ANSI/RESNET/ICC 380-2022

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 a legal jurisdiction makes compliance mandatory.

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

This is the third edition of this Standard that updates the second edition that was designated and titled ANSI/RESNET/ICC 380-2019 *Standard for Testing Airtightness of Building Enclosures, Airtightness of Heating and Cooling Air Distribution Systems, and Airflow of Mechanical Ventilation Systems*. This third edition incorporates a number of substantive changes, the more significant of which are: the addition and refinement of several test methods for measuring ventilation air; revision of the setup of Attics, crawlspaces, basements and adjacent mechanical closets for the building and dwelling unit envelope airtightness test; revision of the setup of dampers and openings for the building and dwelling unit envelope airtightness test, duct airtightness test, and ventilation airflow test; added a section to address pet door configuration during building and dwelling unit envelope airtightness test; added new definitions and aligned existing definitions to correlate with Standards ANSI/RESNET/ICC 301 and ANSI/RESNET/ACCA/ICC 310.

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/ on the page titled ”RESNET-ANSI AMERICAN NATIONAL 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

Foreword (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 https://www.resnet.us/about/standards/submit-proposed-amendments/ 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 foreword, 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.

Attached Dwelling Unit – A Dwelling Unit sharing demising walls, floors, ceilings, or common corridors with another Dwelling Unit or Occupiable Space.

Attic – A space volume directly below the roof assembly that is not included in the Conditioned Floor Area. Attics may be either vented or air sealed[1].

Blower Fan – The fan inside the equipment of a Forced-Air HVAC System that forces the heated and/or cooled air to be distributed within a Dwelling.

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.

[1] (Normative Note) Conditioned Space Volume that is intended for human activities, including but not limited to those for living, sleeping, dining, or cooking as well as toilets, closets, halls, utility areas and above the main Dwelling Unit, (for example a 'Cape Cod' home), is not considered Attic space and shall be included in the Conditioned Floor Area.

Conditioned Floor Area (CFA)[2] **–** The floor area of the Conditioned Space Volume within a building or Dwelling Unit, not including the floor area of Attics or crawlspaces, and basements below air sealed and insulated floors. The following specific spaces are addressed to ensure consistent application of this definition:

- The CFA shall include the floor area of the full width of a wall assembly that is within the Conditioned Space Volume.

  Exception: If the subject Dwelling Unit shares a wall assembly[3] with another Dwelling Unit, then the CFA of the subject Dwelling Unit shall extend to the midpoint of that shared wall assembly.

- The CFA shall include the floor area of a basement only-if it is contiguous with and dedicated[4] to 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 judgment of the party conducting evaluations, are capable of maintaining space conditions at 78°F (26°C) for cooling and 68°F (20°C) for heating.
- The CFA shall exclude the floor area of a garage even when it is conditioned.
- The CFA shall exclude the floor area of a thermally isolated sunroom.
- The CFA shall exclude the floor area of an Attic even when it is Conditioned Space Volume[5].
- The CFA shall exclude the floor area of a crawlspace even when it is Conditioned Space Volume.

Conditioned Space Volume (CSV)[6] **–** 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 CSV shall include the volume of the full depth of the floor assembly. Otherwise, the volume of the full depth of the floor assembly shall be excluded.

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[2] (Informative Note) Informative Annex A contains a table that summarizes parts of a Dwelling Unit that are included in CFA.
[3] (Informative Note) For example, a common or demising wall.
[4] (Informative Note) That is, it does not span multiple Dwelling Units undivided.
[5] (Informative Note) Conditioned Space Volume that is intended for human activities (e.g., for living, sleeping, dining, or cooking; as well as toilets, closets, halls, utility areas, and laundry areas) and above the main Dwelling Unit, such as in a 'Cape Cod' home, is not considered Attic space and can be included in the Conditioned Floor Area.
[6] (Informative Note) Informative Annex A has a table that summarizes parts of a Dwelling Unit that are included in Conditioned Space Volume.

Exception: The wall height used to determine the volume shall extend from the finished floor to the bottom surface of the floor decking above the subject Dwelling Unit for all floors other than the top floor level. For Dwelling Units on the top floor, this dimension shall extend from the top surface of the finished floor to the interior surface of the enclosure air barrier.

- 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, CSV shall include the volume of the full width of the wall assembly. Otherwise, the volume of the full width of the wall assembly shall be excluded.

  Exception: If the subject Dwelling Unit shares a wall assembly[7] with another Dwelling Unit, then the CSV of the subject Dwelling Unit shall include half the volume of the full width of that shared wall assembly.

- The CSV shall exclude the volume of a garage even when it is conditioned.
- The CSV shall exclude the volume of a thermally isolated sunroom.
- The CSV shall include the volume of an Attic, crawlspace, or a basement only if it is contiguous with and dedicated[8] to 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 judgment of the party conducting evaluations, are capable of maintaining space conditions at 78°F (26°C) for cooling and 68°F (20°C) for heating.
- The CSV shall include the volume of an adjacent mechanical closet, regardless of access location, only if it is contiguous with and dedicated[8] to the subject Dwelling Unit, only includes equipment serving 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 judgment of the party conducting evaluations, are capable of maintaining space conditions at 78°F (26°C) for cooling and 68°F (20°C) for heating.

Detached Dwelling Unit – A Dwelling Unit that does not meet the definition of Attached Dwelling Unit.

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[7] (Informative Note) For example, a common or demising wall.
[8] (Informative Note) That is, it does not span multiple Dwelling Units undivided.

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 System – A Ventilation system, operating continuously or through a programmed intermittent schedule, consisting of powered Ventilation equipment,[9] related mechanical components,[10] and automated control devices that provides Dwelling Unit Ventilation at a known or measured airflow rate.

Exhaust Ventilation System (Exhaust System) – One or more fans that remove air from the Dwelling Unit, causing outdoor air to enter by Ventilation inlets or normal leakage paths through the Dwelling Unit envelope.

Forced-Air HVAC System – A type of HVAC System that incorporates a Blower Fan to move conditioned air.

HVAC System – Cooling-only, heating-only, or combined cooling-heating equipment, including any supply and/or return distribution systems.

Infiltration Volume[11] – The sum of the following spaces of the subject Dwelling Unit:

- The Conditioned Space Volume, excluding any Attics, basements, crawlspaces, and adjacent mechanical closets.
- The Conditioned Space Volume and Unconditioned Space Volume of the following adjacent spaces if included[12] during the airtightness measurement of the enclosure: Attics, crawlspaces and the full depth of their floor assemblies above, basements and the full depth of their floor assemblies above, and adjacent mechanical closets and the full width of their wall assemblies between them and the subject Dwelling Unit.

Occupiable Space – A room or enclosed space designed for human occupancy in which individuals congregate for amusement, educational or similar purposes or in which occupants are engaged at labor, and which is equipped with means of egress and light and Ventilation facilities meeting the requirements of this standard.

Residential Building – Includes detached one-family Dwellings and two-family Dwellings and multiple single-family Dwellings (Townhouses) and Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane.[13]

Shall – As used in this Standard, the word "shall" means that the action specified is mandatory and shall be accomplished by the responsible party.

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[9] (Informative Note) Such as motor-driven fans and blowers.
[10] (Informative Note) Such as ducts, inlets, dampers, or filters.
[11] (Informative Note) Informative Annex A has a table that summarizes parts of a Dwelling Unit that are included in Infiltration Volume.
[12] (Informative Note) Sections 4.2.4, 4.2.5, 4.2.6, and 4.2.7 define whether these adjacent spaces are to be included in Infiltration Volume.
[13] (Normative Note) The definition of Residential Building corresponds to the IECC definition of Residential Building. The Occupancy Groups R-2, R-3 and R-4 are as established by the International Building Code.

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 the foundation to roof and with open space on at least two sides.

Unconditioned Space Volume[14] **–** 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 full depth 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 full width of the wall assembly shall be included.

  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 the full width of that wall assembly shall be evenly divided between both adjacent Dwelling Units.
- 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 a crawlspace, or a basement shall be included unless it meets the definition of Conditioned Space Volume.

Ventilation – The process of supplying outdoor air to or removing indoor air from a Dwelling Unit by natural or mechanical means. Such air may or may not have been conditioned.

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, thereby drawing outdoor air into a home through open windows and doors for the purpose of cooling the home.

[14] (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 percent of reading or 0.25 Pa (0.001 in. H_2O), whichever is greater.

4.1.3. Airflow meter. A device to measure volumetric airflow with a maximum error of 5 percent 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.[15]

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

4.2.2. Pet doors. Exterior pet doors shall be closed and latched to the extent that a specific closing and/or latching mechanism exists. No additional sealing shall be performed.

~~4.2.~~24.2.3. 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 an unrestricted air pathway larger than 20 square feet shall be opened between the attached garage and outside[16].

4.2.4. Attics. An Attic shall be configured as follows, and excluded from the Infiltration Volume, unless it meets the conditions in Section 4.2.4.1: any doors and hatches between the subject Dwelling Unit and the Attic shall be closed; and any exterior Attic access doors, hatches, and vents shall be left in their as-found position.

4.2.4.1. If an Attic is contiguous with and dedicated[17] to the subject Dwelling Unit and is either: a) Conditioned Space Volume or b) Unconditioned Space Volume that is, unvented with roof deck and all exterior walls both insulated and air-sealed; then any exterior Attic access doors, hatches, and vents shall be closed to the extent possible. The pressure difference between the Attic and subject Dwelling Unit shall be evaluated during the airtightness test, per Section 4.4.1.3 (one-point airtightness test) or 4.4.2.3 (multi-point airtightness test), to determine whether to include the Attic in the Infiltration Volume.

[15] (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.
[16] (Informative Note) For example, by opening a window or door between the attached garage and outside.
[17] (Informative Note) That is, it does not span multiple Dwelling Units undivided.

4.2.5. Crawlspaces. A crawlspace shall be configured as follows, and the crawlspace and full depth of its floor assembly above excluded from the Infiltration Volume, unless it meets the conditions in Section 4.2.5.1: any doors and hatches between the subject Dwelling Unit and the crawlspace shall be closed; and any exterior crawlspace access doors, hatches, and vents shall be left in their as-found position.

4.2.5.1. If a crawlspace is contiguous with and dedicated[Error! Bookmark not defined.] to the subject Dwelling Unit and is either: a) Conditioned Space Volume or b) Unconditioned Space Volume that is unvented with all exterior walls both insulated and air-sealed; then any exterior crawlspace access doors, hatches, and vents shall be closed to the extent possible. The pressure difference between the crawlspace and subject Dwelling Unit shall be evaluated during the airtightness test, per Section 4.4.1.3 (one-point airtightness test) or 4.4.2.3 (multi-point airtightness test), to determine whether to include the crawlspace and full depth of its floor assembly above in the Infiltration Volume.

4.2.6. Basements. A basement shall be configured as follows, and the basement and full depth of its floor assembly above excluded from the Infiltration Volume, unless it meets the conditions in Section 4.2.6.1 or 4.2.6.2: any doors and hatches between the subject Dwelling Unit and the basement shall be closed; and any exterior basement access doors, hatches, and vents shall be left in their as-found position.

4.2.6.1. If a basement is contiguous with and dedicated[Error! Bookmark not defined.] to the subject Dwelling Unit and is either: a) Conditioned Space Volume or b) Unconditioned Space Volume that is unvented with all exterior walls both insulated and air-sealed; then any exterior basement access doors, hatches, and vents shall be closed to the extent possible. The pressure difference between the basement and subject Dwelling Unit shall be evaluated during the airtightness test, per Section 4.4.1.3 (one-point airtightness test) or 4.4.2.3 (multi-point airtightness test), to determine whether to include the basement and full depth of its floor assembly above in the Infiltration Volume.

4.2.6.2. If a basement is contiguous with and dedicated[Error! Bookmark not defined.] to the subject Dwelling Unit and is Unconditioned Space Volume that is unvented with no insulation present in either its exterior walls or floor assembly above; then the basement and full depth of its floor assembly above are permitted to be either included or excluded from the Infiltration Volume, dependent on its configuration during the airtightness test. If it is to be excluded, then it shall be configured according to Section 4.2.6. If it is to be included, then any exterior basement access doors, hatches, and vents shall be closed to the extent possible, and the pressure difference between the basement and subject Dwelling Unit shall be evaluated during the airtightness test, per Section 4.4.1.3 (one-point airtightness test) or 4.4.2.3 (multi-point airtightness test), to determine whether to include the basement and full depth of its floor assembly above in the Infiltration Volume.

4.2.7. Adjacent mechanical closets. An adjacent mechanical closet shall be configured as follows, and the mechanical closet and full width of the wall assembly between it and the subject Dwelling Unit excluded from the Infiltration Volume, unless it meets the conditions in Section 4.2.7.1: any doors and hatches between the subject Dwelling

Unit and the mechanical closet shall be closed; and any exterior mechanical closet access doors, hatches, and vents shall be left in their as-found position.

4.2.7.1. If an adjacent mechanical closet is contiguous with and dedicated[Error! Bookmark not defined.] to the subject Dwelling Unit, only includes equipment serving the Dwelling Unit, and is either: a) Conditioned Space Volume or b) Unconditioned Space Volume that is unvented with the wall assembly between it and the subject Dwelling Unit not air-sealed; then any exterior mechanical closet access doors, hatches, and vents shall be closed to the extent possible. The pressure difference between the mechanical closet and subject Dwelling Unit shall be evaluated during the airtightness test, per Section 4.4.1.3 (one-point airtightness test) or 4.4.2.3 (multi-point airtightness test), to determine whether to include the mechanical closet and full width of the wall assembly between it and the subject Dwelling Unit in the Infiltration Volume.

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

4.2.9. 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.

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

4.2.11. 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.[18] 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 that sealing select registers will not compromise the system and the sealed registers remain sealed during the test.

4.2.12. Dampers.

4.2.12.1. Non-motorized dampers[19] shall be left in their as-found positions.[20]

4.2.12.2. Motorized dampers shall be placed in their closed positions.

4.2.13. Openings for Ventilation air.

[18] (Informative Note) For example, a system intended to meet ASHRAE Standard 62.2.
[19] (Informative Note) For example, pressure-activated (i.e., barometric) dampers, fixed dampers, balancing dampers.
[20] (Informative Note) For example, a fixed damper in a duct supplying outdoor air for an intermittent Dwelling Unit Mechanical Ventilation System that utilizes the HVAC fan shall be left in its as-found position.

4.2.13.1. Each continuously-operating local mechanical exhaust system[21] and continuously-operating Dwelling Unit Mechanical Ventilation System shall be sealed[22] for the duration of the test at the inlet terminal for that fan, at a location within the Ventilation or exhaust duct, at the Ventilation or exhaust equipment itself, or at the outlet terminal for that fan[23], whichever is accessible. The sealing location selected shall be documented.

4.2.13.2. All intermittently-operating local mechanical exhaust systems and intermittently-operating Dwelling Unit Mechanical Ventilation Systems shall not be sealed, including such systems that control the HVAC fan.

4.2.13.3. If a continuously-operating Exhaust Ventilation System is present in the Dwelling Unit, all operable window trickle vents, operable through-the-wall vents, outdoor air intakes with an operable shutoff damper[24], and other operable Ventilation air openings shall be placed in their closed position for the duration of the test, but shall not be sealed.

4.2.13.4. Ventilation air openings besides those listed in Section 4.2.13.3 shall be left in their as-found position and shall not be sealed.

4.2.14. Openings for combustion air and make-up air. Combustion air openings and make-up air openings shall be left in their as-found position and shall not be sealed.

4.2.15 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.

4.2.16. 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.

4.2.17. 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.

4.2.18. Plumbing drains with P traps. Plumbing drains with empty P traps shall be sealed or filled with water.

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

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[21] (Informative Note) Examples of local exhaust ventilation systems are bath and kitchen fans.

[22] (Normative Note) A motorized damper placed in its closed position or a non-motorized damper pushed into its closed position during the test shall satisfy the intent of this section to seal the opening if it is located at one of the listed sealing locations. In such cases, additional sealing is permitted, but not required.

[23] (Informative Note) See Figure 1 in Section 6 for an illustration of the inlet terminal, ventilation duct, and outlet terminal. To provide an example of potential sealing locations, for an inline fan connected to the return-side of the HVAC System, it may be sealed at the exterior of the Dwelling Unit, at the filter slot of the inline fan, or where the ventilation duct terminates in the return duct of the HVAC System, whichever is accessible.

[24] (Informative Note) For example, a manual shut-off damper in a duct supplying outdoor air to the return-side of the HVAC System shall be closed if a continuously-operating local mechanical exhaust system or continuously-operating Exhaust Ventilation System is present.

4.2.20. Required air bypass. Where building code or manufacturer specifications require air bypass around a component, the leakage point shall not be sealed.[25]

4.3 Procedures to install the test apparatus and prepare for the airtightness test.

4.3.1. Procedure 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 larger than 20 square feet between the Unconditioned Space Volume and outside[26].

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.

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.

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

4.3.2. Procedure for an Attached Dwelling Unit.[27]

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 when one exists.[28] 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

[25] (Informative Note) For example, fire and smoke suppression systems.
[26] (Informative Note) For example, by opening a window or door between the Unconditioned Space Volume and outside.
[27] (Informative Note) This test is the same as a compartmentalization test.
[28] (Informative Note) For example, a corridor.

measure the difference in pressure between the subject Dwelling Unit and the enclosed space in accordance with manufacturer's instructions.

4.3.2.2.2. An unrestricted air pathway larger than 20 square feet shall be opened between the enclosed space and outside.[29]

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.[30]

4.3.2.3. If the blower door has been installed in a doorway leading to an enclosed space, then where access is permitted, doors shall be opened between the enclosed space and any Dwelling Units that are horizontally adjacent to the subject Dwelling Unit.[31]. If the blower door has been installed in an exterior door or window, then where access is permitted, doors shall be opened between the outside and any Dwelling Units that are horizontally adjacent to the subject Dwelling Unit.

4.3.2.3.1. Windows and interior doors in adjacent Dwelling Units shall be left 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 as well as the presence, installation quality and condition of the door seal shall be documented in the final test report.[32]

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

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

4.3.2.7 The altitude of the building site above sea level shall be recorded with an accuracy of 500 feet.

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

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[29] (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.

[30] (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.

[31] (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).

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

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. If an Attic, crawlspace, basement, or adjacent mechanical closet is to be evaluated for inclusion in the Infiltration Volume, per Sections 4.2.4.1, 4.2.5.1, 4.2.6.1, 4.2.6.2, or 4.2.7.1, then a manometer shall be used to measure the pressure difference between that space and the subject Dwelling Unit to verify that it is ≤ 10% of the induced enclosure pressure difference measured in Section 4.4.1.2.[33] To achieve this limit, openings between the adjacent space and the subject Dwelling Unit are permitted to be created during this test.[34] Additional air-moving fans are also permitted to be operated in the adjacent space to achieve this limit, as long as the same induced enclosure pressure difference as the subject Dwelling Unit is achieved and the airflow of the additional air-moving fans is included in the recorded airflow.

4.4.1.3.1. If the pressure difference is not within the 10% limit, then the adjacent space shall be excluded from the Infiltration Volume. Any doors and

[33] (Informative Note) For example, if the induced enclosure pressure difference is 50 Pa, then the pressure differential between the adjacent space and the subject Dwelling Unit must be ≤5 Pa for the space to be included in the Infiltration Volume.

[34] (Informative Note) Examples include, but are not limited to, opening doors and hatches between the adjacent space and the subject Dwelling Unit or removing the blower compartment panel of a Forced Air HVAC System in the adjacent space.

hatches between the subject Dwelling Unit and the adjacent space shall be closed; any exterior access doors, hatches, and vents shall be returned to their as-found position; and Section 4.4.1 shall be repeated.

4.4.1.~~3~~4. The air-moving fan shall be turned off, and the Dwelling Unit returned to its as-found condition.

4.4.1.5. If the results of the test will be reported as Air Changes Per Hour at 50 Pa (0.2 in. H_2O) (ACH50), the following shall be recorded: the Infiltration Volume of the Dwelling Unit; whether or not the Attic, crawlspace, basement, and/or adjacent mechanical closet, if present, was included or excluded from the Infiltration Volume; and, if included, the measured pressure difference between the space(s) and the subject Dwelling Unit.

4.4.1.6. 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.

4.4.1.7. 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.

4.4.1.~~4~~8. 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 4.4-1a or 4.4-1b. Alternatively, a manometer that is equipped to automatically make the conversion to CFM50 or CMS50 is permitted to be used.

$$C\mathit{CFM}50\ \left(\frac{ft^3}{min}\right) = Q_{measured}\left(\frac{ft^3}{min}\right)\left(\frac{50}{dP_{measured}}\right)^{0.65} \qquad \textbf{(Equation 4.4-1a)}$$

$$C\mathit{CFM}50\ \left(\frac{m^3}{s}\right) = Q_{measured}\left(\frac{m^3}{s}\right)\left(\frac{50}{dP_{measured}}\right)^{0.65} \qquad \textbf{(Equation 4.4-1b)}$$

4.4.1.~~5~~9. Corrected CFM50 (corrected CMS50) shall be calculated by making the adjustments due to density and viscosity using Section 9 of ASTM E779.[35] 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~~10. The Effective Leakage Area (ELA) shall be calculated using Equation 4.4-2a or 4.4-2b:

$$E\mathit{LA}\left(in^2\right) = \frac{Corrected\ CFM50}{18.2} \qquad \textbf{(Equation 4.4-2a)}$$

[35] (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.

$$\mathbf{E}ELA(\mathbf{m}^2)=\frac{Corrected\ CMS50}{13.6} \qquad \textbf{(Equation 4.4-2b)}$$

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.

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,[36] 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. If an Attic, crawlspace, basement, or adjacent mechanical closet is to be evaluated for inclusion in the Infiltration Volume, per Sections 4.2.4.1, 4.2.5.1, 4.2.6.1, 4.2.6.2, or 4.2.7.1, then a manometer shall be used to measure the pressure difference between that space and the subject Dwelling Unit to verify that it is ≤ 10% of the induced enclosure pressure difference measured in Section 4.4.2.2.[37] To achieve this limit, openings between the adjacent space and the subject Dwelling Unit are permitted to be created during this test.[38] Additional air-moving fans are also permitted to be operated in the adjacent space to achieve this limit, as long as the same induced enclosure pressure difference as the subject Dwelling Unit is achieved and the airflow of the additional air-moving fans is included in the recorded airflow.

4.4.2.3.1. If the pressure difference is not within the 10% limit, then the adjacent space shall be excluded from the Infiltration Volume. Any doors and hatches between the subject Dwelling Unit and the adjacent space shall be

[36] (Informative Note) For example, a "baseline" or "extrapolation" feature that automatically subtracts a previously measured baseline from the measured value before displaying the measurement.
[37] (Informative Note) For example, if the induced enclosure pressure difference is 50 Pa, then the pressure differential between the adjacent space and the subject Dwelling Unit must be ≤5 Pa for the space to be included in the Infiltration Volume.
[38] (Informative Note) Examples include, but are not limited to, opening doors and hatches between the adjacent space and the subject Dwelling Unit or removing the blower compartment panel of a Forced Air HVAC System in the adjacent space.

closed; any exterior access doors, hatches, and vents shall be returned to their as-found position; and Section 4.4.2 shall be repeated.

4.4.2.4. The air-moving fan shall be turned off, and the Dwelling Unit returned to its as-found condition.

4.4.2.5. If the results of the test will be reported as Air Changes Per Hour at 50 Pa (0.2 in. H2O) (ACH50), the following shall be recorded: the Infiltration Volume of the Dwelling Unit; whether or not the Attic, crawlspace, basement, and/or adjacent mechanical closet, if present, was included or excluded from the Infiltration Volume; and, if included, the measured pressure difference between the space(s) and the subject Dwelling Unit.

4.4.2.6. 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.

4.4.2.7. 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. H2O) (CFM50/ft2 of enclosure), the Compartmentalization Boundary area of the Dwelling Unit shall be recorded.

4.4.2.8. 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.[39]

4.4.2.9. 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 C and n.[40, 41]

4.4.2.10. The Effective Leakage Area (ELA) shall be calculated using Equation 4.4-3a or 4.4-3b:

$$ELA\,(in^2) = C\left(\frac{ft^3}{minPa^n}\right) \times 0.567 \times 4^{(n-0.5)} \qquad \textbf{(Equation 4.4-3a)}$$

$$ELA\,(m^2) = C\left(\frac{m^3}{sPa^n}\right) \times 0.775 \times 4^{(n-0.5)} \qquad \textbf{(Equation 4.4-3b)}$$

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

4.4.2.11. 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 4.4-4a or 4.4-4b:

$$CFM50 = C\left(\frac{ft^3}{minPa^n}\right) \times 50^{(n)} \qquad \textbf{(Equation 4.4-4a)}$$

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[39] (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.

[40] (Informative Note) For example, using the procedures in ASTM E779, Section 9 and Annex A.1.

[41] (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.

$$C CFM50 = C\left(\frac{m^3}{sPa^n}\right) \times 50^{(n)} \quad \textbf{(Equation 4.4-4b)}$$

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, then the corrected airflow determined using a one-point test shall be adjusted using Equation 4.5-1a or 4.5-1b[42]

Adjusted CFM50 = 1.1 x Corrected CFM50 **(Equation 4.5-1a)**

Adjusted CMS50 = 1.1 x Corrected CMS50 **(Equation 4.5-1b)**

The ELA determined in Section 4.4.1.6 for a one-point air leakage test shall be adjusted using Equation 4.5-2.

Adjusted ELA = 1.1 x ELA **(Equation 4.5-2)**

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 the following equations shall be used. Where adjusted or corrected CFM50, CMS50 or ELA values have been calculated in previous sections, they shall be used in the following equations.

ACH50 = CFM50 x 60 / Infiltration Volume in cubic feet **(Equation 4.5-3a)**

ACH50 = CMS50 x 3600 / Infiltration Volume in cubic meters **(Equation 4.5-3b)**

SLA = 0.00694 x ELA in in^2 / Conditioned Floor Area in square feet **(Equation 4.5-4a)**

SLA = 10.764 x ELA in m^2 / Conditioned Floor Area in square meters **(Equation 4.5-4b)**

NLA = SLA x (S)0.4, where S is the number of stories above grade **(Equation 4.5-5)**

$CFM50/ft^2$ = CFM50 / Compartmentalization Boundary area in square feet **(Equation 4.5-6)**

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

5. Procedure for measuring airtightness of duct systems.

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 5.2.9 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 shall be used.[43] 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 percent of reading or 0.25 Pa (0.0010 in. H_2O), whichever is greater.

5.1.3. Flow meter. A device to measure volumetric airflow with a maximum error of 5 percent 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 45.1.1 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. HVAC System components. The presence of all components that are included in the HVAC design for the Dwelling Unit[44] 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, then the test shall not be conducted.[45]

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.

5.2.2. HVAC System controls. The HVAC System controls shall be adjusted so that the Blower Fan does not turn on during the test.

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[43] (Informative Note) For example, windows and doors opening to decks or patios.

[44] (Informative Note) For example, heating, cooling, ventilation, dehumidification, humidification, and filtration components.

[45] (Informative Note) For example, in new construction the test shall not be conducted if an air handler has not yet been installed.

5.2.3. Fans. Any fans that could change the pressure in either the Conditioned Space Volume or any spaces containing ducts or air handlers shall be turned off.[46]

5.2.4. Vented combustion appliances. 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. Filters. 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. Dampers within the duct system shall be treated as set forth in Section 5.2.6.1 through Section 5.2.6.4.

5.2.6.1. Non-motorized dampers[47] within the duct system shall be left in their as-found positions.[48]

5.2.6.2. Motorized dampers within the duct system except zone and bypass dampers.

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

5.2.7. Openings for Ventilation air within the duct system shall be treated in accordance with Sections 5.2.7.1 through 5.2.7.4:

Exception: If the test is being conducted for a purpose other than to complete an Energy Rating Index Energy Rating in accordance with ANSI / RESNET / ICC 301[49], and the authority having jurisdiction allows openings for ventilation air to not have a damper, then such openings are permitted to be sealed for the duration of the test.

5.2.7.1. Each continuously-operating Dwelling Unit Mechanical Ventilation System connected to the duct system shall be sealed[50] for the duration of the test at the inlet terminal for that fan, at a location within the Ventilation or exhaust duct, at the Ventilation or exhaust equipment itself, or at the outlet terminal for that fan[51], whichever is accessible. The sealing location selected shall be documented.

5.2.7.2. All intermittently-operating Dwelling Unit Mechanical Ventilation Systems connected to the duct system shall not be sealed, including such systems that control the HVAC fan.

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[46] (Informative Note) For example, bathroom fans, clothes dryers, kitchen vent hood, Attic fan.
[47] (Informative Note) For example, pressure-activated (i.e., barometric) dampers, fixed dampers, balancing dampers.
[48] (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.
[49] (Informative Note) For example, if the test is to comply with the prescriptive compliance option of a code.
[50] (Normative Note) A motorized damper placed in its closed position or a non-motorized damper pushed into its closed position during the test shall satisfy the intent of this section to seal the opening if it is located at one of the listed sealing locations. In such cases, additional sealing is permitted, but not required.
[51] (Informative Note) See Figure 1 in Section 6 for an illustration of the inlet terminal, ventilation duct, and outlet terminal. To provide an example of potential sealing locations, for an inline fan connected to the return-side of the HVAC System, it may be sealed at the exterior of the Dwelling Unit, at the filter slot of the inline fan, or where the ventilation duct terminates in the return duct of the HVAC System, whichever is accessible.

5.2.7.3.-If a continuously-operating Exhaust Ventilation System is present in the Dwelling Unit, all outdoor air intakes with an operable shutoff damper[52] connected to the duct system and other operable Ventilation air openings connected to the duct system shall be placed in their closed position for the duration of the test, but shall not be sealed.

5.2.7.4.-Ventilation air openings connected to the duct system besides those listed in Section 5.2.7.3 shall be left in their as-found position and shall not be sealed.

5.2.8. Openings for combustion air and make-up air. Combustion air openings and make-up air openings connected to the duct system shall be left in their as-found position and shall not be sealed.

5.2.9. Heating and cooling supply registers and return grilles. 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 face of the duct boot temporarily sealed during testing. For Dwelling Units without registers and grilles present, the face of the duct boots shall be sealed instead.[53]

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 1 Installation*. The air handler blower access panel shall be removed and the duct leakage tester attached to the blower compartment access.

Method 2 is permitted only if certain conditions are met.

- *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.

  Method 2 is permitted only if:

  1. The duct system has three or fewer return grilles; or
  2. The total duct leakage is less than 50 CFM (25 L/s) at 25 Pa; or
  3. Local codes require licensing that parties conducting the test have not obtained in order to remove the blower access panel; or
  4. The air handler blower access is in an Attic or crawlspace that has limited or restricted entry or exit.[54]

[52] (Informative Note) For example, a manual shut-off damper in a duct supplying outdoor air to the return-side of the HVAC System shall be closed if a continuously-operating local mechanical exhaust system or continuously-operating Exhaust Ventilation System is present.
[53] (Informative Note) For example, new construction.
[54] (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.

5.3.1. If the duct leakage to outside will be measured, then a blower door shall be installed in the enclosure in accordance with 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, Item 4), 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. A second probe also shall be located in the return plenum 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.

5.3.3. 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 5.4-1a or 5.4-1b. Alternatively, a manometer that is equipped to automatically make the conversion to CFM25 or CMS25 is permitted to be used.

$$\boldsymbol{CFM25 = CFM_{measured}\left(\frac{25}{dP}\right)^{0.6}} \qquad \textbf{(Equation 5.4-1a)}$$

$$\boldsymbol{CMS25 = CMS_{measured}\left(\frac{25}{dP}\right)^{0.6}} \qquad \textbf{(Equation 5.4-1b)}$$

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. 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 depending 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 Pa (0.10 in. H_2O) 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 rechecked 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 Pa (0.10 in. H_2O), in accordance with Section 5.4.2.3, or the airflow required to maintain an induced duct system pressure difference of 0.0 Pa (0.0 in. H_2O), in accordance with Section 5.4.2.4.

5.4.2.6. The induced duct system pressure difference shall be rechecked, and the duct leakage tester shall be adjusted to maintain 0.0 ± 0.5 Pa (0.0 ± 0.002 in. H_2O), in accordance with Section 5.4.2.4.

5.4.2.7. Repeat Sections 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 5.4-1a or 5.4-1b. Alternatively, a manometer

that is equipped to make the conversion automatically 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,[55] then the total duct leakage determined in Section 5.4.1.2 or 5.4.1.5 shall be used.

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,[56] 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.[57]

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.

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

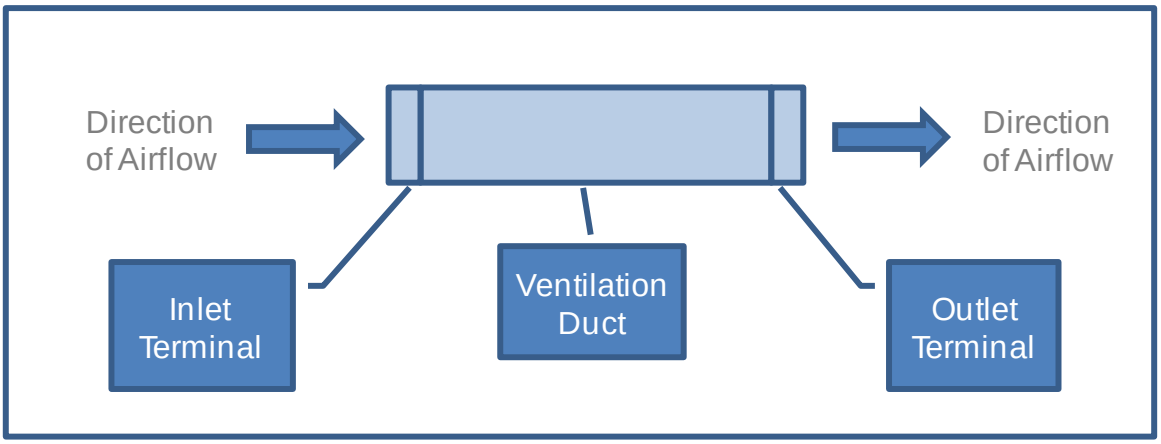
6. Procedure for measuring airflow of mechanical Ventilation systems.

The purpose of this test procedure is to measure the volumetric airflow through a mechanical Ventilation system including a Dwelling Unit Mechanical Ventilation System[58] or a local mechanical exhaust system.[59, 60]

The airflow is permitted to be measured at the inlet terminal in accordance with Section 6.2, at the outlet terminal in accordance with Section 6.3, mid-stream in the Ventilation duct in accordance with Section 6.4, or at the equipment itself using an integrated diagnostic tool in accordance with Section 6.5.

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. Dampers.

[58] (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.
[59] (Informative Note) For example, bathroom exhaust fan, kitchen exhaust fan.
[60] (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.

6.1.2.1. All dampers except zone and bypass dampers shall be left in their as-found positions[61].

6.1.2.2. If a Dwelling Unit Mechanical Ventilation System is to be tested and is interconnected with a Forced-Air HVAC 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.

6.1.3. Openings for Ventilation air.

6.1.3.1. Continuously-operating and intermittently-operating Dwelling Unit Mechanical Ventilation Systems shall not be sealed, including such systems that control the HVAC fan.

6.1.3.2. Operable window trickle-vents, operable through-the-wall vents, outdoor air intakes with an operable shutoff damper[62], and other operable Ventilation air openings shall be fully opened.

6.1.3.3. Ventilation air openings besides those listed in Section 6.1.3.2 shall be left in their as-found position and shall not be sealed.

6.1.4. 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.

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

6.1.6 Forced-Air HVAC System components. If a Dwelling Unit Mechanical Ventilation System is to be tested and uses the Blower Fan of a Forced-Air HVAC System as its primary fan, then the presence of all components included in the Forced-Air HVAC System design for the Dwelling Unit and integrated with the duct system shall be verified. [63] If these components have not yet been installed, then the test shall not be conducted. [64]

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

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

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

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[61] (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.

[62] (Informative Note) For example, a manual shut-off damper in a duct supplying outdoor air to the return-side of the HVAC System shall be opened.

[63] (Informative Note) For example, heating, cooling, ventilation, dehumidification, humidification, and filtration components.

[64] (Informative Note) For example, in new construction the test shall not be conducted if an air handler has not yet been installed.

6.1.8. Local mechanical exhaust or Dwelling Unit Mechanical Ventilation System. 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 HVAC System as its primary fan, this shall be accomplished according to Section 6.1.7.

6.1.9. 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[65] 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), an airflow resistance device (Section 6.2.2), a passive flow hood (Section 6.2.3), or a vane anemometer with hood (Section 6.2.4).

6.2.1 Powered flow hood.

6.2.1.1. 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.

6.2.1.1.1. 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 a maximum error of 5 percent 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 percent of reading or 0.25 Pa (0.0010 in. H_20), 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.

[65] (Informative Note) For example, clothes dryers, Attic fan.

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 percent of reading or 0.25 Pa (0.0010 in. H_2O), 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. If the mechanical Ventilation system has multiple branches, then an airflow resistance device shall be placed over each inlet terminal at the same time, such that the combined airflow through all terminals can be assessed simultaneously[66].

6.2.2.2.2. The opening area of the airflow resistance device(s) 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. H_2O).

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

6.2.2.2.4. Using the average pressure difference of the airflow resistance device(s), the airflow shall be calculated using the manufacturer's flow conversion table or for devices without a flow conversion table, Equation 6.2-1a or 6.2-1b:

$$\boldsymbol{Airflow\ (CFM) = Opening\ Area\ x\ 1.07\ x\ (dP)^{0.5}} \qquad \textbf{(Equation 6.2-1a)}$$

$$\boldsymbol{Airflow\ (L/s) = Opening\ Area\ x\ 0.078\ x\ (dP)^{0.5}} \qquad \textbf{(Equation 6.2-1b)}$$

where: For Equation 6.2-1a, Opening Area is in square inches and dP is in Pa.

For Equation 6.2-1b Opening Area is in square centimeters and dP is in Pa.

6.2.3. Passive flow hood.

[66] (Informative Note) In a system with multiple branches, an airflow resistance device must be placed over each inlet at the same time to account for the change in pressure caused by the device. This can be accomplished, for example, by positioning a device over each inlet and holding it in place with a pole, allowing a single person to assess the airflow.

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 percent 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 percent of the 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 flow capture element 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 average volumetric airflow through the airflow meter, measured over at least a 10-second period, shall be recorded.

6.2.4. Vane anemometer with hood.

6.2.4.1. 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.

6.2.4.1.2. Vane anemometer with hood. A device consisting of a flow capture element capable of creating an airtight perimeter seal around the inlet terminal connected to a vane anemometer capable of measuring the volumetric airflow through the flow capture element with a maximum error of 5 percent or 5 CFM (2.5L/s or 0.0025 m^3/s), whichever is greater.

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

6.2.4.2. Procedure to conduct airflow test.

6.2.4.2.1. The flow capture element of the vane anemometer with hood shall be placed over inlet terminal, ensuring that an airtight perimeter seal has been created.

6.2.4.2.2. A tube shall be inserted inside the flow capture element between the vane anemometer and inlet terminal to allow for measurement of the pressure difference between inside the flow capture element and the room. Devices that have a built-in pressure tube are acceptable.

6.2.4.2.3. 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.

6.2.4.2.4. The average volumetric airflow through the vane anemometer, measured over at least a 10-second period, shall be recorded.

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), a bag inflation device (Section 6.3.2), or a vane anemometer with hood (Section 6.3.3).

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 holding the bag open[67] 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 percent 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.

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

6.3.2.2.1. The bag shall be completely emptied of air, and the shutter is 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 is recorded.

6.3.2.2.5. The airflow shall be calculated using Equation 6.3-1a or 6.3-1b

$$\boldsymbol{Airflow\ (CFM) = \frac{8 \times Volume}{Elapsed\ Time}} \qquad \textbf{(Equation 6.3-1a)}$$

$$\boldsymbol{Airflow\ (L/s) = \frac{4 \times Volume}{Elapsed\ Time}} \qquad \textbf{(Equation 6.3-1b)}$$

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

6.3.3 Vane anemometer with hood. To measure airflow at an outlet terminal using a vane anemometer with hood, Section 6.2.4 shall be followed except with all occurrences of the phrase "inlet terminal" replaced with "outlet terminal."

6.4 Procedure to measure airflow mid-stream in the Ventilation duct. This Section defines procedures 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), a velocity pressure probe (Section 6.4.2), or a hot wire anemometer (Section 6.4.3).

6.4.1 Airflow measurement station.

6.4.1.1 Equipment needed.

6.4.1.1.1 Airflow measurement station. A permanently-installed airflow measurement instrument capable of measuring average velocity pressure across a duct diameter or static pressure across an in-line aperture of known area. The airflow measurement instrument shall contain a port that allows it to be connected to a manometer. The airflow measurement instrument must have a calculation procedure provided by the manufacturer to convert the measured velocity pressure or static pressure into volumetric air flow with a maximum error of 10 percent or 5 CFM (2.5 L/s), whichever is greater.

6.4.1.1.2 Manometer. A device that is capable of measuring pressure difference with a maximum error of 1 percent of reading or 0.25 Pa (0.0010 in. H_2O), whichever is greater.

6.4.1.2 Procedure to conduct airflow test.

6.4.1.2.1. To facilitate accurate readings, a section of permanently installed smooth-walled ductwork must be installed with the airflow measurement station. This length of smooth-walled ductwork 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.[68]

6.4.1.2.2. The manometer shall be connected to the airflow measurement instrument and the average velocity pressure or static pressure, measured over at least a 10-second period, shall be recorded.

6.4.1.2.3. Using the average velocity pressure or static pressure, the volumetric airflow shall be calculated using the airflow measurement instrument's instructions.

6.4.2 Velocity pressure probe.

6.4.2.1. 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.

6.4.2.1.2. Velocity pressure probe. A device that can be inserted into the measurement location to measure pressures caused by air flow over the probe. The probe must have a calculation procedure provided by the manufacturer to convert the measured pressure(s) into volumetric air flow with a maximum error of 10 percent or 5 CFM (2.5 L/s), whichever is greater.

6.4.2.1.2. Manometer. A device that is capable of measuring pressure difference with a maximum error of 1 percent of reading or 0.25 Pa (0.0010 in. H_2O), whichever is greater.

6.4.2.2. Procedure to conduct airflow test.

6.4.2.2.1. To facilitate accurate readings, a section of permanently installed smooth-walled ductwork must be installed with a hole that accommodates the test instrument. This length of smooth-walled ductwork 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.[69]

6.4.2.2.2. The manometer shall be connected to the velocity pressure probe. Measurements shall be made across the diameter of the Ventilation duct following manufacturer's instructions. A probe that performs pressure averaging across the duct may be used. The pressure measurements, averaged over at least a 10-second period, shall be recorded.

6.4.2.2.3. The airflow measurement instrument manufacturer's instructions shall be used to covert the measured pressure(s) into volumetric air flow.

6.4.2.2.4. The velocity pressure probe shall be removed and the port sealed with a sheet metal plug or metallic tape.

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[68] (Informative Note) To minimize turbulence and ensure an accurate reading.
[69] (Informative Note) To minimize turbulence and ensure an accurate reading.

6.4.3 Hot wire anemometer.

6.4.3.1 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.

6.4.3.1.1. Hot wire anemometer. A device that can be inserted into the measurement location that uses a thermal heating effect to determine air velocity. The anemometer must have a calculation procedure provided by the manufacturer to convert the measured velocities into volumetric air flow with a maximum error of 10 percent or 5 CFM (2.5 L/s), whichever is greater.

6.4.3.2 Procedure to conduct airflow test.

6.4.3.2.1. To facilitate accurate readings, a section of permanently installed smooth-walled ductwork must be installed with a hole that accommodates the test instrument. This length of smooth-walled ductwork 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.[70]

6.4.3.2.2. Measurements shall be made across the diameter of the Ventilation duct following manufacturer's instructions. The velocity measurements, averaged over at least a 10-second period, shall be recorded.

6.4.3.2.3. The airflow measurement instrument manufacturer's instructions shall be used to covert the measured velocities into volumetric air flow.

6.4.3.2.4. The hot wire anemometer shall be removed and the port sealed with a sheet metal plug or metallic tape.

6.5 Procedure to measure airflow at equipment itself using an integrated diagnostic tool.

6.5.1. Equipment.

6.5.1.1. Integrated diagnostic tool. A tool that is integrated into the Ventilation equipment[71] that permits assessment of airflow. The maximum error of the integrated diagnostic tool shall be 15 percent of the highest flow setting of the Ventilation equipment.

6.5.2 Procedure to conduct airflow test. Follow the manufacturer's instructions for the integrated diagnostic tool to determine the airflow.

[70] (Informative Note) To minimize turbulence and ensure an accurate reading.
[71] (Informative Note) For example, pressure taps or a device that measures a parameter such as watt draw that can be translated to airflow.

7. Hazards.

7.1. Equipment guards. The air-moving equipment shall be listed by an accredited certification body[72] 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.

7.2. Personal protective equipment. Use of safety equipment appropriate for general fieldwork is required. All local or federal OSHA requirements shall be followed.

7.3. 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.

7.4. Access and working space. The testing procedures for Ventilation flow measurements sometimes require the use of ladders 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.

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

7. 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 301-2022 “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 62.2-2019 “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)

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

8. Informative references.

American National Standards Institute, ANSI. (https://www.ansi.org)

International Code Council, ICC. (https://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 for the Subject Dwelling Unit?			
	Cond. Space Volume	Uncond. Space Volume	Cond. Floor Area	Infiltration Volume
General				
Space conditioned to 68°F/78°F (excluding Attics, crawlspaces, basements, adjacent mechanical closets, garages, and sunrooms, which are addressed below)	Yes		Yes	Yes
Walls				
Wall with at least one horizontally-adjacent space conditioned [1] and part of the subject Dwelling Unit, (i.e., wall is not shared with another Dwelling Unit).	Yes		Yes	Yes
Wall with at least one horizontally-adjacent space conditioned [1] and the subject Dwelling Unit shares the wall assembly with another Dwelling Unit (e.g. wall separates subject Dwelling Unit from an adjacent Dwelling Unit).	Yes, but only ½ of the wall volume is included		Yes, but only ½ of the wall area is included	Yes, but only ½ of the wall volume is included
Wall with both horizontally-adjacent spaces unconditioned and part of the subject Dwelling Unit (i.e., wall is not shared with another Dwelling Unit).		Yes		
Wall with both horizontally-adjacent spaces unconditioned and the subject Dwelling Unit shares the wall assembly with another Dwelling Unit (e.g., wall separates subject Dwelling Unit from adjacent Dwelling Unit).		Yes, but only ½ of the wall volume is included		
Floors				
Floor assembly with spaces both above and below conditioned [1] and part of the subject Dwelling Unit. A floor assembly is part of the subject Dwelling Unit when no Dwelling Units are above or below the subject Dwelling Unit. Where a floor assembly separates two Dwelling Units, the floor assembly above the ceiling of the lower unit is part of lower Dwelling Unit.	Yes			Sometimes[2]
Floor assembly, with either volume above or below unconditioned		Yes		Sometimes [3]
Floor assembly, with both volume above and below unconditioned		Yes		
Attics				
Attic is contiguous with and dedicated to subject Dwelling Unit and conditioned [1]	Yes			Sometimes[4]
Attic is contiguous with and dedicated to subject Dwelling Unit, is not conditioned, is unvented, and its roof deck and exterior walls are both insulated & air-sealed		Yes		Sometimes[4]
All other Attics		Yes		
Crawlspaces				
Crawlspace is contiguous with and dedicated to subject Dwelling Unit and conditioned [1]	Yes			Sometimes[4]

Crawlspace is contiguous with and dedicated to subject Dwelling Unit, is not conditioned, is unvented, and its exterior walls are both insulated & air-sealed		Yes		Sometimes[4]
All other crawlspaces		Yes		
Basements				
Basement is contiguous with and dedicated to subject Dwelling Unit and conditioned [1]	Yes			Yes
Basement is contiguous with and dedicated to subject Dwelling Unit, is not conditioned, is unvented, and its exterior walls are both insulated & air-sealed		Yes		Yes
Basement is contiguous with and dedicated to subject Dwelling Unit, is not conditioned, is unvented, and no insulation is in either its exterior walls or floor assembly above		Yes		Sometimes[4]
All other basements		Yes		
Mechanical Closets Adjacent to Dwelling Unit				
Closet is contiguous with and dedicated to subject Dwelling Unit, only includes equipment serving the subject Dwelling Unit, and conditioned [1]	Yes		Yes	Sometimes[4]
Closet is contiguous with and dedicated to subject Dwelling Unit, only includes equipment serving the subject Dwelling Unit, is not conditioned, is unvented, and wall assembly between it and the subject Dwelling Unit is not air sealed		Yes		Sometimes[4]
All other mechanical closets adjacent to Dwelling Unit		Yes		
Other				
Garage, even if conditioned		Yes		
Thermally isolated sunroom		Yes		
Notes				

1) To be considered conditioned, the party conducting evaluations must either:
   a. 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
   b. Verify through visual inspection that both the heating and cooling equipment and distribution system serve the volume and, in the judgment of the party conducting evaluations, are capable of maintaining space conditions at 78°F (26°C) for cooling and 68°F (20°C) for heating.

2) A floor assembly in this category is included in the Infiltration Volume, except if the space below is a crawlspace or basement, in which case it's only included if the crawlspace or basement is included in the Infiltration Volume. See Sections 4.2.5.1 and 4.2.6.1 for details.

3) A floor assembly in this category is only included in the Infiltration Volume if the space below is a crawlspace or basement that is included in the Infiltration Volume. See Sections 4.2.5.1 and 4.2.6.1 for details.

4) An Attic, crawlspace, basement, or adjacent mechanical closet in this category is only included in the Infiltration Volume if the pressure difference between it and the subject Dwelling Unit has been evaluated during the airtightness test and is within a specified limit. See Section 4.2.4.1, 4.2.5.1, 4.2.6,1, 4.2.6.2, and 4.2.7.1, respectively, for details.