February 26th 2015

BSR/RESNET/ICC 380-201x PDS-02

Standard for Testing Airtightness~~Air Leakage~~ of Building Enclosures, Airtightness~~Air Leakage~~ of Heating and Cooling Air Distribution Systems, and Airflow of Mechanical Ventilation Systems

1. Purpose

1.1. The provisions of this document are intended to establish national standards for testing the airtightness~~air leakage~~ of enclosures and heating and cooling air distribution systems, and the airflow of mechanical ventilation systems. These standards are intended for use by home energy raters, energy auditors, or code officials to evaluate the performance of residential buildings.

2. Scope

2.1. This standard defines procedures for measuring the airtightness~~air leakage~~ of building enclosures, the airtightness~~air leakage~~ of heating and cooling air distribution systems, and the airflow of mechanical ventilation systems.

This standard is applicable to all single family dwelling units.

The procedure for measuring the airtightness~~air leakage~~ of building enclosures is also applicable to dwelling units in multifamily buildings~~ three stories or less in height above ground~~.

The procedure for measuring the airtightness~~air leakage~~ of heating and cooling air distribution systems is also applicable to dwelling units in multifamily buildings~~ three stories or less in height above ground~~, where each dwelling unit has its own duct system separate from other dwelling units.

The procedure for measuring the airflow of mechanical ventilation systems is also applicable to dwelling units in multifamily buildings~~ three stories or less in height above ground~~, where each dwelling unit has its own ventilation system separate from other dwelling units.

3. Procedure for Measuring Airtightness~~Air Leakage~~ of Building Enclosure

3.1. Equipment

The equipment listed in this section shall be tested annually for calibration using the manufacturer’s recommended calibration procedure.

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

3.1.2. Manometer. A device that can measure pressure difference with an accuracy equal to or better than ±1 % of reading,~~5 %~~ or 0.25 Pa (0.001 in. H2O), whichever is greater.

3.1.3. Airflow Meter. A device to measure volumetric airflow with an accuracy equal to or better than ± 5 % of the measured flow.

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

3.1.5. Blower Door. A device that combines an Air-Moving Fan as defined in Section 3.1.1, ~~and~~ an Airflow Meter as defined in Section 3.1.3, and a covering to integrate the Air-Moving Fan into the building opening.

3.2. Procedure to Prepare the Building for Testing

3.2.1. Fenestration. Doors and windows ~~that are part of the conditioned space boundary~~ shall be closed and latched.

3.2.2. Attached garages. All~~If attached garage is not within the pressure boundary of the house,~~ exterior garage doors and windows ~~shall be opened. If attached garage is within the pressure boundary of the home, exterior garage doors~~ shall be closed and latched unless the blower door is~~. In either case, windows in the attached garage shall be closed. The Air-Moving Fan shall only be permitted to be~~ installed between the house and the garage, in which case the garage shall be opened to outside by opening at least one exterior garage door.~~ if the garage is not within the pressure boundary of the house.~~

3.2.3. Crawlspaces. If a crawlspace is unvented~~inside the conditioned space boundary~~, interior access doors and hatches between the house and the crawlspace shall be opened and exterior crawlspace access doors, vents, and hatches shall be closed. If a crawlspace is ~~outside~~ vented the ~~conditioned space boundary,~~ interior access doors and hatches shall be closed and crawlspace vents shall be left in their as-found position and their position shall be recorded on the test report.

3.2.4. Attics. Attic access doors and hatches shall be closed unless the attic is air sealed and insulated at the roofdeck, in which case the access doors and hatches shall be opened. The position of the attic access doors and hatches shall be recorded. Exterior ~~If an attic is inside the conditioned space boundary, interior access doors and hatches between the house and the conditioned attic shall be opened and attic exterior access doors and windows shall be closed. If an attic is outside the conditioned space boundary, interior access doors and hatches shall be closed. In addition, exterior~~ access doors, dampers, or vents shall be left in their as-found position and their position shall be recorded on the test report.

3.2.5. Basements. All doors between basements and Conditioned Space Volume shall be opened unless the house floor above the basement is air sealed and insulated, in which case the door between the basement and Conditioned

Space Volume shall be closed. The position of the basement doors shall be recorded. If the door to the basement is closed, the basement shall be excluded from Infiltration Volume and Conditioned Floor Area.

~~3.2.4.~~

~~3.2.5.~~3.2.6. **Interior doors.** All doors between rooms inside the C~~c~~onditioned S~~s~~pace Volume ~~boundary~~ shall be opened.

~~3.2.6.~~3.2.7. **Chimney dampers and combustion-air inlets on solid fuel appliances.** Chimney dampers and combustion-air inlets on solid fuel appliances shall be closed. Precautions shall be taken to prevent ashes or soot from entering the house during testing.

~~3.2.7.~~3.2.8. **Combustion appliance flue gas vents.** Combustion appliance flue gas vents shall be left in their as-found position.

~~3.2.8.~~3.2.9. **Fans.** Any fan or appliance capable of inducing airflow across the building enclosure shall be turned off including, but not limited to, clothes dryers, attic fans, kitchen and bathroom exhaust fans, air handlers, ventilation fans used in a whole-house mechanical ventilation system (e.g., a system intended to meet ASHRAE Standard 62.2), and crawlspace and attic ventilation fans. This requirement to turn fans off includes accessible fans in adjacent attached dwelling units.

~~3.2.9.~~3.2.10. **Dampers**

~~3.2.9.1.~~3.2.10.1. Non-motorized dampers (e.g., pressure-activated operable dampers, fixed dampers) that connect the Conditioned Space Volume ~~conditioned space~~ to the exterior or to ~~u~~Unconditioned ~~s~~Space Volumes shall be left in their as-found positions. 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.

~~3.2.9.2.~~3.2.10.2. Motorized dampers that connect the conditioned space to the exterior or to unconditioned spaces shall be placed in their closed positions and shall not be further sealed.

~~3.2.10.~~3.2.11. **Non-dampered openings for ventilation, combustion air and make-up air ~~openings~~**

~~3.2.10.1.~~3.2.11.1. Non-dampered ventilation openings of intermittently operating local exhaust ventilation systems (e.g., bath fan, kitchen range fan) that connect the Conditioned Space Volume ~~conditioned space~~ to the exterior or to Unconditioned Space Volume ~~unconditioned spaces~~ shall be left open.

~~3.2.10.2.~~3.2.11.2. Non-dampered ventilation openings of intermittently operating whole-house ventilation systems, including HVAC fan-integrated outdoor air inlets, that connect the Conditioned Space Volume ~~conditioned space~~ to the exterior or to Unconditioned Space Volume ~~unconditioned spaces~~ shall not be sealed.

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3.2.11.3. Non-dampered ventilation openings of continuously operating local exhaust ventilation systems (e.g., bathroom or kitchen exhaust) that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volume shall be sealed, preferably at the exterior of the enclosure.

~~3.2.10.3.~~3.2.11.4. Non-dampered ventilation openings of continuously operating whole-house ventilation systems that connect the Conditioned Space Volume ~~conditioned space~~ to the exterior or to Unconditioned Space Volume ~~unconditioned spaces~~ shall be sealed, preferably at the exterior of the enclosure.

3.2.11.5. All other Non-dampered intentional openings between Conditioned Space Volume and the exterior or Unconditioned Space Volume shall be left open. For example undampered combustion air or make-up air openings shall be left in their open position.

~~3.2.11.~~3.2.12. Whol**e-building fan louvers/shutters.** Whole-building fan louvers and shutters shall be closed. In addition, if there is a seasonal cover present, it shall be installed.

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~~3.2.12.~~3.2.13. **Evaporative coolers.** The opening to the exterior of evaporative coolers shall be placed in its off position. In addition, if there is a seasonal cover present, it shall be installed.

~~3.2.13.~~3.2.14. **Operable window trickle-vents and through-the-wall vents.** Operable window trickle-vents and through-the-wall vents shall be closed.

~~3.2.14.~~3.2.15. **Supply registers and return grilles.** Supply registers and return grilles shall be left in their as-found position and left uncovered.

~~3.2.15.~~3.2.16. **Plumbing drains with p-traps.** Plumbing drains with empty p-traps shall be sealed or filled with water.

~~3.2.16.~~3.2.17. **Vented combustion appliances.** Vented combustion appliances shall remain off or in "pilot only" mode for the duration of the test.

3.3. Procedure to Install the Test Apparatus and Prepare for Airtightness~~Air Leakage~~ Test

3.3.1. The Blower Door shall be installed in an exterior doorway or window that has an unrestricted air pathway into the building and no obstructions to airflow within five feet of the fan inlet and two feet of the fan outlet. The opening that is chosen shall be noted on the test report. If possible, the system shall not be installed in a doorway or window exposed to wind. It is permissible to use a doorway or window between the Conditioned Space Volume ~~conditioned space~~ and an Unconditioned Space Volume ~~unconditioned space~~ as long as the Unconditioned Space Volume~~unconditioned space~~ has an unrestricted air pathway to the outdoors and all operable exterior windows and doors of the Unconditioned Space Volume ~~unconditioned space~~ are opened to the outdoors. For multifamily dwelling units, 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 (e.g., leading to a deck or patio) shall be used.

3.3.2. 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.

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

3.3.4. The altitude of the building site above sea level shall be recorded with an accuracy of 500~~2,000~~ feet (150 m~~750m~~).

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

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

3.3.7. If the results of the test will be reported as Specific Leakage Area (SLA), the Conditioned Floor Area~~floor area~~ of the house shall be recorded.

3.4. Procedure to Conduct Airtightness~~Air Leakage~~ Test. The leakage of the enclosure shall be measured using either the One-Point Airtightness~~Air Leakage~~ Test in Section 3.4.1 or the Multi-Point Airtightness~~Air Leakage~~ Test in Section 3.4.2**.**

3.4.1. One-Point Airtightness~~Air Leakage~~ Test

3.4.1.1. 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 Building Pressure.

3.4.1.2. 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 Building 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 house shall be recorded.

If a 50 Pa (0.2 in. H_2O) induced enclosure pressure difference can be 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 cannot be achieved, then additional Air-Moving Fans shall be used or the highest induced enclosure pressure difference (dPmeasured~~high~~) and airflow (Qmeasured~~high~~) 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.

3.4.1.3. The Air-Moving Fan shall be turned off and the home returned to its as-found condition.

3.4.1.4. If an induced enclosure pressure difference of 50 Pa (0.2 in. H_2O) was not achieved in Section 3.4.1.2, then the recorded airflow (Qmeasured~~high~~) shall be converted to a nominal airflow at 50 Pa (0.2 in. H_2O) using Equation 1. Alternately, a Manometer that is equipped to automatically make the conversion to CFM50 or CMS50 is permitted to be used.

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

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

3.4.1.5. The airflow at 50 Pa shall be corrected for altitude and temperature to determine the corrected airflow at 50 Pa using the calculations in Section 9 of ASTM E779-10[1], resulting in the term Corrected CFM50.~~Equation 2:~~

$$\cancel{Corrected\ CFM50 = CFM50 \times ACF \times TCF} \quad \cancel{(2a)}$$

~~Where:~~

~~ACF = Altitude Correction Factor = 1 + 0.000006 x Altitude in feet, using the altitude measured in Section 3.3.4.~~

~~TCF = Temperature Correction Factor = Value selected from Table 1a for pressurization and Table 1b for depressurization, using the indoor and outdoor temperature measured in Section 3.3.3. Alternatively, a manufacturer's temperature correction is permitted to be used.~~

[1] Software provided by manufacturers of test equipment may be used to perform these calculations if the manufacturer certifies that the calculations are performed in accordance with ASTM E779-10.

$$Corrected\ CMS50 = CMS50 \times ACF \times TCF \qquad (2b)$$

~~Where:~~

~~ACF = Altitude Correction Factor = 1 + 0.000003 x Altitude in meters, using the altitude measured in Section 3.3.4.~~

~~TCF = Temperature Correction Factor = Value selected from Table 1a for pressurization and Table 1b for depressurization, using indoor and outdoor temperature measured in Section 3.3.3. Alternatively, a manufacturer's temperature correction is permitted to be used.~~

~~Table 1a. Temperature Correction Factors for Pressurization Testing, Calculated According to ASTM E779-10~~

Outside Temp (F)	Inside Temperature (F)								
	50	55	60	65	70	75	80	85	90
-20	1.16	1.17	1.18	1.19	1.20	1.22	1.23	1.24	1.25
-10	1.13	1.14	1.16	1.17	1.18	1.19	1.20	1.21	1.22
0	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.20
10	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17
20	1.06	1.07	1.08	1.09	1.10	1.11	1.13	1.14	1.15
30	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12
40	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10
50	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08
60	0.98	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06
70	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.04
80	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.02
90	0.93	0.94	0.95	0.95	0.96	0.97	0.98	0.99	1.00
100	0.91	0.92	0.93	0.94	0.95	0.96	0.96	0.97	0.98
110	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.96

Outside Temp (C)	Inside Temperature (C)								
	12	14	16	18	20	22	24	26	28
-20	1.13	1.13	1.14	1.15	1.16	1.17	1.17	1.18	1.19

-15	1.10	1.11	1.12	1.13	1.14	1.14	1.15	1.16	1.17
-10	1.08	1.09	1.10	1.11	1.11	1.12	1.13	1.14	1.14
-5	1.06	1.07	1.08	1.09	1.09	1.10	1.11	1.12	1.12
0	1.04	1.05	1.06	1.07	1.07	1.08	1.09	1.10	1.10
5	1.03	1.03	1.04	1.05	1.05	1.06	1.07	1.08	1.08
10	1.01	1.01	1.02	1.03	1.04	1.04	1.05	1.06	1.06
15	0.99	1.00	1.00	1.01	1.02	1.02	1.03	1.04	1.05
20	0.97	0.98	0.99	0.99	1.00	1.01	1.01	1.02	1.03
25	0.96	0.96	0.97	0.98	0.98	0.99	1.00	1.00	1.01
30	0.94	0.95	0.95	0.96	0.97	0.97	0.98	0.99	0.99
35	0.93	0.93	0.94	0.94	0.95	0.96	0.96	0.97	0.98

~~Table 1b. Temperature Correction Factors for Depressurization Testing, Calculated According to ASTM E779-10~~

	Inside Temperature (F)								
Outside Temp (F)	50	55	60	65	70	75	80	85	90
-20	0.86	0.85	0.85	0.84	0.83	0.82	0.81	0.81	0.80
-10	0.88	0.87	0.87	0.86	0.85	0.84	0.83	0.83	0.82
0	0.90	0.89	0.88	0.88	0.87	0.86	0.85	0.84	0.84
10	0.92	0.91	0.90	0.90	0.89	0.88	0.87	0.86	0.85
20	0.94	0.93	0.92	0.91	0.91	0.90	0.89	0.88	0.87
30	0.96	0.95	0.94	0.93	0.92	0.92	0.91	0.90	0.89
40	0.98	0.97	0.96	0.95	0.94	0.93	0.93	0.92	0.91
50	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.94	0.93
60	1.02	1.01	1.00	0.99	0.98	0.97	0.96	0.95	0.95
70	1.04	1.03	1.02	1.01	1.00	0.99	0.98	0.97	0.96
80	1.06	1.05	1.04	1.03	1.02	1.01	1.00	0.99	0.98
90	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00
100	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02
110	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04

	~~Inside Temperature (C)~~								
~~Outside Temp (C)~~	~~12~~	~~14~~	~~16~~	~~18~~	~~20~~	~~22~~	~~24~~	~~26~~	~~28~~
~~-20~~	~~0.89~~	~~0.88~~	~~0.88~~	~~0.87~~	~~0.86~~	~~0.86~~	~~0.85~~	~~0.85~~	~~0.84~~
~~-15~~	~~0.91~~	~~0.90~~	~~0.89~~	~~0.89~~	~~0.88~~	~~0.87~~	~~0.87~~	~~0.86~~	~~0.86~~
~~-10~~	~~0.92~~	~~0.92~~	~~0.91~~	~~0.90~~	~~0.90~~	~~0.89~~	~~0.89~~	~~0.88~~	~~0.87~~
~~-5~~	~~0.94~~	~~0.93~~	~~0.93~~	~~0.92~~	~~0.91~~	~~0.91~~	~~0.90~~	~~0.90~~	~~0.89~~
~~0~~	~~0.96~~	~~0.95~~	~~0.94~~	~~0.94~~	~~0.93~~	~~0.93~~	~~0.92~~	~~0.91~~	~~0.91~~
~~5~~	~~0.98~~	~~0.97~~	~~0.96~~	~~0.96~~	~~0.95~~	~~0.94~~	~~0.94~~	~~0.93~~	~~0.92~~
~~10~~	~~0.99~~	~~0.99~~	~~0.98~~	~~0.97~~	~~0.97~~	~~0.96~~	~~0.95~~	~~0.95~~	~~0.94~~
~~15~~	~~1.01~~	~~1.00~~	~~1.00~~	~~0.99~~	~~0.98~~	~~0.98~~	~~0.97~~	~~0.96~~	~~0.96~~
~~20~~	~~1.03~~	~~1.02~~	~~1.01~~	~~1.01~~	~~1.00~~	~~0.99~~	~~0.99~~	~~0.98~~	~~0.97~~
~~25~~	~~1.05~~	~~1.04~~	~~1.03~~	~~1.02~~	~~1.02~~	~~1.01~~	~~1.00~~	~~1.00~~	~~0.99~~
~~30~~	~~1.06~~	~~1.06~~	~~1.05~~	~~1.04~~	~~1.03~~	~~1.03~~	~~1.02~~	~~1.01~~	~~1.01~~
~~35~~	~~1.08~~	~~1.07~~	~~1.07~~	~~1.06~~	~~1.05~~	~~1.04~~	~~1.04~~	~~1.03~~	~~1.02~~

3.4.1.6. The Effective Leakage Area (ELA) shall be calculated using Equation 2~~3~~:

$$ELA(in^2) = \frac{Corrected\ CFM50}{18.2} \quad (2\cancel{3}a)$$

$$ELA(m^2) = \frac{Corrected\ CMS50}{9.13} \quad (2\cancel{3}b)$$

3.4.2. Multi-Point Airtightness~~Air Leakage~~ Test

3.4.2.1. 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 Building Pressure.

3.4.2.2. The Air-Moving Fan shall be unsealed, turned on, and adjusted to create at least five~~a range of~~ 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 induced enclosure pressure minus the Pre-Test Baseline Building 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 house shall be recorded.

At each pressure station, the average value of the induced enclosure pressure difference, the airflow, and the temperature, 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) cannot be achieved, the One-Point Airtightness~~Air Leakage~~ Test in Section 3.4.1 shall be used.

3.4.2.3. The Air-Moving Fan shall be turned off and the home returned to its as-found condition.

3.4.2.4. The airflow at each pressure station shall be corrected for altitude and temperature to determine the corrected airflow using the calculations in Section 9 of ASTM E779-10[2]~~Equation 2~~.

3.4.2.5. The corrected airflow (Q) and the induced enclosure pressure difference measured at each pressure station (dP) shall be used in a log-linearized regression of the form $Q = C(dP)^n$ (e.g., using the procedures in ASTM E779-10, Section 9 and Annex A.1) to calculate C and n[3].

3.4.2.6. The Effective Leakage Area (ELA) shall be calculated using Equation 3~~4~~:

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

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

Where C and n are the values determined in Section 3.4.2.5.

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

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

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

[2] Software provided by manufacturers of test equipment may be used to perform these calculations if the manufacturer certifies that the calculations are performed in accordance with ASTM E779-10.

[3] Alternatively, the Rater shall use software provided by the test equipment manufacturer that automatically calculates C and n if the manufacturer certifies that the calculations are performed in accordance with ASTM E779-10.

Where C and n are the values determined in Section 3.4.2.5.

3.5. Procedure to Apply Results of Enclosure Air Leakage Test

~~**3.5.1.** If the results of the building enclosure air leakage test are to be used for the purpose of calculating the expected energy savings from a retrofit, conducting an energy audit, or assessing the relative enclosure air leakage of a group of buildings, then the corrected airflow determined in Section 3.4.1.5 or Section 3.4.2.4 shall be used.~~

~~3.5.2.~~3.5.1. If the results of the building enclosure air leakage test are to be used for conducting a home energy rating or assessing compliance with a building enclosure leakage limit (e.g., defined by code or by an energy efficiency program), then the corrected airflow determined using a one-point test shall be adjusted using Equation 5~~5~~a or 5~~5~~b~~ and the corrected airflow determined using a multi-point test shall be adjusted using Equation 6a or 6b~~.

Adjusted CFM50 = 1.1~~22~~ x Corrected CFM50 (5~~5~~a)

Adjusted CMS50 = 1.1~~22~~ x Corrected CMS50 (5~~5~~b)

~~*Adjusted CFM50 = 1.1 x Corrected CFM50* (6a)~~

~~*Adjusted CMS50 = 1.1 x Corrected CMS50* (6b)~~

The ELA determined in Section 3.4.1.6 for a o~~O~~ne-p~~P~~oint a~~A~~ir l~~L~~eakage t~~T~~est shall be adjusted using ~~Equation 7a or the ELA determined for a Multi-Point Air Leakage Test in Section 3.4.2.6 shall be adjusted using~~ Equation 6~~7b~~.

Adjusted ELA = 1.1~~22~~ x ELA (6~~7a~~)

~~*Adjusted ELA = 1.1 x ELA* (7b)~~Other applications of building enclosure air leakage testing and the results of multi-point testing do not require the corrections in this section.

~~3.5.3.~~3.5.2. If the results of the building 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), or Normalized Leakage Area (NLA), then Equations 7~~8~~ through 9~~10~~ shall be used~~, as applicable, where CFM50, CMS50, and ELA have been adjusted in section 3.5.2, if necessary~~.

ACH50 = CFM50 x 60 / Infiltration Volume~~Building Volume~~ in cubic feet (7~~8~~a)

ACH50 = CMS50 x 60 / Infiltration Volume~~Building Volume~~ in cubic meters (7~~8~~b)

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SLA = 0.00694 x ELA in in^2 */ Conditioned~~Building~~ Floor Area in square feet* (8~~9~~a)

SLA = 10.764 x ELA in m^2 */ Conditioned~~Building~~ Floor Area in square meters* (8~~9~~b)

NLA = SLA x $(S)^{0.4}$*, where S is the number of stories above grade* (9~~10~~)

4. Procedure for Measuring ~~Leakage~~ Airtightness of Duct Systems

In addition to the test procedures in this section, test method A from ASTM E1554-13 is approved for use provided that the building and duct system preparation procedures in Section 4.2 of this standard are followed.

~~For multifamily buildings where each unit has its own duct system, each unit shall be tested individually.~~ The leakage to outside test shall be performed using a Blower Door in the main entry to the unit to pressurize 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 (such as to deck or patio) shall be used. Only the ducts in the home being~~unit under test are~~ tested shall be included in the air leakage test.

4.1. Equipment Needed

~~4.1.~~ The equipment below shall be tested at least annually for calibration using the manufacturer's calibration procedure.

4.1.1. 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~~1~~ in. H_2O).

4.1.2. Manometer. A device that can measure pressure difference with an accuracy of ± 1~~5~~ % of reading~~the measured pressure~~ or 0.25 Pa (0.0010~~001~~ in. H2O), whichever is greater.

4.1.3. Flow Meter. A device to measure volumetric airflow with an accuracy equal to or better than ± 5% of the measured flow.

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

4.1.5. Duct Leakage Tester. A device that combines an Air-Moving Fan as defined in Section 4.1.1 and a Flow Meter as defined in Section 4.1.3.

4.2. Procedure to Prepare the Building and the Duct System for Testing

4.2.1. The presence of all components that are included in the HVAC design for the rated home (e.g., heating, cooling, ventilation, dehumidification, humidification, and filtration components) and integrated with the duct system shall be verified, such that leakage from these components will be captured when the test is conducted. If these components have not yet been installed (e.g., an air handler has not yet been installed a new home), then the test shall not be conducted.

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~~4.2.1.~~4.2.2. The HVAC system controls shall be adjusted so that the air handler fan does not turn on during the test.

~~4.2.2.~~4.2.3. Any fans that could change the pressure in either the ~~conditioned space~~Conditioned Space Volume or any spaces containing ducts or air handlers (e.g., bathroom fans, clothes dryers, kitchen vent hood, attic fan) shall be turned off.

~~4.2.3.~~4.2.4. All vented combustion appliances shall be turned off if there is a possibility that the space containing the appliance will be depressurized during the test procedure.

~~4.2.4.~~4.2.5. All filters in the duct system and air handler cabinet shall be removed. If the Duct Leakage Tester is installed at a return grille, any filters present at that grille shall also be removed. If present, filter slot cover(s) shall be replaced after removing filters.

~~4.2.5.~~4.2.6. Dampers within the duct system shall be treated as follows:

~~4.2.5.1.~~4.2.6.1. Non-motorized dampers (e.g., pressure-activated operable dampers, fixed dampers) that connect the Conditioned Space Volume ~~conditioned space~~ (including space conditioning duct systems) to the exterior or to Unconditioned Space Volume~~unconditioned spaces~~ shall be left in their as-found positions. 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.

~~4.2.5.2.~~4.2.6.2. Motorized dampers that connect the Conditioned Space Volume ~~conditioned space~~ (including space conditioning duct systems) to the exterior or to Unconditioned Space Volume~~unconditioned spaces~~ shall be placed in their closed positions and shall not be further sealed.

~~4.2.5.3.~~4.2.6.3. All zone and bypass dampers shall be set to their open position to allow uniform pressures throughout the duct system.

~~4.2.5.4.~~4.2.6.4. All balancing dampers shall be left in their as-found position.

~~4.2.6.~~4.2.7. Non-dampered ventilation openings within the duct system shall be treated as follows:

~~4.2.6.1.~~4.2.7.1. Non-dampered ventilation openings of intermittently operating whole-house ventilation systems, including HVAC fan-integrated outdoor air inlets, that connect the Conditioned Space Volume ~~conditioned space~~ (including space conditioning duct systems) to the exterior or to Unconditioned Space Volume~~unconditioned spaces~~ shall not be sealed.

~~4.2.6.2.~~4.2.7.2. Non-dampered ventilation openings of continuously operating whole-house ventilation systems that connect the Conditioned Space Volume ~~conditioned space~~ (including space conditioning duct systems) to the exterior or ~~to unconditioned spaces~~to Unconditioned

Space Volume shall be sealed, preferably at the exterior of the enclosure.

~~4.2.7.~~4.2.8. Supply registers and return grilles shall be temporarily sealed at both the face and the perimeter. Registers atop carpets are permitted to be removed and the face of the duct boot temporarily sealed during testing. For homes without registers and grilles present (e.g., new construction), the face of the duct boots shall be sealed instead.

4.3. Procedure to Install the Test Apparatus and Prepare for ~~Leakage~~ Airtightness Test

There are two acceptable methods for attaching the Duct Leakage Tester to the duct system. Method 1 may only be used for duct systems with three or fewer return grilles.

- *Method 1 Installation*. The Duct Leakage Tester shall be attached to the return grille closest to the air handler. The remaining opening in the return grille shall be temporarily sealed.
- *Method 2 Installation*. The air handler blower access panel shall be removed and the Duct Leakage Tester attached to the blower compartment access.

Exception 1: If local codes require licensing that the inspector or rater conducting the test has not obtained in order to remove the blower access panel, Method 1 is permitted to be used even if there are more than three returns. Method 2 is permitted to be used for all systems.

Exception 2: If the total duct leakage is less than 50 cfm (25 L/s) then either method may be used.

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4.3.1. If the duct leakage to outside will be measured then a Blower Door shall be installed in the enclosure per Section 3.3.1 and 3.3.2.

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

Note*: When using Method 1 for a duct system with more than three returns (based on the exception in Section 4.3), then Section 4.3.2.4 shall be used.*

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

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

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

4.3.2.4. A single static pressure probe shall be located according to Section 4.3.2.1, 4.3.2.2, or 4.3.2.3, and a second probe 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.

4.3.3. The Manometer and tubing for the Duct Leakage Tester shall be connected to the pressure probe(s) installed in Section 4.3.2, 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.

If Section 4.3.2.4 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.

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

4.4. Procedure to Conduct ~~Leakage~~ Airtightness Test

The total leakage of the duct system shall be measured using the total duct leakage test in Section 4.4.1 or the leakage of the duct system to the outside shall be measured using the duct leakage to outside test in Section 4.4.2.

4.4.1. Total Duct Leakage Test

4.4.1.1. If ducts run through Unconditioned Space Volume such as 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 and the outside shall be opened to prevent changes in building pressure when the Duct Leakage Tester is running.

4.4.1.2. 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. H2O) with reference to outside.~~Pa (±0.5 Pa).~~ 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 can be 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 cannot be 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.

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

4.4.1.4. The Duct Leakage Tester shall be turned off and the home returned to its as-found condition.

4.4.1.5. If an induced duct system pressure difference of 25 Pa (0.1 in. H_2O) was not achieved in Section 4.4.1.2, then the recorded airflow ($CFM_{measured}$, $CMS_{measured}$) shall be converted to a nominal airflow at 25 Pa (0.1 in. H_2O) (CFM25, CMS25) using Equation 10~~1~~. Alternately, a Manometer that is equipped to automatically make the conversion to CFM25 or CMS25 is permitted to be used.

$$CFM25 = CFM_{measured}\left(\frac{25}{dP}\right)^{0.6}$$ (10~~1~~a)

$$CMS25 = CMS_{measured}\left(\frac{25}{dP}\right)^{0.6}$$ (10~~1~~b)

4.4.2. Duct Leakage to Outside Test

4.4.2.1. If ducts run through ~~unconditioned spaces~~Unconditioned Space Volume such as attics, garages or crawlspaces, any vents, access panels, doors, or windows between those spaces and the outside shall be opened.~~in normal operating condition.~~ All exterior doors and windows between the ~~building~~ Conditioned Space Volume and outside shall be closed, and other openings to the outside that may 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.

4.4.2.2. 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 Building Pressure.

4.4.2.3. 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 ~~(±0.5 Pa)~~ (0.1 ±0.012~~002~~ in. H_2O ~~±0.002~~), defined as the induced enclosure pressure minus the Pre-Test Baseline Building Pressure. Note that this value is permitted to be positive or negative, which will be dependent upon whether the enclosure is pressurized or depressurized.

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

4.4.2.4. 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 house. If an induced duct system pressure difference of 0.0 Pa (0.0 in. H_2O) cannot be achieved, 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) can be achieved.

4.4.2.5. The induced enclosure pressure difference shall be re-checked and, if necessary, the Air-Moving Fan for the enclosure shall be adjusted to maintain 25 Pa (0.10 in. H_2O) or the highest achievable value up to 25 (0.10 in. H_2O) Pa, per Section 4.4.2.3, or the airflow required to maintain an induced duct system pressure difference of 0.0 Pa (0.0 in. H_2O), per Section 4.4.2.4.

4.4.2.6. The induced duct system pressure difference shall be re-checked and, if necessary, the Duct Leakage Tester shall be adjusted to maintain 0.0 ± 0.5 Pa (0.0±0.002 in. H_2O), per Section 4.4.2.4.

4.4.2.7. Repeat 4.4.2.5 and 4.4.2.6 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 can be 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 cannot be 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.

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

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

4.4.2.10. 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 11. Alternately, a Manometer that is equipped to automatically make the conversion to CFM25 or CMS25 is permitted to be used.

4.5. Procedure to Apply Results of Duct System Leakage Test

4.5.1. If the results of the duct system leakage test are to be used for assessing compliance with a limit on total duct system leakage (e.g., defined by code or by an energy efficiency program), then the total duct leakage determined in Section 4.4.1.2 or 4.4.1.5 shall be used.

4.5.2. 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 (e.g., defined by code, by an energy efficiency program, or for a home energy rating), then the duct system leakage to outside determined in Section 4.4.2.7 or 4.4.2.10 shall be used. Alternatively, the total duct leakage determined in Section 4.4.1.2 or 4.4.1.5 is permitted to be used as if it were the leakage to outside (e.g., the total leakage value is permitted to be used in software as if it were leakage to the outside).

4.5.3. 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 4.4.2.7 or 4.4.2.10 shall be used.

5. 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, such as a whole-house ventilation system (e.g., an outdoor air duct connected to~~ventilation inlet on~~ the return trunk~~side~~ of an HVAC system, an in-line supply fan, an HRV, or an ERV) or a local mechanical exhaust system (e.g., bathroom exhaust fan, kitchen exhaust fan)[4].

The airflow is permitted to be measured at the inlet terminal, per Section 5.1; or at the outlet terminal, per Section 5.2; or mid-stream in the ventilation duct, per Section 5.3.

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

[4] Informative Note: Measuring the ~~A multifamily building that has~~ ventilation air supplied to corridors ~~for the purpose~~ of multifamily buildings is beyond the scope of this standard. However, measuring the flow rate of exhaust systems used for whole house mechanical~~fresh air distribution to dwelling units does not have a~~ ventilation in~~system separate from other dwelling units, even if each dwelling has~~ individual dwelling units is~~continuous exhaust ventilation. Although measurement of the individual dwelling exhaust could be considered~~ within the scope of this standard~~, the overall ventilation system for each dwelling includes the central corridor supply system, and is thus outside the scope of this standard~~.

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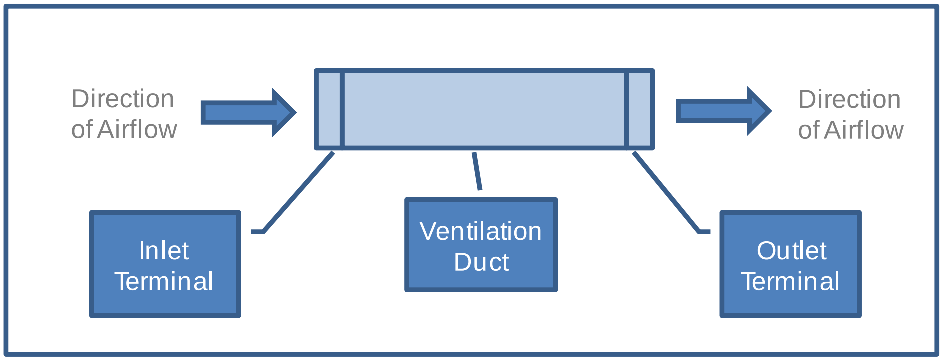

5.1. Procedure to Measure Airflow at Inlet Terminal

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 5.1.1); using an Airflow Resistance Device (Section 5.1.2); or using a Passive Flow Hood (Section 5.1.3).

5.1.1. Powered Flow Hood

5.1.1.1. Equipment Needed

~~5.1.1.1.~~ The equipment below shall be tested at least annually for calibration using the manufacturer's calibration procedure

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

5.1.1.1.2. Manometer. A device that can measure the static pressure inside the flow capture element relative to the room with an accuracy equal to or better than ±1% of reading or 0.25 Pa (0.0010 in. H2O),~~± 5 % or 0.25 Pa (0.001 in. H₂O),~~ whichever is greater.

5.1.1.2. Procedure to Conduct Airflow Test

5.1.1.2.1. 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.

5.1.1.2.2. 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.

5.1.1.2.3. 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.

5.1.2. Airflow Resistance Device

5.1.2.1. Equipment Needed

~~5.1.2.1.~~ The equipment below shall be tested at least annually for calibration using the manufacturer's calibration procedure.

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5.1.2.1.1. 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.

5.1.2.1.2. Manometer. A device that can measure pressure difference with an accuracy equal to or better than ±1% of reading or 0.25 Pa (0.0010 in. H2O), ~~± 5 % or 0.25 Pa (0.001 in. H_2O),~~ whichever is greater.

5.1.2.2. Procedure to Conduct Airflow Test

5.1.2.2.1. 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.

5.1.2.2.2. The opening area of the Airflow Resistance Device shall be adjusted until, using the Manometer, the pressure difference between the flow capture element and the room is between 1 and 8~~5~~ Pa.

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

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

$$Airflow\ (CFM) = Opening\ Area\ x\ 1.07\ x\ (dP)^{0.5} \quad (11\cancel{2}a)$$

$$Airflow\ (L/s) = Opening\ Area\ x\ 0.078\ x\ (dP)^{0.5} \quad (11\cancel{2}b)$$

Where:

For Eq. 11~~2~~a, Opening Area is in in^2 and dP is in Pa

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

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

5.1.3. Passive Flow Hood

5.1.3.1. Equipment Needed

~~5.1.3.1.~~ The equipment below shall be tested at least annually for calibration using the manufacturer's calibration procedure.

5.1.3.1.1. 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 an accuracy equal to or better than ± 5 % or 5 cfm (2.5 L/s or 0.0025 m^3/s), whichever is greater.

5.1.3.1.2. Manometer. A device that can measure pressure difference with an accuracy equal to or better than ±1% of reading or 0.25 Pa (0.0010 in. H2O)~~± 5 % or 0.25 Pa (0.001 in. H₂O)~~, whichever is greater.

5.1.3.2. Procedure to Conduct Airflow Test

5.1.3.2.1. 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.

5.1.3.2.2. The pressure tubing shall be inserted inside the flow capture element between the Airflow Meter and inlet terminal.

5.1.3.2.3. The pressure difference between the flow capture element and the room shall be measured using the Manometer. If the pressure difference is more than 8~~5~~ Pa, the procedure shall be terminated and no results recorded.

5.1.3.2.4. If the pressure difference is ≤ 8~~5~~ Pa (0.03~~2~~ in H_2O), then the average volumetric airflow through the Airflow Meter, measured over at least a 10 second period, shall be recorded.

5.2. 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 5.2.1) or using a Bag Inflation Device (Section 5.2.2).

5.2.1. Powered Flow Hood. To measure airflow at an outlet terminal using a Powered Flow Hood, Section 5.1.1 shall be followed except with all occurrences of the phrase "inlet terminal" replaced with "outlet terminal".

5.2.2. Bag Inflation Device

5.2.2.1. Equipment Needed

5.2.2.1.1. Bag Inflation Device. A flow capture element capable of creating an airtight perimeter seal around the outlet terminal that is connected to a plastic bag of known volume and holds the bag open (e.g., a lightweight frame made of wood, plastic or metal wire), and a shutter that controls airflow into the bag.

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

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

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

5.2.2.2. Procedure to Conduct Airflow Test

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

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

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

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

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

$$Airflow\ (CFM) = \frac{8 \times Volume}{Elapsed\ Time}$$ (12~~3~~a)

$$Airflow\ (L/s) = \frac{4 \times Volume}{Elapsed\ Time}$$ (12~~3~~b)

Where:

Volume = The volume of the plastic bag, in gallons

Elapsed Time = The time that elapsed until the bag was filled, in seconds.

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

This Section defines a procedure to measure the airflow of a mechanical ventilation system mid-stream in the ventilation duct. The airflow is permitted to be measured using an Airflow Measurement Station (Section 5.3.1) or using an Integrated Diagnostic Tool (Section 5.3.2).

5.3.1. Equipment Needed

5.3.1.1. Airflow Measurement Station. An Airflow Measurement Instrument capable of simultaneously measuring and averaging velocity pressure at a minimum of five locations across a duct diameter with an accuracy equal to or better than +/- 10% or 5 CFM (2.5 L/s), whichever is greater, coupled with a section of permanently installed smooth-walled ductwork designed to facilitate accurate readings (i.e., the Station). The Airflow Measurement Instrument shall either be temporarily inserted into the Station for the duration of the procedure or be permanently installed as part of the Station (e.g., as part of a manufacturer-assembled device consisting of the instrument factory-mounted in a housing). In either case, the Airflow Measurement Instrument shall contain a port that allows it to be connected to a Manometer. Any temporary air flow station shall be tested at least annually for calibration using the manufacturer's calibration procedure.

5.3.1.2. Manometer. A device that can measure pressure difference with an accuracy equal to or better than ±1% of reading or 0.25 Pa (0.0010 in. H2O)~~± 5 % or 0.25 Pa (0.001 in. H_2O)~~, whichever is greater.

5.3.2. Procedure to Conduct Airflow Test

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

5.3.2.2. To minimize turbulence and ensure an accurate reading, the installation shall be visually verified to comply with the Airflow Measurement Instrument's specifications for minimum distance to both upstream and downstream duct fittings and fan outlets.

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

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

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

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

5.3.2.7. Equation 13~~4~~ shall be used to convert the average velocity to airflow.

$$Airflow\ (CFM) = V\ x\ A \qquad (13\cancel{4}a)$$

$$Airflow\ (L/s) = 1000\ x\ V\ x\ A \qquad (13\cancel{4}b)$$

Where:

For Equation 13~~4~~a, V = Velocity, in fpm, and A = Cross-Sectional Duct Area, in ft^2.

For Equation 134b, V = Velocity, in m/s, and A = Cross-Sectional Duct Area, in m^2.

5.3.3. Integrated Diagnostic Tool

5.3.3.1. Equipment

5.3.3.1.1. Integrated Diagnostic Tool. A tool that is integrated into the ventilation equipment (e.g., pressure taps, a device that measures a parameter such as watt draw that can be translated to airflow) that permits assessment of airflow with a manufacturer-reported accuracy equal to or better than ±15% of the measured flow at the highest speed setting of the ventilation equipment.

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

6. Hazards

6.1 Equipment Guards—The air-moving equipment shall have proper guards or cages to house the fan or blower and to prevent accidental access to any moving parts of the equipment.

6.2 Personal Protective Equipment—Use of safety equipment appropriate for general fieldwork is required; including safety shoes, dust masks/respirators, eye protection, hearing protection and hard hats.

6.3 Debris and Fumes—The blower or fan forces a large volume of air into or out of a building while in operation. Caution shall be exercised against sucking debris or exhaust gases from fireplaces and flues into the interior of the building. 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 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.

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

7. Definitions

Blower Door – A device that combines an Air-Moving Fan as defined in Section 3.1.1, an Airflow Meter as defined in Section 3.1.3, and a covering to integrate the Air-Moving Fan into the building opening.

Conditioned Floor Area (CFA) – The floor area of the Conditioned Space Volume within a building, minus the floor area of attics, floor cavities, and crawlspaces, and basements below air sealed and insulated floors. The following specific spaces are addressed to ensure consistent application of this definition:

- The floor area of a wall cavity that is Conditioned Space Volume shall be included.
- The floor area of a basement shall only be included if the Rater has obtained a Manual J, S, and 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.
- The floor area of a garage shall be excluded, even if it is conditioned.
- The floor area of a thermally isolated sunroom shall be excluded.
- The floor area of an attic shall be excluded, even if it is Conditioned Space Volume.
- The floor area of a floor cavity shall be excluded, even if it is Conditioned Space Volume.
- The floor area of a crawlspace shall be excluded, even if it is Conditioned Space Volume.

Conditioned Space Volume - The volume within a building 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 cavity meets this definition, then the volume of the floor cavity shall also be included. Otherwise the volume of the floor cavity shall be excluded.
- If the volume of one or both of the spaces horizontally adjacent to a wall cavity meets this definition, then the volume of the wall cavity shall also be included. Otherwise, the volume of the wall cavity shall be excluded.
- The volume of an attic that is not air sealed and insulated at the roof deck shall be excluded.
- The volume of a vented crawlspace shall be excluded.
- The volume of a garage shall be excluded, even if it is conditioned.
- The volume of a thermally isolated sunroom shall be excluded.
- The volume of an attic this is air sealed and insulated at the roof deck, an unvented crawlspace, or a basement shall only be included if the Rater has obtained a Manual J, S, and 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.

Crawl Space-A shallow unfinished space, beneath the first floor or under the roof of a building allowing access to wiring or plumbing.

Infiltration Volume – The sum of the Conditioned Space Volume and Unconditioned Space Volume in the dwelling unit, minus the volume of:

- Floor cavities that have Unconditioned Space Volume both above and below,
- Unconditioned wall cavities,
- Attics that are air sealed and insulated at the roof deck,
- Vented crawlspaces,
- Garages,
- Basements, if the door between the basement and Conditioned Space Volume is closed during enclosure air leakage testing (Section 3.2.5), and,
- Thermally isolated sunrooms.

Unconditioned Space Volume **-** The volume within a building that is not Conditioned Space Volume but which may contain 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:

- The volume of a floor cavity shall be included, unless the volume both above and below the floor cavity meets the definition of Conditioned Space Volume.
- The volume of a wall cavity shall be included, unless the wall cavity meets the definition of Conditioned Space Volume.
- The volume of a vented attic shall be included.
- The volume of a vented crawlspace shall be included.
- The volume of a garage shall be included, even if it is conditioned.
- The volume of a thermally isolated sunroom shall be included.
- The volume of an attic sealed and insulated at the roof deck, an unvented crawlspace, or a basement shall be included unless it meets the definition of Conditioned Space Volume.

8. References

ASHRAE Standard 62.2-2013 "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings", ASHRAE, Atlanta, GA.

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

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