METROPOLITAN
Community College

Residential Energy Code – Session 2

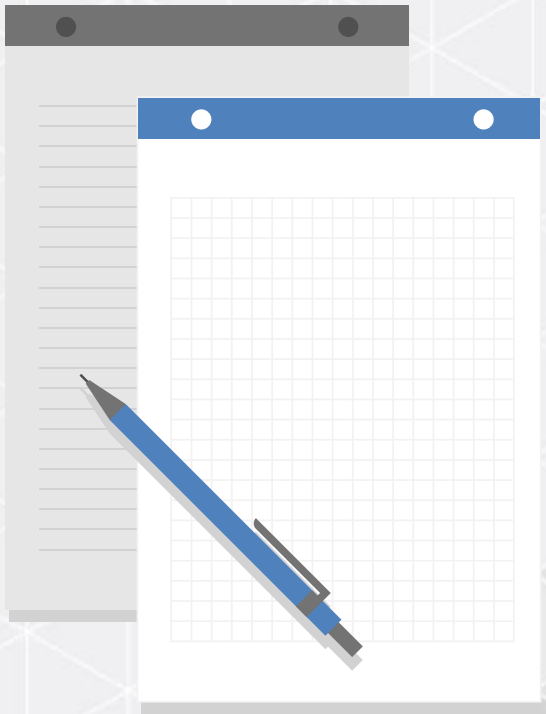
Building Science and Moisture Management

Instructor: Matt Belcher

February 2, 2021: 6:30-8:30pm

Today's Agenda

- Building Science Basics
- Moisture Management
- Air Movement
- Heat Transfer
- Quality Management
- Performance Testing
- Wrap Up & Quiz



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 nwestfall@mwalliance.org with questions

BUILDING SCIENCE BASICS

What is Building Science?

Architecture should be dedicated to keeping the outside out and the inside in.

Leonard Baskin

What is Building Science?

- **Building science** is the collection of scientific knowledge that focuses on physical phenomena affecting buildings.

- In other words – Building Performance!
  - Building Envelope
  - Mechanical Systems
  - Lighting Systems
  - Occupant Health and Comfort

What is Building Science?

The first rule of building science is…

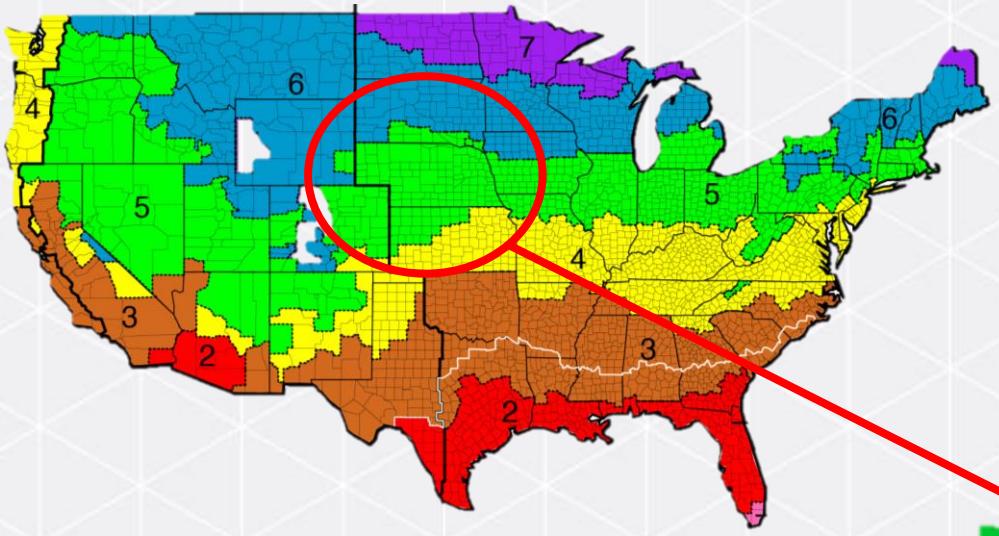
Moisture ***will always*** get where you don't want it to go

What is Building Science?

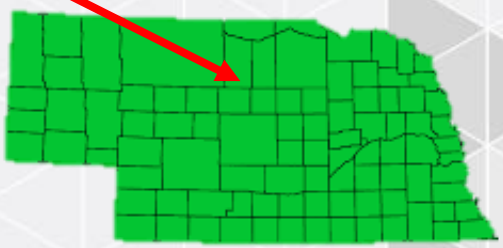
The first question of building science is…

How will the moisture get out?

The 1st Consideration is Climate Zone



- Nebraska has only one climate zone – 5A
- Cold & Moist climate



Advanced Physics in Building Science

Hot → **Cold**

Wet → **Dry**

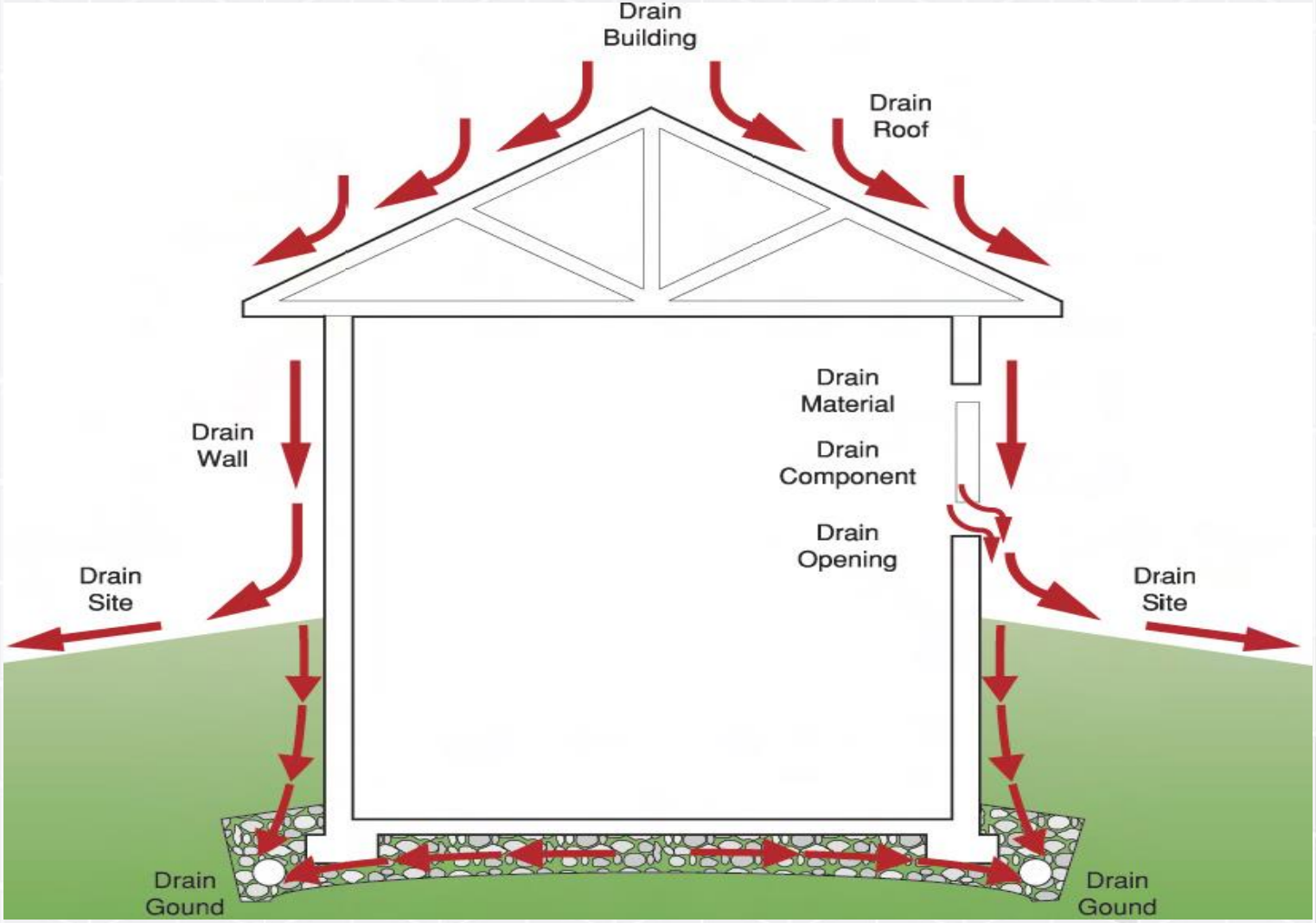
It’s that simple!

The major “damage functions”

- Liquid water (bulk and capillary)
- Air-borne water
- Vapor
- Radiation (UV degradation)
- Pests
- People

MOISTURE MANAGEMENT

Water: A Builder's Worst Enemy



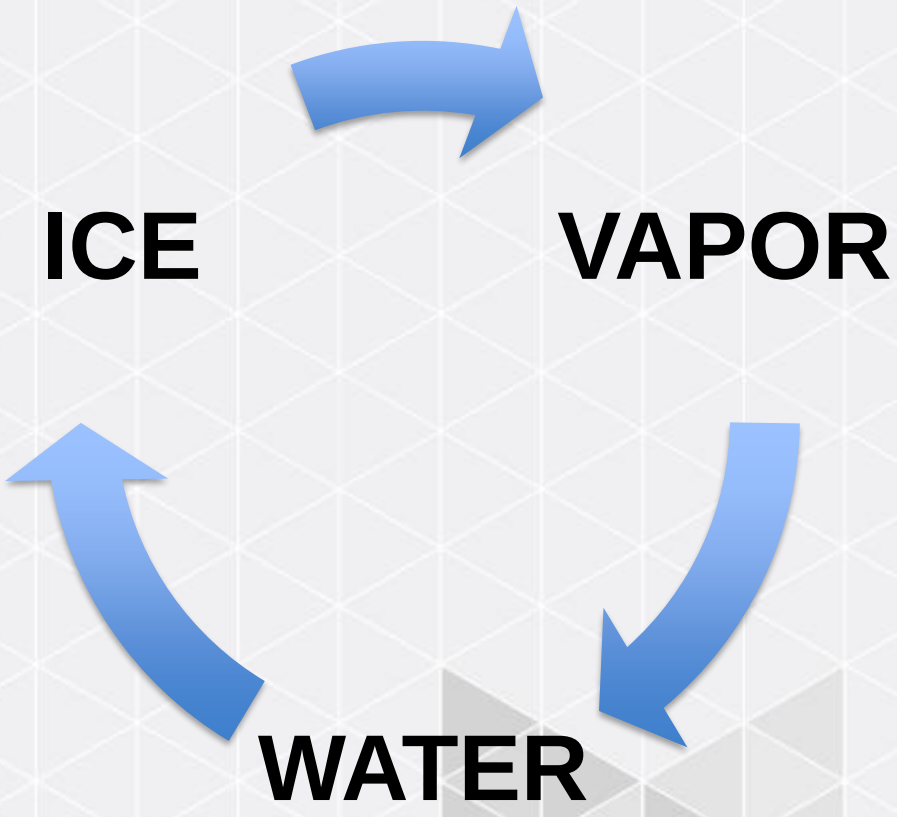
Prioritizing Moisture Movement

#1 – Bulk Water

#2 – Capillary Water

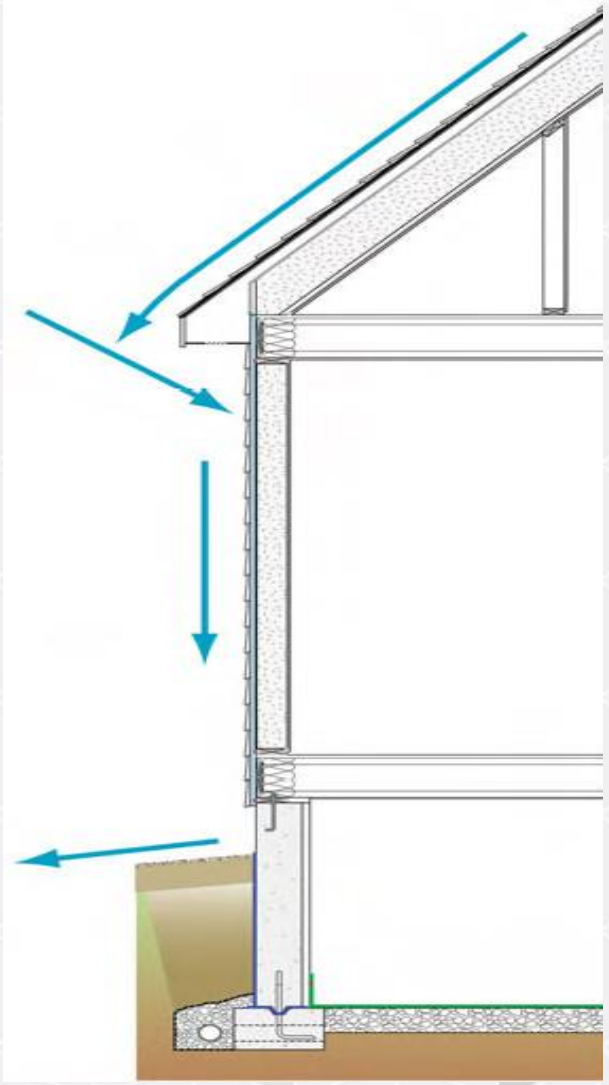
#3 – Air-transported Water

#4 – Diffusive Moisture Management



Managing Bulk Moisture – Priority #1

- Planning for proper drainage is the best way to effectively deal with bulk moisture/water
- Keep water out of and away from building



Bulk Water Management – Priority #1

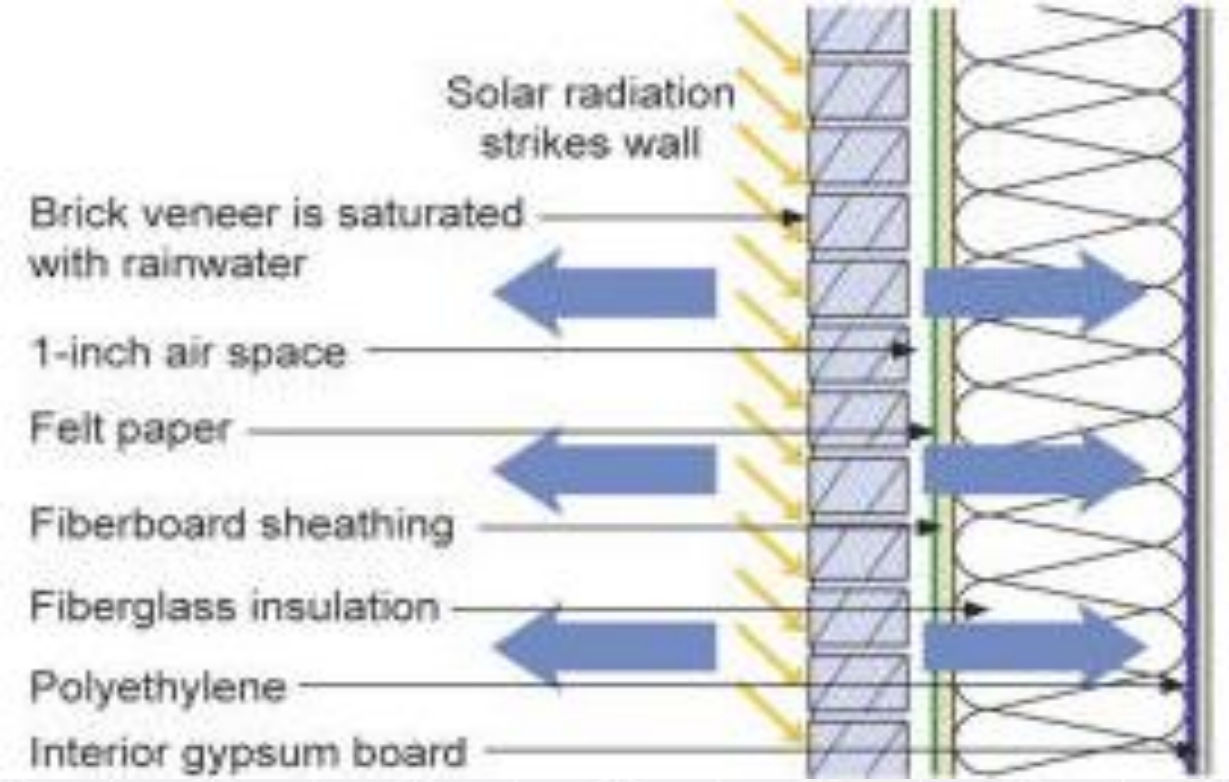
- Flow is not a straight line
  - Lateral cohesive movement
  - Wind-driven rain
- Can involve LOTS of water—from an outside or inside source

Always Allow for Drying

Exterior Conditions
Temperature: 80° F
Relative Humidity: 75%
Vapor Pressure: 2.49 kPa

Conditions Within Cavity
Temperature: 120° F
Relative Humidity: 100%
Vapor Pressure: 11.74 kPa

Interior Conditions
Temperature: 75° F
Relative Humidity: 60%
Vapor Pressure: 1.82 kPa



Vapor is driven both inward and outward by a high vapor pressure differential between the brick and interior and the brick and exterior

Properly Lap Flashing

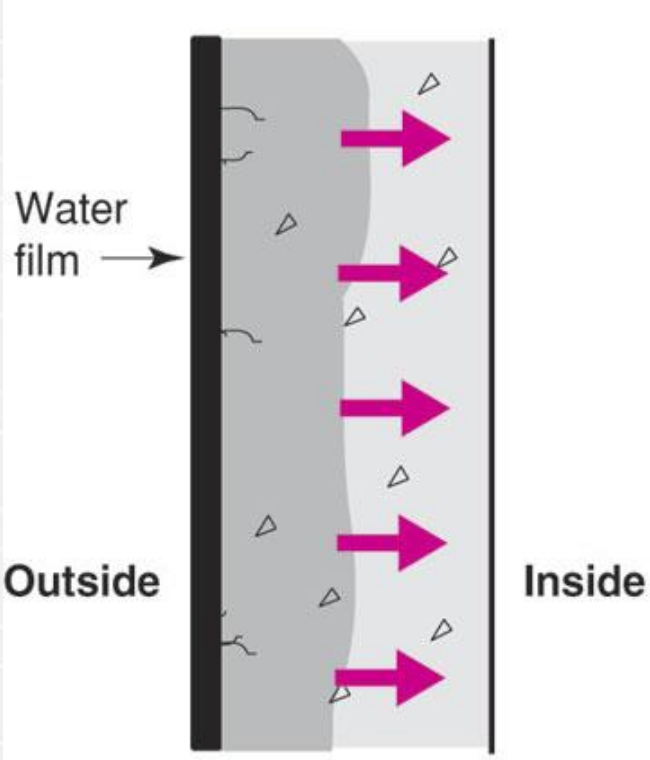
- The mason's flashing (black) was installed after and in front of the house wrap (green). This is reverse flashing that will trap any drain water that gets past the brick veneer.

Direct Water Away from Corners

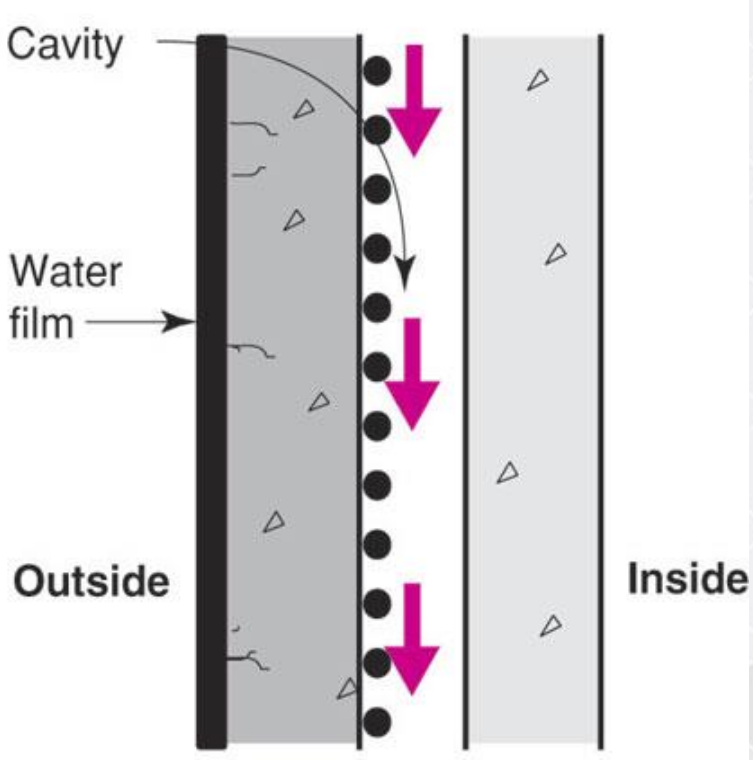
No Kick-Out Flashing

Effectively Sheds Water

Capillary Moisture Flows – Priority #2



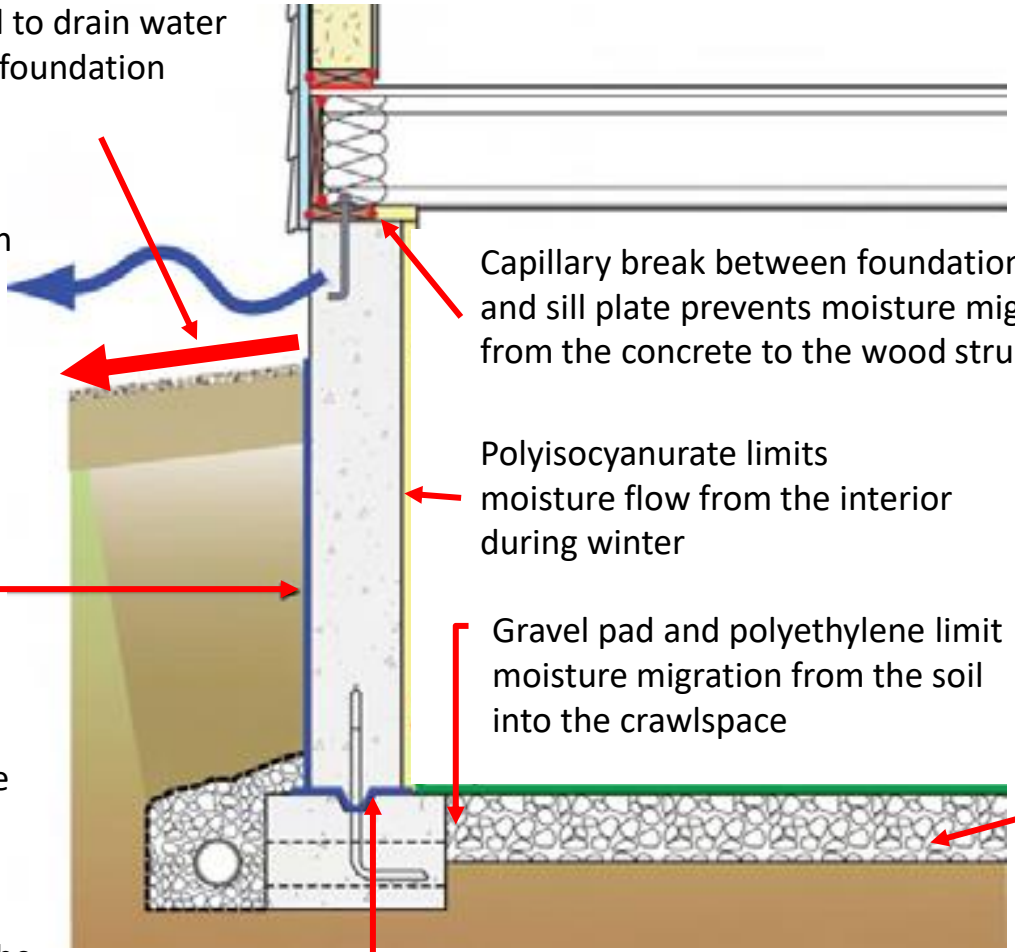
Capillary suction draws water into porous material and tiny cracks



Cavity acts as capillary break and receptor for capillary water interrupting flow

Image courtesy of Building Science Corp.

Foundation Moisture Management



Grade is sloped to drain water away from the foundation

Exposed portion of foundation wall able to dry to exterior

Capillary break between foundation wall and sill plate prevents moisture migration from the concrete to the wood structure

Polyisocyanurate limits moisture flow from the interior during winter

Damp-proofing limits moisture flow from soil

Gravel pad and polyethylene limit moisture migration from the soil into the crawlspace

Gravel pad is connected to the perimeter drain through pipes cast into the footing

Water against the foundation wall drains down the free draining backfill and out the perimeter drain at the footing

Capillary break between footing and foundation wall

Sill Plates Need Capillary Breaks

Air Transport of Moisture – Priority #3

- Air leakage
  - Moisture flow
    - 4X8 Drywall
    - 70 F
    - 40% RH
    - 1 square inch hole
- Flow quantity
  - 30 Quarts of water!!

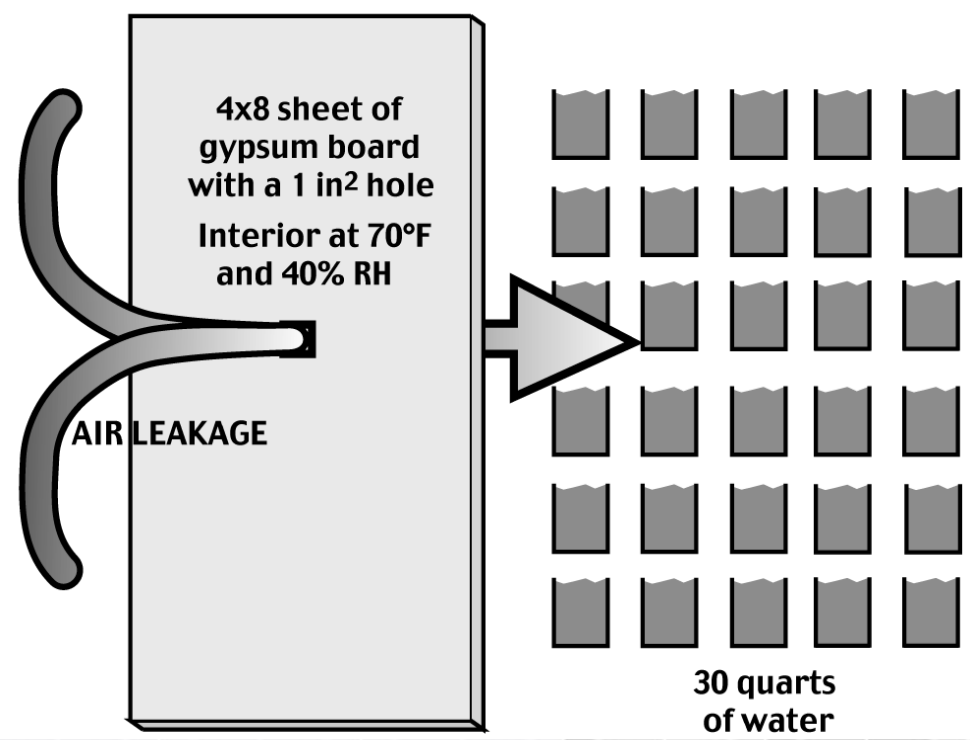


Image courtesy of Building Science Corp.

A Critical Tool in the Fight Against Moisture

- Blower door tests quantify a home's air tightness
- Proper building tightness will help:
  - Reduce energy consumption
  - Avoid moisture condensation
  - Avoid uncomfortable drafts caused by cold air leaking in
  - Help maximize proper HVAC performance

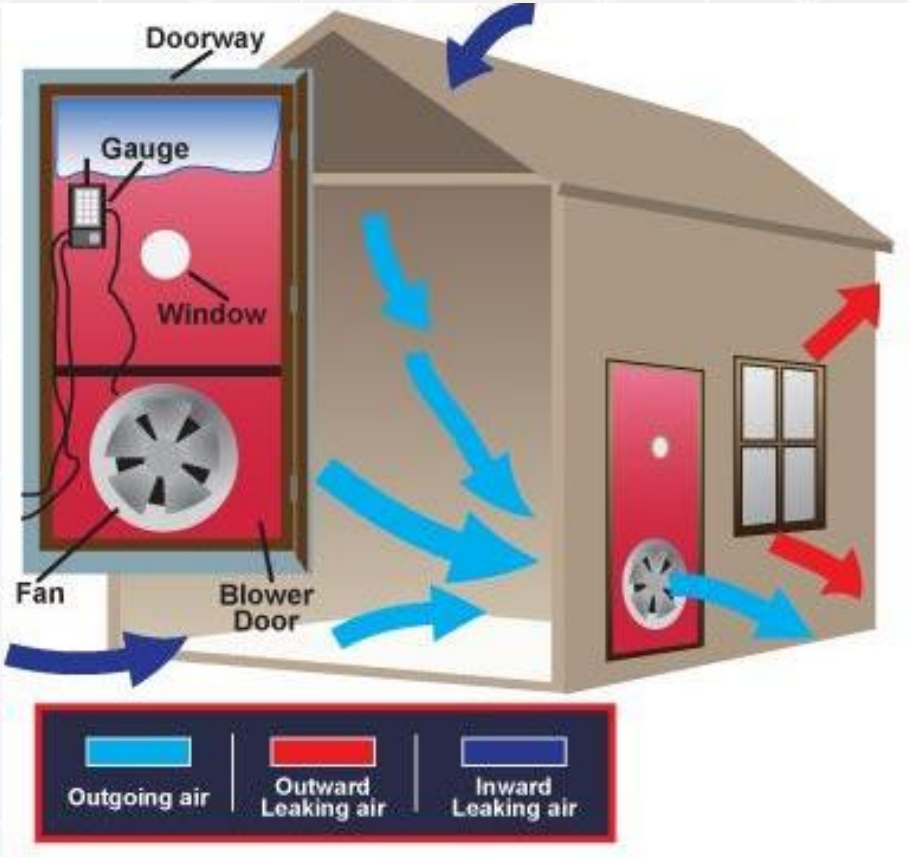
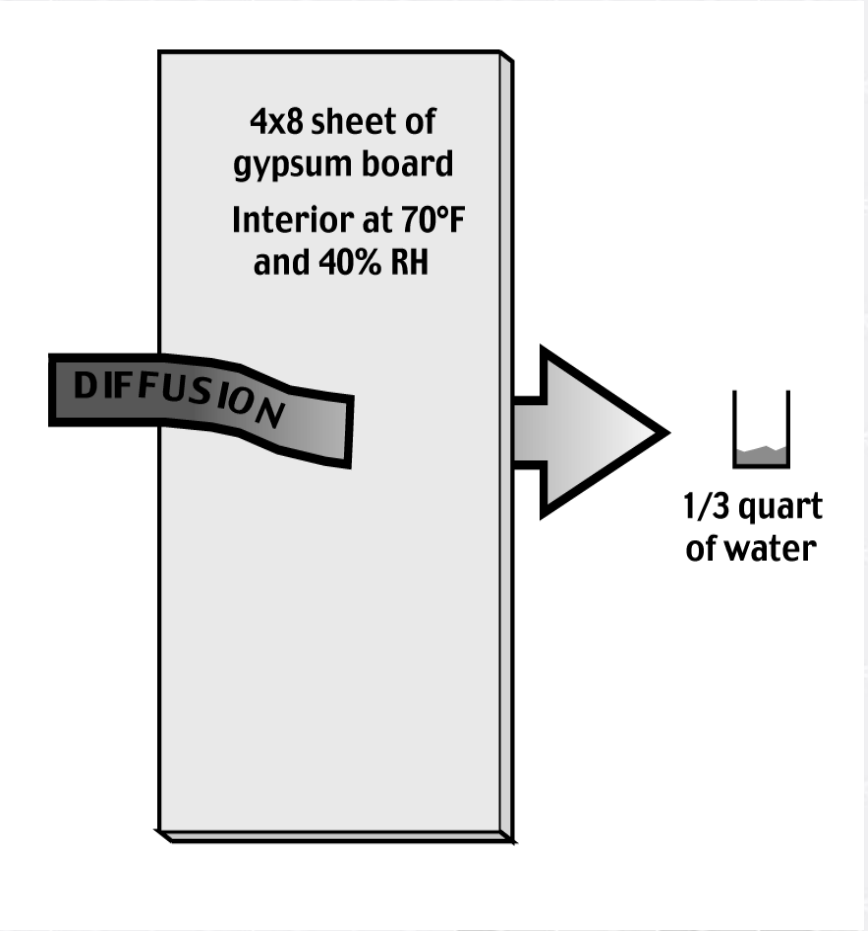


Image courtesy of Building Performance Institute

Diffusion – Priority #4

- Migration of moisture by means of vapor pressure differential
- Occurs in either direction based on climate conditions and exterior/interior levels of humidity
- Different materials have different permeability



Perm Rating - How Vapor Moves Through Building Materials

- Vapor permeability – how fast water vapor moves through a material
- Perm = grain/(hr • in Hg • ft^2)

Perm Rating	Permeability
<0.1	Impermeable
>0.1 but <1	Low permeability
1-5	Semi-permeable
>5	Vapor Permeable

Practical Application: Solar-Driven Moisture in Brick Veneer

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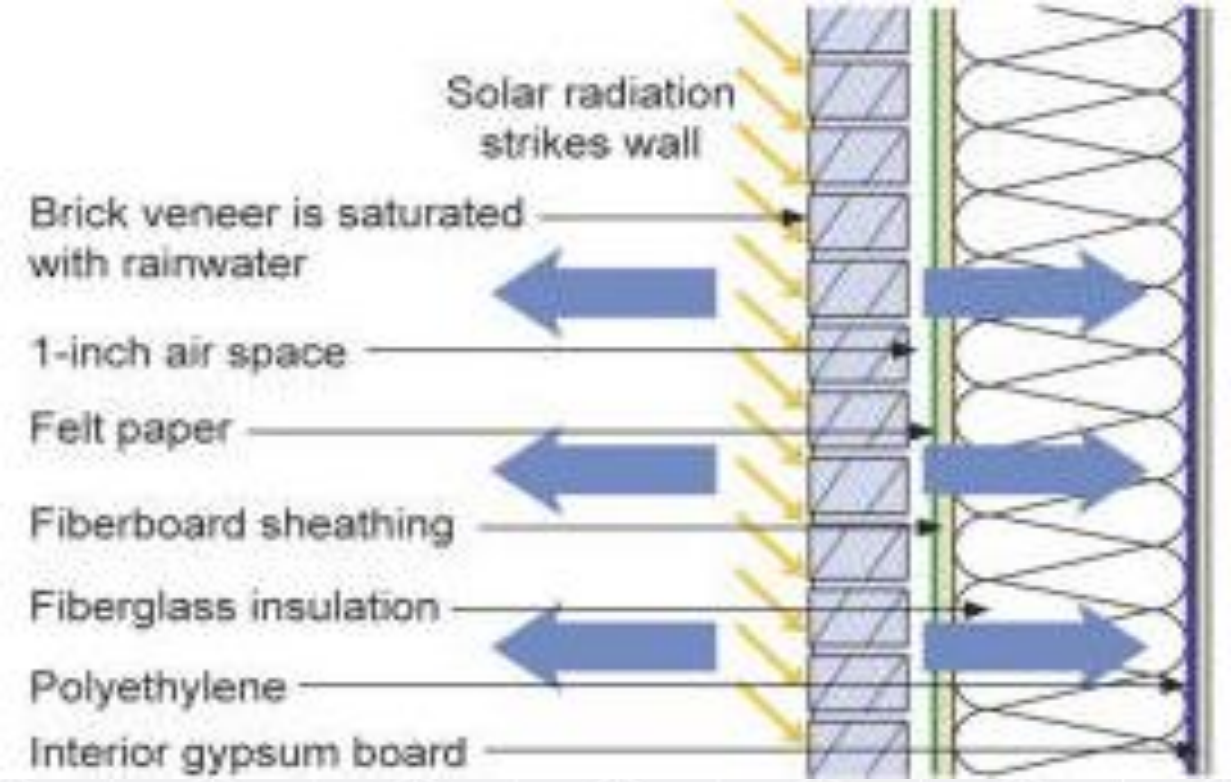

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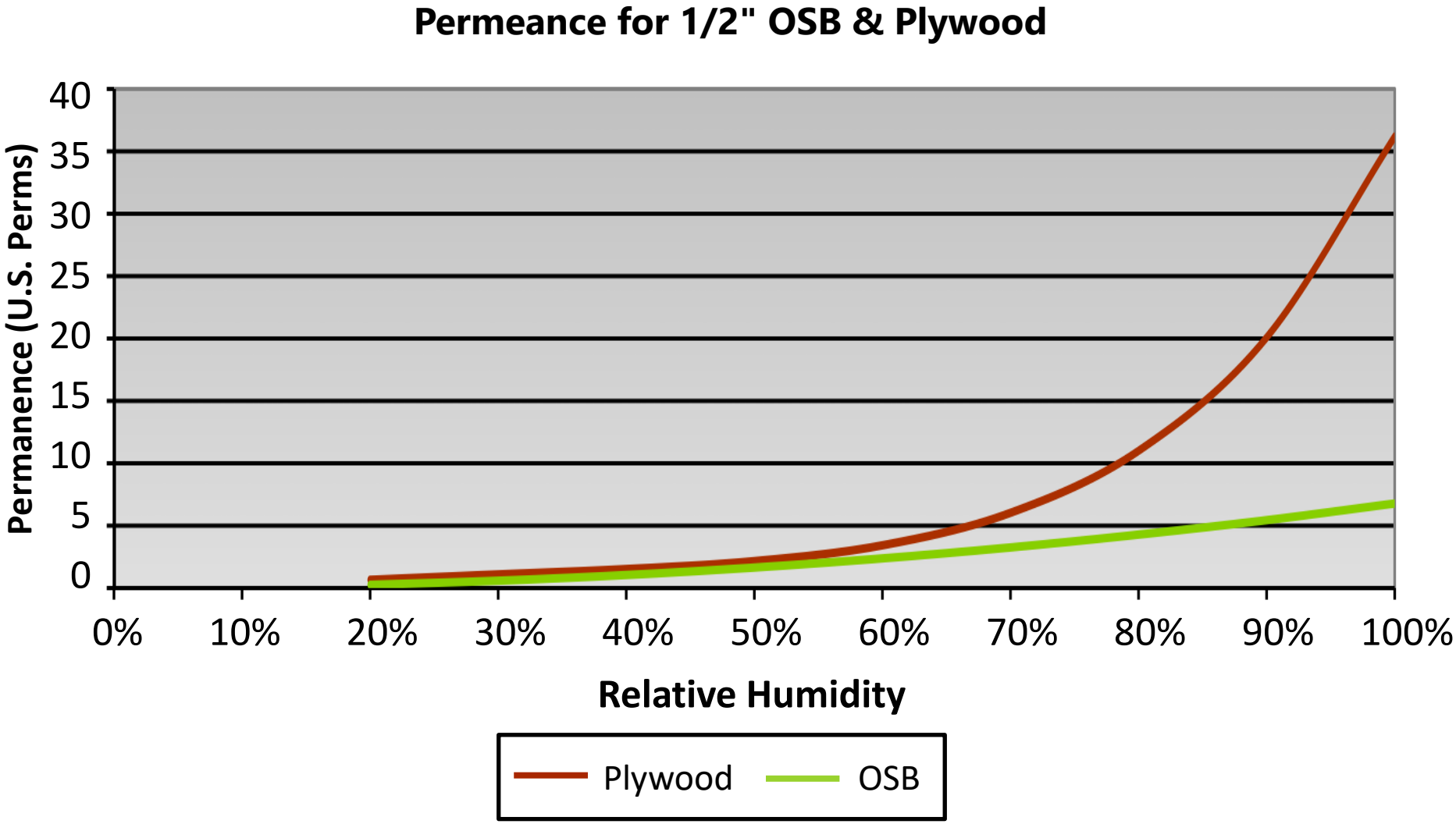
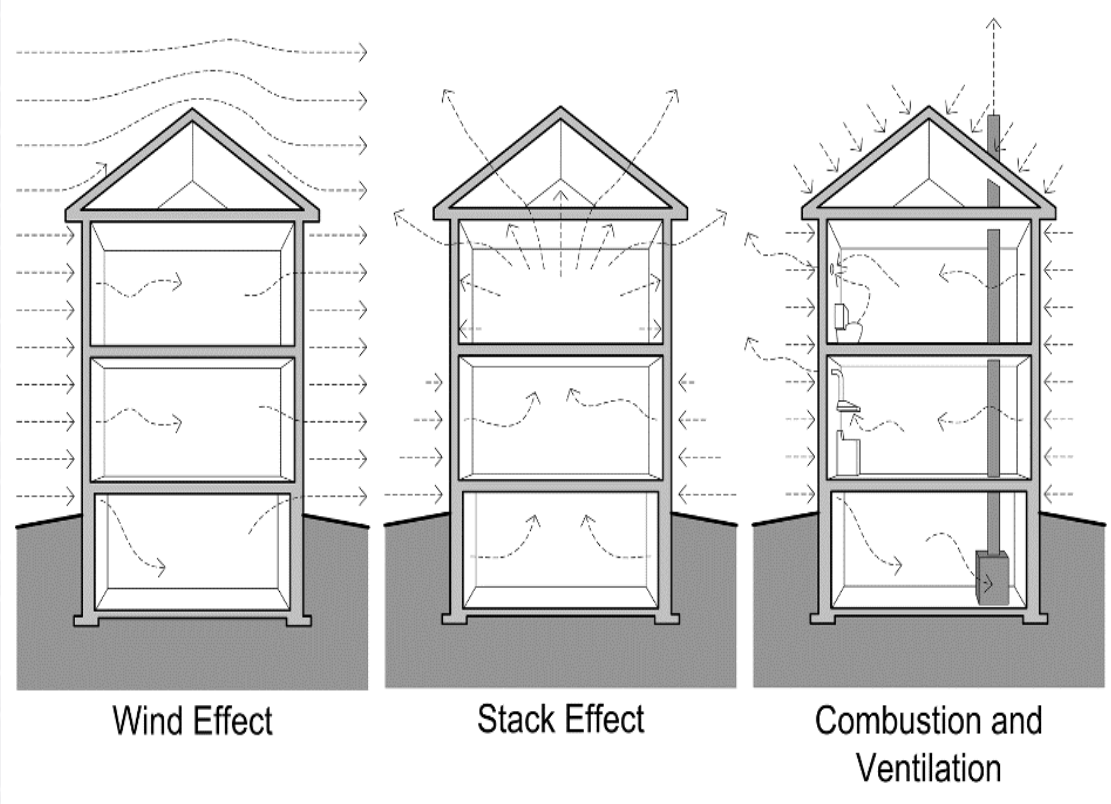
Permeability Can Change!
OSB vs Plywood



AIR MOVEMENT

How Does Air Get Around?

- Pressure differential eventually evens out
- Air in = Air Out
- For air to move, you need:
  - A hole
  - A driving force
  - Another hole



Internally Generated Air Pressure

Expansion of Conditioned Space

- 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

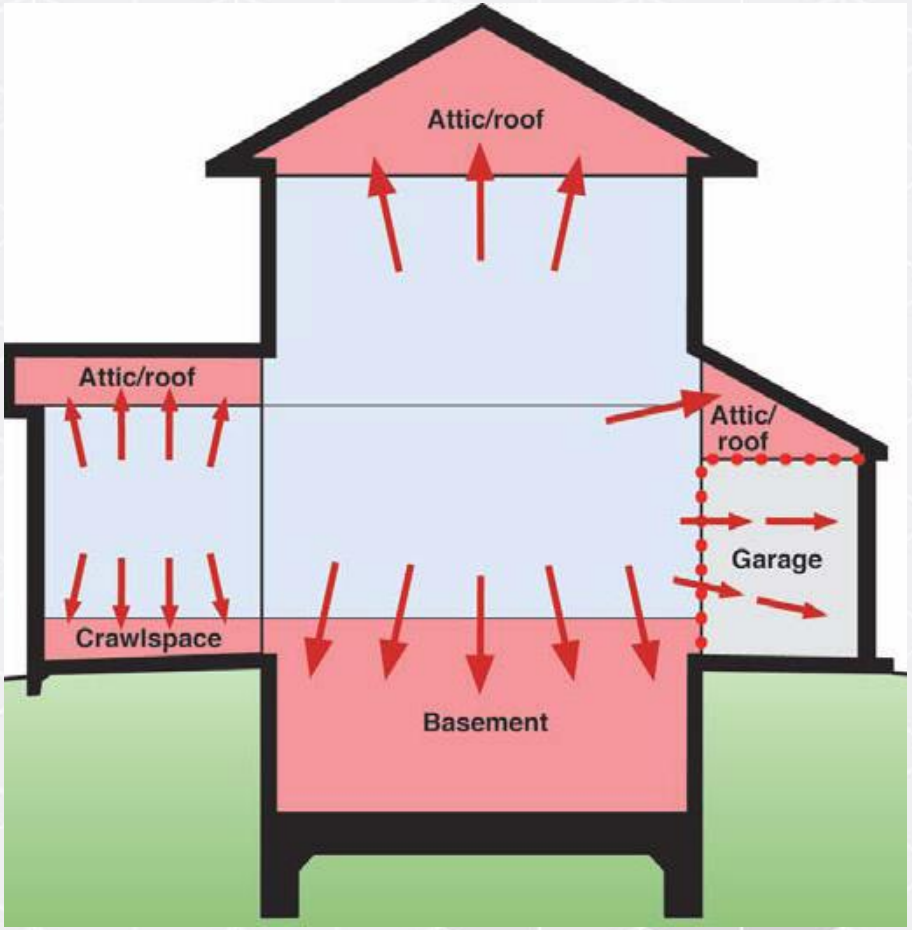
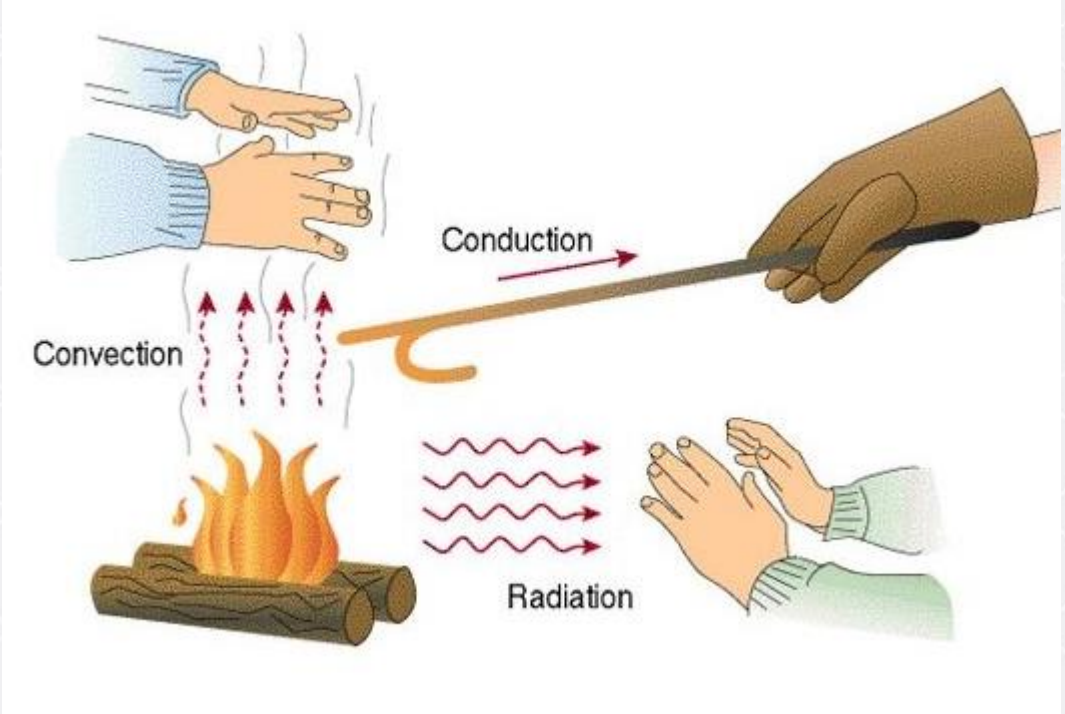


Image courtesy of Betzwood Associates

HEAT TRANSFER

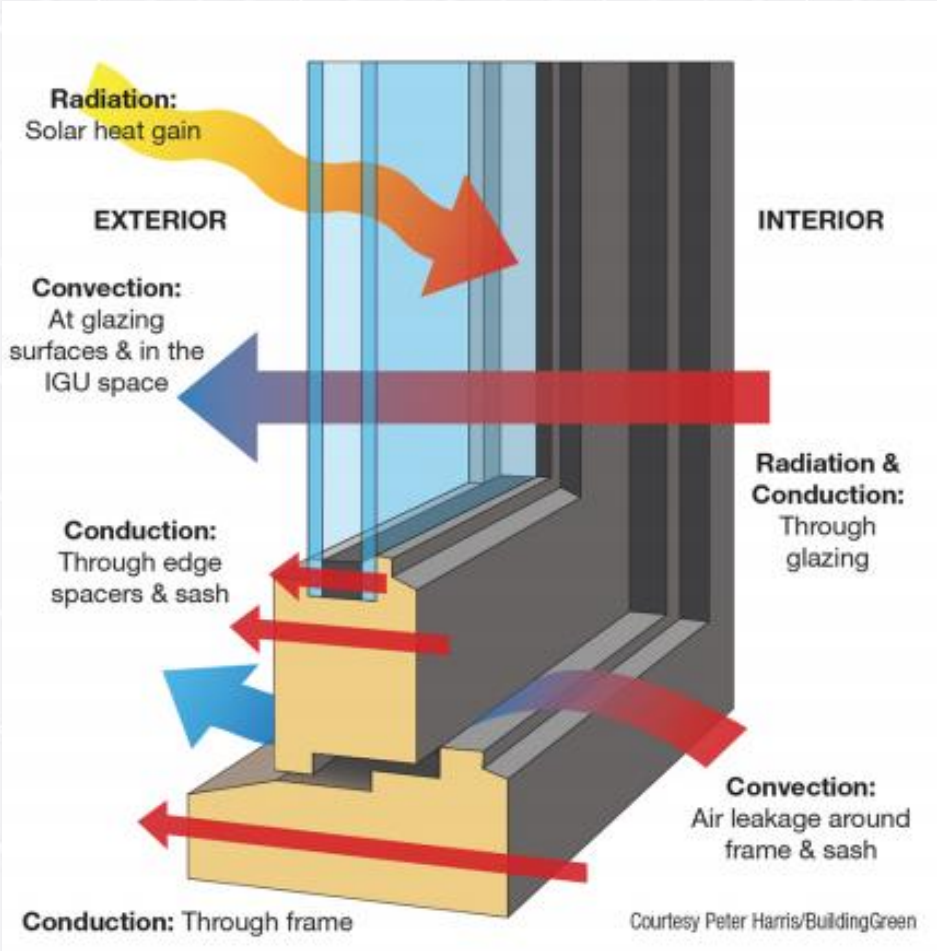
Heat Transfers in 3 Ways

- ***Radiation*** - Mostly windows
- ***Conduction*** - Through solids
- ***Convection*** - Through fluids (liquid or gas)



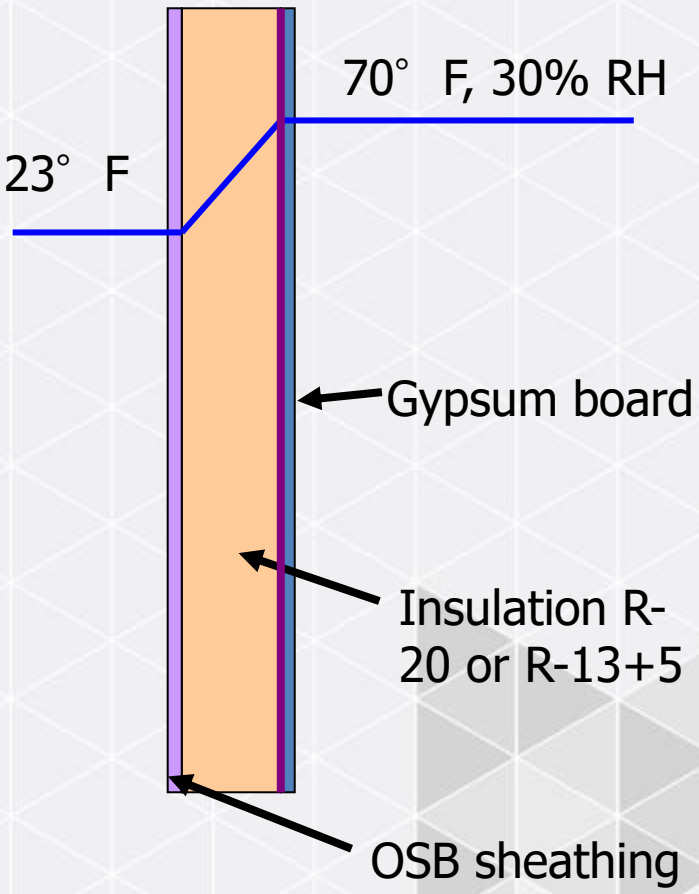
Practical Application – Windows and Heat Transfer

- Heat always moves from hot to cold
- Heat transfer always occurs in a combination of ways
- Different rates of transfer can be important
- So how does low-e work?



Condensing Surface Temperatures

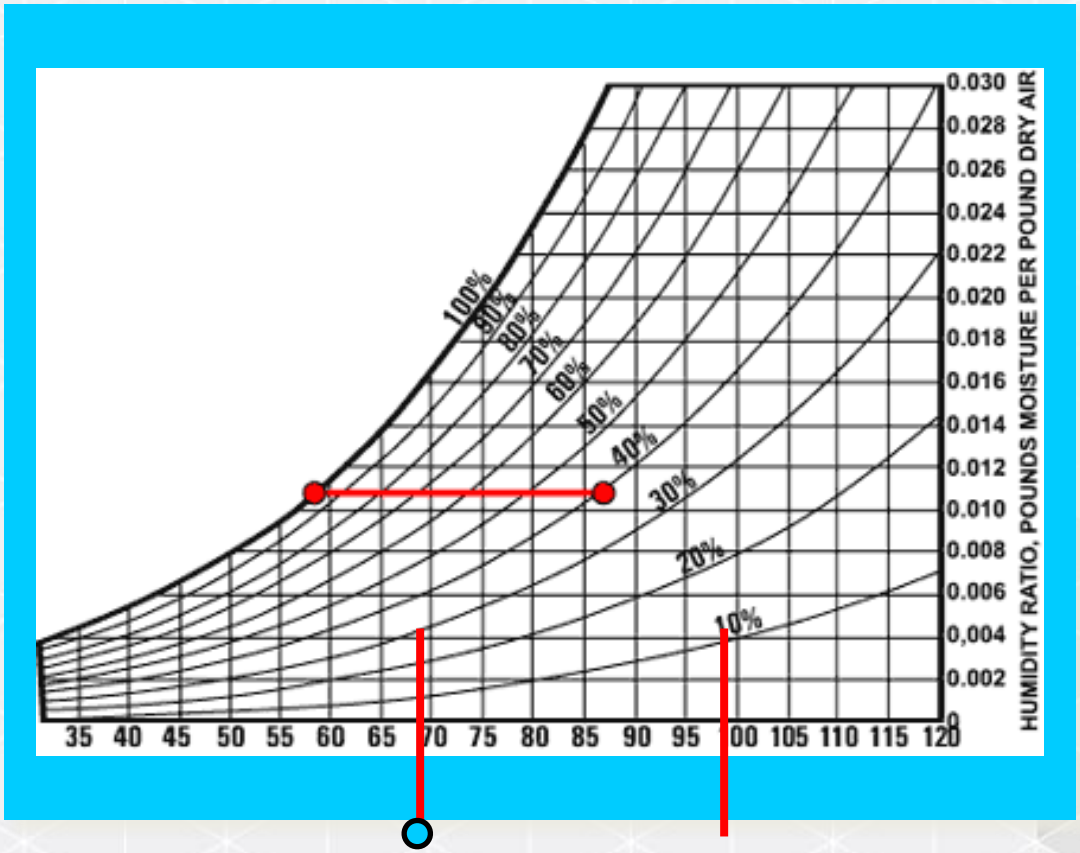
- Dewpoint of interior air = 37°F
- Where will condensation occur?
  - *Inside surface of exterior sheathing*
- Possible solutions?



Condensation is REAL!

Psychometric Chart

- If we know the air temperature and relative humidity, we know the dewpoint



QUALITY MANAGEMENT

The Major Building Envelope Protection Systems

- Water Barrier
- Air Barrier
- Thermal Barrier
- Vapor Profile (not just the designated vapor retarder)
- Finishes (UV protection)
- Commissioning & Maintenance documents

Qualities of the Major Protection Systems

- Systematic
- Comprehensive
- Continuous
- Best Practices
- Each system should be addressed by at least one, preferably two, ideally three of the following:
  - Design; Materials; Workmanship

Quality Management

“You don’t get what you expect, you get what you inspect!”

Quality Management

- Moisture Control testing prior to cover up

PERFORMANCE TESTING

Performance Testing – Data is Key

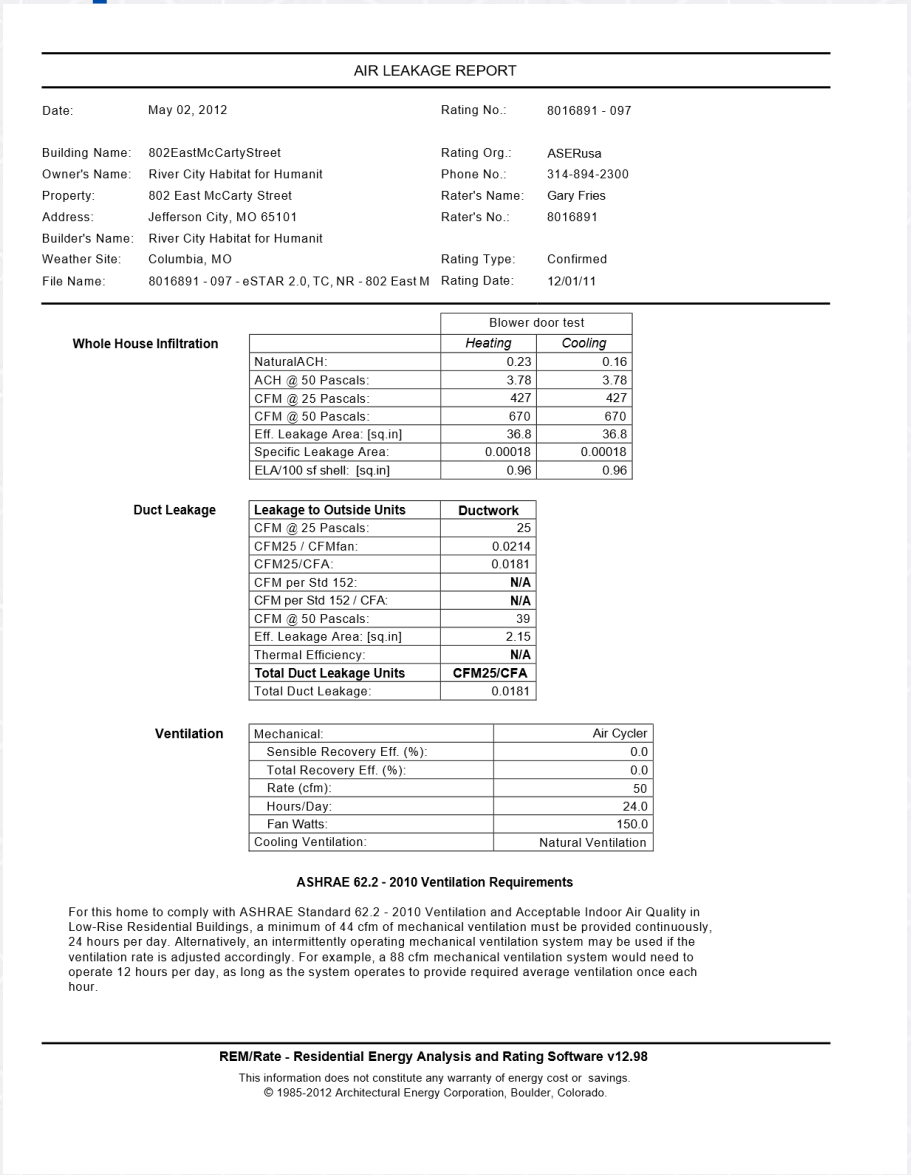
- Testing/verification important step in quality management
- Essential for
  - Building performance
  - Moisture management
  - Energy efficiency
  - Health and comfort of occupants

HVentilateAC: Minimum Ventilation Guideline

- Blower door test result is in CFM.
- Converting to ACH creates a baseline for a building's MVG:
  - ≥ the MVG, then no additional ventilation is needed.
  - ≤ the MVG, then mechanical ventilation is required.
- Achieving the MVG should be planned for in advance.

Air Leakage Test Report

- Documents home's performance
- **Required by code** and above code programs
- Third-party verification (some areas; performed by Inspectors)
- Provides data for final equipment adjustment and energy use/cost forecast
- Great liability protection for builder/designer



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

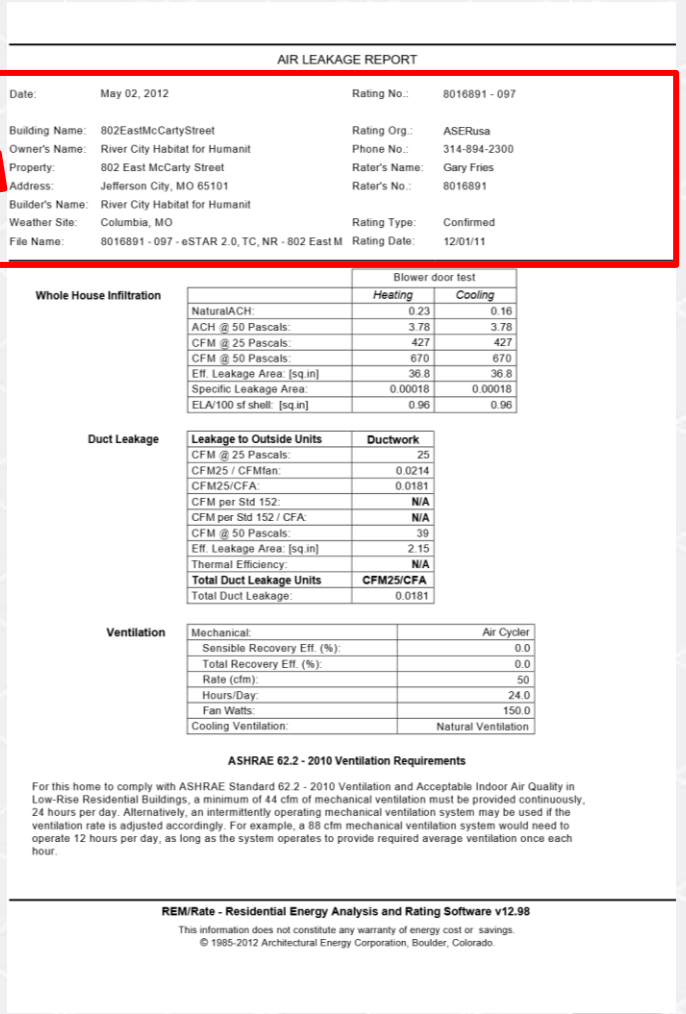
For this home to comply with ASHRAE Standard 62.2 - 2010 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, a minimum of 44 cfm of mechanical ventilation must be provided continuously, 24 hours per day. Alternatively, an intermittently operating mechanical ventilation system 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.

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



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ACH @ 50 Pascals:	3.78	3.78
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CFM @ 50 Pascals:	670	670
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ELA/100 sf shell: [sq.in]	0.96	0.96

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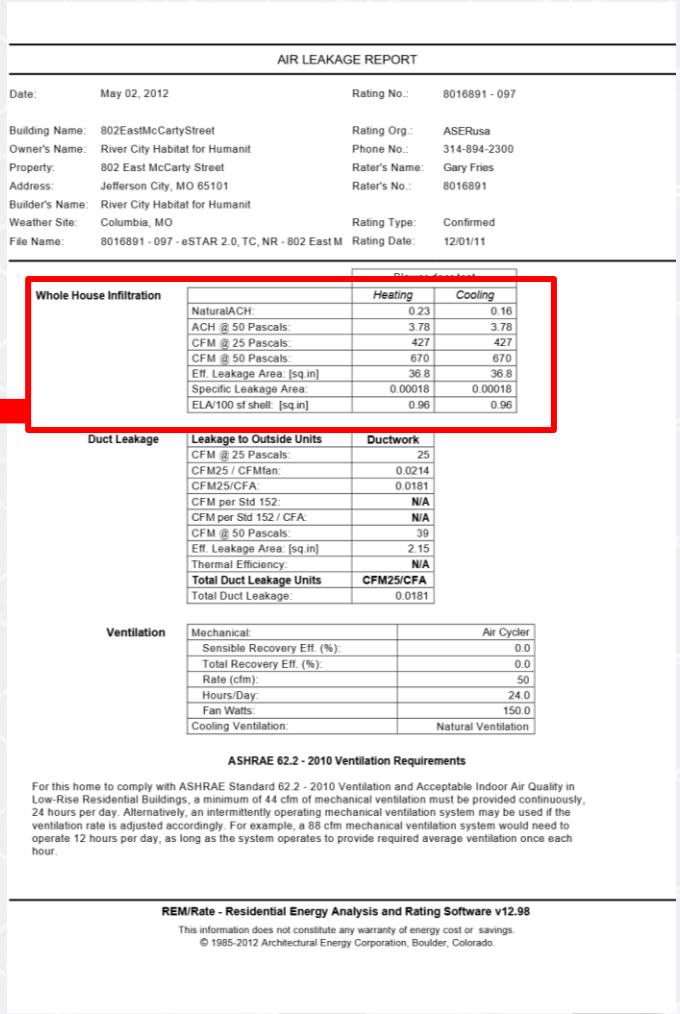

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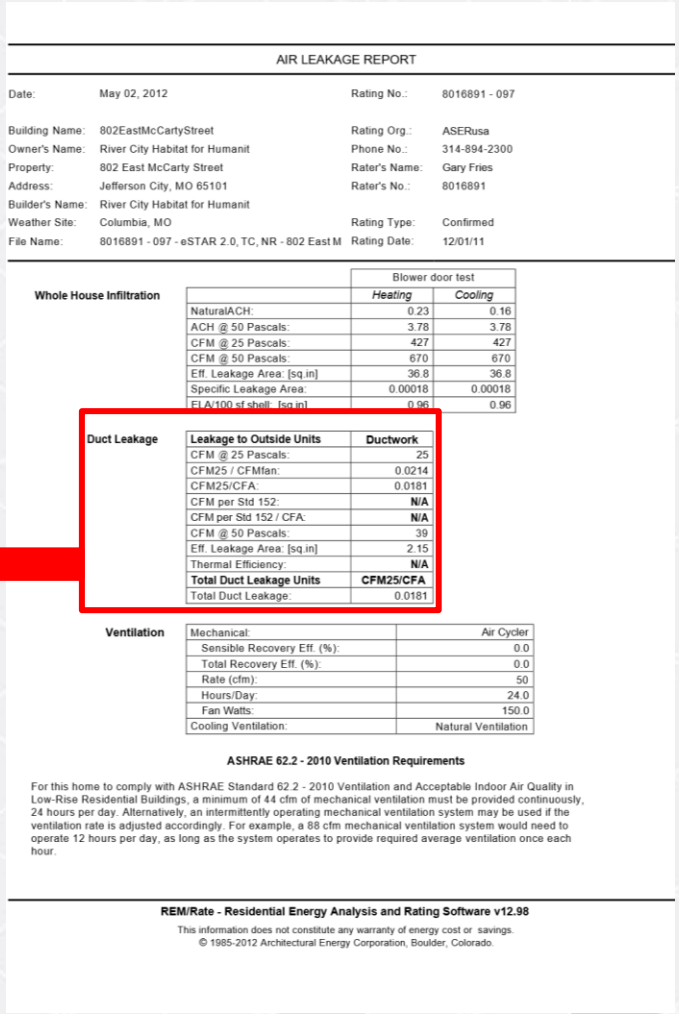

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Owner's Name:	River City Habitat for Humanit	Phone No.:	314-894-2300
Property:	802 East McCarty Street	Rater's Name:	Gary Fries
Address:	Jefferson City, MO 65101	Rater's No.:	8016891
Builder's Name:	River City Habitat for Humanit		
Weather Site:	Columbia, 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

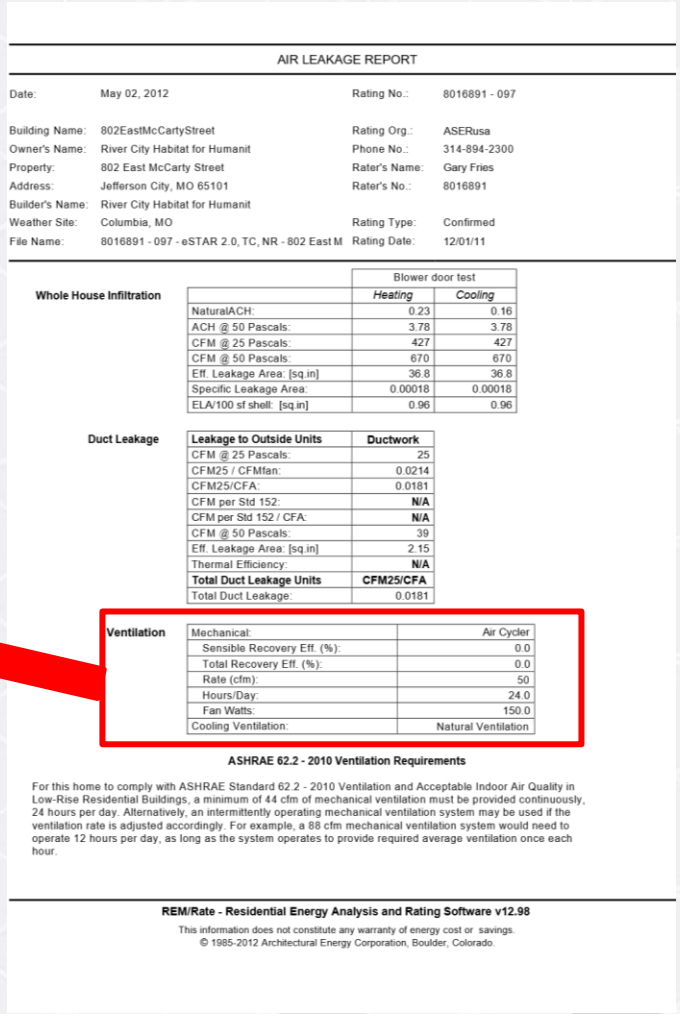
For this home to comply with ASHRAE Standard 62.2 - 2010 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, a minimum of 44 cfm of mechanical ventilation must be provided continuously, 24 hours per day. Alternatively, an intermittently operating mechanical ventilation system 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

Air Leakage Report

Ventilation

Mechanical:	Air Cycler
Sensible Recovery Eff (%):	0.0
Total Recovery Eff (%):	0.0
Rate (cfm):	50
Hours/Day:	24
Fan Watts:	150.0
Cooling Ventilation:	Natural Ventilation



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

HVentilationAC: Minimum Ventilation

- Blower door test result must be ≤ 3ACH50 to be compliant
  - Air Changes per Hour @50 Pascals. ~20 MPH wind.
- Mechanical ventilation must be installed per 2018 M303.4

Key Takeaways

- Building Performance includes:
  - Building Envelope
  - Mechanical Systems
  - Lighting Systems
  - Occupant Health and Comfort

- Controlling moisture is *critical*
  - Proper air sealing is key
  - Mechanical ventilation must be installed and takes on new importance
  - Performance testing is essential for quality building performance

Questions?

- Submit a question in the chat or unmute yourself to ask a question

Review Questions – Session 2

- What are the two Advanced Physics Principles applied to Building Science?

a. Rich always goes to Poor. Smooth always goes to Fuzzy
b. Wet always goes to Dry. Hot always goes to Cold
c. Dry always goes to Wet. Cold always goes to Hot.
d. Hard always goes to Soft. Small always goes to Large

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- What are the building science principles that are critical to building energy efficient and sustainable structures?

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b. Component Transfer, Air Transfer, Moisture Transfer
c. Heat Transfer, Property Transfer, Cold Transfer
d. Cold Transfer, Wet Transfer, Cash Transfer

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Review Questions – Session 2

- What are three types of heat transfer that occur in buildings?

a. Radiation, Component, Conviction
b. Radiation, Carpet, Convection
c. Radiation, Conduction, Convection
d. Radiation, Hydrogen, Conventional

Review Questions – Session 2

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a. Wet, Dry
b. Rain, Sun
c. Bulk, Vapor
d. Vapor, Retail

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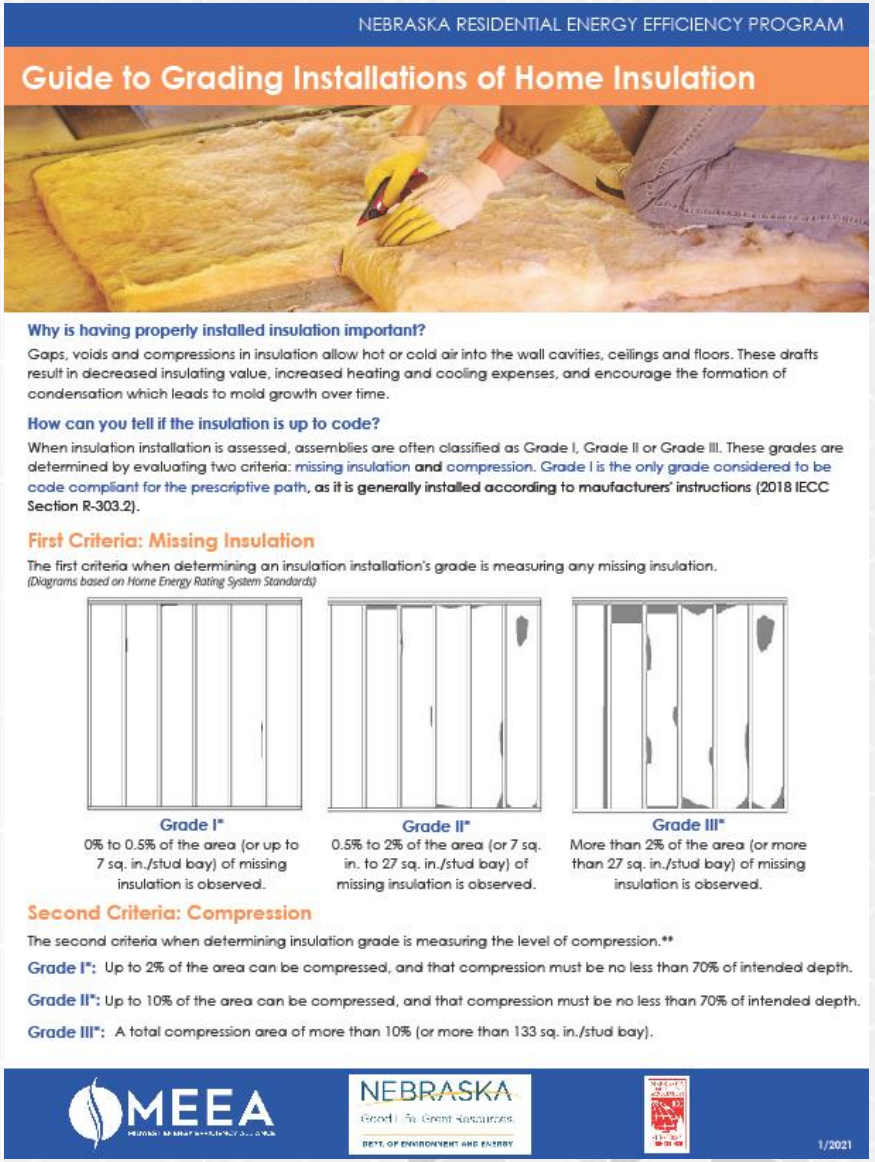
Resources

- Handouts on specific topics
  - Insulation installation
  - HVAC Right Sizing
  - Others coming soon
- Made to share with Trades/Subs, etc.
- Visit: https://www.mwalliance.org/metropolitan-community-college-energy-code-course



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).

MEEA NEBRASKA 1/2021

Continuing Education Credits

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

- Course ID: **27056**
- CEUs: **0.20**

- If you would like a certificate of completion for this session, email Nicole at nwestfall@mwalliance.org

Next Week

- February 9, 2021, 6:30-8:30pm
- Topic: Basic Building Science: Part 2
- Contact Matt with Questions: matt@verda-solutions.com

SEE YOU NEXT WEEK!