Air Sealing Principles and Ventilation Strategies

Instructor: Matt Belcher

July 13, 2021

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Today's Agenda

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

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Housekeeping

- Attendees are muted upon entry
- Questions? Enter them in the chat box
- Webinar is being recorded – slides and recording will be sent to attendees
- CEU's will be available upon request (ICC)
  - Information at end of presentation
- Email kgredvig@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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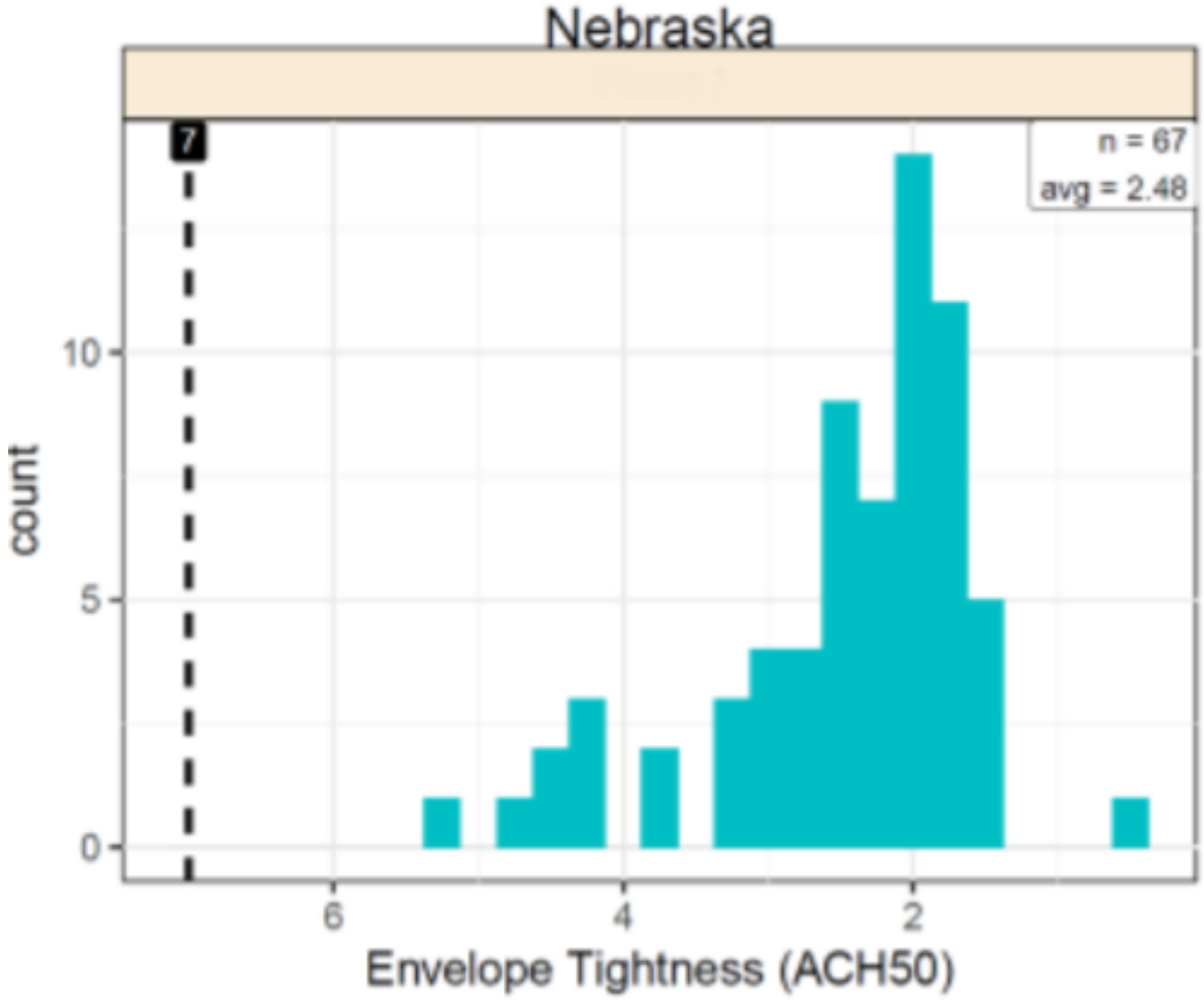
NE Residential Field Study - Results

- **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!

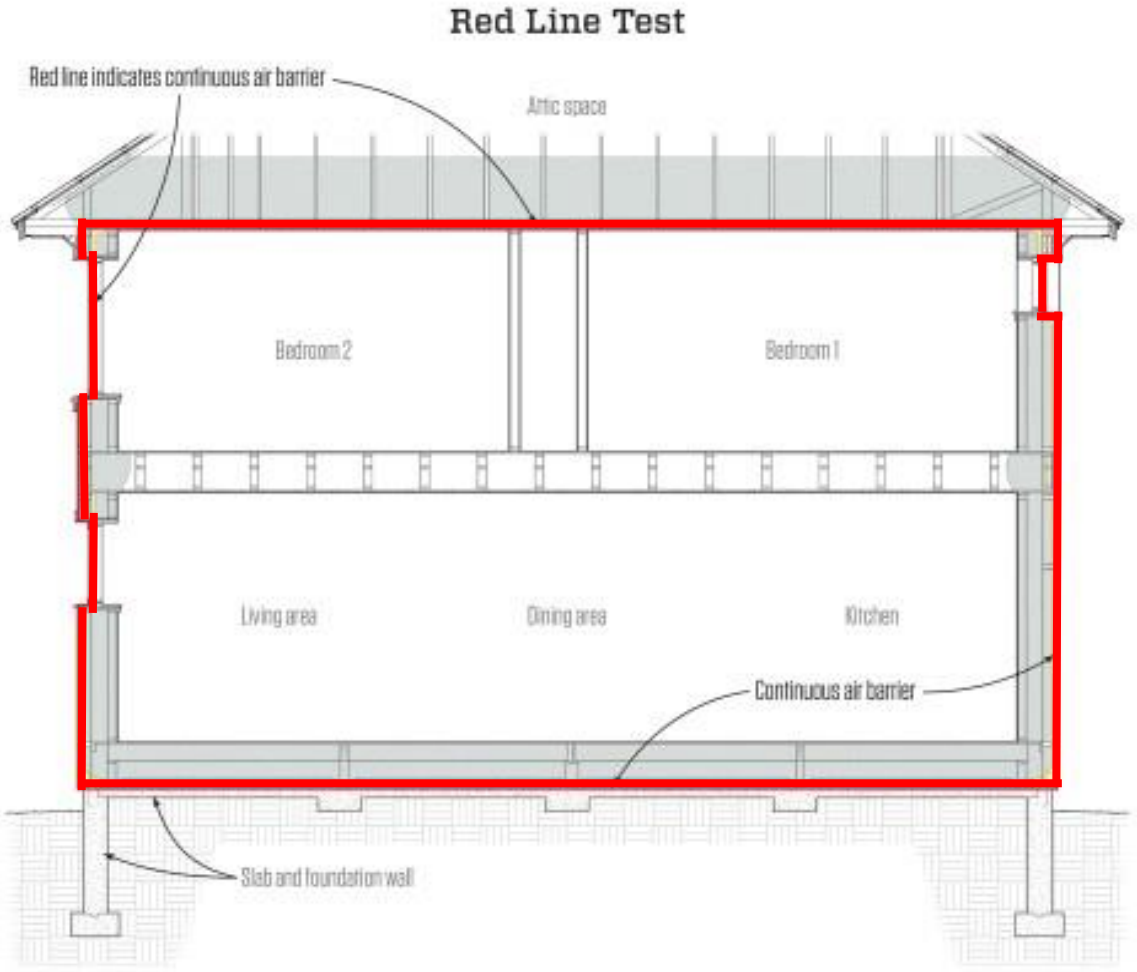

Image: jlconline.com

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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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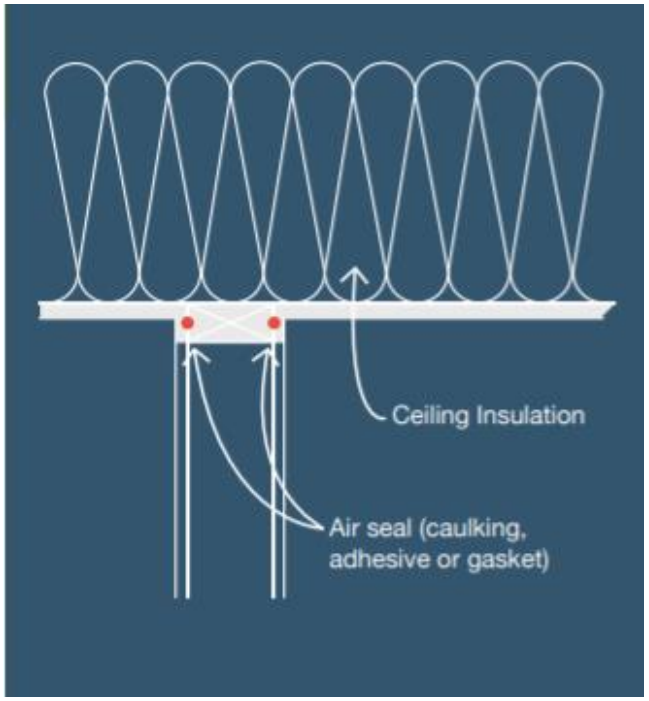
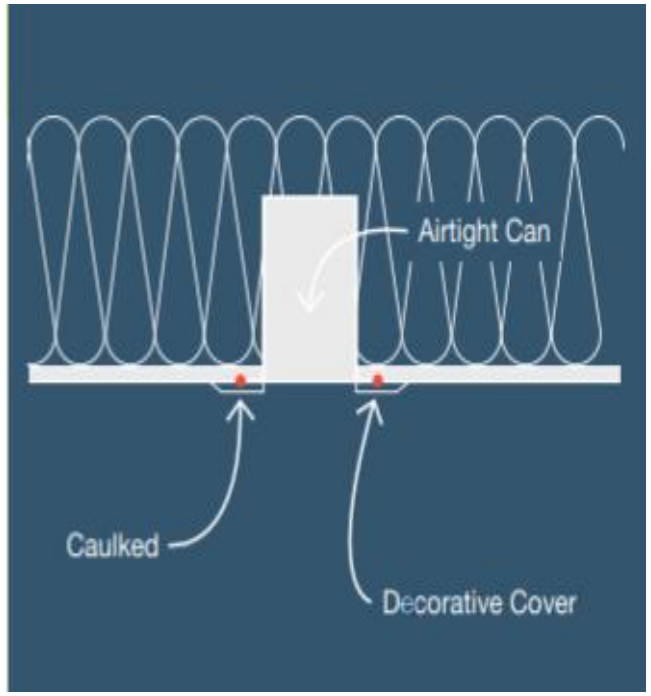
Priorities for Air Sealing

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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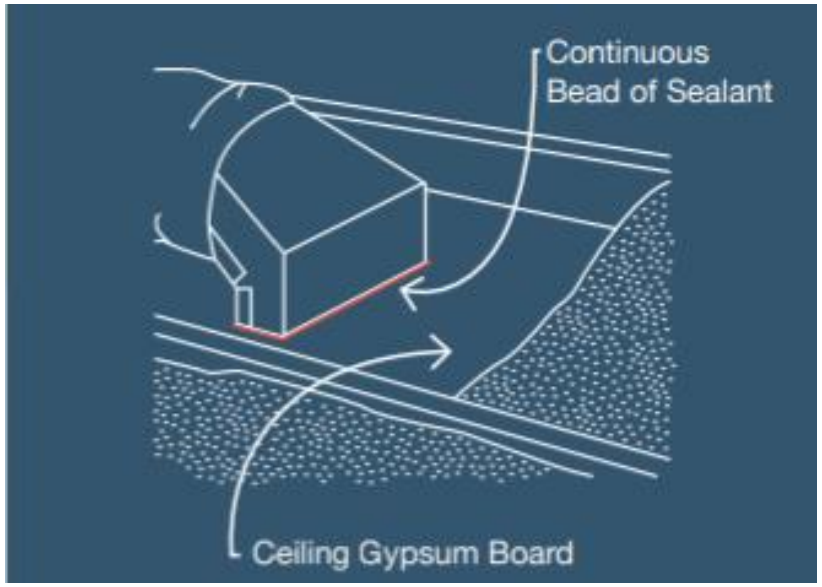
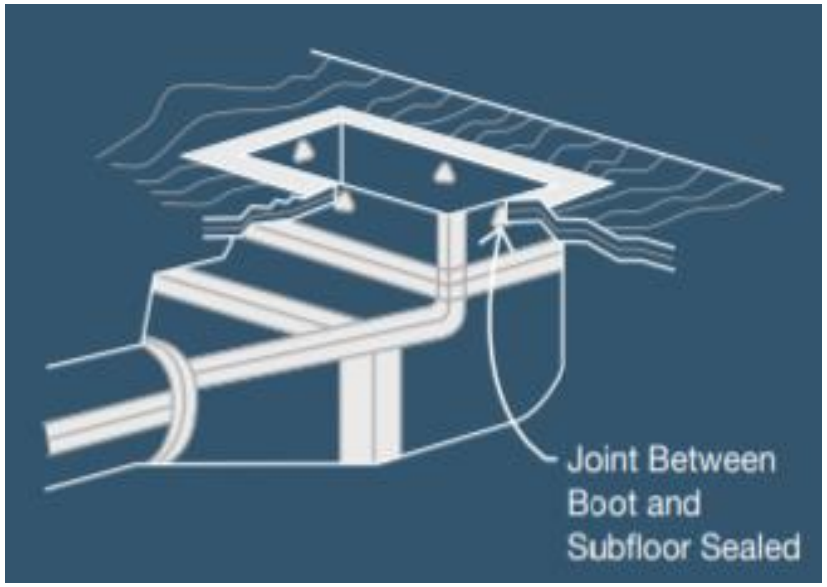
Priority Locations for Air Sealing





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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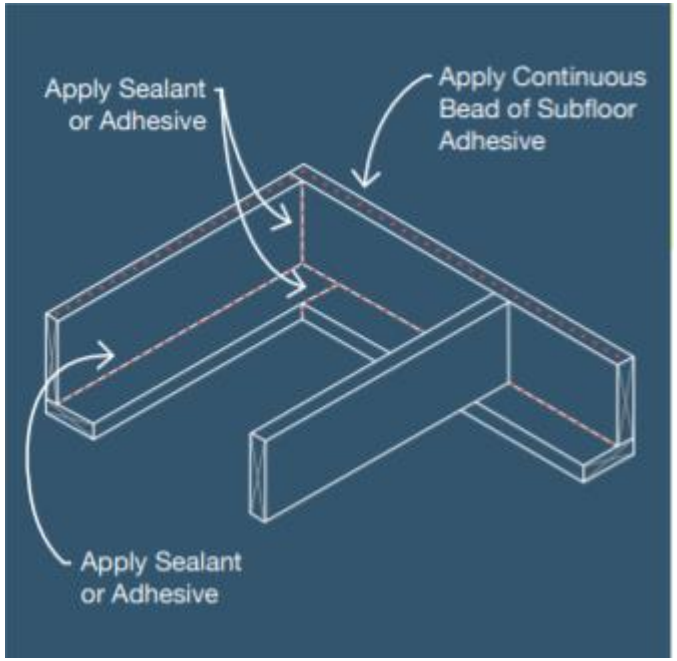
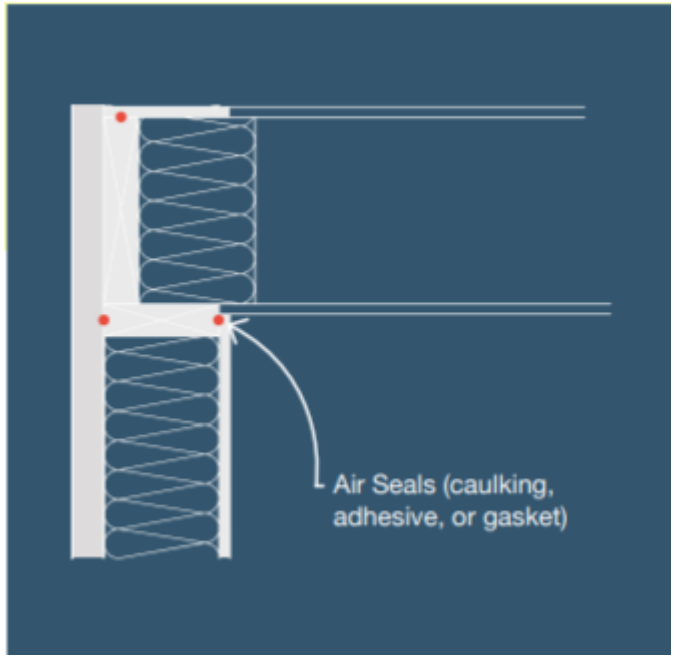
Priority Locations for Air Sealing



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

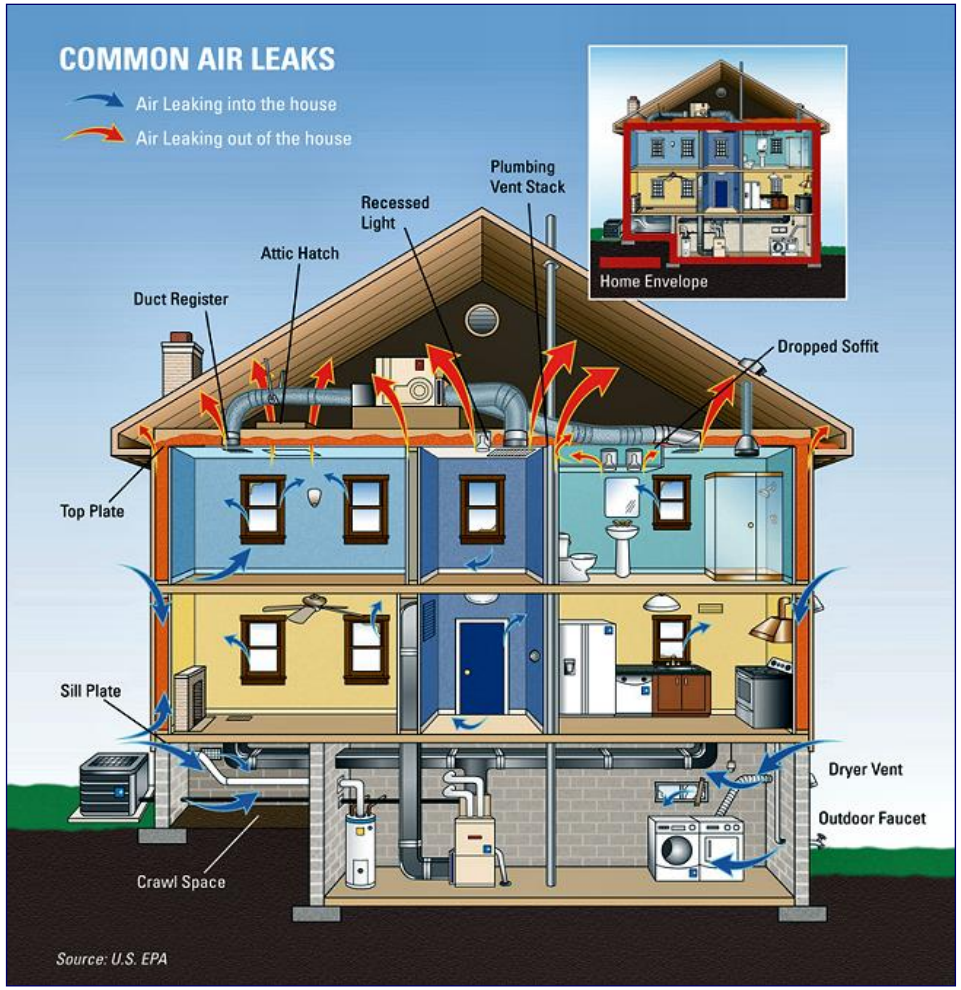

Image: epa.gov

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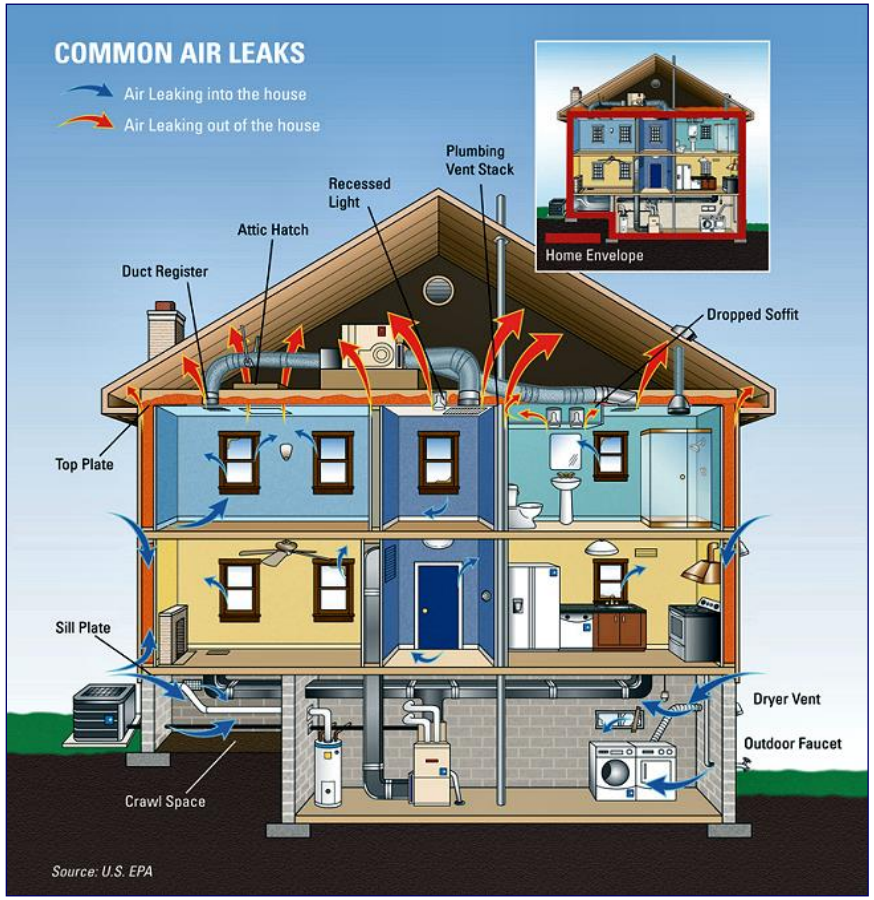
Air Barrier – Strategies (cont.)

- 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



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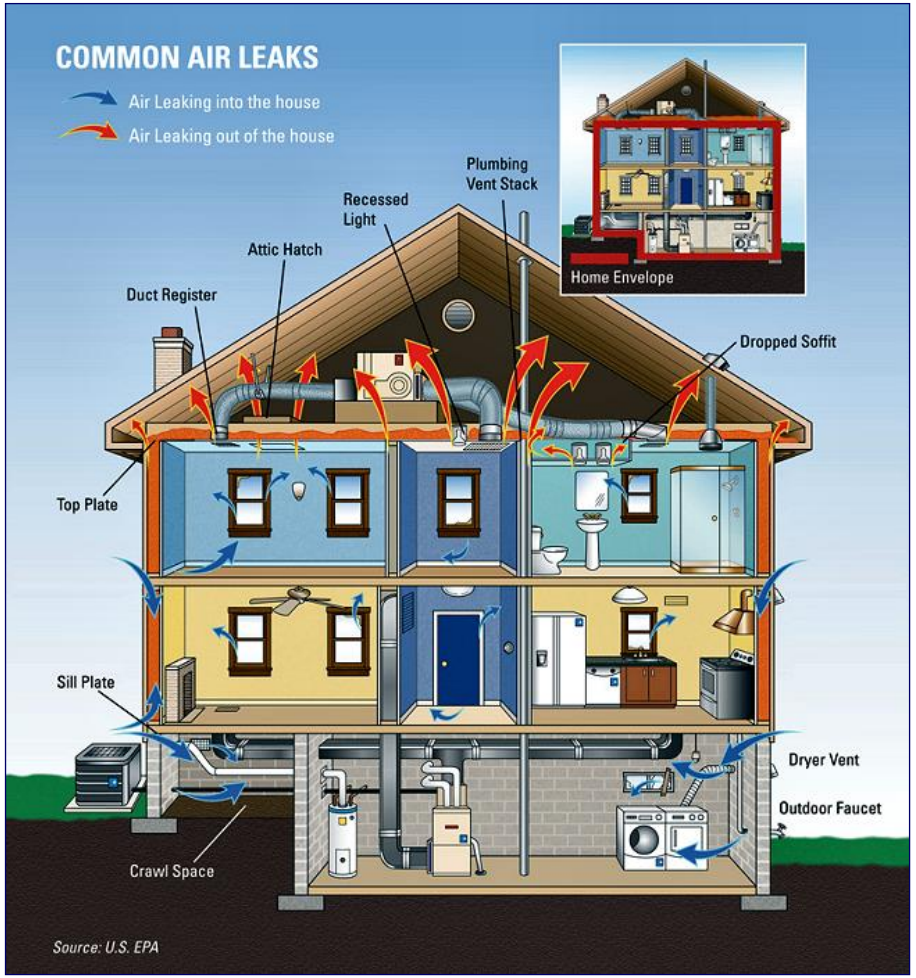
Review - Air Barrier Strategies

- 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



Courtesy of U.S. Environmental Protection Agency

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

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!"

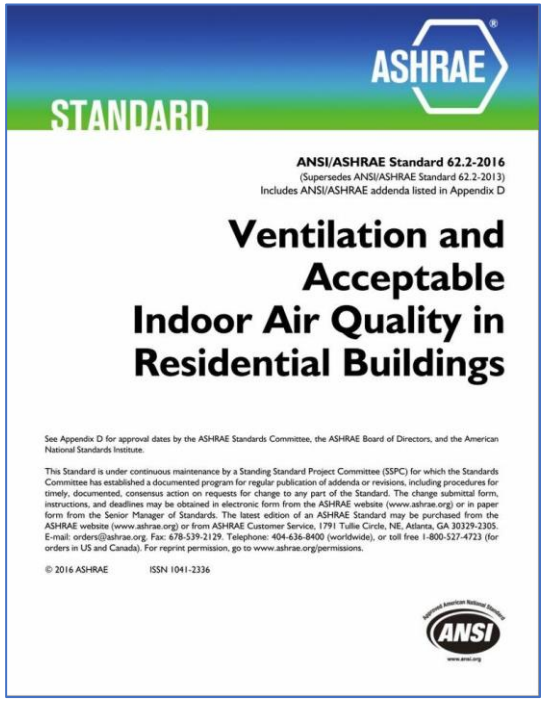


Image:ashrae.org

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)

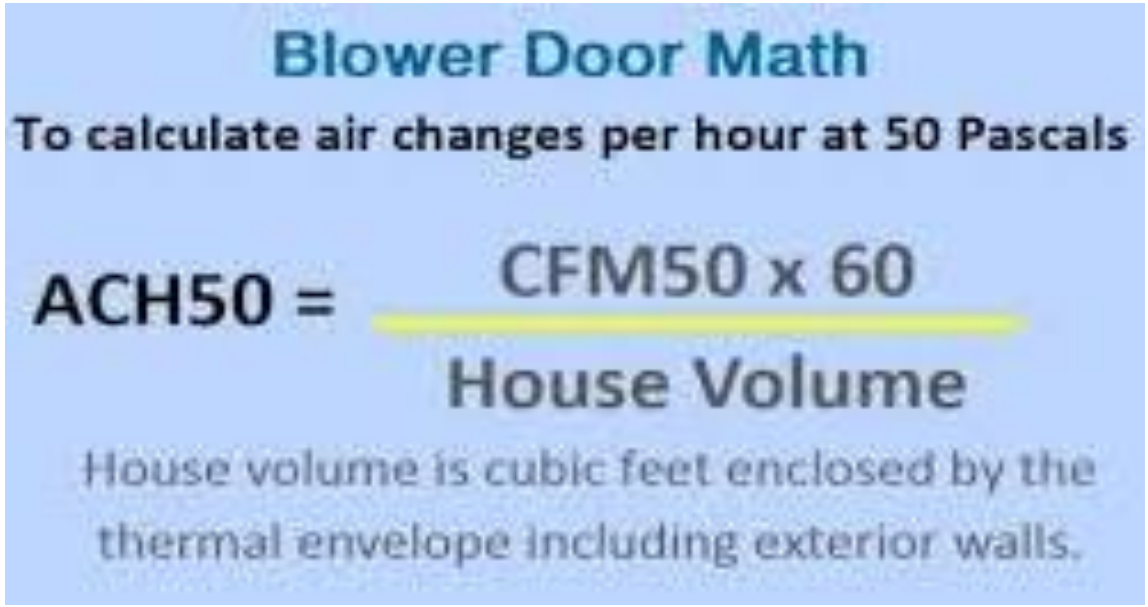
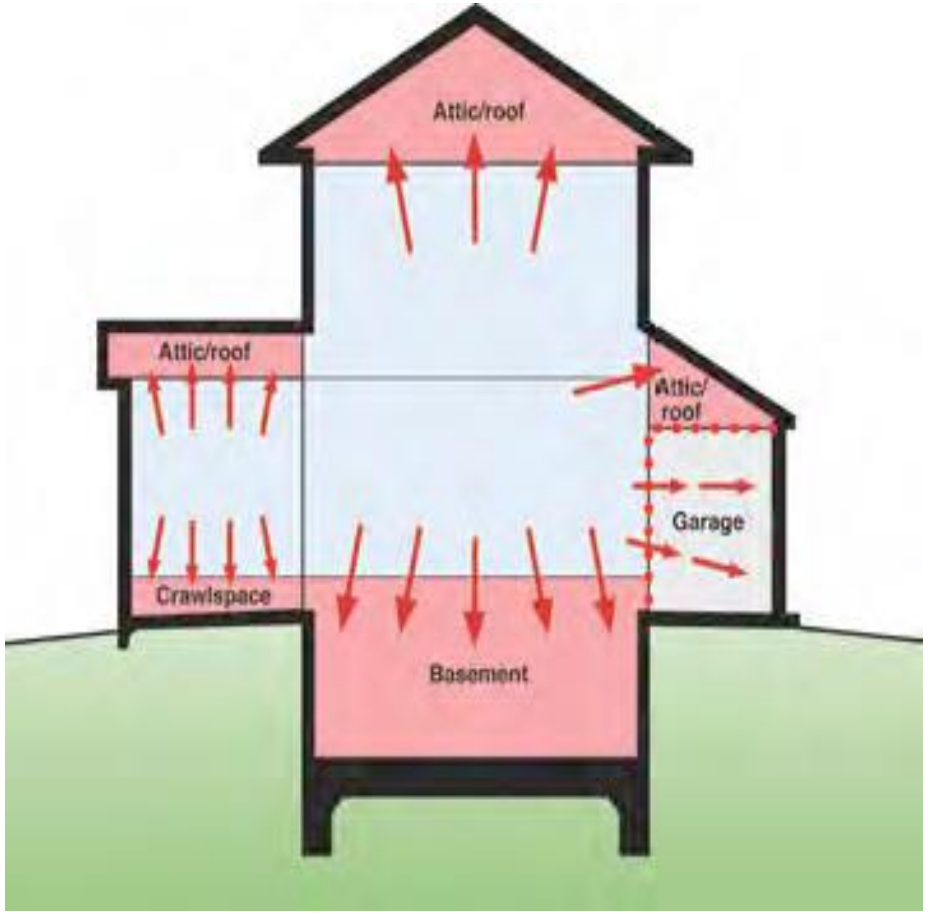


Image: deq.mt.gov

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

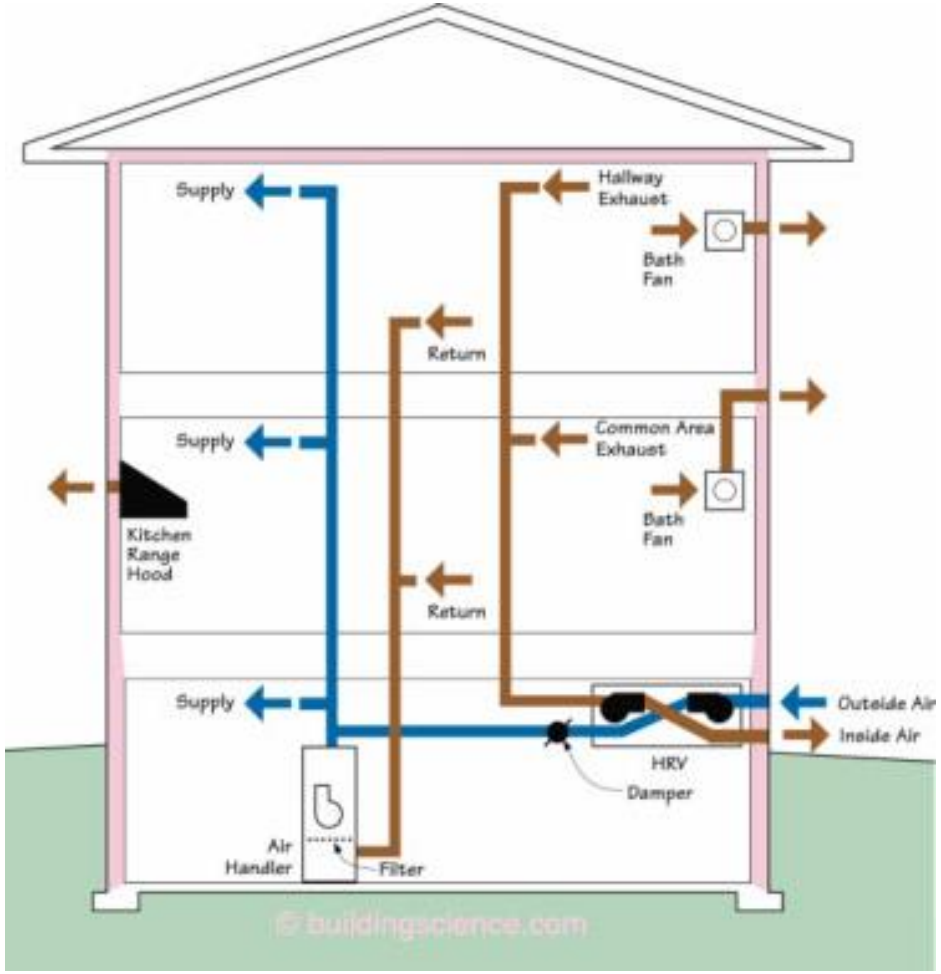

Image: buildingscience.com

- 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

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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.

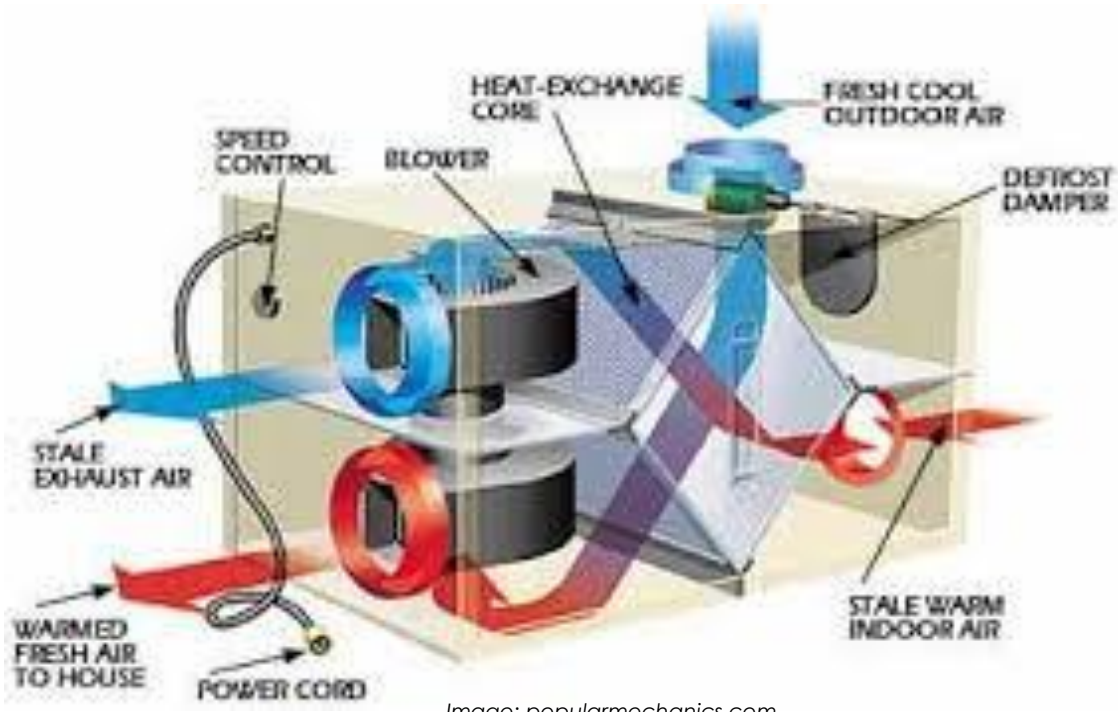

Image: popularmechanics.com

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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.

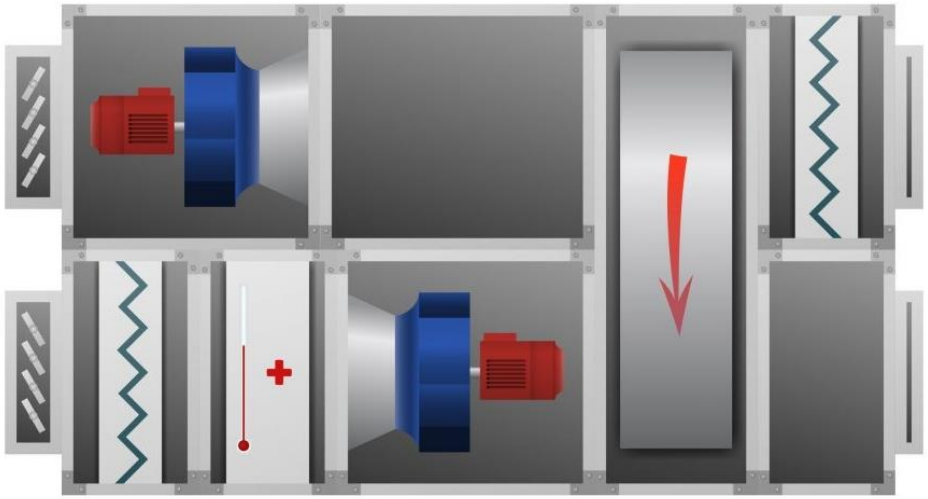

Image: totalcomfortma.com

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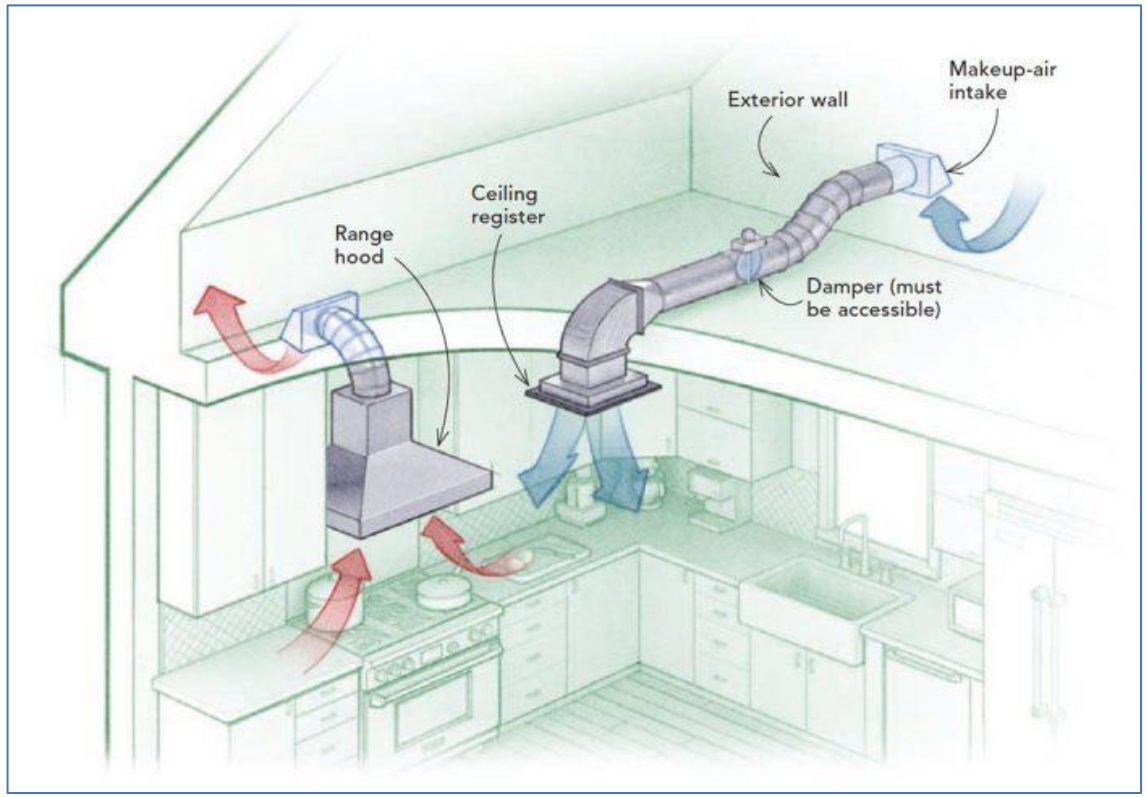
Spot Ventilation (Supply-only and Exhaust-only)

- 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 • 14 to 16 high efficiency	• 17 to 20 typical	• 1 to 4 typical
PROS			
• Inexpensive • Reinforced	• Pleats increase filter efficiency • Resists airflow less than HEPA	• Catches up to 99.97% of all particles • Recognized by EPA and OSHA	• Last longer than disposable filters • 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 • Retrofitting for HEPA is costly	• Require cleaning and maintenance • May harbor germs if not fully dry

Image: angieslist.com

Air Filters: MERV

- 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

Image: unitedfilter.com

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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

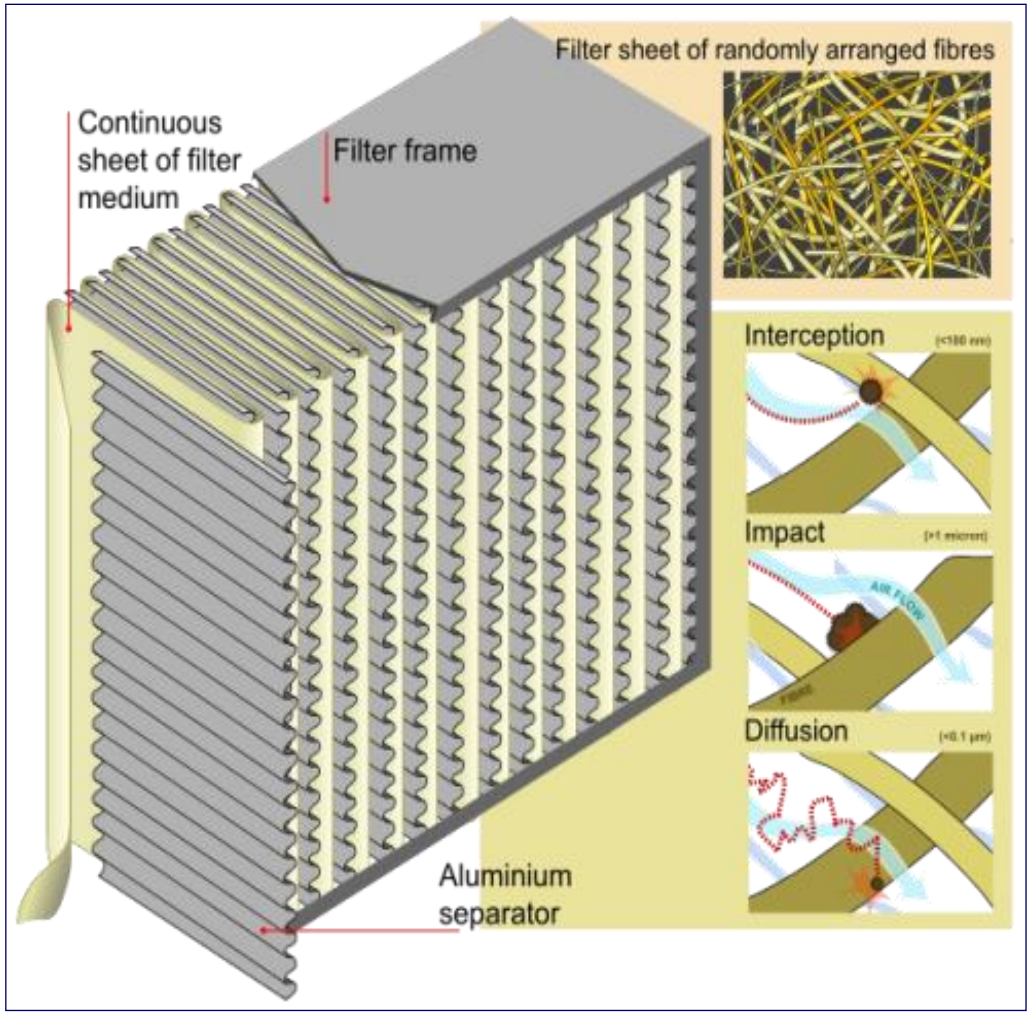

Image: Wikipedia.com

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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

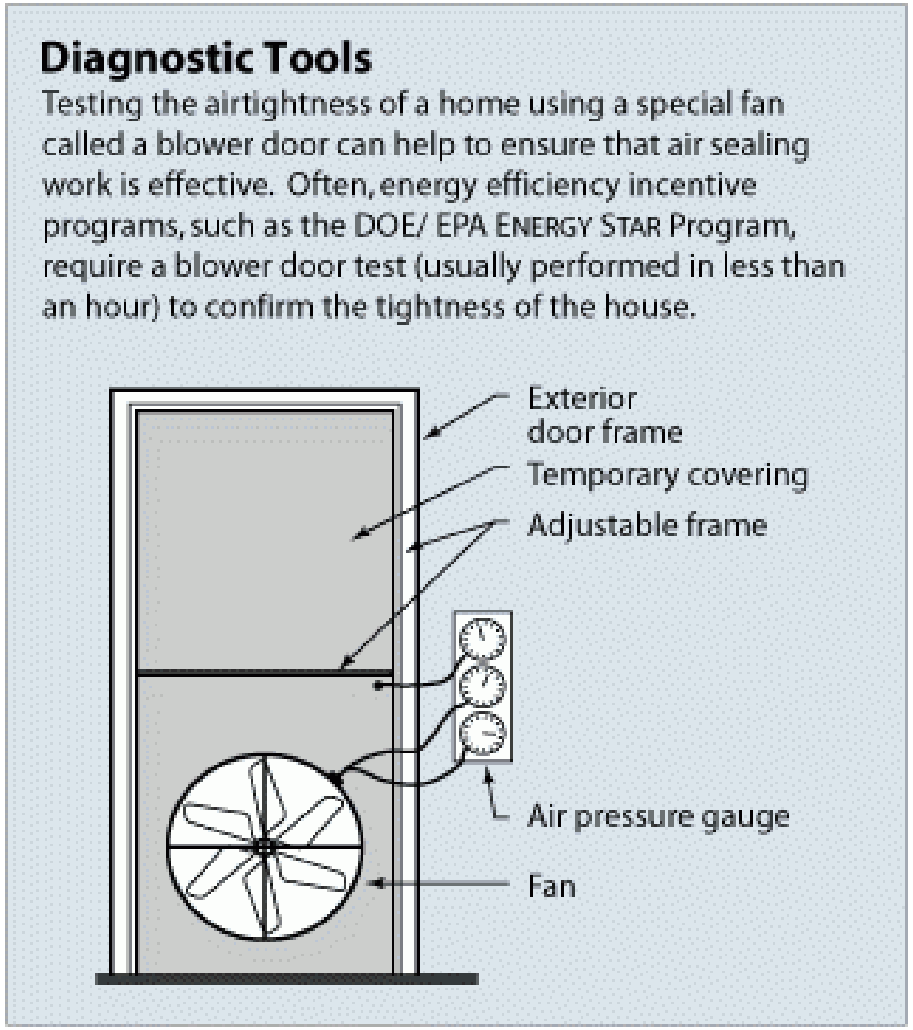

Image: U.S. DOE

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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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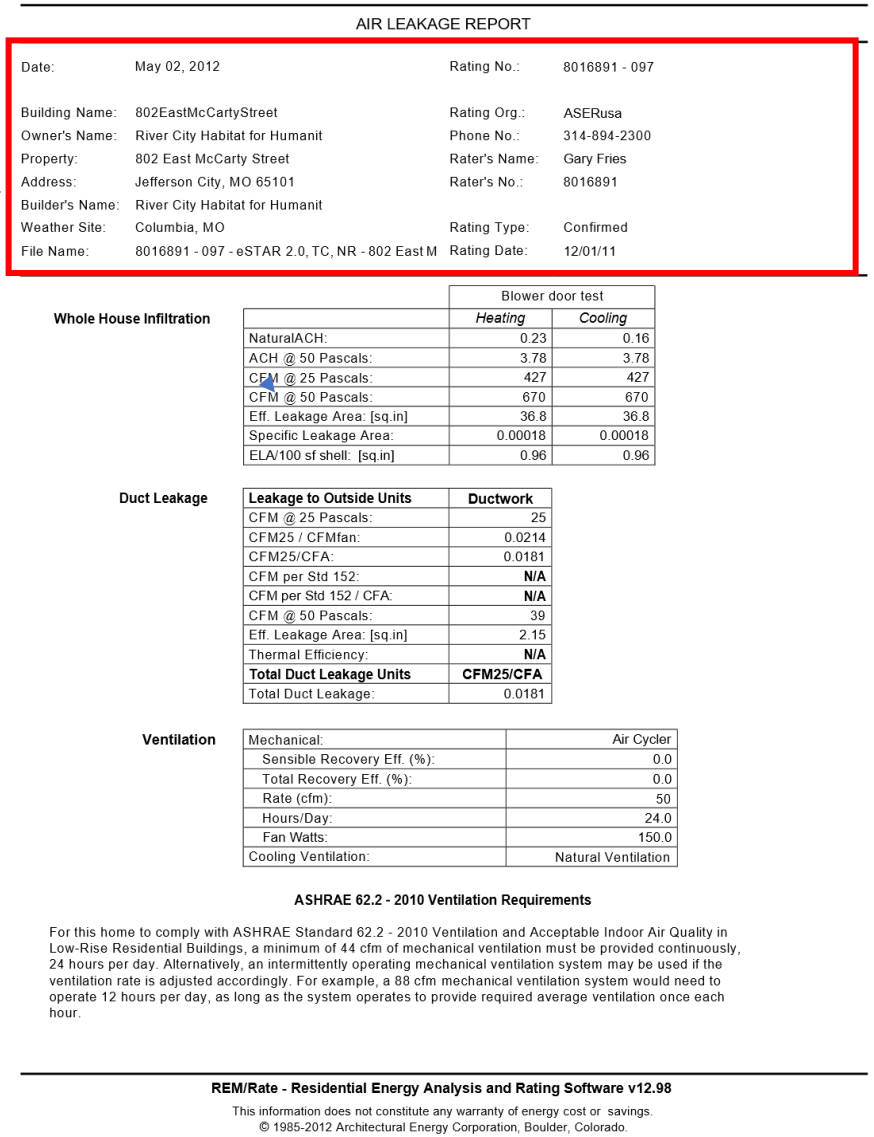
Air Leakage Report

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 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

This information does not constitute any warranty of energy cost or savings.

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Key Takeaways

- Proper air sealing **and testing** is key to improving indoor air quality, comfort and health of the home
  - 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

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Questions?

Continuing Education Credits

- Participants of this training are eligible for continuing education credits from the International Code Council

- Course ID: 28902
- CEUs: 0.2

- Certificates will be emailed to attendees. Contact Karin Gredvig (kgredvig@mwalliance.org) with questions.

Upcoming Trainings

July 2021

- July 28 - *Nebraska's Commercial Energy Code: An Introduction to the 2018 IECC*

September 2021

- September 7 - *Nebraska's Residential Energy Code: An Introduction to the 2018 IECC*
- September 30 - *Commercial Building Envelope Fundamentals*

For more information and to register, visit: https://www.mwalliance.org/nebraska-energy-codes-training-program

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Thank you!

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Nicole Westfall

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