The HERS Associate and Taking the Performance Path

Module 1 – Fundamentals of Building Science

VIRTUAL HIGH PERFORMANCE HOME SUMMIT 2020

EEBA SEPT 29 - OCT 9 | ONLINE VIA WHOVA

Presented by:
Mike Barcik
Southface

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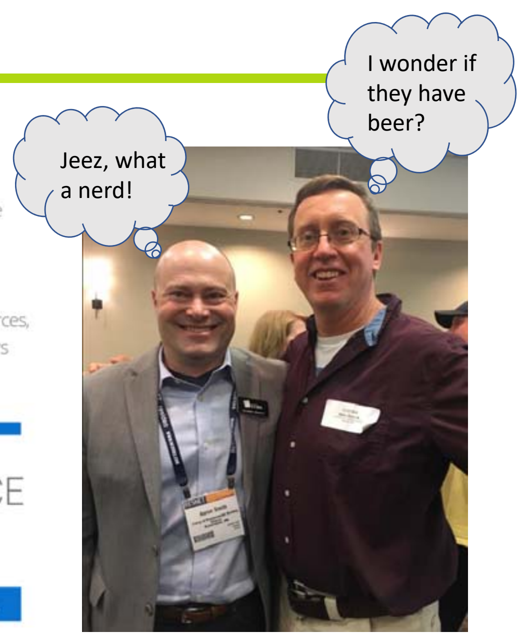

Introductions

Mike Barcik – Technical Principal

- mikeb@southface.org

About Southface

- *Building a Regenerative Economy, Responsible Resource Use & Social Equity Through a Healthy Built Environment for All*

www.southface.org

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Module Learning Objectives – Building Science Fundamentals

- Understand the concept of houses are systems
- Master Heat flow
- Appreciate Air movement
- Comprehend Moisture transport
- Learn from real world application

EEBA

The house as a system

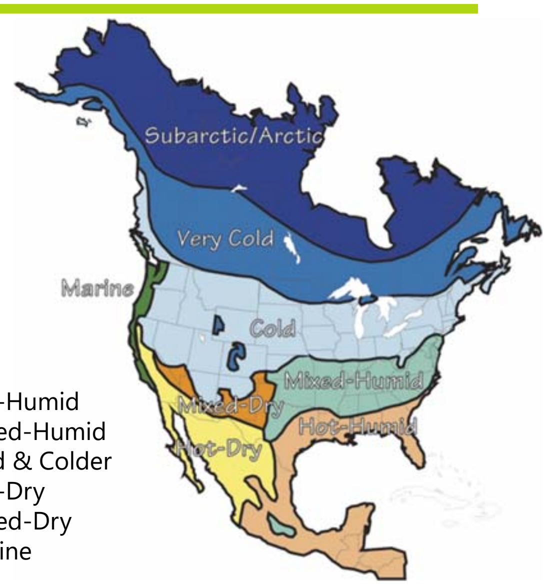
A house is a system made up of interrelated parts:

- The building thermal envelope
- The weather barrier
- Space conditioning
- Ventilation
- Lighting & appliances & plumbing
- The site and neighboring homes

- All efficiency measures should take occupants into account (e.g., air sealing & ventilation)

Building Science:

- Employ scientific principles from a variety of fields that govern building performance
- Optimize building performance and understand, predict, prevent and correct building failures
- Systems approach to houses
- Physics of:
  - **Heat:** Flows from hot to cold
  - **Air:** Flows from high pressure to low
  - **Moisture:** Flows from wet to dry (liquid and vapor)



A. Hot-Humid
B. Mixed-Humid
C. Cold & Colder
D. Hot-Dry
E. Mixed-Dry
F. Marine

Occupants – Question 1

In your opinion, how much impact do the occupants have on building performance?

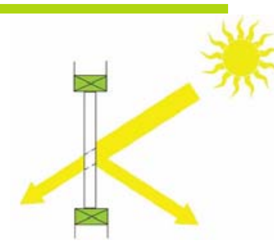
- A. < 10%
- B. Between 10 & 15%
- C. I don't know but I think it's a lot

Building Science: Heat transfer

- Heat is a form of energy
- Heat moves from hot to cold
- 3 methods of heat transfer:
  - **Radiation:**
    Heat emits from a hot surface or hot object, e.g. hot coals
  - **Conduction:**
    Heat moves through a material by contact, e.g. the grill grates
  - **Convection:**
    Heat energy carried by a fluid, e.g. the air inside the covered grill

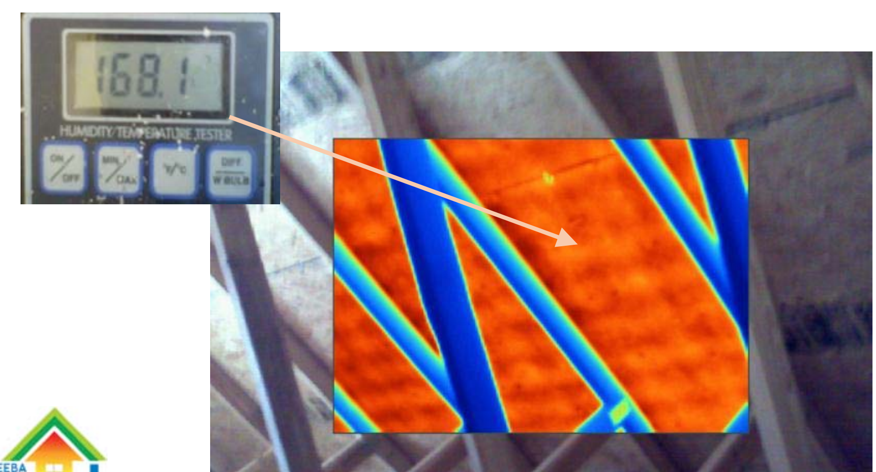
Heat transfer: Radiation

- **Radiation** is the movement of heat from a hot surface to a cooler surface with nothing solid or opaque in between



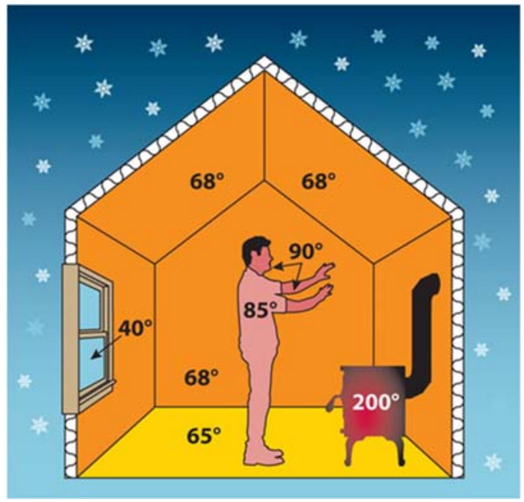
Heat transfer: Radiation

- Low-emitting surfaces slow radiation



Mean radiant temperature

- When the surfaces in the home (walls, floors, ceilings, windows, and doors), are different than the room air temperature, additional body heat can be lost or gained through radiation.
- This can have a major impact on comfort



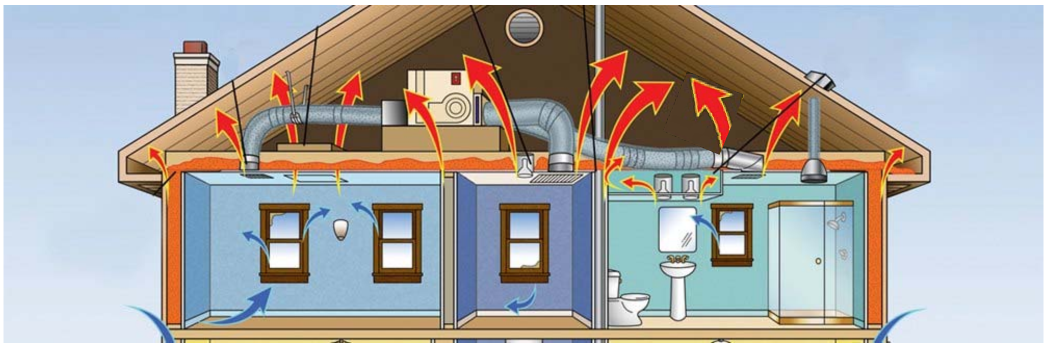
$(T_H{}^{\wedge}4 - T_L{}^{\wedge}4)$ = (660^4 – 550^4) = (190Billion – 91Billion) = 100Billion

Heat transfer: Conduction

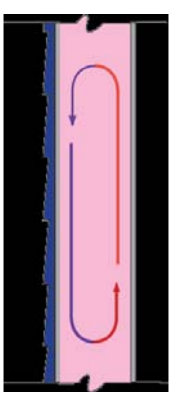
- **Conduction** is heat flowing through a solid material (insulation slows conduction)

Heat transfer: Convection

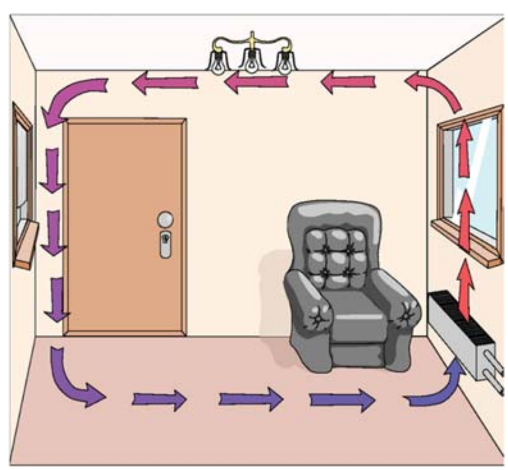
Convection is the transfer of heat caused by the movement of a fluid, like water or air (air barriers slow convection)



Convective Loop



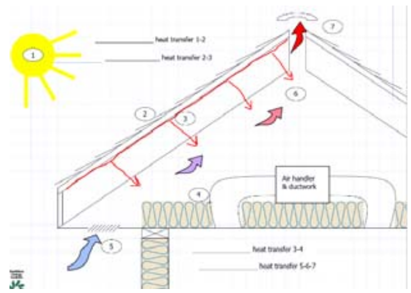
- Air movement due to temper-ature and pressure gradients
- Air rises along warm surface and falls along cold surface
- Creates circular movement of air within enclosed space
  (wall cavity, band between floors, even a room within living space!)
- Increases heat flow and can reduce insulation effectiveness



Question 2

On the following slide, a section of an attic on a hot afternoon is featured. Describe the dominant type of heat transfer for each segment described. Answer choices:

- Conduction (solid)
- Convection (air)
- Radiation (surfaces)



Knowledge Check

Heat Transfer Problem – Question 2

<u>Your Choices:</u>

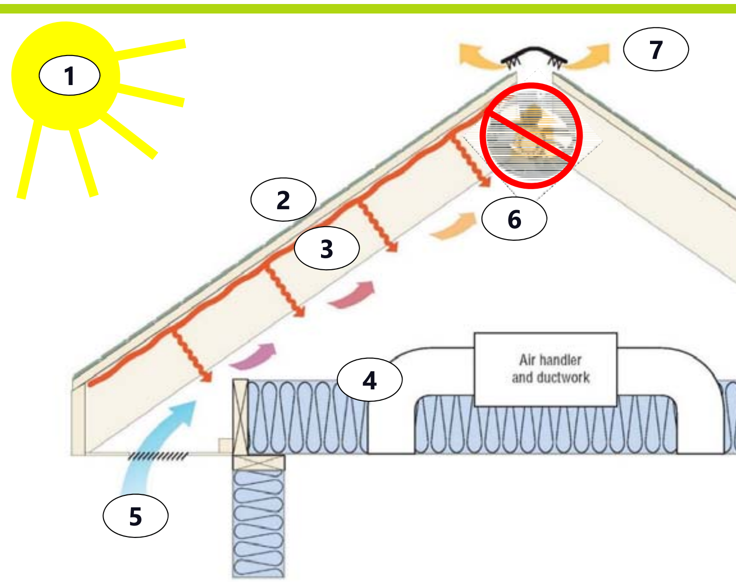
Radiation
Conduction
Convection

1 → 2 = Radiation

2 → 3 = Conduction

3 → 4 = Radiation

5 → 6 → 7 = Convection



Spray foam rooflines

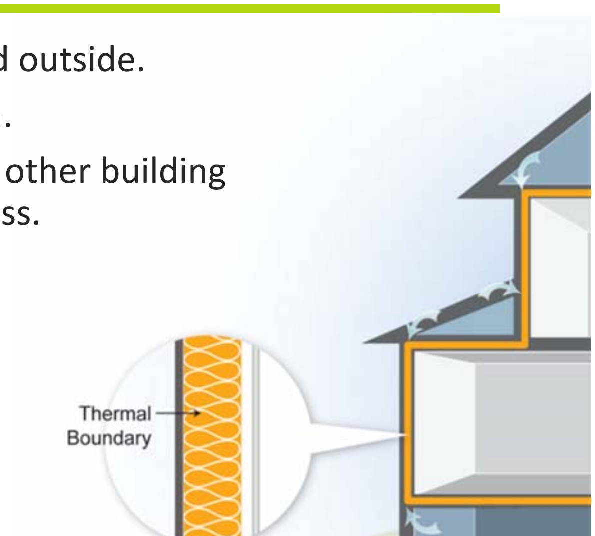
There are multiple ways of defining the building thermal envelope.

What's the advantage when a home's envelope is defined by the roof, not the flat ceiling?

Thermal Boundary

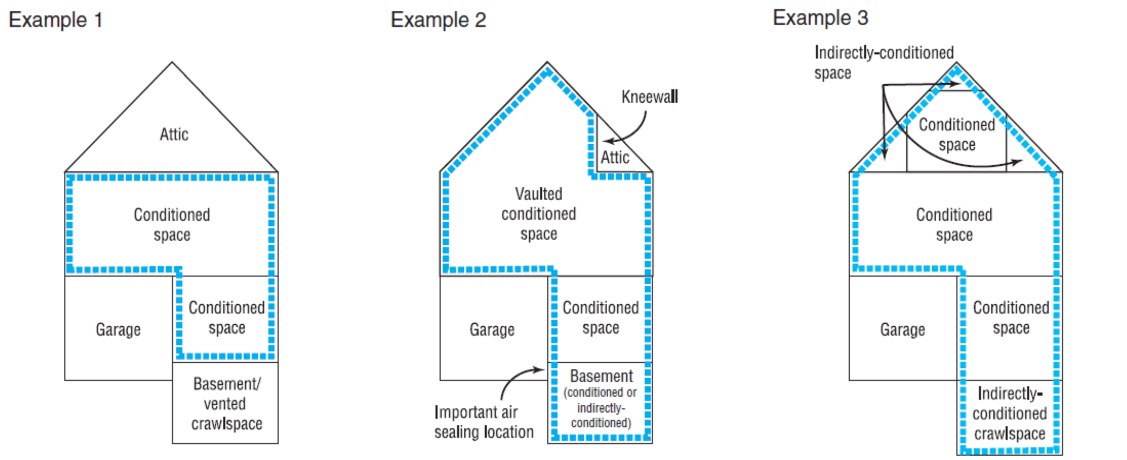
- Limits heat transfer between inside and outside.
- Identified by the presence of insulation.
- The location of insulation in relation to other building components is critical to its effectiveness.

- Even small areas of missing insulation are very important.
- Voids of 7% can reduce effective R-value by half.



Graphic developed for the US DOE WAP Standardized Curricula

Building Thermal Envelope



- Although these three homes look identical from the outside, each has defined the building thermal envelope differently

Heat Flow Calculations

Conduction Heat Flow Calculations

- Heat transfer through a solid object: the formula for calculating transmission heat loss is:

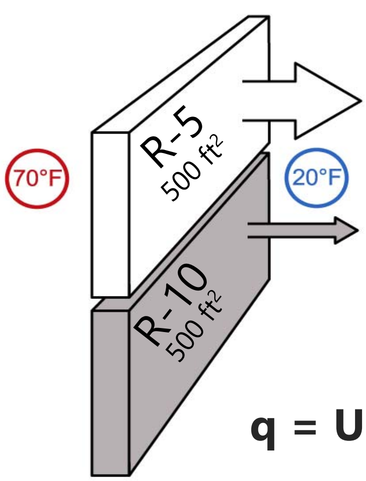
$$\boxed{q = U \times A \times \Delta T}$$

- q = heat flow (Btu/hr)
- U = inverse of R-Value [U=1/R, R=1/U] (Btu/hr ft^2°F)

  U is referred to as the *Conductance* or *Thermal Transmittance*
- A = area (square feet)
- ΔT = temperature difference across component (°F)

Btu = British Thermal Unit

Conduction Example



$$q = U \times A \times \Delta T$$

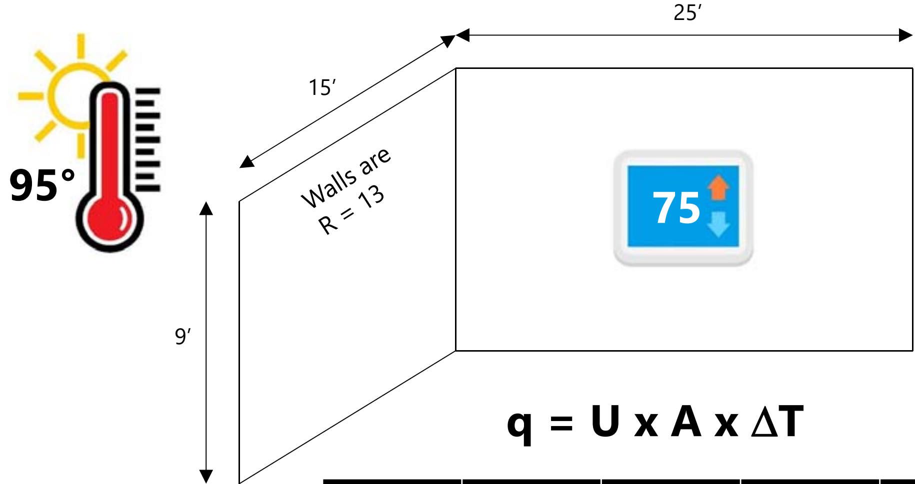
- Low R-value (R-5)
- (1/5) x 500 x (70-20) = 5,000 Btu/hr

High R-value (R-10)

(1/10) x 500 x (70-20) = 2,500 Btu/hr

Total = 7,500 Btu/hr

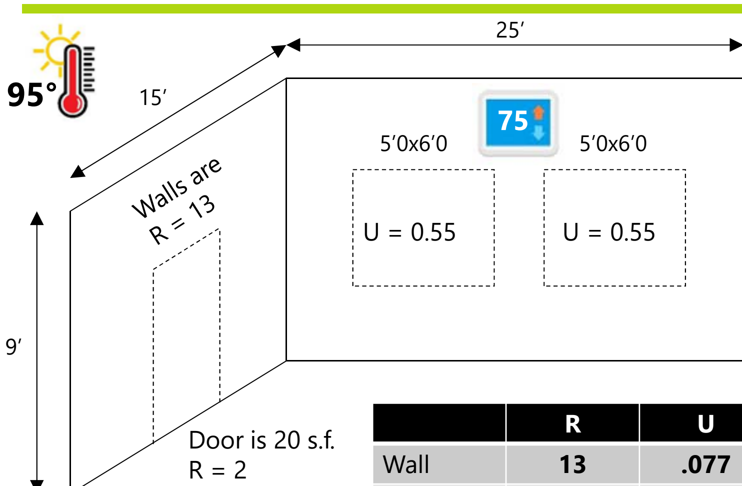
Gross Wall Area Example



$$q = U \times A \times \Delta T$$

R	U	Area	Delta T	q
13	.077	360	20	554 Btu/hr

Net Wall Area Example



(1/13) x 360 x 20 = **554**

$$q = U \times A \times \Delta T$$

	R	U	Area	Delta T	q
Wall	13	.077	280	20	431Btu/hr
Door	2	.5	20	20	200Btu/hr
Window		.55	60	20	660Btu/hr
					1291 Btu/hr

Convection Heat Flow

- Heat transfer through a fluid (liquid or gas) – usually air.
  For air, the formula for calculating convective heat transfer is

$\boxed{q = 1.08 \times CFM \times \Delta T}$ = convective heat flow (Btu/hr)

- CFM = Cubic Feet per Minute of air being transported
- ΔT = temperature difference of entering air and ambient air (°F)

<u>Example</u>:
A supply fan delivers 50 cfm of OA into a 75°F home when the ambient is 90°F.
Sensible heat added is q = 1.08 x 50 x (15) = <u>810</u> Btu / hr

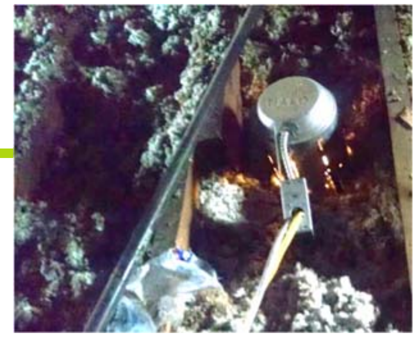
Conduction - Question 3

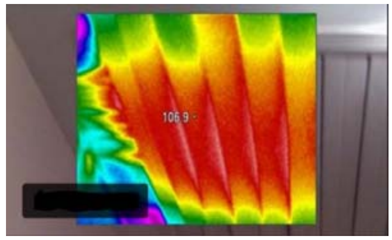
- Which of these is NOT needed to calculate heat transfer?

a) Area
b) Delta T
c) U-Factor
d) Material Density

d) Material Density

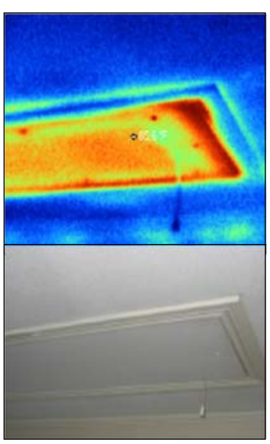






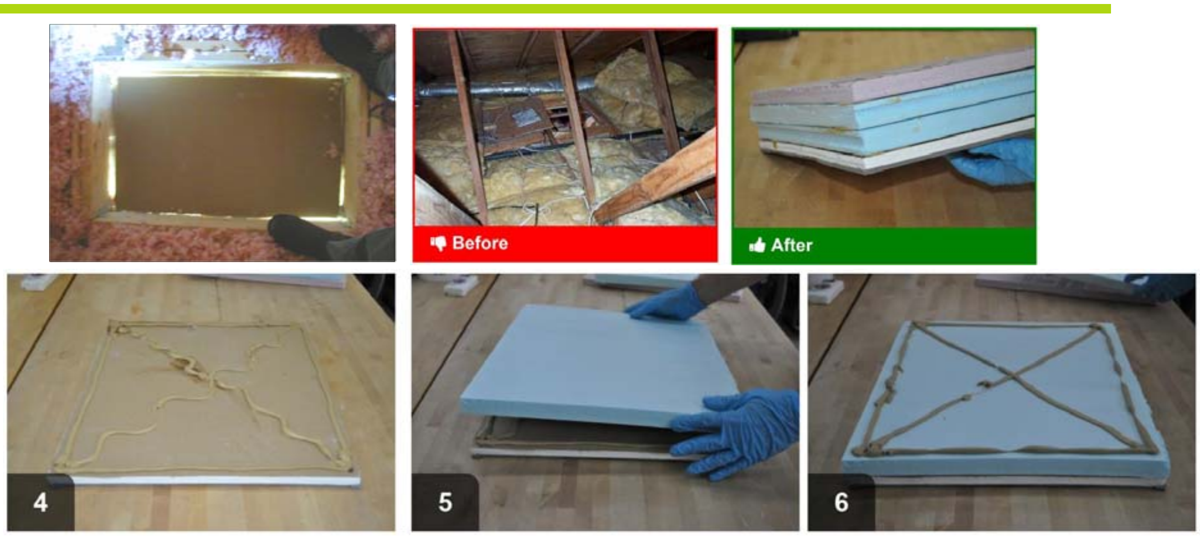
Insulation
Coverage is Key!

Attic Stairs




- Attic pull-down stairs efficiency retrofit

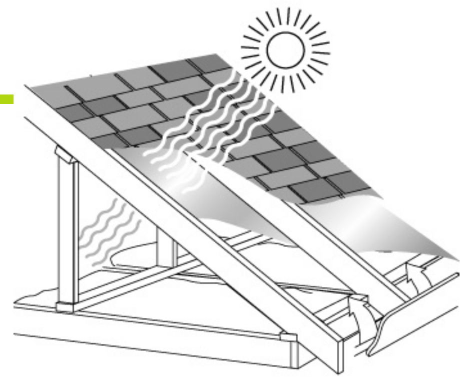
Attic Hatch



- Attic scuttle hole efficiency retrofit

- Whole house fan insulated cover efficiency retrofit

Keeping Attics Cool



- Dark, asphalt shingles are excellent solar collectors (unfortunately)
- One option is to reduce the solar gain into an attic by using a less absorptive roofing material such as an ENERGY STAR shingle or metal roof with reflective coating

Radiant Barriers

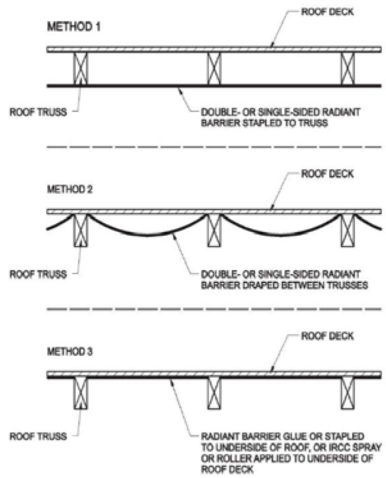
- All materials give off, or emit, energy by thermal radiation as a result of their temperature.
- Radiant barriers work by reducing heat transfer by thermal radiation between the roof and the rest of the attic.
- According to the Oak Ridge National Lab, radiant barriers can reduce cooling bills by 2-10 percent.

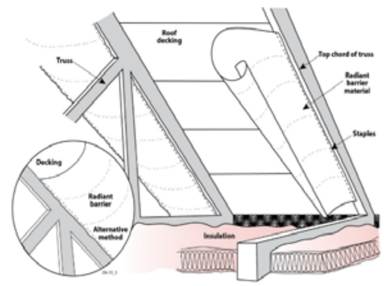
- RB decking is easiest for new construction
- Perforated products permit the decking to "breath," allowing the passage of moisture

Radiant Barrier Installation

- Radiant barriers can be installed four ways:

1. Along top chord of truss
2. Against the roof deck (with an air space)
3. As part of the roof decking assembly (foil or spray-on product)
4. ~~On top of ceiling insulation~~





- Attic catwalk / platform retrofit

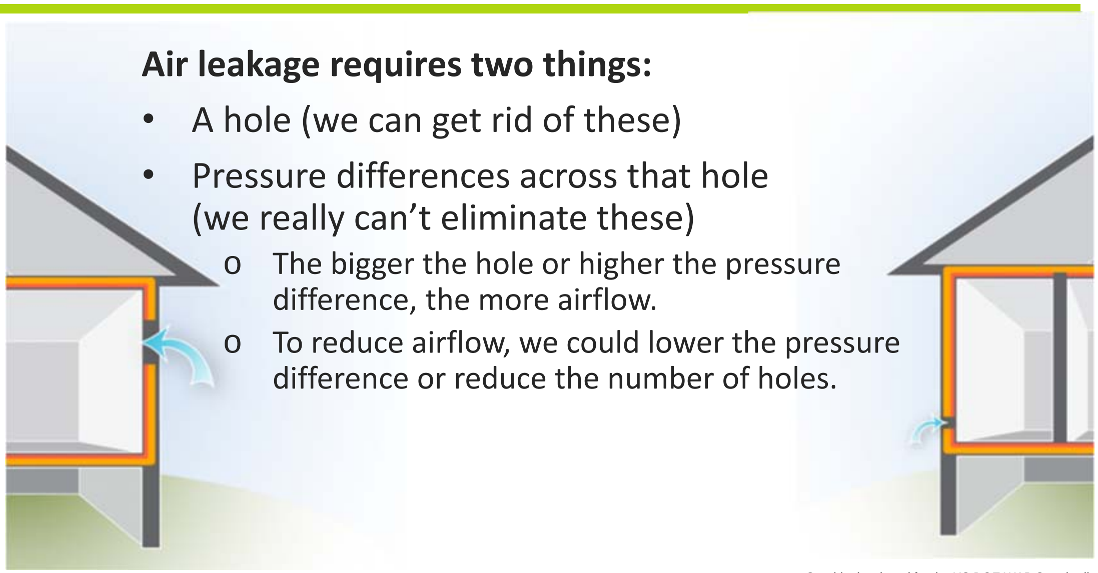
- Attic radiant barrier retrofit

Air Leakage

Building Science: Air Movement

- Air moves from high pressure to low
- Air leakage requires
  - A hole or pathway
  - A pressure difference
- 3 forces cause pressure differences:
  - **Wind**
  - **Stack**
  - **Fans**

Air leakage



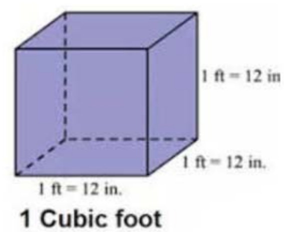
Air leakage requires two things:

- A hole (we can get rid of these)
- Pressure differences across that hole (we really can't eliminate these)
  - o The bigger the hole or higher the pressure difference, the more airflow.
  - o To reduce airflow, we could lower the pressure difference or reduce the number of holes.

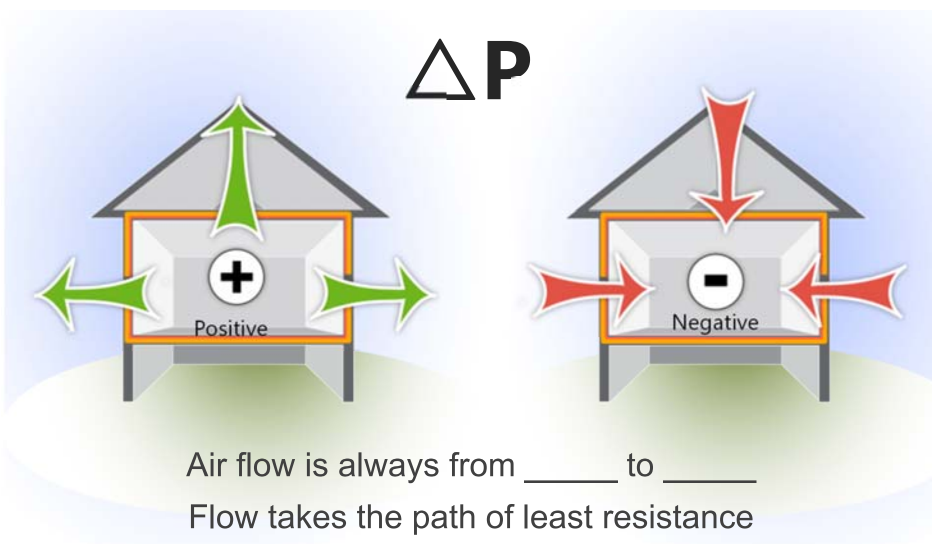
Graphic developed for the US DOE WAP Standardized Curricula

Air Leakage

- Airflow is measured in cubic feet per minute, also written as ft^3/min, or CFM.
- 1 CFM out = 1 CFM in
- Airflow takes the path of least resistance.
- Air moves from high to low pressure areas.
- Warm air rises, cool air sinks.



Air Leakage: Pressure

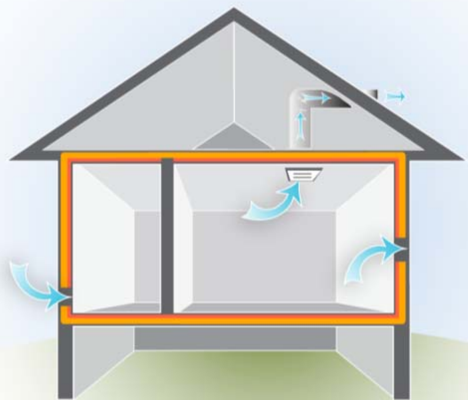


Graphic developed for the US DOE WAP Standardized Curricula

Air Leakage

Ventilation = Controlled air exchange

Infiltration =
Air leaking in

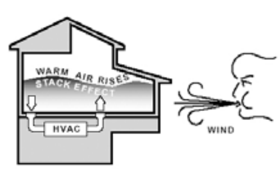


Exfiltration =
Air leaking out

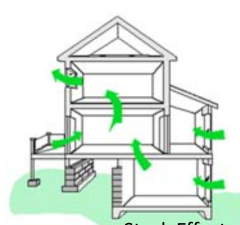
Graphic developed for the US DOE WAP Standardized Curricula

Air Leakage: Driving Forces

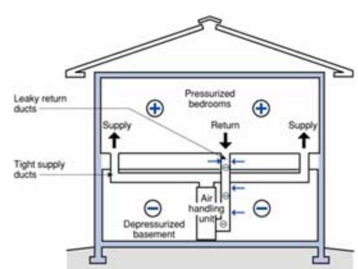
- **Three forces create pressure differences in a home:**
- Wind
- Stack Effect
- Mechanical Fans



Wind



Stack Effect

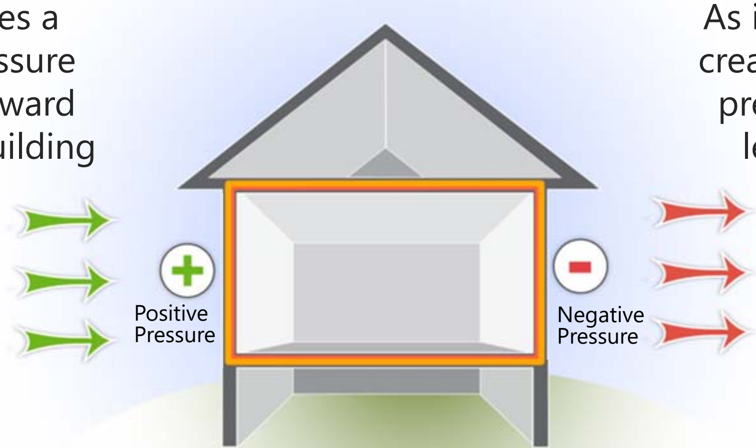


Mechanical Systems

Driving Forces: Wind Effect

Wind creates a positive pressure on the windward side of the building

As it flows past, it creates a negative pressure on the leeward side



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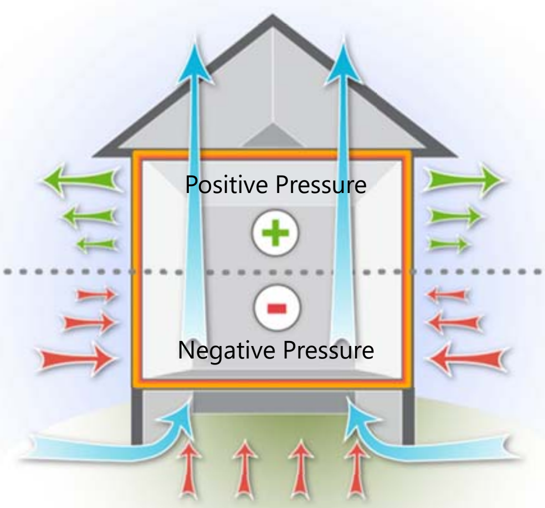
Driving Forces: Stack effect

Warmer air rises and escapes out of the top of the house…

…which creates a suction that pulls in outside air at the bottom of the house.



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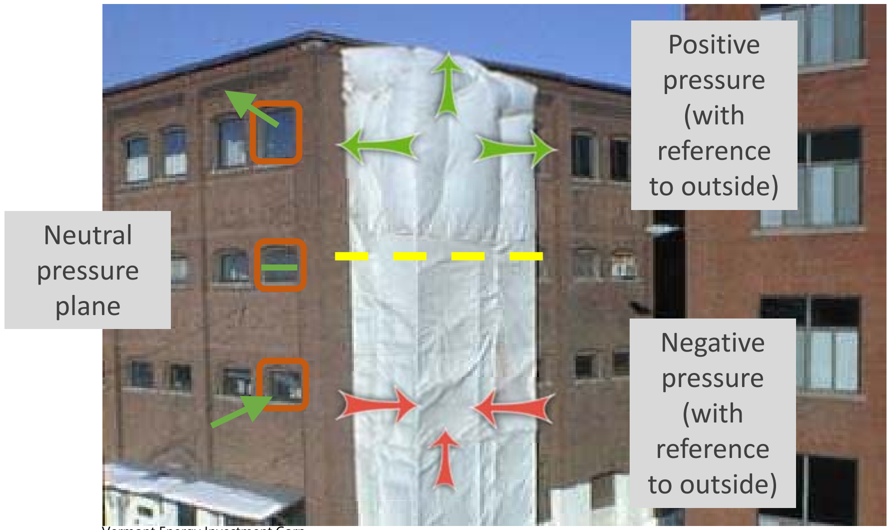
Stack effect

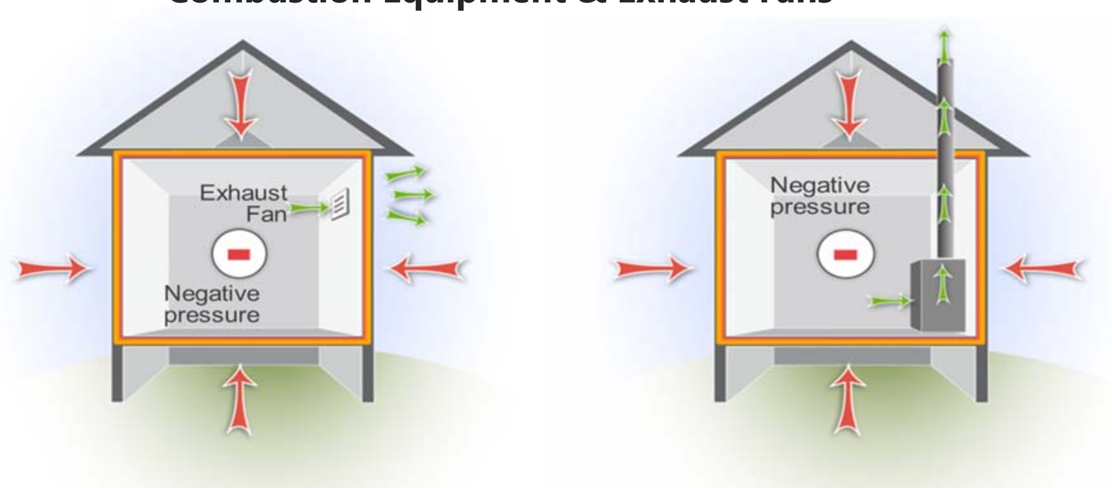
- Function of
  - Building Height
  - Temperature difference



Vermont Energy Investment Corp.

Driving Forces: Mechanical effect

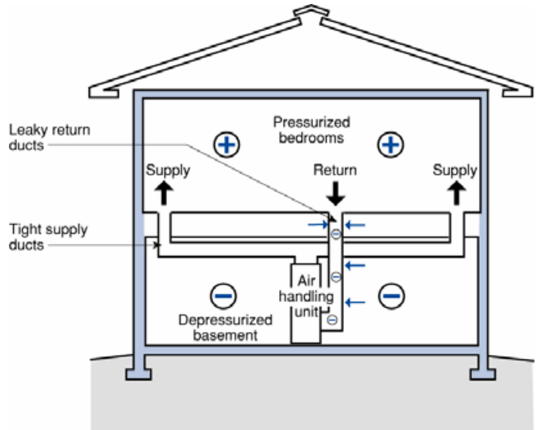
Combustion Equipment & Exhaust Fans



Graphic developed for the US DOE WAP Standardized Curricula

Fans—Driving Forces for Infiltration

Device	CFM
Bath	50
Range hood	150
Downdraft hood	500
"Commercial" Hood	1500
Dryer	200
Air Handler	400 / ton



Make up air for large kitchen hoods

Details

- Motorized damper for make up air (not shown)
- Wire damper to open when fan operates

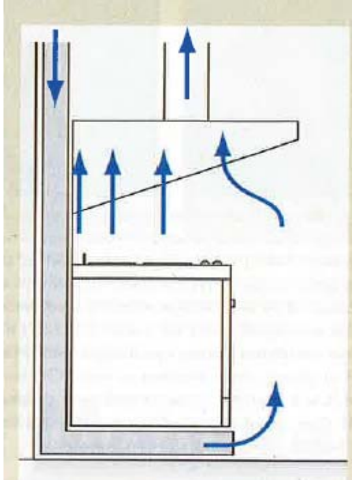


Figure 2: Capture the Effluent. The first thing we make sure is that the exhaust hood actually works to capture the effluent. The hood must overhang the cooking surface big-time. The absolute best approach is to use a backshelf hood with side panels and large overhangs on both sides and the front. Backshelf hoods can typically use 30% less exhaust to capture bad stuff compared to other hoods. Side panels can get you another 30% improvement. Note the direct makeup air using a modified backwall approach such that this makeup air is introduced at floor level. This direct makeup air introduced at floor level should never provide more than 60% to 70% of the hood exhaust. Why? Ah, we need a zone of negative pressure around the cooking surface. You don't want to push the bad stuff; you want to pull the bad stuff.

www.buildingscience.com

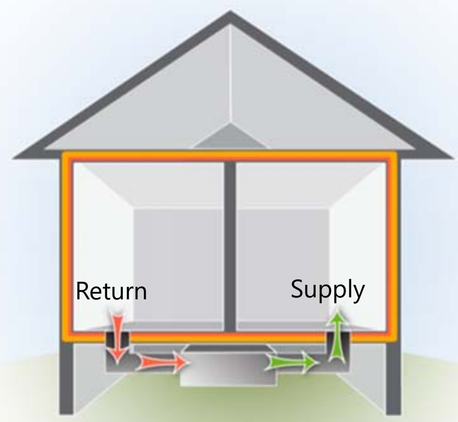
http://www.youtube.com/watch?v=NsSvMB9bJeE

Driving Forces: mechanical effect

Duct Leakage

Duct leakage can create positive and negative pressures in different areas of the house

The pressures associated with duct leaks can be larger and more significant because the driving force is stronger.



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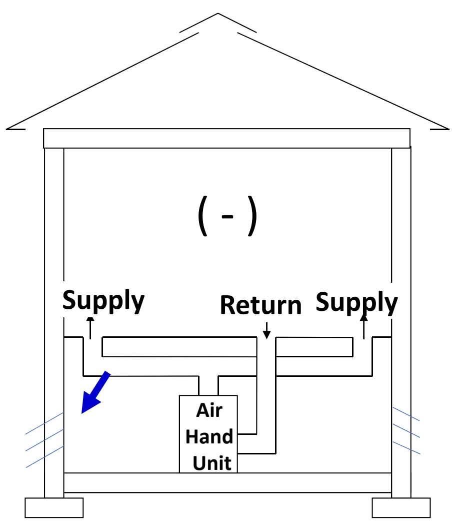
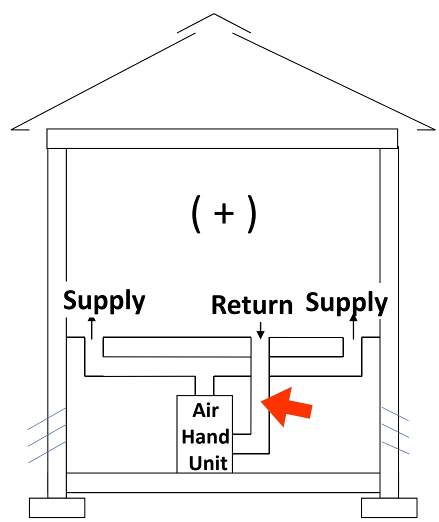
Driving Forces: mechanical effect

Duct Leakage

Duct leakage can create positive and negative pressures in a house.

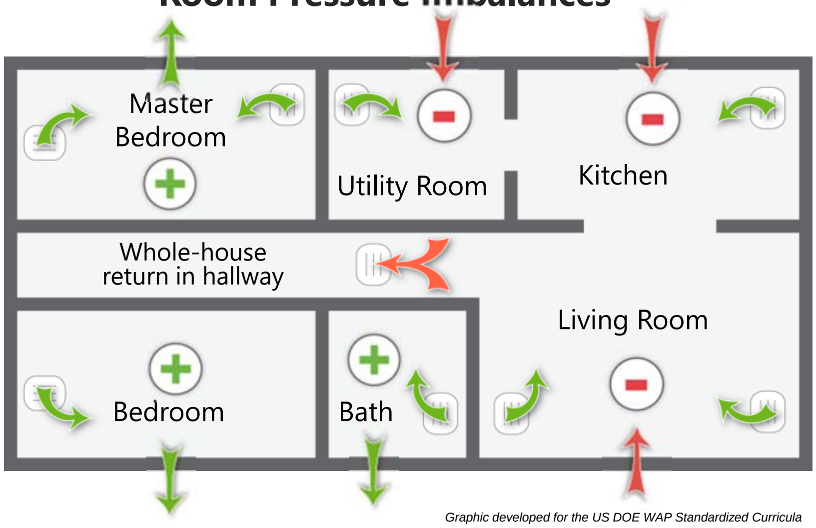


Leakage in supply side of duct system



Leakage in return side of duct system

Driving Forces: mechanical effect



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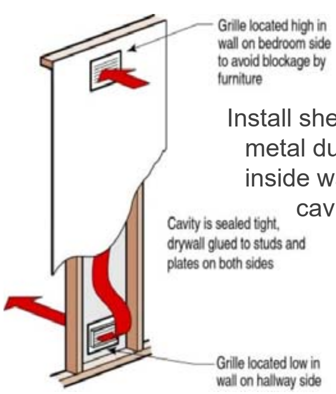
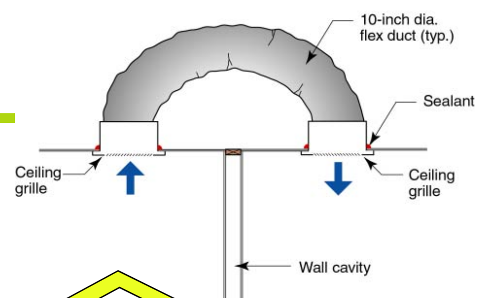
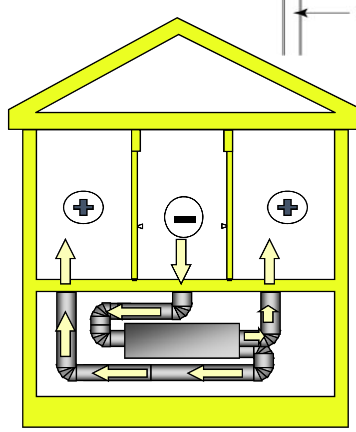
Driving Forces: mechanical effect

DESIGN FOR PROPER RETURN PATH



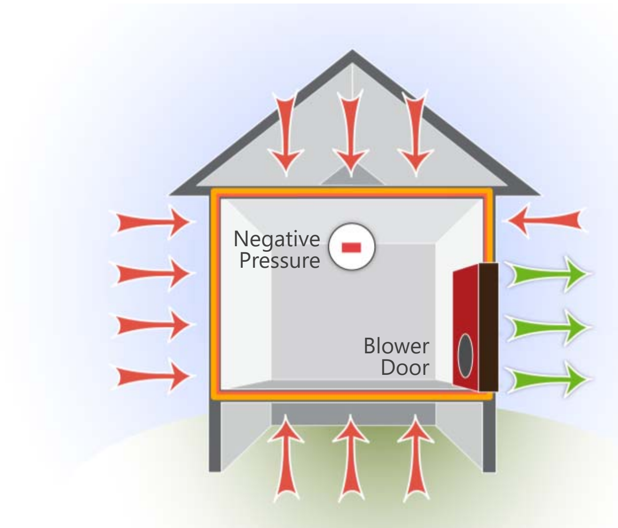
Install sheet metal duct inside wall cavity





Driving Forces: mechanical effect

- **Use a Blower Door as a Controlled Driving Force**
- Using the blower door depressurizes the house, drawing air through all the holes between inside and outside.



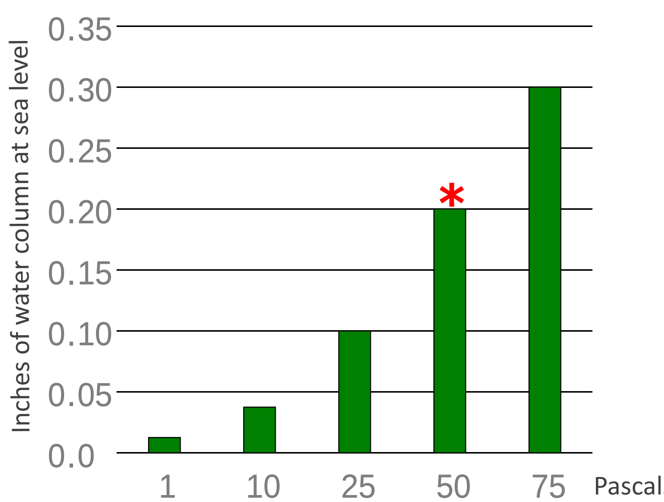
Graphic developed for the US DOE WAP Standardized Curricula

What is a Pascal?

50 Pascals (0.2” w.c.) is approximately the same as a 20 mph wind blowing on all six surfaces of a house

A Pascal is the unit of pressure in the International System of Units. Named after French scientist Blaise Pascal (1623-1662), it is abbreviated Pa.

1 Pa = 1 Newton of force applied over 1 square meter.



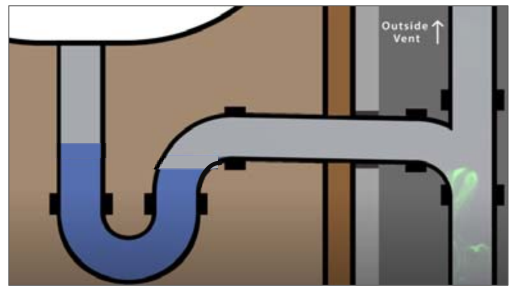
1 inch of water column = 248 Pascals

Blower Door – Question 4

A blower door is used to depressurize a house to -50 Pa.

While the fan is running, the water in a sink's P-trap will…

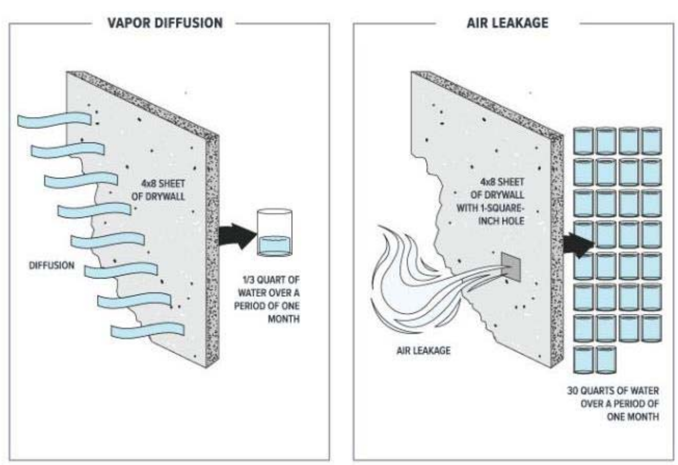
a. Be pushed downward by 0.2"
b. Stay the same – it wouldn't move
c. Rise up (towards the house) by 0.2"
d. Rise up (towards the house) by 1"



ANSWER: c. Water in trap will rise up 0.2" towards the house

Managing Water Vapor

- Another reason to limit air flow in a home is to reduce moisture intrusion.
- Even a small hole can allow a large amount of water vapor into the building.

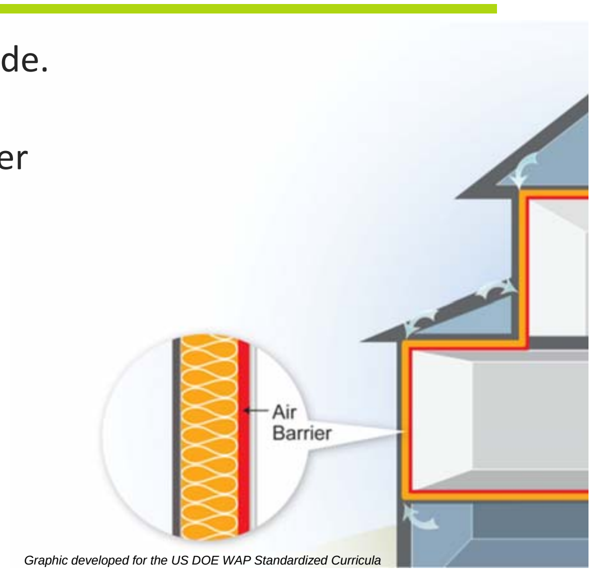


VAPOR DIFFUSION VS. AIR LEAKAGE
INTERIOR TEMPERATURE = 70° F
RELATIVE HUMIDITY = 40%

Air Barrier Installation

Air Barrier

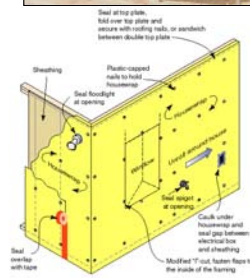
- Limits airflow between inside and outside.
- The IECC defines the air barrier as materials assembled and joined together to limit air leakage.
- Should be collocated with the thermal boundary
- New homes – wall sheathing
  Old homes – wall interior finish



Graphic developed for the US DOE WAP Standardized Curricula

Air Seal Exterior Sheathing

- No unsealed gaps
- Tape or caulk sheathing seams / penetrations
- Caulk or glue to framing



- Seal to framing, top plate, bottom plate
- Seal window & door openings
- Seal all penetrations

Shower/Tub on Exterior Wall

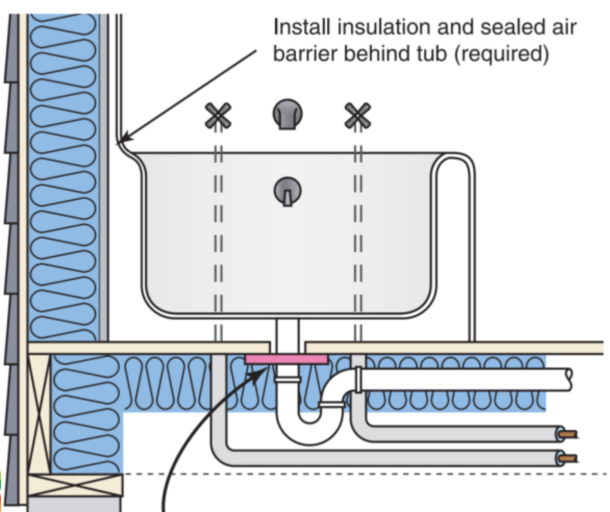
Photo courtesy of Anthony Cox

Shower/Tub on Insulated Wall

- Coordinate with your subcontractors so that insulation and air sealing details are not missed before it is too late!

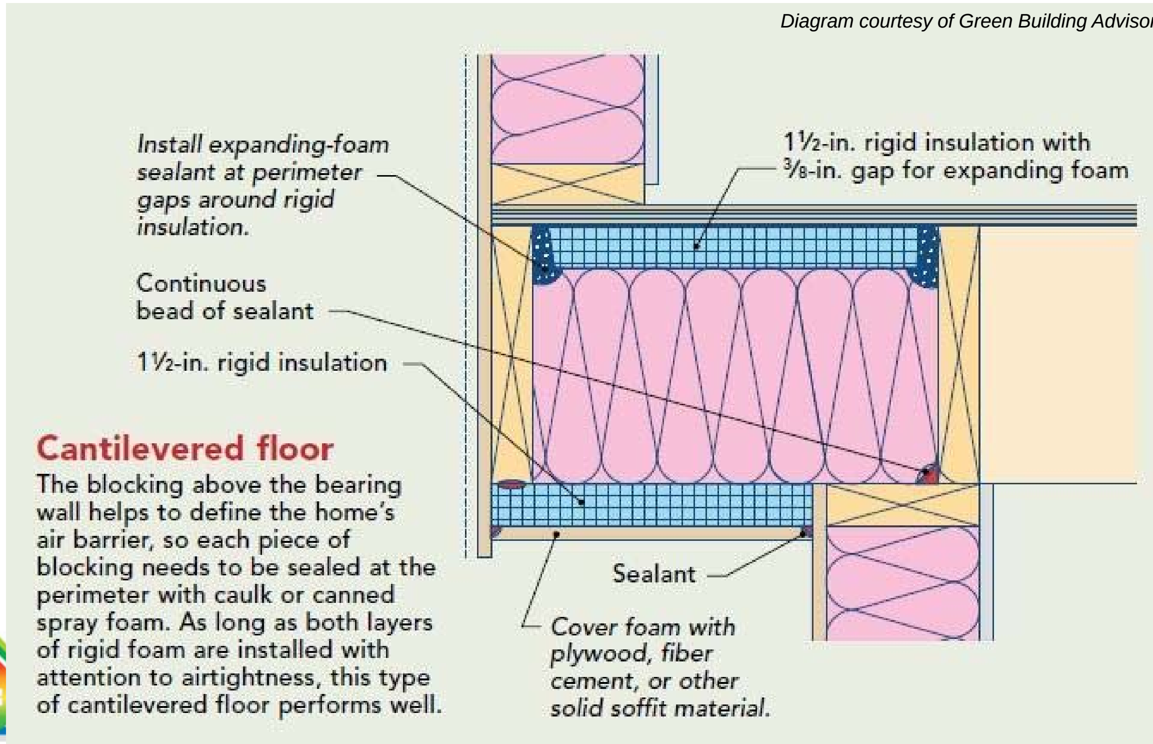
Complete air barrier behind tub

Plumbing and wiring



Cantilevered floor

Fiberglass does not stop airflow!



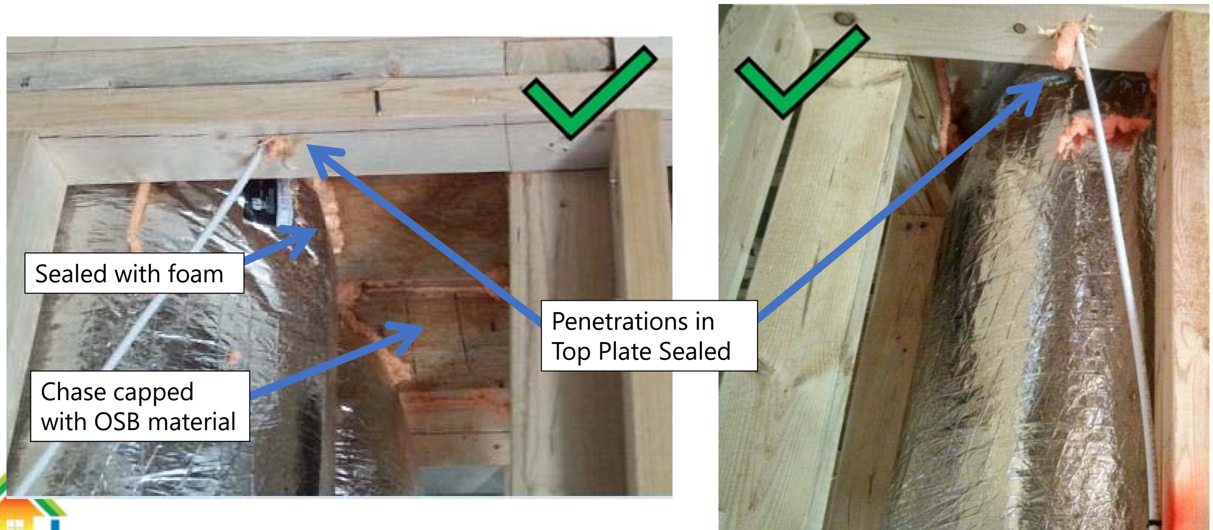
Garage Separation

Cantilever support wall

Duct Shafts

Cap chases with rigid material and seal tight around ducts or flue pipes

Duct Shafts



Recessed Lights

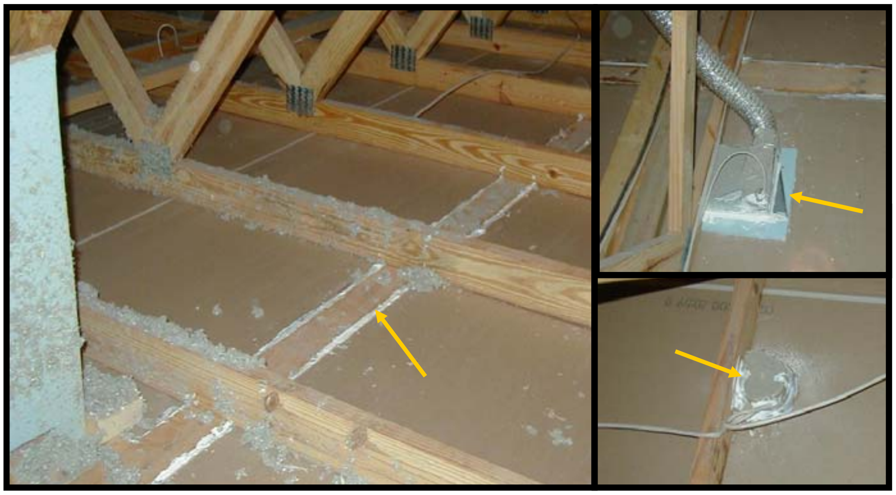
- **Standard Can Light**

Airtight and IC Rated

- All recessed luminaires shall be labeled as having an air leakage rate not more than 2.0 cfm tested at 75 pa
- All recessed luminaires shall be sealed with a gasket or caulk between the housing and the interior wall or ceiling covering

Air Sealing After Drywall

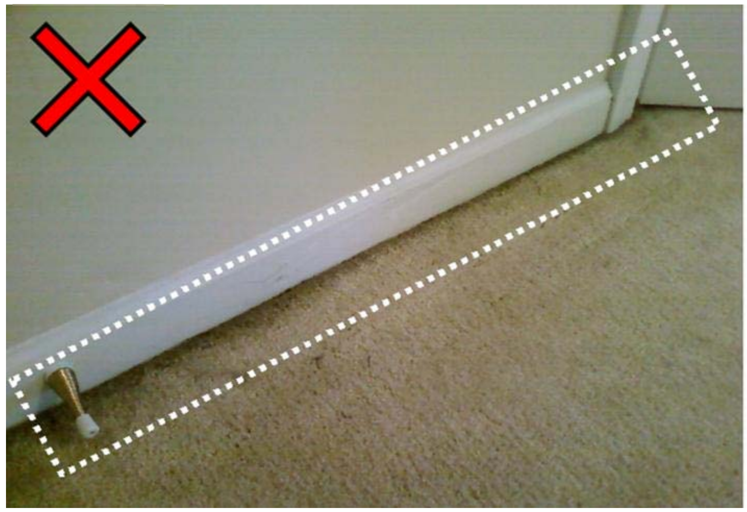
- Top plate to drywall (interior wall cavities often connect to attic)
- HVAC, plumbing and electrical penetrations



Sill (bottom) plate

Sill (bottom) plate

- Dirty carpet on **exterior** wall indicates leak at wall sill plate
- On **interior** wall indicates wall leaking to attic

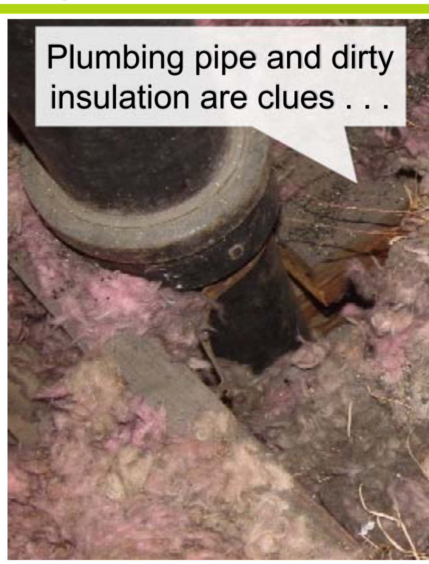


Air Sealing 101 - No BIG Holes!

- First, cover with sheet material and seal
- Then insulate

Air Sealing - Tubs

Looking for Leaks



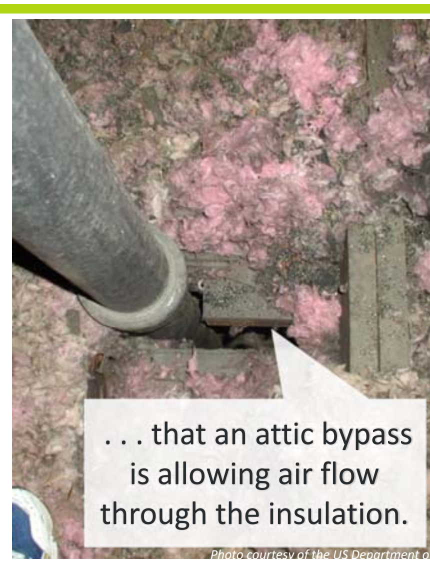
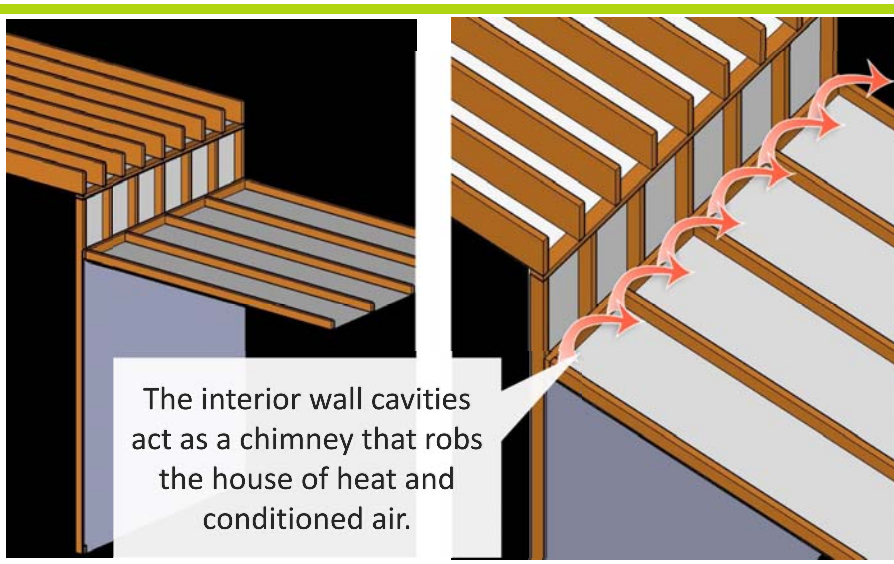


Photo courtesy of the US Department of

Sealing Attic penetrations

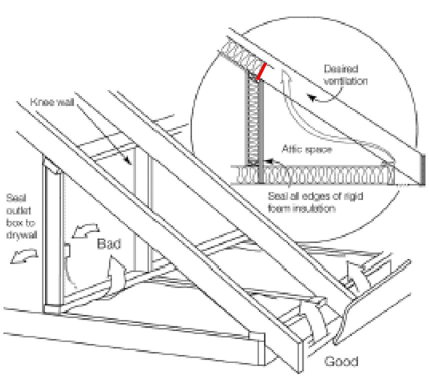
Changes in Ceiling Height

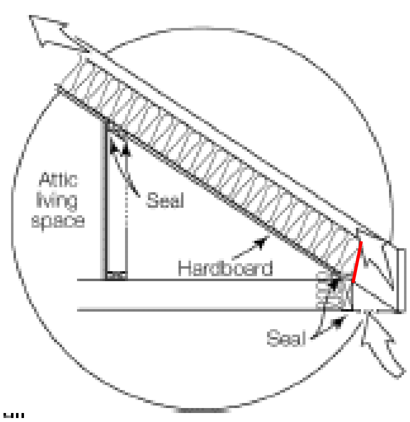


Changes in Ceiling Height

Sealing Attic Kneewalls

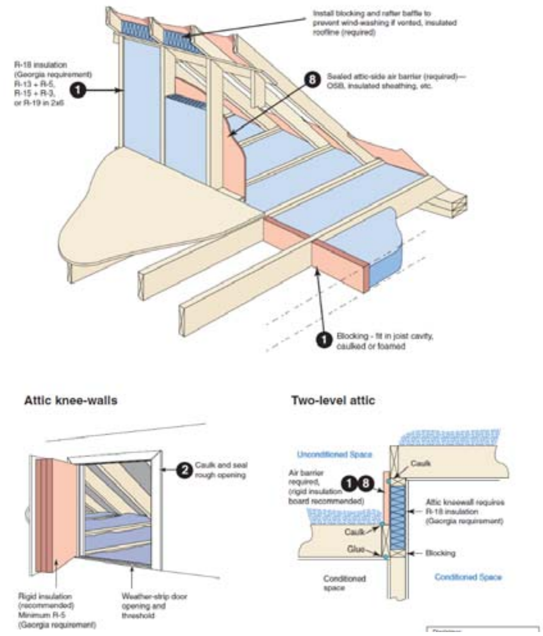
An attic *kneewall* has unconditioned attic space on one side and conditioned space on the other





ATTIC KNEEWALLS

(Want higher R-value with attic- side air barrier)

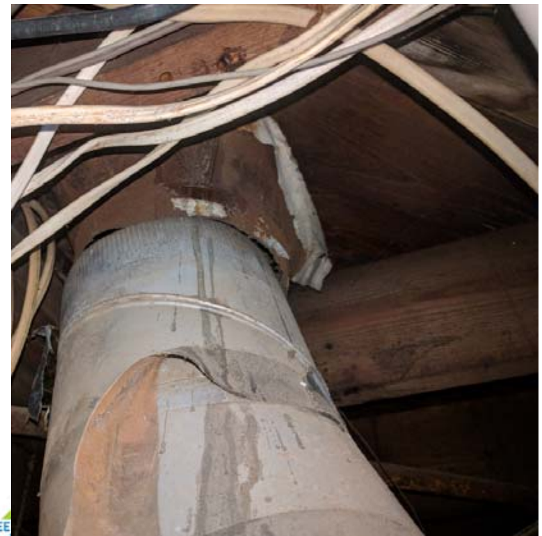


No Blocking under Attic Kneewalls

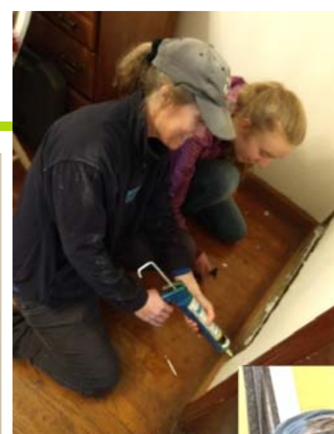
KNEEWALL – PICS SHOWS NEED FOR BLOCKING & SHEATHING

Proper Blocking under Attic Kneewalls

Sealing ducts with mastic



Sealing wall hvac boots



Forms of Moisture flow

Building Science: Moisture transport

- Moisture moves from wet to dry
- Liquid water flows downhill (but can be wicked up)
- Water vapor diffuses from high concentration to lower concentration
- Air movement can carry lots of humidity

Forms of Moisture flow

LIQUID and **VAPOR**

Bulk
Liquid water (rain, drainage, plumbing leaks)

Capillarity
Wicking through porous materials (concrete, wood, paper drywall, fiberglass and cellulose insulation)

Diffusion
Molecules of water moving through porous materials

Infiltration
Moisture laden air brought into the house

Wet → Dry

Managing Bulk Moisture

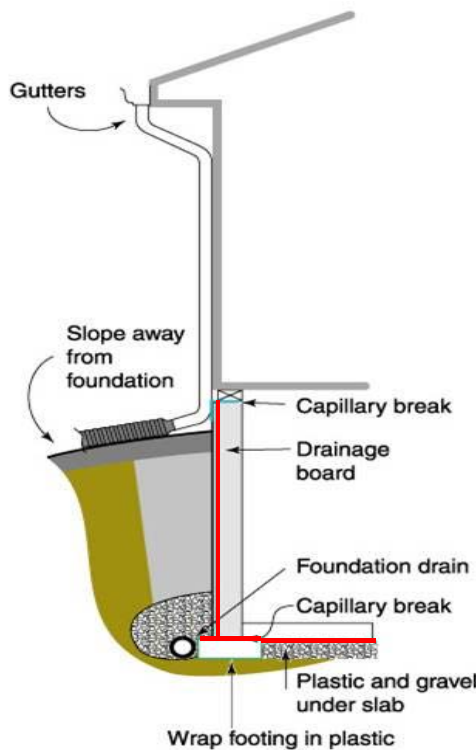
- Foundation waterproofing
- Proper site drainage
  - Gutters channel water away from foundation
- Drainage planes with proper flashing in walls allows water to escape (e.g. behind brick)

Encountering Bulk Moisture

Managing Bulk Moisture

Foundation waterproofing

- Plastic under slab
  - Gravel base under plastic
- Waterproofing foundation wall
  - Drainage mat, dimpled with filter, then backfill
- Footing
  - Wrap footing in plastic –tie into other plastic and waterproofing
  - OR waterproof top of footing before stem wall is poured
- Foundation drain tile
  - Adjacent to footing (better than on top)
  - Routed to daylight or sump pump
- Positive exterior drainage
  - Gutters, downspouts, grading slopes away from foundation
- Capillary break at top of stem wall



Bulk Moisture – foundation waterproofing

Dimpled drainage mat with filter

- Spray on water-proofing plus drainage board

Drainage system

Plastic wrapped beneath footing

Managing Bulk Moisture

- Proper site drainage is crucial

Bulk Moisture Control

- Proper site drainage
  - Swales
  - Positive slope grading
  - French drains

Bulk Moisture Control

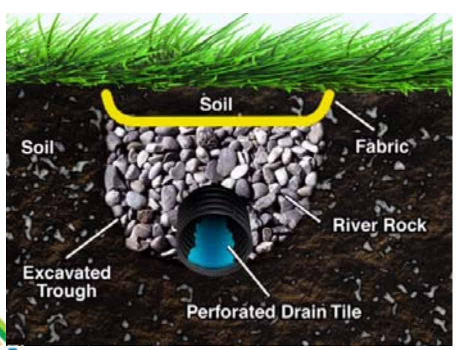
- Proper site drainage
  - Swales
  - Positive slope grading
  - French drains

Bulk Moisture Control

- Proper site drainage
  - Swales
  - Positive slope grading
  - French drains

Bulk Moisture Control

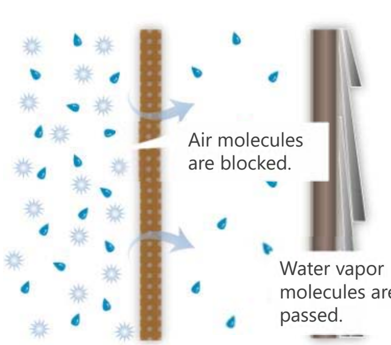
- Proper site drainage
  - Swales
  - Grading with positive slope
  - French drains



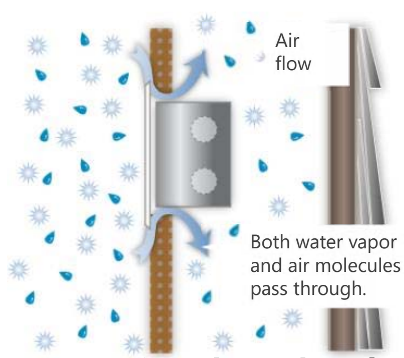
Encountering Water Vapor

Managing Water Vapor

Water Vapor Movement



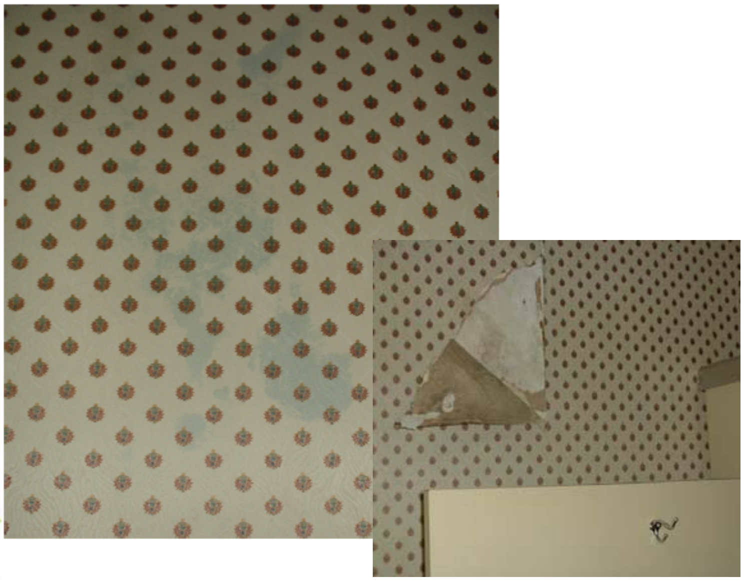
Diffusion Through Surface



Convection Through Holes

The measurement of the permeability of a material is its **Perm Rating**

Vapor Diffusion Retarders



Appropriate measures for moisture control are essential!

Moisture – Question 5

- Which of these is not one of the four forms of moisture transport?

1. Bulk
2. Capillarity
3. Air Movement
4. Diffusion
5. Flux Capacitance

Flux Capacitance

Psychrometrics

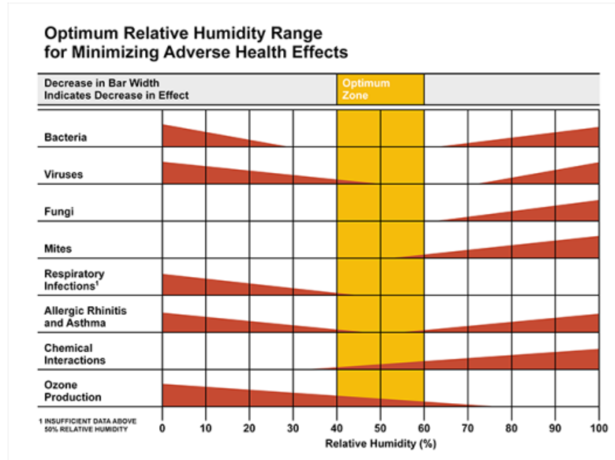
Moisture: Some Definitions

- **Psychrometrics*:*** The measurement of water vapor and heat in an air sample
- **Absolute humidity*:*** The ratio of the mass of water vapor to the mass of dry air in a given volume of air at a given temperature - the amount of moisture in the air (grains)
- **Relative humidity*:*** is the percent of moisture absorbed in the air compared to the maximum amount possible (the amount of moisture in the air in relation to the amount of moisture the air could hold at that temperature)
- **Dew Point*:*** The temperature at which water vapor condenses into liquid (related to absolute humidity)

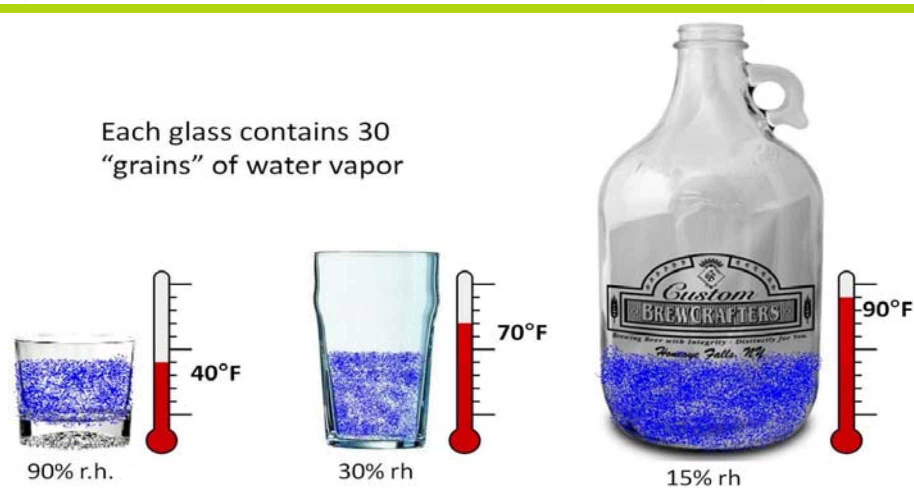
Moisture Vapor content

- Ideal Health & Comfort is **~50% RH** at room temperature (~72°F)

- Building decay 100% RH
- Interior Mold RH > 70%
- Dust Mites RH > 50%
- Viruses RH < 40%
- Static electricity, dry sinus RH < 25%



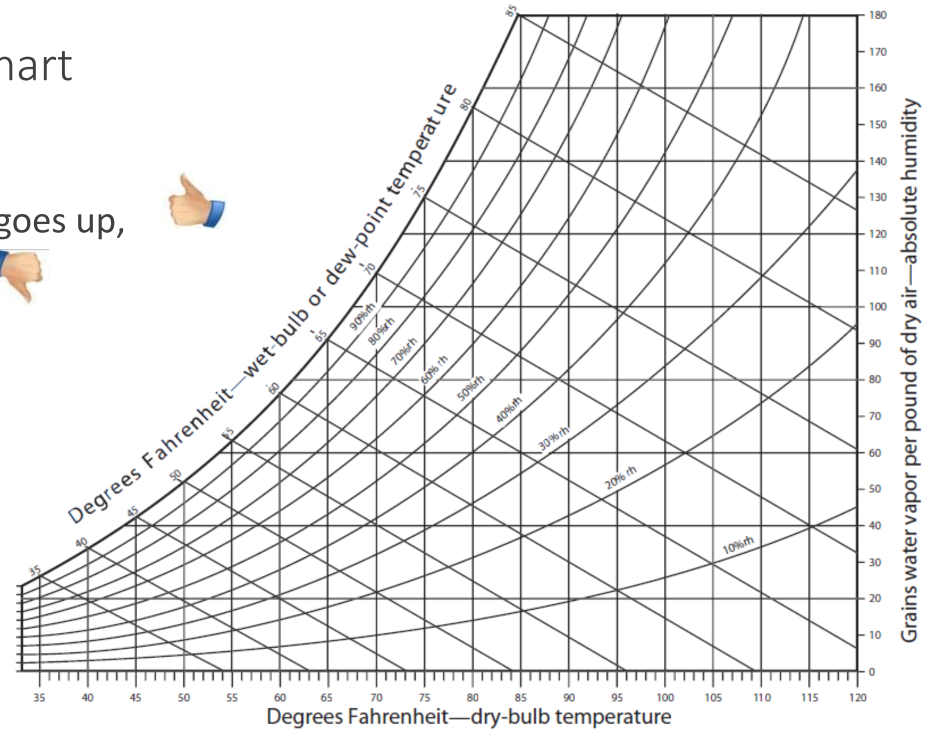
Temperature and Relative Humidity



- Warm air can hold more moisture than cold air

Psychrometric Chart

- As temperature goes up,
- RH goes down



Room Temperature Example

Find 75°F and 50% Relative Humidity.

Record the grains: 63

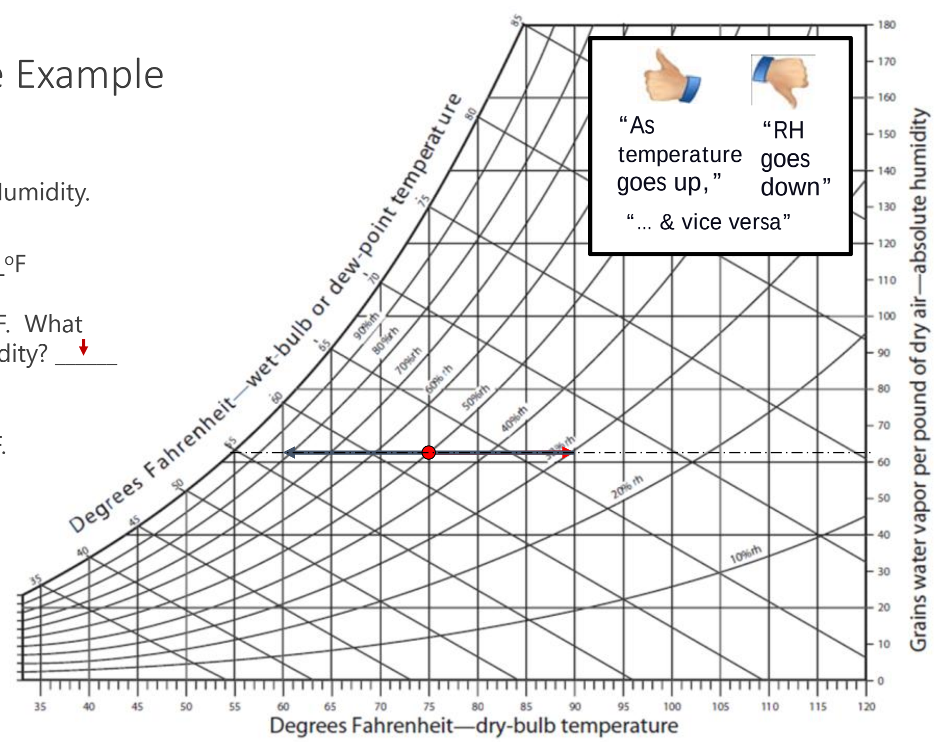
What is the Dew Point? 55 °F

This air is then heated to 90°F. What happens to the relative humidity? ↓

What is the RH? 30 %

This air is now cooled to 60°F. What happens to the relative humidity ↑ ?

What is the relative humidity? 85 %



Example Problem – Winter

Find 40°F and 90% Relative Humidity.

Record the grains: ___30___

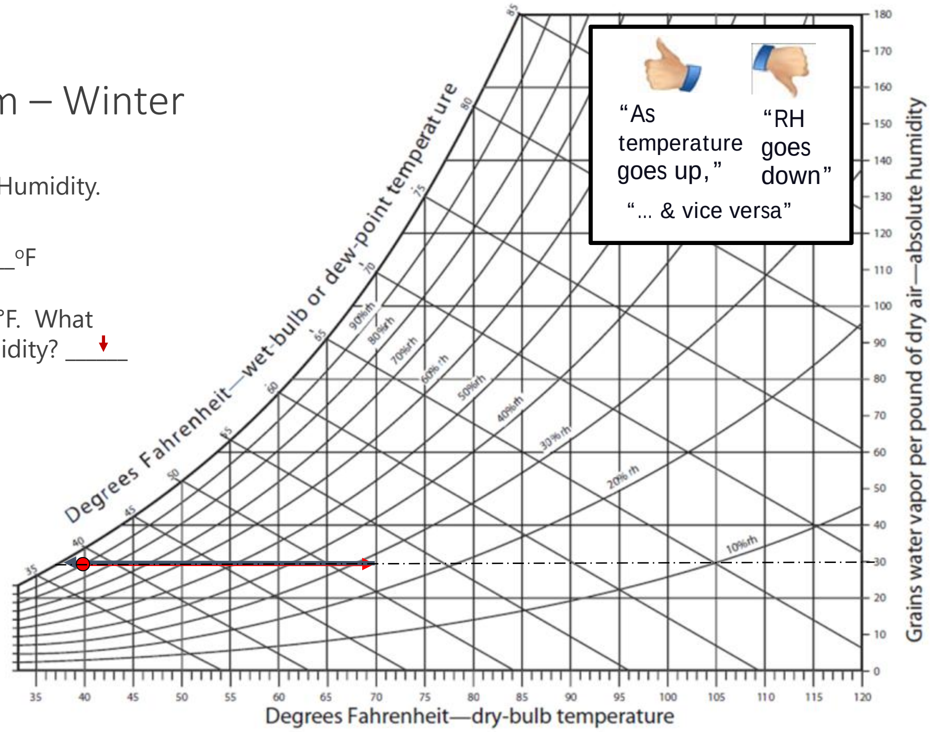
What is the Dew Point? ___38___ °F

This air is then heated to 70°F. What happens to the relative humidity? ___↓___

What is the RH? ___28___%

This air is now cooled to 38°F. What happens to the relative humidity___↑___?

What is the relative humidity? ___99___%



Summer Temperature Example

Find 80°F and 80% Relative Humidity.

Record the grains: ___123___

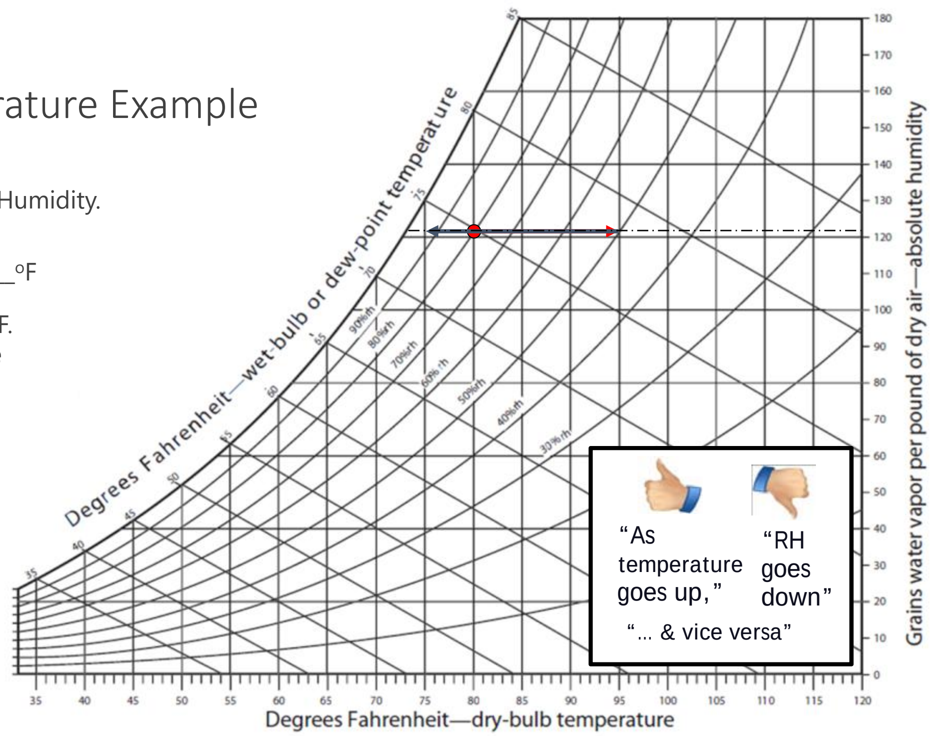
What is the Dew Point? ___73___ °F

This air is then heated to 95°F. What happens to the relative humidity? ___↓___

What is the RH? ___50___%

This air is now cooled to 75°F. What happens to the relative humidity?___↑___

What is the relative humidity? ___95___%



Questions 6 - Psychrometrics

“As temperature goes up,” “RH goes down”
“… & vice versa”

“Cold air is very __dry__ air”

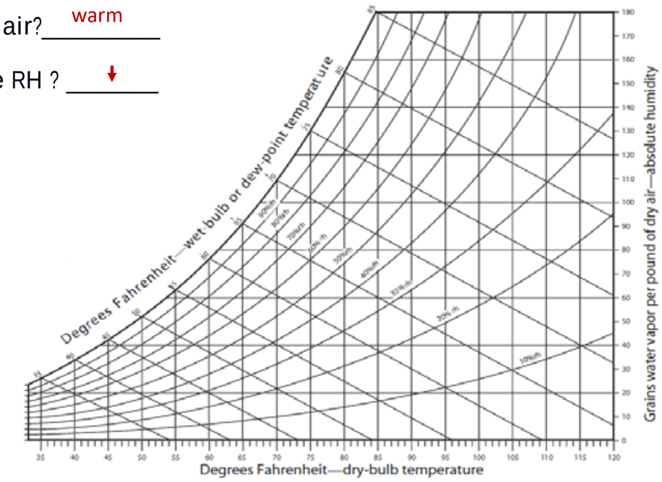
Which can hold more moisture, warm air or cold air?__warm__

If a cubic foot air is heated, what happens to the RH ? __↓__

If a cubic foot of air is cooled, what happens to the relative humidity? __↑__

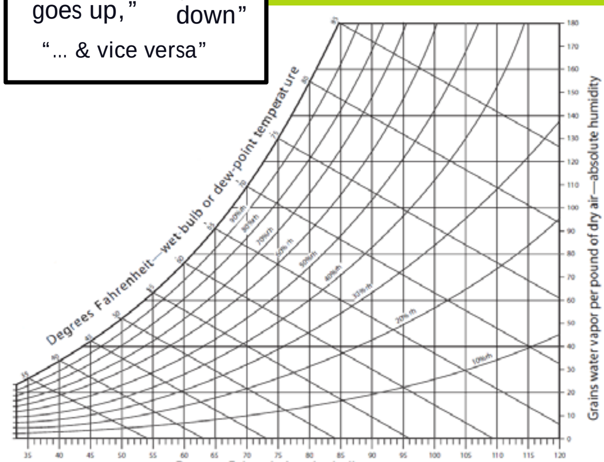
Misting 75F water vapor into 75F air will cause the RH to__↑__?

Adding a desiccant to a humid closet will cause the RH to __↓__?



“As temperature goes up,” “RH goes down”
“… & vice versa”

Questions 6 – Psychrometrics, cont.

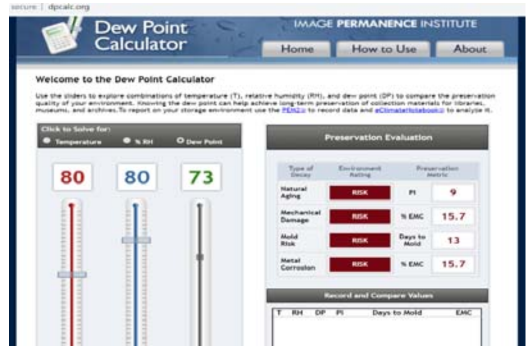


If a cubic foot of air held exactly 1/3 of the water vapor that it theoretically could hold, the relative humidity would be? __33__%

Because a person’s body cools via sweat evaporation, humid air generally feels __less__ comfortable in the summer.

Air that is too __dry (cold)__ in the winter is uncomfortable and can lead to chapped lips, nosebleeds, and static electricity.

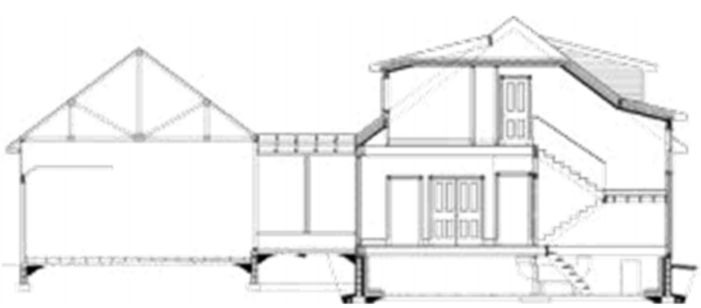
Mold generally starts to grow at __70__% RH

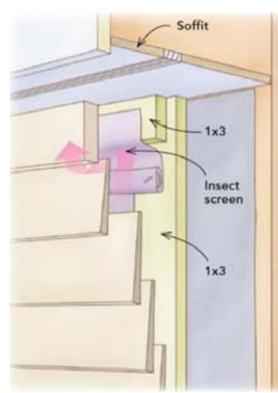


www.dpcalc.org

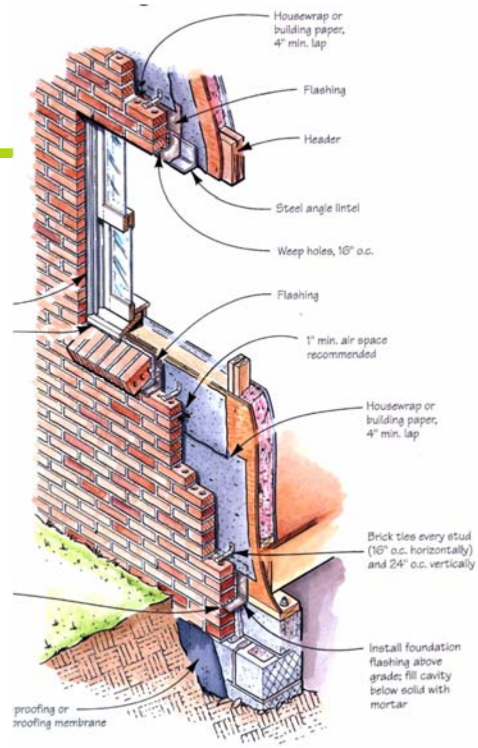
Practical applications

Moisture transport
Drainage Planes and Cladding



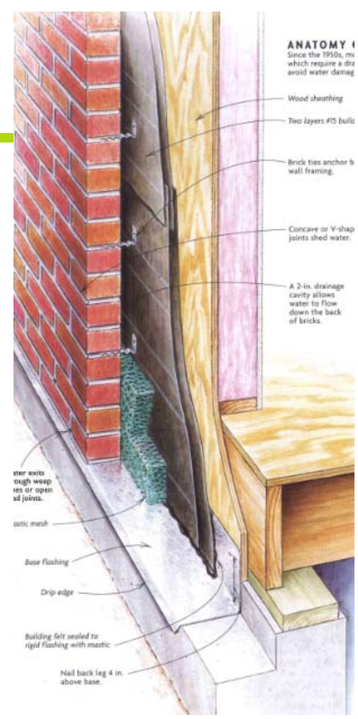


Cladding – Brick Veneer



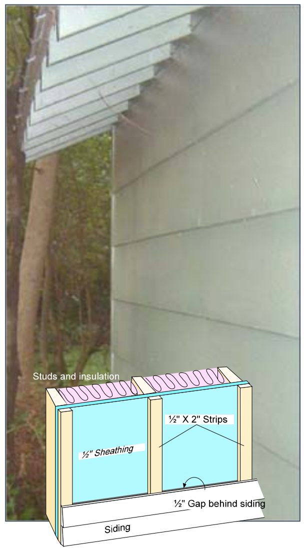
- Water shedding surface
- Gap / air space

Brick Veneer

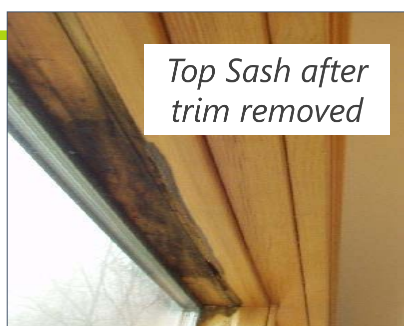


- Weeps are critical

Rain Screen / Drainage Pane



Housewrap: Details are Critical

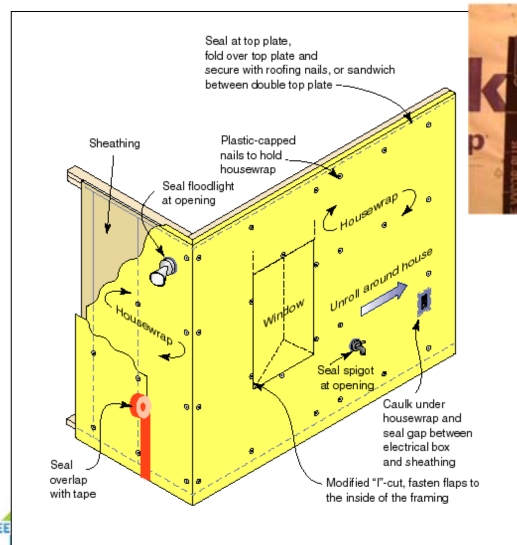


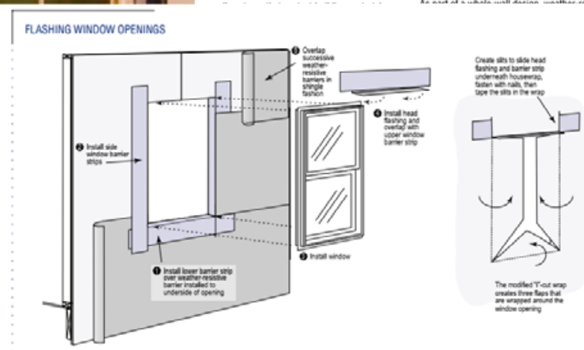
Windows (incorrectly) have flange over housewrap

See WRB factsheet for more details

"The bitterness of poor quality remains long after the sweetness of low price is forgotten" -Benjamin Franklin

Housewrap as a Weather Barrier





Managing Bulk Moisture – flashing

Flashing must be integrated with wall and roof drainage plane surfaces

No Weather Barrier

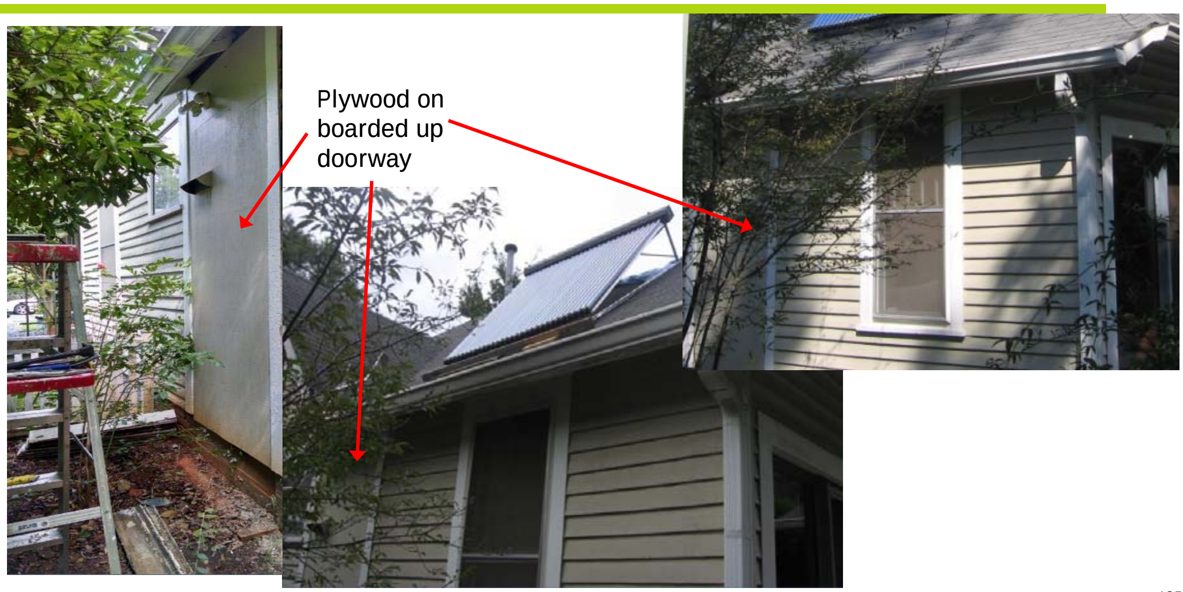
- Rotted siding
  - Air leakage
  - Wicking

Alternative WR Barriers

- WRB pre-attached to sheathing

Fluid-Applied Weather Resistive Barrier

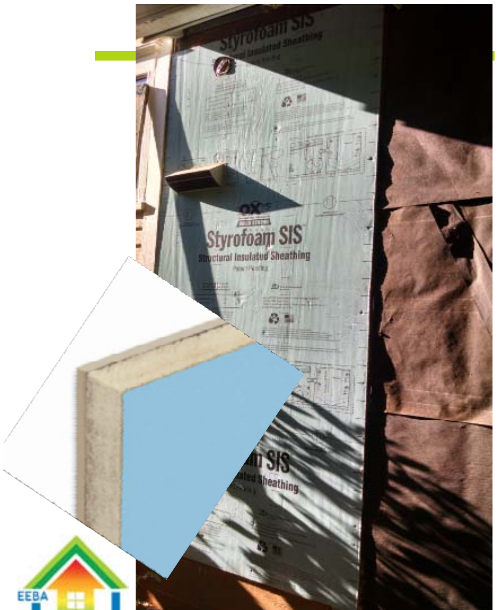
Retrofit: Lap Siding nailed directly to studs



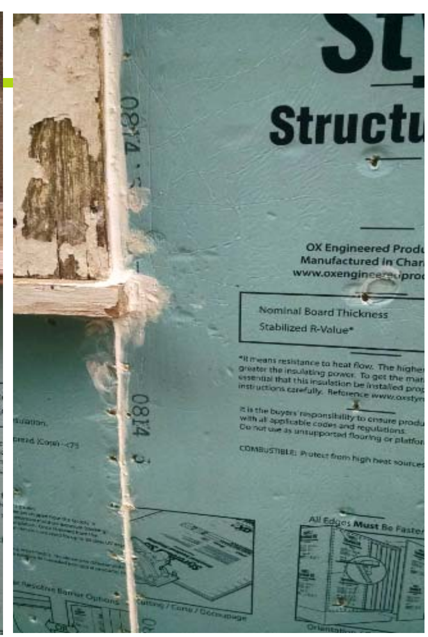
Siding Drainage Plane Retrofit

Siding Drainage Plane Retrofit

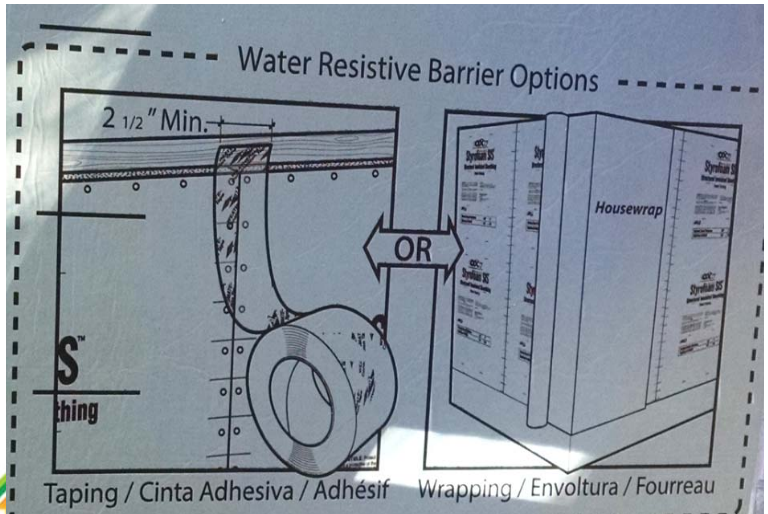
Install Structural Insulated Sheathing (SIS)

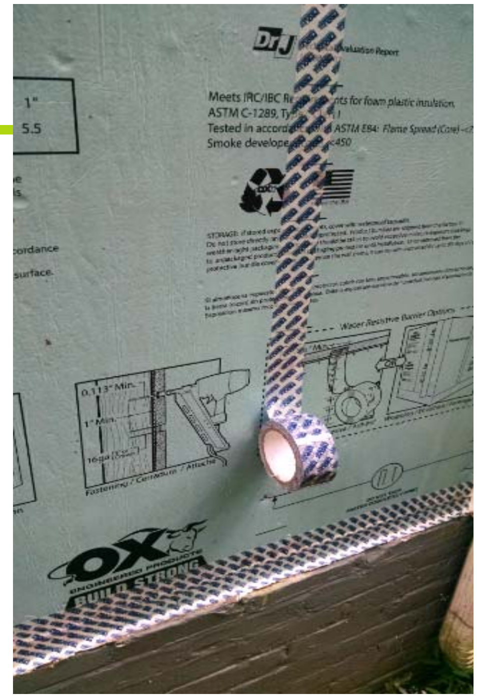


Set Nails in SIS



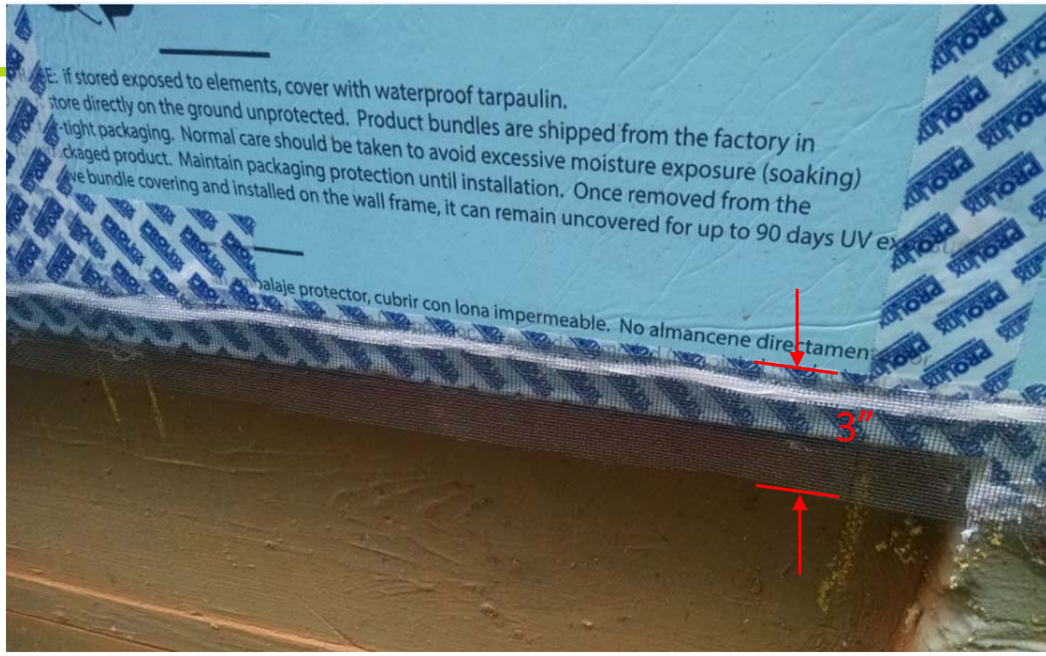
Seal Seams of SIS





Prep for Furring Strips

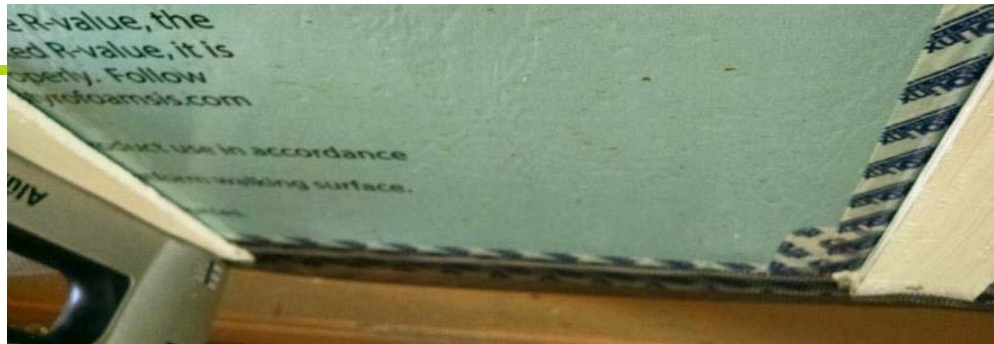
3” Insect Screen Before Furring



3/16” PT Furring Strips (with lower end primed)

Aligns with Wall Studs and Covers Top Half of Insect Screen

Bottom of Screen Folded Up & Stapled



Ready for Siding …

Siding Caulked At Edge, Not At Butt Joints

Floating Butt Joint With Flashing

3/16" Gap Between Siding & WRB

Siding Installation

Siding Drainage Plane Retrofit

Siding Drainage Plane Retrofit

Kitchen hood exhaust penetration

Siding Drainage Plane Retrofit

Constructing a system

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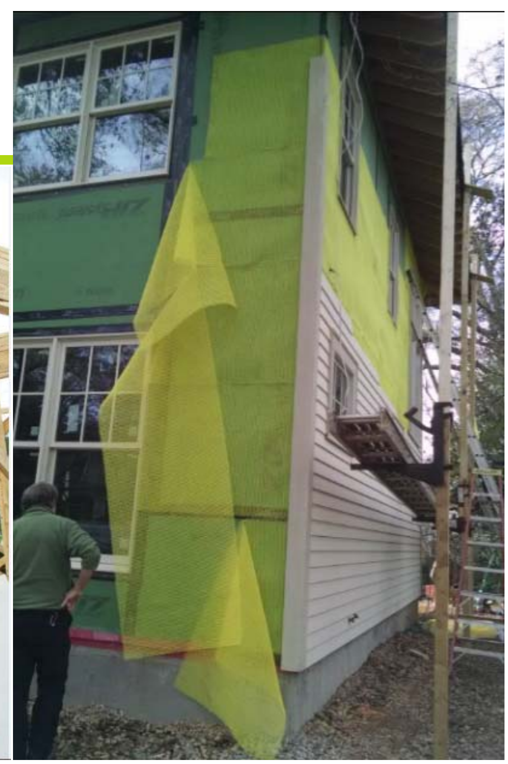
Siding Drainage Plane – New Construction



Question 7 Moisture (Setup)

On the following slide, 4 different moisture scenarios are described. Define the likely method of transport.

Answer choices:

- **Bulk** (liquid flow)
- **Capillarity** (liquid wicking)
- **Air Movement** (infiltration humidity)
- **Diffusion** (molecular movement)

EEBA

Question 7: Moisture Scenarios

1. A homeowner notes that their house is on a hillside and digs a shallow swale to divert flow around their foundation.
2. After taking a shower, a homeowner runs an exhaust fan for 30 minutes to remove the moisture.
3. A homeowner notes that the bottom 6” of the drywall in the garage has some mold growing on it (even though the plumbing line leak that flooded the garage last month was vacuumed up fairly quickly).
4. A homeowner notes that plastic installed over their crawlspace ground frequently has water droplets underneath it.

Answer choices:

- **Bulk** (liquid flow)
- **Capillarity** (liquid wicking)
- **Air Movement** (humidity)
- **Diffusion** (molecular movement)

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Questions?

The HERS Associate
Taking the Performance Path

An Introduction to the HERS Index and IECC Compliance

- June 4: It All Begins with Building Science
- June 11: Cracking the Building Energy Code
- June 18: Demystifying Energy Modeling
- June 25: Healthy Homes Matter - Understanding IAQ & Ventilation
- July 2: An Industry That Puts It All Together: The World of HERS Raters

Thank you!
mikeb@southface.org

MARK YOUR CALENDAR

Southface Applied BS Webinars
Third Thursdays! 11 a.m. ET
- **June 18th -** Combustion Safety
- **July 16th -** HVAC Load Calcs
- **Aug 20th -** High Performance Design

www.eeba.org

- aaron@eeba.org

www.southface.org

- mikeb@southface.org