# Nebraska Residential Energy Code: Air Sealing and Insulation

Instructor: Matt Belcher

February 9, 2023

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# Today's Agenda

- Energy Code Requirements for Air Sealing
- Air Sealing Principles
- Air Sealing Strategies and Priorities
- Performance Testing
- Ventilation
- Insulation Best Practices
- Q&A

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# Housekeeping

- Attendees are muted upon entry
- Questions? Enter them in the chat box or unmute
- Webinar is being recorded – slides and recording will be sent to attendees and posted on website
- CEUs from ICC and AIA provided
- Email canderson@mwalliance.org with questions

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# Introduction Poll #1

- What is your profession?
  - Code Official
  - Home Builder
  - State/local government
  - Energy Rater/Consultant
  - Architect/Engineer
  - Non-profit
  - Academic
  - Utility
  - Other (type in chat)

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# Introduction Poll #2

- How long have you been in the construction industry?
  - 0-5 years
  - 5-10 years
  - 11-15 years
  - 16-20 years
  - 21+ years

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# Introduction Poll #3

- How familiar are you with the residential provisions in the 2018 IECC?
  - Extremely Familiar
  - Somewhat Familiar
  - Somewhat Unfamiliar
  - Not familiar at all

# Energy Code Requirements

# 2018 IECC Mandatory Requirements

## Air Sealing

- Building or dwelling unit must have continuous air barrier installed
- All holes between floors and through exterior walls/ceilings have been sealed in **accordance with table R402.4.1.1**
- Building or dwelling unit is **tested to verify air leakage rate of ≤ 3 Air Changes per Hour (ACH50)**

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# Nebraska Residential Field Study

- Conducted in 2017 by **Nebraska Department of Environment and Energy** 2009 IECC was the baseline.

- Collected and analyzed several data points for new homes, including:
  - Envelope air leakage
  - Efficacy in lighting
  - Duct leakage
  - Ceiling & exterior wall insulation
  - Basement & slab insulation
  - Windows

**For More Information and Data:**

https://www.energycodes.gov/sites/default/files/documents/Nebraska_Residential_Compliance_Evaluation_final.pdf

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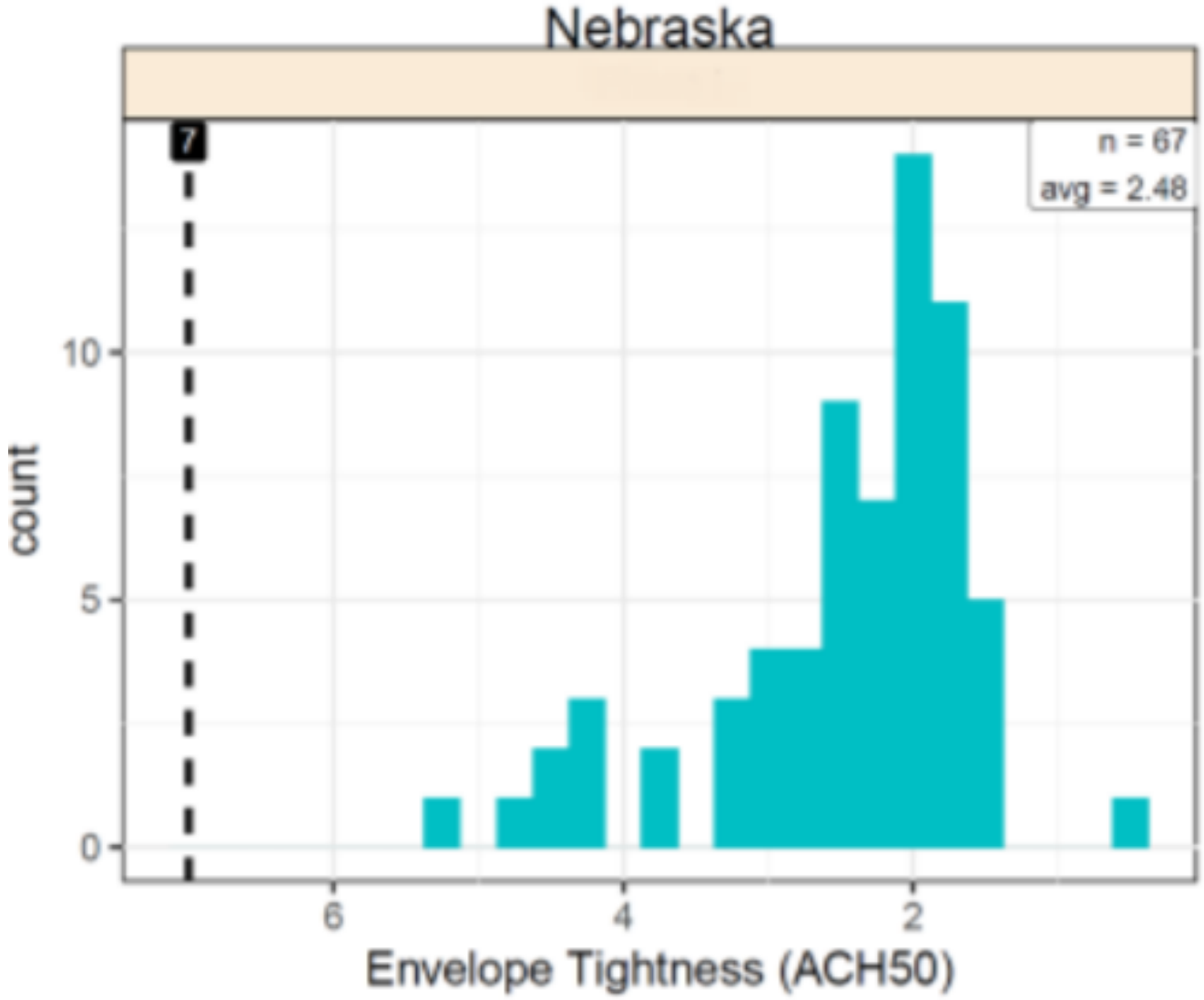
# NE Residential Field Study - Results

- **Envelope Air Leakage**: Better than code(7 ACH50)
  - Not all would meet 2018 IECC

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# Air Sealing Principles

# Building Thermal Envelope

- A well-designed building envelope promotes energy conservation through proper placement and appropriate use of materials for effective:
  - Air barrier
  - Insulation
  - Moisture control
  - Windows, doors and skylights

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# Air Barrier

- Air movement leads to both **energy loss and moisture transmission**.
- An **integrated air barrier prevents air movement** through the insulation and must be continuous and contiguous with the insulation.
- Air barrier must be **continuous** across walls, ceilings, and floors.
  - You should be able to trace the air barrier in a building cross section and never lift your pencil!

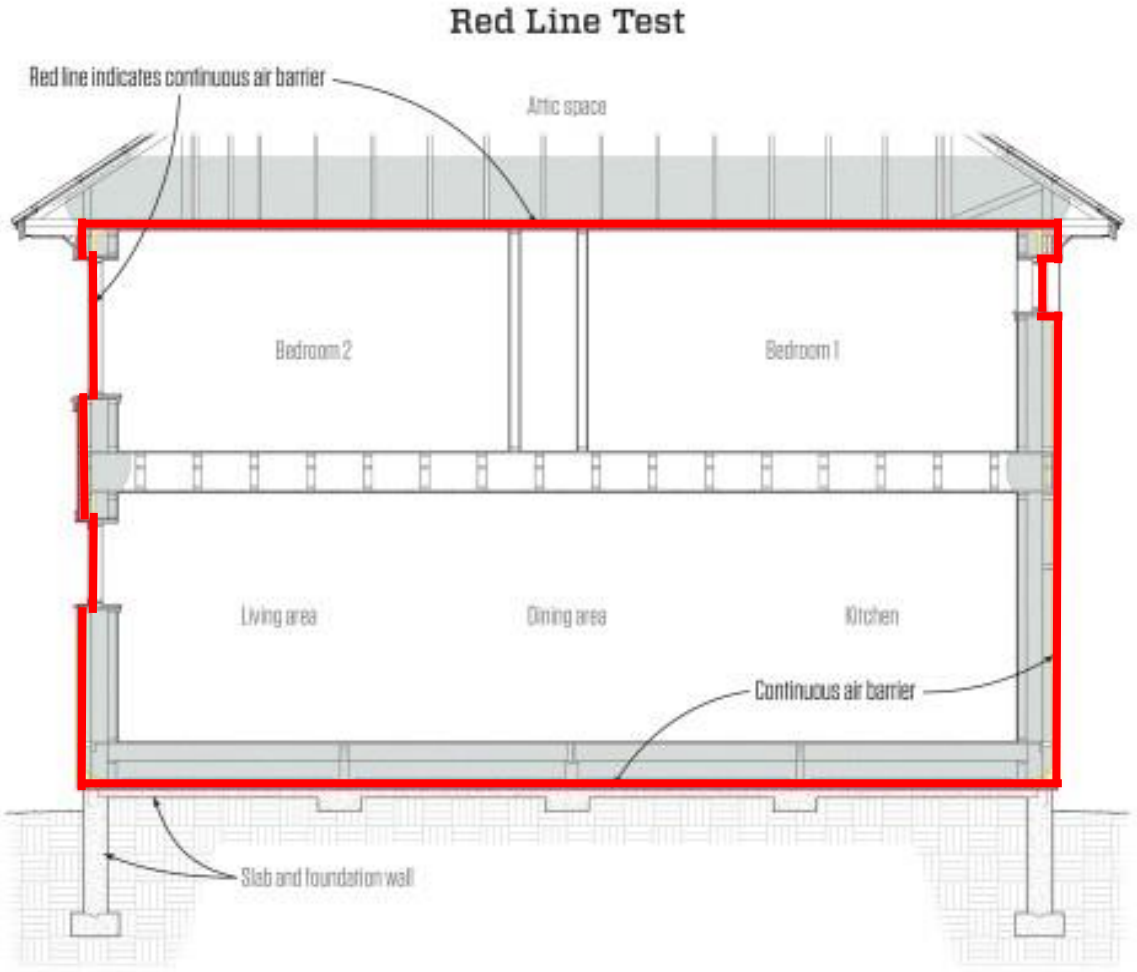


*Image: jlconline.com*

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# Importance of Air Sealing

- You can not control the indoor environment if you let the outside in
- Continuous air barrier and thermal barrier are essential
- They will define the HVAC system requirements
- The only way to know envelope tightness is a blower door test

*Images: barriersciences.com; energy.gov*

# Air Barrier

- Primary air barrier:
  - Exterior sheathing
  - House wrap
  - Seam sealing
  - Interior drywall
- Penetrations in the primary air barrier create air leaks.
- *2018 IECC requires blower door test*
  - ***Maximum leakage: 3 ACH50***
  - ***Average Air Leakage Rate in NE: 2.8 ACH50***

*Image: huberwood.com*

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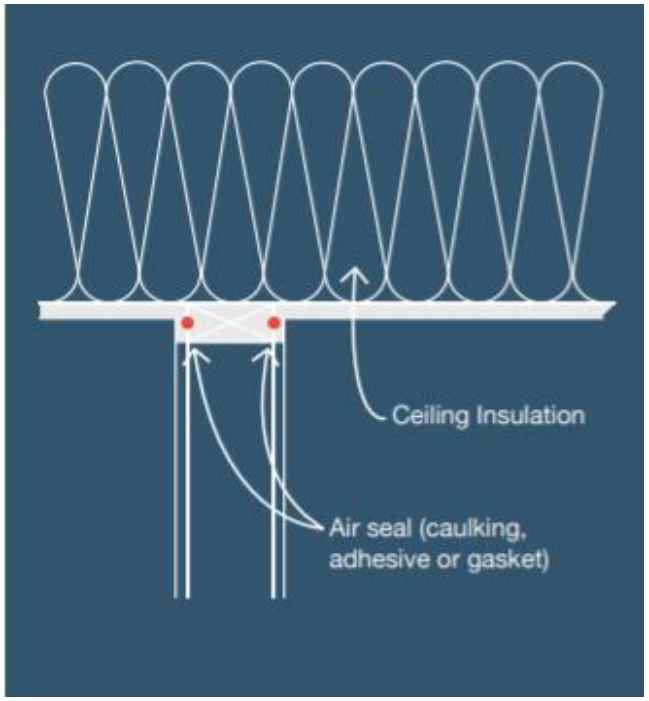
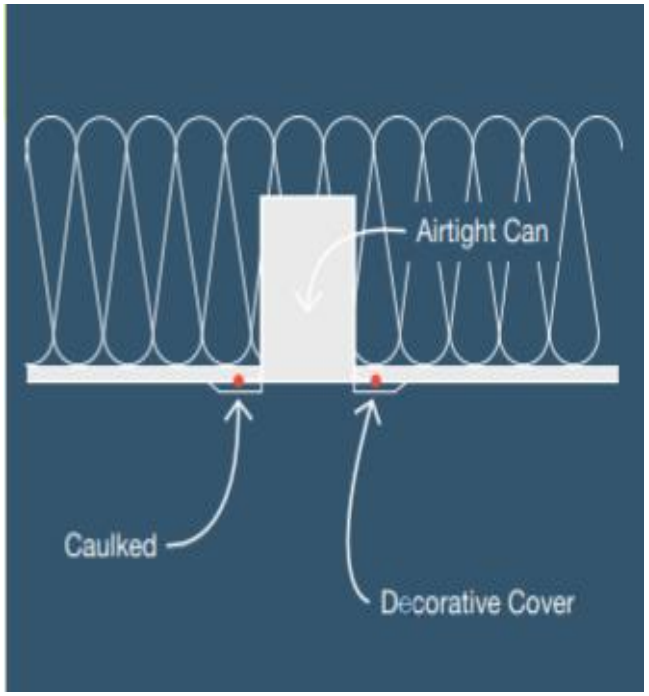
# Priorities for Air Sealing

# Priority Locations for Air Sealing




**Top Plate to Attic Drywall**




**Recessed Light to Finished Surface**

Source: https://insulationinstitute.org/wp-content/uploads/2018/05/N090-5-Air-Sealing-Locations-for-New-Homes.pdf

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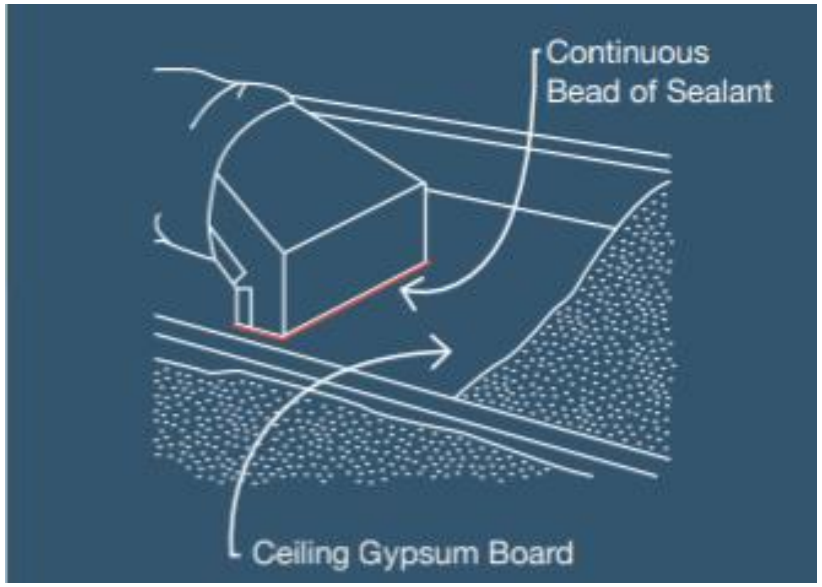
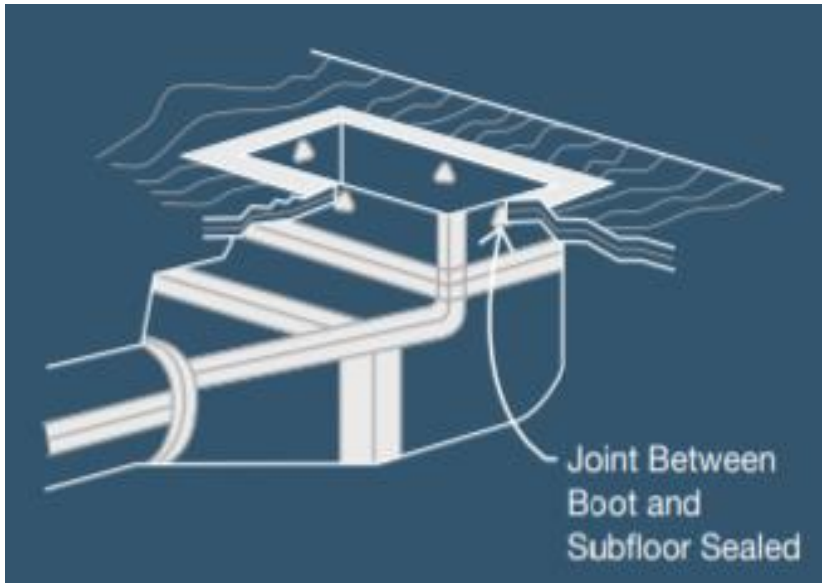
# Priority Locations for Air Sealing




## Duct Boot to Finished Surface

Source: https://insulationinstitute.org/wp-content/uploads/2018/05/N090-5-Air-Sealing-Locations-for-New-Homes.pdf

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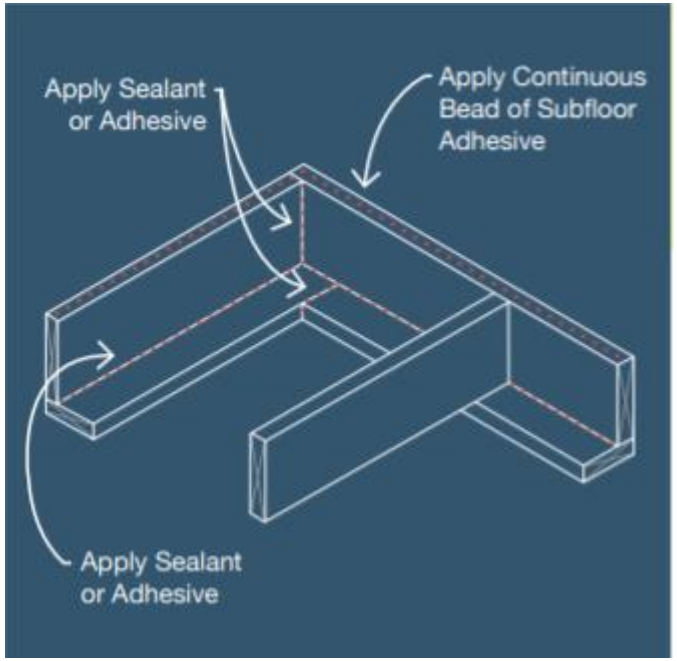
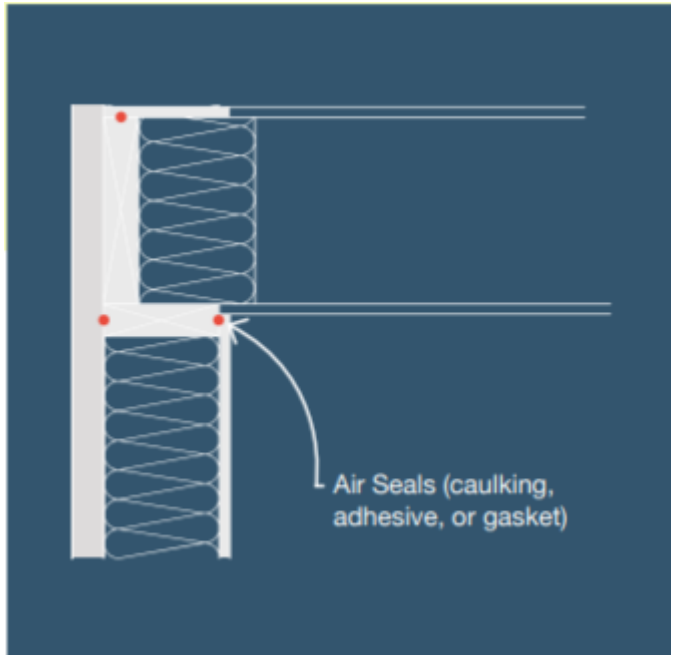
# Priority Locations for Air Sealing




**Band Joist (Top & Bottom)**




**Garage House to Common Wall**

Source: https://insulationinstitute.org/wp-content/uploads/2018/05/N090-5-Air-Sealing-Locations-for-New-Homes.pdf

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# Air Barrier - Strategies

- Drywall glued to the studs and plates
- Lapped and taped joints
- Close alignment with insulation
- Sealed air permeable insulation
- Taped or caulked sheathing seams
- Caulked or foam-sealed outlets, penetrations, sill plates, windows and doors

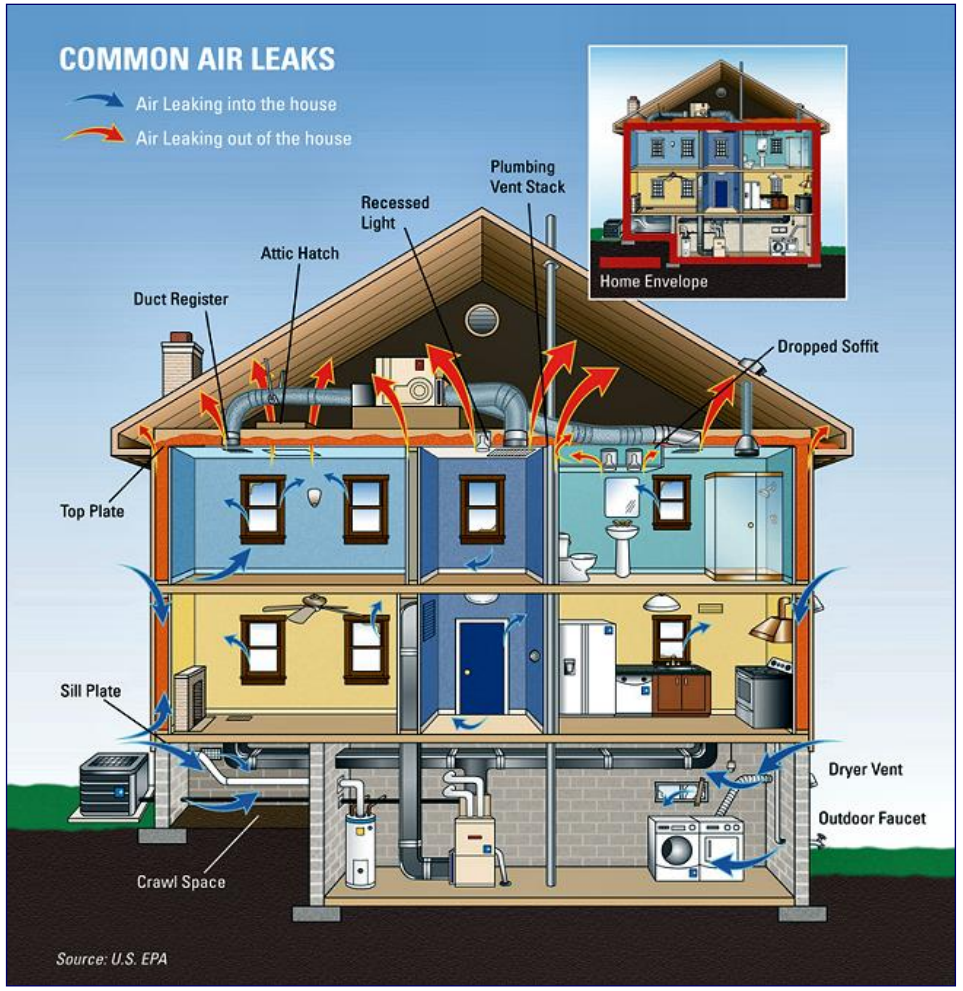


Image: epa.gov

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# Air Barrier – Strategies

- Sealed joist bays
- Sealed HVAC supply and return outlets
- Sealed soffits and chases
- Sealing around the backside of tubs, knee walls and garages
- Sealed off garages
- Sealed recessed lighting cans

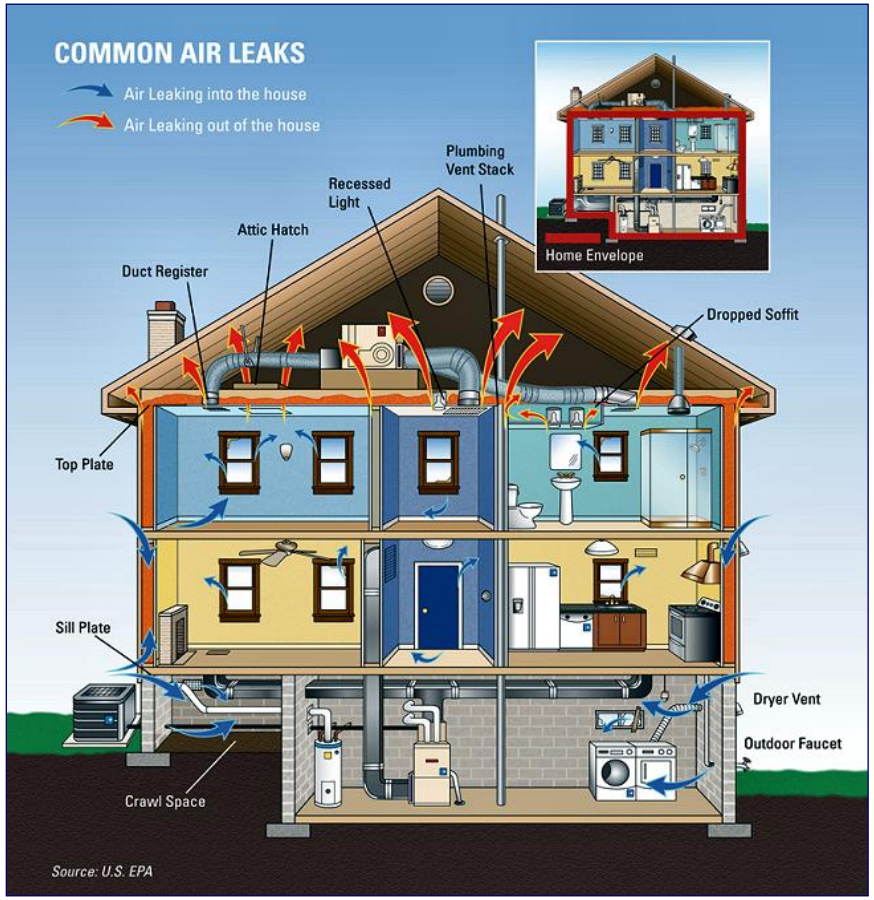


*Image: epa.gov*

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# All About Ventilation

# 2018 IECC Mandatory Requirement

## Mechanical Ventilation

- Installed according to requirements in the International Mechanical Code
- Required for all homes ≤ 5 ACH50 per Section M303.4
  - Air Leakage rate of 3 ACH50 is a 2018 IECC mandatory requirement

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# Ventilation

- Mechanical ventilation systems circulate fresh air using ducts and fans, rather than relying on airflow through holes or cracks in a home's walls, roof, or floors
  - You don't know where uncontrolled ventilation draws air from
  - Exhaust fans often do not provide rated / code ventilation post installation – air flow should be tested
- ASHRAE 62.2
  - Establishes ventilation and indoor air quality (IAQ) rates in residential buildings(Low rise)
  - Provides criteria for exhaust fans & spot ventilation
  - Minimum Standard!
- "Build it Tight and Ventilate Right!"

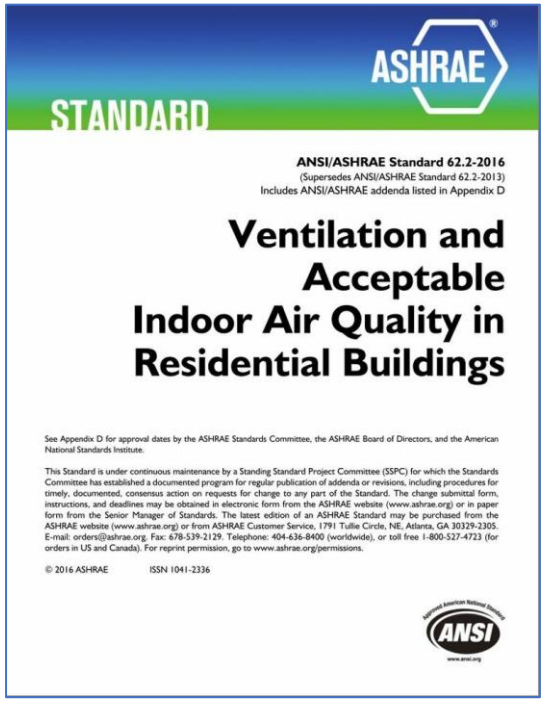


*Image:ashrae.org*

**Ventilation Rate in CFM**
(0.01 x total square foot area of house) + [7.5 x (number of bedrooms +1)]

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# Ventilation and Air Sealing

- Both natural and mechanical ventilation provide fresh air that can dilute and remove indoor pollutant levels
- Per the IMC/IRC, mechanical ventilation is required when homes are <5 ACH 50
  - Need to do a blower door test to determine leakage rate
  - **Liability concerns when not performed**
- A blower door test measures a building's existing air leakage
- Can not design a code compliant system without knowing air leakage

*Courtesy of AC Tool Supply, Inc.*

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# Ventilation and Air Sealing

- Blower door test result can be in CFM.
- Converting to ACH determines building's need for mechanical ventilation (≤5 ACH50)

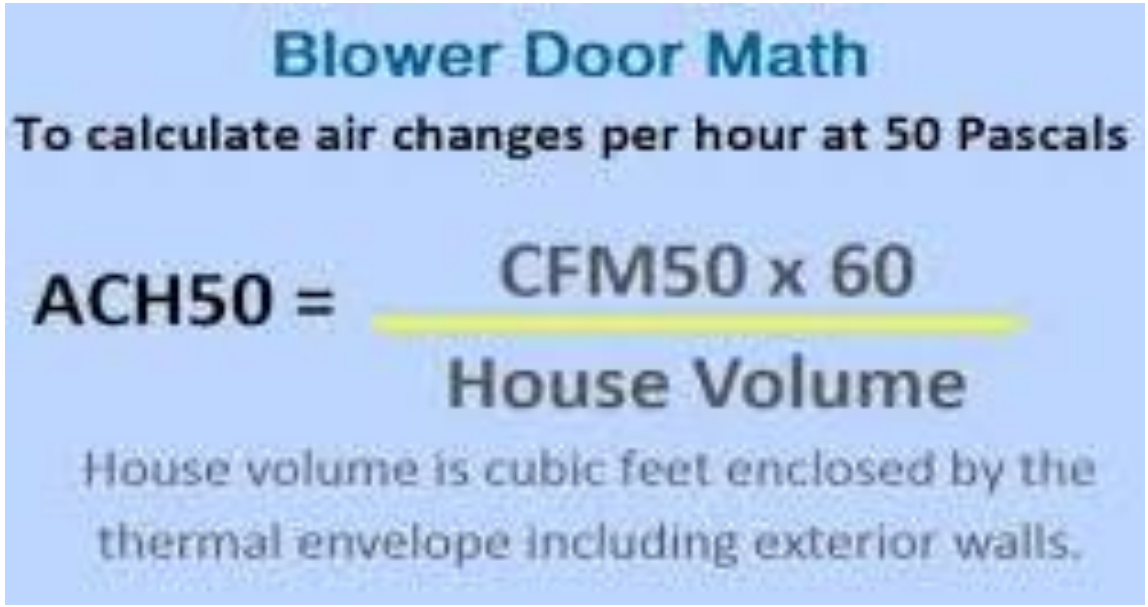
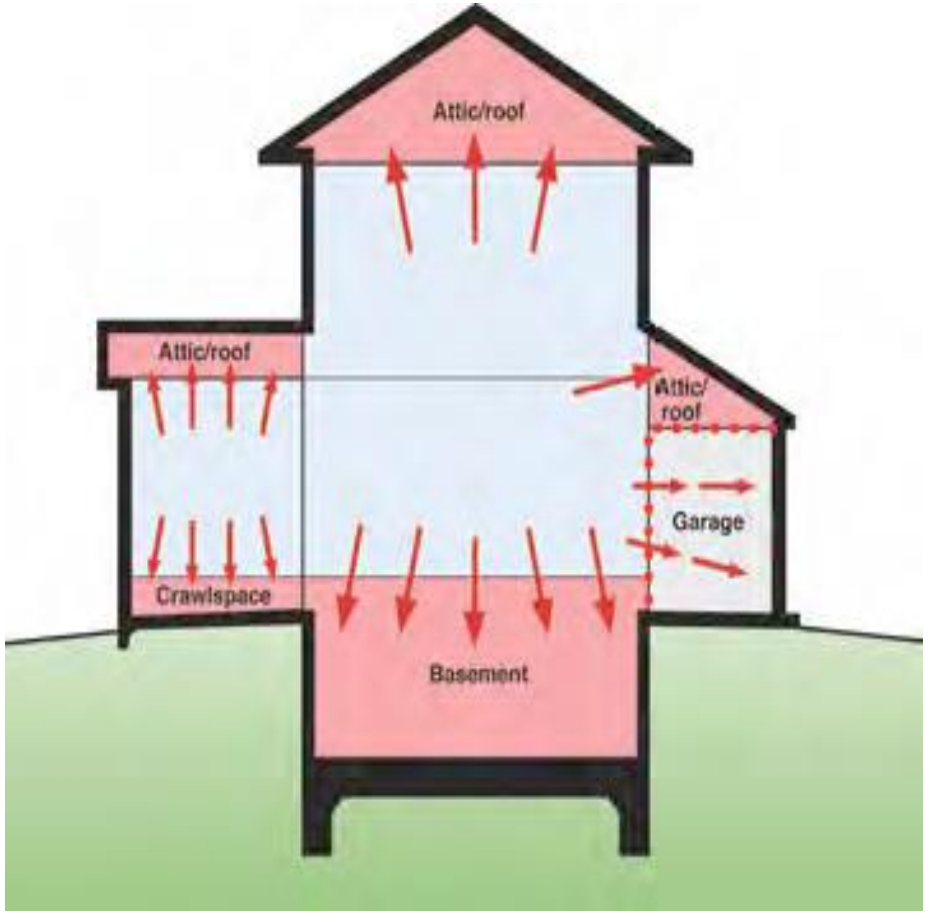



Image: deq.mt.gov

# Ventilation – Pressure Differential




**Expansion of Conditioned Space**

- HVAC systems, temperature, wind, and stack effect all cause pressure differentials between inside and outside
- HVAC systems pressurize the home and conditioned space boundaries moving towards exterior surfaces of building
- Garage isolated from house by air barrier/pressure boundary
- Garage ventilated and conditioned independently of rest of conditioned spaces

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# Ventilation

- Tips and cautions:
  - Natural ventilation may be inadequate or excessive if the indoor environment's driving forces are inadequate.
  - Ventilating air from an unknown source can have a higher level of pollutant than the indoor air (e.g., moisture, pollen, smoke)
    - Balanced whole house ventilation solves this problem
- The priority is to control ventilation:
  - Spot ventilation systems (supply-only and exhaust-only)
  - Balanced ventilation systems (heat recovery and energy recovery ventilators)


*Image: healmyheart.ca*

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# Considering HVAC Design and Loads

- Today's homes risk health problems from inadequate ventilation
- New construction materials and techniques result in tighter homes
  - Sometimes <1 ACH50
- In some jurisdictions blower door tests are not required so builders are unaware of the need for ventilation
- Average from NE Residential Baseline Study is a new home air leakage of 2.8 ACH50
- More chemicals and products are used in and around a house
  - Concentration levels can be 2 to 100 times higher than outside.

*Image: conditionedairsolutions.com*

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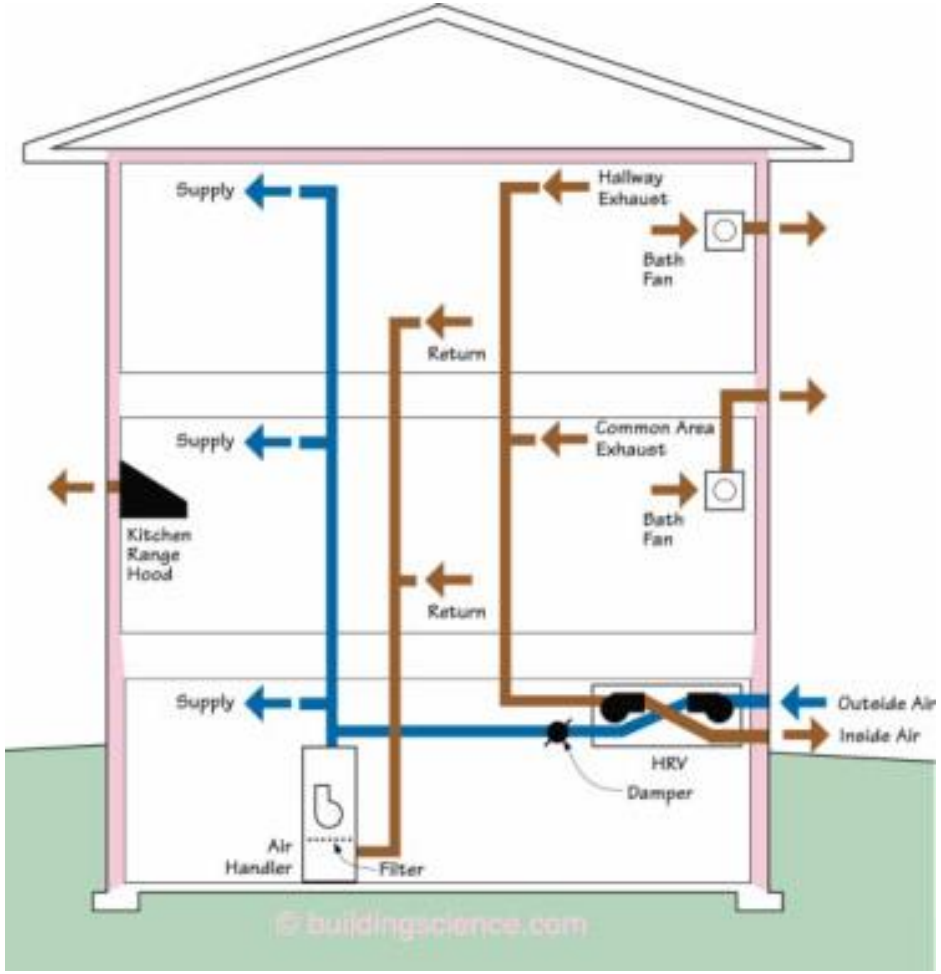
# Balanced Ventilation




- Blows air into and out of the house
- ERV/HRV makes this cost effective by reclaiming energy from exhaust and supply airflows (60%-80%!)
- Balances exhaust and supply flows
- Maintains the Minimum Ventilation Guidelines automatically with proper set-up

*Image: buildingscience.com*

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# Balanced Ventilation - HRV

A heat recovery ventilator (HRV) uses a heat exchanger to condition incoming fresh air:

- It consists of a cube-shaped transfer unit made from special conductive materials.
- Airflows pass through different sides of the cube (but are not mixed).
- Conditioned exhaust air raises or lowers the incoming fresh air temperature.
- Air passes through an HVAC air handler or directly to rooms.

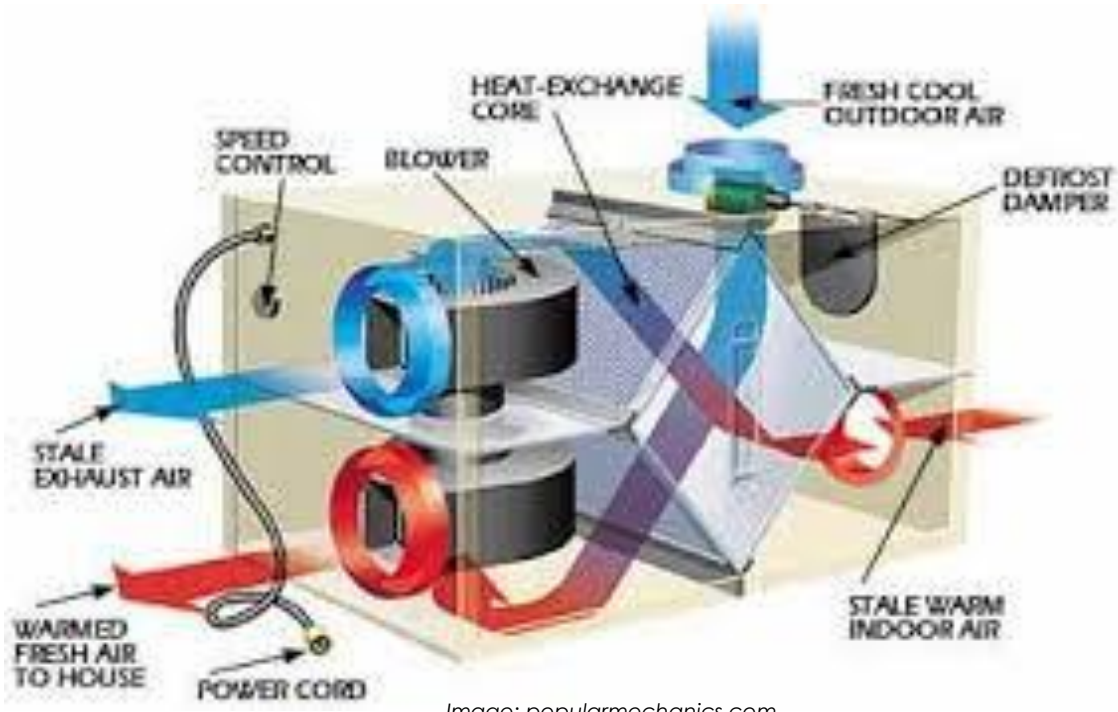


*Image: popularmechanics.com*

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# Balanced Ventilation - ERV

An energy recovery ventilator (ERV) exchanges heat and moisture between the two air streams:

- It transfers moisture by a desiccant wheel.
- It allows the exchange of moisture to control humidity.
- It preconditions the incoming flow with return air ducts before it exits.
- It passes air through an HVAC air handler or directly to rooms.

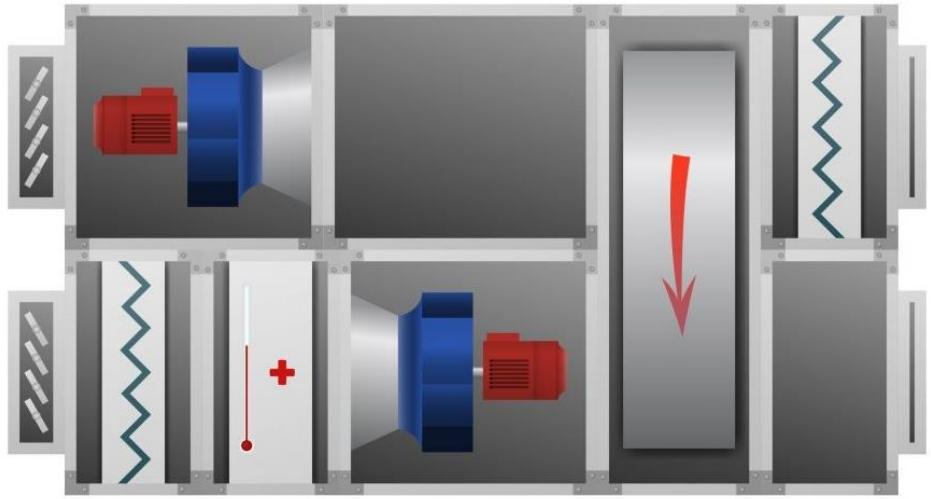

*Image: totalcomfortma.com*

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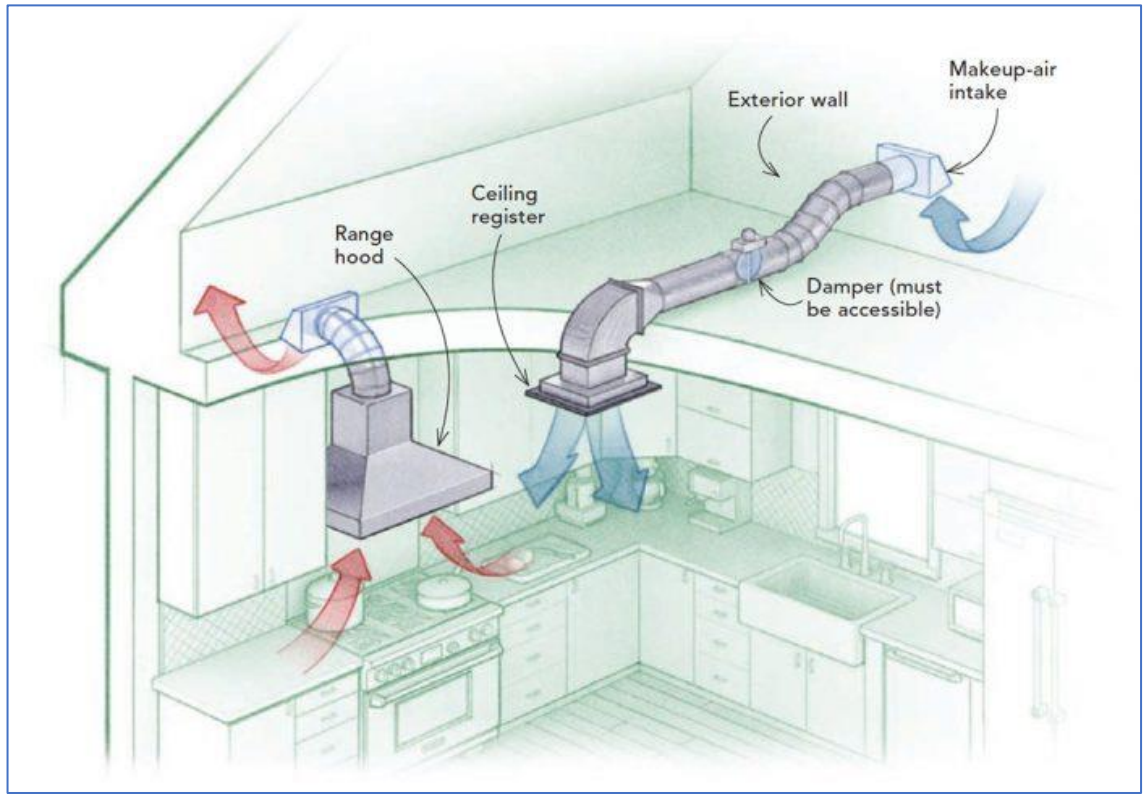
# Spot Ventilation (Supply-only and Exhaust-only)

- Supply spot ventilation:
  - Whole house
  - Makeup air or combustion air for appliances
- Exhaust spot ventilation:
  - Bathroom exhaust fan
  - Range hood vent
  - Ducted garage fan
  - Central vacuum
- Fans or portals with humidity-sensitive nylon strips




*Images: greenbuildingadvisor.com*

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# Air Filters

- Use filters to remove pollutants from the indoor air
  - They are characterized by the size of particle they remove
  - Type and size of filter should properly fit equipment
  - The higher the MERV rating, the finer the particulate filtered
  - Determining the best filter relies on understanding which substance(s) needs to be removed
  - System must be designed to accommodate the static pressure created by filter

# Types of Furnace Filters

| FLAT-PANEL FIBERGLASS | PLEATED MEDIA | HEPA (High Efficiency Particulate Air) | WASHABLE/ REUSABLE |
|---|---|---|---|
| **MERV RATING*** | | | |
| • 1 to 4 typical | • 5 to 13 typical<br>• 14 to 16 high efficiency | • 17 to 20 typical | • 1 to 4 typical |
| **PROS** | | | |
| • Inexpensive<br>• Reinforced | • Pleats increase filter efficiency<br>• Resists airflow less than HEPA | • Catches up to 99.97% of all particles<br>• Recognized by EPA and OSHA | • Last longer than disposable filters<br>• Durably designed |
| **CONS** | | | |
| • Protects HVAC components more than it cleans air | • Cheaper than HEPA, but less efficient with very fine particles | • Too big for most residential systems<br>• Retrofitting for HEPA is costly | • Require cleaning and maintenance<br>• May harbor germs if not fully dry |

*Image: angieslist.com*

# Air Filters: MERV


*Image: unitedfilter.com*

- An air filter's minimum efficiency reporting value (MERV) rating measures how effectively the filter stops dust and other contaminants from passing through the filter and into the air stream
- Higher MERV value provides greater filtration but also increases pressure drop across filter
- MERV ratings should be determined during HVAC design

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# Air Filters: HEPA

- A HEPA filter works by forcing air through a fine mesh that traps harmful particles such as pollen, pet dander, dust mites, and tobacco smoke
- Not MERV rated but generally considered MERV 17-20
- HEPA filters:
  - Are 95 percent efficient
  - Are 99.97 percent effective:
    - Filter particles down to < one micron
  - Alter the particles' airflow stream lines
  - Vary in pressure drop characteristics
  - Are effective against bacteria and some viruses

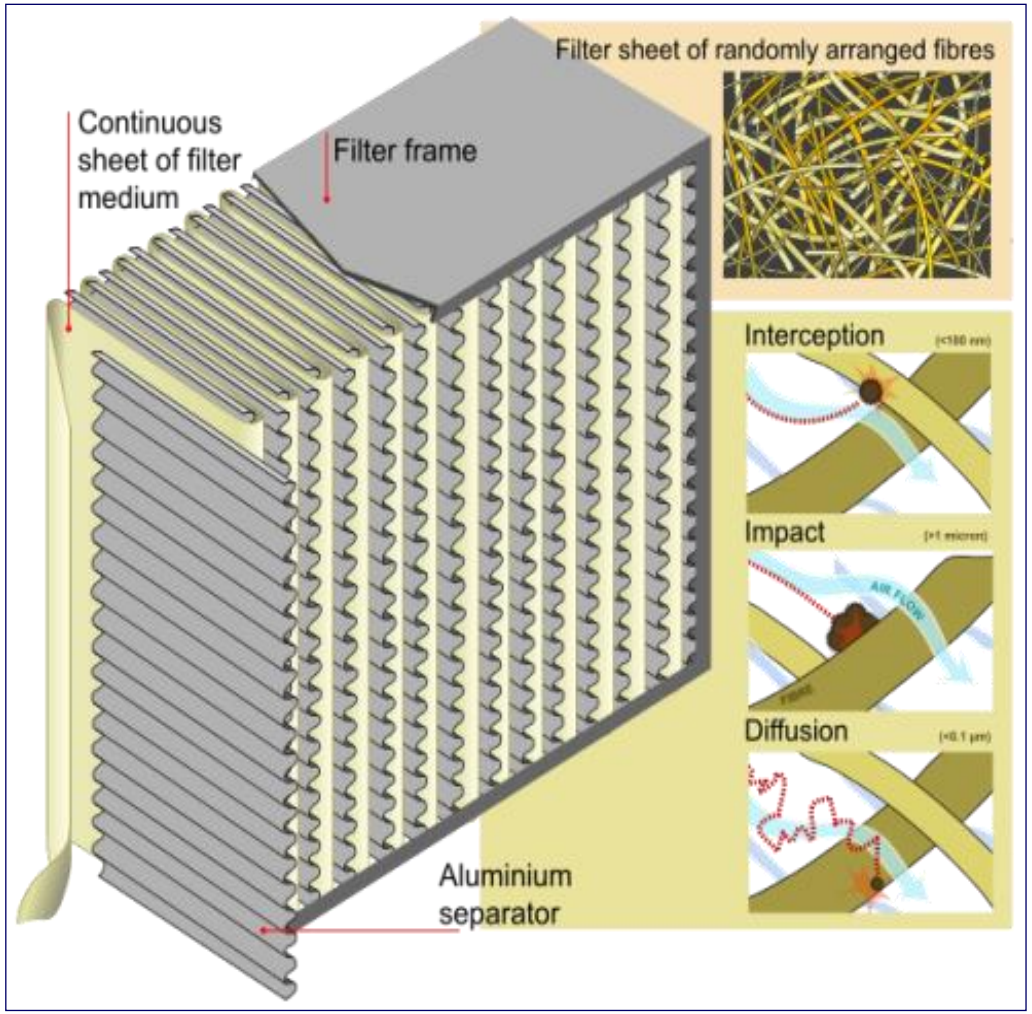


*Image: Wikipedia.com*

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# Construction and Filtration

- Construction activities generate a **lot** of dust
- Solutions:
  - Protect HVAC ducts during construction
  - Provide covers at the supplies and returns
  - Vacuum the ducts prior to occupancy
  - Seal the door between the garage and the home tightly
    - Should be done regardless to prevent infiltration of auto exhaust and other pollutants

*Image: toulmincabinetry.com*

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# Performance Testing

# Blower Door Testing

- Can be performed at final inspection or earlier in construction process
- Depressurizes the home to identify areas of leakage
- Leakage calculated in ACH50
  - Indicates how many times the volume of air that is inside the building changes with the outside air under test conditions
  - 3 ACH50 or lower required by model code

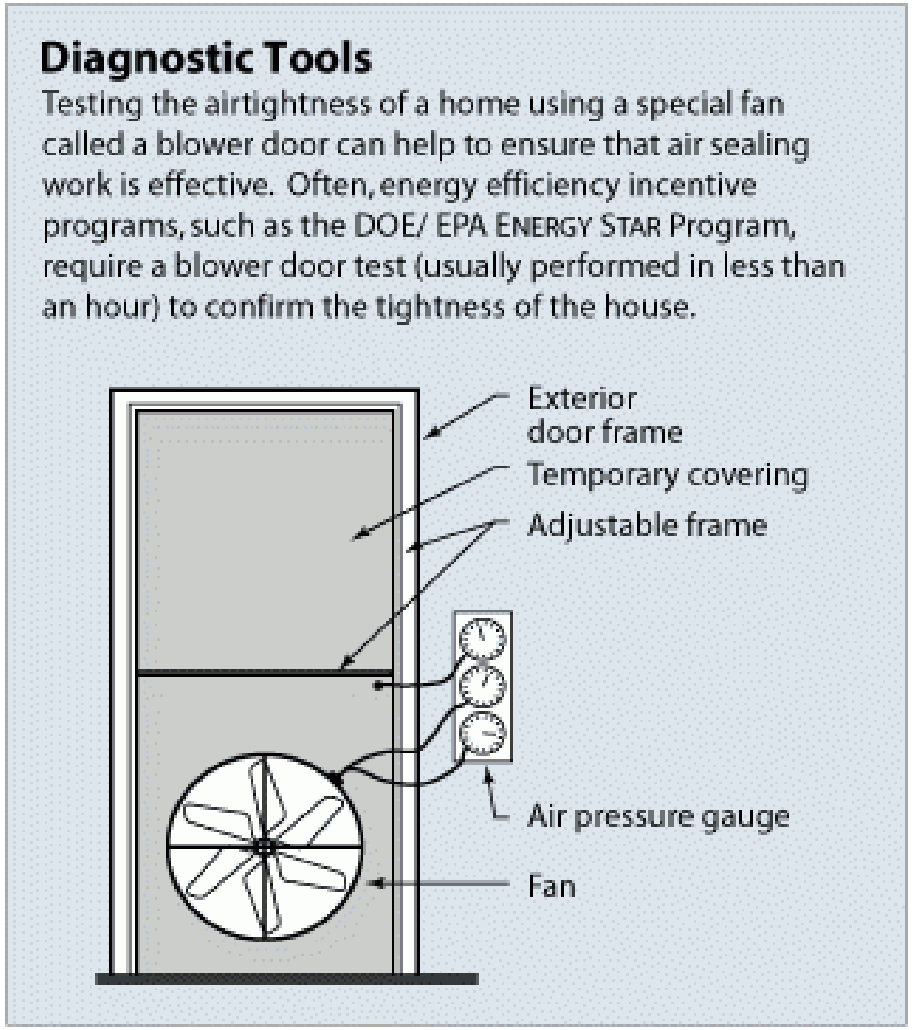


Image: U.S. DOE

# Benefits of Blower Door Testing

- Documents and quantifies home's air leakage
- Third party verification (some areas; performed by Inspectors)
- Not required in Lincoln's Energy Code (but still a really good idea!)
  - Provides data needed for understanding ventilation needs, final equipment adjustment and energy use/cost forecast
  - Great liability protection for all involved
  - Improved Home Performance

Image: Green Building Advisor

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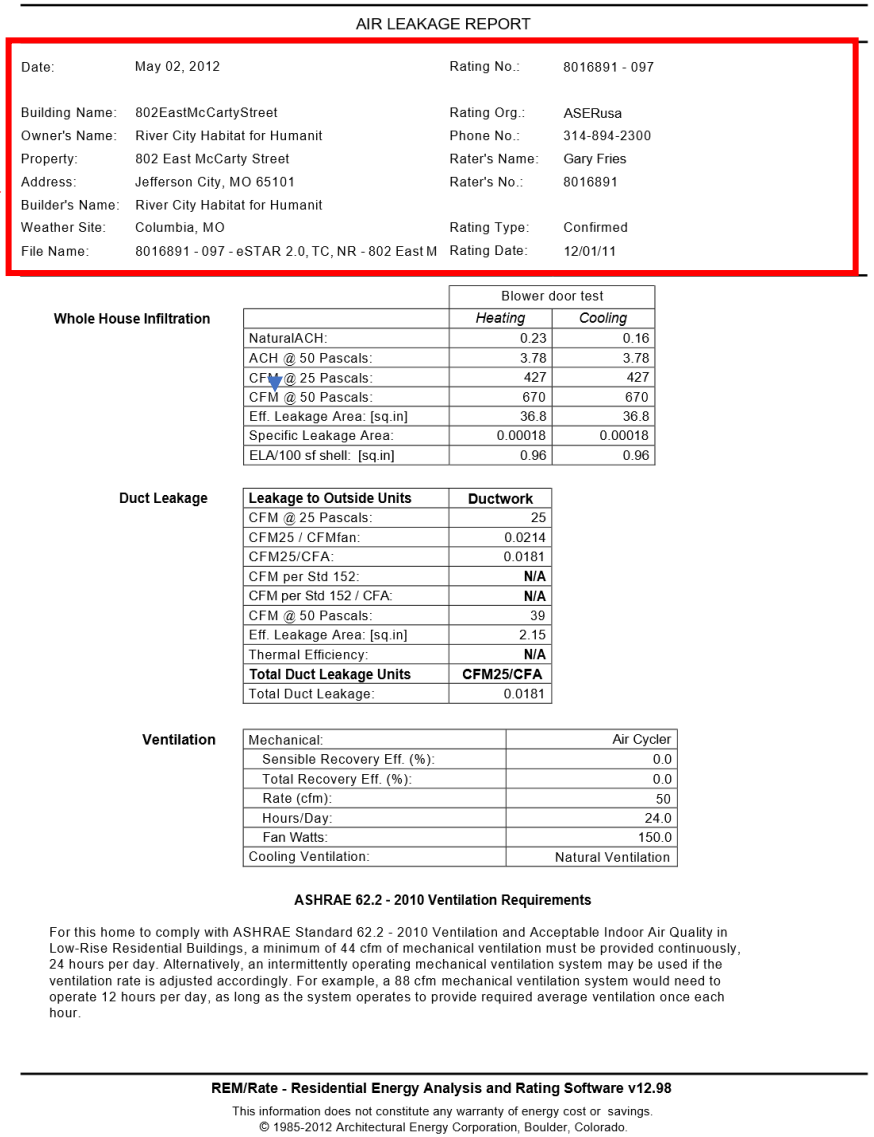
# Air Leakage Report

| | | | |
|---|---|---|---|
| **Date:** | May 02, 2012 | **Rating No.:** | 81158891-901 |
| **Building Name:** | 123 Main Street | **Rating Org.:** | Raters USA |
| **Owners Name:** | Jane Smith | **Phone:** | 555-555-5555 |
| **Property Address:** | 123 Main Street<br>Omaha, NE 68007 | **Rater's Name:** | John Williams |
| **Builder's Name:** | ABC Construction | **Rater's No:** | 1234567 |
| **Weather Site:** | Omaha, NE | **Rating Type:** | Confirmed |
| **File Name:** | 101682391-097 eSTAR | **Rating Date:** | 12/01/20 |



AIR LEAKAGE REPORT

| | | | |
|---|---|---|---|
| Date: | May 02, 2012 | Rating No.: | 8016891 - 097 |
| Building Name: | 802EastMcCartyStreet | Rating Org.: | ASERusa |
| Owner's Name: | River City Habitat for Humanit | Phone No.: | 314-894-2300 |
| Property: | 802 East McCarty Street | Rater's Name: | Gary Fries |
| Address: | Jefferson City, MO 65101 | Rater's No.: | 8016891 |
| Builder's Name: | River City Habitat for Humanit | | |
| Weather Site: | Columbia, MO | Rating Type: | Confirmed |
| File Name: | 8016891 - 097 - eSTAR 2.0, TC, NR - 802 East M | Rating Date: | 12/01/11 |

**Whole House Infiltration**

| | Blower door test | |
|---|---|---|
| | *Heating* | *Cooling* |
| NaturalACH: | 0.23 | 0.16 |
| ACH @ 50 Pascals: | 3.78 | 3.78 |
| CFM @ 25 Pascals: | 427 | 427 |
| CFM @ 50 Pascals: | 670 | 670 |
| Eff. Leakage Area: [sq.in] | 36.8 | 36.8 |
| Specific Leakage Area: | 0.00018 | 0.00018 |
| ELA/100 sf shell: [sq.in] | 0.96 | 0.96 |

**Duct Leakage**

| **Leakage to Outside Units** | **Ductwork** |
|---|---|
| CFM @ 25 Pascals: | 25 |
| CFM25 / CFMfan: | 0.0214 |
| CFM25/CFA: | 0.0181 |
| CFM per Std 152: | **N/A** |
| CFM per Std 152 / CFA: | **N/A** |
| CFM @ 50 Pascals: | 39 |
| Eff. Leakage Area: [sq.in] | 2.15 |
| Thermal Efficiency: | **N/A** |
| **Total Duct Leakage Units** | **CFM25/CFA** |
| Total Duct Leakage: | 0.0181 |

**Ventilation**

| | |
|---|---|
| Mechanical: | Air Cycler |
| Sensible Recovery Eff. (%): | 0.0 |
| Total Recovery Eff. (%): | 0.0 |
| Rate (cfm): | 50 |
| Hours/Day: | 24.0 |
| Fan Watts: | 150.0 |
| Cooling Ventilation: | Natural Ventilation |

**ASHRAE 62.2 - 2010 Ventilation Requirements**

For this home to comply with ASHRAE Standard 62.2 - 2010 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, a minimum of 44 cfm of mechanical ventilation must be provided continuously, 24 hours per day. Alternatively, an intermittently operating mechanical ventilation system may be used if the ventilation rate is adjusted accordingly. For example, a 88 cfm mechanical ventilation system would need to operate 12 hours per day, as long as the system operates to provide required average ventilation once each hour.

**REM/Rate - Residential Energy Analysis and Rating Software v12.98**

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# Air Leakage Report

## Whole House Infiltration

| | Blower Door Test | |
|---|---|---|
| | *Heating* | *Cooling* |
| Natural ACH: | 0.23 | 0.16 |
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|---|---|---|---|
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# Air Leakage Report

## Duct Leakage

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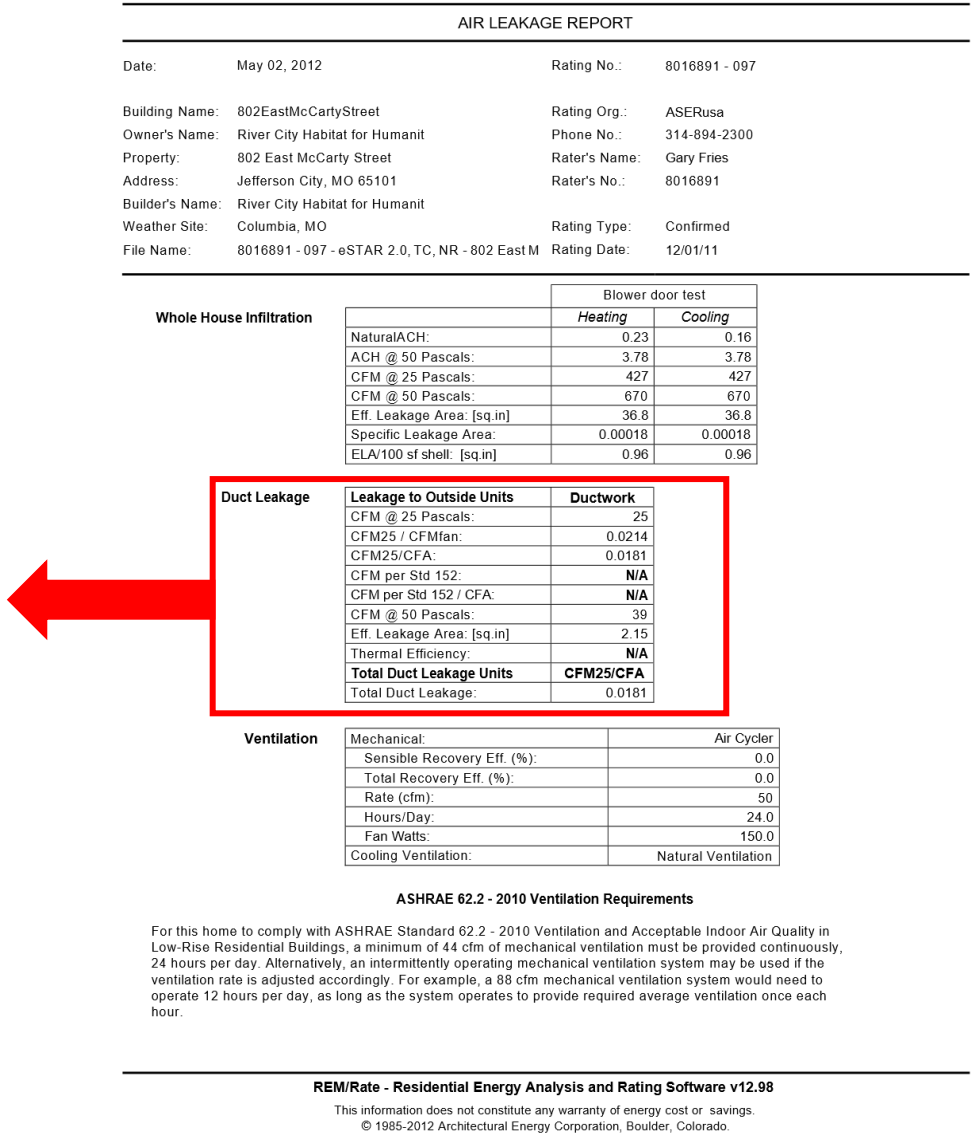

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# Insulation Best Practices

# Insulation

- Energy efficiency is maximized in homes that address these insulation issues strategically:
  - Placement
  - Type
  - Installation

*Image: fmlink.com*

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# Insulation - Placement

- Limiting airflow is a key factor for insulation effectiveness.
- Insulation should be in contact with the air barrier and entirely encapsulated.

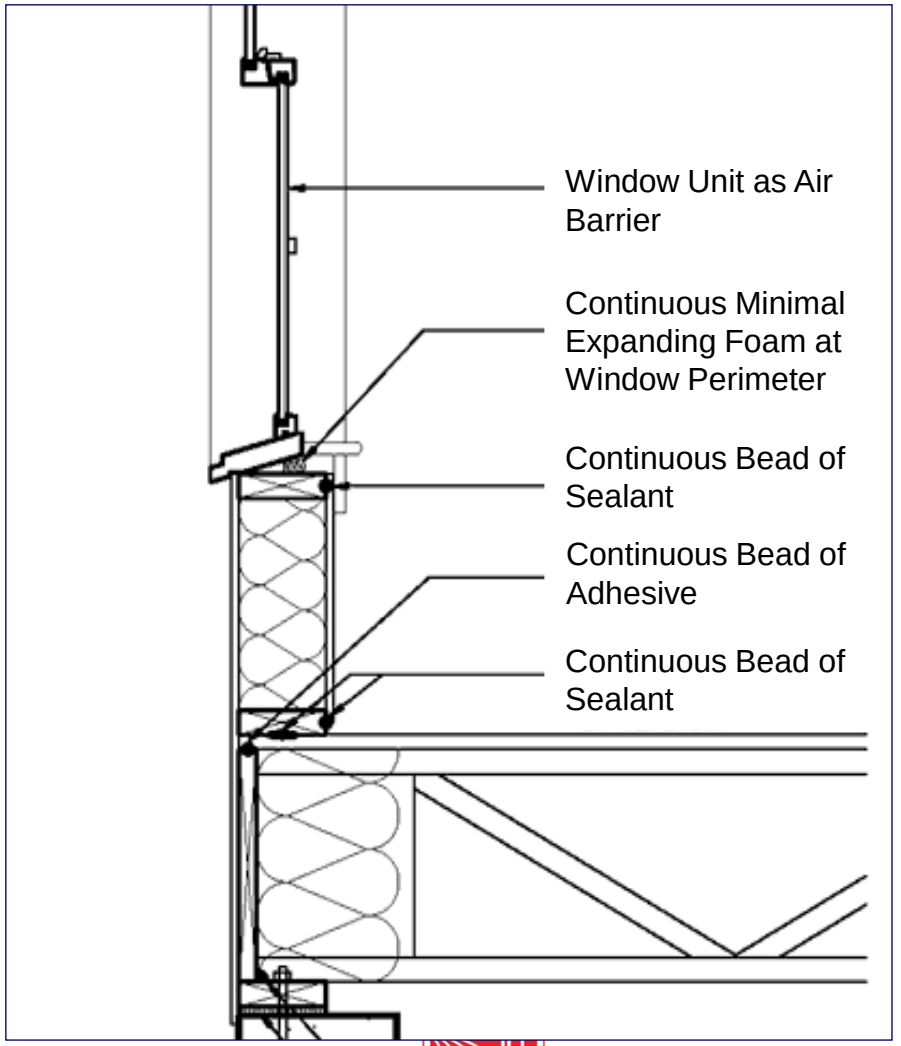


Image: basc.pnnl.gov

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# Insulation - Type

The energy code does not require specific types of insulation, only required R-value

**Materials**:

- Fiberglass
- Cellulose
- Low-density or open-cell foam
- High-density or closed-cell foam
- Foam sheathing

**Forms**:

- Batts and blankets
- Loose-fill and blown-in
- Damp spray (cellulose, spider micro-filament fiberglass)
- Blown-in batt system (BIBS)
- Dense pack insulation
- Foams (sheet-applied)
- Foams (spray-applied)
- Reflective systems

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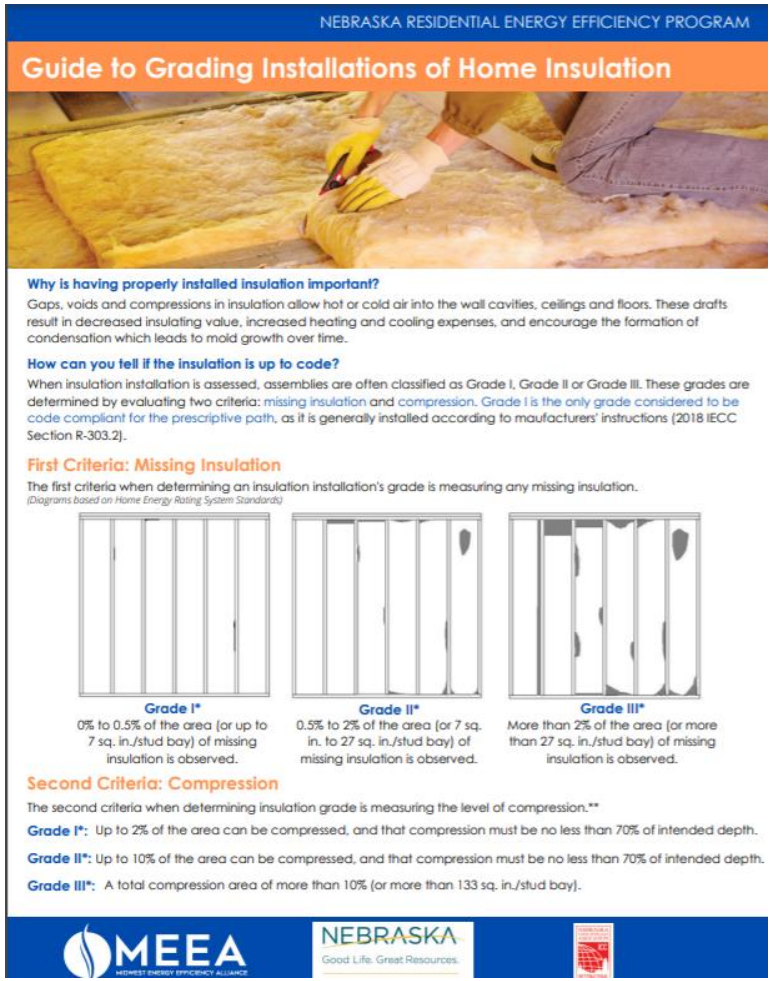
# Insulation - Installation

- Inspection ratings:
  - Grade 1: Installed correctly (code required)
  - Grade 2: You tried, but not quite there
  - Grade 3: You've got to be kidding me!

  R-value:
  - Indicates a material's resistance to heat flow
- U-factor:
  - Indicates rate of heat loss by the product or assembly



NEBRASKA RESIDENTIAL ENERGY EFFICIENCY PROGRAM

Guide to Grading Installations of Home Insulation

**Why is having properly installed insulation important?**

Gaps, voids and compressions in insulation allow hot or cold air into the wall cavities, ceilings and floors. These drafts result in decreased insulating value, increased heating and cooling expenses, and encourage the formation of condensation which leads to mold growth over time.

**How can you tell if the insulation is up to code?**

When insulation installation is assessed, assemblies are often classified as Grade I, Grade II or Grade III. These grades are determined by evaluating two criteria: missing insulation and compression. Grade I is the only grade considered to be code compliant for the prescriptive path, as it is generally installed according to maufacturers' instructions (2018 IECC Section R-303.2).

**First Criteria: Missing Insulation**

The first criteria when determining an insulation installation's grade is measuring any missing insulation.

*(Diagrams based on Home Energy Rating System Standards)*

**Grade I***
0% to 0.5% of the area (or up to 7 sq. in./stud bay) of missing insulation is observed.

**Grade II***
0.5% to 2% of the area (or 7 sq. in. to 27 sq. in./stud bay) of missing insulation is observed.

**Grade III***
More than 2% of the area (or more than 27 sq. in./stud bay) of missing insulation is observed.

**Second Criteria: Compression**

The second criteria when determining insulation grade is measuring the level of compression.**

**Grade I*:** Up to 2% of the area can be compressed, and that compression must be no less than 70% of intended depth.

**Grade II*:** Up to 10% of the area can be compressed, and that compression must be no less than 70% of intended depth.

**Grade III*:** A total compression area of more than 10% (or more than 133 sq. in./stud bay).

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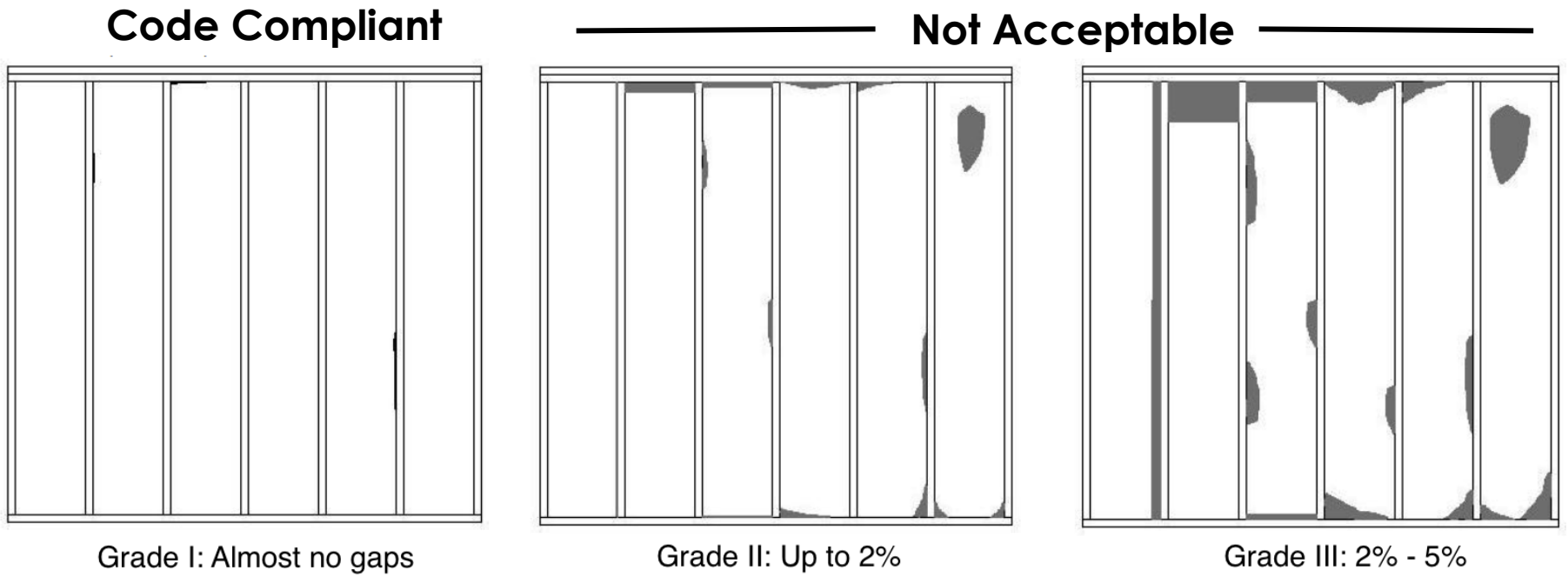
# Batt Insulation Grading



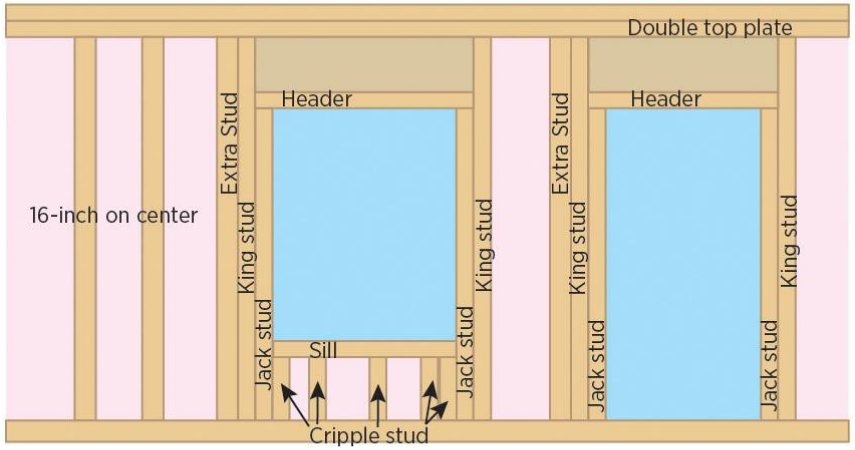

RESNET protocol for the effect of missing insulation on installation grade

Diagrams from the HERS Standards

# Alternative Systems

- Alternative framing techniques can make holistic improvements to a building envelope assembly. For example:
  - Increase stud spacing to 24 inches on center and raise headers above the top plate or hung on single jacks with header hangers:
    - U-factor: 0.058 to 0.055
    - R-value: 17.24 to 18.18
  - Double stud wall assemblies and truss wall assemblies
  - SIPs, ICFs and precast concrete

Traditional Framing




Advanced Framing Techniques

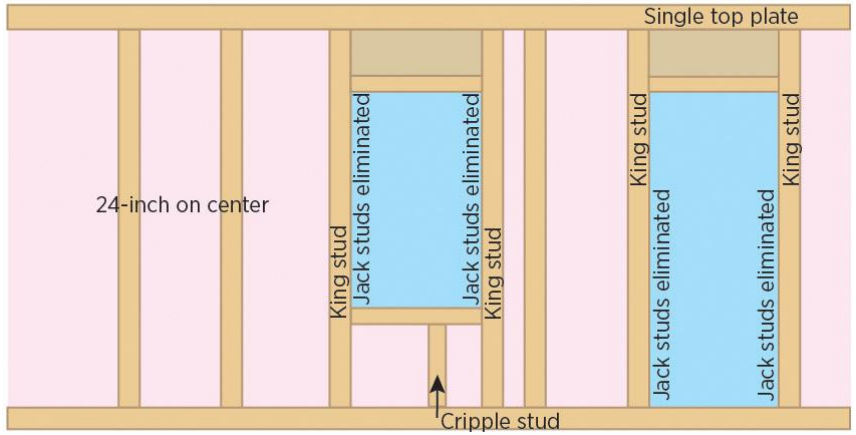



*Image: Pacific Northwest National*

# Key Takeaways

- Proper air sealing **and testing** is key to improving indoor air quality, comfort and health
  - Mechanical ventilation must be installed and takes on new importance
- Ventilation
  - Whole house ventilation is required by model code
  - Average house is now built tight enough to need it
  - Balanced ventilation is best practice
- Insulation
  - Proper placement, type and installation are key

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# Questions?

# MEEA YouTube Video

## Residential Air Sealing

- https://youtu.be/Vr3O2_IvgpU
- With Spanish subtitles: https://youtu.be/Vr3O2_IvgpU

## Residential Insulation

- https://youtu.be/URLeqmuH-ys
- With Spanish subtitles: https://youtu.be/y0ouENI6Yws

# Upcoming Trainings

## March 2023

- Wednesday, March 15 (10 a.m.-11:30 a.m.) – **Nebraska Commercial Energy Code: Air Infiltration, Lighting and HVAC**
- Register: https://www.eventbrite.com/e/nebraska-commercial-energy-code-air-infiltration-lighting-and-hvac-tickets-520889964907

## April 2023

- In-person trainings TBD – what would you like to see?

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# Thank you!

*Matt Belcher*

*Matt@verda-solutions.org*

*Corie Anderson*

*canderson@mwalliance.org*

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