RESNET - INTERNATIONAL CODE COUNCIL ANSI CONSENSUS STANDARD ON BLOWER DOOR AND DUCT LEAKAGE TESTING

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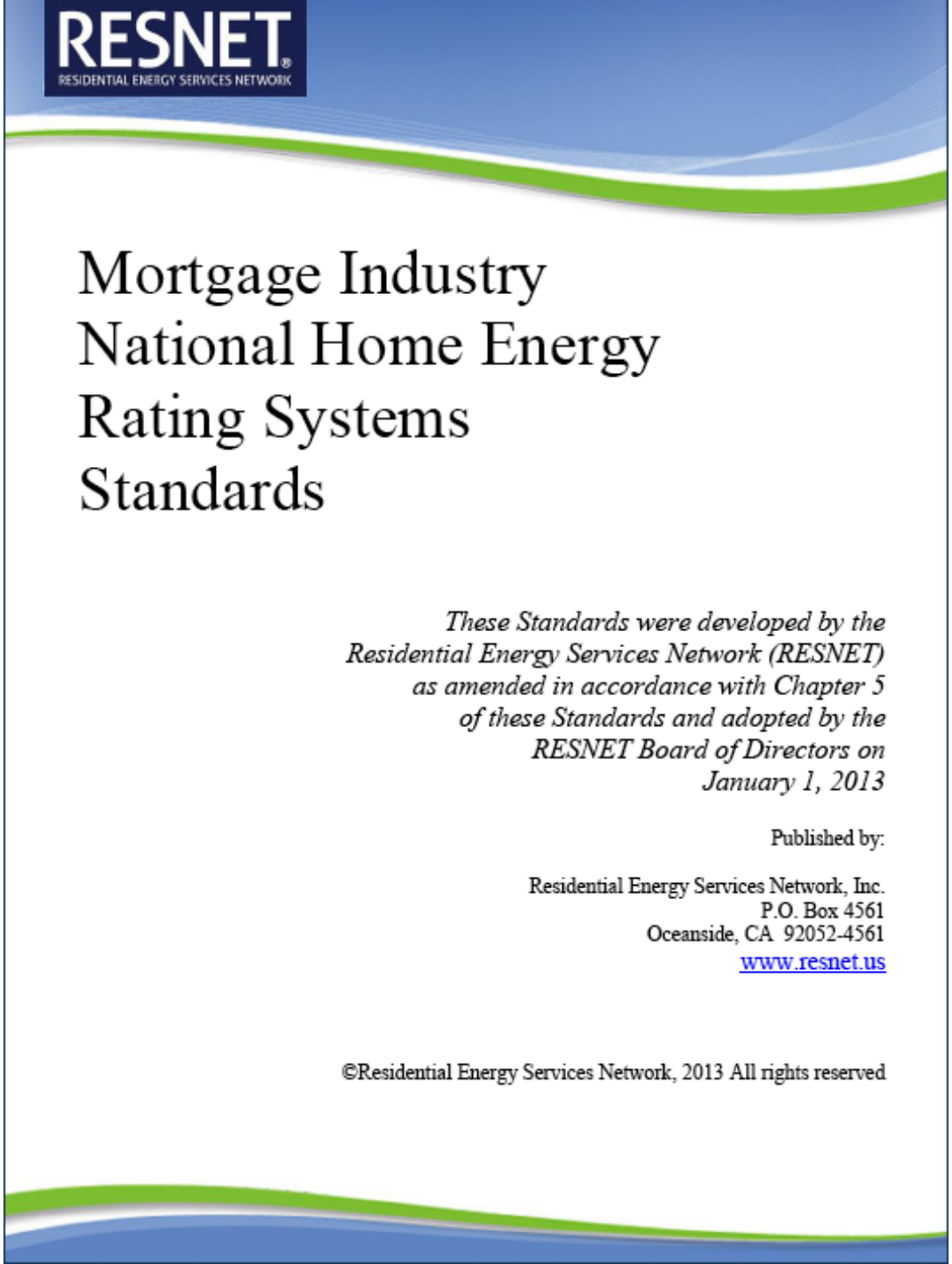
Standard 380

Waiting for final ANSI approval – a consensus process including public reviews (completed)

Together with ICC – proposed to be used as a code reference document e.g., for house leakage testing



MINHERS

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

Will refer to 380 in the future

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 (volume defined)
     - ELA = effective leakage area = hole size at 4 Pa
     - SLA = ELA/conditioned floor area (CFA defined)
     - 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
   - could be referred to by ASHRAE 62.2
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 is 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

- Diagnostic testing is for MINHERS
- All single-family, but 3-story or less in MF ("applicable to all single family dwelling units")
- Proposed code amendment to have 380 referenced in the 2018 IECC/IRC

What is different from Chapter 8 of MINHERS?

- Definitions
  - 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

Why New Definitions?

- There are several key terms in Std 380 that need to be clearly defined to ensure consistent application of the standard:
  - Conditioned Space Volume
  - Unconditioned Space Volume
  - Infiltration Volume
  - Conditioned Floor Area
- Several of these terms are also defined in ANSI/RESNET 301-2014, but those definitions are problematic in one regard or another.
- The general approach for this proposal was to favor *consistency* over *rater discretion* and to use detailed definitions to ensure more consistent application of the standard.

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

- ***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 when it is conditioned.
- The volume of a thermally isolated sunroom shall be excluded.

New Definitions

- ***Conditioned Space Volume, continued…***The volume of an attic that is air sealed and insulated at the roof deck or an unvented crawlspace shall only be included if the Rater has 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.
- The volume of a basement shall only be included if the Rater 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 Rater's judgement**, 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.

New Definitions

- ***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:
- 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 when 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.

New Definitions

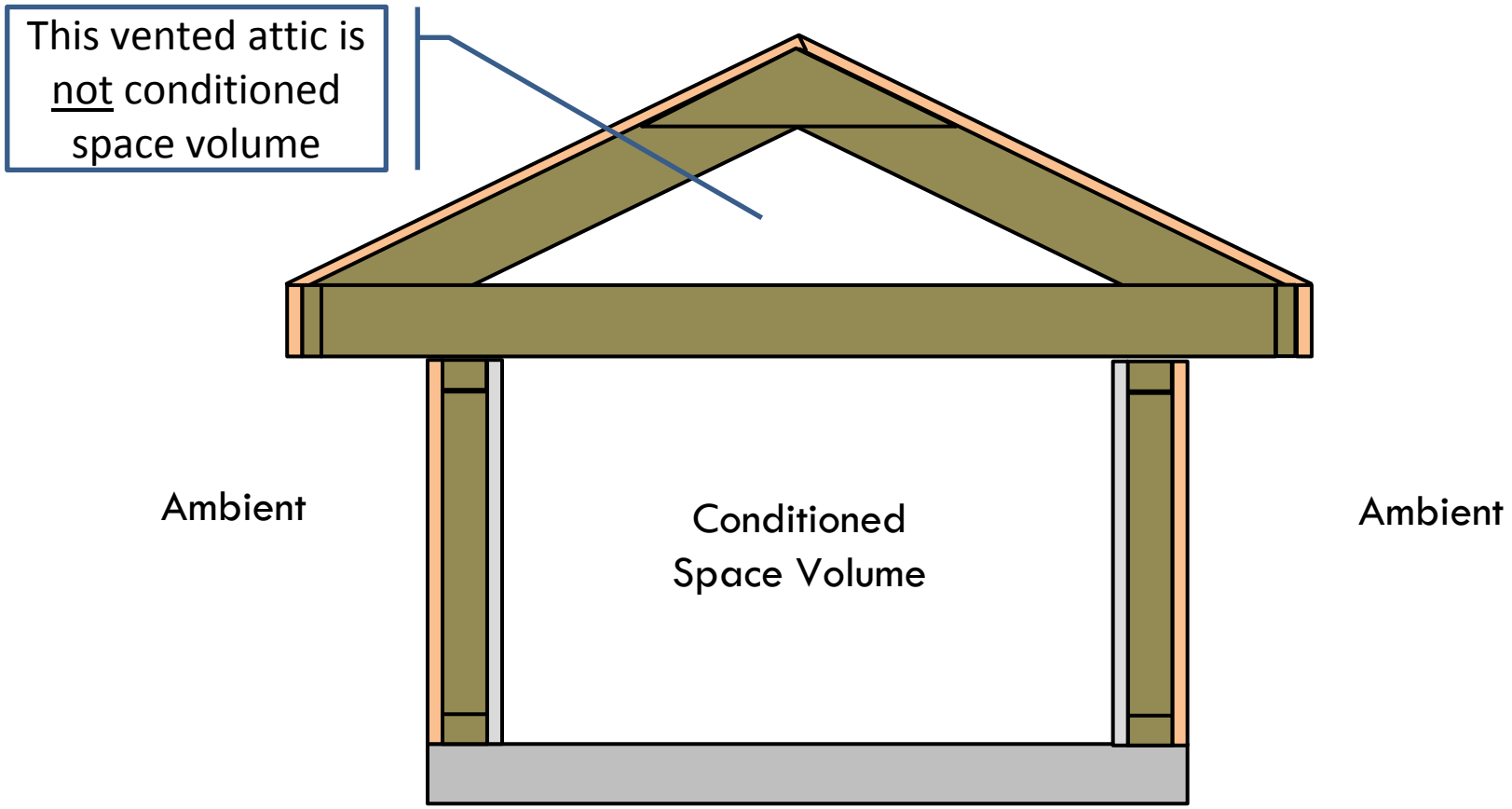
- ***Conditioned Floor Area (CFA)*** – The floor area of the Conditioned Space Volume within a building, minus the floor area of attics, floor cavities, crawlspaces, and basements below air sealed and insulated floors. The following specific spaces are addressed to ensure consistent application of this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

New Definitions

- ***Conditioned Floor Area (CFA), continued***
- 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 floor cavity 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

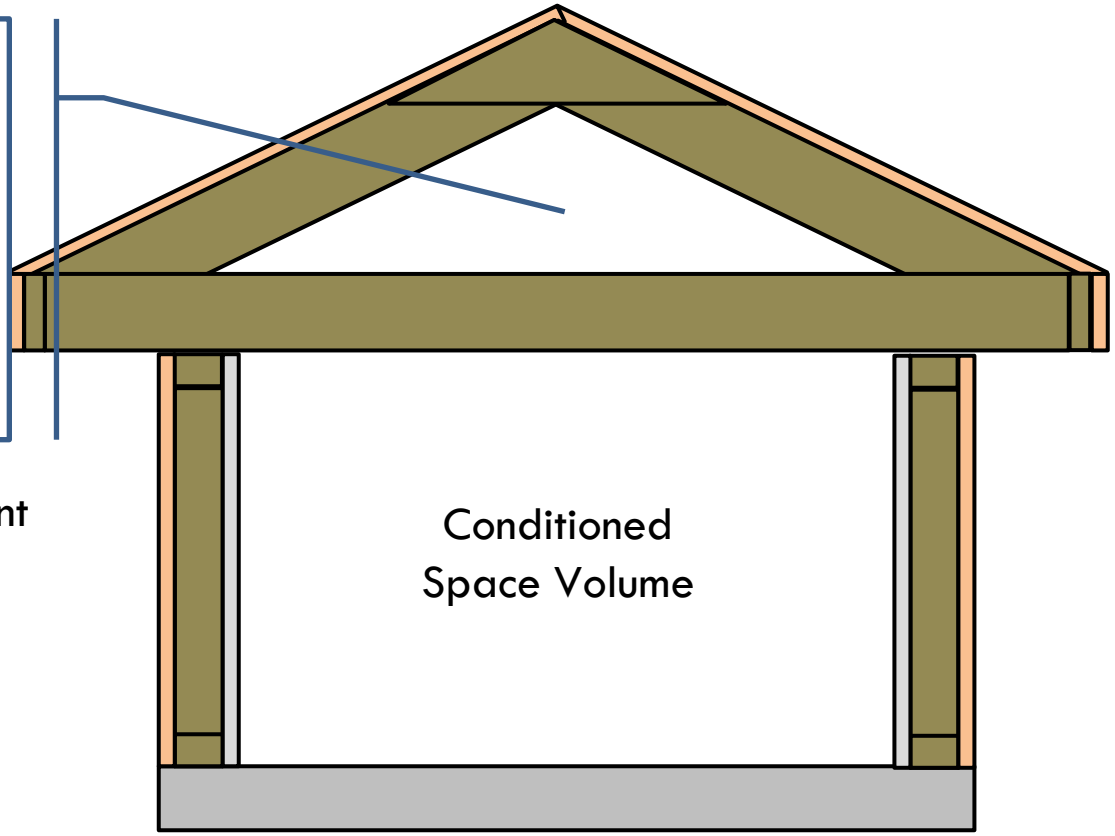
- *The volume of an attic that is not air sealed and insulated at the roof deck shall be excluded.*



Conditioned Space Volume

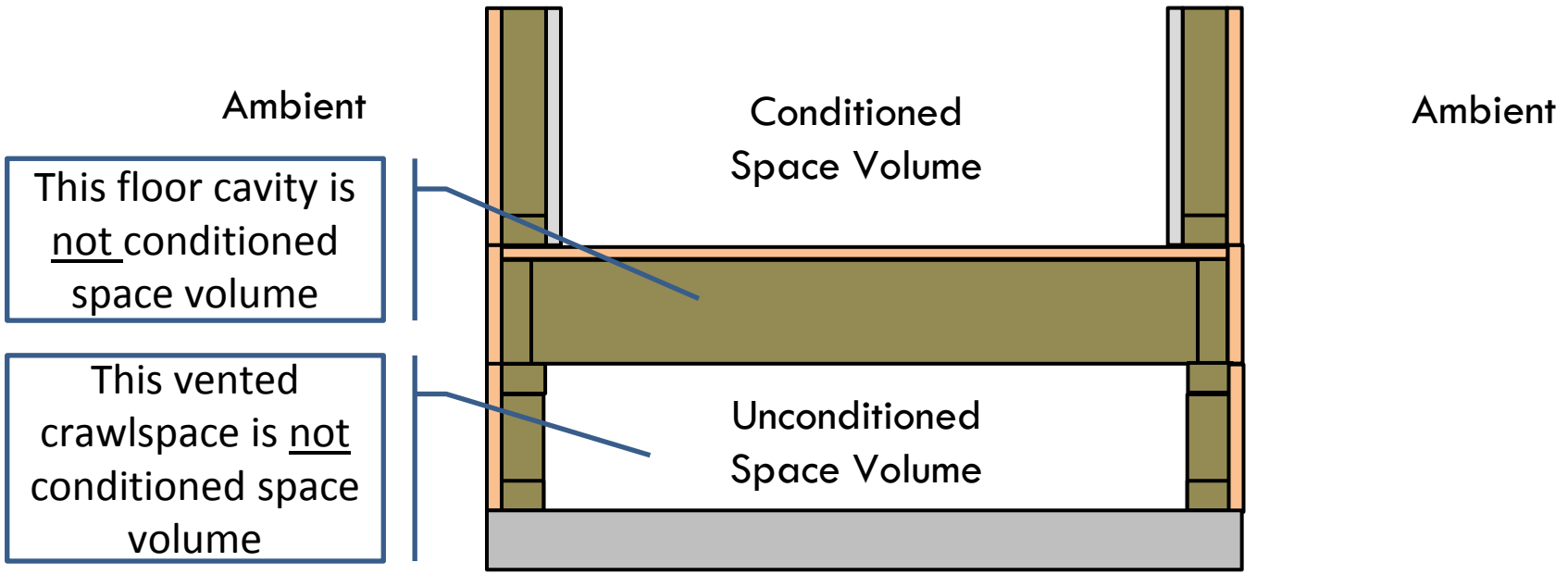
- *The volume of an attic that is air sealed and insulated at the roof deck or an unvented crawlspace shall only be included if the Rater has obtained an ACCA Manual J, S, and either B or D report and verified that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume.*

This unvented attic is not conditioned space volume in most cases. Only if the HVAC system offsets the entire load would it be considered conditioned space volume.



Conditioned Space Volume

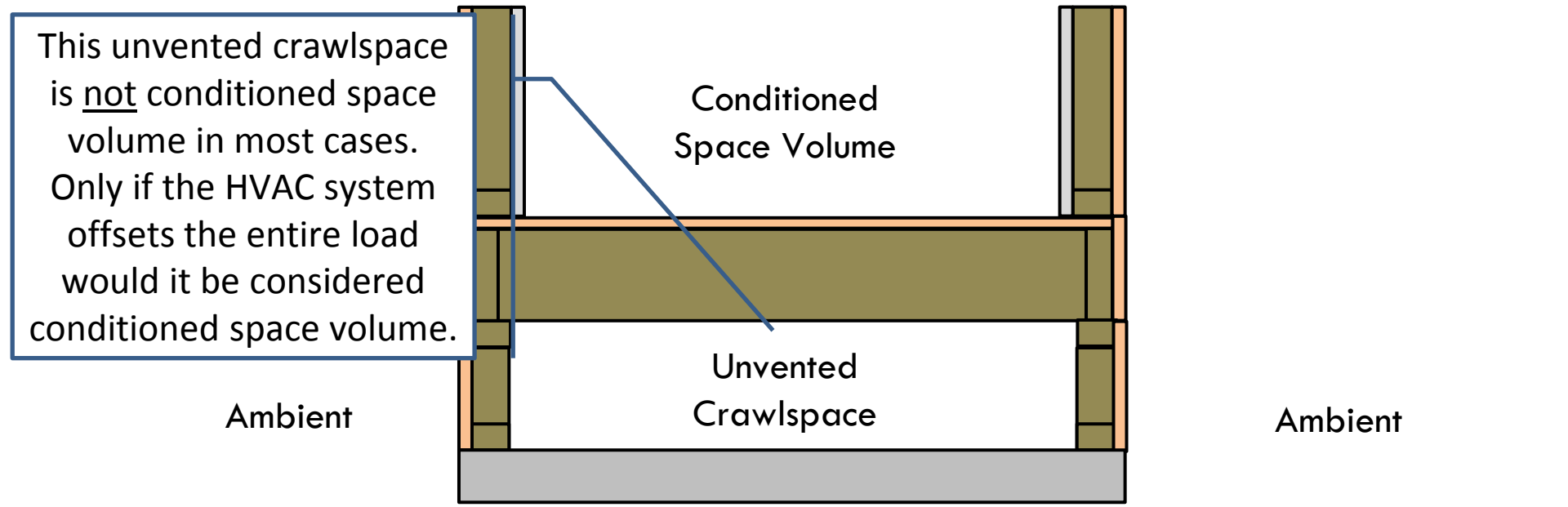
- *The volume of a vented crawlspace shall be excluded.*



Conditioned Space Volume

- *The volume of an attic that is air sealed and insulated at the roof deck or an unvented crawlspace shall only be included if the Rater has 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.*

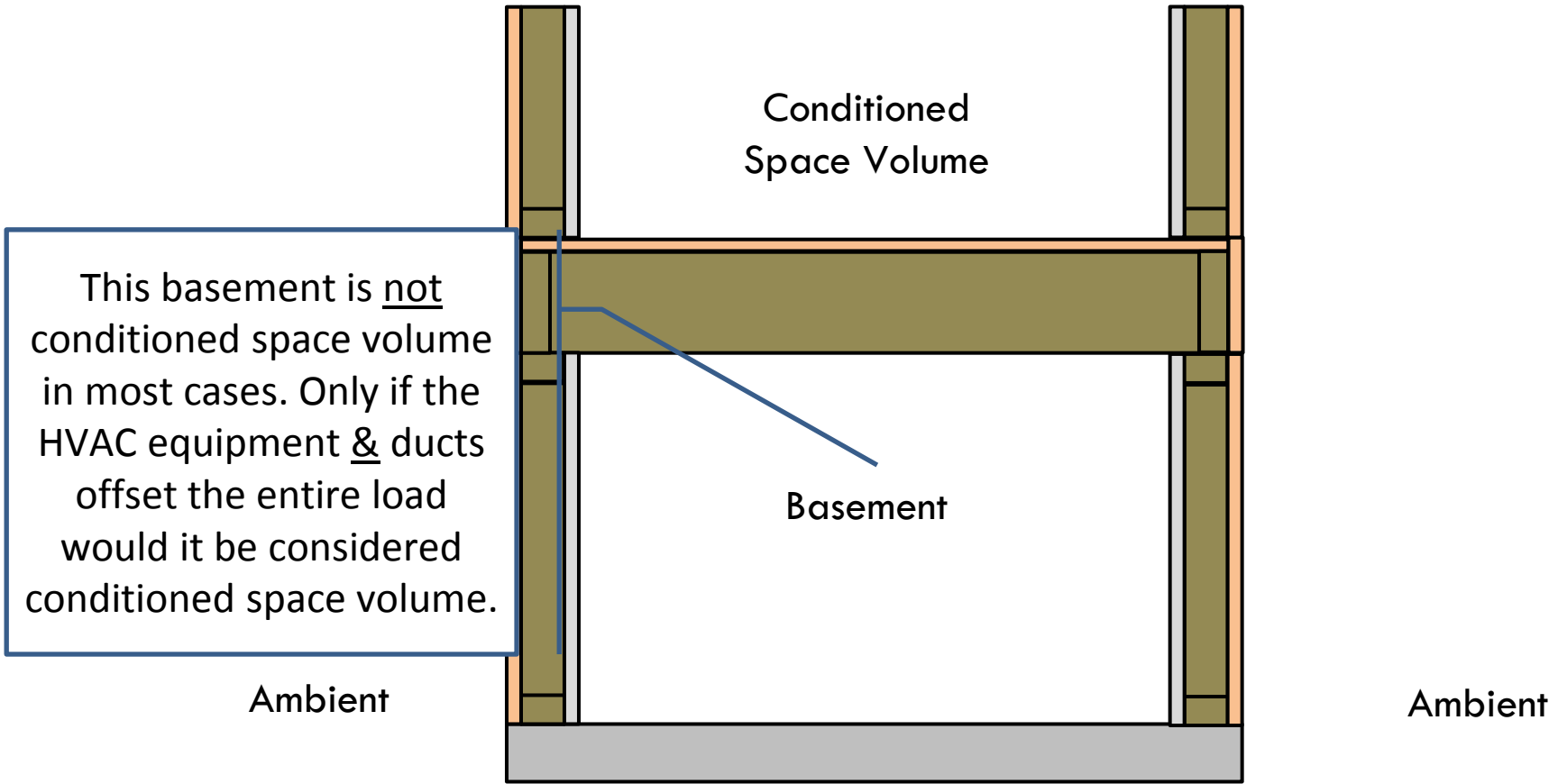
This unvented crawlspace is not conditioned space volume in most cases. Only if the HVAC system offsets the entire load would it be considered conditioned space volume.



Conditioned Space Volume - Basements

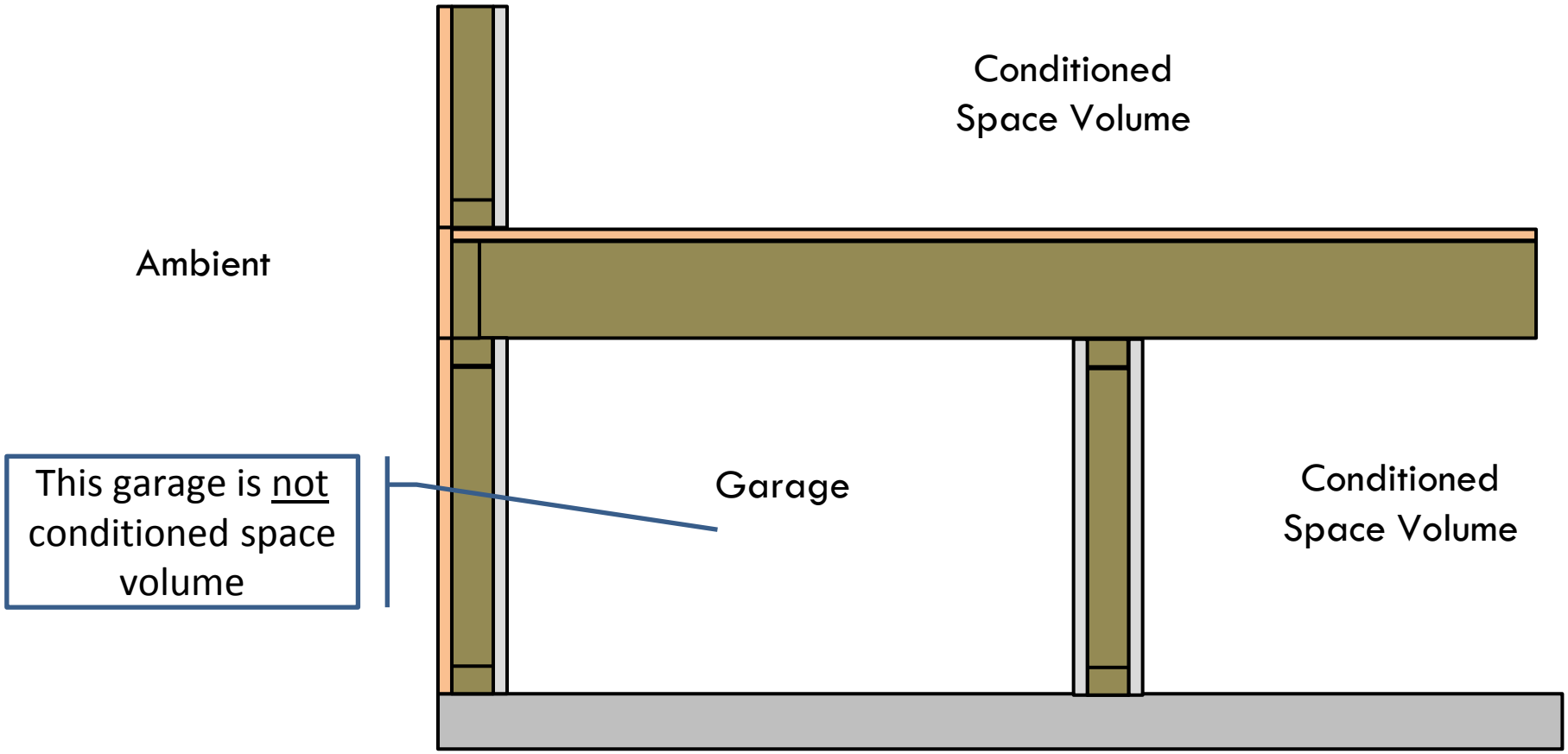
- *The volume of a basement shall only be included if the Rater has either:*
  - *Obtained an ACCA Manual J, S, and either B or D report and verified that both the heating and cooling equipment and distribution system are designed to offset the entire design load of the volume, or,*
  - *Verified through visual inspection that both the heating and cooling equipment and distribution system serve the volume and, in the Rater's judgement, 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 Space Volume



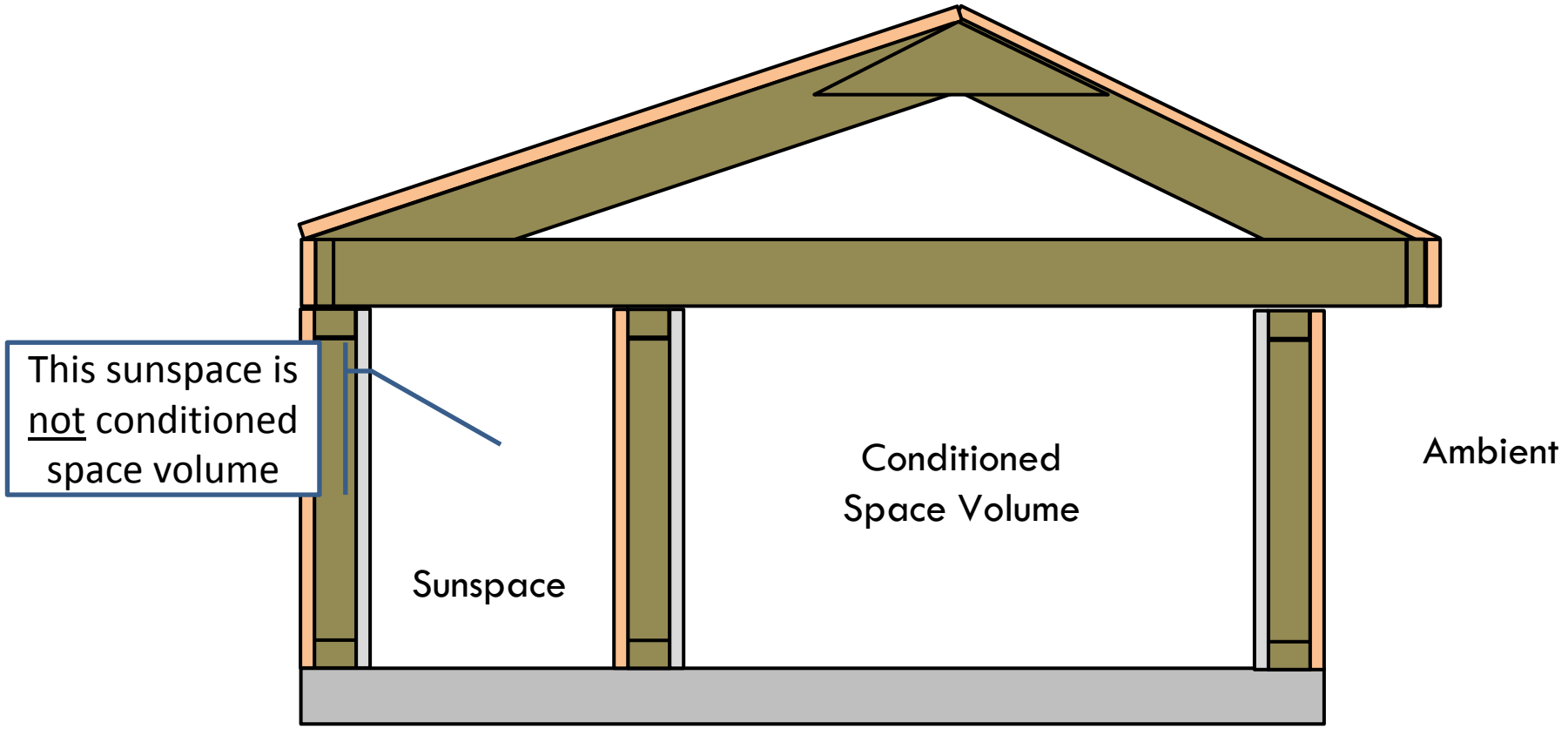
Conditioned Space Volume

- *The volume of a garage shall be excluded, even if it is heated.*



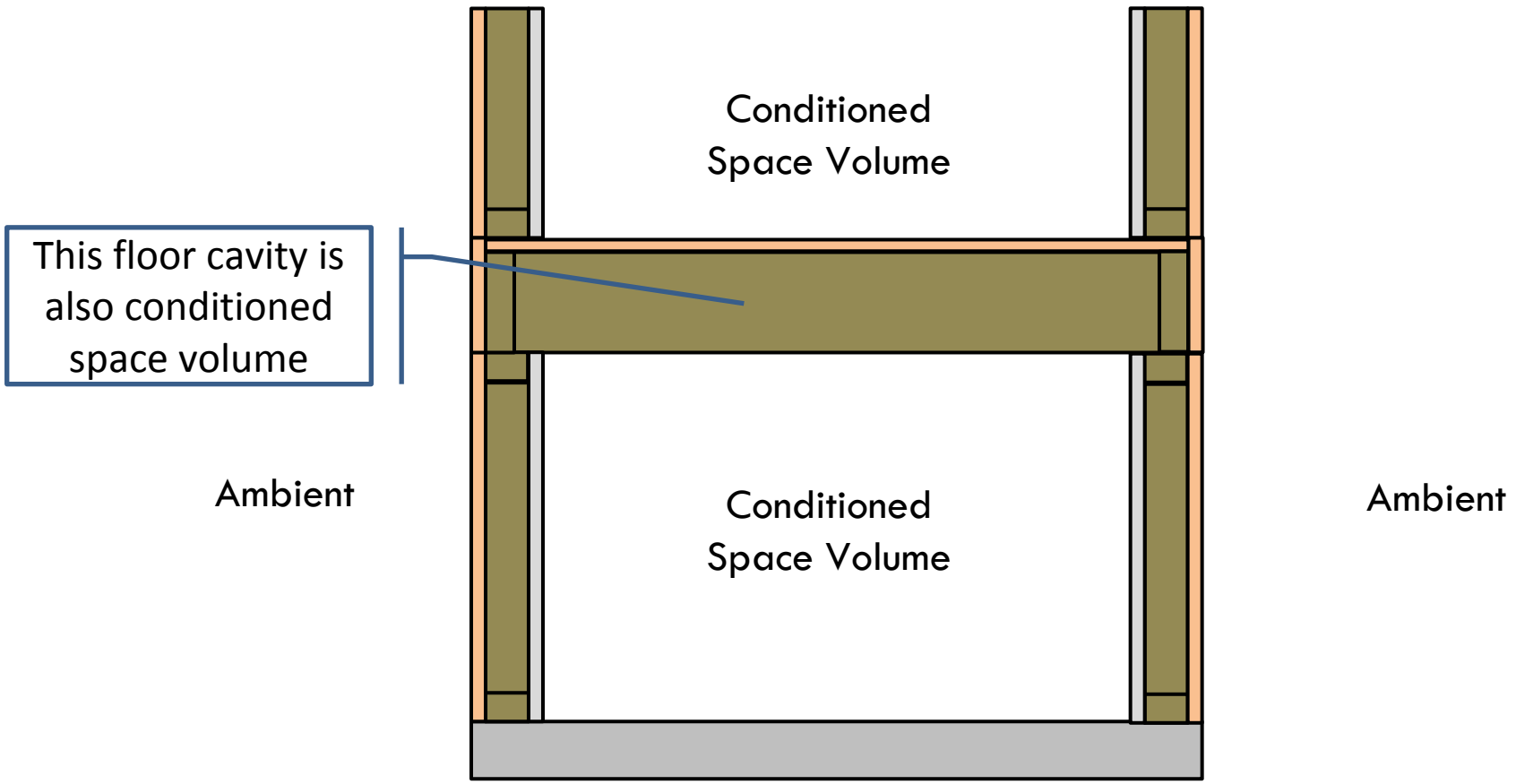
Conditioned Space Volume

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



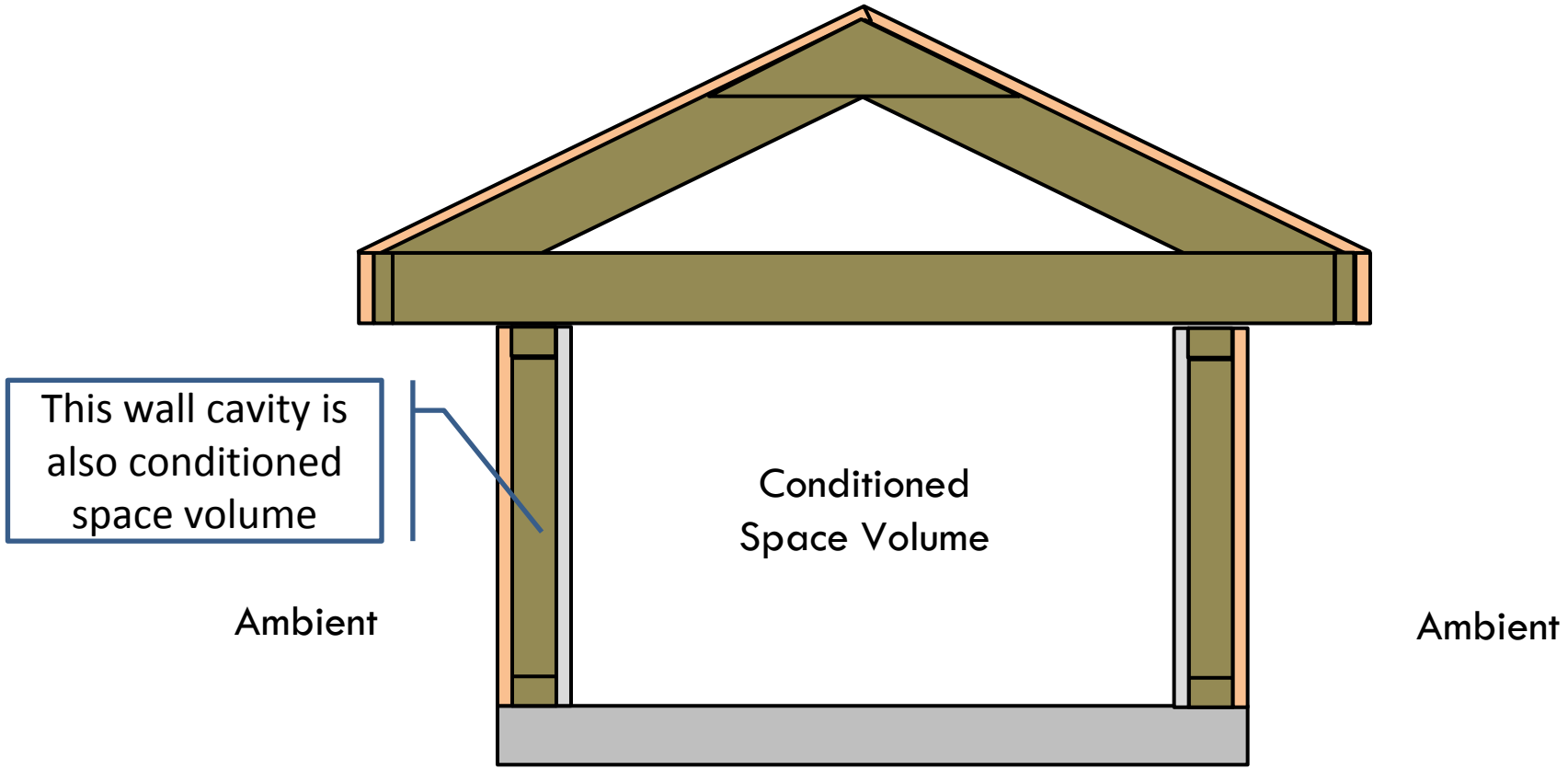
Conditioned Space Volume

- *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.*



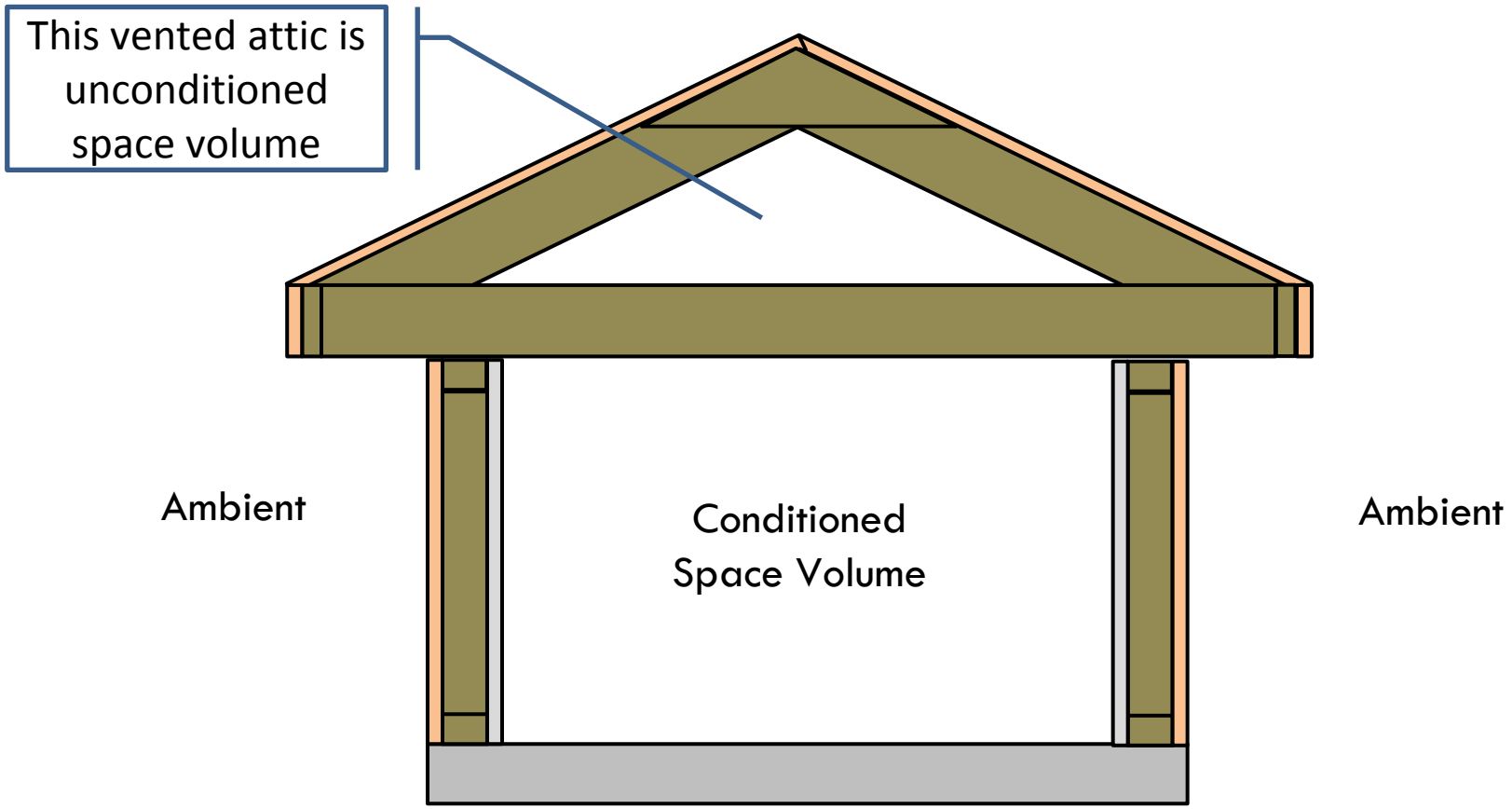
Conditioned Space Volume

- *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.*



Unconditioned Space Volume

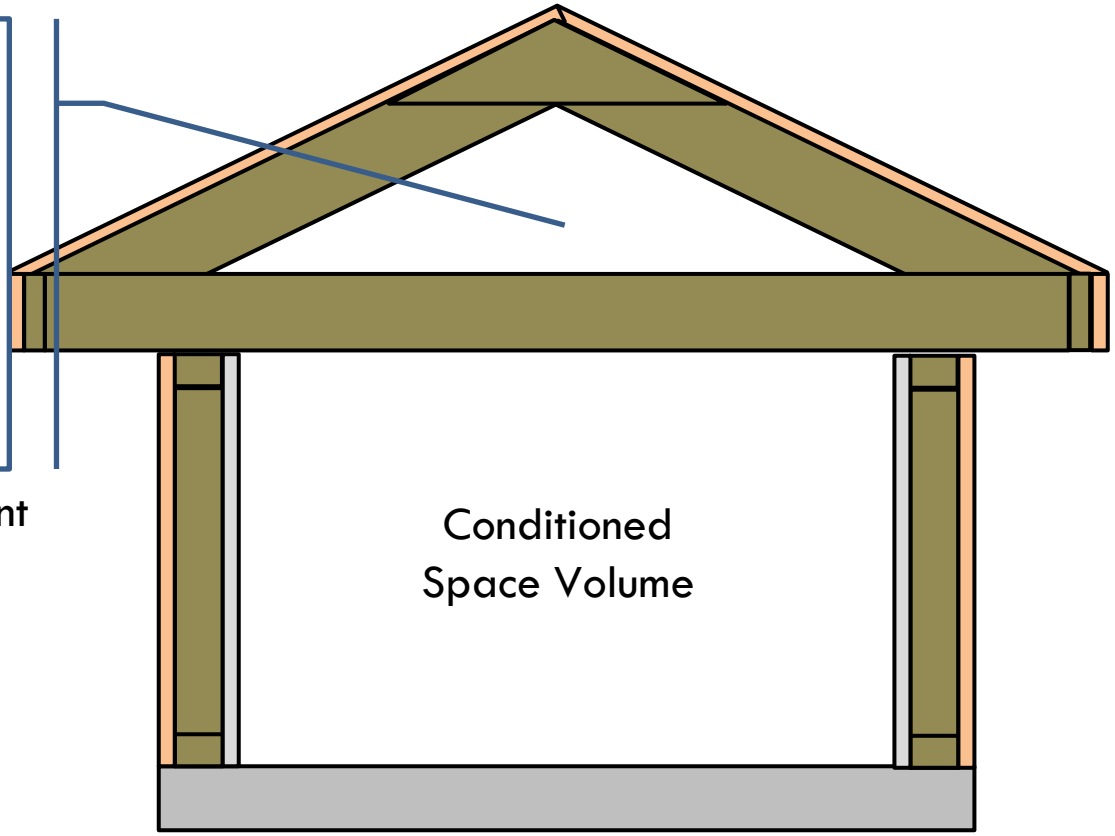
- *The volume of a vented attic shall be included.*



Unconditioned Space Volume

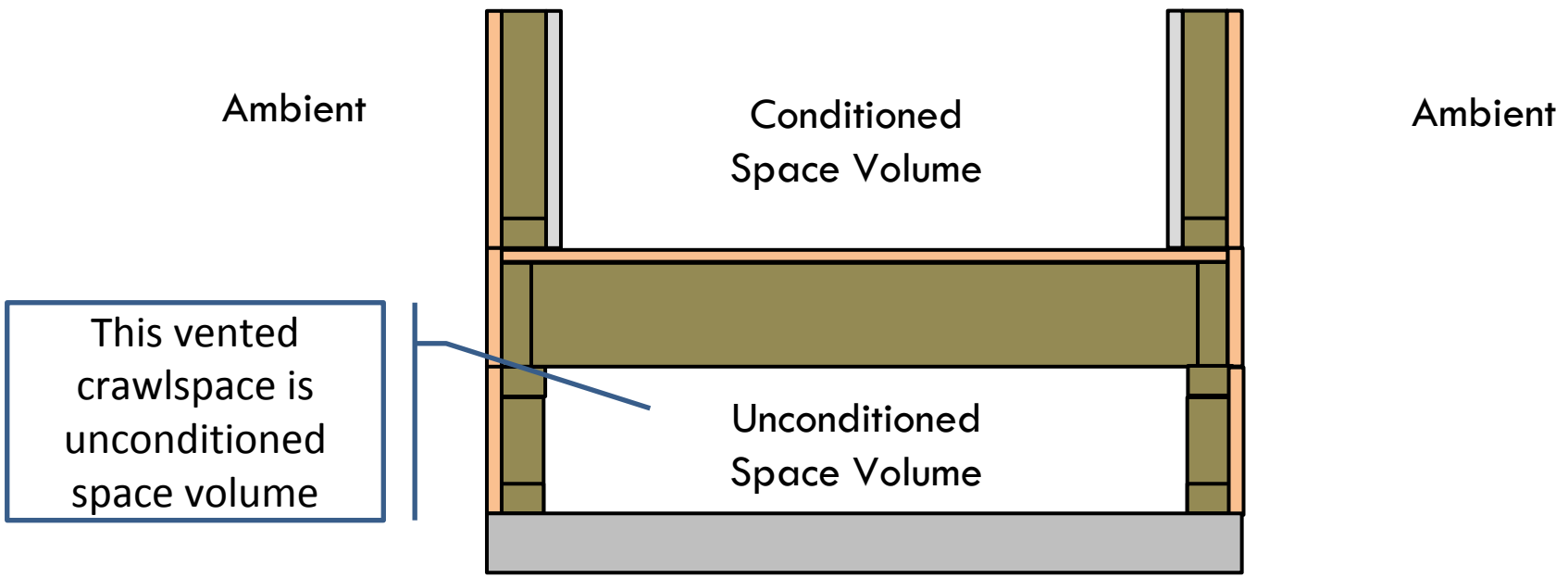
- *The volume of an attic sealed and insulated at the roof deck, an unvented crawlspace, or a basement shall be included unless it meets the definition of Conditioned Space Volume.*

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



Unconditioned Space Volume

- *The volume of a vented crawlspace shall be included.*



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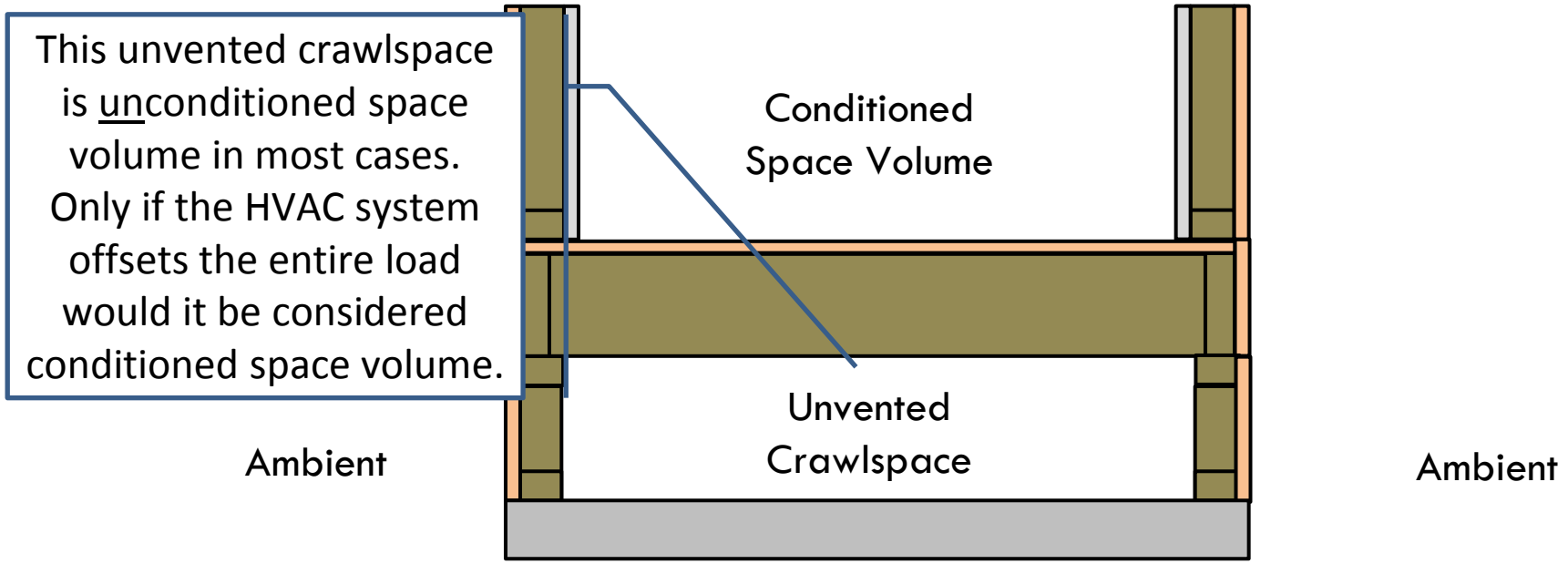

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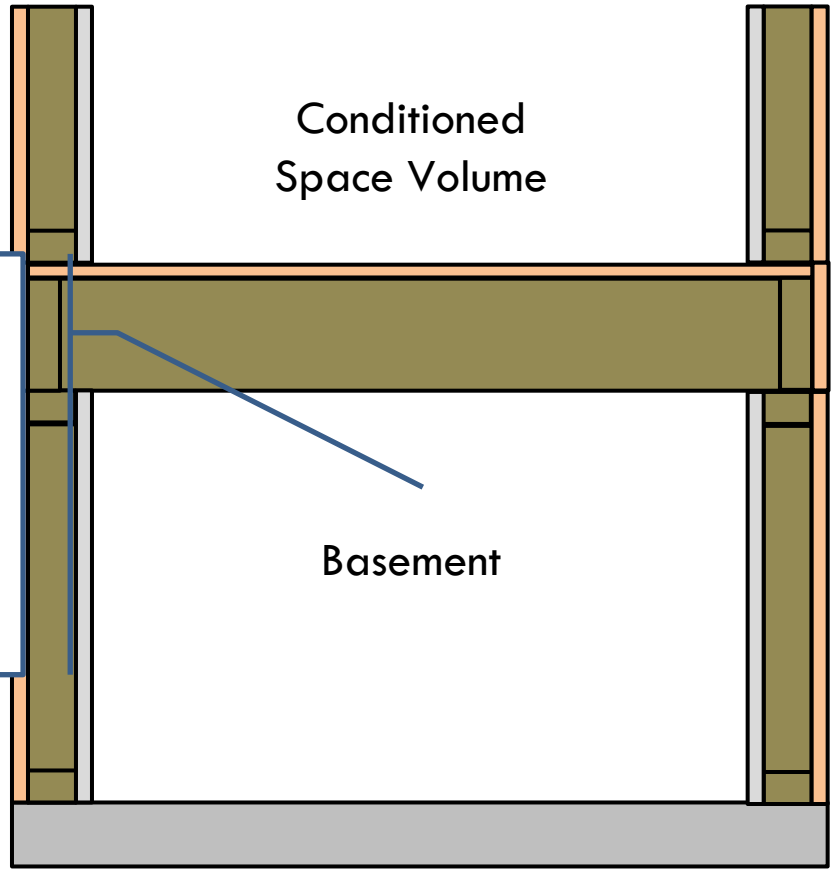
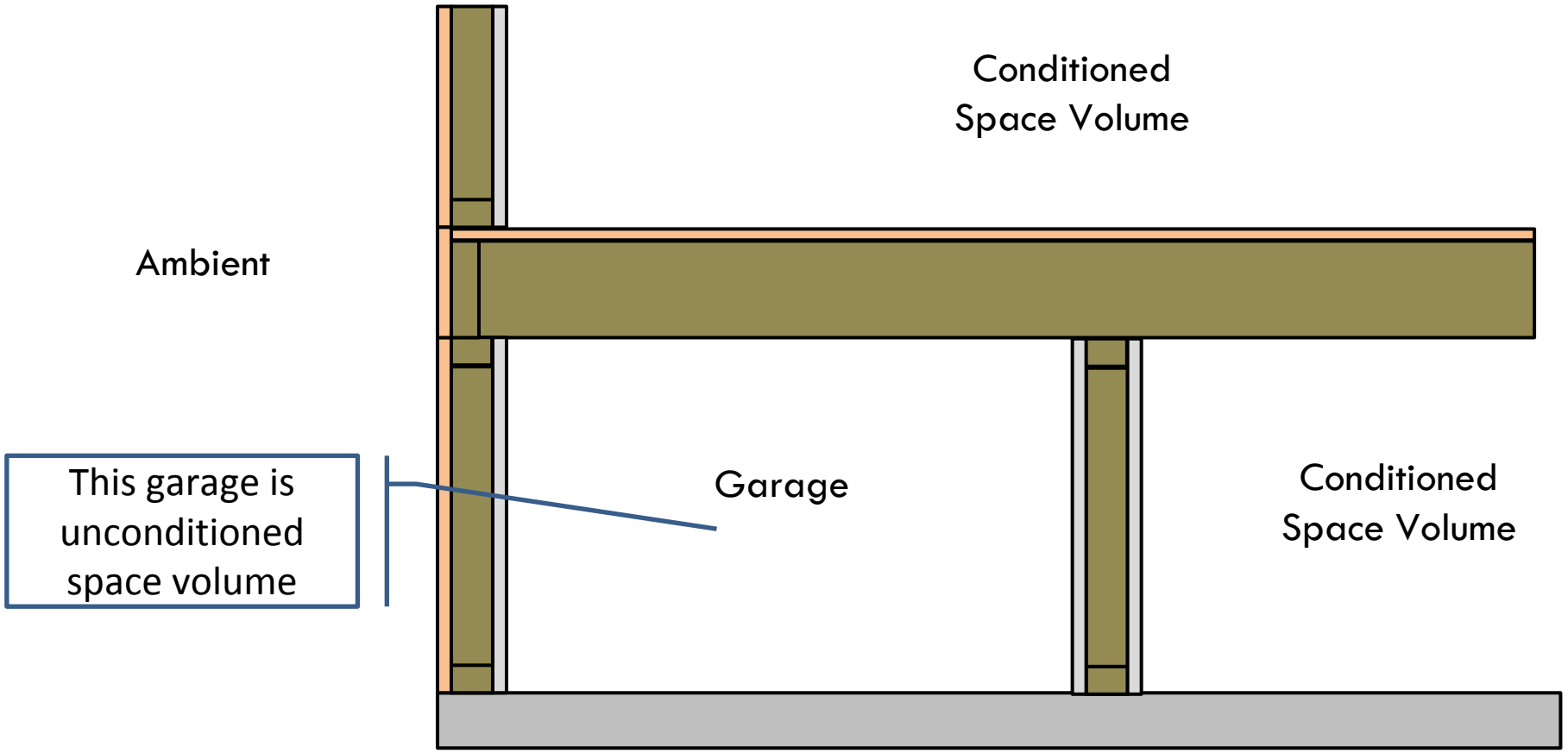


This basement is unconditioned space volume in most cases. Only if the HVAC system offsets the entire load would it be considered conditioned space.

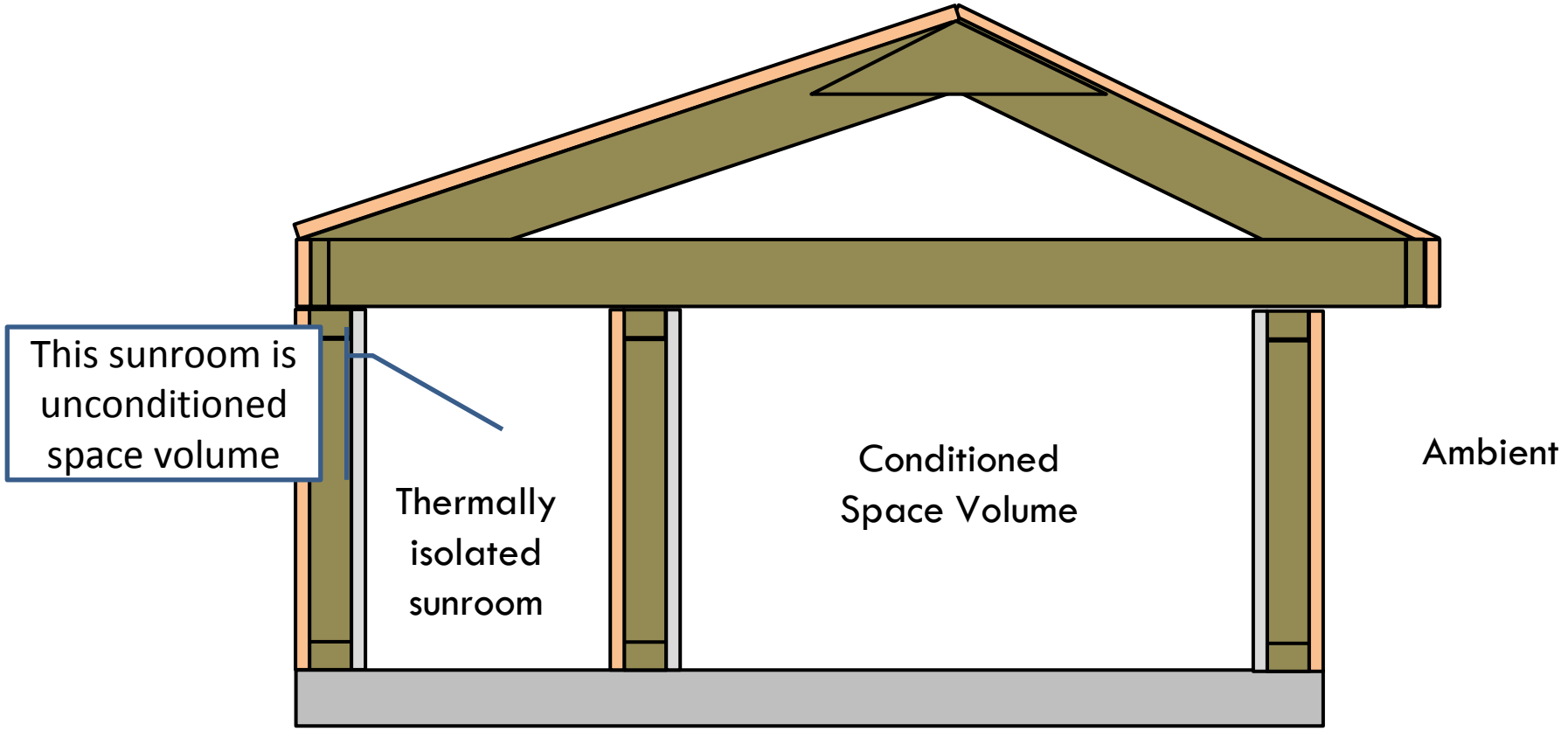
Unconditioned Space Volume

- *The volume of a garage shall be included, even if it is heated.*



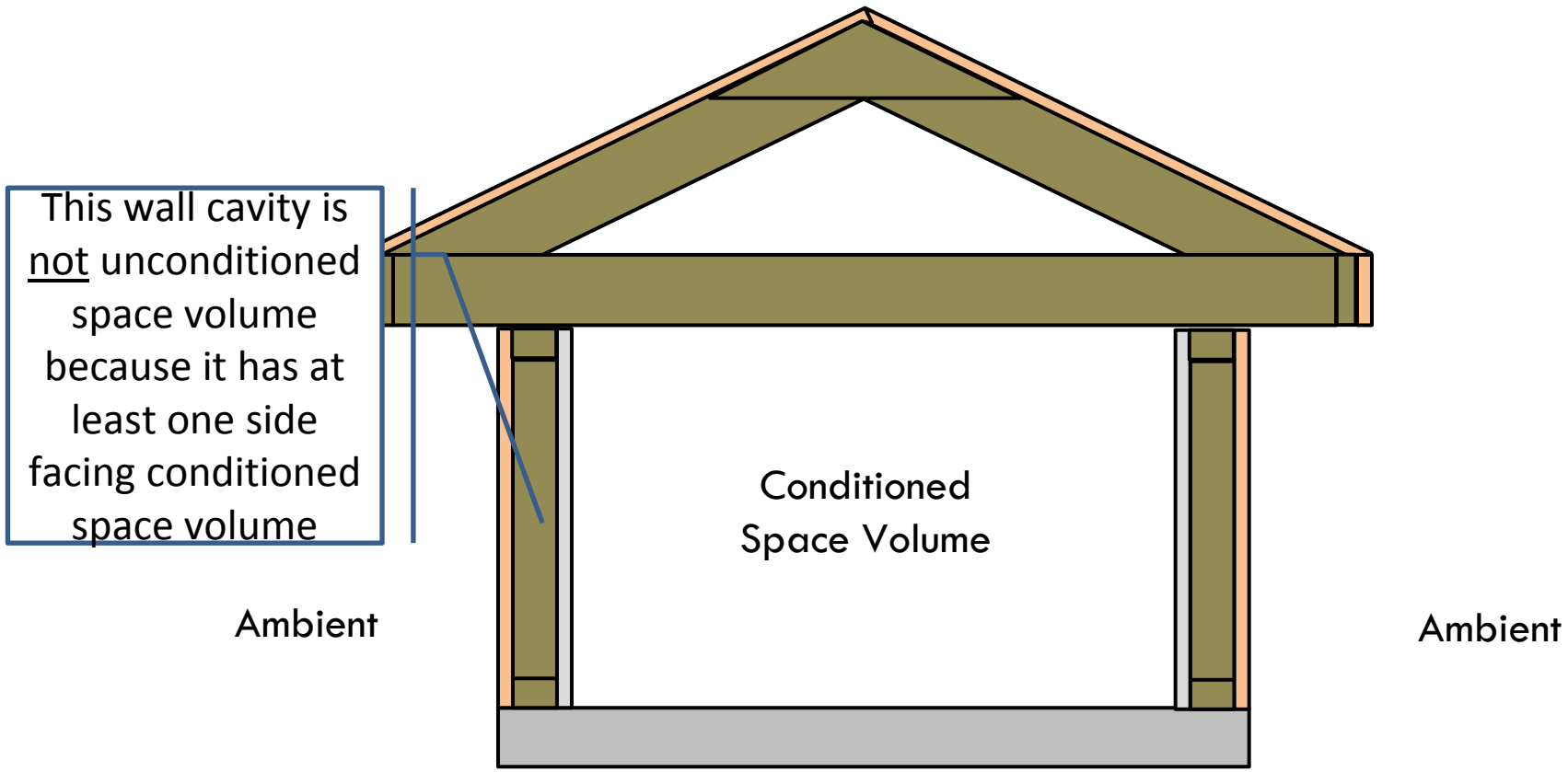
Unconditioned Space Volume

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



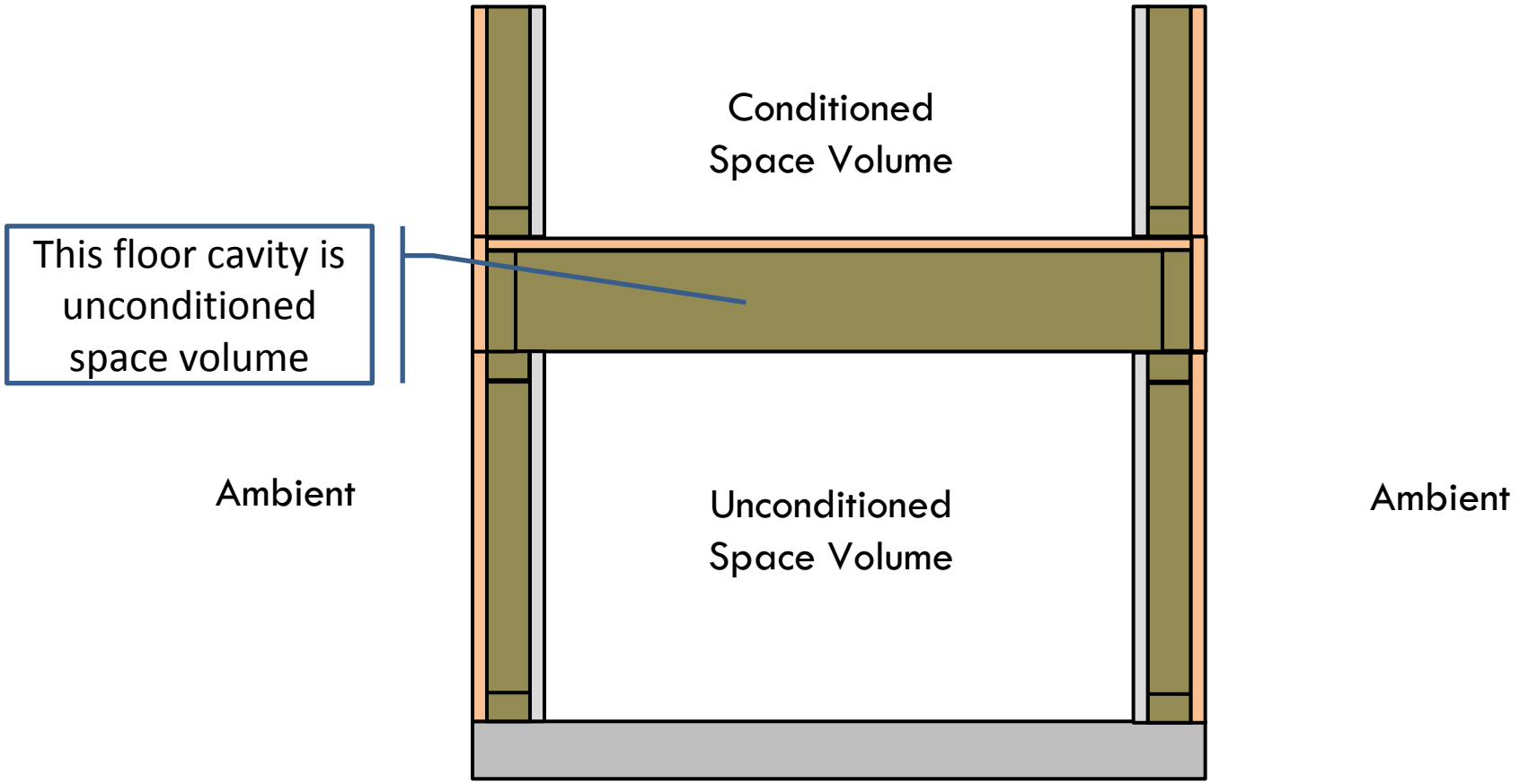
Unconditioned Space Volume

- *The volume of a wall cavity shall be included, unless the wall cavity meets the definition of Conditioned Space.*



Unconditioned Space Volume

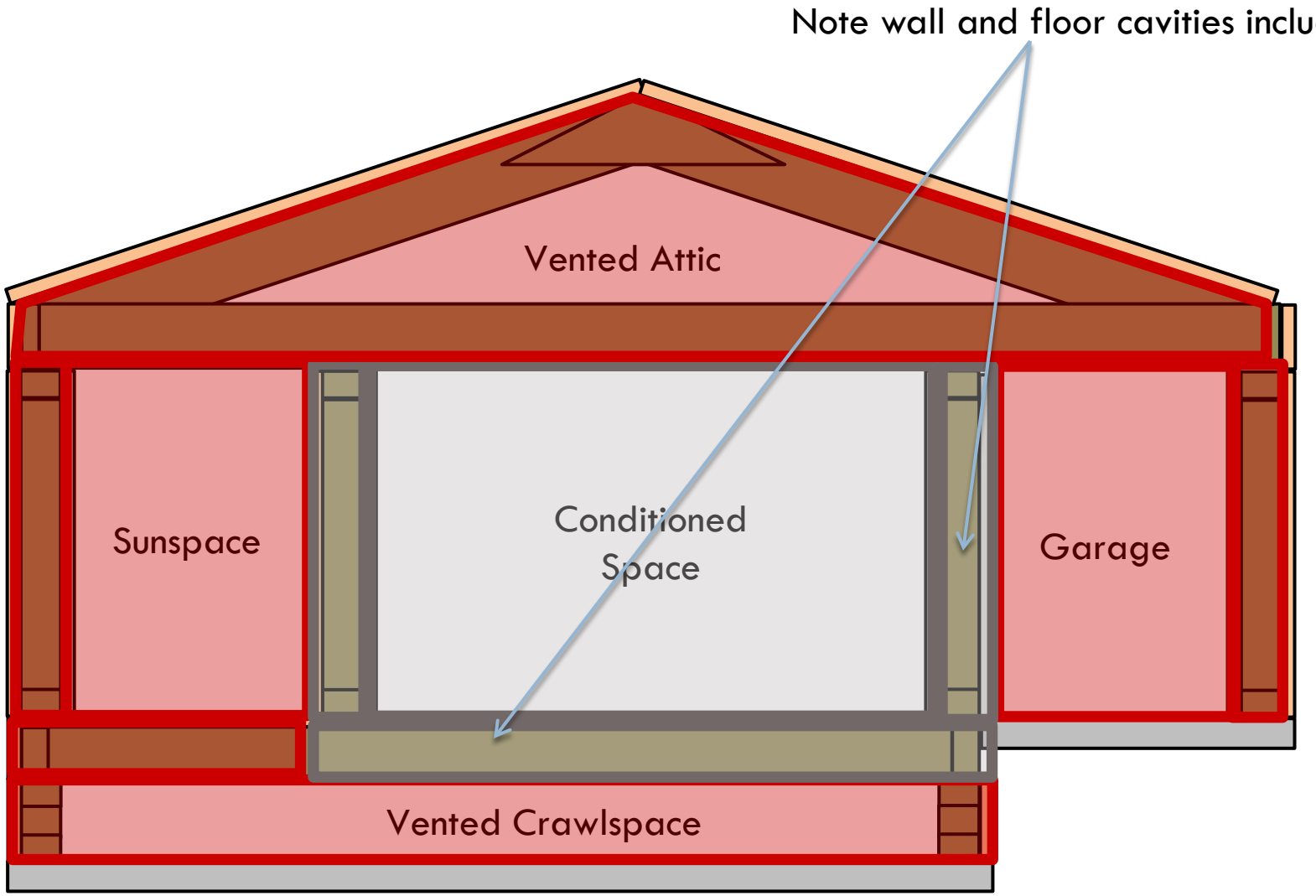
- *The volume of a floor cavity shall be included, unless the volume both above and below the floor cavity meets the definition of Conditioned Space Volume.*



New Definitions

- ***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,
  - 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.

Infiltration Volume



Summary of volumes

	CSV	UCSV	CFA	IV
Space conditioned to 68/78F	■		■	■
Vented Attic		■		
Uvented attic		■		
Unvented attic with conditioning	■			
Vented Crawlspace		■		
Unvented Crawlspace		■		■
Unvented Crawlspace with conditioning	■			■
Basement		■		**
Basement with conditioning	■		*	**
Garage		■		
Garage with conditioning		■		
Wall Cavity – both sides unconditioned space		■		
Wall Cavity – at least one side facing conditioned space	■		■	■
Floor Cavity – both sides unconditioned space		■		
Floor Cavity – at least one side facing conditioned space	■		■	■
Sunroom		■		

** some rater discretion*

*** basement included only if door between basement and house open during testing: Door is closed if the space between the basement and house is air sealed and insulated*

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

- Normally: attic access closed, basement doors open, BUT……
- If an attic is air sealed and insulated at the roof deck:
  - Access doors shall be opened
    - Note that this is true even though the attic is not in the IV because we are evaluating the tightness of the "air control surface".
- If the basement is air sealed and insulated at the basement ceiling:
  - Access doors shall be closed
  - The volume of the basement spaces shall not be included in the conditioned space volume used in ratings and HERS

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>

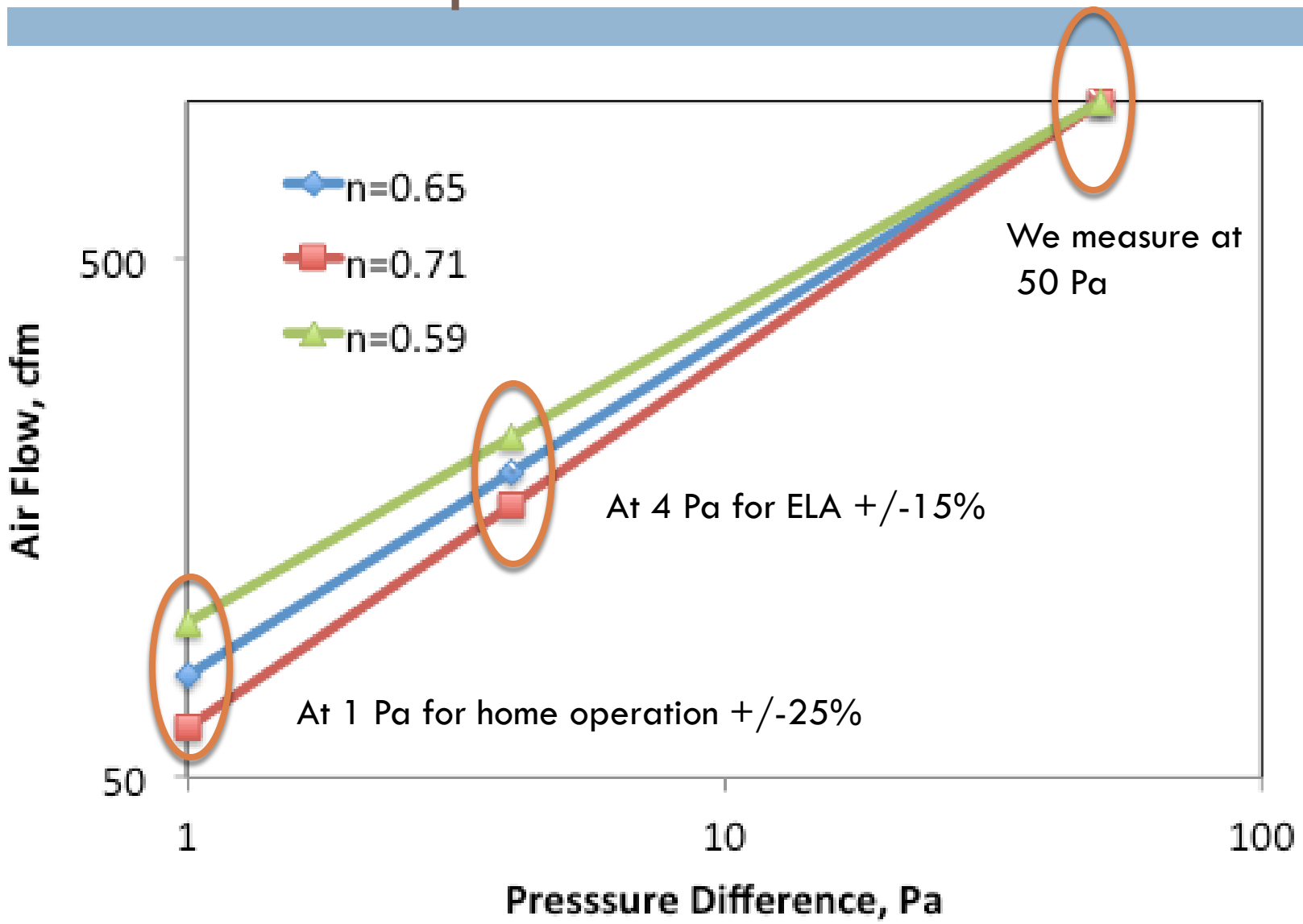
$$ELA(in^2) = \frac{Corrected\ CFM50}{18.2}$$

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

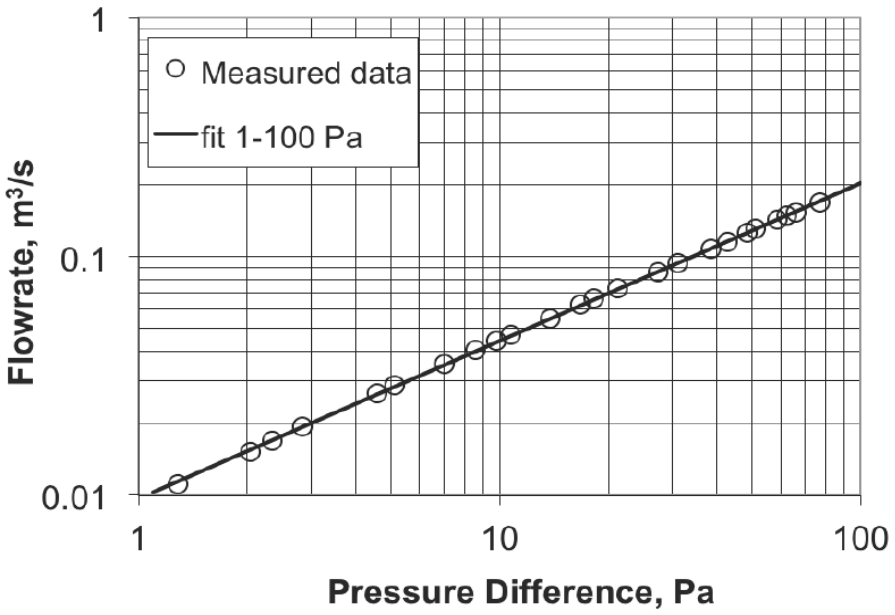
$$ELA(in^2) = C\left(\frac{ft^3}{minPa^n}\right) \times 0.567 \times 4^{(n-0.5)}$$

Envelope Leakage Test Issues: Single Point - extrapolation

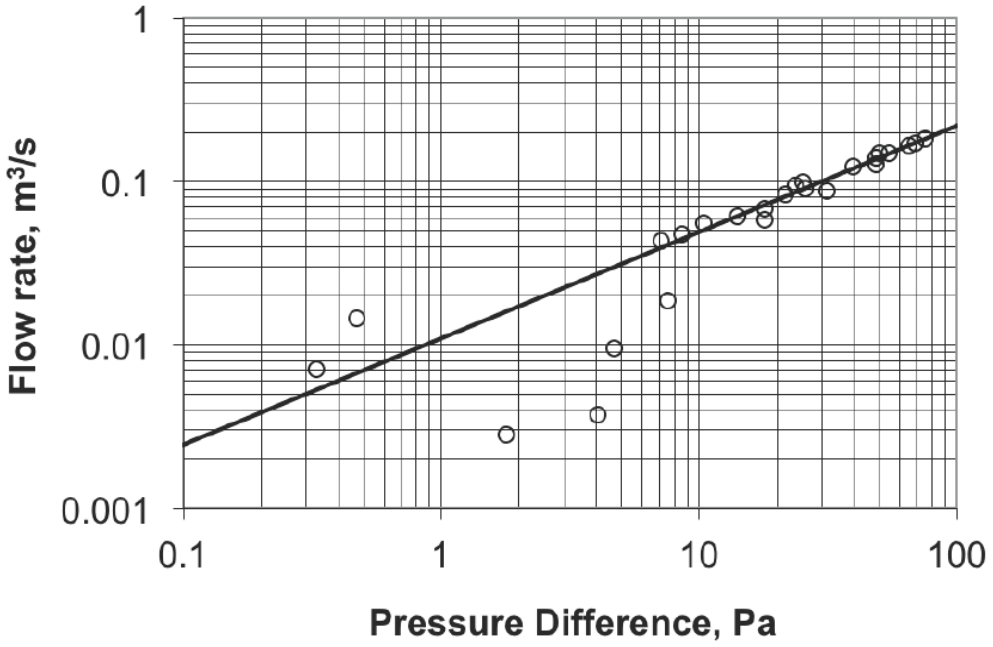


Envelope Leakage Test Issues: Multipoint – windy days

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 be attached at return grille or blower access panel
- 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

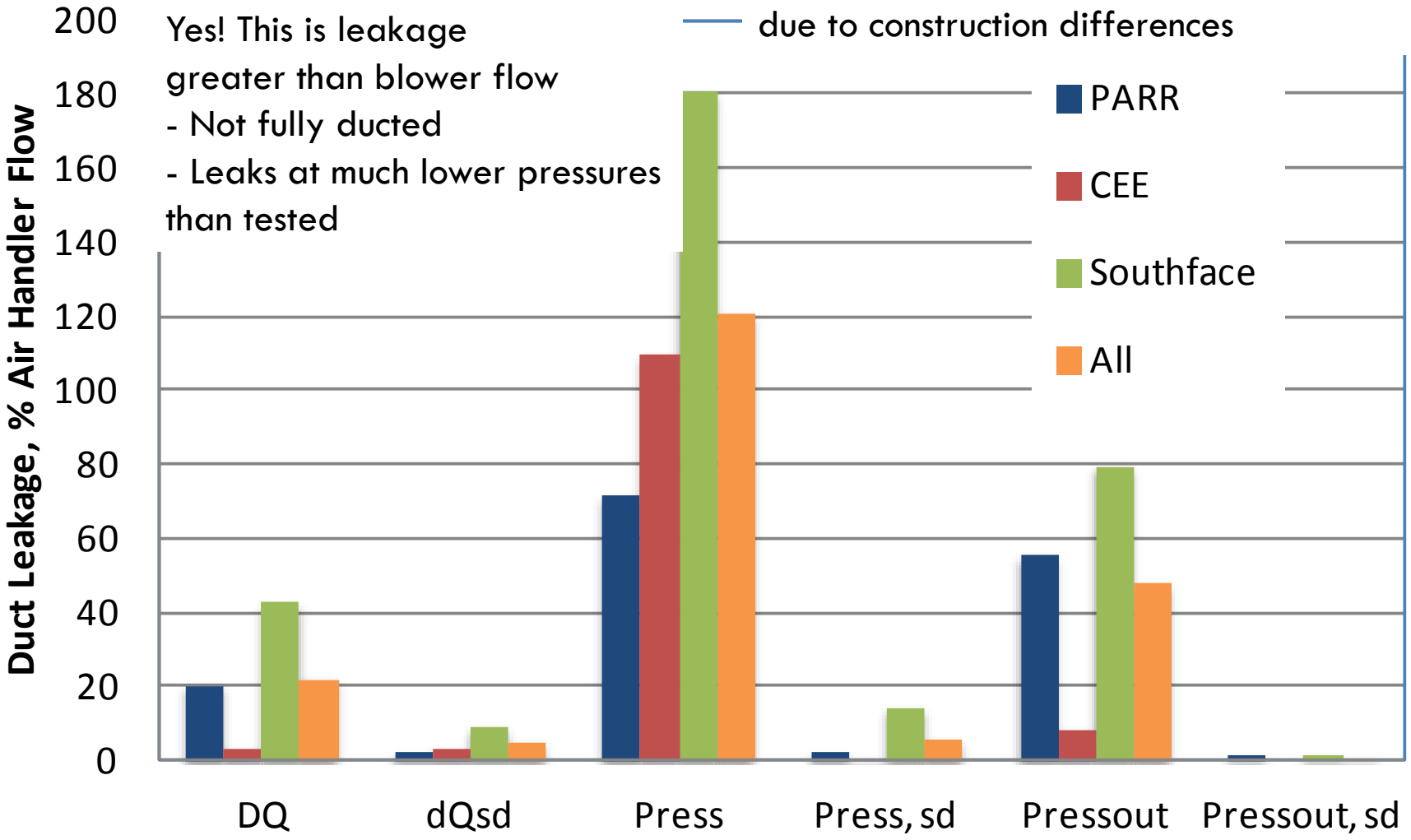
Duct Leakage Performance Issues

- 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

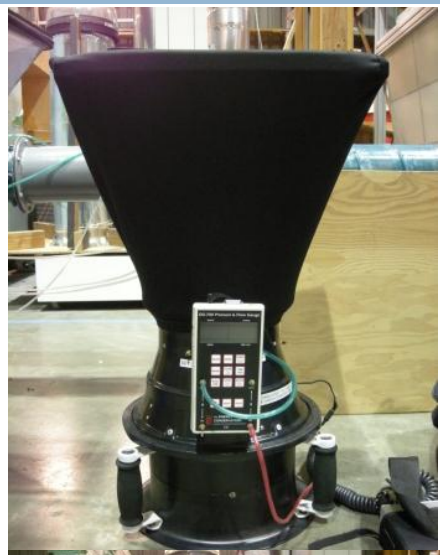
- For DeltaQ and Total Pressurization: +/- 6%
- For Pressurization to outside: +/- 1%
- For low leak (<6% by DeltaQ) systems much better repeatability:
  - Pressurization: +/- 1%
  - Pressurization to outside: +/- 0.3%
  - DeltaQ: +/- 3%

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)

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)

Flow at Outlet Terminal – Bag Inflation

ABOUT YOUR HOUSE

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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.

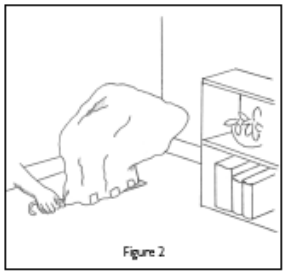

Figure 2

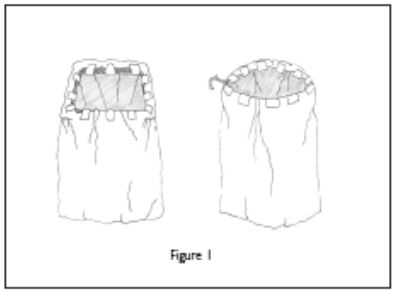

Figure 1

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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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):

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

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

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