INTRODUCING THE ANSI/RESNET/ICC STANDARD 380 – THE AMERICAN CONSENSUS STANDARD FOR CONDUCTING AIR AND DUCT LEAKAGE TESTS

RESNET 2017

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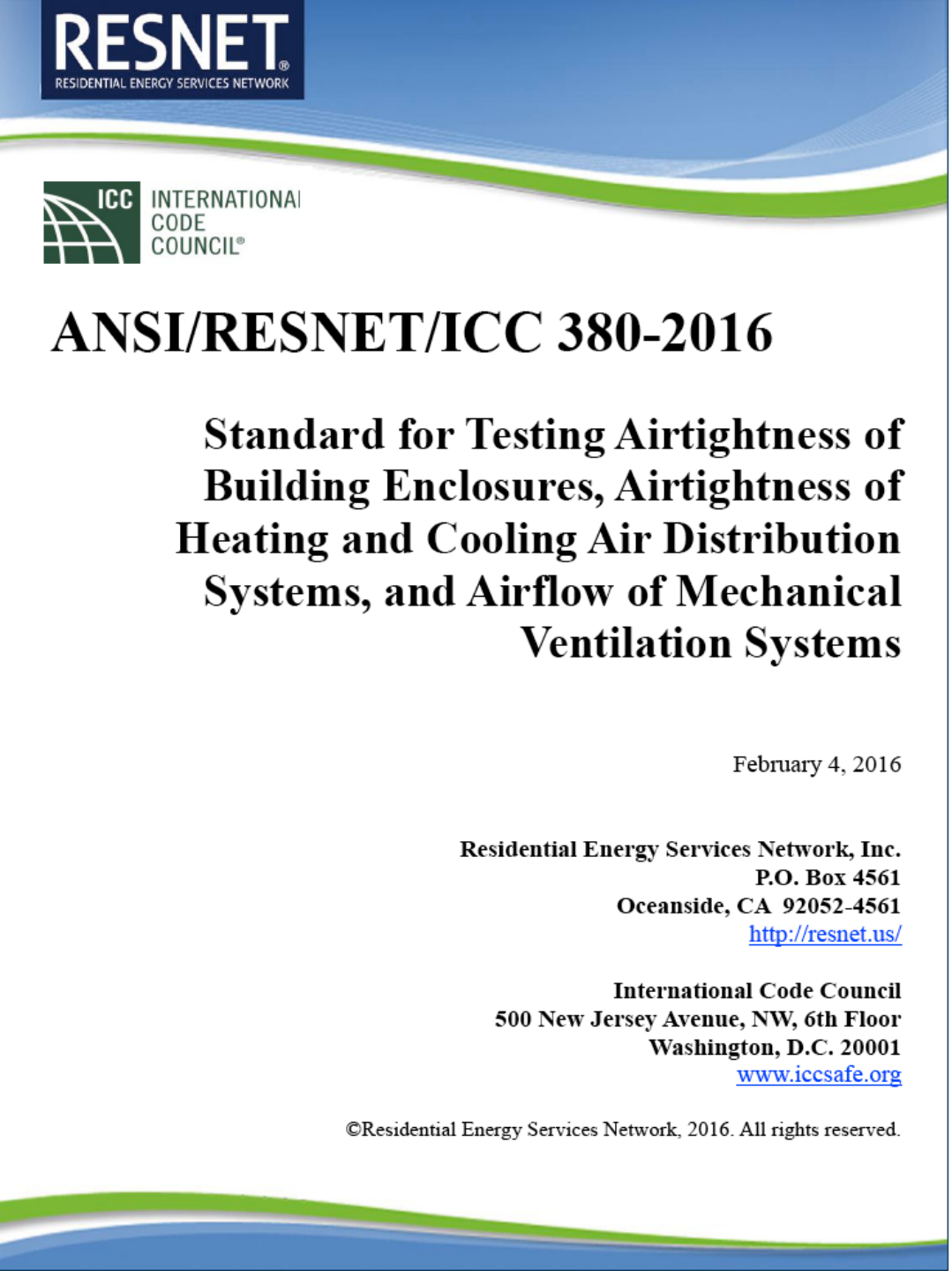

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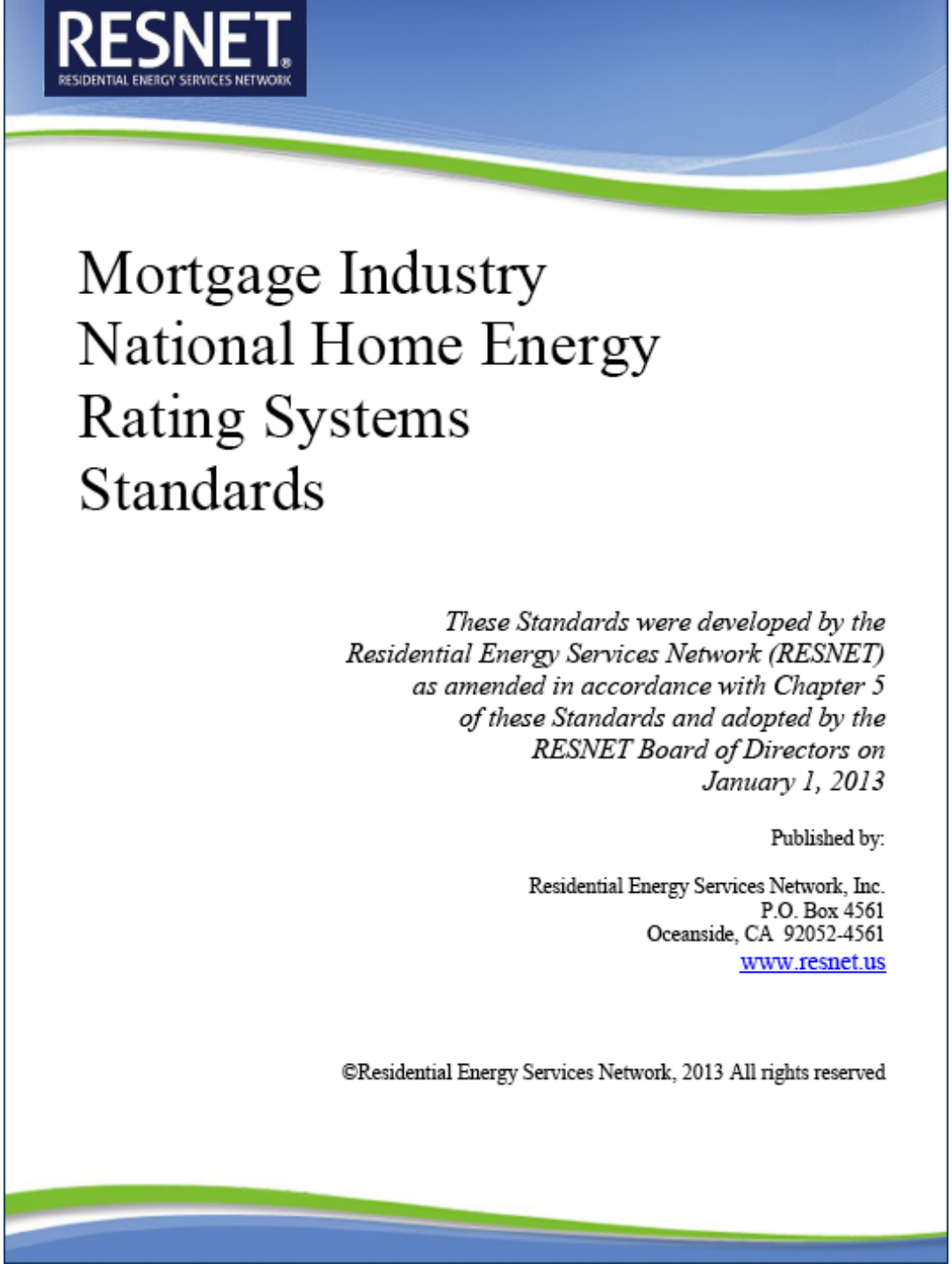


MINHERS

Much of what was (is) Chapter 8 on enclosure and duct leak testing now in 380

Recent updates refer to 380

Why a new standard?

1. Existing standards are not quite right for RESNET
   - Change of focus – More detail on envelope and HVAC preparation, less on other details, e.g., extra measurements ensuring pressure uniformity
   - More metrics – CFM50, ACH50, NLA, SLA & ELA
     - Allows direct reference by a wide range of codes and standards
     - CFM50 = air flow
     - ACH50 = air flow/house volume
     - ELA = effective leakage area = hole size at 4 Pa
     - SLA = ELA/conditioned floor area
     - NLA = SLA with height correction
   - Different applications and how to use test results
     - Energy rating vs. minimum compliance

Why a new standard?

2. No existing standard for diagnostic testing of ventilation air flows
3. Provides a stand-alone standard that is easier for other entities to refer to. Part of an effort to get everyone using the same testing: RESNET, BPI, ICC, etc.
4. Gives step-by-step instructions for easier training and consistency

What is Standard 380?

- Brings together diagnostic tests related to building air flow (much of which was in existing Chapter 8 of MINHERS):
  - Envelope leakage
  - Duct leakage
  - Mechanical ventilation
- Allows multiple test procedures for flexibility
- What is not included?
  - No CAZ testing – still in Chapter 8 of MINHERS
  - inspection protocols currently found in Appendix A of MINHERS will be moved into Chapter 8

Standard 380 Applications

- All single-family, but 3-story or less in Multi-Family
- 380 referenced in the 2018 IECC/IRC
- 380 referenced in ASHRAE 62.2 for envelope leakage measurement
- Could be referenced in future ASHRAE 62.2 for air flow measurement/verification

What is different from Chapter 8 of MINHERS?

New Definitions: *consistency* over *rater discretion*

- Conditioned Space Volume
- Unconditioned Space Volume
- Infiltration Volume
- Conditioned Floor Area
- ELA definition

- Uncertainty calculations removed
- Repeated Single Point Test removed
- Post baseline measurement removed

Uses of Defined Terms

- **Conditioned Space Volume (CSV)**: The volume within a building that is deliberately heated or cooled.
- **Unconditioned Space Volume (UCSV)**: space that is not deliberately conditioned but is part of the shell of the building: attics, crawlspaces, garages, sunrooms

Both CSV and UCSV depend on location of insulation and air barrier and are used in house preparation for envelope leakage testing, e.g., all doors inside CSV must be open

Uses of Defined Terms

- **Infiltration Volume (IV):** This is the volume of concern for pollutants in the home. Used to convert air leakage in cfm to air exchange in ACH. Used for checking airtightness criteria. e.g., 3 ACH50 limit.
- **Conditioned Floor Area (CFA):** Used in SLA calculations and in MINHERS energy modeling to determine window area, mechanical ventilation sizing, internal gains/MELS, etc.

New Definitions – there are some changes from first version of 380 for clarity

- ***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.

Conditioned Space Volume cont…

- If the volume of at least one 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 both air sealed and insulated at the roof deck shall be excluded.
- The volume of a **vented crawlspace** shall be excluded.
- The volume of a **garage** shall be excluded, even when it is conditioned.
- The volume of a **thermally isolated sunroom** shall be excluded.

Conditioned Space Volume cont…

- The volume of **an attic that is both air sealed and insulated at the roof deck,** the volume of **an unvented crawlspace,** and the volume of **a basement** shall only be included if the party conducting evaluations has either:
  - Obtained an ACCA Manual J, S, and either B or D report and verified that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume, or,
  - Verified through visual inspection that both the heating and cooling equipment and distribution system serve the volume and, in the judgement of the party conducting evaluations, are capable of maintaining the heating and cooling temperatures specified by the Thermostat section in Table 4.2.2(1) of ANSI/ RESNET/ICC 301-2014.

Unconditioned Space Volume

- ***Unconditioned Space Volume*** **-** The volume within a building that is not Conditioned Space Volume but which contains heat sources or sinks that influence the temperature of the area or room. The following specific spaces are addressed to ensure consistent application of this definition:
  - If either one or both of the volumes above and below a floor cavity is Unconditioned Space Volume, then the volume of the floor cavity shall be included.
  - If the volume of both of the spaces horizontally adjacent to a wall cavity are Unconditioned Space Volume, then the volume of the wall cavity shall be included.

Unconditioned Space Volume cont…

- The volume of **an attic that is not both air sealed and insulated** at the roof deck shall be included.
- The volume of **a vented crawlspace** shall be included.
- The volume of **an attached garage** shall be included, even when it is conditioned.
- The volume of **a thermally isolated sunroom** shall be included.
- The volume of **an attic that is both air sealed and insulated at the roof deck**, the volume of an unvented crawlspace, and the volume of a basement shall be included unless it meets the definition of Conditioned Space Volume.

Conditioned Floor Area

- ***Conditioned Floor Area (CFA)*** – The floor area of the Conditioned Space Volume within a building, not including the floor area of attics, crawlspaces, and basements below air sealed and insulated floors. The following specific spaces are addressed to ensure consistent application of this definition:
- The floor area of a **wall cavity** that is adjacent to Conditioned Space Volume shall be included.

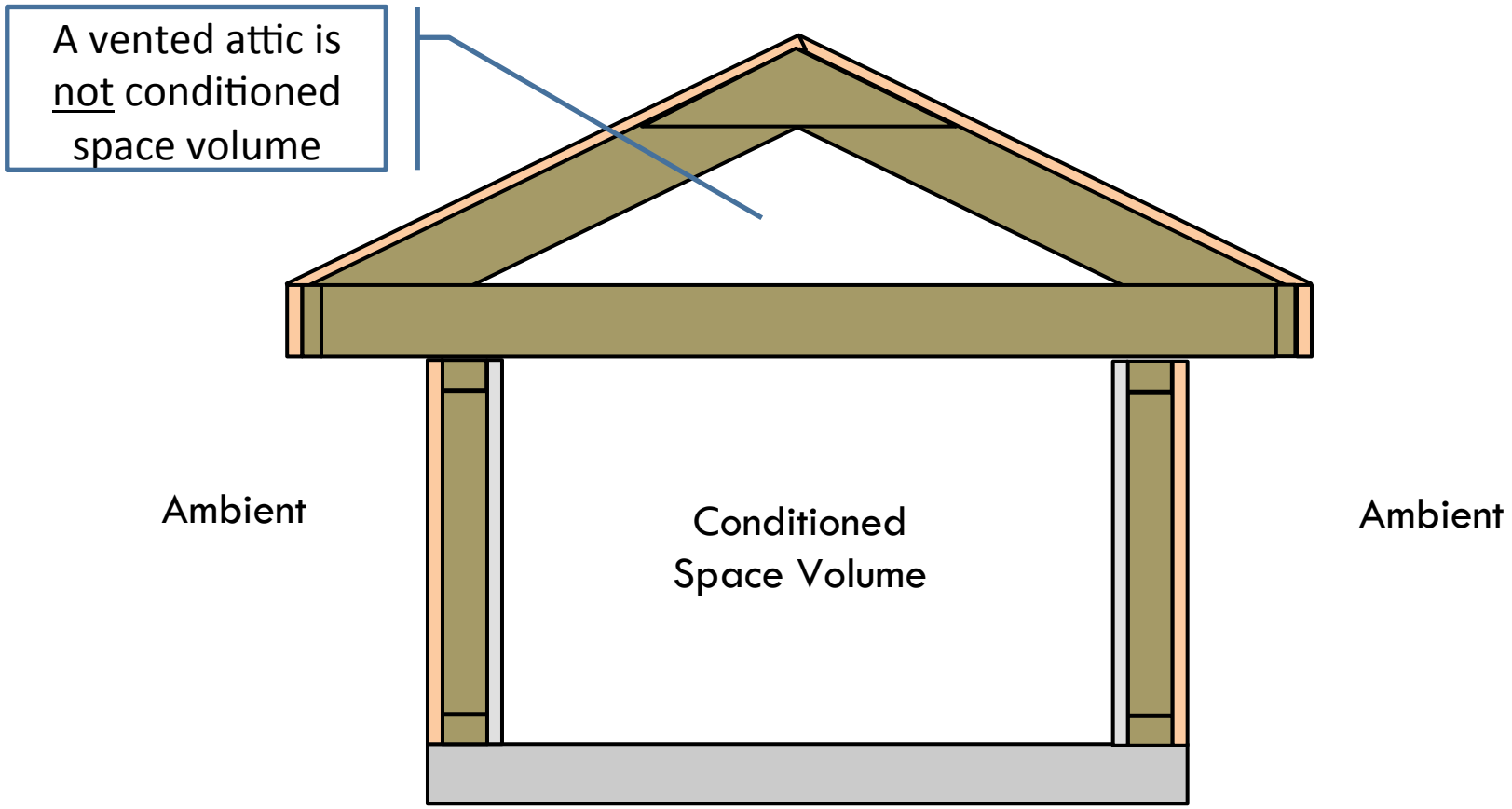
Conditioned Floor Area cont…

- The floor area of a **basement** shall be included if the party conducting the evaluation has either:
  - Obtained an ACCA Manual J, S, and either B or D report and verified that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume, or,
  - Verified through visual inspection that both the heating and cooling equipment and distribution system serve the volume and, in the judgenent of the party conducting evaluations, are capable of maintaining the heating and cooling temperatures specified by the Thermostat section in Table 4.2.2(1) of ANSI/RESNET 301-2104.

Conditioned Floor Area Cont…

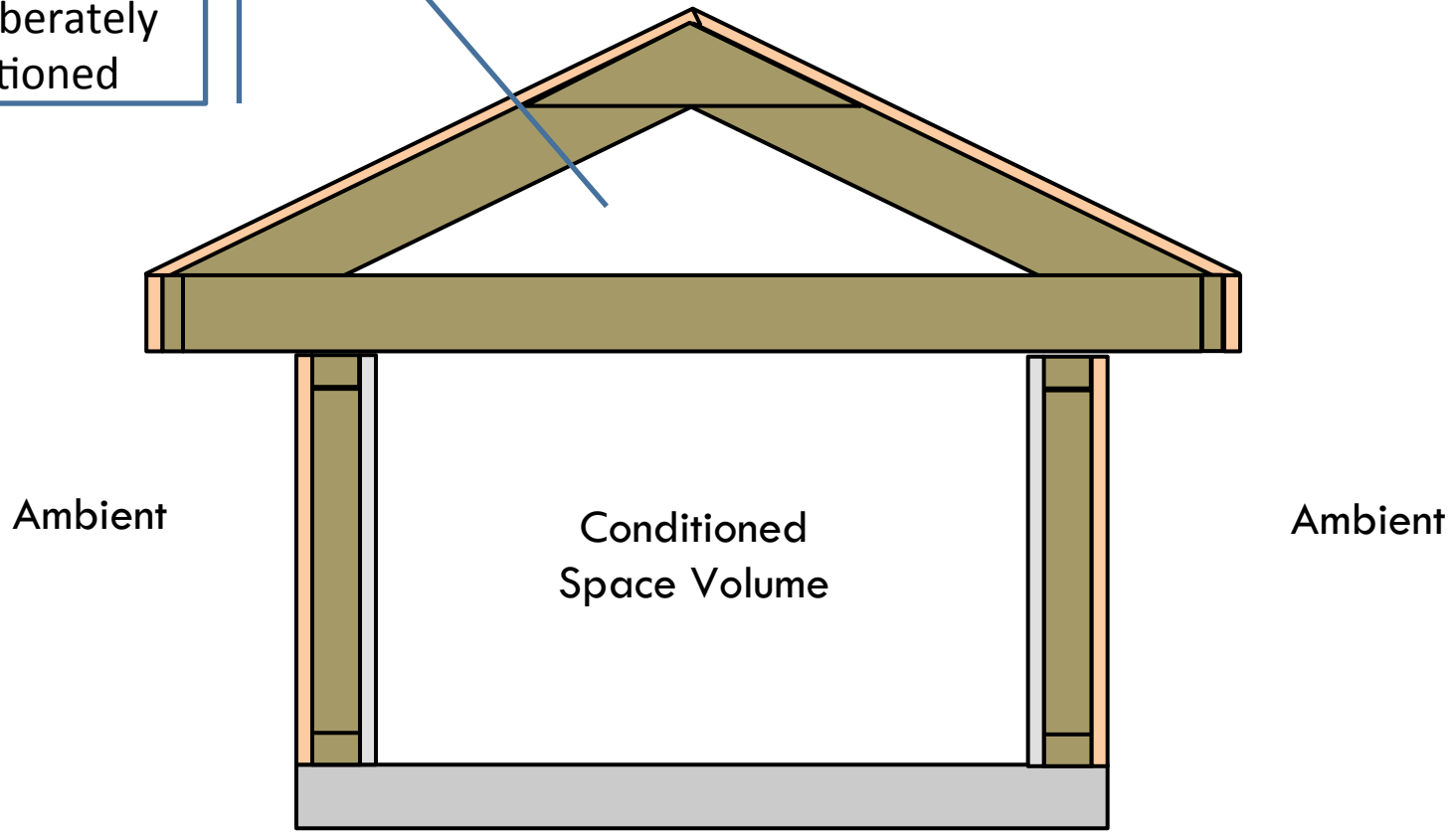
- The floor area of a **garage** shall be excluded, even when it is conditioned.
- The floor area of a **thermally isolated sunroom** shall be excluded.
- The floor area of an **attic** shall be excluded, even when it is Conditioned Space Volume.
- The floor area of a **crawlspace** shall be excluded, even when it is Conditioned Space Volume.

Conditioned Space Volume - Attic



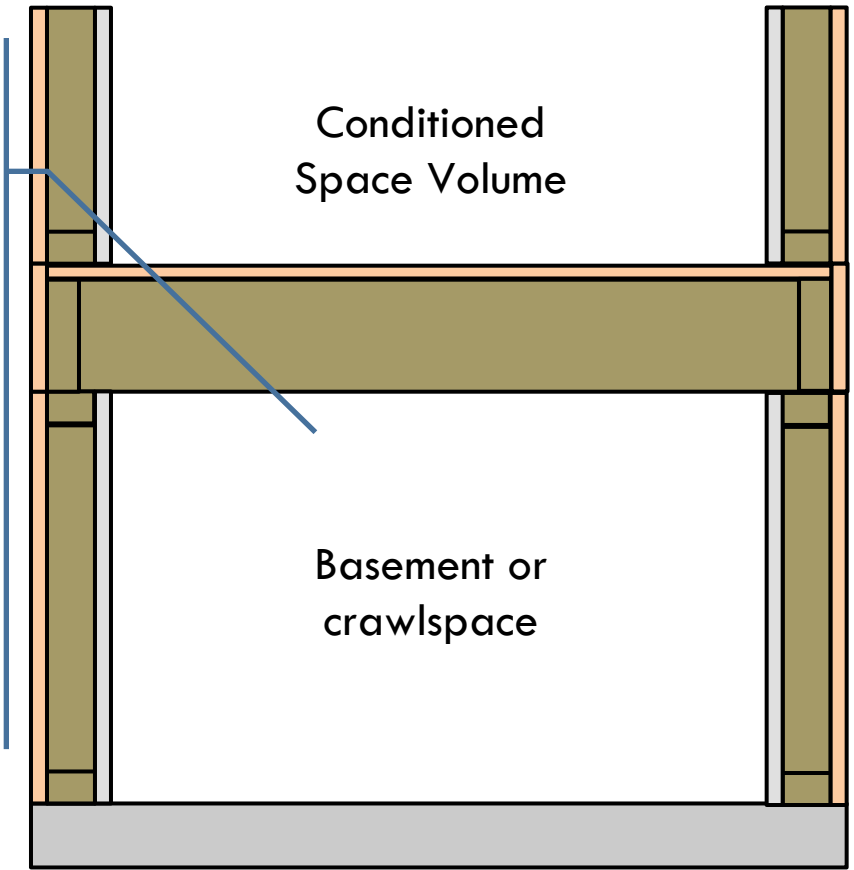
Conditioned Space Volume - Attic

An air sealed and insulated attic is conditioned space volume BUT only if it is deliberately conditioned



Conditioned Space Volume – Crawlspace or Basement

A basement or crawlspace is <u>not</u> conditioned space volume in most cases. The HVAC equipment needs to offset the space load for it be considered conditioned space volume. Plus a crawlspace needs to be sealed

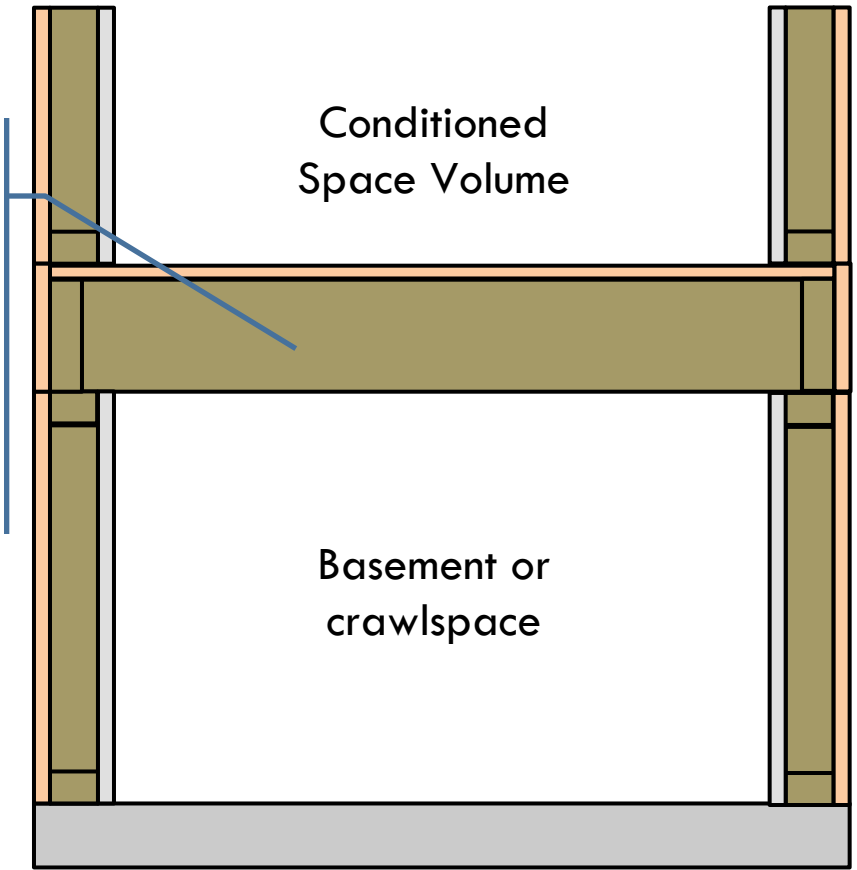


Ambient

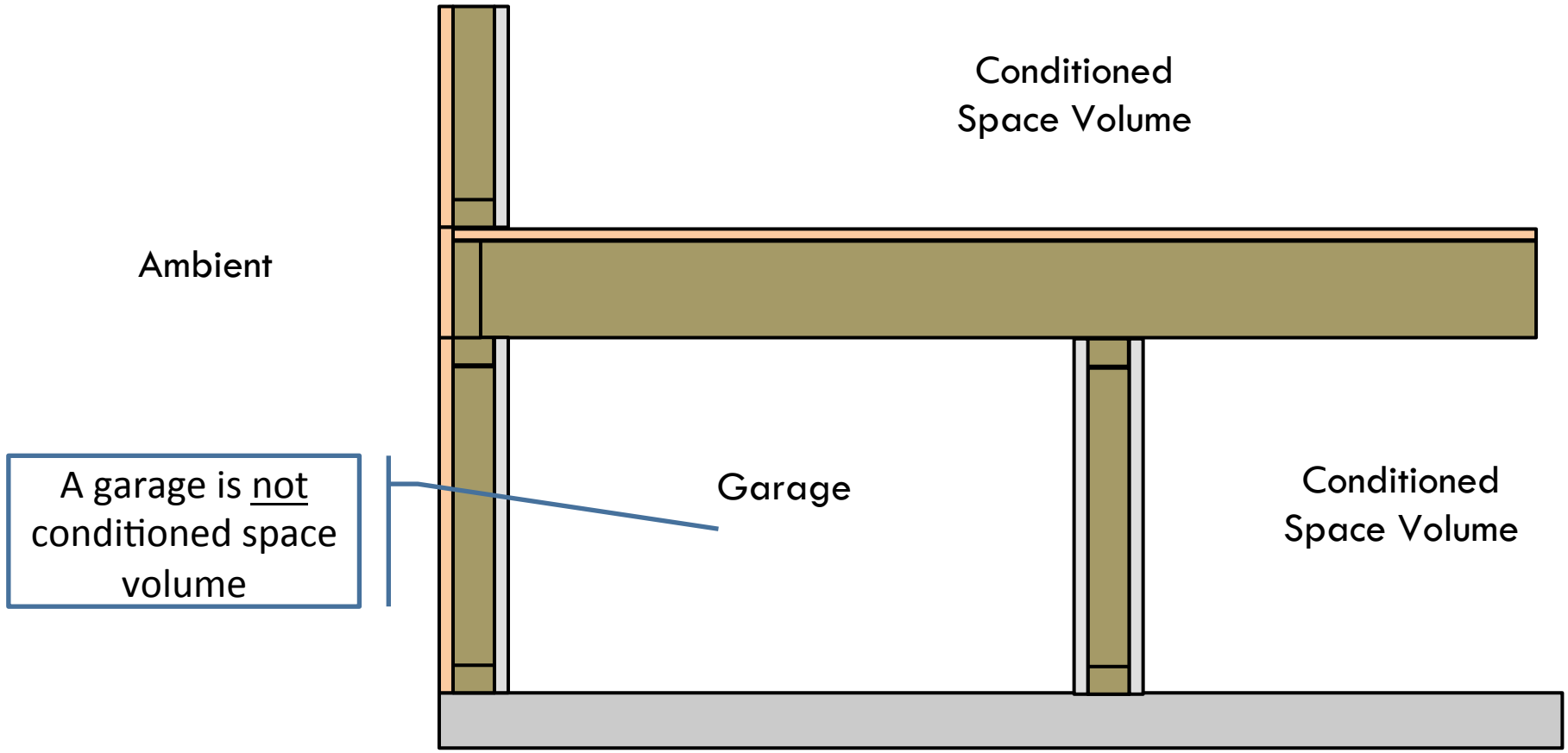
Ambient

Conditioned Space Volume – Floor Cavity

This floor cavity is only in conditioned space if the crawlspace or basement below are also in conditioned space.

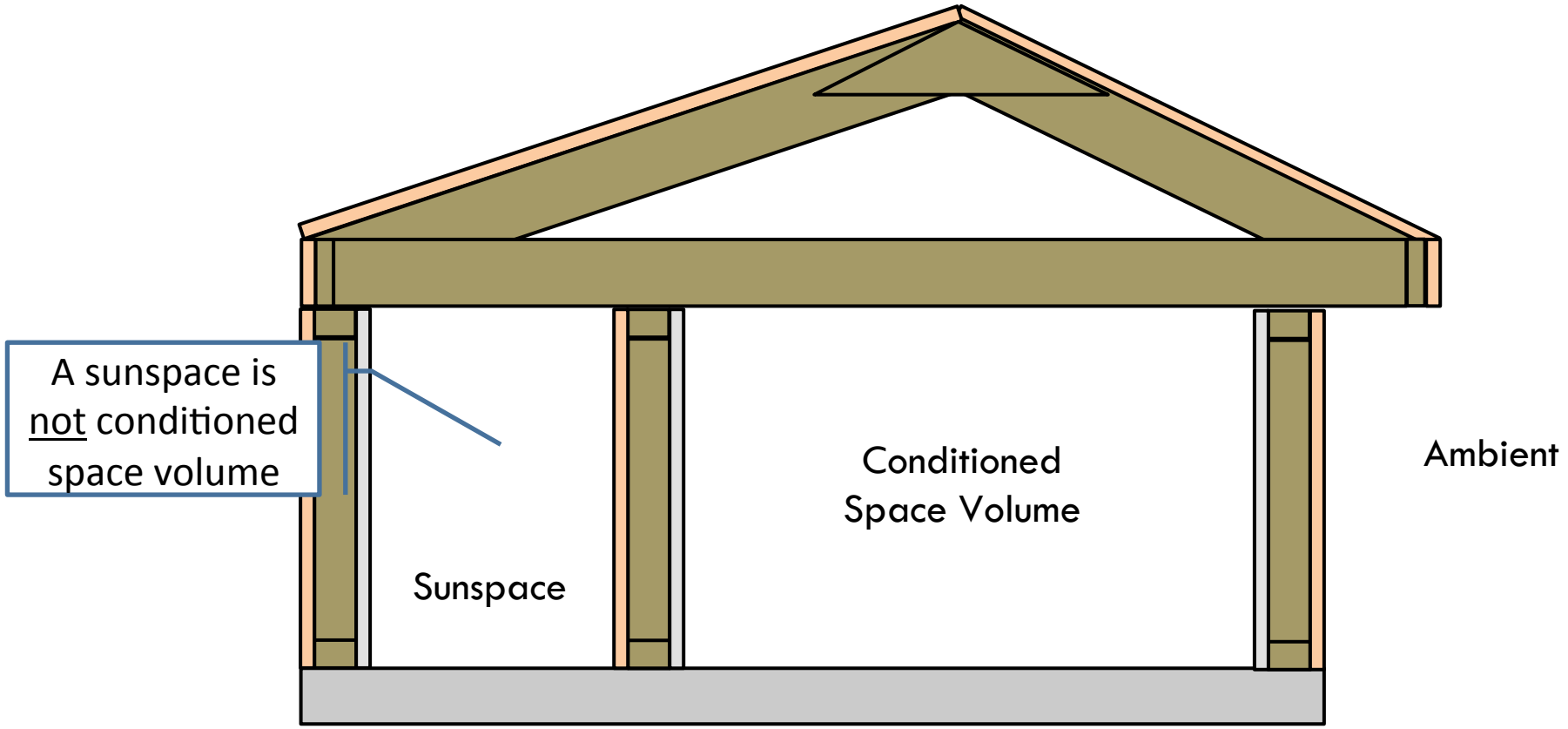


Conditioned Space Volume - Garage



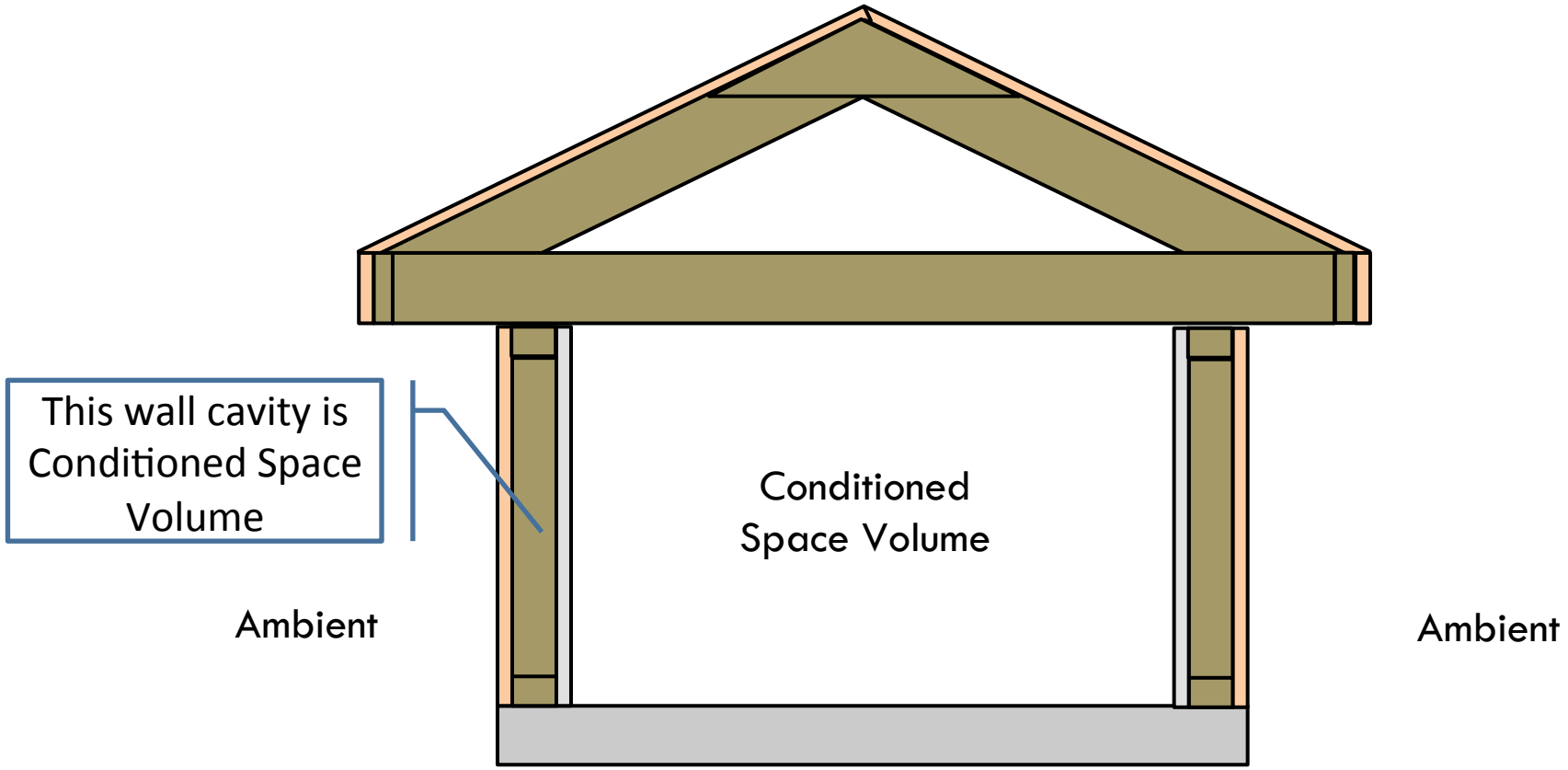
Conditioned Space Volume - Sunspace

- *The volume of a thermally isolated sunroom shall be excluded.*

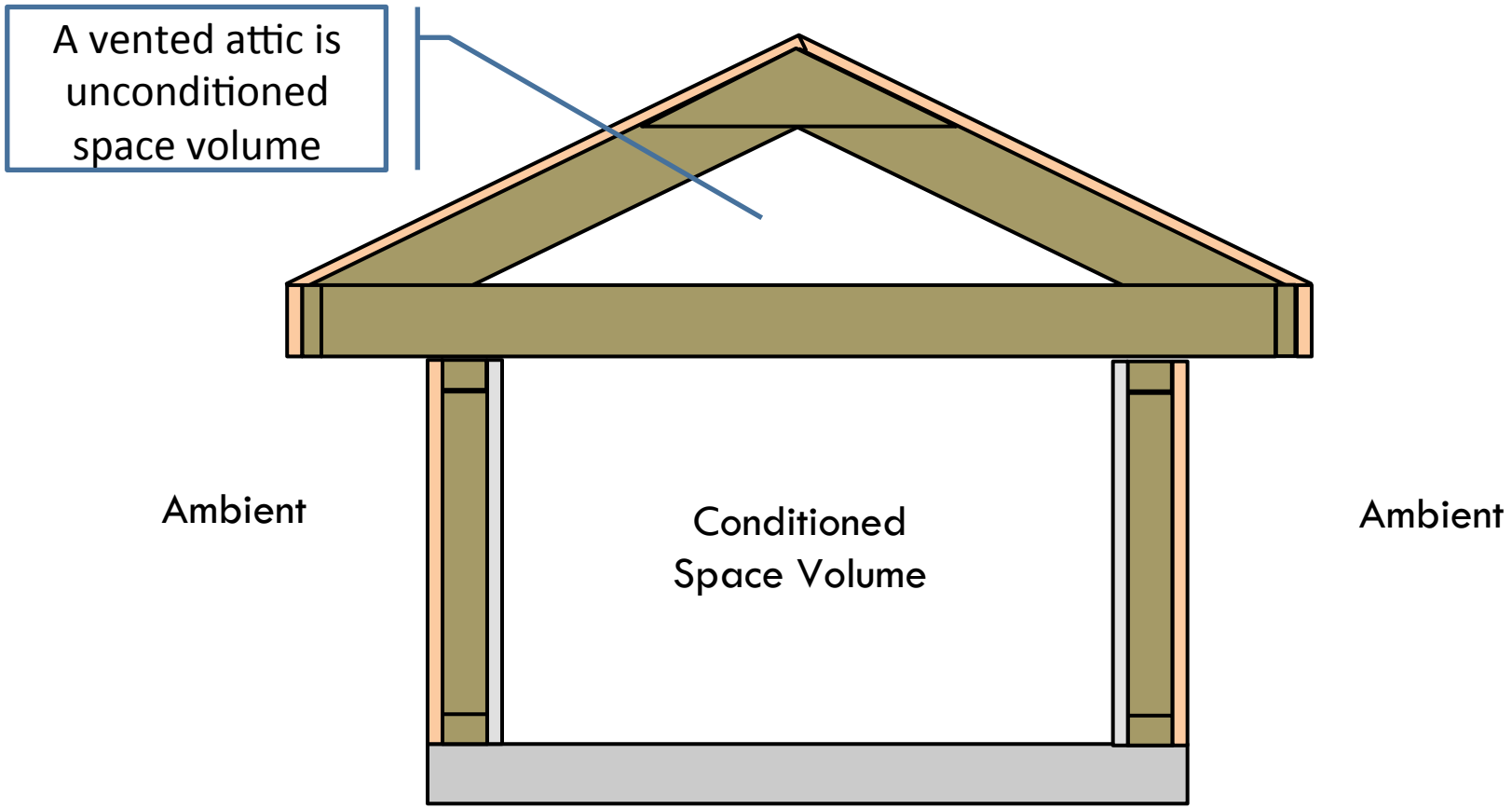


Conditioned Space Volume - Wall

Exterior measurements used for CSV

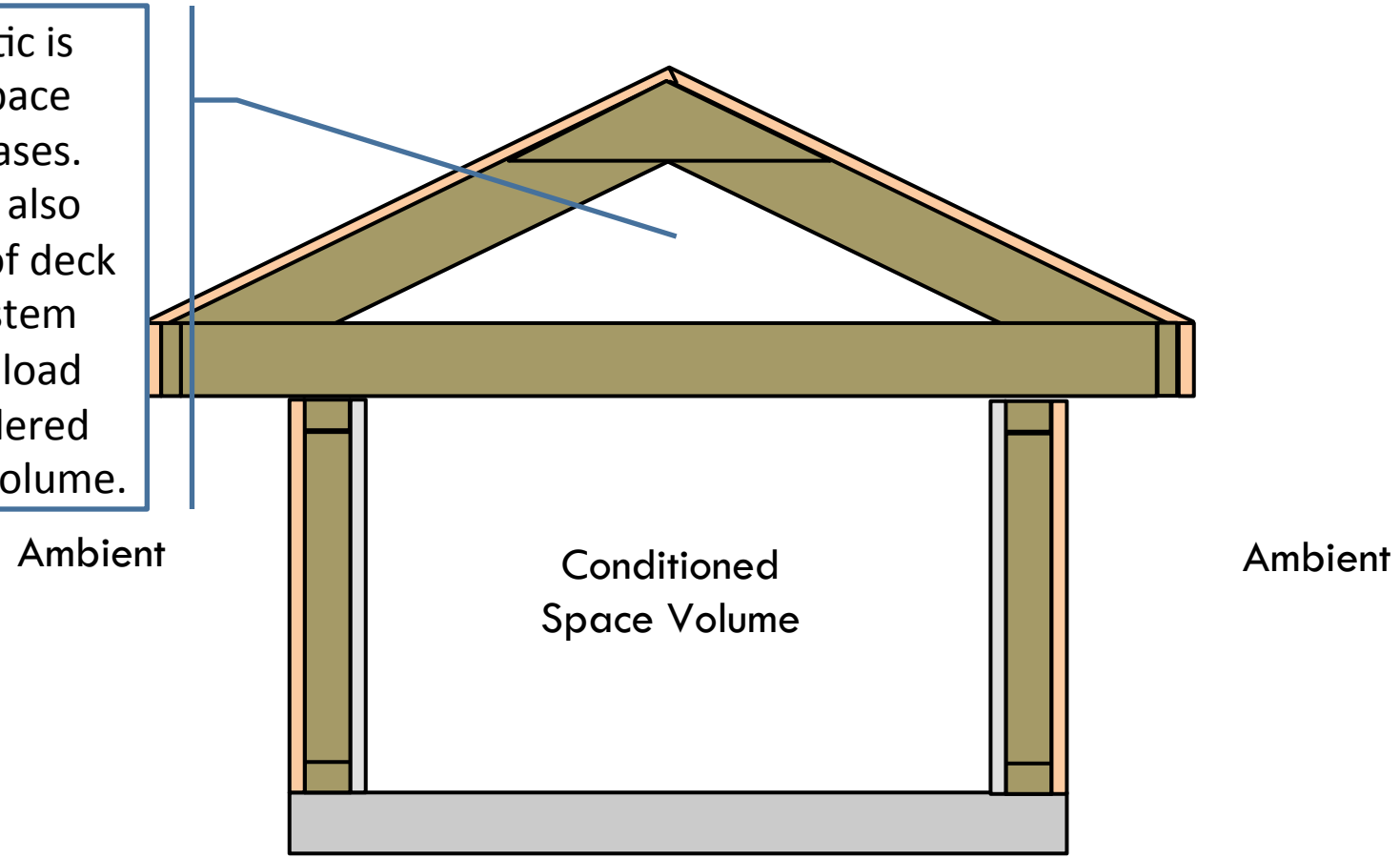


Unconditioned Space Volume - Attic



Unconditioned Space Volume - Attic

This unvented attic is unconditioned space volume in most cases. Only if the attic is also insulated at the roof deck and the HVAC system offsets the entire load would it be considered conditioned space volume.



Infiltration Volume

Changed to be based on testing configuration for consistency

- ***Infiltration Volume*** – The sum of the Conditioned Space Volume and additional adjacent volumes in the dwelling unit that meet the following criteria:
  - **Crawlspaces,** when the access doors or hatches between the crawlspace and Conditioned Space Volume are open during the enclosure airtightness test (Section 3.2.3),
  - **Attics,** when the access doors or access hatches between the attic and Conditioned Space Volume are open during the enclosure airtightness test (Section 3.2.4),
  - **Basements,** where the doors between the basement and Conditioned Space Volume are open during the enclosure airtightness test (Section 3.2.5).

Summary of volumes – soon to be table in 380

	Conditioned Space Volume	Un-Conditioned Space Volume	Conditioned Floor Area	Infiltration Volume
Space conditioned to 68/78F	Yes		Yes	Yes
Attic air sealed & insulated at roof deck, and conditioned [1]	Yes			Yes
Attic air sealed & insulated at roof deck, but not conditioned		Yes		Yes
Attic not air sealed & insulated at roof deck		Yes		
Wall cavity, with at least one horizontally-adjacent space conditioned	Yes		Yes	Yes
Wall cavity, with both horizontally-adjacent spaces unconditioned		Yes		
Floor cavity, with volume above & below conditioned	Yes			Yes
Floor cavity, with either volume above or below unconditioned		Yes		Yes
Floor cavity, with both volume above and below unconditioned		Yes		
Unvented crawlspace, conditioned [1]	Yes			Sometimes [3]
Unvented crawlspace, not conditioned		Yes		Sometimes [3]
Vented crawlspace		Yes		
Basement, conditioned [2]	Yes		Yes	Sometimes [3]
All other basements		Yes		Sometimes [3]
Garage, even if conditioned		Yes		
Thermally isolated sunroom		Yes		

1. *To be considered conditioned, the party conducting evaluations must obtain an ACCA Manual J, S, and either B or D report and verify that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume.*
2. *To be considered conditioned, the party conducting evaluations must: obtain an ACCA Manual J, S, and either B or D report and verify that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume; or verify through visual inspection that both the heating and cooling equipment and distribution system serve the volume and, in the judgement of the party conducting evaluations, are capable of maintaining the heating and cooling temperatures specified by the Thermostat section in Table 4.2.2(1) of ANSI/RESNET 301-2104.*
3. *Include attic, basement or crawl space in Infiltration Volume if the door(s) or hatch(es) between that space and Conditioned Space Volume are open during enclosure air leakage testing (Section 3.2.3, 3.2.4, and 3.2.5).*

Envelope Leakage Test Methods

- Single point pressurization or depressurization of the building envelope to 50 Pa
- Multi point pressurization or depressurization of the building envelope from 10 to 60 Pa
  - Uses calculation procedure from ASTM E779-10

Envelope Preparation – some details about holes….

What is an infiltration site during normal home operation?

- **Non-motorized dampers** 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.
- **Motorized dampers** shall be **placed in their closed positions and shall not be further sealed.**
- Non-dampered ventilation openings of *intermittently* operating **local exhaust ventilation systems** (e.g., bath fan, kitchen range hood) shall be **left open.**
- Non-dampered ventilation openings of *intermittently* operating **whole-house ventilation systems,** including HVAC fan-integrated outdoor air inlets **shall not be sealed.**
- Non-dampered ventilation openings of *continuously* operating **whole-house ventilation systems shall be sealed**

More house preparation

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

More house preparation – Crawlspaces

- Vented Crawlspace:
  - Interior access doors/hatches closed
- Unvented Crawlspace:
  - Generally, interior access doors/hatches open.
  - Doors/hatches closed for following exceptions:
    1. If floor between crawlspace and home is air sealed and insulated
    2. In a multifamily building where the crawlspace is common to one or more units

More house preparation - Attics

- NOT air sealed and insulated at the roof deck:
  - Interior access doors/hatches closed
- Air sealed and insulated at the roof deck:
  - Generally, interior access doors/hatches open.
  - Exception: Doors/hatches closed for in a multifamily building where the crawlspace is common to one or more units

More house preparation - Basements

- Generally, doors/hatches to conditioned space are open.
- Doors/hatches closed for following exceptions:
  1. If floor above the basement is air sealed and insulated
  2. In a multifamily building where the basement is common to one or more units

Envelope Leakage – Single Point

- Pressurize or depressurize to 50 Pa
- Corrections for not reaching 50 Pa

$$CFM50\ \left(\frac{ft^3}{min}\right) = Q_{high}\left(\frac{ft^3}{min}\right)\left(\frac{50}{dP_{high}}\right)^{0.65}$$

- Altitude and temperature corrections from ASTM E779-10: <u>software allowed</u>

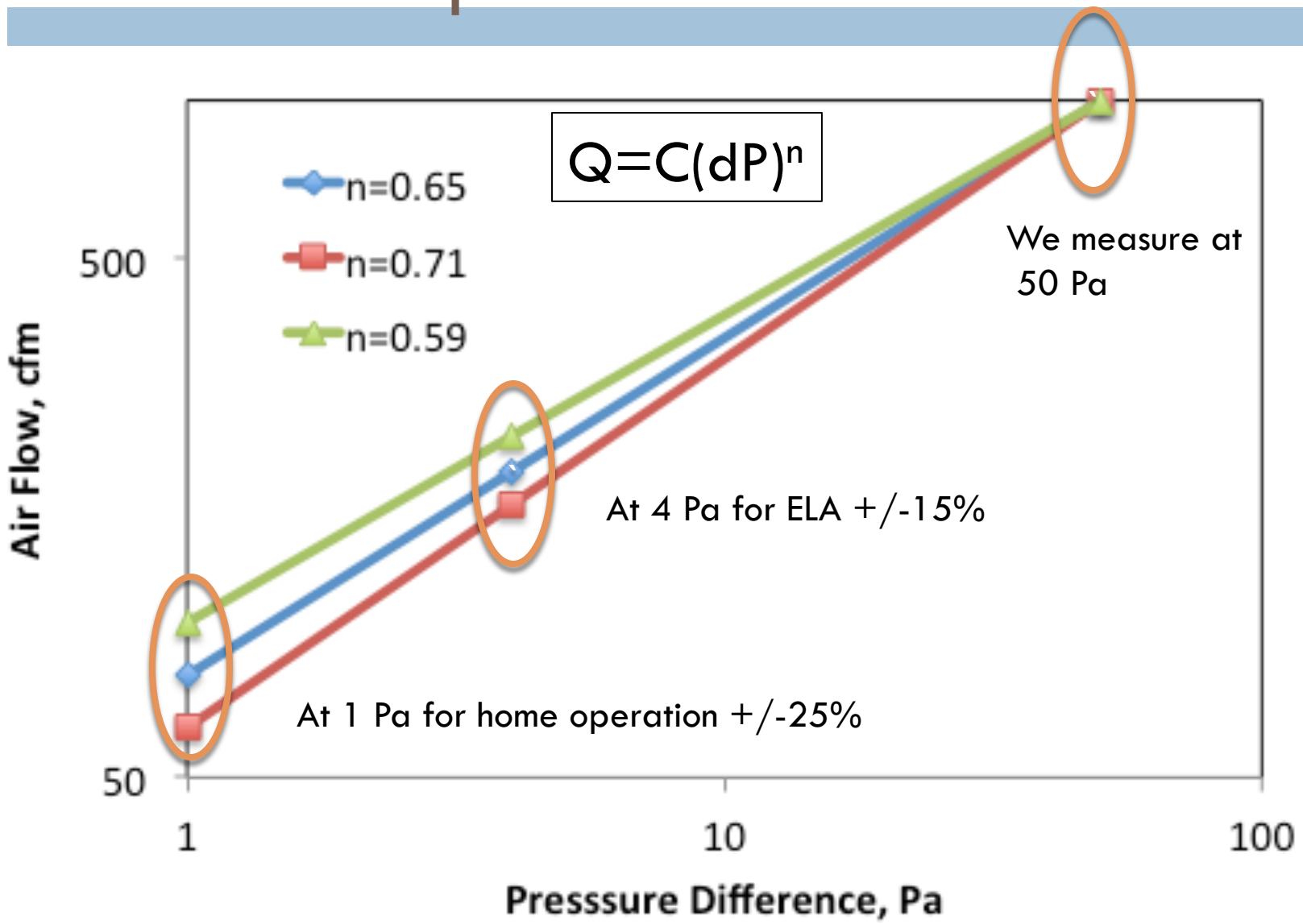
$$ELA(in^2) = \frac{Corrected\ CFM50}{18.2}$$

Multipoint Envelope Leakage

- 10 -60 Pa pressure range
- Same Altitude and temperature corrections
- Fit to: $Q = C(dP)^n$ using methods in ASTM E779-10: software provided by manufacturers allowed for calculations if manufacturer certifies that calculations done according to E779-10

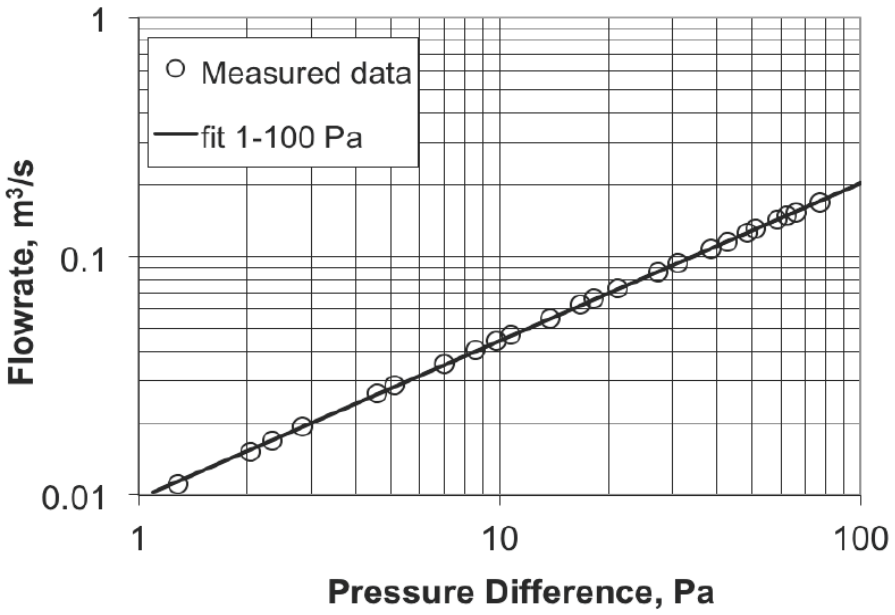
$$ELA(in^2) = C\left(\frac{ft^3}{minPa^n}\right) \times 0.567 \times 4^{(n-0.5)}$$

Envelope Leakage Test Issues: Single Point - extrapolation

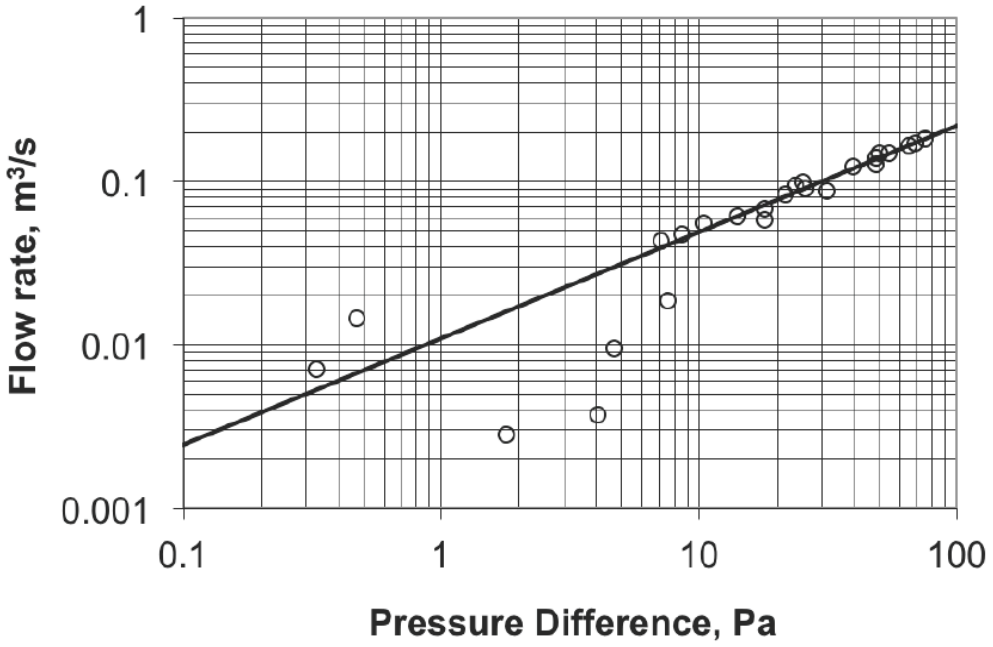


Envelope Leakage Test Issues: Multipoint – windy days

Low Wind



High Wind



Strong function of windspeed: errors small < 12 mph

Overall ~ 10% better than single point for infiltration calculations

Correcting for test uncertainty

- For retrofit energy savings, conducting an energy audit, or assessing the relative enclosure air leakage of a group of buildings, then no further corrections are made
- For a home energy rating or compliance with enclosure leakage limit we account for extrapolation to operating conditions:
  - Single Point:

  Adjusted CFM50 = 1.1 x CFM50

  Adjusted ELA = 1.1 x ELA

Conversions to other metrics

- ACH50 = CFM50 x 60 / Infiltration Volume in cubic feet
  - Used in IECC requirements
- SLA = 0.00694 x ELA in in^2 / Conditioned Floor Area in square feet
  - Used in RESNET Standard (MINHERS) and CA T24
- NLA = SLA x $(S)^{0.4}$, where S is the number of stories above grade
  - Used in ASHRAE 62.2 for infiltration credit

Total Duct Leakage – System Preparation

- All zone and bypass dampers shall be set to their open position to allow uniform pressures throughout the duct system
- All balancing dampers shall be left in their as-found position
- Non-dampered ventilation openings are sealed if continuous and open if intermittent
- You may remove registers atop carpets and seal the face of the duct boot

Duct Leakage Test Methods

- Duct Leakage pressurization or depressurization to 25 Pa
  - Total duct leakage or
  - Leakage to outside by pressurizing or depressurizing the house to the same test pressure
  - Does not separate supply from return
  - Includes provisions for “can’t reach 25”
- For Air Leakage at operating conditions: Test method A of ASTM E1554 (DeltaQ)

Total duct leakage

- Exterior access panels open for unconditioned spaces containing ducts
- Duct leak tester may always be attached at blower access panel
- Duct leak tester may be attached to a return grille only:
  - if there are three or less return grilles,
  - if local jurisdiction requirements prevent installation at the blower access panel, or
  - if total leakage < 50 cfm
- Several options for duct pressure location (must be recorded)
- Pressurize house to 25 Pa
- Zero pressure between house and ducts

Duct Leakage Applications

- For compliance with a total duct leakage limit use total duct leakage
- For compliance with a leakage to outside limit use either total or leakage to outside
- For use in an energy audit or prediction of energy savings use leakage to outside

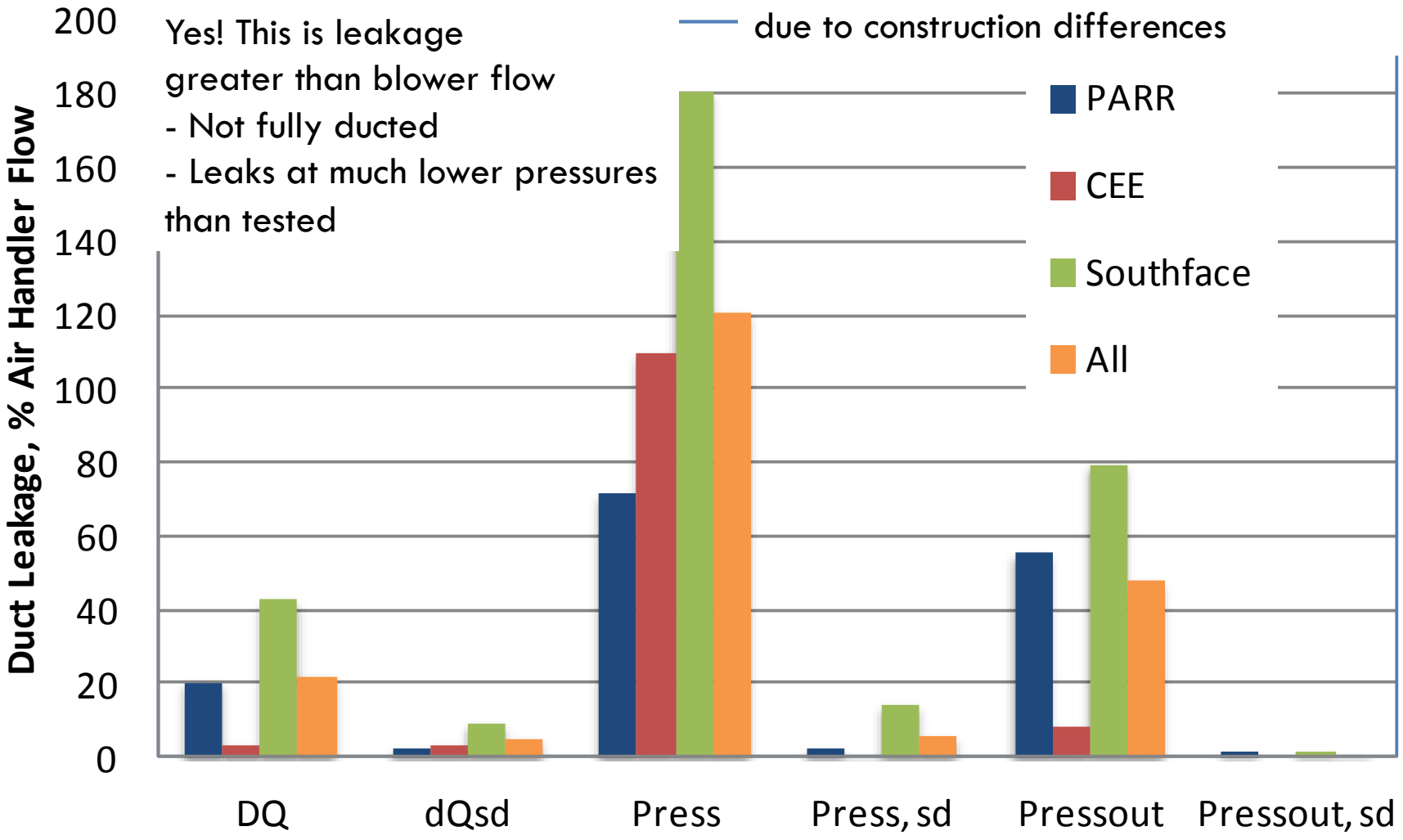
Duct Leakage Performance Issues

- Some duct systems have no attempt at sealing (northern tier basements in particular) and have nonsensical pressurization results
- On very windy days DeltaQ testing is unreliable
- What about repeatability?
  - Recent study on 30 homes by Building America
  - 3 teams in different locations, ten homes each
  - All three tests repeated continuously for a day – about ten repeats – so about 900 total tests

Test results – average and standard deviations

Large variation between sample locations due to construction differences

Yes! This is leakage greater than blower flow
- Not fully ducted
- Leaks at much lower pressures than tested

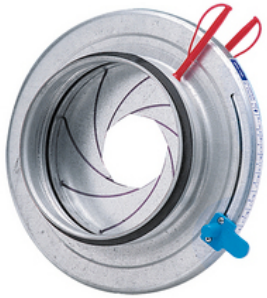


Repeatability results

- For DeltaQ and Total Pressurization: +/- 6%
- For Pressurization to outside: +/- 1%
- For low leak (<6% by DeltaQ) systems much better repeatability:
  - Pressurization: +/- 1%
  - Pressurization to outside: +/- 0.3%
  - DeltaQ: +/- 3%

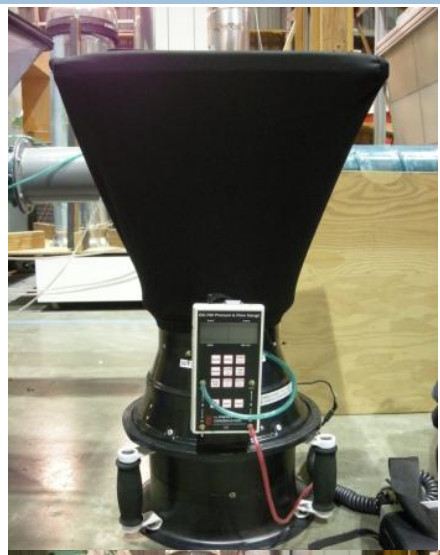
Ventilation Air Flow Test Methods in RESNET 380

- Airflow at inlet
  - Powered flow hood
  - Air flow resistance
  - Passive flow hood
- Airflow at outlet
  - Powered flow hood
  - Bag inflation
- In-duct airflow
  - Flow measurement station



Flow at Inlet or Outlet terminal

- Powered flow hood
  - Fan zeros pressure between capture hood and room
  - Can be commercial devices or build your own



Flow at Outlet Terminal – Bag Inflation

- If you know volume (gallons) and time (seconds)

Airflow (CFM)=(8 × Volume)/ (Elapsed Time)

Flow at Outlet Terminal – Bag Inflation

ABOUT YOUR HOUSE

CE33

CMHC GARBAGE BAG AIRFLOW TEST

There are times when you need to know the airflow from your furnace registers, bathroom exhaust fan or clothes dryer exhaust.

For example, if a house has one cold room in the winter, it is useful to find out if this is because your furnace isn't supplying enough warm air. If you installed a new bathroom exhaust fan, you could use the test to see if it is working properly.

This publication tells you how to do the *CMHC Garbage Bag Airflow Test*. The Test is a quick way to estimate airflow, by determining how long it takes to fill a common plastic garbage bag.

It is not a precise measurement, but it is a vast improvement over no measurement at all.

How to do the test

Here's how to use the test to measure airflow from a register or exhaust:

- Tape the mouth of the garbage bag to a bent coat hanger or a piece of cardboard to keep it open. (See Figure 1)
- Crush the bag flat.
- Place it over the register or exhaust hood.
- Count how many seconds it takes for the bag to inflate. (See Figure 2)
- Find the airflow from the register or exhaust from one of the following tables.

If you want to measure air going out, you can hold an inflated bag against an exhaust grill, and count how many seconds it takes for the bag to deflate. Deflation testing is not as accurate as inflation testing, but it is still a reasonable test. Low airflow is difficult to measure by deflation testing.

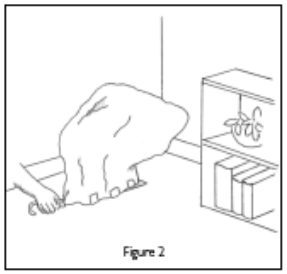


Figure 2

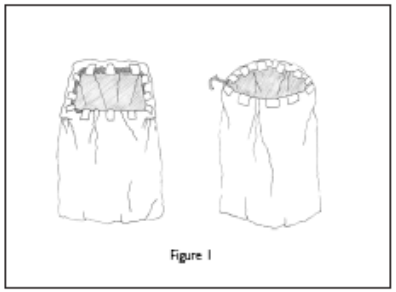


Figure 1

CMHC SCHL

HOME TO CANADIANS

Canada

Small green garbage bag (Glad 66 x 91 cm)

Time to inflate	Flow of air into the bag
2 seconds	35 L/s (75 cfm)*
4 seconds	20 L/s (40 cfm)
10 seconds	10 L/s (20 cfm)

* L/s = litres per second; cfm = cubic feet a minute

For deflation, add a second. Therefore, 35 L/s would take about three seconds and 20 L/s about five seconds.

Big orange garbage bag (Glad 79 x 119 cm)

Time to inflate	Flow of air into the bag
2 seconds	100 L/s (210 cfm)*
4 seconds	50 L/s (105 cfm)
6 seconds	35 L/s (75 cfm)
10 seconds	20 L/s (40 cfm)

* L/s = litres per second; cfm = cubic feet a minute

Deflation times for the big orange bag are about the same as inflation times.

How to use the test

Using the examples mentioned above, if the measured airflow from a forced-air register is less than 10 L/s, the furnace is delivering only a small amount of heat to a room.

If you install a 100 cfm exhaust fan, and the fan inflates a standard bag in less than two seconds, you have the rated exhaust flow for the fan.

CMHC's Garbage Bag Airflow Test is also useful if you have changed your heating or cooling systems, or if you have made major renovations to your house.

To find more *About Your House* fact sheets plus a wide variety of information products, visit our Web site at

www.cmhc-schl.gc.ca

or contact:

Your local CMHC office
or
Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa ON K1A 0P7

Phone: 1 800 668-2642
Fax: 1 800 245-9274

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Sometimes bag inflation is the only way?

Flow at Outlet Terminal

Flow at Inlet Terminal

- Air flow resistance
  - Single branch only!!!!!
  - Known air flow resistance: measure pressure difference
  - If you know opening area (square inches) and pressure difference (Pa), you can build your own and use:

$$\text{Air Flow (cfm)} = 1.07 \times \text{Opening Area (in}^2\text{)} \times (\text{dP})^{0.5}$$

Flow at Inlet Terminal

- Passive flow hood
- Only if pressure difference between hood and room < 5 Pa
  - Many commercially available devices are not precise or accurate enough at ventilation air flow rates (e.g., < 50 cfm)

In-Duct Air Flows

- Requires air flow measurement station in duct + a manometer + measurement of duct cross sectional area
- Can be permanent or temporary installation
- Air flow derived from converting pressure to average air velocity, V (fpm), and multiplying by cross-sectional area, A (ft^2):

$$\text{Airflow (CFM)} = V \times A$$

NEW: Total Heating/Cooling system air flow

- Refers to ASHRAE Standard 152 and ASTM E1554
- From E1554: pressure matching
  - Measure dP from supply plenum to home
  - Attach fan/flowmeter at blower access or return grille
  - Turn on system blower and flow meter blower and match measured dP
- From 152: flow plate
  - Insert calibrated flow plate in filter slot

A note on measurement accuracy

- Duct and house leakage:
  - Manometer: +/- 1% of measurement or 0.25 Pa
  - Air Flow meter: +/- 5% of measurement
- In duct air flow stations:
  - +/- 10% of 5 cfm
  - Manometer: +/- 1% of measurement or 0.25 Pa
  - Integrated flowmeter: +/-15% of highest flow for device, e.g., 100 cfm whole house ventilator is +/- 15 cfm

Questions?

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