ANSI/RESNET/ICC 380-2019

Standard for Testing Airtightness of Building, Dwelling Unit, and Sleeping Unit Enclosures; Airtightness of Heating and Cooling Air Distribution Systems; and Airflow of Mechanical Ventilation Systems

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SPECIAL NOTE

This ANSI/RESNET/ICC Standard is a voluntary consensus standard developed under the auspices of the Residential Energy Services Network (RESNET) in accordance with RESNET's *Standards Development Policy and Procedures Manual*, Version 2.1, August 25, 2017. RESNET is an American National Standards Institute (ANSI) Accredited Standards Developer. Consensus is defined by ANSI as "substantial agreement reached by directly and materially affected interest categories." This signifies the concurrence of more than a simple majority but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution. Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory.

RESNET obtains consensus through participation of it national members, associated societies, and public review.

This is the second edition of this Standard and supercedes the first edition that was designated and titled ANSI/RESNET 380-2016 Standard for Testing Airtightness of Building Enclosures, Airtightness of Heating and Cooling Air Distribution Systems, and Airflow of Mechanical Ventilation Systems. This second edition incorporates a number of substantive changes, the more significant of which are all addenda to the first edition and criteria specific to attached Dwelling and attached Sleeping Units in buildings of all heights.

This Standard is under continuous maintenance in accordance with Section 10.9 of the *RESNET Standard Development Policy and Procedures Manual.* Continuous maintenance

proposals should be submitted to the Manager of Standards via the online form on the RESNET website. The Procedures Manual and online forms for submitting continuous maintenance proposals and requests for interpretation can be accessed from the website at www.resnet.us/blog/resnet-consensus-standards/ under the heading **RESNET CONSENSUS STANDARDS**.

The Manager of Standards should be contacted for:

a. Interpretation of the contents of this Standard
b. Participation in the next review of the Standard
c. Offering constructive criticism for improving the Standard
d. Permission to reprint portions of the Standard

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Standard for Testing Airtightness of Building, Dwelling Unit, and Sleeping Unit Enclosures; Airtightness of Heating and Cooling Air Distribution Systems; and Airflow of Mechanical Ventilation Systems

Forward (Informative)

Standard 380 has been developed to provide a consensus national standard for consistent measurement of several air-flow related building metrics. It builds on existing American National Standards to provide standard procedures essential to the evaluation of the energy performance of Residential Buildings, as well as Dwelling Units and Sleeping Units within Residential or Commercial Buildings.

This Standard provides a consistent, uniform methodology for evaluating the airtightness of building, Dwelling Unit, and Sleeping Unit enclosures and heating and cooling air distribution systems, and the air flows of mechanical ventilation systems. These test procedures can be used as diagnostics, in quality assurance and control, for determining compliance with codes and standards, and to determine inputs to energy simulations and ratings. The Standard recognizes that some test procedures are easier to perform depending on building and HVAC system characteristics and that different codes and standards have specific testing requirements. Therefore, the Standard presents several alternative approaches for each measurement to allow flexibility in application of the standard.

Requirements for recording, documenting and reporting how the tests established by this standard are conducted and the test results shall be those established by the adopting entities.

This Standard is under continuous maintenance pursuant to RESNET's ANSI-accredited *Standards Development Policy and Procedures Manual*. Forms and procedures for submitting change proposals may be found on RESNET's Website at www.resnet.us/blog/resnet-consensus-standards/ under the heading **STANDARDS DEVELOPMENT**. When proposed addenda are available for public review and when approved addenda are published, notices will be published on RESNET's Website.

This Standard contains both normative and informative material. Normative materials make up the body of the Standard and must be complied with to conform to the Standard. Informative materials are clearly marked as such, are not mandatory, and are limited to this forward, footnotes, references and annexes.

1. Purpose

1.1. The provisions of this document are intended to establish national standards for testing the airtightness of enclosures and heating and cooling air distribution systems, and the airflow of mechanical ventilation systems. This Standard is intended for use by parties including home energy raters, energy auditors, or code officials who are evaluating the performance of Residential Buildings, or of Dwelling Units or Sleeping Units within Residential or Commercial Buildings.

2. Scope

2.1. This Standard defines procedures for measuring the airtightness of building, Dwelling Unit, and Sleeping Unit enclosures, the airtightness of heating and cooling air distribution systems, and the airflow of mechanical ventilation systems.

This Standard is applicable to all Dwelling Units and Sleeping Units in Residential and Commercial Buildings. The term Dwelling Unit can be replaced with Sleeping Unit throughout the standard, except where specifically noted.

This Standard provides separate procedures for measuring the airtightness of building enclosures and the airtightness of attached Dwelling Unit and Sleeping Unit enclosures.

The procedure for measuring the airtightness of heating and cooling air distribution systems is applicable to Dwelling Units and Sleeping Units with their own duct system separate from other Dwelling Units and Sleeping Units.

The procedure for measuring the airflow of mechanical ventilation systems is applicable to Dwelling Units and Sleeping Units with their own ventilation system or with a central/shared system.

3. Definitions

Blower Door – A device that combines an Air-Moving Fan as defined in Section 4.1.1, an Airflow Meter as defined in Section 4.1.3, and a covering to integrate the Air-Moving Fan into the building or Dwelling Unit opening.

Commercial Building – All buildings that are not included in the definition of Residential Buildings.

Compartmentalization Boundary - The surface that bounds the Infiltration Volume of the Dwelling Unit.

Conditioned Floor Area (CFA)[1] – The floor area of the Conditioned Space Volume within a building or Dwelling Unit, not including the floor area of attics, crawlspaces, and basements below air sealed and insulated floors. The following specific spaces are addressed to ensure consistent application of this definition:

[1] (Informative Note) Informative Annex A contains a table that summarizes parts of a Dwelling Unit that are included in Conditioned Floor Area.

- The floor area of a wall assembly that is adjacent to Conditioned Space Volume shall be included.
- The floor area of a basement shall be included if the party conducting the evaluation has either:
    - Obtained an ACCA Manual J, S, and either B or D report and verified that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume, or,
    - Verified through visual inspection that both the heating and cooling equipment and distribution system serve the volume and, in the judgement of the party conducting evaluations, are capable of maintaining the heating and cooling temperatures specified by the Thermostat section in Table 4.2.2(1) of ANSI/RESNET/ICC 301.
- The floor area of a garage shall be excluded, even when it is conditioned.
- The floor area of a thermally isolated sunroom shall be excluded.
- The floor area of an attic shall be excluded, even when it is Conditioned Space Volume.
- The floor area of a crawlspace shall be excluded, even when it is Conditioned Space Volume.

Conditioned Space Volume[2] - The volume within a building or Dwelling Unit serviced by a space heating or cooling system designed to maintain space conditions at 78 °F (26 °C) for cooling and 68 °F (20 °C) for heating. The following specific spaces are addressed to ensure consistent application of this definition:

- If the volume both above and below a floor assembly meets this definition and is part of the subject Dwelling Unit, then the volume of the floor assembly shall also be included. Otherwise the volume of the floor assembly shall be excluded.
    - Exception: The wall height shall extend from the finished floor to the bottom side of the floor decking above the subject Dwelling Unit for non-top floor level Dwelling Units and to the exterior enclosure air barrier for top floor level Dwelling Units.
- If the volume of at least one of the spaces horizontally adjacent to a wall assembly meets this definition, and that volume is part of the subject Dwelling Unit, then the volume of the wall assembly shall also be included. Otherwise, the volume of the wall assembly shall be excluded.
    - Exception: If the volume of one of the spaces horizontally adjacent to a wall assembly is a Dwelling Unit other than the subject Dwelling Unit, then the volume of that wall assembly shall be evenly divided between both adjacent Dwelling Units.

[2] (Informative Note) Informative Annex A has a table that summarizes parts of a Dwelling Unit that are included in Conditioned Space Volume.

- The volume of an attic that is not both air sealed and insulated at the roof deck shall be excluded.
- The volume of a vented crawlspace shall be excluded.
- The volume of a garage shall be excluded, even when it is conditioned.
- The volume of a thermally isolated sunroom shall be excluded.
- The volume of an attic that is both air sealed and insulated at the roof deck, the volume of an unvented crawlspace, and the volume of a basement shall only be included if the volume is contiguous with the subject Dwelling Unit and the party conducting evaluations has either:
    - Obtained an ACCA Manual J, S, and either B or D report and verified that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume, or,
    - Verified through visual inspection that both the heating and cooling equipment and distribution system serve the volume and, in the judgement of the party conducting evaluations, are capable of maintaining the heating and cooling temperatures specified by the Thermostat section in Table 4.2.2(1) of ANSI/RESNET/ICC 301.
- The volume of a mechanical closet, regardless of access location, that is contiguous with the subject Dwelling Unit shall be included if:
    - it is serviced by a space heating or cooling system designed to maintain space conditions at 78 °F (26 °C) for cooling and 68 °F (20 °C) for heating, and
    - it only includes equipment serving the subject Dwelling Unit, and
    - the mechanical room is not intentionally air sealed from the subject Dwelling Unit

Dwelling - Any building that contains one or two Dwelling Units used, intended, or designed to be built, used, rented, leased, let or hired out to be occupied, or that are occupied for living purposes.

Dwelling Unit - a single unit providing complete, independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

Dwelling Unit Mechanical Ventilation – A mechanical exchange of indoor air with outdoor air throughout a Dwelling Unit, using a Balanced System, Exhaust System, Supply System, or combination thereof that is designed to operate continuously or through a programmed intermittent schedule to satisfy a Dwelling Unit ventilation rate.

Infiltration Volume[3] – The sum of the Conditioned Space Volume and additional adjacent volumes in the Dwelling Unit that meet the following criteria:

[3] (Informative Note) Informative Annex A has a table that summarizes parts of a Dwelling Unit that are included in Infiltration Volume.

- Crawlspaces and floor assemblies above crawlspaces, when the access doors or hatches between the crawlspace and Conditioned Space Volume are open during the enclosure airtightness test (Section 4.2.3),
- Attics, when the access doors or access hatches between the attic and Conditioned Space Volume are open during the enclosure airtightness test (Section 4.2.4),
- Basements and floor assemblies above basements, where the doors between the basement and Conditioned Space Volume are open during the enclosure airtightness test (Section 4.2.5).

Residential Building - Includes detached single-family Dwellings, two-family Dwellings and multiple single-family Dwellings (Townhouses) as well as International Building Code Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane. (i.e. residential other than where occupants are transient, such as hotels and motels)

Sleeping Unit – A room or space in which people sleep, which can also include permanent provisions for living, eating, and either sanitation or kitchen facilities but not both. Such rooms and spaces that are also part of a Dwelling Unit are not Sleeping Units.

Townhouse - A single-family Dwelling Unit constructed in a group of three or more attached units in which each unit extends from foundation to roof and with open space on at least two sides.

Unconditioned Space Volume[4] - The volume within a building or Dwelling Unit that is not Conditioned Space Volume but which contains heat sources or sinks that influence the temperature of the area or room. The following specific spaces are addressed to ensure consistent application of this definition for inclusion in Unconditioned Space Volume:

- If either one or both of the volumes above and below a floor assembly is Unconditioned Space Volume, then the volume of the floor assembly shall be included.
- If the volume of both of the spaces horizontally adjacent to a wall assembly are Unconditioned Space Volume, then the volume of the wall assembly shall be included.
- The volume of an attic that is not both air sealed and insulated at the roof deck shall be included.
- The volume of a vented crawlspace shall be included.
- The volume of an attached garage shall be included, even when it is conditioned.
- The volume of a thermally isolated sunroom shall be included.
- The volume of an attic that is both air sealed and insulated at the roof deck, the volume of an unvented crawlspace, and the volume of a basement shall be included unless it meets the definition of Conditioned Space Volume.

Whole-House Fan – A forced air system consisting of a fan or blower that exhausts at least 5 ACH of indoor air to the outdoors and thereby drawing outdoor air into a home through open windows and doors for the purpose of cooling the home.

[4] (Informative Note) Informative Annex A has a table that summarizes parts of a Dwelling Unit that are included in Unconditioned Space Volume.

4. Procedure for Measuring Airtightness of Building or Dwelling Unit Enclosure

4.1. Equipment

The Equipment listed in this section shall have their calibrations checked at the manufacturer's recommended interval, and at least annually if no time is specified.

4.1.1. Air-Moving Fan. A fan that is capable of moving air into or out of the building or Dwelling Unit to achieve one or more target pressure differences between the building or Dwelling Unit and the exterior.

4.1.2. Manometer. A device that is capable of measuring pressure difference with a maximum error of 1 % of reading, or 0.25 Pa (0.001 in. H2O), whichever is greater.

4.1.3. Airflow Meter. A device to measure volumetric airflow with a maximum error of 5% of the measured flow.

4.1.4. Thermometer. An instrument to measure air temperature with an accuracy of ±1°C (2°F).

4.1.5. Blower Door. A device that combines an Air-Moving Fan as defined in Section 4.1.1, an Airflow Meter as defined in Section 4.1.3, and a covering to integrate the Air-Moving Fan into the building opening.

4.2. Procedure to Prepare the Building or Dwelling Unit for Testing[5]

4.2.1. Fenestration. Exterior doors and windows shall be closed and latched.

4.2.2. Attached garages. All exterior garage doors and windows shall be closed and latched unless the Blower Door is installed between the Conditioned Space Volume and the garage, in which case the garage shall be opened to outside by opening at least one exterior garage door.

4.2.3. Crawlspaces. Crawlspaces shall be configured as follows and the position of the crawlspace access doors and hatches shall be recorded. When the access doors and hatches between Conditioned Space Volume and the crawlspace are closed, due to requirements in 4.2.3.1or 4.2.3.2.1, the crawlspace shall be excluded from Infiltration Volume and Conditioned Space Volume.

4.2.3.1. If a crawlspace is vented to the exterior, interior access doors and hatches between the Conditioned Space Volume and the crawlspace shall be closed. Exterior crawlspace access doors, hatches, and vents shall be left in their as-found position.

4.2.3.2. If a crawlspace is not vented to the exterior, all access doors and hatches between the Conditioned Space Volume and crawlspace shall be opened.

[5] (Normative Note) It is permissible for air tightness testing of Dwelling Units that contain fire suppression systems to be performed with temporary sprinkler head covers in place.

Exterior crawlspace access doors, hatches, and vents shall be closed to the extent possible.

4.2.3.2.1. Exception: If the floor above the crawlspace is air sealed and insulated, the access doors and hatches between the Conditioned Space Volume and crawlspace shall be closed. Exterior crawlspace access doors, hatches, and vents shall be left in their as-found position.

4.2.4. Attics. Attics shall be configured as follows and the position of the attic access doors and hatches shall be recorded. When the access doors and hatches between the Conditioned Space Volume and the attic are closed, due to requirements in 4.2.4.1 or there are no access doors, the attic shall be excluded from Infiltration Volume and Conditioned Space Volume.

4.2.4.1. If an attic is not *both* air sealed and insulated at the roof deck, access doors and hatches between the Conditioned Space Volume and the attic shall be closed. Exterior attic access doors, hatches and vents shall be left in their as-found position.

4.2.4.2. If an attic is both air sealed and insulated at the roof deck, interior access doors and hatches between the Conditioned Space Volume and the attic shall be opened. Exterior attic access doors, vents, and hatches shall be closed to the extent possible.

4.2.5. Basements. Basements shall be configured as follows and the position of the basement doors shall be recorded. When doors between the Conditioned Space Volume and the basement are closed, due to requirements in 4.2.5.1.1, the basement shall be excluded from Infiltration Volume and Conditioned Space Volume.

4.2.5.1. All doors between the Conditioned Space Volume and basement shall be opened. Exterior basement access doors, vents, and hatches shall be closed to the extent possible.

4.2.5.1.1. Exception: When the floor above the basement is air sealed and insulated, doors between the basement and Conditioned Space Volume shall be closed. Exterior basement access doors, hatches and vents shall be left in their as-found position.

4.2.6. Interior doors. All doors between rooms inside the Conditioned Space Volume shall be opened.

4.2.7. Chimney dampers and combustion-air inlets on solid fuel appliances. Chimney dampers and combustion-air inlets on solid fuel appliances shall be closed. Precautions shall be taken to prevent ashes or soot from entering the building or Dwelling Unit during testing.

4.2.8. Combustion appliance flue vents. Combustion appliance flue vents shall be left in their as-found position.

4.2.9. Fans. Any fan or appliance capable of inducing airflow across the building or Dwelling Unit enclosure shall be turned off including, but not limited to, clothes dryers, attic and crawlspace fans, kitchen and bathroom exhaust fans, air

handlers, and ventilation fans used in a Dwelling Unit Mechanical Ventilation system[6]. The party conducting the test shall not turn on fans in adjacent attached Dwelling Units. For continuously operating central ventilation systems serving more than one Dwelling Unit in a building with multiple Dwelling Units, the registers shall be sealed in the subject Dwelling Unit. The central ventilation system shall be turned off where possible. If it is not possible to turn off the system, then it can be left operating provided sealing select registers will not compromise the system and the sealed registers remain sealed during the test.

4.2.10. Dampers

4.2.10.1. Non-motorized dampers[7] that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volumes shall be left in their as-found positions.[8]

4.2.10.2. Motorized dampers that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volume shall be placed in their closed positions and shall not be further sealed.

4.2.11. Non-dampered openings for ventilation, combustion air and make-up air

4.2.11.1. Non-dampered ventilation openings of intermittently operating local exhaust ventilation systems[9] that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volume shall be left open.

4.2.11.2. Non-dampered ventilation openings of intermittently operating Dwelling Unit ventilation systems, including HVAC fan-integrated outdoor air inlets, that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volume shall not be sealed.

4.2.11.3. Non-dampered ventilation openings of continuously operating local exhaust ventilation systems[10] that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volume shall be sealed at the exterior of the enclosure where conditions allow.

4.2.11.4. Non-dampered ventilation openings of continuously operating Dwelling Unit ventilation systems that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volume shall be sealed at the exterior of the enclosure where conditions allow.

4.2.11.5. All other non-dampered intentional openings between Conditioned Space Volume and the exterior or Unconditioned Space Volume shall be left open.[11] This includes non-dampered openings to a duct, unless it has a fan that is

[6] (Informative Note) For example, a system intended to meet ASHRAE Standard 62.2.
[7] (Informative Note) For example, pressure-activated operable dampers and fixed dampers.
[8] (Informative Note) For example, a fixed damper in a duct supplying outdoor air for an intermittent ventilation system that utilizes the HVAC fan shall be left in its as-found position.
[9] (Informative Note) For example, bath fan and kitchen range fan.
[10] (Informative Note) For example, bathroom or kitchen exhaust.
[11] (Informative Note) For example, un-dampered combustion air or make-up air openings shall be left in their open position.

independent of the HVAC air-handler fan directly connected to the duct and continuously inducing a pressure difference[12].

4.2.12. Whole-House Fan louvers/shutters. Whole-House Fan louvers and shutters shall be closed. In addition, if there is a seasonal cover present, it shall be installed.

4.2.13. Evaporative coolers. The opening to the exterior of evaporative coolers shall be placed in its off position. In addition, if there is a seasonal cover present, it shall be installed.

4.2.14. Operable window trickle-vents and through-the-wall vents. Operable window trickle-vents and through-the-wall vents shall be closed.

4.2.15. Heating and cooling supply registers and return grilles. Heating and cooling supply registers and return grilles shall be left in their as-found position and left uncovered.

4.2.16. Plumbing drains with p-traps. Plumbing drains with empty p-traps shall be sealed or filled with water.

4.2.17. Vented combustion appliances. Vented combustion appliances shall remain off or in "pilot only" mode for the duration of the test.

4.2.18. Required air bypass. Where building code or manufacturer specifications require air bypass around a component, the leakage point shall not be sealed[13].

4.3. Procedures to Install the Test Apparatus and Prepare for Airtightness Test

4.3.1. Procedure to Install the Test Apparatus and Prepare for Airtightness Test for a Detached Dwelling Unit

4.3.1.1. The Blower Door shall be installed in an exterior doorway or window that has an unrestricted air pathway into the Dwelling Unit and no obstructions to airflow within 5 feet of the fan inlet and 2 feet of the fan outlet. The opening that is chosen shall be noted on the test report. The system shall not be installed in a doorway or window exposed to wind, where conditions allow. It is permissible to use a doorway or window between the Conditioned Space Volume and an Unconditioned Space Volume as long as the Unconditioned Space Volume has an unrestricted air pathway to the outdoors and all operable exterior windows and doors of the Unconditioned Space Volume are opened to the outdoors.

4.3.1.2. Tubing shall be installed to measure the difference in pressure between the enclosure and the outdoors in accordance with manufacturer's instructions. The tubing, especially vertical sections, shall be positioned out of direct sunlight.

[12] (Informative Note) For example, a non-dampered duct connecting an air handler to outside shall be left open, even if a separate continuous or intermittent bathroom exhaust fan is present in the Dwelling Unit.
[13] (Informative Note) For example, fire and smoke suppression systems.

4.3.1.3. The indoor and outdoor temperatures shall be measured using the Thermometer and recorded. Observations of general weather conditions shall be recorded.

4.3.1.4. The altitude of the building site above sea level shall be recorded with an accuracy of 500 feet (150 m).

4.3.1.5. The model and serial number(s) of all measurement equipment shall be recorded.

4.3.1.6. If the results of the test will be reported as Air Changes Per Hour at 50 Pa (0.2 in. H_2O) (ACH50), the Infiltration Volume of the Dwelling Unit shall be recorded.

4.3.1.7. If the results of the test will be reported as Specific Leakage Area (SLA), the Conditioned Floor Area of the Dwelling Unit shall be recorded.

4.3.1.8. If the results of the test will be reported as Cubic Feet per Minute per square foot of enclosure surface area at 50 Pa (0.2 in. H_2O) ($CFM50/ft^2$ of enclosure), the Compartmentalization Boundary area of the Dwelling Unit shall be recorded.

4.3.2. Procedure to Install the Test Apparatus and Prepare for Airtightness Test for an Attached Dwelling Unit[14]

4.3.2.1. Pressures shall be induced only via a Blower Door (or Blower Doors) attached to the subject Dwelling Unit. Pressures shall not be induced through the use of Blower Doors attached to spaces adjacent to the subject Dwelling Unit.

4.3.2.2. The Blower Door shall be installed in a doorway leading to an enclosed space[15], when one exists. The Blower Door shall have an unrestricted air pathway into the subject Dwelling Unit and no obstructions to airflow within 5 feet of the fan inlet and 2 feet of the fan outlet. When a doorway leading to an enclosed space is not available, the Blower Door is permitted to be installed in an exterior door or window. The tubing setup procedures listed in Section 4.3.1.2 shall be followed. The opening that is chosen shall be noted on the test report.

4.3.2.2.1. The reference tube for the Dwelling Unit pressure shall terminate in the enclosed space. The end of the reference tube shall be located where it is not impacted by the turbulence created by the fan. Tubing shall be installed to measure the difference in pressure between the subject Dwelling Unit and the enclosed space in accordance with manufacturer's instructions.

[14] (Informative Note) This test is the same as a compartmentalization test.
[15] (Informative Note) For example, a corridor.

4.3.2.2.2. An unrestricted air pathway larger than 20 square feet shall be opened between the enclosed space and outside[16].

4.3.2.2.2.1. Where an unrestricted air pathway larger than 20 square feet cannot be created, the pressure difference between the enclosed space and outside shall be measured. The pressure difference shall change by less than 3 Pa when the Blower Door is turned on to pressurize or depressurize the subject Dwelling Unit by 50 Pa[17].

4.3.2.2.3. When a doorway leading to an enclosed space is not available, the Blower Door is permitted to be installed in an exterior door or window. The tubing setup procedures listed in Section 4.3.1.2 shall be followed.

4.3.2.3. Where access is permitted, open doors between the enclosed space and any Dwelling Units that are horizontally adjacent to the subject Dwelling Unit[18].

4.3.2.3.1. Leave windows and interior doors in adjacent Dwelling Units in the condition they are found.

4.3.2.4. The door where the Blower Door is installed shall be inspected for the presence of a door seal installed to minimize air leakage between the door and door frame. Where such seal is not present or is not properly installed, 140 CFM50 shall be added to the measured airflow. This adjustment, and the presence, installation quality and condition of the door seal shall be documented in the final test report[19].

4.3.2.5. If a door is present between the subject Dwelling Unit and its mechanical closet, it shall be open during the test if the mechanical closet is Conditioned Space Volume and closed during the test if the mechanical closet is Unconditioned Space Volume.

4.3.2.6. Ductwork between units shall be sealed at the register(s) of the subject Dwelling Unit.

4.3.2.7. Where the crawlspace volume is continuous below multiple adjacent Dwelling Units, interior access doors and hatches between the subject Dwelling Unit and the crawlspace shall be closed. Exterior crawlspace access doors, hatches and vents shall be left in their as-found position.

4.3.2.8. Where the attic volume is continuous above multiple adjacent Dwelling Units, interior access doors and hatches between the subject Dwelling Unit and the attic shall be closed. Exterior attic access doors, hatches and vents shall be left in their as-found position.

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[16] (Informative Note) For example, 1) opening windows in a corridor 2) opening a door between a corridor and a common stairwell and also opening a door between the common stairwell and outside 3) opening a door between an adjacent Dwelling Unit and the corridor and also opening windows in the adjacent unit.

[17] (Informative Note) It is permitted to reduce the pressure difference between the enclosed space and outside by opening interior doors to increase the volume of the enclosed space.

[18] (Informative Note) For example, the units on either side of the subject Dwelling Unit in a double loaded corridor style subject Dwelling Unit (2 units total).

[19] (Normative Note) The adjustment may be subsequently removed if the door sweep continuity is inspected and confirmed.

4.3.2.9. Where the basement volume is continuous below multiple adjacent Dwelling Units, interior doors between the subject Dwelling Unit and the basement shall be closed. Exterior basement access doors, hatches and vents shall be left in their as-found position.

4.3.2.10. Where the mechanical room volume is continuous below multiple adjacent Dwelling Units, interior doors between the subject Dwelling Unit and the mechanical room shall be closed. Exterior mechanical room access doors, hatches and vents shall be left in their as-found position.

4.3.2.11. The indoor and outdoor temperatures shall be measured using the Thermometer and recorded. Observations of general weather conditions shall be recorded.

4.3.2.12. The altitude of the building site above sea level shall be recorded with an accuracy of 500 feet (150 m).

4.3.2.13. The model and serial number(s) of all measurement equipment shall be recorded.

4.3.2.14. If the results of the test will be reported as Air Changes Per Hour at 50 Pa (0.2 in. H_2O) (ACH50), the Infiltration Volume of the Dwelling Unit shall be recorded.

4.3.2.15. If the results of the test will be reported as Specific Leakage Area (SLA), the Conditioned Floor Area of the Dwelling Unit shall be recorded.

4.3.2.16. If the results of the test will be reported as Cubic Feet per Minute per square foot of enclosure surface area at 50 Pa (0.2 in. H_2O) ($CFM50/ft^2$ of enclosure), the Compartmentalization Boundary area of the Dwelling Unit shall be recorded.

4.4. Procedure to Conduct Airtightness Test. The leakage of the enclosure shall be measured using either the One-Point Airtightness Test in Section 4.4.1 or the Multi-Point Airtightness Test in Section 4.4.2**.**

4.4.1. One-Point Airtightness Test

4.4.1.1. With the Air-Moving Fan turned off and sealed, the pressure difference across the enclosure shall be recorded using the Manometer, with the outside as the reference. The measurement shall represent the average value over at least a 10-second period and shall be defined as the Pre-Test Baseline Dwelling Unit Pressure.

4.4.1.2. The Air-Moving Fan shall be unsealed, turned on, and adjusted to create an induced enclosure pressure difference of 50 ±3 Pa (0.2 in. ±0.012 H_2O), defined as the induced enclosure pressure minus the Pre-Test Baseline Dwelling Unit Pressure. Note that this value is permitted to be positive or negative, which will be dependent upon whether the enclosure is pressurized or depressurized. An indication of whether the Air-Moving Fan pressurized or depressurized the Dwelling Unit shall be recorded.

If a 50 Pa (0.2 in. H_2O) induced enclosure pressure difference is achieved, then the average value of the induced enclosure pressure difference and the airflow at 50 Pa (0.2 in. H_2O), measured over at least a 10-second period, shall be recorded.

If a 50 Pa (0.2 in. H_2O) induced enclosure pressure difference is not achieved, then additional Air-Moving Fans shall be used or the highest induced enclosure pressure difference ($dP_{measured}$) and airflow ($Q_{measured}$) that was achieved with the equipment available, measured over at least a 10-second period, shall be recorded. A minimum of 15 Pa (0.06 in. H_2O) must be induced across the enclosure for the test to be valid.

4.4.1.3. The Air-Moving Fan shall be turned off and the Dwelling Unit returned to its as-found condition.

4.4.1.4. If an induced enclosure pressure difference of 50 Pa (0.2 in. H_2O) was not achieved in Section 4.4.1.2, then the recorded airflow ($Q_{measured}$) shall be converted to a nominal airflow at 50 Pa (0.2 in. H_2O) using Equation 1. Alternately, a Manometer that is equipped to automatically make the conversion to CFM50 or CMS50 is permitted to be used.

$$CFM50\ \left(\frac{ft^3}{min}\right) = Q_{measured}\left(\frac{ft^3}{min}\right)\left(\frac{50}{dP_{measured}}\right)^{0.65} \quad (1a)$$

$$CMS50\ \left(\frac{m^3}{s}\right) = Q_{measured}\left(\frac{m^3}{s}\right)\left(\frac{50}{dP_{measured}}\right)^{0.65} \quad (1b)$$

4.4.1.5. Corrected CFM50 (corrected CMS50) shall be calculated by making the adjustments due to density and viscosity using Section 9 of ASTM E779[20]. Equations 1 and 2 in Section 9 shall be used to convert air flows to flows through the building envelope. Equation 4 in Section 9 shall be used to convert to standard conditions by substituting CFM50 (CMS50) for C and Corrected CFM50 (corrected CMS50) for C_0.

4.4.1.6. The Effective Leakage Area (ELA) shall be calculated using Equation 2:

$$ELA(in^2) = \frac{Corrected\ CFM50}{18.2} \quad (2a)$$

$$ELA(m^2) = \frac{Corrected\ CMS50}{13.6} \quad (2b)$$

4.4.2. Multi-Point Airtightness Test

4.4.2.1. With the Air-Moving Fan turned off and sealed, the pressure difference across the enclosure shall be recorded using the Manometer, with the outside as the reference. The measurement shall represent the average value over at least a 10-second period and shall be defined as the Pre-Test Baseline Dwelling Unit Pressure.

[20] (Normative Note) Software provided by manufacturers of test equipment is permitted to be used to perform these calculations if the manufacturer certifies that the calculations are performed in accordance with ASTM E779.

4.4.2.2. The Air-Moving Fan shall be unsealed, turned on, and adjusted to create at least five induced enclosure pressure differences at approximately equally-spaced pressure stations between 10 Pa (0.04 in. H_2O) and either 60 Pa (0.24 in. H_2O) or the highest achievable pressure difference up to 60 Pa. The induced enclosure pressure difference is defined as the measured enclosure pressure at the pressure station, with reference to the exterior, minus the Pre-Test Baseline Dwelling Unit Pressure. If a manometer is used that has automatic baseline adjustments[21] then the Pre-Test Baseline Dwelling Unit Pressure shall not be subtracted from the adjusted value. The induced enclosure pressure difference is positive for pressurization and negative for depressurization. An indication of whether the Air-Moving Fan pressurized or depressurized the Dwelling Unit shall be recorded.

At each pressure station, the average value of the induced enclosure pressure difference, and the airflow, measured over at least a 10-second period, shall be recorded. The highest induced enclosure pressure difference shall be at least 25 Pa (0.1 in. H_2O). If 25 Pa (0.1 in. H_2O) is not achieved, the One-Point Airtightness Test in Section 4.4.1 shall be used.

4.4.2.3. The Air-Moving Fan shall be turned off and the Dwelling Unit returned to its as-found condition.

4.4.2.4. The airflow at each pressure station shall be corrected for altitude and temperature to determine the corrected airflow using the calculations in Section 9 of ASTM E779[22].

4.4.2.5. The corrected airflow (Q) and the induced enclosure pressure difference measured at each pressure station (dP) shall be used in a log-linearized regression of the form $Q = C(dP)^n$ to calculate[23,24] C and n.

4.4.2.6. The Effective Leakage Area (ELA) shall be calculated using Equation 3:

$$ELA(in^2) = C\left(\frac{ft^3}{minPa^n}\right) \times 0.567 \times 4^{(n-0.5)} \quad (3a)$$

$$ELA(m^2) = C\left(\frac{m^3}{sPa^n}\right) \times 0.775 \times 4^{(n-0.5)} \quad (3b)$$

Where C and n are the values determined in Section 4.4.2.5.

4.4.2.7. The flow through the building or Dwelling Unit enclosure at 50 Pa (0.20 in. H_2O) (CFM50 or CMS50) shall be calculated using Equation 4:

[21] (Informative Note) for example, a "baseline" or "extrapolation" feature that automatically subtracts a previously-measured baseline from the measured value before displaying the measurement.
[22] (Normative Note) Software provided by manufacturers of test equipment is permitted to be used to perform these calculations if the manufacturer certifies that the calculations are performed in accordance with ASTM E779.
[23] (Informative Note) For example, using the procedures in ASTM E779, Section 9 and Annex A.1.
[24] (Normative Note) Software provided by the test equipment manufacturer that automatically calculates C and n shall not be used unless the manufacturer certifies that the calculations are performed in accordance with ASTM E779.

$$CFM50 = C\left(\frac{ft^3}{minPa^n}\right) \times 50^{(n)} \quad (4a)$$

$$CMS50 = C\left(\frac{m^3}{sPa^n}\right) \times 50^{(n)} \quad (4b)$$

Where C and n are the values determined in Section 4.4.2.5.

4.5. Procedure to Apply Results of Enclosure Air Leakage Test

4.5.1. If the results of the building or Dwelling Unit enclosure air leakage test are to be used for conducting an energy rating or assessing compliance with a building or Dwelling Unit enclosure leakage limit[25], then the corrected airflow determined using a one-point test shall be adjusted using Equation 5a or 5b.

Adjusted CFM50 = 1.1 x Corrected CFM50 (5a)

Adjusted CMS50 = 1.1 x Corrected CMS50 (5b)

The ELA determined in Section 4.4.1.6 for a one-point air leakage test shall be adjusted using Equation 6.

Adjusted ELA = 1.1 x ELA (6)

Other applications of building or Dwelling Unit enclosure air leakage testing and the results of multi-point testing do not require the corrections in this section.

4.5.2. If the results of the building or Dwelling Unit enclosure leakage test are to be converted to Air Changes Per Hour at 50 Pa (0.2 in. H_2O) (ACH50), Specific Leakage Area (SLA), Normalized Leakage Area (NLA), or compartmentalization leakage ratio at 50 Pa (CFM50/ft^2), then Equations 7 through 10 shall be used. Where adjusted or corrected CFM50, CMS50 or ELA values have been calculated in previous sections they shall be used in Equations 7 through 10.

ACH50 = CFM50 x 60 / Infiltration Volume in cubic feet (7a)

ACH50 = CMS50 x 3600 / Infiltration Volume in cubic meters (7b)

SLA = 0.00694 x ELA in in^2 / Conditioned Floor Area in square feet (8a)

SLA = 10.764 x ELA in m^2 / Conditioned Floor Area in square meters (8b)

NLA = SLA x (S)$^{0.4}$, where S is the number of stories above grade (9)

CFM50/ft^2 = CFM50 / Compartmentalization Boundary area in square feet (10)

5. Procedure for Measuring Airtightness of Duct Systems

[25] (Informative Note) For example, defined by code or by an energy efficiency program.

In addition to the test procedures in this section, Test Method A from ASTM E1554 is approved for use provided that the building, Dwelling Unit, and duct system preparation procedures in Sections 5.2.1 through 5.2.8 of this Standard are followed. The supply and return air leakage from Test Method A shall be added together and assumed equivalent to CFM25 or CMS25 to outside.

The leakage to outside test shall be performed using a Blower Door in the main entry to the Dwelling Unit to pressurize or depressurize the individual unit with reference to outside. If the main entry door is in an interior hallway then the hallway shall be well connected to outside through open windows or doors, or an exterior window or door[26] shall be used. Only the ducts serving the Dwelling Unit being tested shall be included in the test.

5.1. Equipment Needed

The Equipment listed in this section shall have their calibrations checked at the manufacturer's recommended interval, and at least annually if no time is specified.

5.1.1. Air-Moving Fan. A fan that is capable of moving air into or out of the duct system to achieve a pressure difference of 25 Pa (0.10 in. H_2O).

5.1.2. Manometer. A device that is capable of measuring pressure difference with an accuracy of ± 1% of reading or 0.25 Pa (0.0010 in. H2O), whichever is greater.

5.1.3. Flow Meter. A device to measure volumetric airflow with a maximum error of 5% of the measured flow.

5.1.4. Thermometer. An instrument to measure air temperature with an accuracy of ±1°C (±2°F).

5.1.5. Duct Leakage Tester. A device that combines an Air-Moving Fan as defined in Section 4.1.1 and a Flow Meter as defined in Section 5.1.3.

5.2. Procedure to Prepare the Building or Dwelling Unit and the Duct System for Testing

5.2.1. The presence of all components that are included in the HVAC design for the Dwelling Unit[27] and integrated with the duct system shall be verified. The leakage from these components must be captured when the test is conducted. If these components have not yet been installed[28], then the test shall not be conducted.

Exception: Complete installation of all components is not required if the authority having jurisdiction allows testing with missing components. Any missing components shall be documented in the final test report.

[26] (Informative Note) Such as windows and doors opening to decks or patios.
[27] (Informative Note) For example, heating, cooling, ventilation, dehumidification, humidification, and filtration components.
[28] (Informative Note) For example, an air handler has not yet been installed in new construction.

5.2.2. The HVAC system controls shall be adjusted so that the air handler fan does not turn on during the test.

5.2.3. Any fans that could change the pressure in either the Conditioned Space Volume or any spaces containing ducts or air handlers[29] shall be turned off.

5.2.4. All vented combustion appliances shall be turned off if there is a possibility that the space containing the appliance will be depressurized during the test procedure.

5.2.5. All filters in the duct system and air handler cabinet shall be removed. If the Duct Leakage Tester is installed at a return grille, any filters present at that grille shall also be removed. If present, filter slot cover(s) shall be replaced after removing filters.

5.2.6. Dampers within the duct system shall be treated as follows:

5.2.6.1. Non-motorized dampers[30] in ducts that connect the Conditioned Space Volume or any space-conditioning duct systems to the exterior or to Unconditioned Space Volume shall be left in their as-found positions.[31]

5.2.6.2. Motorized dampers in ducts that connect the Conditioned Space Volume or any space-conditioning duct systems to the exterior or to Unconditioned Space Volume shall be placed in their closed positions and shall not be further sealed.

5.2.6.3. All zone and bypass dampers shall be set to their open position to allow uniform pressures throughout the duct system.

5.2.6.4. All balancing dampers shall be left in their as-found position.

5.2.7. Non-dampered ventilation openings within the duct system shall be treated as follows:

5.2.7.1. Non-dampered ventilation openings or ducts that serve intermittently operating Dwelling Unit ventilation systems, including HVAC fan-integrated outdoor air inlets, that connect the Conditioned Space Volume or any space-conditioning duct systems to the exterior or to Unconditioned Space Volume shall not be sealed.

5.2.7.2. Non-dampered ventilation openings or ducts that serve continuously operating Dwelling Unit ventilation systems that connect the Conditioned Space Volume or any space-conditioning duct systems to the exterior or to Unconditioned Space Volume shall be sealed at the exterior of the enclosure where conditions allow.

5.2.8. Supply registers and return grilles shall be temporarily sealed at both the face and the perimeter. Registers atop carpets are permitted to be removed and the

[29] (Informative Note) For example, bathroom fans, clothes dryers, kitchen vent hood, attic fan.
[30] (Informative Note) For example, pressure-activated operable dampers, fixed dampers.
[31] (Informative Note) For example, a fixed damper in a duct supplying outdoor air for an intermittent ventilation system that utilizes the HVAC fan shall be left in its as-found position.

face of the duct boot temporarily sealed during testing. For Dwelling Units without registers and grilles present[32], the face of the duct boots shall be sealed instead.

5.3. Procedure to Install the Test Apparatus and Prepare for Airtightness Test

There are two acceptable methods for attaching the Duct Leakage Tester to the duct system. Method 1 is permitted to be used for all duct systems. Method 2 is permitted only if:

i) the duct system has three or fewer return grilles, or

ii) the total duct leakage is less than 50 cfm (25 L/s) at 25 Pa, or

iii) local codes require licensing, that parties conducting the test have not obtained, in order to remove the blower access panel or

iv) the air handler blower access is in an attic or crawlspace that has limited or restricted entry or exit[33]

- *Method 1 Installation*. The air handler blower access panel shall be removed and the Duct Leakage Tester attached to the blower compartment access.

- *Method 2 Installation*. The Duct Leakage Tester shall be attached to the largest return grille in the system. For systems with multiple returns of equal largest size, the return closest to the air handler shall be used. The remaining opening in the return grille and all other return grilles shall be temporarily sealed.

5.3.1. If the duct leakage to outside will be measured, then a Blower Door shall be installed in the enclosure per Sections 4.3.1.1 and 4.3.1.2 for a Detached Dwelling Unit or Section 4.3.2.2 for an attached Dwelling Unit.

5.3.2. The static pressure probe(s) for the Duct Leakage Tester shall be installed using one of the following options.

When using Method 2 for a duct system with more than three returns (based on the exception in Section 5.3 iv), then only Section 5.3.2.4 shall be used.

5.3.2.1. A single static pressure probe shall be located at the supply register closest to the air handler; or,

5.3.2.2. A single static pressure probe shall be located in the main supply trunk line, at least 5 feet from the air handler; or,

5.3.2.3. A single static pressure probe shall be located in the supply plenum; or,

5.3.2.4. A single static pressure probe shall be located according to Section 5.3.2.1, 5.3.2.2, or 5.3.2.3, and a second probe shall be located in the return plenum

[32] (Informative Note) For example, new construction.
[33] (Informative Note) For example, ladders, and temporary, movable, spiral, or articulated stairs will usually be considered a limited or restricted means of entry or exit.

or in the closest return grill to the air handler, unless this is where the Duct Leakage Tester is installed, in which case the second closest return grille to the air handler shall be used. The return duct system pressure probe shall not be located in the airstream of the duct tester.

5.3.3. The Manometer and tubing for the Duct Leakage Tester shall be connected to the pressure probe(s) installed in Section 5.3.2, in accordance with the manufacturer's instructions, so that the duct system pressure is capable of being measured with reference to the inside of the building or Dwelling Unit.

If Section 5.3.2.4 has been selected, then both the supply- and return-side duct system pressure probes shall be connected to a "tee" fitting, and the third leg of the "tee" shall then be connected to the Manometer in the position indicated by the manufacturer's instructions to measure the duct system pressure.

5.3.4. The locations where the Duct Leakage Tester and pressure probe(s) have been installed shall be recorded.

5.4. Procedure to Conduct Airtightness Test

The total leakage of the duct system shall be measured using the total duct leakage test in Section 5.4.1 or the leakage of the duct system to the outside shall be measured using the duct leakage to outside test in Section 5.4.2.

5.4.1. Total Duct Leakage Test

5.4.1.1. If ducts run through Unconditioned Space Volume including attics, garages or crawlspaces, then any vents, access panels, doors, or windows between those spaces and the outside shall be opened. At least one door, window or comparable opening between the building or Dwelling Unit and the outside shall be opened to prevent changes in building or Dwelling Unit pressure when the Duct Leakage Tester is running.

5.4.1.2. The Duct Leakage Tester shall be turned on and adjusted to create an induced duct system pressure difference of 25 ± 3 Pa (0.1± 0.012 in. H_2O) with reference to outside. Note that this value is permitted to be positive or negative, which will be dependent upon whether the duct system is pressurized or depressurized.

If a 25 Pa (0.1 in. H_2O) induced duct system pressure difference is achieved, then the average value of the duct system pressure difference and the airflow at 25 Pa (0.1 in. H_2O) (CFM25, CMS25), measured over at least a 10-second period, shall be recorded.

If a 25 Pa (0.1 in. H_2O) induced duct system pressure difference is not achieved, then the highest induced duct system pressure difference ($dP_{measured}$) and airflow ($CFM_{measured}$, $CMS_{measured}$) that was achieved with the equipment available, measured over at least a 10-second period, shall be recorded.

5.4.1.3. An indication of whether the Duct Leakage Tester is pressurizing or depressurizing the duct system shall be recorded.

5.4.1.4. The Duct Leakage Tester shall be turned off and the Dwelling Unit returned to its as-found condition.

5.4.1.5. If an induced duct system pressure difference of 25 Pa (0.1 in. H_2O) was not achieved in Section 5.4.1.2, then the recorded airflow ($CFM_{measured}$, $CMS_{measured}$) shall be converted to a nominal airflow at 25 Pa (0.1 in. H_2O) (CFM25, CMS25) using Equation 10. Alternately, a Manometer that is equipped to automatically make the conversion to CFM25 or CMS25 is permitted to be used.

$$CFM25 = CFM_{measured}\left(\frac{25}{dP}\right)^{0.6} \quad (10a)$$

$$CMS25 = CMS_{measured}\left(\frac{25}{dP}\right)^{0.6} \quad (10b)$$

5.4.2. Duct Leakage to Outside Test

5.4.2.1. If ducts run outside the Infiltration Volume including attics, garages or crawlspaces, then any vents, access panels, doors, or windows between those spaces and the outside shall be opened. All exterior doors and windows between the Infiltration Volume and outside shall be closed, and other openings to the outside with potential to hinder the ability of the Air-Moving Fan to achieve an induced enclosure pressure difference of 25 Pa (0.1 in. H_2O) with reference to outside shall be closed or covered in some manner. Interior doors shall be opened.

5.4.2.2. With the Air-Moving Fan for the enclosure and the Duct Leakage Tester sealed and turned off, one measurement of the pressure difference across the enclosure shall be recorded, with the outside as the reference. The measurement shall represent the average value over at least a 10-second period and shall be defined as the Pre-Test Baseline Dwelling Unit Pressure.

5.4.2.3. The Air-Moving Fan for the enclosure shall be unsealed, turned on, and adjusted to create an induced enclosure pressure difference of 25 ± 3 Pa (0.1 ±0.012 in. H_2O), defined as the induced enclosure pressure minus the Pre-Test Baseline Dwelling Unit Pressure. Note that this value is permitted to be positive or negative, which will be dependent upon whether the enclosure is pressurized or depressurized.

If a 25 Pa (0.10 in. H_2O) induced enclosure pressure difference is not achieved, then the highest possible value up to 25 (0.10 in. H_2O) Pa shall be achieved with the equipment available.

5.4.2.4. The Duct Leakage Tester shall be unsealed, turned on, and adjusted to create an induced duct system pressure difference of 0.0 ± 0.5 Pa (0.0±0.002 in. H_2O), relative to the Dwelling Unit. If an induced duct system pressure difference of 0.0 Pa (0.0 in. H_2O) is not achieved, then the airflow of the Air-Moving Fan for the enclosure shall be reduced until an induced duct system pressure difference of 0.0 Pa (0.0 in. H_2O) is achieved.

5.4.2.5. The induced enclosure pressure difference shall be re-checked and the Air-Moving Fan for the enclosure shall be adjusted to maintain 25 Pa (0.10 in. H_2O) or the highest achievable value up to 25 (0.10 in. H_2O) Pa, per Section 4.4.2.3, or the airflow required to maintain an induced duct system pressure difference of 0.0 Pa (0.0 in. H_2O), per Section 5.4.2.4.

5.4.2.6. The induced duct system pressure difference shall be re-checked and the Duct Leakage Tester shall be adjusted to maintain 0.0 ± 0.5 Pa (0.0±0.002 in. H_2O), per Section 5.4.2.4.

5.4.2.7. Repeat 5.4.2.5 and 5.4.2.6 until the induced enclosure pressure difference is 25 Pa (0.10 in. H_2O) or the highest achievable value up to 25 Pa (0.10 in. H_2O) and the induced duct system pressure difference is 0.0 Pa (0.0 in. H_2O).

- If a 25 Pa (0.10 in. H_2O) induced enclosure pressure difference is achieved, then the average value of the induced enclosure pressure difference, the induced duct system pressure difference, and the airflow at 25 Pa (0.10 in. H_2O) (CFM25, CMS25), measured over at least a 10-second period, shall be recorded.
- If a 25 Pa (0.10 in. H_2O) induced enclosure pressure difference is not achieved, then the average value of the highest induced enclosure pressure difference (dP_{high}), the induced duct system pressure difference, and the airflow (Q_{high}) that was achieved with the equipment available, measured over at least a 10-second period, shall be recorded.

5.4.2.8. An indication of whether the Air-Moving Fan for the enclosure is pressurizing or depressurizing the Dwelling Unit and whether the Duct Leakage Tester is pressurizing or depressurizing the duct system shall be recorded.

5.4.2.9. The Air-Moving Fan for the enclosure and the Duct Leakage Tester shall be turned off and the Dwelling Unit returned to its as-found condition.

5.4.2.10. If an induced enclosure pressure difference of 25 Pa (0.10 in. H_2O) was not achieved or a different value was used to achieve an induced duct system pressure difference of 0.0 Pa (0.0 in. H_2O), then the recorded airflow ($CFM_{measured}$, $CMS_{measured}$) shall be converted to a nominal airflow at 25 Pa (0.10 in. H_2O) (CFM25,CMS25) using Equation 10. Alternately, a Manometer that is equipped to automatically make the conversion to CFM25 or CMS25 is permitted to be used.

5.5. Procedure to Apply Results of Duct System Leakage Test

5.5.1. If the results of the duct system leakage test are to be used for assessing compliance with a limit on total duct system leakage[34], then the total duct leakage determined in Section 5.4.1.2 or 5.4.1.5 shall be used.

[34] (Informative Note) For example, defined by code or by an energy efficiency program.

5.5.2. If the results of the duct system leakage test are to be used for assessing compliance with a limit on duct system leakage to the outside[35], then the duct system leakage to outside determined in Section 5.4.2.7 or 5.4.2.10 shall be used. Alternatively, the total duct leakage determined in Section 5.4.1.2 or 5.4.1.5 is permitted to be used as if it were the leakage to outside[36].

5.5.3. If the results of the duct system leakage test are to be used for conducting an energy audit or predicting savings from retrofits, then the duct system leakage to outside determined in Section 5.4.2.7 or 5.4.2.10 shall be used.

[35] (Informative Note) For example, defined by code, by an energy efficiency program, or for a home energy rating.
[36] (Informative Note) For example, the total leakage value is permitted to be used in software as if it were leakage to the outside.

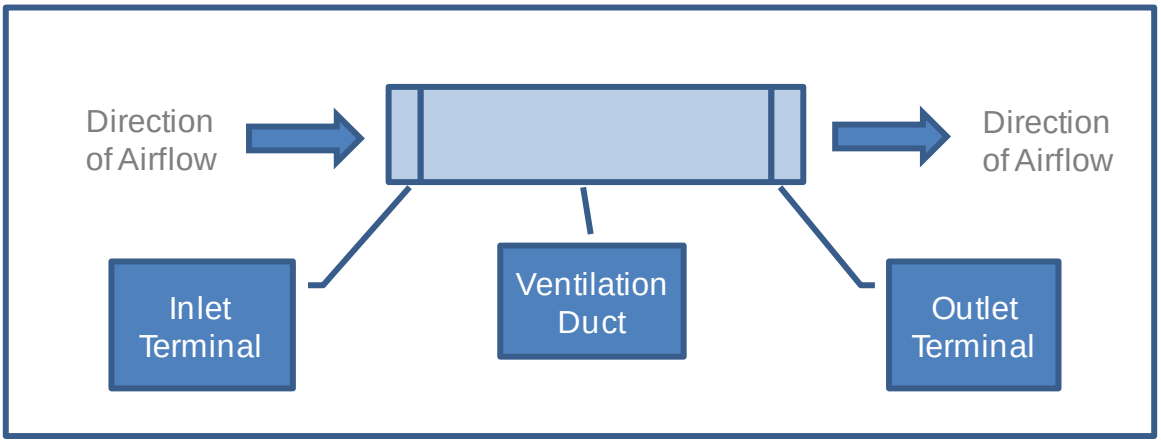
6. Procedure for Measuring Airflow of Mechanical Ventilation Systems

The purpose of this test procedure is to measure the volumetric airflow through a mechanical ventilation system including a Dwelling Unit Mechanical Ventilation system[37] or a local mechanical exhaust system[38, 39].

The airflow is permitted to be measured at the inlet terminal, per Section 6.2; or at the outlet terminal, per Section 6.3; or mid-stream in the ventilation duct, per Section 6.4.

The inlet terminal is defined as the location where the ventilation air enters the mechanical ventilation system and the outlet terminal is defined as the location where the ventilation air exits the mechanical ventilation system. A diagram of these locations for a generic mechanical ventilation system is shown in Figure 1.

Figure 1: Location of Terminals in Generic Mechanical Ventilation System



6.1. Procedure to Prepare the Building or Dwelling Unit and Mechanical Ventilation System for Testing

6.1.1. Interior Doors. All interior doors between rooms inside the Conditioned Space Volume shall be opened.

6.1.2. Ventilation openings. Operable window trickle-vents and through-the-wall vents shall be opened. Dampered and non-dampered ventilation openings shall not be sealed [40].

6.1.3. Supply registers and return grilles. Heating and cooling supply registers and return grilles shall be left in their as-found position and shall not be sealed.

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[37] (Informative Note) For example, an outdoor air duct connected to the return trunk of an HVAC system, an in-line supply fan, an HRV, or an ERV. The mechanical system ventilating the Dwelling Unit may be also ventilating other units.
[38] (Informative Note) For example, bathroom exhaust fan, kitchen exhaust fan.
[39] (Informative Note) Measuring the ventilation air supplied to corridors of buildings with multiple Dwelling Units is beyond the scope of this Standard. However, measuring the flow rate of exhaust or supply systems used for mechanical ventilation in individual Dwelling Units is within the scope of this Standard.
[40] (Informative Note) For example, a fixed damper in a duct supplying outdoor air for an intermittent ventilation system that utilizes the Blower Fan shall be left in its as-found position.

6.1.4. Balancing dampers. All balancing dampers shall be left in their as-found position.

6.1.5. Zone dampers. If a Dwelling Unit Mechanical Ventilation system is to be tested and is interconnected with a Forced-Air System, then all zone and bypass dampers shall be set to their open position. Otherwise, zone and bypass dampers shall be left in their as-found position.

6.1.6. Vented combustion appliances. Vented combustion appliances shall remain off or in "pilot only" mode for the duration of the test.

6.1.7. Forced-Air System Components. If a Dwelling Unit Mechanical Ventilation system is to be tested and uses the Blower Fan of a Forced-Air System as its primary fan, then the presence of all components included in the Forced-Air System design for the Dwelling Unit and integrated with the duct system [41] shall be verified. If these components have not yet been installed [42], then the test shall not be conducted.

6.1.8. Forced-Air System Blower Fan. The system controls shall be adjusted as follows:

6.1.8.1. If a Dwelling Unit Mechanical Ventilation system is to be tested and uses the Blower Fan of a Forced-Air System as its primary fan, then the Forced-Air System controls shall be adjusted to "Fan" mode so that the Blower Fan operates during the test.

6.1.8.2. Otherwise, the Forced-Air System controls shall be adjusted so that the Blower Fan does not operate during the test.

6.1.9. Local Mechanical Exhaust or Dwelling Unit Mechanical Ventilation System Fan. The fan of the Local Mechanical Exhaust system or Dwelling Unit Mechanical Ventilation system under test shall be turned on. For Dwelling Unit Mechanical Ventilation systems that use the Blower Fan of a Forced-Air System as its primary fan, then this shall be accomplished according to Section 6.1.8.

6.1.10. Other Fans. Any other fans that could change the pressure in either the Conditioned Space Volume or any spaces containing the ducts of the Dwelling Unit Mechanical Ventilation system or Local Mechanical Exhaust system [43] under test shall be turned off.

6.2. Procedure to Measure Airflow at Inlet Terminal

This Section defines procedures to measure the airflow of a mechanical ventilation system at an inlet terminal. The airflow is permitted to be measured using a Powered Flow Hood (Section 6.2.1); using an Airflow Resistance Device (Section 6.2.2); or using a Passive Flow Hood (Section 6.2.3).

6.2.1. Powered Flow Hood

6.2.1.1. Equipment Needed

[41] (Informative Note) For example, heating, cooling, ventilation, dehumidification, humidification, and filtration components.
[42] (Informative Note) For example, an air handler has not yet been installed in new construction.
[43] (Informative Note) For example, clothes dryers, attic fan.

The Equipment listed in this section shall have their calibrations checked at the manufacturer's recommended interval, and at least annually if no time is specified.

6.2.1.1.1. Powered Flow Hood. A device consisting of a flow capture element capable of creating an airtight perimeter seal around the inlet terminal; an Airflow Meter capable of measuring the volumetric airflow through the flow capture element with an a maximum error of 5 % or 5 cfm (2.5 L/s or 0.0025 m^3/s), whichever is greater; and a variable-speed Air-Moving Fan that is capable of moving air through the flow capture element and Airflow Meter.

6.2.1.1.2. Manometer. A device that is capable of measuring the static pressure inside the flow capture element relative to the room with a maximum error of 1% of reading or 0.25 Pa (0.0010 in. H2O), whichever is greater.

6.2.1.2. Procedure to Conduct Airflow Test

6.2.1.2.1. The flow capture element of the Powered Flow Hood shall be placed over the inlet terminal, ensuring that an airtight perimeter seal has been created.

6.2.1.2.2. The variable-speed Air-Moving Fan shall be turned on and the airflow adjusted until, using the Manometer, zero pressure difference (+/- 0.1 Pa (0.0004 in H_2O)) is measured between the flow capture element and the room.

6.2.1.2.3. The average volumetric airflow through the Airflow Meter, measured over at least a 10-second period, shall be recorded, and the variable-speed Air-Moving Fan shall be turned off.

6.2.2. Airflow Resistance Device

6.2.2.1. Equipment Needed

The Equipment listed in this section shall have their calibrations checked at the manufacturer's recommended interval, and at least annually if no time is specified.

6.2.2.1.1. Airflow Resistance Device. A device consisting of a flow capture element that has a known opening area and is capable of creating an airtight perimeter seal around the inlet terminal.

6.2.2.1.2. Manometer. A device that can measure pressure difference with a maximum error of 1% of reading or 0.25 Pa (0.0010 in. H2O), whichever is greater.

6.2.2.2. Procedure to Conduct Airflow Test

6.2.2.2.1. The flow capture element of the Airflow Resistance Device shall be placed over the inlet terminal, ensuring that an airtight perimeter seal has been created.

6.2.2.2.2. The opening area of the Airflow Resistance Device shall be adjusted until, using the Manometer, the pressure difference between the flow capture element and the room meets the manufacturer's requirements. If no manufacturer's requirement exists then the pressure shall be between 1 and 8 Pa (0.004 and 0.032 in. water).

6.2.2.2.3. The average pressure difference (dP) between the flow capture element and the room, measured over at least a 10-second period, shall be recorded.

6.2.2.2.4. Using the average pressure difference, the airflow shall be calculated using the manufacturer's flow conversion table or, for devices without a flow conversion table, the following equations:

$$Airflow\ (CFM) = Opening\ Area\ x\ 1.07\ x\ (dP)^{0.5} \quad (11a)$$

$$Airflow\ (L/s) = Opening\ Area\ x\ 0.078\ x\ (dP)^{0.5} \quad (11b)$$

Where: For Eq. 11a, Opening Area is in in^2 and dP is in Pa
For Eq. 11b, Opening Area is in cm^2 and dP is in Pa

6.2.2.3. Limitations of Procedure. An Airflow Resistance Device is only permitted to be used on mechanical ventilation systems that do not have multiple duct branches.

6.2.3. Passive Flow Hood

6.2.3.1. Equipment Needed

The Equipment listed in this section shall have their calibrations checked at the manufacturer's recommended interval, and at least annually if no time is specified.

6.2.3.1.1. Passive Flow Hood. A device consisting of a flow capture element capable of creating an airtight perimeter seal around the inlet terminal; and an Airflow Meter capable of measuring the volumetric airflow through the flow capture element with a maximum error of 5 % or 5 cfm (2.5 L/s or 0.0025 m^3/s), whichever is greater.

6.2.3.1.2. Manometer. A device that is capable of measuring pressure difference with a maximum error of 1% of reading or 0.25 Pa (0.0010 in. H2O), whichever is greater.

6.2.3.2. Procedure to Conduct Airflow Test

6.2.3.2.1. The flow capture element of the Passive Flow Hood shall be placed over the inlet terminal, ensuring that an airtight perimeter seal has been created.

6.2.3.2.2. A tube shall be inserted inside the flow capture element between the Airflow Meter and inlet terminal to allow for measurement of the pressure difference between inside the Passive Flow Hood and the room. Devices that have a built-in pressure tube are acceptable.

6.2.3.2.3. The pressure difference between the flow capture element and the room shall be measured. The procedure shall be terminated and no results recorded if: (1) the pressure difference exceeds test equipment manufacturer's recommendations, or (2) there is no manufacturer recommendation, and the pressure difference is more than 8 Pa.

6.2.3.2.4. The airflow through the Airflow Meter shall be averaged over at least a 10-second period.

6.3. Procedure to Measure Airflow at Outlet Terminal

This Section defines procedures to measure the airflow of a mechanical ventilation system at an outlet terminal. The airflow is permitted to be measured using a Powered Flow Hood (Section 6.3.1) or using a Bag Inflation Device (Section 6.3.2).

6.3.1. Powered Flow Hood. To measure airflow at an outlet terminal using a Powered Flow Hood, Section 6.2.1 shall be followed except with all occurrences of the phrase "inlet terminal" replaced with "outlet terminal".

6.3.2. Bag Inflation Device

6.3.2.1. Equipment Needed

6.3.2.1.1. Bag Inflation Device. A flow capture element capable of creating an airtight perimeter seal around the outlet terminal that is connected to a plastic bag of known volume and holds the bag open[44], and a shutter that controls airflow into the bag.

The plastic bag shall be selected such that three or more measurements of a single outlet terminal produce results that are within 20% of each other.

The volume of the plastic bag shall be selected such that the bag will completely fill with air from the outlet terminal in the range of 3 to 20 seconds.

6.3.2.1.2. Stopwatch. A stopwatch capable of recording elapsed time +/- 0.1 seconds.

6.3.2.2. Procedure to Conduct Airflow Test

6.3.2.2.1. The bag shall be completely emptied of air and the shutter closed to prevent airflow into the bag.

6.3.2.2.2. The Bag Inflation Device shall be placed over the outlet terminal.

6.3.2.2.3. The shutter shall be removed rapidly and the Stopwatch started.

6.3.2.2.4. The Stopwatch shall be stopped when the bag is completely filled with air from the outlet terminal and the elapsed time recorded.

6.3.2.2.5. The airflow shall be calculated using the following equations:

[44] (Informative Note) For example, a lightweight frame made of wood, plastic or metal wire.

$$Airflow\ (CFM) = \frac{8 \times Volume}{Elapsed\ Time} \quad (12a)$$

$$Airflow\ (L/s) = \frac{4 \times Volume}{Elapsed\ Time} \quad (12b)$$

Where: Volume = The volume of the plastic bag, in gallons
Elapsed Time = The time that elapsed until the bag was filled, in seconds.

6.4. Procedure to Measure Airflow Mid-Stream in the Ventilation Duct

This Section defines a procedure to measure the airflow of a mechanical ventilation system mid-stream in the ventilation duct. The airflow is permitted to be measured using an Airflow Measurement Station (Section 6.4.1) or using an Integrated Diagnostic Tool (Section 6.4.3).

6.4.1. Equipment Needed

6.4.1.1. Airflow Measurement Station. An Airflow Measurement Instrument capable of simultaneously measuring and averaging velocity pressure across a duct diameter with a maximum error of 10% or 5 CFM (2.5 L/s), whichever is greater, coupled with a section of permanently installed smooth-walled ductwork designed to facilitate accurate readings. The Airflow Measurement Instrument shall either be temporarily inserted into the Station for the duration of the procedure or be permanently installed as part of the Station.[45] The Airflow Measurement Instrument shall contain a port that allows it to be connected to a Manometer. Any temporary air flow station shall have its calibration checked at the manufacturer's recommended interval, and at least annually if no time is specified.

6.4.1.2. Manometer. A device that is capable of measuring pressure difference with a maximum error of 1% of reading or 0.25 Pa (0.0010 in. H2O), whichever is greater.

6.4.2. Procedure to Conduct Airflow Test

6.4.2.1. The Air Flow Measurement Station shall be installed in an accessible location, per manufacturer's instructions, or it shall be verified that such a device has been installed and is accessible. If the Airflow Measurement Instrument is not permanently installed, it shall be inserted into the measurement port of the Station.

6.4.2.2. The installation shall be visually verified to comply with the Airflow Measurement Instrument's specifications for minimum distance to both upstream and downstream duct fittings and fan outlets.[46]

6.4.2.3. The cross-sectional area of the duct at the Station shall be recorded in ft^2 or m^2.

[45] (Informative Note) For example, as part of a manufacturer-assembled device consisting of the instrument factory-mounted in a housing.
[46] (Informative Note) To minimize turbulence and ensure an accurate reading.

6.4.2.4. The Manometer shall be connected to the Airflow Measurement Instrument, and the average velocity pressure, measured over at least a 10-second period, shall be recorded.

6.4.2.5. If the Airflow Measurement Instrument is not permanently installed, then it shall be removed and the port sealed with a sheet metal plug or metallic tape.

6.4.2.6. Using the average velocity pressure, the average velocity in feet per minute (FPM) or meter per second (m/s) shall be calculated using the Airflow Measurement Instrument manufacturer's velocity conversion table or equation.

6.4.2.7. Equation 13 shall be used to convert the average velocity to airflow.

$$Airflow\ (CFM) = V\ x\ A \quad (13a)$$

$$Airflow\ (L/s) = 1000\ x\ V\ x\ A \quad (13b)$$

Where:

For Equation 13a, V = Velocity, in fpm, and A = Cross-Sectional Duct Area, in ft^2.

For Equation 13b, V = Velocity, in m/s, and A = Cross-Sectional Duct Area, in m^2.

6.4.3. Integrated Diagnostic Tool

6.4.3.1. Equipment

6.4.3.1.1. Integrated Diagnostic Tool. A tool that is integrated into the ventilation equipment[47] that permits assessment of airflow. The maximum error of the integrated diagnostic tool shall be 15% of the highest flow setting of the ventilation equipment.

6.4.3.2. Procedure to Conduct Airflow Test. Follow the manufacturer-provided instructions for the Integrated Diagnostic Tool to determine the airflow.

7. Air Handler Flow

7.1. The air handler flow shall be measured in accordance with ASHRAE 152 or ASTM E1554M.

8. Hazards

8.1. Equipment Guards - The air-moving equipment shall be listed by an accredited certification body[48] and include all proper guards or cages to house the fan or blower and to prevent accidental access to any moving parts of the equipment.

[47] (Informative Note) For example, pressure taps, a device that measures a parameter such as watt draw that can be translated to airflow.

[48] (Informative Note) Listing is indicated by the certification body's certification mark on the equipment such as "UL", "CSA", "CE" or equivalent.

8.2. Personal Protective Equipment - Use of safety equipment appropriate for general fieldwork is required; all local or federal OSHA requirements shall be followed.

8.3. Debris and Fumes - The blower or fan forces a large volume of air into or out of a building or Dwelling Unit while in operation. Caution shall be exercised against sucking debris or exhaust gases from fireplaces and flues into the interior of the building or Dwelling Unit. Care shall be exercised to prevent damage to internal furnishings, plants or pets due to influx of cold, warm or humid air. If the building or Dwelling Unit will not remain unoccupied, except for testing personnel during the test, care shall be exercised regarding the potential for the fans to introduce respiratory hazards to the breathing zone of the occupied space.

8.4. Access and Working Space - The testing procedures for ventilation flow measurements sometimes require the use of ladders and/or access to equipment rooms, unfinished attics, and other volumes containing air distribution ducting in the building or Dwelling Unit that are not intended for occupancy. Caution must be exercised in these spaces to avoid injury and damage to the building or Dwelling Unit.

9. Normative References

ACCA, “Manual B Balancing and Testing Air and Hydronic Systems”, Air Conditioning Contractors of America, Arlington, VA.

ACCA, “Manual D Residential Duct Systems”, [ANSI/ACCA 1 Manual D-2016], Air Conditioning Contractors of America, Arlington, VA.

ACCA, “Manual J Residential Load Calculation,” 8th Edition, [ANSI/ACCA 2 Manual J-2016]. Air Conditioning Contractors of America, Arlington, VA.

ACCA, “Manual S Residential Heating and Cooling Equipment Selection”, 2nd Edition, [ANSI/ACCA 3 Manual S-2014]. Air Conditioning Contractors of America, Arlington, VA.

ANSI/RESNET/ICC 301-2019 “Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index” and ANSI approved Addenda. Residential Energy Services Network, Oceanside, CA.

ASHRAE Standard 62.2-2016 "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings", ASHRAE, Atlanta, GA.

ASHRAE 152-2014 “Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems”, ASHRAE, Atlanta, GA.

ASTM E1554-13 “Standard Test Methods for Determining Air Leakage of Air Distribution Systems by Fan Pressurization”, published by ASTM International, www.astm.org

ASTM E779-10 “Standard Test Method for Determining Air Leakage Rate by Fan Pressurization”, published by ASTM International, www.astm.org

International Building Code 2018, International Code Council, Washington, D.C.

10. Informative References

American National Standards Institute, ANSI, (http://www.ansi.com)

International Code Council, ICC, (http://www.iccsafe.org)

Occupational Safety and Health Administration, OSHA, (https://www.osha.gov)

Residential Energy Services Network, Inc., RESNET, (http://www.resnet.us)

Informative Annex A

Space Type	Included In the Following Categories?			
	Conditioned Space Volume	Unconditioned Space Volume	Conditioned Floor Area	Infiltration Volume
Space conditioned to 68/78F (excluding attics, basements, crawlspaces, garages, and sunrooms, which are addressed below)	Yes		Yes	Yes
Attic				
Attic air sealed & insulated at roof deck, and conditioned [1]	Yes			Sometimes
Attic air sealed & insulated at roof deck, but not conditioned		Yes		Sometimes
Attic not air sealed & insulated at roof deck		Yes		
Walls				
Wall assembly, where at least one horizontally-adjacent space is conditioned, and where it is part of the subject Dwelling Unit (it is not adjacent to another Dwelling Unit)	Yes		Yes	Yes
Wall assembly, where both horizontally-adjacent spaces are conditioned, and where one of the spaces is *not* part of the subject Dwelling Unit (it is a wall that separates the subject Dwelling Unit from an adjacent Dwelling Unit)	Yes, but only ½ of the wall is included		Yes, but only ½ of the wall area	Yes, but only ½ of the volume
Wall assembly, with both horizontally-adjacent spaces unconditioned		Yes		
Floors				
Floor assembly, where volume above & below is conditioned, and where it is part of the subject Dwelling Unit (floor cavity above the subject Dwelling Unit's ceiling), or bottom-floor floor cavity below the subject Dwelling Unit). All floor cavities are part of the subject Dwelling Unit when there are no other Dwelling Units above or below the subject Dwelling Unit.	Yes			Yes
Floor assembly, with either volume above or below unconditioned		Yes		Yes
Floor assembly, with both volume above and below unconditioned		Yes		
Crawlspaces				
Unvented crawlspace, conditioned [1]	Yes			Sometimes [3]
Unvented crawlspace, not conditioned		Yes		Sometimes [3]
Vented crawlspace		Yes		

Other				
Basement, conditioned [2]	Yes		Yes	Sometimes [3]
All other basements		Yes		Sometimes [3]
Garage, even if conditioned		Yes		
Thermally isolated sunroom		Yes		
Mechanical closet in Conditioned Space Volume[4]	Yes		Yes	Yes
Mechanical closet not in Conditioned Space Volume[4]		Yes		

1) *To be considered conditioned, the party conducting evaluations must obtain an ACCA Manual J, S, and either B or D report and verify that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume.*
2) *To be considered conditioned, the party conducting evaluations must: obtain an ACCA Manual J, S, and either B or D report and verify that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume; or verify through visual inspection that both the heating and cooling equipment and distribution system serve the volume and, in the judgement of the party conducting evaluations, are capable of maintaining the heating and cooling temperatures specified by the Thermostat section in Table 4.2.2(1) of ANSI/RESNET/ICC 301.*
3) *Include attic, basement or crawl space in Infiltration Volume if the door(s) or hatch(es) between that space and Conditioned Space Volume are open during enclosure air leakage testing (Section 4.2.3, 4.2.4, and 4.2.5).*
4) *Refer to definition of Conditioned Space Volume*