STANDARD

ASHRAE®

ANSI/ASHRAE Standard 16-2016
(Supersedes ANSI/ASHRAE Standard 16-1983 [RA2014])

Method of Testing for Rating Room Air Conditioners, Packaged Terminal Air Conditioners, and Packaged Terminal Heat Pumps for Cooling and Heating Capacity

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b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard, or
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Method of Testing for Rating Room Air Conditioners, Packaged Terminal Air Conditioners, and Packaged Terminal Heat Pumps for Cooling and Heating Capacity

NOTE

Approved addenda, errata, or interpretations for this standard can be downloaded free of charge from the ASHRAE website at www.ashrae.org/technology.

(This foreword is not part of this standard. It is merely informative 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 standard prescribes methods of test for obtaining cooling capacity, heating capacity, and airflow quantity for rating room air conditioners and heat pumps and packaged terminal air conditioners and heat pumps.

ASHRAE Standard 16-2016 is the latest revision of one of ASHRAE's oldest standards. A short publishing history of this standard traces the origins of its provisions. The standard, originally evolved from the American Society of Refrigerating Engineers' (ASRE) Circular 13-42, Standard Methods of Rating and Testing Air-Conditioning Equipment, and ASRE Standard 16-56, was first issued as ASHRAE Standard 16-1961, Method of Testing for Rating Room Air Conditioners, with revisions in 1969 and 1983.

The 1983 standard was approved by the ASHRAE Standards Committee on September 16, 1983; by the ASHRAE Board of Directors on December 1, 1983; and by the American National Standards Institute on February 24, 1984.

The 1983 standard was submitted for reaffirmation with minor editorial changes by the Standards Committee on January 31, 1988. Because the ASHRAE Journal intent-to-reaffirm notice elicited no negative comments, the Board of Directors approved the reaffirmation with minor editorial changes on June 30, 1988. The reaffirmed standard was recognized as an American National Standard by ANSI on December 14, 1988.

In 2015, the standard was revised to incorporate the method of test for obtaining heating capacity for rating room air-conditioner and packaged terminal air-conditioner heating capacity prescribed in ASHRAE Standard 58, Method of Testing for Rating Room Air Conditioner and Packaged Terminal Air-Conditioner Heating Capacity. ASHRAE Standard 58 was originally issued in 1965, revised in 1974, and last reaffirmed in 1999. ASHRAE Standard 16 was last reaffirmed in 2014. This standard also includes heating capacity testing of these products with a hydronic or a steam coil.

1. PURPOSE

The purpose of this standard is to prescribe test methods for determining the cooling and heating capacity of room air conditioners, packaged terminal air conditioners, and packaged terminal heat pumps.

2. SCOPE

This standard

a. establishes uniform methods of testing to obtain rating data,
b. specifies test equipment for performing such tests,
c. specifies data required and calculations to be used, and
d. lists and defines the terms used in testing.

3. DEFINITIONS

air conditioner: the room air conditioner, packaged terminal air conditioner, or packaged terminal heat pump being tested.

apparatus: refers exclusively to test room facilities and associated instrumentation.

capacity, latent cooling: the rate, expressed in watts (British thermal units), that the equipment removes moisture from the air passing through it under specified conditions of operation.

capacity, sensible cooling: the rate, expressed in watts (British thermal units), that the equipment removes sensible heat from the air passing through it under specified conditions of operation.

capacity, total cooling: the rate, expressed in watts (British thermal units), that the equipment removes heat from the air passing through it under specified condition of operation.

capacity, latent heating: the rate, expressed in watts (British thermal units), that the equipment adds latent heat to the air passing through it under specific conditions of operation.

capacity, sensible heating: the rate, expressed in watts (British thermal units), that the equipment adds sensible heat to the air passing through it under specific conditions of operation.

capacity, total heating: the rate, expressed in watts (British thermal units), that the equipment adds heat to the air passing through it under specific conditions of operation.

electric resistance heater: the electric resistance element located in the indoor airstream of the equipment under test.

equilibrium conditions: UUT inlet conditions that fall within allowable variations as stated in Table 1 of this standard.

heat leakage factor: the amount of energy (Btu/h·°F) transfer across a surface or surfaces for a given temperature difference.

heating coil: a hydronic or steam coil located in the indoor airstream of the equipment under test.

hybrid calorimeter: a test facility consisting of a fully functional balanced ambient or calibrated calorimeter with additional psychrometric test apparatus included within the indoor-side compartment and possibly in the outdoor-side compartment.

indoor air enthalpy test method: a procedure for determining indoor cooling or heating capacity that involves measurement of the enthalpy of air entering and leaving the equipment and the mass airflow rate leaving the equipment.

indoor coil: the heat exchanger that removes heat from or adds heat to the conditioned space by the vapor compression cycle.

leakage airflow: the amount of air interchanged between the room side and outdoor side through the air conditioner as a result of construction features or sealing techniques.

outdoor coil: the heat exchanger that rejects heat to or absorbs heat from a source external to the conditioned space by the vapor compression cycle.

packaged terminal air conditioner: a wall sleeve and a separate unencased combination of heating and cooling assemblies specified by the manufacturer and intended for mounting through the wall; includes refrigeration components, separable outdoor louvers, forced ventilation, and heating availability by purchaser's choice of at least hot water, steam, or electrical resistance heat.

packaged terminal heat pump: a separate unencased refrigeration system installed in a cabinet of the same function and configuration to that of a packaged terminal air conditioner; uses reverse cycle refrigeration as its prime heat source and has other supplementary heat sources with the choice of at least hot water, steam, or electric resistance heat.

pressure, standard barometric: a barometric pressure of 101.325 kPa (14.696 psia or 29.921 in. Hg).

qualification test: a procedure employed for verifying the accuracy of the measuring techniques (temperature, airflow rates, duct heater calibration) employed in determination of simulated heating capacity of a UUT. This qualification procedure is employed in the verification of the air enthalpy measurements.

recirculated airflow: the air discharged from the air conditioner to the conditioned space when all UUT ventilating dampers are closed.

recognized third-party laboratory: an ISO 17025 accredited laboratory with measurements from all instruments traceable to primary or secondary standards calibrated by the National Institute of Standards and Technology (NIST), or to the Bureau International des Poids et Mesures (BIPM) if a National Metrology Institute (NMI) other than NIST is used, and having the product types covered in this standard within the laboratory's scope of accreditation.

room air conditioner: an encased assembly designed as a unit for mounting in a window or through the wall for the purpose of providing conditioned air to an enclosed space; systems include cooling only or cooling and heating, and may incorporate ventilation.

room calorimeter: a test facility consisting of an indoor-side compartment and an outdoor-side compartment, each equipped with instrumented reconditioning equipment. The output of this equipment is measured and controlled to counterbalance the room-side total cooling effect of the equipment under test.

standard air I-P: dry air at 21.1°C (70°F) and 101.325 kPa (14.696 psia) (at conditions, dry air has a mass density of 0.075 lb/ft^3).

standard air SI: dry air at 21.1°C (70°F) and 101.325 kPa (14.696 psia) (at conditions, dry air has a mass density of 0.075 lb/ft^3).

thermopile: a series connection of thermocouples across two surfaces that results in a microvolt reading equated to a temperature difference across the two surfaces.

unit under test (UUT): the air conditioner under test.

UUT stability: the UUT is stable when the measured capacities from three sets of 5-minute data are within 2% of each other and are not trending.

4. CLASSIFICATIONS

4.1 Three basic types of product are covered in this standard: room air conditioners, packaged terminal air conditioners, and packaged terminal heat pumps. For the sake of brevity, throughout the body of the text the term "air conditioner" is used.

4.2 UUT cooling shall only be from the vapor compression cycle of the refrigeration system of the air conditioner.

4.3 UUT heating shall be from one or multiple of the following heating means:

a. Heat pump (vapor compression reverse cycle)
b. Hydronic heating coil
c. Steam heating coil
d. Electric resistance

4.4 There are two methods of testing heat-pump units: steady state (no defrosting) and transient (with defrost cycles); only steady-state testing is covered in this standard.

4.5 There are two heating capacity calculations when conducting a psychrometric test: the specific heat method for no moisture change and the enthalpy method when moisture is added.

5. INSTRUMENTS

5.1 Temperature Measuring Instruments

5.1.1 All temperature measurements (with the exception of dew-point temperature) shall be made in accordance with ANSI/ASHRAE Standard 41.1 [1].

5.1.2 If used in determining the water vapor content of the air, dew-point hygrometers shall be applied as specified in ANSI/ASHRAE Standard 41.6 [2] and shall be accurate to within ±0.22°C (0.4°F).

5.1.3 Outlet air temperature measurements shall be taken downstream of the static pressure taps on the outlet duct (psychrometric test). This is so as not to interfere with the measurement of the duct static pressure.

5.1.4 Instrument Accuracy

a. Dry- and wet-bulb temperatures of reconditioned air in calorimeter compartments and cooling water temperatures shall be ±0.06°C (0.1°F).
b. Dry- and wet-bulb temperatures for airflow measurements shall be ±0.6°C (1.0°F).
c. All other temperatures shall be ±0.28°C (0.5°F).

5.1.5 In no case shall the smallest scale division of the temperature measuring instrument exceed twice the specified accuracy. For example, for the specified accuracy of ±0.06°C (0.1°F), the smallest scale division shall not exceed 0.12°C (0.2°F).

5.1.6 Temperature measuring instruments shall be calibrated over the range of temperatures to be encountered during test against temperature measuring instruments with a calibration that is traceable to the National Institute of Standards and Technology (NIST) or other international measurement standard recognized by NIST.

5.2 Liquid and Barometric Pressure Measuring Instruments

5.2.1 Pressure measurements shall be made with one of the following instruments:

a. Electronic pressure transducer
b. Bourdon tube gage

5.2.2 The accuracy of pressure measuring instruments shall permit measurements to within ±1% of the reading.

5.2.3 Calibration of the pressure measuring instruments shall be with respect to a dead-weight tester or by comparison with a liquid column.

5.2.4 In no case shall the smallest scale division of the pressure measuring instrument exceed two times the specified accuracy.

5.2.5 Apply and use instruments in accordance with ASHRAE Standard 41.3 [3].

5.3 Pressure Measuring Instruments (not Including Barometers)

5.3.1 Pressure measurements shall be made with at least one of the following instruments:

a. Mercury column
b. Bourdon tube gage
c. Aneroid pressure gage
d. Calibrated pressure transducer

5.3.2 Air pressure measuring instruments shall have an accuracy of ±1% of the value measured or the greater value of ±2.5 Pa (0.01 in. of water).

5.3.3 Hydronic-coil or steam-coil differential pressure measurements shall be made with an instrument having an accuracy of ±1% of the value measured.

5.3.4 Calibration shall be with respect to a dead-weight tester or by comparison to a mercury column or other reference standard traceable to the NIST or other international measurement standard recognized by NIST.

5.3.5 In no case shall the smallest scale division of the pressure measuring instrument exceed two times the specified accuracy.

5.3.6 Apply and use instruments in accordance with ASHRAE Standard 41.3 [3].

5.4 Condensate Measuring Instruments

5.4.1 Condensate collection rates shall be measured by weight to an accuracy of ±0.5 g (0.01 lbs).

5.5 Airflow Measurements

5.5.1 Airflow measurements shall be made in accordance with ASHRAE Standard 41.2 [4] using equipment with a total accuracy within 1% of the quantity measured. The static pressure difference across nozzles and velocity pressures at nozzle throats shall be measured with manometers or electronic pressure transducers that have been calibrated against a pressure standard to within ±1.0% of the reading or the greater value of ±2.5 Pa (0.01 in. of water).

5.5.2 The air-conditioner discharge duct static pressure and the differential pressure between the room and outdoor side compartments shall be measured by an instrument with an accuracy of ±2.5 Pa (0.01 in. of water).

5.5.3 Airflow nozzles shall be specified and used in accordance with ASHRAE 41.2 [4].

5.6 Electrical Instruments

5.6.1 Electrical measurements shall be made with indicating or integrating instruments.

5.6.2 Instruments used for measuring electrical input to the air conditioner under test, as well as input to heaters or other apparatus furnishing heat loads, shall be accurate to ±0.5% of the value measured.

5.6.3 Voltages shall be measured at the receptacle for cord-connected units and within 1.83 m (6 ft) of the wiring connections of the air conditioner of correctly rated wire for hard-wired units.

5.6.4 Apply and use instruments in accordance with ASHRAE Standard 41.11 [5].

5.7 Liquid Flow Measurements

5.7.1 Water (other than condensate) and brine flow rates shall be measured with a liquid flow or quantity meter that is accurate to within ±0.5% of the quantity measured.

5.8 Speed Measuring Instruments

5.8.1 Speed measuring instruments shall be made with a revolution counter, tachometer, stroboscope, or oscilloscope that is accurate to within ±1.0% of the reading.

5.9 Time and Mass Instruments

5.9.1 Time interval measurements shall be made with an instrument that is accurate to within ±0.2% of the reading.

5.9.2 Mass measurements shall be made with an instrument that is accurate to within ±1.0% of the value measured or the greater value of 0.01 kg (0.02 lb).

5.10 Calibrations

5.10.1 Specified accuracy of all instruments shall be verified at least annually by comparison with a secondary standard whose calibration is traceable to NIST or comparable international measurement standard recognized by NIST.

6. APPARATUS

6.1 Calorimeters

6.1.1 General. Accurate measurement from calorimeters for cooling and heating capacity of air conditioners is dependent on the stability of conditions within and surrounding the calorimeters during room calibration and testing. Refer to Sections 6.1.2.3, 8.2.5, and 8.2.6 for stability requirements.

6.1.1.1 The air conditioner shall be tested in a room air calorimeter of either

a. the calibrated type (see Figure 1) or
b. the balanced ambient type (see Figure 2).

6.1.1.2 Interior surfaces of the calorimeter compartments shall be of nonporous material with all joints sealed against air and moisture leakage. The access door shall be tightly sealed against air and moisture leakage by use of gaskets or other means.

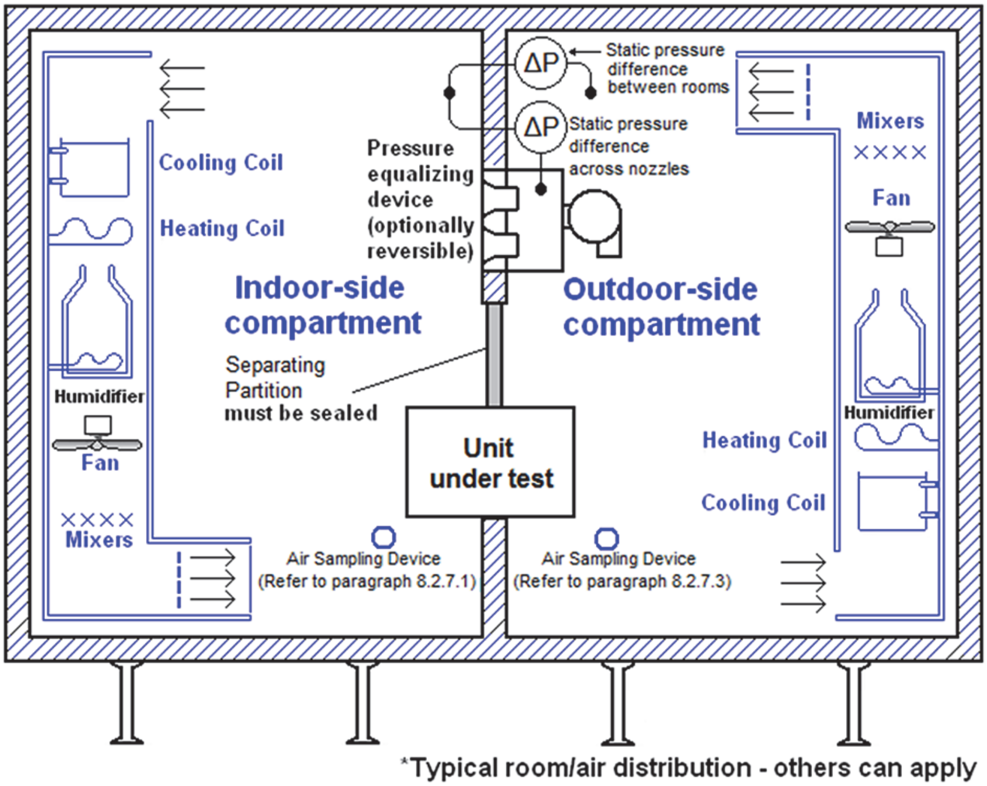

FIGURE 1 Example calibrated room type calorimeter.

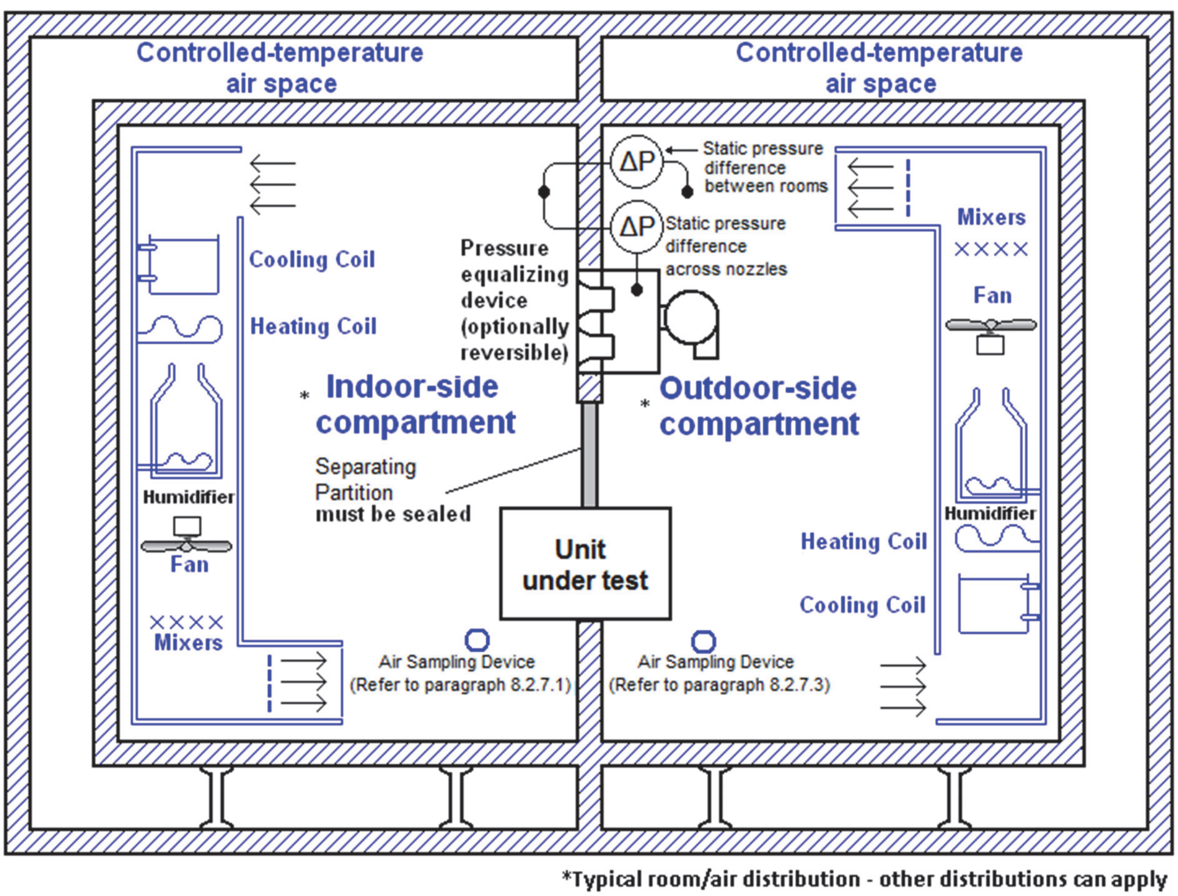

FIGURE 2 Example balanced ambient room type calorimeter.

6.1.1.3 The calorimeter provides a method for determining cooling capacity or heating capacity on the room side and on the outdoor side simultaneously.

a. **Cooling Capacity.** The indoor-side cooling capacity determination is made by balancing the cooling and dehumidifying effects of the air conditioner under test against the measured heat and water energy inputs. The outdoor-side capacity provides a confirming test of the cooling and dehumidifying effect by balancing the heat and water rejection on the condenser side with a measured amount of cooling. These two simultaneous determinations shall agree within ±4.0%.
b. **Heating Capacity.** The indoor-side heating capacity determination is made by balancing the heating effects of the UUT against the measured amount of cooling medium and heat input to the indoor room. If moisture is added to the indoor airstream of the UUT, dehumidifying means shall be required of the room-side conditioning equipment. The outdoor-side capacity provides a confirming test of the heating and humidifying effect by balancing the heat medium and moisture input water rejection on the condenser side against a measured amount of cooling medium that maintains conditions. These two simultaneous determinations shall agree within ±4.0%.

6.1.1.4 The two calorimeter compartments, room side and outdoor side, are separated by an insulated partition having an opening to mount the air conditioner (Figures 1 and 2). The air conditioner shall be installed per the UUT manufacturers' instructions. No effort shall be made to seal the internal construction of the air conditioner to prevent air leakage from the outdoor side to the indoor side or from the indoor side to the outdoor side, other than that specifically provided by the manufacturer's installation instructions. No connections or alterations shall be made to the air conditioner that interferes with its operation. Grille/louver positions, fan speeds, and other user adjustable options shall be set to result in maximum cooling capacity in accordance with manufacturer instructions. When tests are made at other settings, those settings shall be recorded along with the rating results.

The separating partition fitted around the air conditioner shall be sealed to the air conditioner (this allows for an accurate measurement of any air leakage within the air conditioner and the effect on the capacity test results). Any unused space around the air conditioner and the separating partition shall be insulated with the same material as used for the separating partition heat leakage calibration (see Section 6.1.2.3).

a. The separating partition fitted around the air conditioner shall be sealed to the air conditioner (this allows for an accurate measurement of any air leakage within the air conditioner and the effect on the capacity test results). Any unused space around the air conditioner and the barrier wall shall be insulated with the same material as used for the separating partition heat leakage calibration (see Section 6.1.2.3).
b. As shown in Figure 2, the inner chambers must be constructed of insulated panels to improve the accuracy of the capacity measurement.

6.1.1.5 A pressure equalizing device shall be provided in the partition wall between the room-side and outdoor-side compartments to maintain a balanced pressure between these compartments and to permit measurement of leakage air. An arrangement of components for such a device, using nozzles, is shown in Figure 3.

a. As the direction of leakage airflow from one compartment to the other is dependent on the UUT, either pressure equalizing devices mounted in opposite directions or a reversible device shall be used.
b. The pressure differential pickup tubes shall be located as to be unaffected by air discharged from the air conditioner under test or by the exhaust from the pressure equalizing device. The fan or blower that exhausts air from the discharge chamber shall permit variation of its airflow, for example a variable-speed drive or a damper as shown in Figure 3. The exhaust from this fan or blower shall be such that it won't affect the inlet air to the air conditioner under test.
c. The energy input to the fan motor of the equalizing device shall be included in the input to the compartment containing it during capacity testing.
d. The equalizing device shall be adjusted during the calorimeter tests or airflow measurements so that the static pressure difference between the room-side and outdoor-side compartments is not greater than 2.5 Pa (0.01 in. of water).

6.1.1.6 The size of the calorimeter shall be designed not to restrict any intake or discharge openings of the air conditioner. Perforated plates or other air settling means shall be provided at the discharge openings of the reconditioning equipment to prevent reconditioned air velocities exceeding 0.5 m/s (100 fpm) within 0.91 m (3 ft) of the air conditioner under test. Space shall be allowed in front of any inlet or discharge grilles/louvers of the air conditioner to prevent interference with the airflow. Minimum distance from the air conditioner to side walls or ceiling of the compartments shall be 0.91 m (3 ft).

6.1.1.7 Each compartment shall be provided with reconditioning equipment to maintain prescribed entering air temperature conditions. Reconditioning equipment for the room-side compartment shall consist of heaters to supply sensible heat and a humidifier to supply moisture. The water supplied to the humidifier shall be controlled and accurately measured. Reconditioning equipment for the outdoor-side compartment shall provide cooling and dehumidification. A cooling coil equipped with bypass dampers or other means to control the dry-bulb temperature and supplied with variable temperature water and/or variable water quantity to control the wet-bulb temperature is used. A dehumidifying apparatus or reheating apparatus or both is allowable in combination with the cooling coil. Reconditioning equipment for both compartments shall include fans of capacity to overcome the resistance of the other reconditioning equipment and circulate not less than

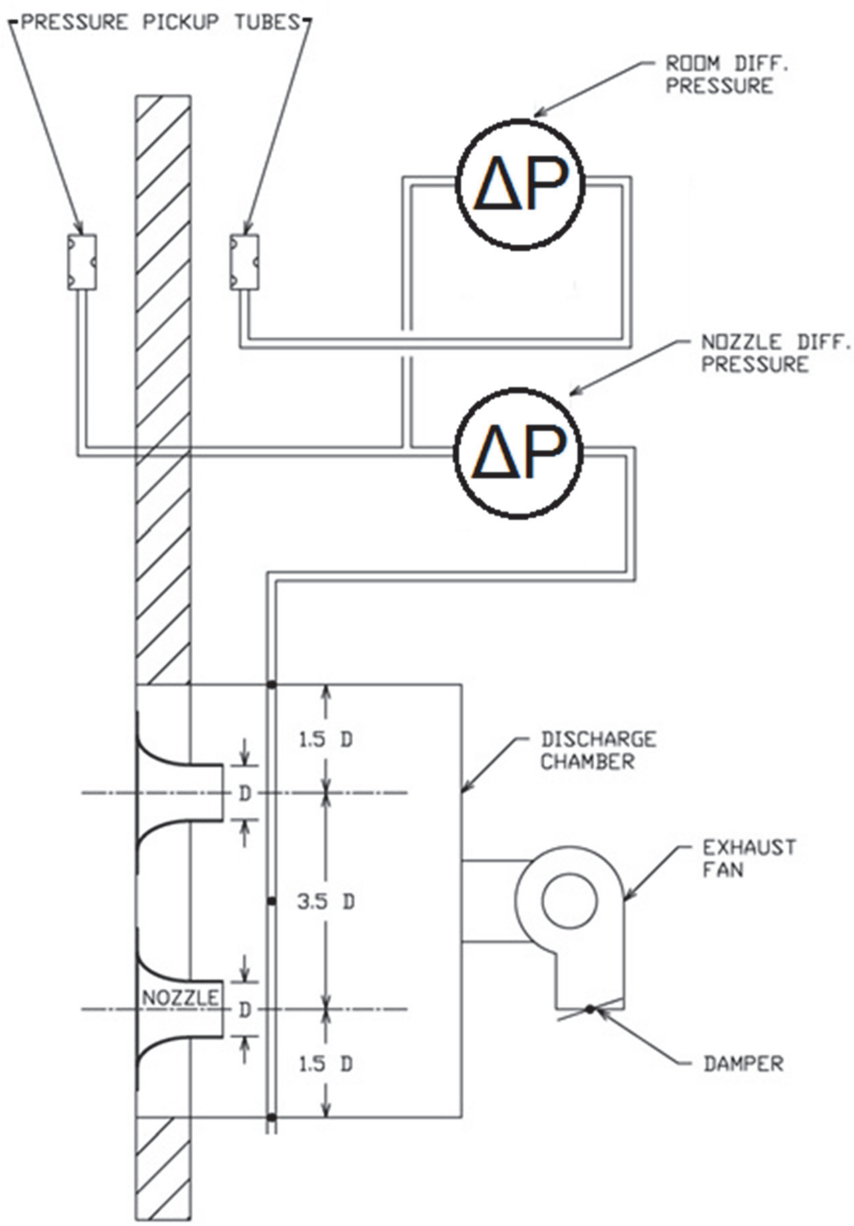

FIGURE 3 Pressure equalizing device.

two times the quantity of air circulated by the air conditioner to the room side or to the outdoor side. In no case shall the reconditioning equipment circulate more than one room air change per minute.

Informative Note: When the base electric load to the test compartment is greater than the capacity of the UUT, a cooling means that is controlled and accurately measured shall be used.

6.1.1.7.1 When calorimeters are used for heat pumps, there shall be heating, humidifying, and cooling capabilities in both rooms (see Figures 1 and 2) or other means, such as rotating the air conditioner (indoor room becomes outdoor room and outdoor room becomes indoor room).

6.1.1.8 Remote reading sensors, instruments for air sampling, shall be used to measure the specified dry- and wet-bulb temperatures in both calorimeter compartments. The inside diameter of air-sampling device tubes, where temperature sensors are inserted, shall be not less than 75 mm (3 in.). The air velocity over the wet-bulb temperature measuring instruments shall be 5 m/s (1000 fpm) ±20%. Wet-bulb measurements above or below 5 m/s (1000 fpm) must be corrected in accordance with ANSI/ASHRAE Standard 41.1 [1]. The air-sampling ductwork shall not be brought outside of the calorimeter walls. The aspirating psychrometer sampler fan/blower motors shall be installed completely within the calorimeter compartments and the electrical input included in the measurement. The fan/blower motor shall be located so that its heat does not cause stratification of air passing into the air conditioner. The fan/blower shall draw the air over the temperature sensors and return it to the same compartment in a manner that does not affect air temperature measurements or circulation of air from the air conditioner.