RESNET/ICC 380 Standard

Jonathan Jones

Miguel Rodriguez

Home Builders Association Tri-Cities

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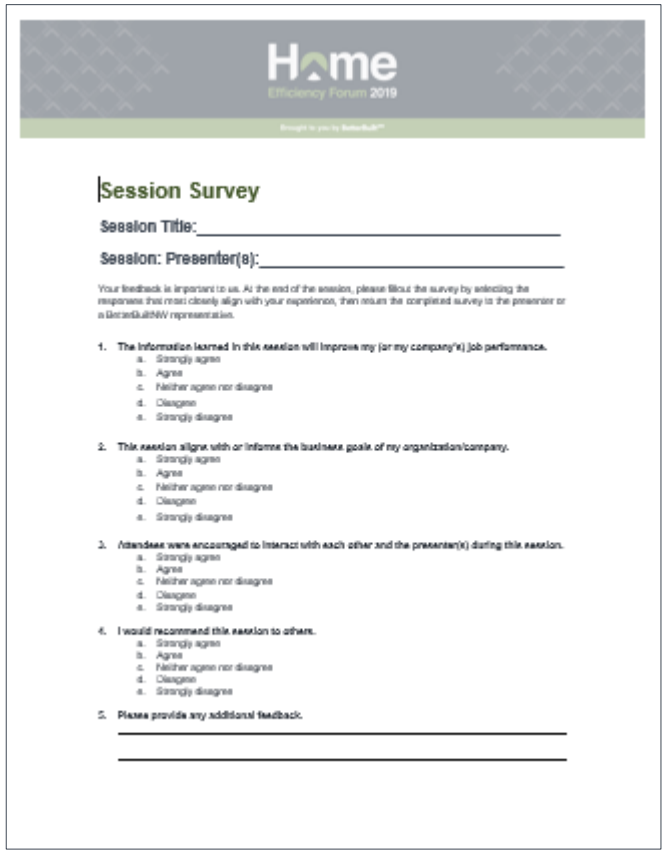

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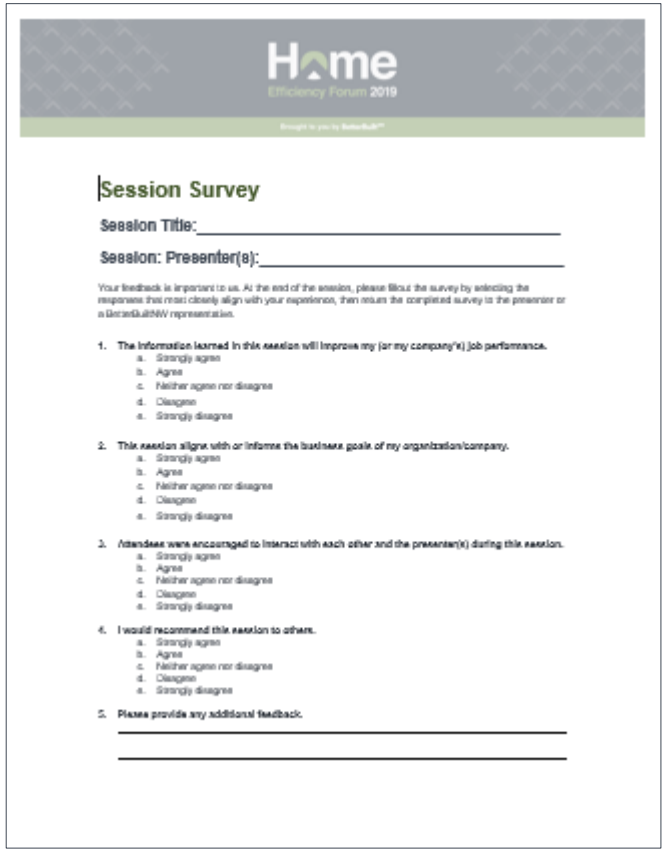
- Jonathan Jones



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What are we covering today?

- Overview of procedures
- Duct Testing
- Blow Door Testing
- Ventilation

Part 1:

BLOW DOOR TESTING

Measuring Airtightness of Building/Dwelling Unit Enclosure Procedure (Blow Door Testing)

- Equipment
- Preparing the Building for Testing
- Installing the Test Apparatus & Preparing for Air Tightness Test
- Conducting the Airtightness Test
- Apply Results of Enclosure Air Leakage Test

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

4.1. Equipment

- **4.1. Equipment -** The Equipment listed in this section shall have their calibrations checked at the manufacturer's recommended interval, and at least annually if no time is specified.
- **4.1.1.** Air-Moving Fan. A fan that is capable of moving air into or out of the building or Dwelling Unit to achieve one or more target pressure differences between the building or Dwelling Unit and the exterior.
- **4.1.2.** Manometer. A device that is capable of measuring pressure difference with a maximum error of 1 % of reading, or 0.25 Pa (0.001 in. H2O), whichever is greater.

4.1. Equipment

- **4.1.3.** Airflow Meter. A device to measure volumetric airflow with a maximum error of 5% of the measured flow.
- **4.1.4.** Thermometer. An instrument to measure air temperature with an accuracy of ±1°C (2°F).
- **4.1.5.** Blower Door. A device that combines an Air-Moving Fan as defined in Section 4.1.1, an Airflow Meter as defined in Section 4.1.3, and a covering to integrate the Air-Moving Fan into the building opening.

4.2 Preparing the Building for Testing

- 4.2.1 Fenestration – All exterior doors & windows must be closed & latched.
- 4.2.2 Attached garages – Exterior garage doors & windows must be closed unless the blower door is installed between the conditioned space volume & garage, in which one garage door should be opened.
- 4.2.3 Crawlspaces – Including hatches should be closed. Crawlspaces should be excluded from the Infiltration & Conditioned Space Volume.

4.2 Preparing the Building for Testing

- 4.2.3.1 If a crawlspace is vented to the exterior, interior access doors and hatches between the Conditioned Space Volume and the crawlspace shall be closed. Exterior crawlspace access doors, hatches, and vents shall be left in their as-found position.
- 4.2.3.2 If a crawlspace is not vented to the exterior, all access doors and hatches between the Conditioned Space Volume and crawlspace shall be opened. Exterior crawlspace access doors, hatches, and vents shall be closed to the extent possible.

4.2 Preparing the Building for Testing

- 4.2.3.2.1 Exception: If the floor above the crawlspace is air sealed and insulated, the access doors and hatches between the Conditioned Space Volume and crawlspace shall be closed. Exterior crawlspace access doors, hatches, and vents shall be left in their as-found position.
- 4.2.4 (Attics) - Attics shall be configured as follows and the position of the attic access doors and hatches shall be recorded. When the access doors and hatches between the Conditioned Space Volume and the attic are closed, due to requirements in 4.2.4.1 or there are no access doors, the attic shall be excluded from Infiltration Volume and Conditioned Space Volume.

4.2 Preparing the Building for Testing

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

4.2 Preparing the Building for Testing

- **4.2.5. Basements.** Basements shall be configured as follows and the position of the basement doors shall be recorded. When doors between the Conditioned Space Volume and the basement are closed, due to requirements in 4.2.5.1.1, the basement shall be excluded from Infiltration Volume and Conditioned Space Volume.
- **4.2.5.1.** All doors between the Conditioned Space Volume and basement shall be opened. Exterior basement access doors, vents, and hatches shall be closed to the extent possible.

4.2 Preparing the Building for Testing

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

4.2 Preparing the Building for Testing

- 4.2.7. **Chimney dampers and combustion-air inlets on solid fuel appliances.** Chimney dampers and combustion-air inlets on solid fuel appliances shall be closed. Precautions shall be taken to prevent ashes or soot from entering the building or Dwelling Unit during testing.
- 4.2.8. **Combustion appliance flue vents.** Combustion appliance flue vents shall be left in their as-found position.

4.2 Preparing the Building for Testing

- 4.2.9. **Fans.** Any fan or appliance capable of inducing airflow across the building or Dwelling Unit enclosure shall be turned off including, but not limited to, clothes dryers, attic and crawlspace fans, kitchen and bathroom exhaust fans, air handlers, and ventilation fans used in a Dwelling Unit Mechanical Ventilation system. The party conducting the test shall not turn on fans in adjacent attached Dwelling Units. For continuously operating central ventilation systems serving more than one Dwelling Unit in a building with multiple Dwelling Units, the registers shall be sealed in the subject Dwelling Unit. The central ventilation system shall be turned off where possible. If it is not possible to turn off the system, then it can be left operating provided sealing select registers will not compromise the system and the sealed registers remain sealed during the test.

4.2 Preparing the Building for Testing

- 4.2.10. **Dampers**
- 4.2.10.1. Non-motorized dampers7 that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volumes shall be left in their as-found positions.8
- 4.2.10.2. Motorized dampers that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volume shall be placed in their closed positions and shall not be further sealed.
- 4.2.11. **Non-dampered openings for ventilation, combustion air and make-up air**
- 4.2.11.1. Non-dampered ventilation openings of intermittently operating local exhaust ventilation systems9 that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volume shall be left open.

4.2 Preparing the Building for Testing

- **4.2.11.2.** Non-dampered ventilation openings of intermittently operating Dwelling Unit ventilation systems, including HVAC fan-integrated outdoor air inlets, that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volume shall not be sealed.
- **4.2.11.3.** Non-dampered ventilation openings of continuously operating local exhaust ventilation systems10 that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volume shall be sealed at the exterior of the enclosure where conditions allow.

4.2 Preparing the Building for Testing

- **4.2.11.4.** Non-dampered ventilation openings of continuously operating Dwelling Unit ventilation systems that connect the Conditioned Space Volume to the exterior or to Unconditioned Space Volume shall be sealed at the exterior of the enclosure where conditions allow.
- **4.2.11.5.** All other non-dampered intentional openings between Conditioned Space Volume and the exterior or Unconditioned Space Volume shall be left open.11 This includes non-dampered openings to a duct, unless it has a fan that is independent of the HVAC air-handler fan directly connected to the duct and continuously inducing a pressure difference12.

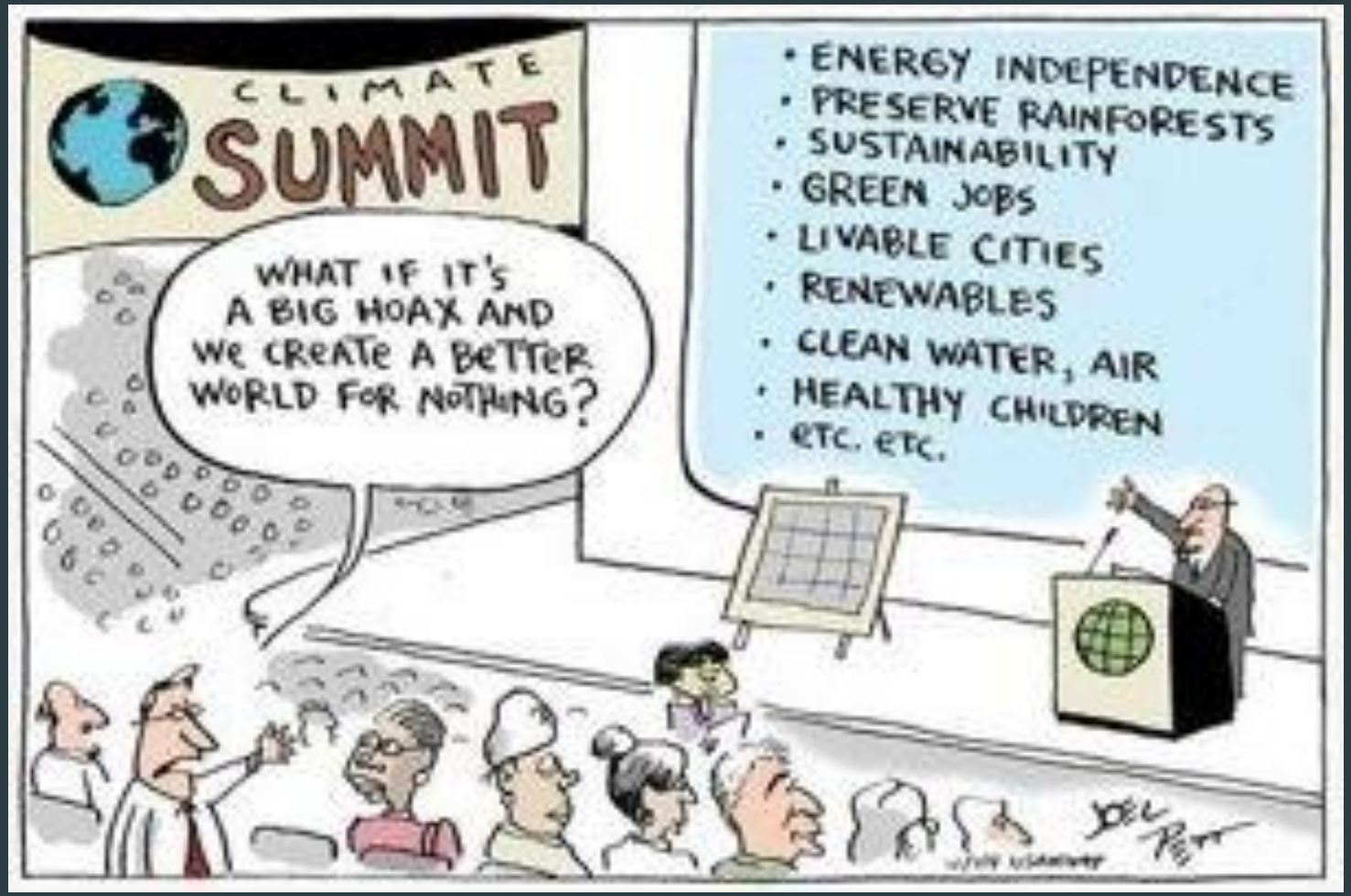
4.2 Preparing the Building for Testing

- 4.2.12. **Whole-House Fan louvers/shutters.** Whole-House Fan louvers and shutters shall be closed. In addition, if there is a seasonal cover present, it shall be installed.
- 4.2.13. **Evaporative coolers.** The opening to the exterior of evaporative coolers shall be placed in its off position. In addition, if there is a seasonal cover present, it shall be installed.
- 4.2.14. **Operable window trickle-vents and through-the-wall vents.** Operable window trickle-vents and through-the-wall vents shall be closed.
- 4.2.15. **Heating and cooling supply registers and return grilles.** Heating and cooling supply registers and return grilles shall be left in their as-found position and left uncovered.

4.2 Preparing the Building for Testing

- 4.2.16. **Plumbing drains with p-traps.** Plumbing drains with empty p-traps shall be sealed or filled with water.
- 4.2.17. **Vented combustion appliances.** Vented combustion appliances shall remain off or in “pilot only” mode for the duration of the test.
- 4.2.18. **Required air bypass.** Where building code or manufacturer specifications require air bypass around a component, the leakage point shall not be sealed13.

Horrible Green Joke #1



4.3 Install the Test Apparatus and Prepare for Airtightness Test

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

4.3 Install the Test Apparatus and Prepare for Airtightness Test

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

4.3 Install the Test Apparatus and Prepare for Airtightness Test

- **4.3.1.6.** If the results of the test will be reported as Air Changes Per Hour at 50 Pa (0.2 in. H2O) (ACH50), the Infiltration Volume of the Dwelling Unit shall be recorded.
- **4.3.1.7.** If the results of the test will be reported as Specific Leakage Area (SLA), the Conditioned Floor Area of the Dwelling Unit shall be recorded.
- **4.3.1.8.** If the results of the test will be reported as Cubic Feet per Minute per square foot of enclosure surface area at 50 Pa (0.2 in. H2O) (CFM50/ft2 of enclosure), the Compartmentalization Boundary area of the Dwelling Unit shall be recorded.

4.3.2 Install the Test Apparatus & Prepare for Airtightness Test for Attached Dwelling Unit Procedure

4.3.2 Install the Test Apparatus and Prepare for Airtightness Test

- **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 space15, when one exists. The Blower Door shall have an unrestricted air pathway into the subject Dwelling Unit and no obstructions to airflow within 5 feet of the fan inlet and 2 feet of the fan outlet. When a doorway leading to an enclosed space is not available, the Blower Door is permitted to be installed in an exterior door or window. The tubing setup procedures listed in Section 4.3.1.2 shall be followed. The opening that is chosen shall be noted on the test report.

4.3.2 Install the Test Apparatus and Prepare for Airtightness Test

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

4.3.2 Install the Test Apparatus and Prepare for Airtightness Test

- **4.3.2.2.2.** An unrestricted air pathway larger than 20 square feet shall be opened between the enclosed space and outside16.
- **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 Pa17.

4.3.2 Install the Test Apparatus and Prepare for Airtightness Test

- **4.3.2.2.3.** When a doorway leading to an enclosed space is not available, the Blower Door is permitted to be installed in an exterior door or window. The tubing setup procedures listed in Section 4.3.1.2 shall be followed.
- **4.3.2.3.** Where access is permitted, open doors between the enclosed space and any Dwelling Units that are horizontally adjacent to the subject Dwelling Unit18.
- **4.3.2.3.1.** Leave windows and interior doors in adjacent Dwelling Units in the condition they are found.

4.3.2 Install the Test Apparatus and Prepare for Airtightness Test

- **4.3.2.4.** The door where the Blower Door is installed shall be inspected for the presence of a door seal installed to minimize air leakage between the door and door frame. Where such seal is not present or is not properly installed, 140 CFM50 shall be added to the measured airflow. This adjustment, and the presence, installation quality and condition of the door seal shall be documented in the final test report19.
- **4.3.2.5.** If a door is present between the subject Dwelling Unit and its mechanical closet, it shall be open during the test if the mechanical closet is Conditioned Space Volume and closed during the test if the mechanical closet is Unconditioned Space Volume.

4.3.2 Install the Test Apparatus and Prepare for Airtightness Test

- **4.3.2.6.** Ductwork between units shall be sealed at the register(s) of the subject Dwelling Unit.
- **4.3.2.7.** Where the crawlspace volume is continuous below multiple adjacent Dwelling Units, interior access doors and hatches between the subject Dwelling Unit and the crawlspace shall be closed. Exterior crawlspace access doors, hatches and vents shall be left in their as-found position.

4.3.2 Install the Test Apparatus and Prepare for Airtightness Test

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

4.3.2 Install the Test Apparatus and Prepare for Airtightness Test

- **4.3.2.10.** Where the mechanical room volume is continuous below multiple adjacent Dwelling Units, interior doors between the subject Dwelling Unit and the mechanical room shall be closed. Exterior mechanical room access doors, hatches and vents shall be left in their as-found position.
- **4.3.2.11.** The indoor and outdoor temperatures shall be measured using the Thermometer and recorded. Observations of general weather conditions shall be recorded.
- **4.3.2.12.** The altitude of the building site above sea level shall be recorded with an accuracy of 500 feet (150 m).

Procedure to Conduct Airtightness Test

- **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.

Procedure to Conduct Airtightness Test

- **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 H2O), 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. H2O) 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. H2O), measured over at least a 10-second period, shall be recorded.
- If a 50 Pa (0.2 in. H2O) induced enclosure pressure difference is not achieved, then additional Air-Moving Fans shall be used or the highest induced enclosure pressure difference (dPmeasured) and airflow (Qmeasured) 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. H2O) must be induced across the enclosure for the test to be valid.

Procedure to Conduct Airtightness Test

- **4.4.1.3.** The Air-Moving Fan shall be turned off and the Dwelling Unit returned to its as-found condition.
- **4.4.1.4.** If an induced enclosure pressure difference of 50 Pa (0.2 in. H2O) was not achieved in Section 4.4.1.2, then the recorded airflow (Qmeasured) shall be converted to a nominal airflow at 50 Pa (0.2 in. H2O) using Equation 1. Alternately, a Manometer that is equipped to automatically make the conversion to CFM50 or CMS50 is permitted to be used.
- $CFM50\ (ft3min)=Qmeasured(ft3min)(50dPmeasured)0.65$ (1a)
- $CMS50\ (m3s)=Qmeasured(m3s)(50dPmeasured)0.65$ (1b)

Procedure to Conduct Airtightness Test

- **4.4.1.5.** Corrected CFM50 (corrected CMS50) shall be calculated by making the adjustments due to density and viscosity using Section 9 of ASTM E77920. 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 C0.
- **4.4.1.6.** The Effective Leakage Area (ELA) shall be calculated using Equation 2:
- $ELA(in2)=Corrected\ CFM5018.2$ (2a)
- $ELA(m2)=Corrected\ CMS5013.6$ (2b)

Procedure to Conduct Airtightness Test

- 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.

Procedure to Conduct Airtightness Test

- **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. H2O) and either 60 Pa (0.24 in. H2O) 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 adjustments21 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. H2O). If 25 Pa (0.1 in. H2O) is not achieved, the One-Point Airtightness Test in Section 4.4.1 shall be used.

Procedure to Conduct Airtightness Test

- **4.4.2.3.** The Air-Moving Fan shall be turned off and the Dwelling Unit returned to its as-found condition.
- **4.4.2.4.** The airflow at each pressure station shall be corrected for altitude and temperature to determine the corrected airflow using the calculations in Section 9 of ASTM E77922.
- **4.4.2.5.** The corrected airflow (Q) and the induced enclosure pressure difference measured at each pressure station (dP) shall be used in a log-linearized regression of the form Q = C(dP)n to calculate23,24 C and n.

Procedure to Conduct Airtightness Test

- **4.4.2.6.** The Effective Leakage Area (ELA) shall be calculated using Equation 3:
- $ELA(in2)=C(ft3minPan)\times0.567\times4(n-0.5)$ (3a)
- $ELA(m2)=C(m3sPan)\times0.775\times4(n-0.5)$ (3b)
- Where C and n are the values determined in Section 4.4.2.5.
- **4.4.2.7.** The flow through the building or Dwelling Unit enclosure at 50 Pa (0.20 in. H2O) (CFM50 or CMS50) shall be calculated using Equation 4:

  $CFM50=C(ft3minPan)\times50(n)$ (4a)

  $CMS50=C(m3sPan)\times50(n)$ (4b)

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

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 limit25, then the corrected airflow determined using a one-point test shall be adjusted using Equation 5a or 5b.

  Adjusted CFM50 = 1.1 x Corrected CFM50 (5a)

  Adjusted CMS50 = 1.1 x Corrected CMS50 (5b)

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

  Adjusted ELA = 1.1 x ELA (6)

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

Procedure to Apply Results of Enclosure Air Leakage Test

- **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. H2O) (ACH50), Specific Leakage Area (SLA), Normalized Leakage Area (NLA), or compartmentalization leakage ratio at 50 Pa (CFM50/ft2), then Equations 7 through 10 shall be used. Where adjusted or corrected CFM50, CMS50 or ELA values have been calculated in previous sections they shall be used in Equations 7 through 10.

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

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

  SLA = 0.00694 x ELA in in2 / Conditioned Floor Area in square feet (8a)

  SLA = 10.764 x ELA in m2 / Conditioned Floor Area in square meters (8b)

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

  CFM50/ft2 = CFM50 / Compartmentalization Boundary area in square feet (10)

Horrible Green Joke #2

5. Procedure for Measuring Airtightness of Duct Systems

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 5.2.8 of this Standard are followed. The supply and return air leakage from Test Method A shall be added together and assumed equivalent to CFM25 or CMS25 to outside.

The leakage to outside test shall be performed using a Blower Door in the main entry to the Dwelling Unit to pressurize or depressurize the individual unit with reference to outside. If the main entry door is in an interior hallway then the hallway shall be well connected to outside through open windows or doors, or an exterior window or door26 shall be used. Only the ducts serving the Dwelling Unit being tested shall be included in the test.

5. Procedure for Measuring Airtightness of Duct Systems

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

5. Procedure for Measuring Airtightness of Duct Systems

- **5.1.3.** Flow Meter. A device to measure volumetric airflow with a maximum error of 5% of the measured flow.
- **5.1.4.** Thermometer. An instrument to measure air temperature with an accuracy of ±1°C (±2°F).
- **5.1.5.** Duct Leakage Tester. A device that combines an Air-Moving Fan as defined in Section 4.1.1 and a Flow Meter as defined in Section 5.1.3.

5. Procedure for Measuring Airtightness of Duct Systems

- 5.2. **Procedure to Prepare the Building or Dwelling Unit and the Duct System for Testing**
- 5.2.1. The presence of all components that are included in the HVAC design for the Dwelling Unit27 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 installed28, then the test shall not be conducted.
- **Exception:** Complete installation of all components is not required if the authority having jurisdiction allows testing with missing components. Any missing components shall be documented in the final test report.

5. Procedure for Measuring Airtightness of Duct Systems

- 5.2.2. The HVAC system controls shall be adjusted so that the air handler fan does not turn on during the test.
- 5.2.3. Any fans that could change the pressure in either the Conditioned Space Volume or any spaces containing ducts or air handlers29 shall be turned off.
- 5.2.4. All vented combustion appliances shall be turned off if there is a possibility that the space containing the appliance will be depressurized during the test procedure.

5. Procedure for Measuring Airtightness of Duct Systems

- 5.2.5. All filters in the duct system and air handler cabinet shall be removed. If the Duct Leakage Tester is installed at a return grille, any filters present at that grille shall also be removed. If present, filter slot cover(s) shall be replaced after removing filters.
- 5.2.6. **Dampers within the duct system shall be treated as follows:**
- 5.2.6.1. Non-motorized dampers30 in ducts that connect the Conditioned Space Volume or any space-conditioning duct systems to the exterior or to Unconditioned Space Volume shall be left in their as-found positions.31
- 5.2.6.2. Motorized dampers in ducts that connect the Conditioned Space Volume or any space-conditioning duct systems to the exterior or to Unconditioned Space Volume shall be placed in their closed positions and shall not be further sealed.

5. Procedure for Measuring Airtightness of Duct Systems

- **5.2.6.3.** All zone and bypass dampers shall be set to their open position to allow uniform pressures throughout the duct system.
- **5.2.6.4.** All balancing dampers shall be left in their as-found position.
- **5.2.7.** Non-dampered ventilation openings within the duct system shall be treated as follows:
- **5.2.7.1.** Non-dampered ventilation openings or ducts that serve intermittently operating Dwelling Unit ventilation systems, including HVAC fan-integrated outdoor air inlets, that connect the Conditioned Space Volume or any space-conditioning duct systems to the exterior or to Unconditioned Space Volume shall not be sealed.

5. Procedure for Measuring Airtightness of Duct Systems

- **5.2.7.2.** Non-dampered ventilation openings or ducts that serve continuously operating Dwelling Unit ventilation systems that connect the Conditioned Space Volume or any space-conditioning duct systems to the exterior or to Unconditioned Space Volume shall be sealed at the exterior of the enclosure where conditions allow.
- **5.2.8.** Supply registers and return grilles shall be temporarily sealed at both the face and the perimeter. Registers atop carpets are permitted to be removed and the face of the duct boot temporarily sealed during testing. For Dwelling Units without registers and grilles present32, the face of the duct boots shall be sealed instead.

5. Procedure for Measuring Airtightness of Duct Systems

- **5.3. Procedure to Install the Test Apparatus and Prepare for Airtightness Test**
- There are two acceptable methods for attaching the Duct Leakage Tester to the duct system. Method 1 is permitted to be used for all duct systems. Method 2 is permitted only if:
- i) the duct system has three or fewer return grilles, or
- ii) the total duct leakage is less than 50 cfm (25 L/s) at 25 Pa, or
- iii) local codes require licensing, that parties conducting the test have not obtained, in order to remove the blower access panel or

5. Procedure for Measuring Airtightness of Duct Systems

(5.3 Cont.)

- iv) the air handler blower access is in an attic or crawlspace that has limited or restricted entry or exit33
- • *Method 1 Installation*. The air handler blower access panel shall be removed and the Duct Leakage Tester attached to the blower compartment access.
- • *Method 2 Installation*. The Duct Leakage Tester shall be attached to the largest return grille in the system. For systems with multiple returns of equal largest size, the return closest to the air handler shall be used. The remaining opening in the return grille and all other return grilles shall be temporarily sealed.

5. Procedure for Measuring Airtightness of Duct Systems

- **5.3.1.** If the duct leakage to outside will be measured, then a Blower Door shall be installed in the enclosure per Sections 4.3.1.1 and 4.3.1.2 for a Detached Dwelling Unit or Section 4.3.2.2 for an attached Dwelling Unit.
- **5.3.2.** The static pressure probe(s) for the Duct Leakage Tester shall be installed using one of the following options.
- When using Method 2 for a duct system with more than three returns (based on the exception in Section 5.3 iv), then only Section 5.3.2.4 shall be used.
- **5.3.2.1.** A single static pressure probe shall be located at the supply register closest to the air handler; or,
- **5.3.2.2.** A single static pressure probe shall be located in the main supply trunk line, at least 5 feet from the air handler; or,

5. Procedure for Measuring Airtightness of Duct Systems

- 5.3.2.3. A single static pressure probe shall be located in the supply plenum; or,
- 5.3.2.4. A single static pressure probe shall be located according to Section 5.3.2.1, 5.3.2.2, or
- 5.3.2.3, and a second probe shall be located in the return plenum 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. Procedure for Measuring Airtightness of Duct Systems

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

5.4. Procedure to Conduct Airtightness Test

- **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.
- 5.4.1.1. 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. Procedure to Conduct Airtightness Test

- **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. H2O) 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. H2O) 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. H2O) (CFM25, CMS25), measured over at least a 10-second period, shall be recorded.

If a 25 Pa (0.1 in. H2O) induced duct system pressure difference is not achieved, then the highest induced duct system pressure difference (dPmeasured) and airflow (CFMmeasured, CMSmeasured) that was achieved with the equipment available, measured over at least a 10-second period, shall be recorded.

5.4. Procedure to Conduct Airtightness Test

- **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. H2O) was not achieved in Section 5.4.1.2, then the recorded airflow (CFMmeasured, CMSmeasured) shall be converted to a nominal airflow at 25 Pa (0.1 in. H2O) (CFM25, CMS25) using Equation 10. Alternately, a Manometer that is equipped to automatically make the conversion to CFM25 or CMS25 is permitted to be used.

$$CFM25 = CFMmeasured(25dP)0.6 \quad (10a)$$

$$CMS25 = CMSmeasured(25dP)0.6 \quad (10b)$$

5.4.2. Duct Leakage to Outside Test

- **5.4.2.1.** If ducts run outside the Infiltration Volume including attics, garages or crawlspaces, then any vents, access panels, doors, or windows between those spaces and the outside shall be opened. All exterior doors and windows between the Infiltration Volume and outside shall be closed, and other openings to the outside with potential to hinder the ability of the Air-Moving Fan to achieve an induced enclosure pressure difference of 25 Pa (0.1 in. H2O) 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. Duct Leakage to Outside Test

- **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. H2O), defined as the induced enclosure pressure minus the Pre-Test Baseline Dwelling Unit Pressure. Note that this value is permitted to be positive or negative, which will be dependent upon whether the enclosure is pressurized or depressurized. If a 25 Pa (0.10 in. H2O) induced enclosure pressure difference is not achieved, then the highest possible value up to 25 (0.10 in. H2O) Pa shall be achieved with the equipment available.

5.4.2. Duct Leakage to Outside Test

- **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. H2O), relative to the Dwelling Unit. If an induced duct system pressure difference of 0.0 Pa (0.0 in. H2O) 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. H2O) is achieved.
- **5.4.2.5.** The induced enclosure pressure difference shall be re-checked and the Air-Moving Fan for the enclosure shall be adjusted to maintain 25 Pa (0.10 in. H2O) or the highest achievable value up to 25 (0.10 in. H2O) 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. H2O), per Section 5.4.2.4.
- **5.4.2.6.** The induced duct system pressure difference shall be re-checked and the Duct Leakage Tester shall be adjusted to maintain 0.0 ± 0.5 Pa (0.0±0.002 in. H2O), per Section 5.4.2.4.

5.4.2. Duct Leakage to Outside Test

- **5.4.2.7.** Repeat 5.4.2.5 and 5.4.2.6 until the induced enclosure pressure difference is 25 Pa (0.10 in. H2O) or the highest achievable value up to 25 Pa (0.10 in. H2O) and the induced duct system pressure difference is 0.0 Pa (0.0 in. H2O).

  • If a 25 Pa (0.10 in. H2O) 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. H2O) (CFM25, CMS25), measured over at least a 10-second period, shall be recorded.

  • If a 25 Pa (0.10 in. H2O) induced enclosure pressure difference is not achieved, then the average value of the highest induced enclosure pressure difference (dPhigh), the induced duct system pressure difference, and the airflow (Qhigh) that was achieved with the equipment available, measured over at least a 10- second period, shall be recorded.

5.4.2. Duct Leakage to Outside Test

- **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. H2O) was not achieved or a different value was used to achieve an induced duct system pressure difference of 0.0 Pa (0.0 in. H2O), then the recorded airflow (CFMmeasured, CMSmeasured) shall be converted to a nominal airflow at 25 Pa (0.10 in. H2O) (CFM25,CMS25) using Equation 10. Alternately, a Manometer that is equipped to automatically make the conversion to CFM25 or CMS25 is permitted to be used.

5.5. Procedure to Apply Results of Duct System Leakage Test

- **5.5.1.** If the results of the duct system leakage test are to be used for assessing compliance with a limit on total duct system leakage34, 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 outside35, 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 outside36.
- **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.

Equipment

Air-Moving Fan

Equipment

Manometer

Equipment

Blower Door

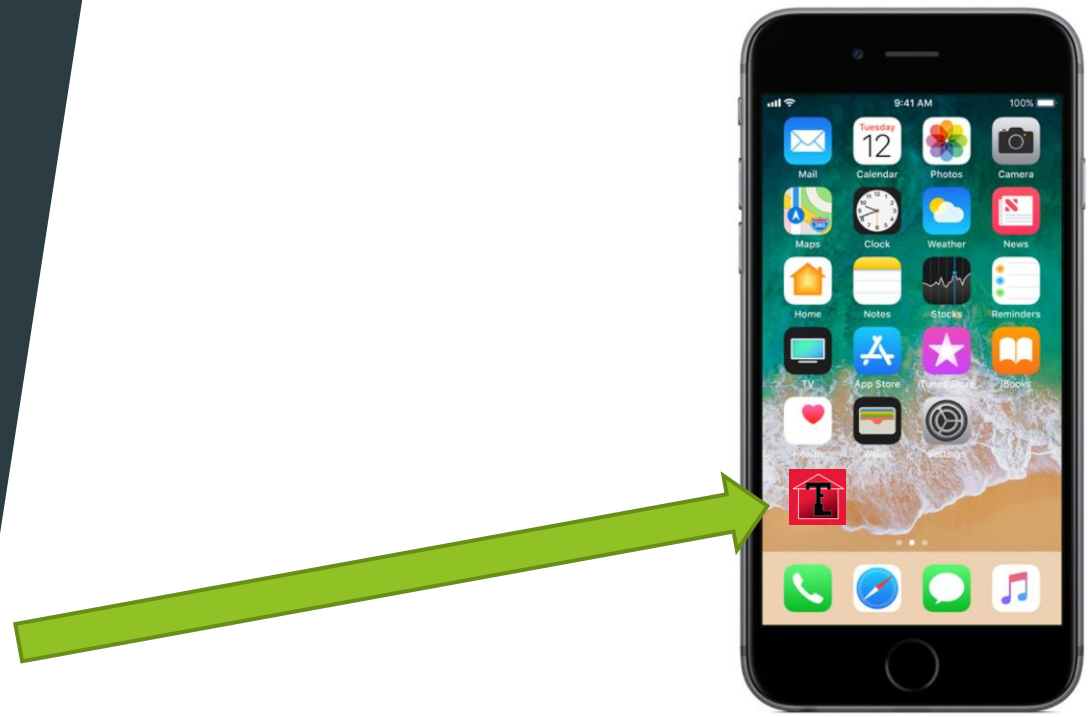
Retrotec Model 1000 Blower Door

Minneapolis Model 3 Blower Door

Equipment

Software?

There’s an app for that



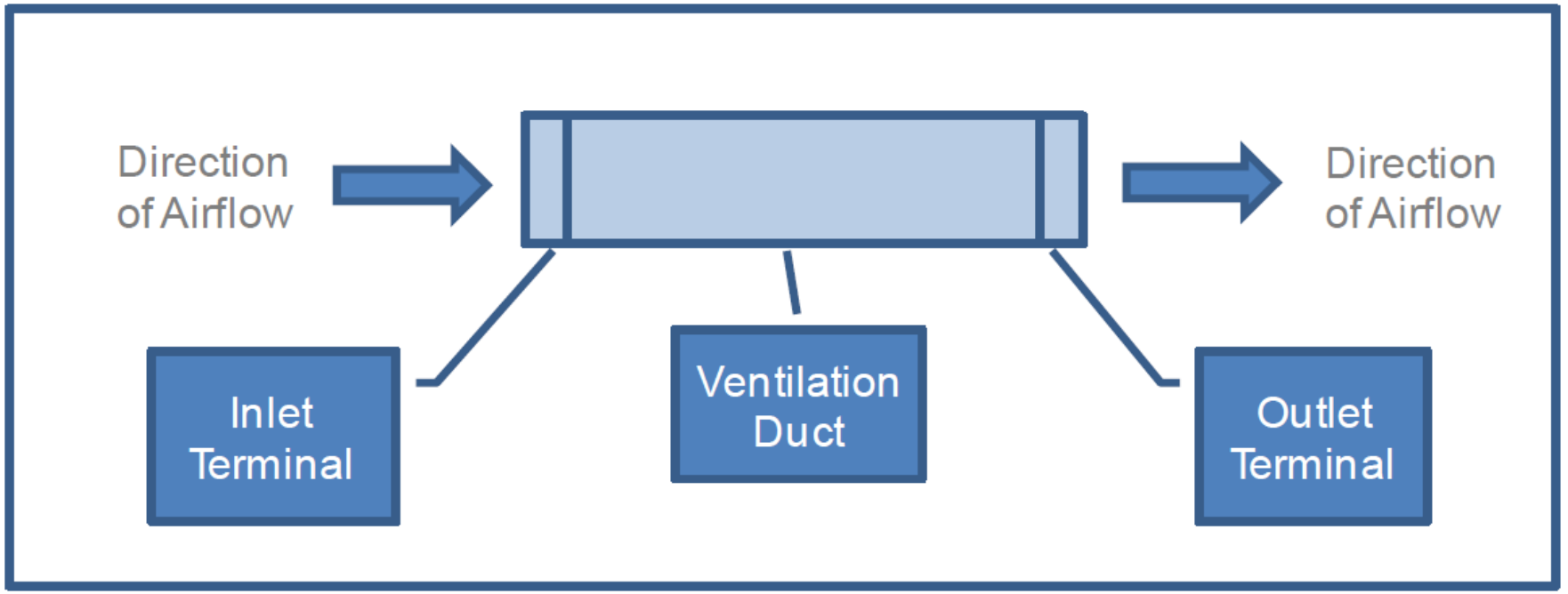
6. Procedure for Measuring Airflow of Mechanical Ventilation Systems

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 system37 or a local mechanical exhaust system38, 39.
- The airflow is permitted to be measured at the inlet terminal, per Section 6.2; or at the outlet terminal, per Section 6.3; or mid-stream in the ventilation duct, per Section 6.4.
- The inlet terminal is defined as the location where the ventilation air enters the mechanical ventilation system and the outlet terminal is defined as the location where the ventilation air exits the mechanical ventilation system. A diagram of these locations for a generic mechanical ventilation system is shown in Figure 1.

6. Procedure for Measuring Airflow of Mechanical Ventilation Systems

Figure 1: Location of Terminals in Generic Mechanical Ventilation System



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

- 6.1.1. **Interior Doors.** All interior doors between rooms inside the Conditioned Space Volume shall be opened.
- 6.1.2. **Ventilation openings.** Operable window trickle-vents and through-the-wall vents shall be opened. Dampered and non-dampered ventilation openings shall not be sealed 40.
- 6.1.3. **Supply registers and return grilles.** Heating and cooling supply registers and return grilles shall be left in their as-found position and shall not be sealed.

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

- 6.1.4. **Balancing dampers.** All balancing dampers shall be left in their as-found position.
- 6.1.5. **Zone dampers.** If a Dwelling Unit Mechanical Ventilation system is to be tested and is interconnected with a Forced-Air System, then all zone and bypass dampers shall be set to their open position. Otherwise, zone and bypass dampers shall be left in their as-found position.
- 6.1.6. **Vented combustion appliances.** Vented combustion appliances shall remain off or in “pilot only” mode for the duration of the test.

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

- 6.1.7. **Forced-Air System Components.** If a Dwelling Unit Mechanical Ventilation system is to be tested and uses the Blower Fan of a Forced-Air System as its primary fan, then the presence of all components included in the Forced-Air System design for the Dwelling Unit and integrated with the duct system 41 shall be verified. If these components have not yet been installed 42, then the test shall not be conducted.
- 6.1.8. **Forced-Air System Blower Fan.** The system controls shall be adjusted as follows: **6.1.8.1.** If a Dwelling Unit Mechanical Ventilation system is to be tested and uses the Blower Fan of a Forced-Air System as its primary fan, then the Forced-Air System controls shall be adjusted to “Fan” mode so that the Blower Fan operates during the test.

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

- 6.1.8.2. Otherwise, the Forced-Air System controls shall be adjusted so that the Blower Fan does not operate during the test.
- 6.1.9. **Local Mechanical Exhaust or Dwelling Unit Mechanical Ventilation System Fan.** The fan of the Local Mechanical Exhaust system or Dwelling Unit Mechanical Ventilation system under test shall be turned on. For Dwelling Unit Mechanical Ventilation systems that use the Blower Fan of a Forced-Air System as its primary fan, then this shall be accomplished according to Section 6.1.8.
- 6.1.10. **Other Fans.** Any other fans that could change the pressure in either the Conditioned Space Volume or any spaces containing the ducts of the Dwelling Unit Mechanical Ventilation system or Local Mechanical Exhaust system 43 under test shall be turned off.

6.2. Procedure to Measure Airflow at Inlet Terminal

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

- **6.2.1.1.1.** Powered Flow Hood. A device consisting of a flow capture element capable of creating an airtight perimeter seal around the inlet terminal; an Airflow Meter capable of measuring the volumetric airflow through the flow capture element with an a maximum error of 5 % or 5 cfm (2.5 L/s or 0.0025 m_3/s), whichever is greater; and a variable-speed Air-Moving Fan that is capable of moving air through the flow capture element and Airflow Meter.
- **6.2.1.1.2.** Manometer. A device that is capable of measuring the static pressure inside the flow capture element relative to the room with a maximum error of 1% of reading or 0.25 Pa (0.0010 in. H2O), whichever is greater.

6.2. Procedure to Measure Airflow at Inlet Terminal

- 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 H2O)) 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. Procedure to Measure Airflow at Inlet Terminal

- 6.2.2.2. **Procedure to Conduct Airflow Test**
- 6.2.2.2.1. The flow capture element of the Airflow Resistance Device shall be placed over the inlet terminal, ensuring that an airtight perimeter seal has been created.
- 6.2.2.2.2. The opening area of the Airflow Resistance Device shall be adjusted until, using the Manometer, the pressure difference between the flow capture element and the room meets the manufacturer's requirements. If no manufacturer's requirement exists then the pressure shall be between 1 and 8 Pa (0.004 and 0.032 in. water).

6.2. Procedure to Measure Airflow at Inlet Terminal

- **6.2.2.2.3.** The average pressure difference (dP) between the flow capture element and the room, measured over at least a 10-second period, shall be recorded.
- **6.2.2.2.4.** Using the average pressure difference, the airflow shall be calculated using the manufacturer's flow conversion table or, for devices without a flow conversion table, the following equations:

  $Airflow\ (CFM) = Opening\ Area\ x\ 1.07\ x\ (dP)0.5$ (11a)

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

  Where: For Eq. 11a, Opening Area is in in2 and dP is in Pa

  For Eq. 11b, Opening Area is in cm2 and dP is in Pa
- **6.2.2.3. Limitations of Procedure.** An Airflow Resistance Device is only permitted to be used on mechanical ventilation systems that do not have multiple duct branches.

6.2.3. Passive Flow Hood

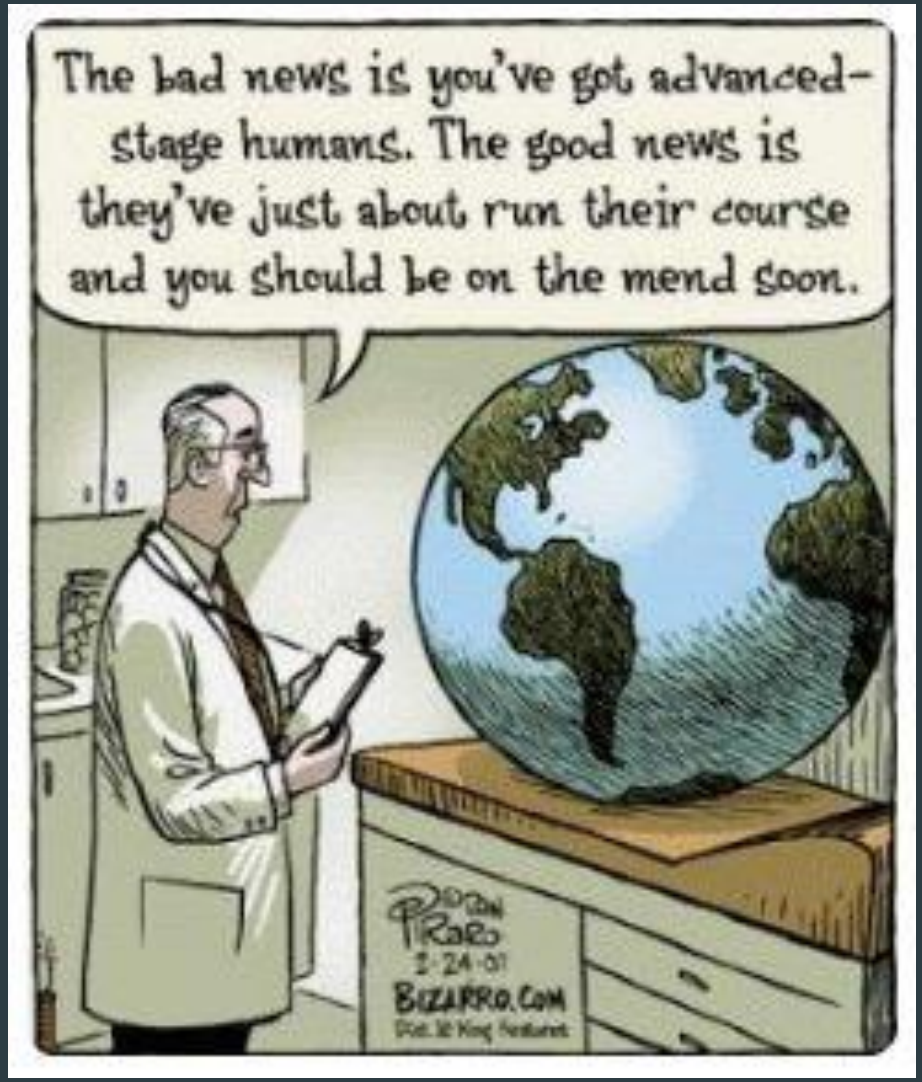
- 6.2.3.1. **Equipment Needed 6.2.3.1.1.** Passive Flow Hood. A device consisting of a flow capture element capable of creating an airtight perimeter seal around the inlet terminal; and an Airflow Meter capable of measuring the volumetric airflow through the flow capture element with a maximum error of 5 % or 5 cfm (2.5 L/s or 0.0025 m3/s), whichever is greater.
- 6.2.3.1.2. Manometer. A device that is capable of measuring pressure difference with a maximum error of 1% of reading or 0.25 Pa (0.0010 in. H2O), whichever is greater.

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. Passive Flow Hood

- **6.2.3.2.1.** The flow capture element of the Passive Flow Hood shall be placed over the inlet terminal, ensuring that an airtight perimeter seal has been created.
- **6.2.3.2.2.** A tube shall be inserted inside the flow capture element between the Airflow Meter and inlet terminal to allow for measurement of the pressure difference between inside the Passive Flow Hood and the room. Devices that have a built-in pressure tube are acceptable.
- **6.2.3.2.3.** The pressure difference between the flow capture element and the room shall be measured. The procedure shall be terminated and no results recorded if: (1) the pressure difference exceeds test equipment manufacturer's recommendations, or (2) there is no manufacturer recommendation, and the pressure difference is more than 8 Pa.
- **6.2.3.2.4.** The airflow through the Airflow Meter shall be averaged over at least a 10-second period.

Horrible Green Joke #3



6.3. Procedure to Measure Airflow at Outlet Terminal

- This Section defines procedures to measure the airflow of a mechanical ventilation system at an outlet terminal. The airflow is permitted to be measured using a Powered Flow Hood (Section 6.3.1) or using a Bag Inflation Device (Section 6.3.2).
- 6.3.1. **Powered Flow Hood.** To measure airflow at an outlet terminal using a Powered Flow Hood, Section 6.2.1 shall be followed except with all occurrences of the phrase “inlet terminal” replaced with “outlet terminal”.

6.3. Procedure to Measure Airflow at Outlet Terminal

- **6.3.2. Bag Inflation Device**
- **6.3.2.1. Equipment Needed**
  - 6.3.2.1.1. Bag Inflation Device. A flow capture element capable of creating an airtight perimeter seal around the outlet terminal that is connected to a plastic bag of known volume and holds the bag open44, and a shutter that controls airflow into the bag.
  - The plastic bag shall be selected such that three or more measurements of a single outlet terminal produce results that are within 20% of each other.
  - The volume of the plastic bag shall be selected such that the bag will completely fill with air from the outlet terminal in the range of 3 to 20 seconds.
- 6.3.2.1.2. Stopwatch. A stopwatch capable of recording elapsed time +/- 0.1 seconds.

6.3. Procedure to Measure Airflow at Outlet Terminal

- 6.3.2.2. Procedure to Conduct Airflow Test
- 6.3.2.2.1. The bag shall be completely emptied of air and the shutter closed to prevent airflow into the bag.
- 6.3.2.2.2. The Bag Inflation Device shall be placed over the outlet terminal.
- 6.3.2.2.3. The shutter shall be removed rapidly and the Stopwatch started.
- 6.3.2.2.4. The Stopwatch shall be stopped when the bag is completely filled with air from the outlet terminal and the elapsed time recorded.

6.3. Procedure to Measure Airflow at Outlet Terminal

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

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

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

Where: Volume = The volume of the plastic bag, in gallons

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

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

- This Section defines a procedure to measure the airflow of a mechanical ventilation system mid-stream in the ventilation duct. The airflow is permitted to be measured using an Airflow Measurement Station (Section 6.4.1) or using an Integrated Diagnostic Tool (Section 6.4.3).
- **6.4.1. Equipment Needed**
- **6.4.1.1.** Airflow Measurement Station. An Airflow Measurement Instrument capable of simultaneously measuring and averaging velocity pressure across a duct diameter with a maximum error of 10% or 5 CFM (2.5 L/s), whichever is greater, coupled with a section of permanently installed smooth-walled ductwork designed to facilitate accurate readings. The Airflow Measurement Instrument shall either be temporarily inserted into the Station for the duration of the procedure or be permanently installed as part of the Station.45 The Airflow Measurement Instrument shall contain a port that allows it to be connected to a Manometer. Any temporary air flow station shall have its calibration checked at the manufacturer's recommended interval, and at least annually if no time is specified.

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

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

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

- **6.4.2. Procedure to Conduct Airflow Test**
- 6.4.2.1. The Air Flow Measurement Station shall be installed in an accessible location, per manufacturer's instructions, or it shall be verified that such a device has been installed and is accessible. If the Airflow Measurement Instrument is not permanently installed, it shall be inserted into the measurement port of the Station.
- 6.4.2.2. The installation shall be visually verified to comply with the Airflow Measurement Instrument's specifications for minimum distance to both upstream and downstream duct fittings and fan outlets.46

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

- **6.4.2.3.** The cross-sectional area of the duct at the Station shall be recorded in ft2 or m2.
- **6.4.2.4.** The Manometer shall be connected to the Airflow Measurement Instrument, and the average velocity pressure, measured over at least a 10-second period, shall be recorded.
- **6.4.2.5.** If the Airflow Measurement Instrument is not permanently installed, then it shall be removed and the port sealed with a sheet metal plug or metallic tape.

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

- 6.4.2.6. Using the average velocity pressure, the average velocity in feet per minute (FPM) or meter per second (m/s) shall be calculated using the Airflow Measurement Instrument manufacturer's velocity conversion table or equation.
- 6.4.2.7. **Equation 13 shall be used to convert the average velocity to airflow.**

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

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

Where:

For Equation 13a, V = Velocity, in fpm, and A = Cross-Sectional Duct Area, in ft2.

For Equation 13b, V = Velocity, in m/s, and A = Cross-Sectional Duct Area, in m2.

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

- 6.4.3. **Integrated Diagnostic Tool 6.4.3.1. Equipment** 6.4.3.1.1. **Integrated Diagnostic Tool.** A tool that is integrated into the ventilation equipment47 that permits assessment of airflow. The maximum error of the integrated diagnostic tool shall be 15% of the highest flow setting of the ventilation equipment.
- 6.4.3.2. **Procedure to Conduct Airflow Test**. Follow the manufacturer-provided instructions for the Integrated Diagnostic Tool to determine the airflow.

7. Air Handler Flow

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

8. Hazards

- **8.1. Equipment Guards** - The air-moving equipment shall be listed by an accredited certification body48 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.
- **8.2. Personal Protective Equipment** - Use of safety equipment appropriate for general fieldwork is required; all local or federal OSHA requirements shall be followed.
- **8.3. Debris and Fumes** - The blower or fan forces a large volume of air into or out of a building or Dwelling Unit while in operation. Caution shall be exercised against sucking debris or exhaust gases from fireplaces and flues into the interior of the building or Dwelling Unit. Care shall be exercised to prevent damage to internal furnishings, plants or pets due to influx of cold, warm or humid air. If the building or Dwelling Unit will not remain unoccupied, except for testing personnel during the test, care shall be exercised regarding the potential for the fans to introduce respiratory hazards to the breathing zone of the occupied space.

8. Hazards

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

Time Line Requirements

- Recently, RESNET staff sent out a memo regarding implementation of correction factors within ANSI/RESNET/ICC Standard 380-2016. As a reminder, homes permitted after July 1, 2018 are subject to the new standard and the testing procedures therein. One component of the new testing standard for air infiltration includes a change to the calculation for correction factors that account for density and viscosity differences in air due to altitude and temperature. Standard 380-2016 references ASTM E779-10. Per footnote 9, software provided by equipment manufacturers is permitted to be used to satisfy these requirements, but only if the software is compliant with ASTM E779-10.

Horrible Green Joke #4

- “Sustainable development is like teenage sex – everybody claims they are doing it but most people aren’t, and those that are, are doing it very badly”

Questions ?

THANK YOU!