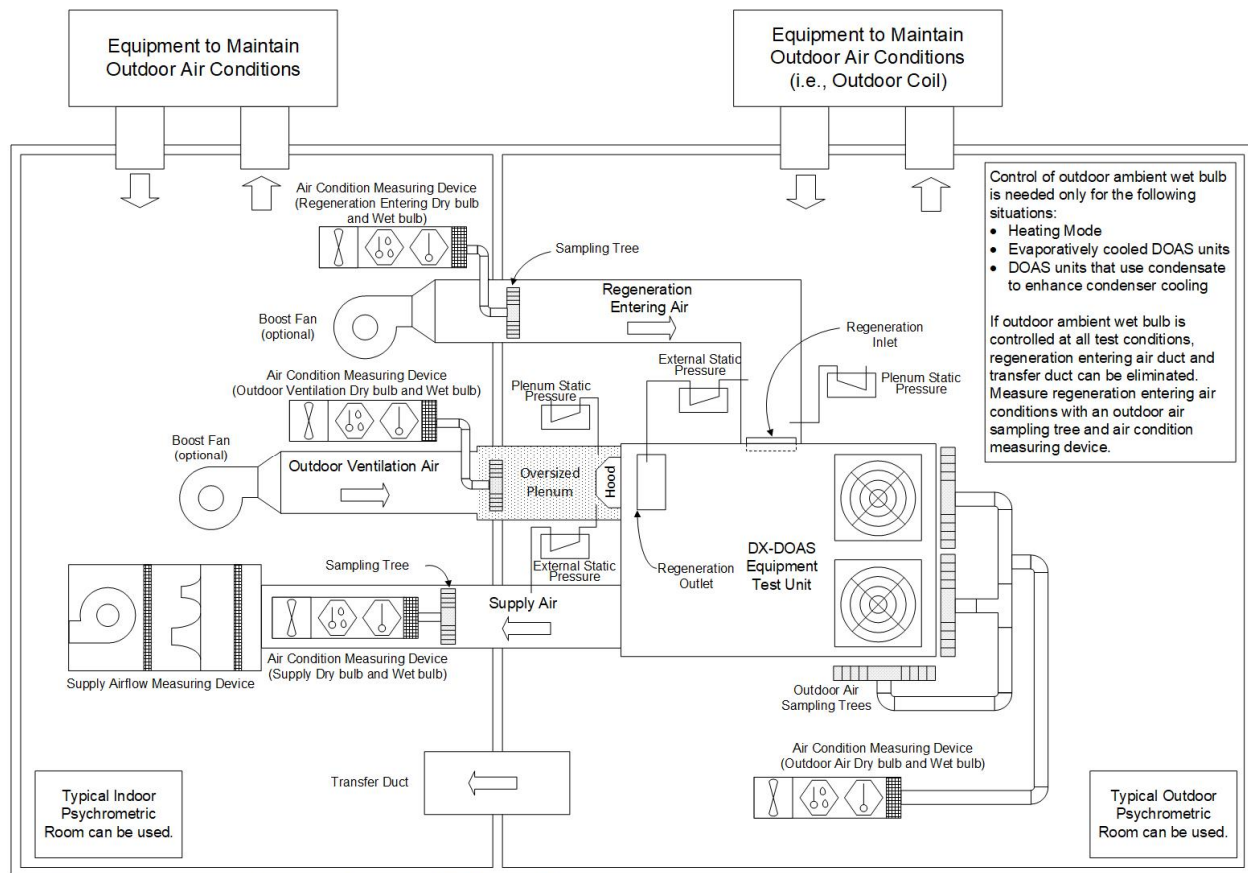
6.1.1 Air-Enthalpy Treatment Apparatus. Possible configurations for the air-enthalpy treatment apparatus and measurement devices are provided below. Configurations for proper testing conditions are not limited to those shown. Unit and conditioning equipment can be relocated to accommodate other configurations of testing rooms or equipment. In all cases, suitable means for determining the dry-bulb temperature and water vapor content of the air entering and leaving the test section and for measuring the external resistance to airflow shall be provided.

6.1.1.1 The arrangement for the air-enthalpy test method to be used with a DX-DOAS unit without VERS is shown schematically in Figure 3. An airflow measuring apparatus is attached to the test unit's supply air outlet. This device discharges directly into the indoor side of the test room, which is provided with a room conditioning apparatus suitable for maintaining the air entering the test unit at the prescribed wet-bulb and dry-bulb temperatures. The room conditioning apparatus is sized to accommodate the load of the unit and any air-cooled remote or packaged condensers. This configuration is suitable for water-cooled and heat pump equipment with the appropriate water conditioning equipment. When the unit incorporates a desiccant heat exchanger for additional dehumidification, an additional regeneration airstream is ducted from the outdoor air condition room as shown in Figure 4.



Note: The oversized plenum design follows specifications prescribed in Section 7.9.

Figure 3. Single Package DX-DOAS Unit Laboratory Schematic (No VERS)



Note: The oversized plenum design follows specifications prescribed in Section 7.9.

Figure 4. Single Package Desiccant DX-DOAS Unit Laboratory Schematic (No VERS)

6.1.1.2 The arrangement for the air-enthalpy test method to be used with a DOAS unit with a Ventilation Energy Recovery System (VERS) is shown schematically in Figure 5. The outdoor air inlet and supply air outlet of the equipment is located in a first conditioned space similar to a unit without energy recovery. Optionally, an additional test room is connected to the return air and exhaust air of the DX-DOAS unit as shown in Figure 6.

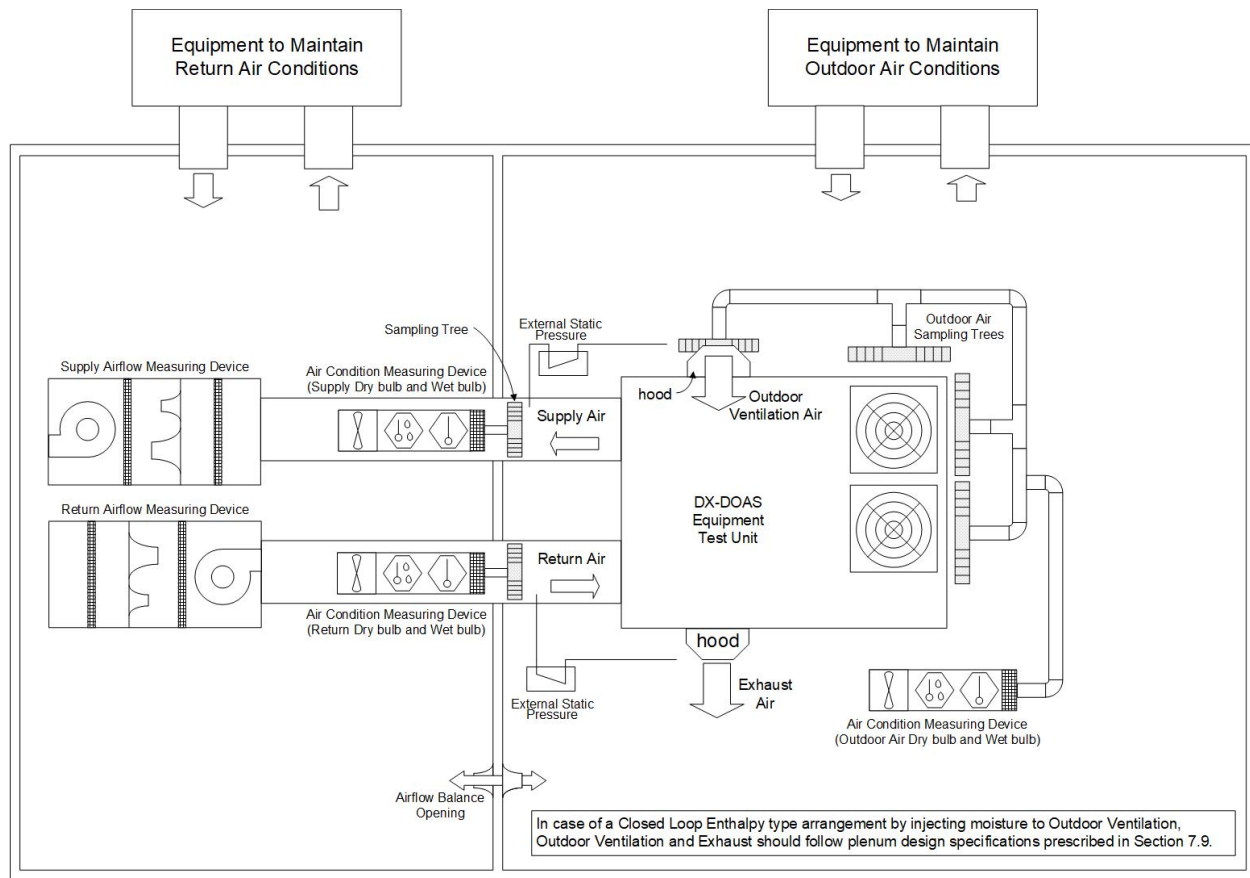


Figure 5. Single Package DX-DOAS Unit with VERS (Option 1 – 2 Rooms)

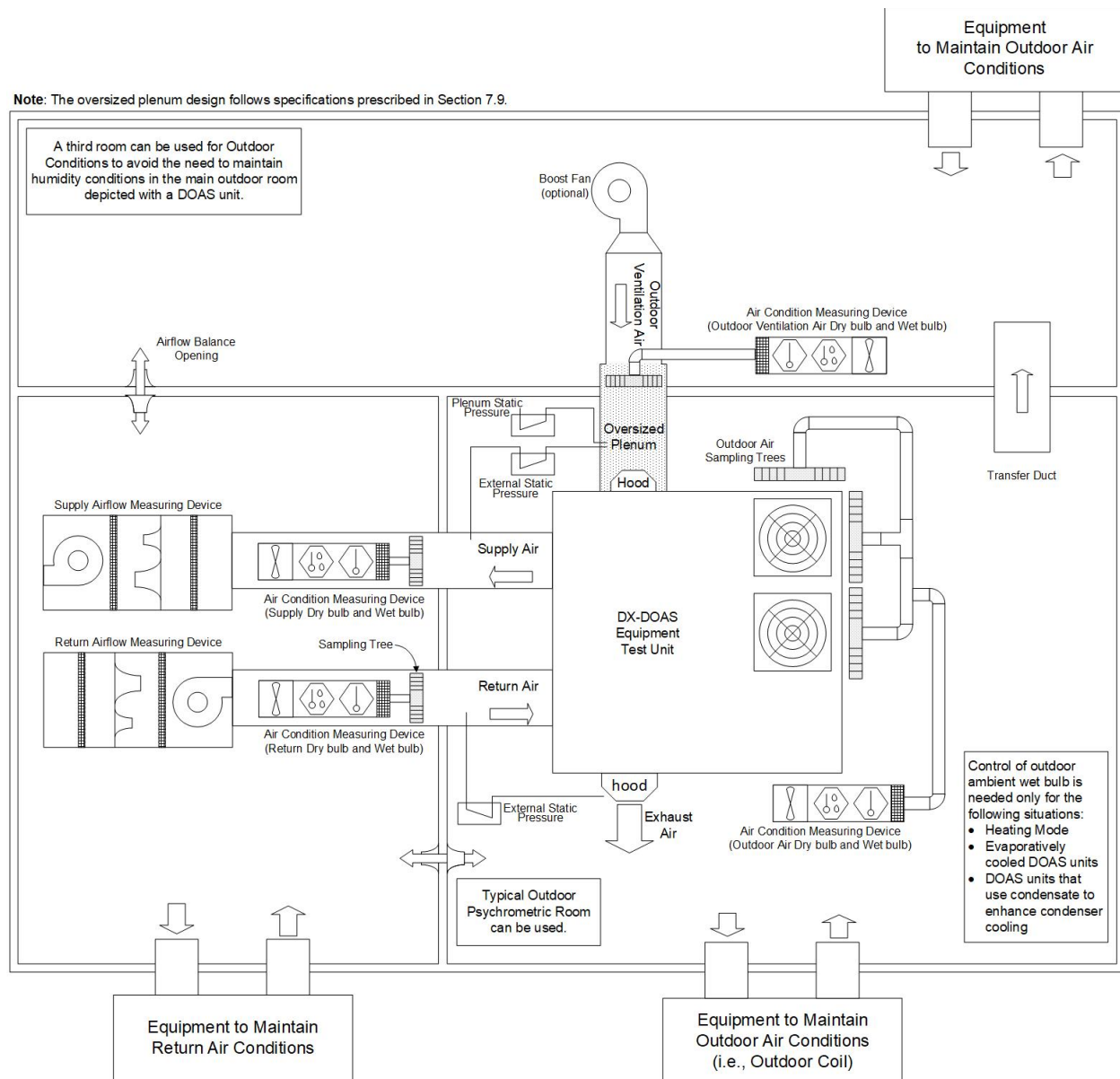


Figure 6. Single Package DX-DOAS Unit with VERS (Option 1 – 3 Rooms)

6.1.1.3 The arrangement for the air-enthalpy test method to be used with a DOAS unit with single package DX-DOAS with desiccant heat exchanger and VERS is shown schematically in Figure 7. If the unit does not contain a desiccant heat exchanger, the arrangement in Figure 8 can be used for a single package DX-DOAS with VERS.

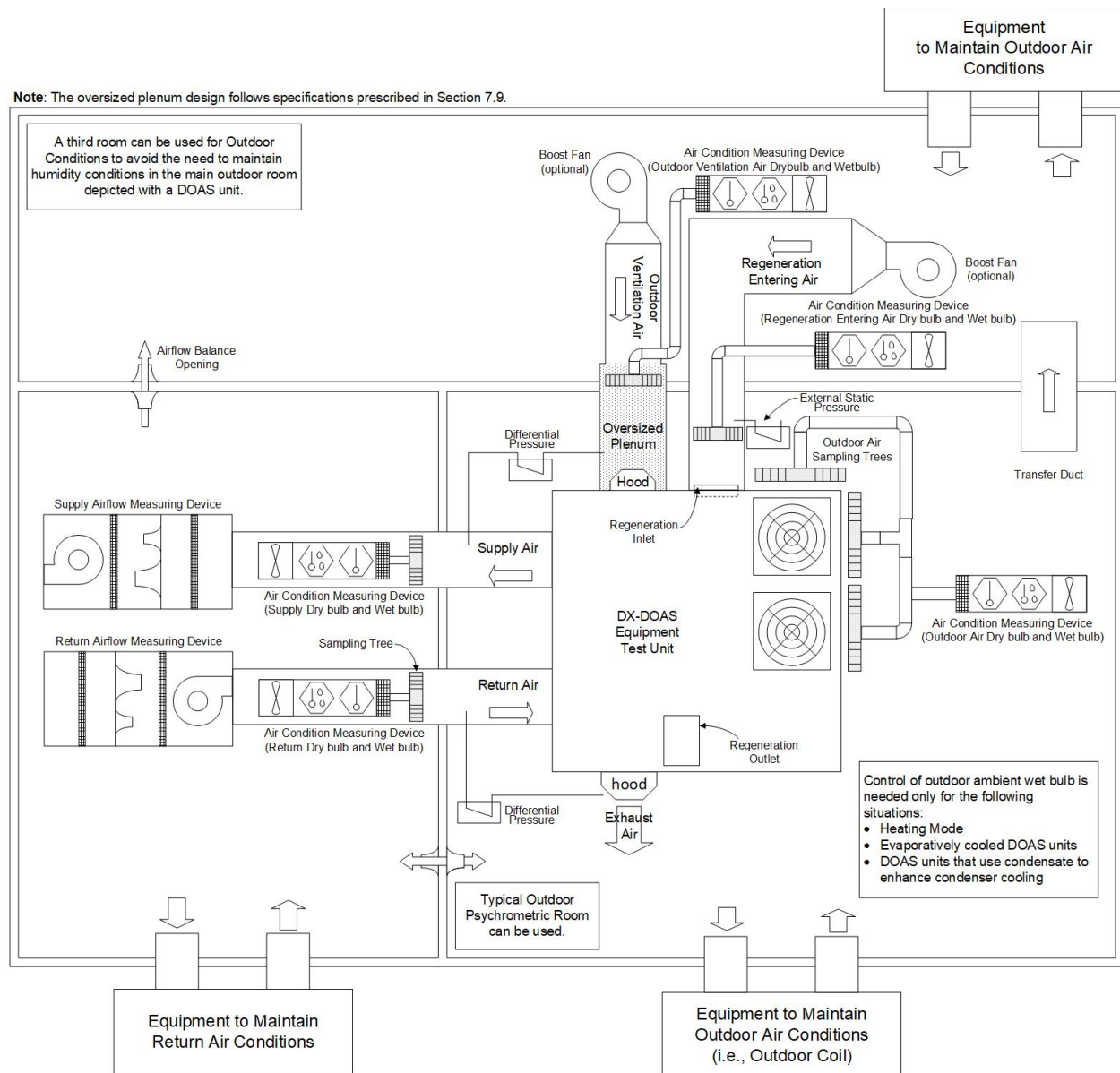
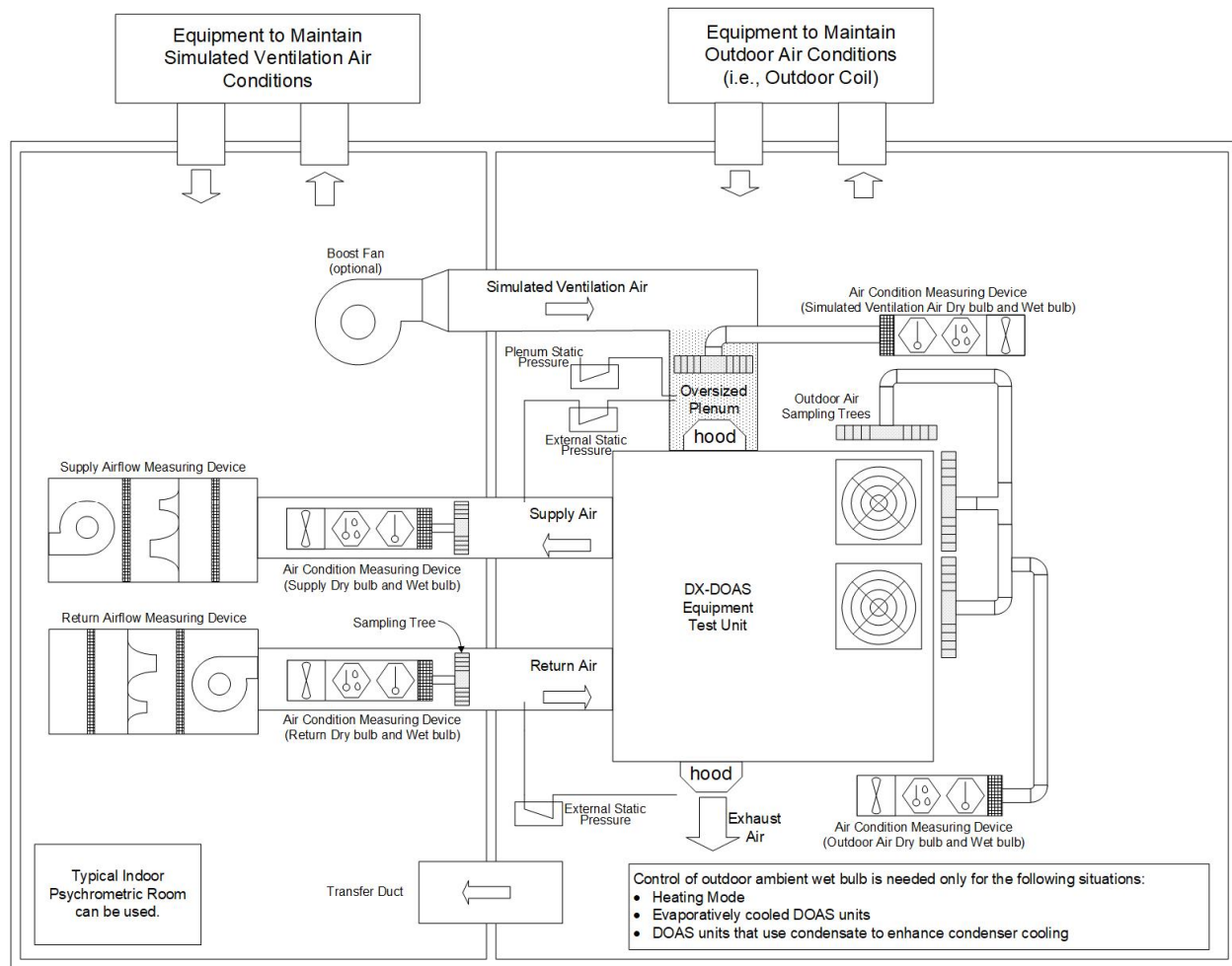


Figure 7. Single Package Desiccant DX-DOAS Unit with VERS (Option 1 – 3 Rooms)



Note: The oversized plenum design follows specifications prescribed in Section 7.9.

Figure 8. Single Package DX-DOAS Unit with VERS (Option 2)

6.1.1.4 The arrangement for the air-enthalpy test method to be used with a relief air-cooled DX-DOAS unit with VERS (Option 1) or without VERS is shown schematically in Figure 9.

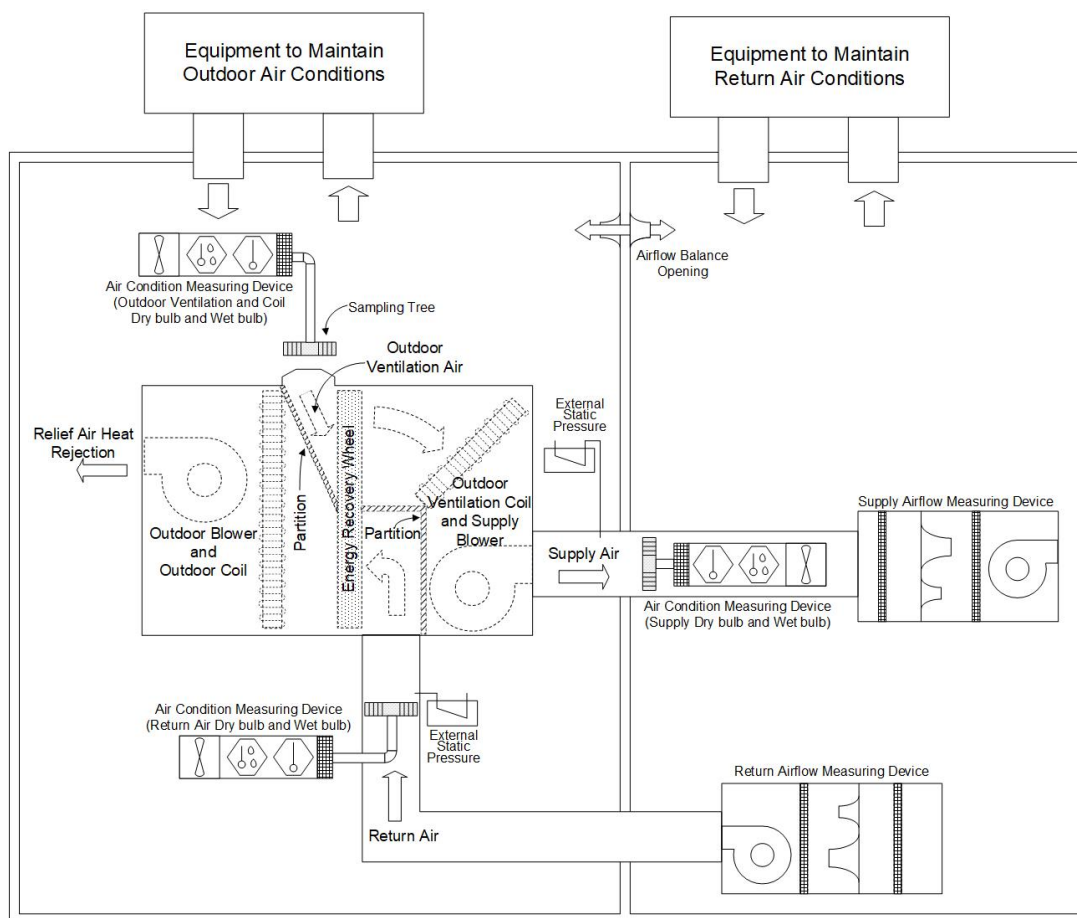


Figure 9. Single Package Relief Air-Cooled DX-DOAS Unit with VERS (Option 1) or without VERS

- 6.2 Enthalpy and Pressure Measurement Apparatus.** Enthalpy and pressure measurement apparatus shall be in accordance with ANSI/ASHRAE Standard 37, Section 6.2.
- 6.3 External Static Pressure Measurement Apparatus.** External static pressure measurement apparatus shall be in accordance with ANSI/ASHRAE Standard 37, Section 6.2, except as specified in Section 5.3 of this standard.

7. TEST ROOM REQUIREMENTS

7.1 Preparation of the Test Room(s)

- 7.1.1 Location of Room Conditioning Apparatus.** Test rooms shall have a room conditioning apparatus which are permitted to be located either inside or adjacent to the room. The airstreams delivered to or received by the test room from the room conditioning apparatus shall not either favorably or adversely affect the air movements created by the test unit or any other aspect of the operation of the test unit. The room conditioning apparatus must take air from the indoor side of the test room and deliver it as such conditions as will provided specified conditions at the intake to the test unit as required for the test, within the tolerances within Table 2.
- 7.1.2 Adjacent to Test Room.** If the room conditioning apparatus is located adjacent to the test room, it is permitted to receive air from the test room and deliver reconditioned air to the test room, through suitable opening or grilles in the ceiling or high on a wall, or is permitted to receive and/or deliver the airstreams through ducts from or to the test unit.

Table 2 Test Tolerances

Readings	Test Operating Tolerances (Total Observed Range)		Test Condition Tolerance	
	Cooling, Dehumidifying		Cooling, Dehumidifying	
Outdoor Air and Return Air Temperatures	°F	°C	°F	°C
Dry-bulb	2.0	1.10	0.5	0.28
Wet-bulb	1.0	0.60	0.3	0.17
Condenser Cooling Water Temperatures	0.5	0.28	0.2	0.11
Liquid Temperatures not Otherwise Specified	0.5	0.28	0.2	0.11
	in. H ₂ O	kPa	in. H ₂ O	kPa
External Resistance to Airflow	0.05	0.005	−0.00/+0.05	−0.000/+0.005
Airflow Rate	±2%		±3%	
Electrical Voltage, %	2		–	
Fluid Flow Rates, %	2		–	

- 7.2 Air Movement in Test Room.** Air velocities in the indoor side of the test room caused by the room conditioning apparatus shall not exceed 500 ft/min (2.50 m/s) at the test unit. The minimum distance from any air discharge outlet on the test unit to a wall surface in the test room is 6.0 ft (1.8 m). The minimum distance between any other surface of the test unit and the test room shall be 3.0 ft (0.9 m), except for clearances for normal installation requirements as called for by the manufacturer’s installation instructions.
- 7.3 Outdoor Test Room Requirements.** When the outdoor test room contains a packaged or remote air-cooled condenser, this test room shall be of sufficient volume and shall circulate air in a manner such that it does not change the normal air circulating pattern of the equipment under test. It shall be of dimensions such that the distance from any room surface to any equipment surface from which air is discharged is not less than 6.0 ft (1.8 m) and the distance from any other room surface to any other equipment surface is not less than 3.0 ft (0.9 m), except for floor or wall relationships required for normal equipment installation.
- 7.4 Equipment Installation.** Units shall be installed per manufacturer’s installation instructions. In the event of conflicting instructions regarding the setup of the unit under test, priority shall be given to the MII that appears on the unit’s label over MII that are shipped with the unit. If the unit is a split system and the components’ MII conflict, priority shall be given to the indoor unit MII over the outdoor unit MII.
- 7.4.1** The unit to be tested shall be installed in the test room(s) in accordance with Section 6 and the equipment manufacturer's installation instructions using recommended installation procedures and accessories as well as any safety precautions specified by the manufacturer. Equipment shall be installed in the indoor test room or outdoor test room based on the intended installation location in the MII. In all cases, the manufacturer's recommendations with respect to distances from adjacent walls, as well as allowances for connection to airflow rate measuring apparatus and plenum and duct section shall be followed.
- 7.4.2** No alterations to the equipment shall be made, except as required for insertion or attachment of test instruments or apparatus in accordance with this standard. Care shall be taken to avoid interference with or enhancement of the airflow performance of the test unit.
- 7.4.3** Where necessary, equipment shall be evacuated and charged with the type and amount of refrigerant specified in the manufacturer's installation instructions.
- Informative Note:** When required, pressure gauges should be connected to the equipment only through short lengths of small diameter tubing and either be located so that the readings are not influenced by fluid heat in the tubing or suitable cooling and heating operation corrections should be made.
- 7.5 Test Unit Location.** A single package air-cooled or air-source DX-DOAS unit shall be installed in a room conditioned to outdoor dry-bulb temperatures during the test. If the conditioning system of this chamber cannot maintain the required outdoor air humidity level, the outdoor ventilation air and desiccant wheel regeneration air is permitted to be ducted from a separate conditioned space.

- 7.5.1** For both outdoor-air-cooled DX-DOAS units and relief-air-cooled DX-DOAS units (both air-cooled and evaporatively-cooled), the outdoor coil entering air conditions shall be maintained as specified in Table 3.
- 7.5.2** If the outdoor air entering the conditioning coil section of the unit is ducted from a remote test chamber, there is no wet-bulb temperature requirement for the ambient air surrounding the unit, unless it is required in accordance with Section 7.5.1.
- 7.5.3** Desiccant wheel regeneration air entering the DX-DOAS unit shall be at the outdoor ventilation air dry-bulb and wet-bulb conditions specified.
- 7.5.4** Interconnecting tubing requirements shall be per ANSI/ASHRAE Standard 37, Section 8.2.

Table 3 Outdoor Coil Entering Air Conditions for Air-Cooled and Evaporatively-Cooled DX-DOAS Units

Air-Cooled Type	Is a VERS Present?	Test Mode	Condition Dry-Bulb Temperature of Air Entering Outdoor Coil to the Value Specified For:	Condition Wet-Bulb Temperature of Air Entering Outdoor Coil to the Value Specified For:
Outdoor	Yes	Heating	Outdoor Air Dry-Bulb	Outdoor Air Wet-Bulb
		Dehumidification for DX-DOAS Units with Evaporative Cooling ^a		
		Dehumidification for other DX-DOAS Units	Outdoor Air Dry-Bulb	N/A
	No	Heating	Outdoor Air Dry-Bulb	Outdoor Air Wet-Bulb
		Dehumidification for DX-DOAS Units with Evaporative Cooling ^a		
		Dehumidification for other DX-DOAS Units	Outdoor Air Dry-Bulb	N/A
Relief	Yes ^b	Heating	N/A	N/A
		Dehumidification for DX-DOAS Units with Evaporative Cooling ^a		
		Dehumidification for other DX-DOAS Units	N/A	N/A
	No	Heating	Return Air Dry-Bulb ^c	Return Air Wet-Bulb ^c
		Dehumidification for DX-DOAS Units with Evaporative Cooling ^a		
		Dehumidification for other DX-DOAS Units	Return Air Dry-Bulb ^c	N/A

a. Also applies to air-cooled DX-DOAS units with condenser cooling enhancement using conditioning coil condensate.

b. Outdoor coil entering conditions are not controlled when testing relief-air-cooled units with VERS.

c. Control for return air conditions at the inlet to the DX-DOAS units rather than at the outdoor coil.

7.6 Use of a Single Airflow Rate Measuring Apparatus per Airflow Path

7.6.1 Return and Exhaust Airflow Path. When testing a DX-DOAS unit equipped with a VERS, an airflow rate measuring apparatus is required for return airflow. An airflow rate measuring apparatus is not required for exhaust airflow.

7.6.2 Outdoor Air or Outdoor Ventilation Air. For an outdoor-air-cooled DX-DOAS unit, the outdoor coil entering air or the desiccant wheel regeneration entering air shall be permitted to be taken from a different test room. If any of these air streams are provided from a separate room from the room housing the test unit, its corresponding leaving air (i.e., supply air, leaving outdoor coil air, or leaving regeneration air) shall be ducted from the unit to the same room from which the air was taken, or pressure relief means (e.g., a separate duct or opening in the separating wall to return air to the first room) shall be provided, if needed to ensure operation at required external static pressures.

- 7.6.3 Return Air or Simulated Ventilation Air.** When testing a DX-DOAS with return air or simulated ventilation air entering the unit, this air shall be taken from a separate room controlled to the specified air conditions during the test. Ducting or pressure relief means shall be provided so that this air can transfer back to the separate room, and, if applicable, any outdoor ventilation air or simulated ventilation air transferred to the exhaust air in the VERS can transfer back to its source.
- 7.6.4 Plenum and Ducting of Air to or from a DX-DOAS to a Separate Room.** When moving air between a DX-DOAS and a separate room, into or out of a connection not designed for duct connections in field installation, using a duct or plenum, the following steps shall be met:
- A preliminary free air test shall be conducted prior to connecting a plenum or ducting to the DX-DOAS unit. Airflow rates shall be set according to target airflow rate and collect data for a period of ten or more minutes.
 - Record the average airflow rate and average fan power for each airflow path.
 - Connect the plenum or duct and recheck the airflow.
 - Check that fan power measured for each airflow path when ducted is within 2.0% of the power measured for the free air test. The test shall be run at the same conditions as a).
 - Where a booster fan is used, adjust any duct booster fan or the fan of an airflow measurement apparatus attached to the duct as necessary to achieve the power recorded in b) within 2.0%.
 - Where no booster fan is used, increase plenum size as necessary to match the fan power within 2.0%.
 - The unit under test fan settings used for the preliminary free air test shall remain unchanged throughout the remaining tests.

8. METHODS OF TESTING AND CALCULATION

- 8.1 Unit Preparation.** The unit shall be prepared such that any optional damper or opening not used for the purpose of introducing outdoor air is sealed to prevent any leakage. This includes optional return air dampers and recirculation dampers. Dampers in the return airstream that are not used for air introduction or recirculation to the outdoor air or supply airstream shall not be sealed. Dampers used for the sole purpose of relieving pressure drop through the VERS to save fan energy shall operate under automatic unit control.

Any energy recovery devices that include a purge or other function that transfers air from supply or exhaust shall be set as specified in the test plan.

The refrigerant charge shall be verified as specified in the test plan.

- 8.1.1 Air Condition Measurements.** Measure the air dry-bulb temperature and water vapor content conditions that are required to be controlled for the test. Measure the supply air dry-bulb temperature and water vapor content for all tests. Also, when using the outdoor air enthalpy method to measure equipment capacity, measure outdoor coil leaving air dry-bulb temperature and water vapor content. These measurements shall be made as described in Sections 5 and 6 of ANSI/ASHRAE Standard 37.
- 8.1.2 Outdoor Coil Air Entering Conditions.** For dehumidification tests of both evaporatively-cooled equipment and air-cooled equipment that uses condensate obtained from the evaporator to enhance condenser cooling, the water vapor content shall be measured as specified in Section 8.1.2.2. For heating tests of all air-cooled heat pumps, the water vapor content shall also be measured as specified in Section 8.1.2.2. The dry-bulb temperature shall be measured as specified in Section 8.1.2.1 for all tests.
- 8.1.2.1 Dry-Bulb Temperature Measurement.** Measure dry-bulb temperatures using the psychrometer dry-bulb sensors, or, if not using psychrometers, use dry-bulb temperature sensors with accuracy as required in ANSI/ASHRAE Standard 37. Measure the dry-bulb temperature within the conduit conducting air sampler air to the fan at a location between the air sampler exit to the conduit and the fan. When a fan draws air through more than one air sampler, the dry-bulb temperature is permitted to be measured separately for each air sampler or for the combined set of air sampler flows. If dry-bulb temperature is measured at the air sampler exit to the conduit, the use of a thermocouple thermopile grid or a grid of individual thermocouples for duplicate measurement of dry-bulb temperature is not required; instead, the air-sampler-exit measurement may be used when checking temperature uniformity.

8.1.2.2 Wet-Bulb or Dew-Point Temperature Measurement to Determine Air Water Vapor Content.

Measure wet-bulb temperatures using one or more psychrometers or measure dew-point temperature using one or more hygrometers. If using hygrometers, measure dew-point temperature within the conduit conducting air sampler air to the air-sampling fan at a location downstream of the dry-bulb temperature measurement. When a fan draws air through more than one air sampler, the dew-point temperature shall be permitted to be measured separately for each air sampler or for the combined set of air sampler flows.

8.1.2.3 Monitoring and Adjustment for Air Sampler Conduit Temperature Change and Pressure Drop.

If dry-bulb temperature is measured at a distance from the air sampler exits, determine average conduit temperature change as the difference in temperature between the remote dry-bulb temperature and the average of thermopiles or thermocouple measurements of all air samplers collecting air that is measured by the remote dry-bulb temperature sensor. If this difference is greater than 0.50 °F (0.28°C), measure dry-bulb temperature at the exit of each air sampler (using dry-bulb temperature sensors with accuracy as described in Table 1), and use these additional sensors to determine average coil-entering dry-bulb temperature.

Measure gauge pressure at the sensor location of any instrument measuring water vapor content. If the pressure differs from room pressure by more than 2 in. H₂O (500 Pa), use the gauge pressure measurement to adjust the atmospheric pressure used to calculate the humidity ratio (in units of pounds of moisture per pound of dry air) at the measurement location.

If either the 0.50°F (0.28°C) temperature difference threshold or the 2 in. H₂O (500 Pa) pressure difference threshold are exceeded, use a two-step process to calculate adjusted air properties (e.g., wet-bulb temperature or enthalpy) for the one or more affected air samplers. First, calculate the moisture level (pounds water vapor per pound dry air) at the humidity measurement location(s) using either the psychrometer dry-bulb and wet-bulb temperature measurements or the hygrometer dew-point measurement, using for either approach the adjusted pressure. Then calculate the air properties for the air sampler location based on the moisture level, the room atmospheric pressure, and the dry-bulb temperature at the air sampler location. If the air sampler fan or psychrometer serves more than one air sampler, and the 0.50°F (0.28°C) threshold was exceeded, the dry-bulb temperature used in this calculation shall be the average of the air sampler exit measurements. Also, for multiple air samplers, if humidity was measured using multiple hygrometers, the moisture level used in this calculation shall be the average of the calculated moisture levels calculated in the first step.

8.1.2.4 Temperature Uniformity. To ensure adequate air distribution, thorough mixing, and uniform air temperature, it is important that the room and test setup is properly designed and operated. The room conditioning equipment airflow shall be set such that recirculation of outdoor coil discharged air is avoided except the recirculation that naturally occurs from the equipment. To check for the recirculation of outdoor coil discharged air back into the outdoor coil(s) the following method shall be used: Multiple individual reading thermocouples (at least one per sampling tree location) shall be installed around the unit air discharge perimeter so that they are below the plane of outdoor coil fan exhaust and just above the top of the outdoor coil(s). These thermocouples shall not indicate a temperature difference greater than 5.0°F (2.8°C) from the average inlet air. Air distribution at the test facility, at the point of supply to the unit, shall be reviewed to determine if it requires remediation prior to beginning testing.

Mixing fans can be used to ensure adequate air distribution in the test room. If used, mixing fans shall be oriented such that they are pointed away from the air intake so that the mixing fan exhaust direction is at an angle of 90 to 270 degrees to the air entrance to the outdoor coil air inlet. Particular attention shall be paid to prevent recirculation of outdoor coil fan exhaust air back through the unit.

When not using psychrometers, the “psychrometer dry-bulb temperature measurement” of Table 5 refers to either (a) the dry-bulb temperature measurement in a single common air conduit serving one or more air samplers, or (b) the average of the dry-bulb temperature measurements made separately for each of the air samplers served by a single air sampler fan. Similarly, “wet-bulb temperature” refers to calculated wet-bulb temperatures based on dew-point measurements. Measurements shall be adjusted as required per Section 8.1.2.1 prior to checking for uniformity. The uniformity requirements apply to test period averages rather than instantaneous measurements.

Informative Note: The 1.50°F (0.80°C) dry-bulb temperature tolerance in Table 5 between the air

sample thermopile (thermocouple) measurements and psychrometer measurements only applies when more than one air sampler serves a given psychrometer (refer to Note b).

When water vapor content measurement is required, uniformity of wet-bulb temperature variation among air samplers shall also be confirmed. When more than one air sampler feeds a single aspirating psychrometer or dew-point sensor, relative humidity of the air external to each of these air samplers shall be measured using a relative humidity sensor having $\pm 0.7\%$ relative humidity accuracy located within 3 in. (8 cm) of geometric center of the air sampler. Wet-bulb temperature for these air samplers shall be calculated using the relative humidity measurement and the dry-bulb temperature measurements from either the thermopiles (thermocouple grid averages), or the measurements at the air sampler exits. The maximum allowable difference between the calculated wet-bulb temperature for any air sampler tree and the average wet-bulb temperature for all air samplers used to measure outdoor entering air conditions shall be 1.00°F (0.60°C).

A valid test shall meet the criteria for adequate air distribution and control of air temperature as shown in Tables 2 and 4.

Table 4 Criteria for Air Distribution and Control of Air Temperature

	Purpose	Maximum Variation	
		°F	K
Dry-Bulb Temperature			
Deviation From the Mean Air Dry-Bulb Temperature to the Air Dry-Bulb Temperature at Any Individual Temperature Measurement Station ^a	Uniform Temperature Distribution	±2.00	±1.11
Difference Between Dry-Bulb Temperature Measured with Air Sampler Tree Thermopile and with Aspirating Psychrometer ^b	Uniform Temperature Distribution	±1.50	±0.83
Difference Between Mean Dry-Bulb Air Temperature and the Specified Target Test Value ^c	Test Condition Tolerance, for Control of Air Temperature	±0.50	±0.28
Mean Dry-Bulb Air Temperature Variation Over Time (from the First to Last Data Sets)	Test Operating Tolerance, Total Observed Range of Variation Over Data Collection Time	±1.50	±0.83
Wet-Bulb Temperature ^d			
Deviation of Calculated Local Air Sampler Wet-Bulb Temperatures and the Mean Wet-Bulb Temperature	Uniform Temperature Distribution	±1.00	±0.56
Deviation from the Mean Wet-Bulb Temperature and the Individual Temperature Measurement Stations	Uniform Temperature Distribution	±1.00	±0.56
Difference between the Mean Wet-Bulb Temperature and the Specified Target Test Value ^c	Test Condition Tolerance, for Control of Air Temperature	±1.00	±0.56
Mean Wet-Bulb Air Temperature Variation Over Time	Test Operating Tolerance, Total Observed Range of Variation Over Data Collection Time	±1.00	±0.56

Notes:

- Each measurement station represents an average value as measured by a single aspirating psychrometer.
- Applies when multiple air samplers are connected to a single psychrometer or conduit dry-bulb temperature sensor. If the average of the thermopile measurements differs from the psychrometer or conduit dry-bulb sensor measurement by more than 0.5°F (0.28 K), use air-sampler exit dry-bulb temperature sensors. In this case, the uniformity requirement is based on comparison of each of the air-sampler exit measurements with the average of these measurements.
- The mean dry-bulb temperature is the average of all measurement stations.
- The wet-bulb temperature measurement is only required for entering outdoor coil air for DX-DOAS units that are evaporatively-cooled or that use pan condensate enhanced condenser cooling and for air-source heat pump DX-DOAS units operating in heating mode.

8.1.3 Outdoor Ventilation Air Conditions. The following requirements shall be used for measuring the DX-

DOAS entering conditions of outdoor ventilation air, desiccant regeneration air, simulated ventilation air, or return air. The requirements for outdoor coil entering air conditions shall be as described in Section 7.5.1, except as otherwise noted below.

- 8.1.3.1 Both dry-bulb temperature and water vapor content measurements shall be required for all tests.
- 8.1.3.2 If the air is drawn from a remote location (e.g., an adjacent chamber) through a duct system that includes a booster fan or airflow measurement apparatus, the air sampler shall be installed in the duct downstream of the fan or airflow measurement apparatus.
- 8.1.3.3 If air is sampled within a duct, the air sampling tree shall be installed with the rectangle defined by the air sampler inlet holes oriented parallel to and centered in the duct cross-section; this rectangle shall have dimensions that are at least 75% of the duct's respective dimensions.
- 8.1.3.4 Sampled air shall be returned to the room from which the system draws the outdoor ventilation air, except for in the following situations. If the loop air enthalpy test method specified in ANSI/ASHRAE Standard 37, Section 6.1.2, is used, the sampled air shall be returned upstream of the air sampler, either to the duct between the airflow measuring apparatus and the room conditioning apparatus, or to the airflow measuring apparatus between the nozzles and the fan. If the air is drawn from a remote location as described in Section 8.1.3.2, through a duct system that includes an airflow measurement apparatus, the sampled air shall be returned to the airflow measuring apparatus between the nozzles and the fan.
- 8.1.4 **Supply Air and Outdoor Coil Leaving Air Conditions.** The requirements for measurement of outdoor coil leaving air conditions shall be as described in Section 7.5.1, except as otherwise noted below.
 - 8.1.4.1 Both dry-bulb temperature and water vapor content measurements shall be required for supply air for all tests.
 - 8.1.4.2 For outdoor coil leaving air tests, both dry-bulb temperature and water vapor content measurements are required for all tests using the outdoor air enthalpy method in the heating mode. For cooling mode tests, only dry-bulb temperature is required.
 - 8.1.4.3 Supply air and outdoor coil leaving air that is drawn from the unit discharge duct into the air sampling tree for measurement shall be returned to the duct just downstream of the air sampling tree and upstream of the airflow-measuring apparatus. An insulated conduit shall transfer the air from the air sampler fan discharge to the duct.
 - 8.1.4.4 The air sampling tree used within the duct transferring air to the airflow measurement apparatus shall be installed with the rectangle defined by the air sampler inlet holes oriented parallel to and centered in the duct cross-section; this rectangle shall have dimensions that are at least 75% of the duct's respective dimensions.
 - 8.1.4.5 A grid of individual thermocouples (rather than a thermopile) shall be used on the air sampling tree, even if air sampler-exit dry-bulb temperature measurement instruments are installed. If the difference between the maximum time-averaged thermocouple measurement and the minimum time-averaged thermocouple measurement is greater than 1.50°F (0.80°C), mixing devices such as those described in Section 8.1.4.9 shall be used to reduce the maximum temperature spread to less than 1.50°F (0.80°C).
 - 8.1.4.6 **Airflow and External Static Pressures.** Where the airflow rate of equipment is adjustable, the equipment shall be set to operate per the equipment manufacturer's instructions and the test plan.
 - 8.1.4.7 **Maximum Data Recording Interval.** Data shall be collected with a maximum interval of 30 seconds for all data points. In cases where the power measurement fluctuation total observed range exceeds 6% of the mean (regardless of cause), integrating watt-hour measurements shall be used.

Informative Note: Digital compressors operating at part load are permitted to require the use of an integrating watt measurement instrument.
 - 8.1.4.8 **Equilibrium.** The test unit and room conditioning apparatus shall be operated until two consecutive 30-minute intervals are within the tolerances outlined in Table 2. The data during the operation of the last 30-minute interval shall be recorded as the official test period.
 - 8.1.4.9 **Nonuniformity in Temperature, Humidity, and Velocity.** Round or rectangular mixers consisting of louvers or deflection plates that produce a combination of shearing action and relative displacement on adjacent areas of airflow shall be used to minimize nonuniformity in temperature, humidity, and velocity. Refer to Figures 10, 11, and 12 for illustrations of typical mixing.

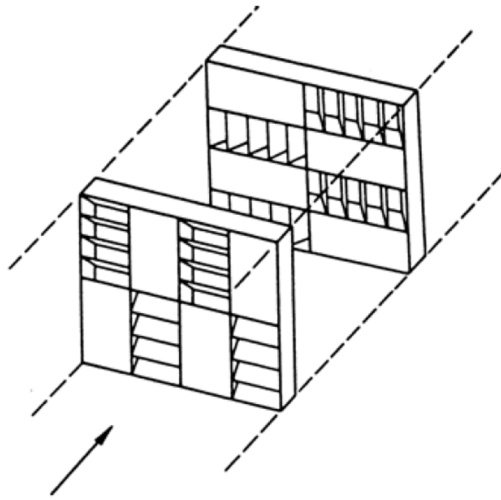


Figure 10. Example of a Mixing Device (1)

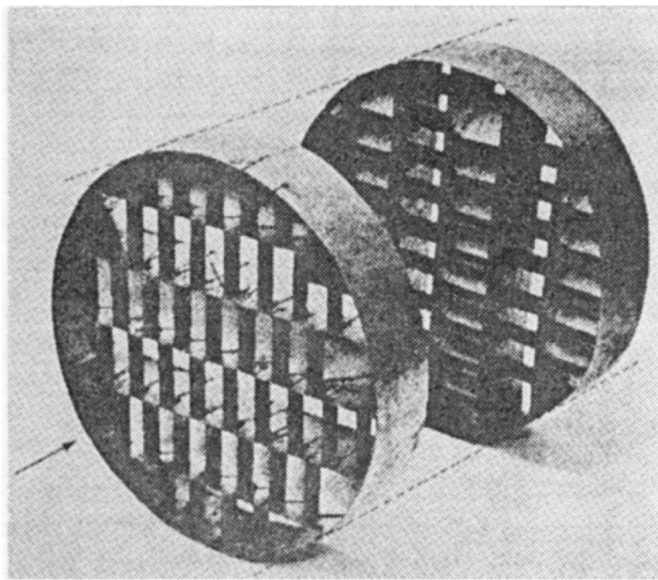


Figure 11. Example of a Mixing Device (2)

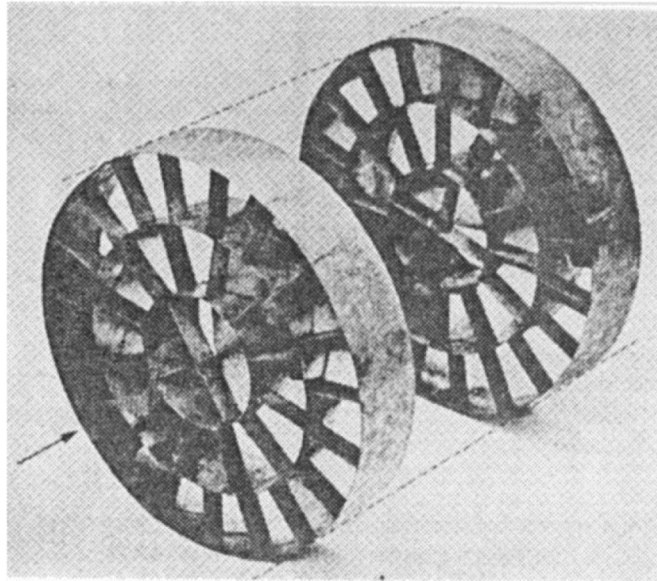


Figure 12. Example of a Mixing Device (3)

8.2 Test Tolerances

- 8.2.1 All test observations shall be within the tolerances specified in Table 2, as appropriate to the test methods and type of instrumentation.
- 8.2.2 The maximum permissible variation of any observation during the capacity test is listed under “Test Operating Tolerance” in Table 2. This represents the greatest permissible difference between minimum and maximum instrument observations during the test. When expressed as a percentage, the maximum allowable variation is the specified percentage of the arithmetical average of the observations.
- 8.2.3 The maximum permissible variations of the average of the test observations from the standard or desired test conditions are shown in “Test Condition Tolerance” in Table 2. Variations greater than those prescribed shall invalidate the test.

8.3 Testing Requirements for DX-DOAS Units Equipped with VERS

- 8.3.1 **VERS Test Options.** DX-DOAS units equipped with VERS shall be tested using one of the options described under Sections 8.3.1.1 or 8.3.1.2.
 - 8.3.1.1 **Option 1.** Option 1 is the VERS is operating, unless otherwise specified in the test plan, and the outdoor ventilation air and return air conditions are separately controlled.
 - 8.3.1.2 **Option 2.** Option 2 is the outdoor ventilation air and return air shall be at simulated ventilation air conditions according to the test plan. The VERS shall be installed, and power consuming components shall operate during the test, unless otherwise specified in the test plan. Option 2 shall not be used for relief-air-cooled DX-DOAS units.
- 8.3.2 **Energy Recovery Wheel Rotational Speed.** For DX-DOAS units with energy recovery wheels, the wheel rotational speed shall be per the test plan.
- 8.3.3 **Deactivation of VERS.** If VERS bypass is specified in the test plan, the airflows shall be confirmed to be at the values specified in the test plan.

Informative Note: Although other methods of deactivation exist, the following examples are three common methods for VERS deactivation:

- a. The rotation of an energy recovery wheel can be stopped.
- b. Controlled shutoff valves can be added to a heat pipe to prevent energy transfer between outdoor air and return air.
- c. Bypass dampers can allow most air to bypass any energy recovery device.

8.4 Testing Requirements for Desiccant DX-DOAS Units.

For desiccant DX-DOAS units employing a desiccant

wheel, the wheel rotational speed shall be per the test plan.

8.5 Dehumidification Capacity Secondary Verification. A secondary dehumidification capacity measurement is required for all dehumidification tests for all DX-DOAS units that

- a. Do not use condensate collected from the dehumidification coil to enhance condenser cooling
- b. Do not include a secondary dehumidification process for which the moisture removed from the supply air is not collectable in liquid form, and
- c. Either are not equipped with VERS or are equipped with VERS and tested using Option 2.

Capacity balance shall be established. If capacity balance was established in a previous test for the current test setup in dehumidification mode, it is not required.

A secondary dehumidification capacity measurement is not required for DX-DOAS units equipped with VERS that are tested using Option 1.

8.5.1 The cooled condensate that drains out from the condensate collection pan shall be collected into a tank with sufficient capacity. For units that use condensate collected from the dehumidification coil to enhance condenser cooling and units that include a secondary dehumidification process for which the moisture removed from the supply air is not collectable in liquid form, conduct a separate test making both primary and secondary MRC measurements for which the condensate is not transferred to the condenser or the secondary dehumidification process is deactivated to verify dehumidification capacity.

8.5.2 Measurement of the Weight of the Collected Condensate. The weight of the tank used to measure the collected condensate shall be recorded before and after the test (i.e., before and after condensate is collected in the tank) using a weighing scale with an accuracy of $\pm 1\%$ of the total condensate mass. $MRC_{secondary}$ shall be calculated using the following equation:

$$MRC_{secondary} = \frac{m_c}{t}$$

The capacity check shall agree within $\pm 5.0\%$.

$$Capacity_{bal} = \frac{MRC_{secondary} - MRC}{MRC} \times 100\%$$

8.6 Heating Capacity Secondary Verification. For all DX-DOAS units that are not equipped with VERS, and DX-DOAS units equipped with VERS that are tested using Option 2, a secondary heating capacity measurement is required for one heating test. The heating capacity secondary verification shall use a method from ANSI/ASHRAE Standard 37, Section 7.2, except that it shall not be required for the tests to be conducted at full load. The test shall be non-transient and non-frosting. The energy balance shall agree within 5.0%.

9. REPORTING REQUIREMENTS

All data shown in Tables 5 and 6 shall be recorded during testing.

Table 5 Data to be Recorded

Item	Air Enthalpy Method
Date	X
Observer(s)	X
Barometric Pressure, in. Hg (kPa)	X
Equipment Nameplate Data (photo is acceptable)	X
Refrigerant	X
Total Refrigerant Charge (optional), lb (kg)	X
Condenser Head Pressure Control Settings	X
VERS Simulated Air or Actual Test	(v)

Table 5 Data to be Recorded

Item	Air Enthalpy Method
g	X
Dry-bulb Temperature of Return Air Entering Equipment, °F (°C)	(v)
Wet-bulb Temperature of Return Air Entering Equipment, °F (°C)	(v)
Dry-bulb Temperature of Exhaust Air Leaving Equipment, °F (°C)	(v1)
Wet-bulb Temperature of Exhaust Air Leaving Equipment, °F (°C)	(v1)
Dry-bulb Temperature of Supply Air Leaving Equipment, °F (°C)	X
Wet-bulb Temperature of Supply Air Leaving Equipment, °F (°C)	X
Dry-bulb Temperature of Outdoor Ventilation Air or Simulated Ventilation Air Entering Equipment, °F (°C)	X
Wet-bulb Temperature of Outdoor Ventilation Air or Simulated Ventilation Air Entering Equipment, °F (°C)	X
Dry-bulb Temperature of Outdoor Air Entering Equipment, °F (°C)	X
Wet-bulb Temperature of Outdoor Air Entering Equipment, °F (°C)	X
External Resistance to Supply Airflow, in. H ₂ O (Pa)	X
External Resistance to Return Airflow, in. H ₂ O (Pa)	(v)
Supply Fan Speed(s), setting or rpm	X
Exhaust Fan Speed(s), setting or rpm	(v)
Supply Airflow, acfm (m ³ /s)	X
Return Airflow, acfm (m ³ /s)	(v)
Supply Airflow, scfm (smcs)	X
Return Airflow, scfm (smcs)	(v)
Diameter of Nozzle(s), in. (mm)	X
Velocity Pressure at Nozzle Throat or Static Pressure Difference Across Nozzle(s), in. H ₂ O (Pa)	X
Temperature at Nozzle, °F (°C)	X
Pressure at Nozzle, in. H ₂ O (Pa)	X
Power input to equipment, W (Total power input and, where required, input to equipment components)	X
Applied Voltage(s), V	X
Current, A	X
Frequency, Hz	X
Break in Time, hours	X

(v) Required only for units with VERS

(v1) Required only for units with VERS when tested using Option 1

Table 6 Data to Be Recorded for Secondary Checks^a

Item	Cooling Condensate Method	Compressor Calibration Method	Refrigerant Flow Method	Outdoor Liquid Coil Method	Outdoor Air Enthalpy Method ^b	Cooling Condensate and Indirect Airflow Measurement Method
Dry-Bulb Temperature of Outdoor Air Leaving Equipment, °F (°C)					X	

Table 6 Data to Be Recorded for Secondary Checks^a

Item	Cooling Condensate Method	Compressor Calibration Method	Refrigerant Flow Method	Outdoor Liquid Coil Method	Outdoor Air Enthalpy Method^b	Cooling Condensate and Indirect Airflow Measurement Method
Wet-Bulb Temperature of Outdoor Air Leaving Equipment, °F (°C)					X	
Outdoor Airflow, acfm (m ³ /s)					X	
Outdoor Airflow, scfm (smcs)					X	
Diameter of Nozzle(s), in. (mm)					X	
Velocity Pressure at Nozzle Throat or Static Pressure Difference Across Nozzles, in. H ₂ O (Pa)					X	
Temperature at Nozzle, °F (°C)					X	
Pressure at Nozzle, in. H ₂ O (Pa)					X	
Condensing Pressure or Temperature, psig (kPa) or °F (°C)		X	X			
Evaporating Pressure or Temperature, psig (kPa) or °F (°C)		X	c			
Temperature of Refrigerant Vapor Entering Compressor, °F (°C)		X				
Temperature of Refrigerant Vapor Leaving Compressor, °F (°C)		X				
Temperature of High Side Refrigerant Vapor Leaving Reversing Valve, °F (°C)		d				
Refrigerant or Surface Temperature Used for Leakage Coefficient Determination, °F (°C)		X				
Refrigerant-oil mixture flow rate, lb _m /h (kg/s)			X			
Refrigerant Volume in Refrigerant-Oil Mixture, ft ³ /ft ³ (m ³ /m ³)			X			
Outdoor coil water flow rate, lb _m /h (kg/s)				X		
Temperature of Outdoor Liquid Entering Equipment, °F (°C)				X		
Temperature of Outdoor Liquid Leaving Equipment, °F (°C)				X		
Rate of Condensate Collection, lb _m /h (kg/s)	X					
Refrigerant Liquid Temperature, Indoor Side, °F (°C)		X	X			
Refrigerant Liquid Temperature, Outdoor Side, °F (°C)						
Refrigerant Vapor Temperature, Indoor Side, °F (°C)		X	X			

Table 6 Data to Be Recorded for Secondary Checks^a

Item	Cooling Condensate Method	Compressor Calibration Method	Refrigerant Flow Method	Outdoor Liquid Coil Method	Outdoor Air Enthalpy Method ^b	Cooling Condensate and Indirect Airflow Measurement Method
Refrigerant Vapor Temperature, Outdoor Side, °F (°C)						
Refrigerant Vapor Pressure, Indoor Side, psig (kPa)		X	X			
Additional data		e	f			

- a. Secondary checks are not required for units with VERS tested using Option 1.
b. For test room layout, refer to additional information in ANSI/ASHRAE Standard 37.
c. Required only during cooling capacity.
d. Only for heat pump units.
e. Additional data required, refer to ANSI/ASHRAE Standard 37, Section 7.6.
f. Additional data required, refer to ANSI/ASHRAE Standard 37, Section 7.7.

10. CALCULATIONS

10.1 All data used for calculations shall be the arithmetic mean of the measurements taken for each point after equilibrium

10.2 Total net cooling capacity shall be calculated based on test data collected using the following equation:

$$\begin{aligned}
 q_{tc} &= \frac{Q_{SA}(c_{pOVA}t_{OVA} - c_{pSA}t_{SA})}{v_{SA}} \\
 &= \frac{Q_{SA}(c_{pOVA}t_{OVA} - c_{pSA}t_{SA})}{v'_{SA}(1 + W_{SA})} \\
 &= (A) \left[\frac{Q_{SA}(c_{pOVA}t_{OVA} - c_{pSA}t_{SA})}{v_{SA}} \right] \\
 &= (A) \left[\frac{Q_{SA}(c_{pOVA}t_{OVA} - c_{pSA}t_{SA})}{v'_{SA}(1 + W_{SA})} \right]
 \end{aligned}$$

where

$$c_{pOVA} = c_{p,dry\ air} + c_{p,water\ vapor}W_{OVA}$$

and

$$c_{pSA} = c_{p,dry\ air} + c_{p,water\ vapor}W_{SA}$$

10.3 Moisture removal capacity based on test data collected according to the air-enthalpy method shall be calculated using the following equation:

$$\begin{aligned}
 MRC &= \frac{Q_{SA}(W_{OVA} - W_{SA})}{v_{SA}(1 + W_{SA})} \\
 &= (A) \frac{Q_{SA}(W_{OVA} - W_{SA})}{v_{SA}(1 + W_{SA})}
 \end{aligned}$$

10.4 Unit total heating capacity shall be calculated based on test data collected using the following equation:

$$q_{th} = \frac{Q_{SA}c_{pSA}(t_{SA} - t_{OVA})}{v_{SA}}$$

$$\begin{aligned}
 &= \frac{Q_{SA} c_{pSA} (t_{SA} - t_{OVA})}{v'_{SA} (1 + W_{SA})} \\
 &\left[= (A) \frac{Q_{SA} c_{pSA} (t_{SA} - t_{OVA})}{v_{SA}} \right] \\
 &= (A) \frac{Q_{SA} c_{pSA} (t_{SA} - t_{OVA})}{v'_{SA} (1 + W_{SA})}
 \end{aligned}$$

where

$$c_{pSA} = c_{p,dry\ air} + c_{p,water\ vapor} W_{SA}$$

and

$$W_{OVA} = W_{SA}$$

10.5 Air dew-point temperature shall be calculated based on supply air dry-bulb temperature and supply air wet-bulb temperature data collected and using equations indicated in the *ASHRAE Handbook–Fundamentals*.

10.6 The unit total heating capacity shall be adjusted for duct losses. The duct loss adjustment shall be added to the capacities. The duct loss adjustment shall be calculated using the following equation:

$$q_{loss} = (UA_{duct})(t_{SA} - t_{OVA})$$

10.7 For each condition tested, the following values shall be reported.

10.7.1 All Tested Conditions

- a. Airflow rate for supply air stream
- b. Airflow rate for return air stream (if applicable for units equipped with exhaust air energy recovery)
- c. External resistance to the supply airflow
- d. External resistance to the return airflow (if applicable for units equipped with exhaust air energy recovery)

10.7.2 Dehumidification Condition – Reheat On

- a. Supply air temperature
- b. Water flow rate (where water is used for heat rejection or absorption)
- c. Water temperature (where water is used for heat rejection or absorption)
- d. Input in Btu/h (kW) of every cooling source
- e. Supply air dew-point temperature
- f. Moisture removal capacity (MRC)
- g. Average power during test

10.7.3 Dehumidification Condition – Reheat Off or Without Reheat Installed

- a. Supply air temperature
- b. Total Net Cooling Capacity
- c. Water flow rate (where water is used for heat rejection or absorption)
- d. Water temperature (where water is used for heat rejection or absorption)
- e. Input in Btu/h (kW) of every cooling source
- f. Supply air dew-point temperature
- g. Moisture removal capacity (MRC)
- h. Average power during test

10.7.4 Heating Conditions

- a. Supply air temperature
- b. Unit total heating capacity
- c. Water flow rate (where water is used for heat rejection or absorption)

11. LETTER SYMBOLS USED IN EQUATIONS

Symbols used in this standard are as follows:

A	=	conversion constant used in equations (For I-P units, $A = 60$; for SI units, $A = 1/3600$)
A_{duct}	=	surface area of duct, ft^2 (m^2)
$c_{p, \text{dry air}}$	=	specific heat of dry air, $0.24 \text{ Btu}/(\text{lb}\cdot^{\circ}\text{F})$ [$1004.65 \text{ J}/(\text{kg}\cdot^{\circ}\text{C})$]
$c_{p\text{OVA}}$	=	specific heat of outdoor ventilation air, $\text{Btu}/(\text{lb}\cdot^{\circ}\text{F})$ [$\text{J}/(\text{kg}\cdot^{\circ}\text{C})$] of dry air
$c_{p\text{SA}}$	=	specific heat of supply air, $\text{Btu}/(\text{lb}\cdot^{\circ}\text{F})$ [$\text{J}/(\text{kg}\cdot\text{K})$]
$c_{p, \text{water vapor}}$	=	specific heat of water vapor, $0.444 \text{ Btu}/(\text{lb}\cdot^{\circ}\text{F})$ [$1858.58 \text{ J}/(\text{kg}\cdot^{\circ}\text{C})$]
$\text{capacity}_{\text{bal}}$	=	dehumidification capacity check, %
m_c	=	mass of moisture removed, lb (kg)
MRC	=	moisture removal capacity, $\text{lb}_{\text{moisture}}/\text{h}$ ($\text{kg}_{\text{moisture}}/\text{h}$)
$\text{MRC}_{\text{secondary}}$	=	moisture removal capacity, secondary check, $\text{lb}_{\text{moisture}}/\text{h}$ ($\text{kg}_{\text{moisture}}/\text{h}$)
P_T	=	power input, total (W)
Q_{SA}	=	supply airflow, scfm (m^3/s)
q_{loss}	=	duct loss adjustment, Btu/h (W)
q_{tc}	=	total cooling capacity, Btu/h (W)
q_{th}	=	total heating capacity, Btu/h (W)
t	=	time period of moisture removal
t_{OVA}	=	temperature, outdoor ventilation air, dry-bulb, $^{\circ}\text{F}$ ($^{\circ}\text{C}$)
t_{SA}	=	temperature, supply air, dry-bulb, $^{\circ}\text{F}$ ($^{\circ}\text{C}$)
v_{SA}	=	specific volume of supply air at dry-bulb and wet-bulb temperature conditions existing at standard barometric pressure, ft^3/lb (m^3/kg) of dry air
v'_{SA}	=	specific volume of supply air, ft^3/lb (m^3/kg) of air-water-vapor mixture
U	=	overall heat transfer coefficient of ductwork wall, $\text{Btu}/\text{h}\cdot\text{ft}^2\cdot^{\circ}\text{F}$ ($\text{W}/\text{m}^2\cdot\text{K}$)
W_{OVA}	=	humidity ratio, outdoor ventilation air, lb/lb (kg/kg) of dry air
W_{SA}	=	humidity ratio, supply air, lb/lb (kg/kg) of dry air

12. REFERENCE PROPERTIES AND DATA

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

12.2 Thermodynamic Properties of Water and Steam. The thermodynamic properties of water and steam shall be obtained from the *ASHRAE Handbook—Fundamentals*.

13. NORMATIVE REFERENCES

1. ASHRAE. 2024. ANSI/ASHRAE Standard 37, *Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment*. Peachtree Corners, GA: ASHRAE.
2. ASHRAE. 2026. ANSI/ASHRAE Standard 41.2, *Standard Methods for Air Velocity and Airflow Measurement*. Peachtree Corners, GA: ASHRAE.
3. ASHRAE. 2025. *ASHRAE Handbook—Fundamentals*. Peachtree Corners, GA: ASHRAE.