


October 12, 2010
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Building Science Corporation


Residential Energy Performance Association of New Hampshire

Wall and Roof Systems



Presentation Overview


- Context for Residential Construction
- The Ideal Building Enclosure
- Moisture Control
- Energy Transfer
- Wall Systems
- Roof System/Attic Systems



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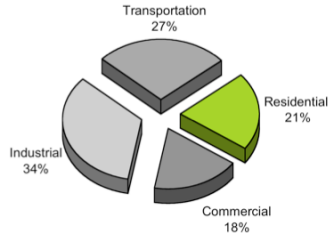
Context for Residential Construction




Energy Use

- Energy is a big consideration in new construction and building retrofits

Primary Energy Consumption by Sector, 2001

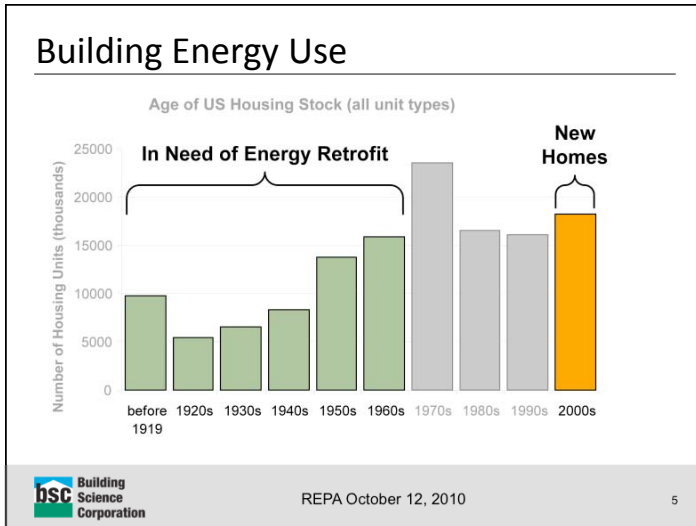


Sector	Percentage
Industrial	34%
Transportation	27%
Residential	21%
Commercial	18%

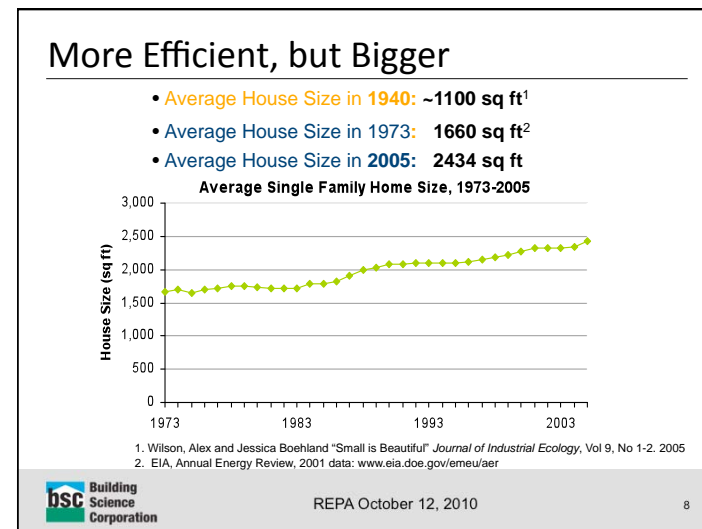
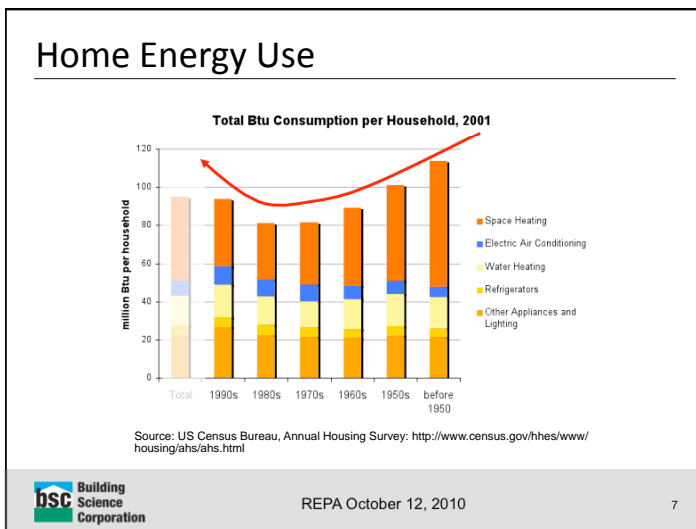


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- ### Building Retrofit Opportunities
- There are approximately 60 million units of housing in the U.S. that were built prior to 1960.
 - Most of these will need major systems replaced in the near future.
 - As siding, windows, roof claddings, mechanicals replaced, opportunities arise to reduce the overall energy use of these homes
- CAPTURE OPPORTUNITIES!*
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Home Energy Use

- Significant portion of the total energy use
- Need to reduce energy
- New buildings should consider not just current standards and requirements but future needs
- Retrofit buildings should look for opportunities to bring levels above current standards as well



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Building Service Life

- Any new construction or significant reworking of an assembly/system essentially inoculates that assembly/system from further improvement for the services life
- Consider service life of measures
- Will components of an assembly provide appropriate performance for the full service life



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Building Enclosure



Building Enclosure

- Key Requirements
 - Control rain and ground water (including snow)
 - Control heat flow, airflow, and water vapor flow
 - Control light and solar radiation
 - Control noise and vibrations
 - Control contaminants, environmental hazards and odors, insects, rodents and vermin
 - Control fire
 - Provide strength and rigidity
 - Be durable
 - Be aesthetically pleasing
 - Be economical



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Building Enclosure

- Rain Control Layer
- Vapor Control Layer
- Air Control Layer
- Thermal Control Layer

The diagram illustrates a building enclosure with an exterior environment on the left and an interior environment on the right. Arrows labeled 'Loads' point towards the enclosure from both sides. The enclosure itself is shown as a series of layers: an external interface, a finish, a support control layer, another finish, and an internal interface. 'Micro Climate Modifiers' are indicated near the exterior interface. The entire assembly is labeled 'Enclosure'.

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The Ideal Building Enclosure

This diagram shows a vertical cross-section of a wall assembly. From left to right, it consists of: 'Cladding' (represented by a vertical stack of rectangular blocks), 'Control layers' (represented by a thin vertical line), and 'Structure' (represented by a thick vertical gray block).

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The Ideal Building Enclosure

The diagram shows three components: 'Wall', 'Slab', and 'Roof'. The 'Wall' is a vertical assembly. Below it, two horizontal assemblies are shown: 'Slab' and 'Roof'. Curved arrows point from the 'Wall' to both the 'Slab' and the 'Roof', indicating their connection or relationship.

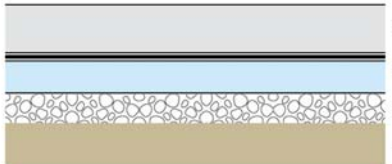
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The Ideal Building Enclosure

This diagram shows a horizontal cross-section of a roof assembly. From top to bottom, the layers are: 'Ballast' (represented by a layer of small circles), 'Filter fabric' (represented by a thin line), 'Control layers' (represented by a thin blue layer), and 'Roof structure' (represented by a thick gray block).

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The Ideal Building Enclosure

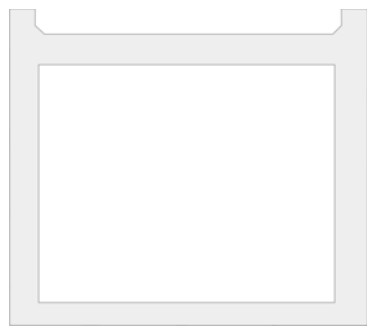


← Slab
← Control layers
← Stones
← Earth

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This diagram shows a cross-section of a floor assembly. From top to bottom, it consists of a grey slab, a thin black line representing control layers, a layer of white stones, and a brown earth layer. Arrows point from the text labels to the corresponding layers in the diagram.

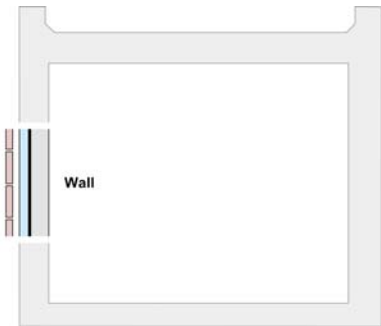
The Ideal Building Enclosure



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This diagram shows a simple floor plan of a rectangular building enclosure with a thick grey border representing the walls and a white interior space.

The Ideal Building Enclosure

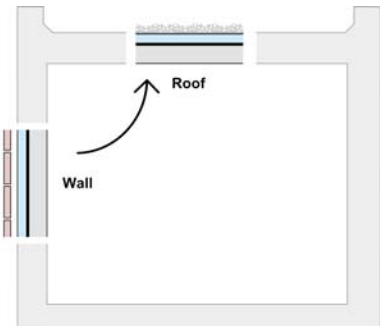


Wall

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This diagram shows the same floor plan as slide 18, but with a detailed view of a wall section on the left side. The wall is shown as a vertical assembly with multiple layers, indicated by different colors and textures.

The Ideal Building Enclosure



Roof

Wall

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This diagram shows the same floor plan as slide 18, but with a detailed view of a roof section at the top. An arrow points from the label 'Roof' to the roof assembly, which is shown as a horizontal assembly with multiple layers. A wall detail is also visible on the left side.

The Ideal Building Enclosure

Roof

Wall

Slab

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The Ideal Building Enclosure

Parapet

Roof

Wall

Slab

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The Ideal Building Enclosure

Parapet

Roof

Wall

Footing

Slab

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Physics


- Heat Flow Is From Warm To Cold
- Moisture Flow Is From Warm To Cold
- Moisture Flow Is From More To Less
- Air Flow Is From A Higher Pressure to a Lower Pressure
- Gravity Acts Down

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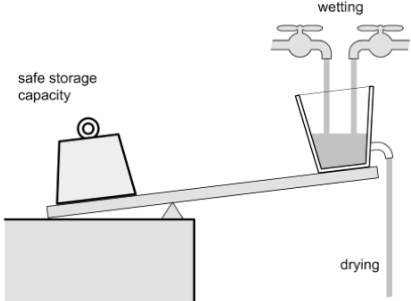

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Moisture Control



Moisture Control

- The Moisture Balance





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Moisture Control

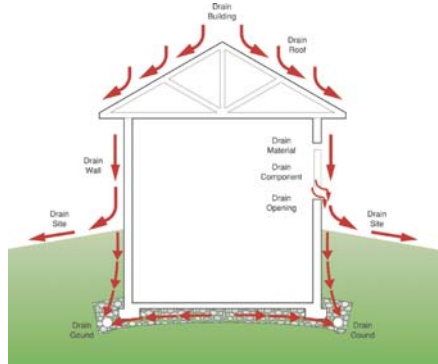

- Wetting
 - Liquid Water Management
 - Rain/Snow
 - Ground water
 - Condensation
 - Air Leakage
 - Vapor Diffusion
- Storage
- Drying
 - Drainage
 - Ventilation
 - Vapor Diffusion



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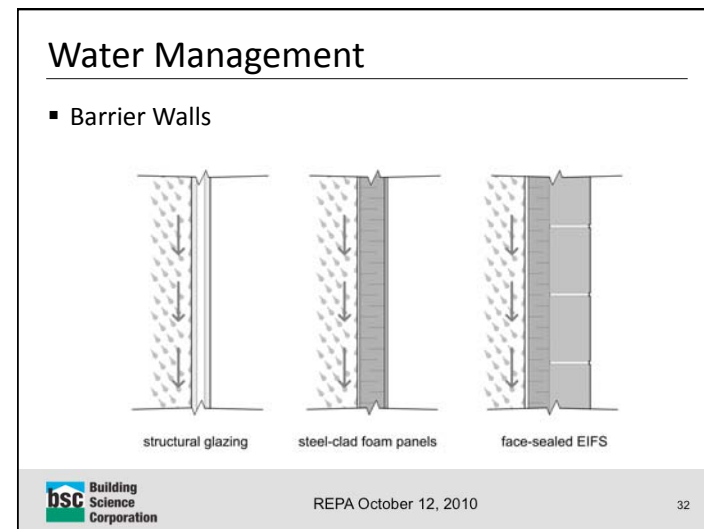
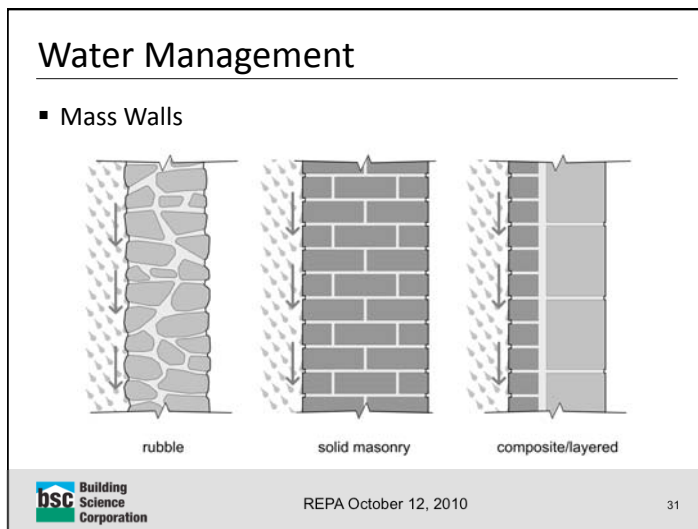
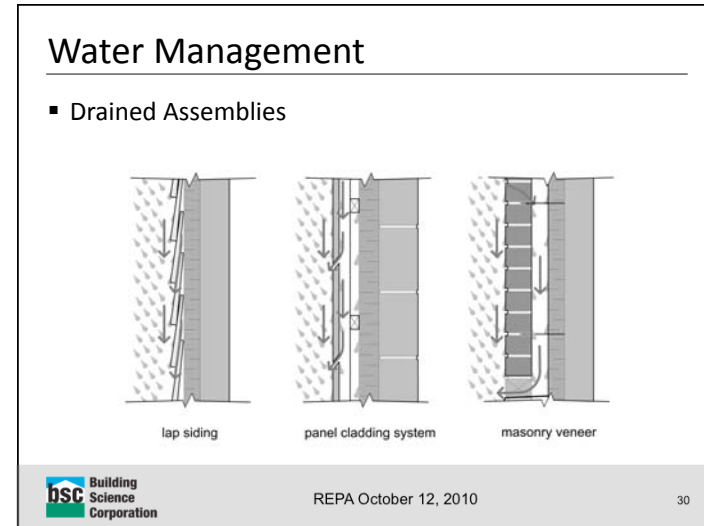
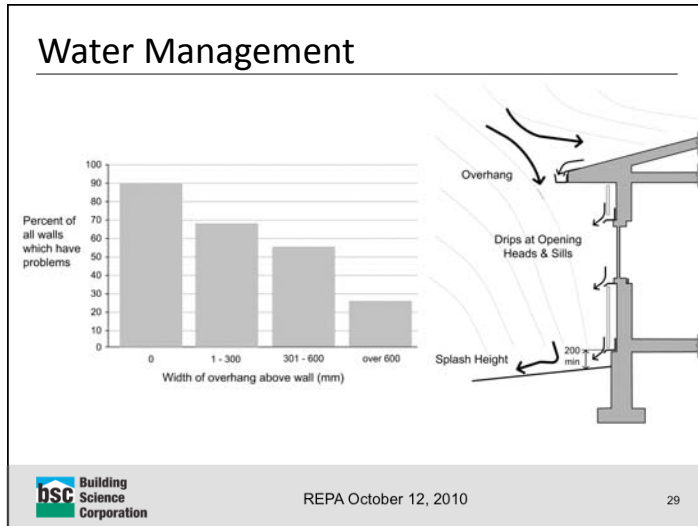
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Water Management

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Water Management

- Water Managed Joints

Mass Joint Perfect Barrier Joint Drained Joint

structural joint drainage opening drainage space

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Water Management

Wood Siding (cladding) Furring Building Paper (drainage plane) Sheathing Flashing

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Water Management

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Vapor Management

- Air leakage
 - Can transport significant amounts of water vapor
 - Driven by air pressure differences
 - Requires a pathway
- Vapor Diffusion
 - Typically slow transport of water vapor – though it can act continuously for long periods of time
 - Driven by partial vapor pressure differences
 - Function of material property and area

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Vapor Management

- Air Leakage

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Vapor Management

- Vapor Diffusion

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Vapor Management

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Vapor Management

- Wood


Moisture Content vs. Relative Humidity

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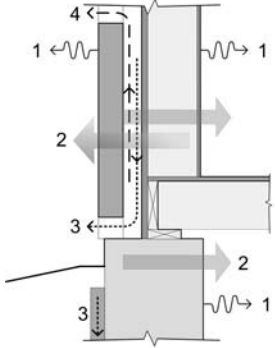
Moisture Storage


- High Storage
 - Masonry
 - Concrete
- Moderate Storage
 - Wood (Cellulose)
- No Storage
 - Glass(Including Fiberglass insulation)
 - Metal

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Drying

- Drainage
- Ventilation
- Vapor Diffusion



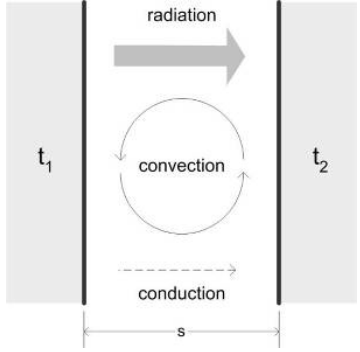
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Thermal Control



Basic Heat Flow


- Conduction
- Convection
- Radiation



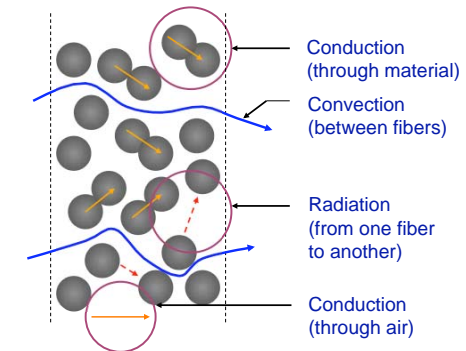
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Heat Flow in Materials

- Function of:
 - Material Type
 - Density and pore structure
 - Moisture content
 - Temperature difference
- Combination of:
 - Conduction through material and air (or other gas)
 - Convection in pores
 - Radiation through pores

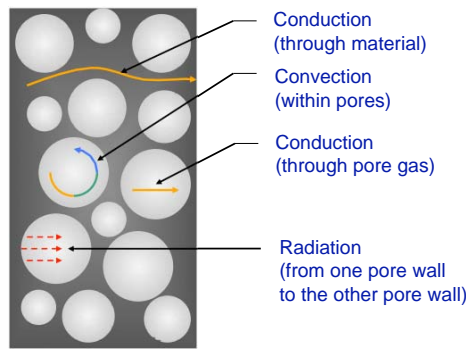
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Heat Flow in Materials



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Heat Flow in Materials

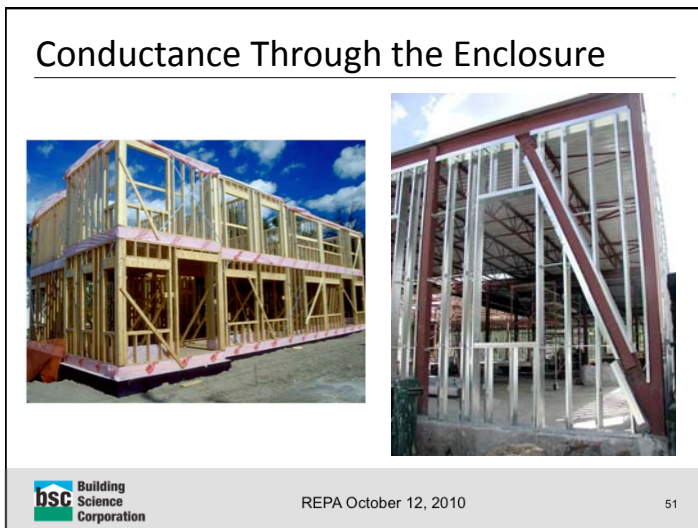
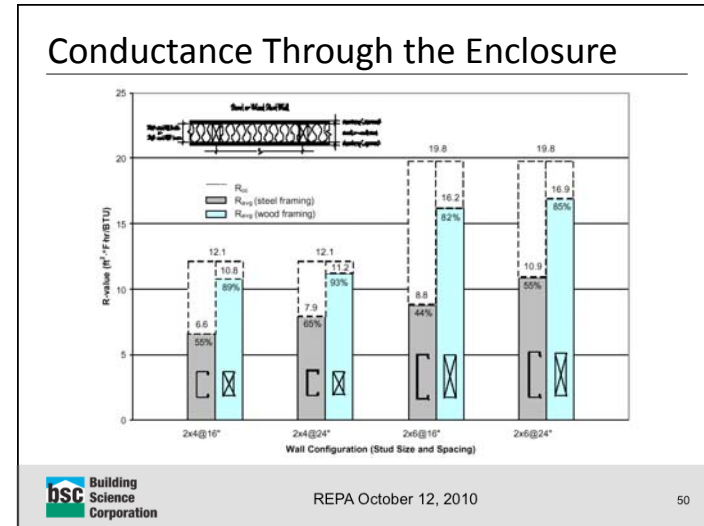
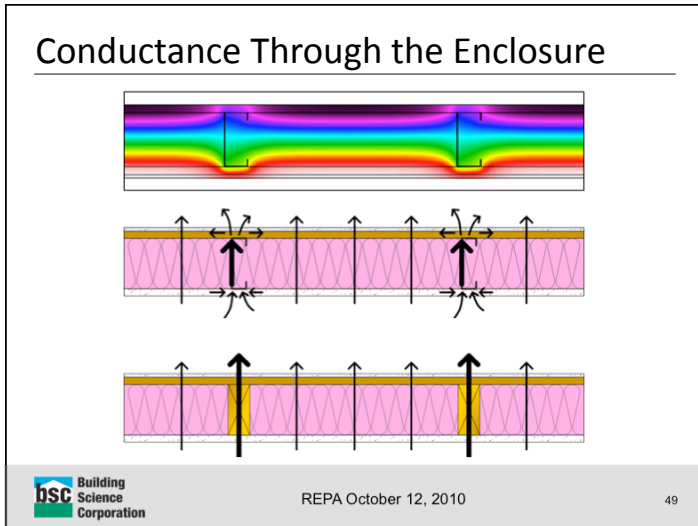


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Heat Flow in Materials

- R-Value or RSI
 - Gives heat flow as “equivalent conductance”
 - Includes all three modes of heat transfer
 - Rarely includes thermal bridging or three dimensional heat flow
 - Never intended to include airtightness or mass

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Convection Through the Enclosure

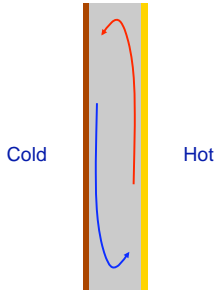
- Commonly referred to as "Air Leakage"
- Driven by air pressure differences
 - Wind
 - Mechanical
 - stack effect
- Large energy impacts (can account for 30% of the heating and cooling energy)

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Convection Within the Enclosure

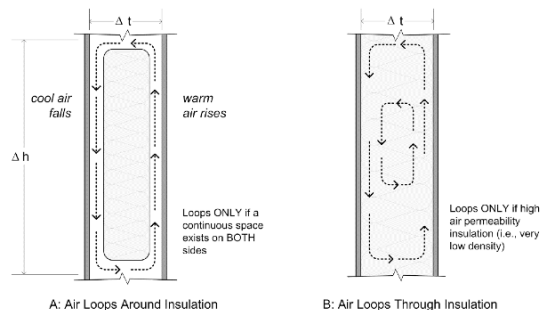
- Commonly referred to as "Convective Loops"
- Driven by natural buoyancy - warm air will rise
- Short circuits insulation
- R-value does not take into account the potential of movement of air within an assembly.



Cold Hot

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Convection Within the Enclosure



A: Air Loops Around Insulation B: Air Loops Through Insulation

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Convection Within the Enclosure



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Convection Within the Enclosure

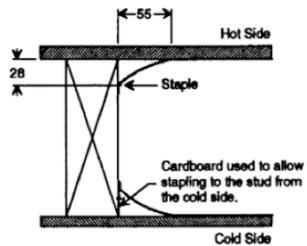
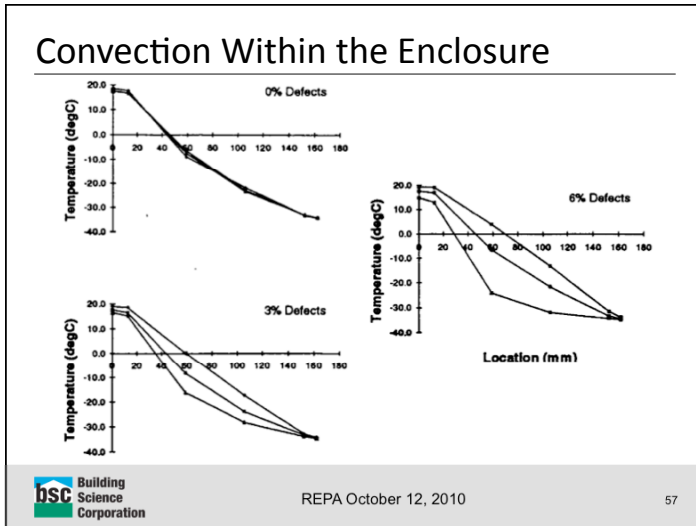


FIGURE 3. Detail of 6% installation defect.

Brown and Bomberg 1993

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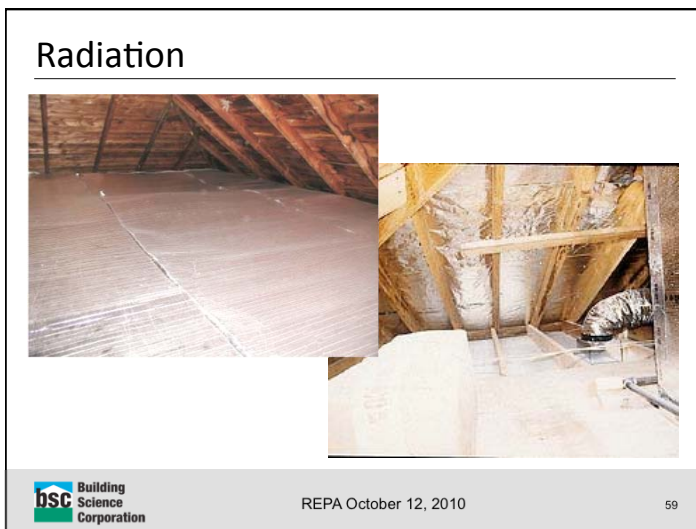


Radiation

- Net radiant flow across a clear cavity
- Emissivity is expressed as a fraction of energy emitted when compared to the radiation from a black body
- Common in attics

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Radiation

- Must have an airspace for radiant products to work
- While low emitting, radiant products are often highly conductive
- Energy will be conducted to other materials in contact with radiant product (framing, dirt)

Cold

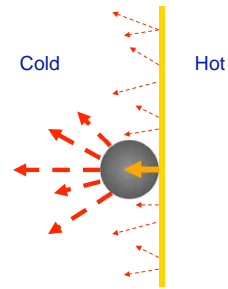
Hot

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Radiation

- Must have an airspace for radiant products to work
- While low emitting, radiant products are often highly conductive
- Energy will be conducted to other materials in contact with radiant product (framing, dirt)



Insulation Types

- Cavity
 - Mineral Fiber Batts
 - Blown/Spray Mineral Fiber
 - Blown/Spray Cellulose
 - Cotton
 - Open Cell Spray Polyurethane
 - Closed Cell Spray Polyurethane

Insulation Types

- Insulating Sheathing
 - Medium Density Mineral Fiber
 - Expanded Polystyrene
 - Extruded Polystyrene
 - Polyisocyanurate
 - Closed Cell Spray Polyurethane

Performance

- Mineral Fiber Batts (Glass/Rock/Slag)
 - R/inch = 2.8 to 3.7
 - Air Permeable
 - Vapor Permeable
 - No moisture storage capacity
 - Uneven cavity fill (difficult to fit around obstructions)
- Blown/Spray Mineral Fiber (Glass/Rock/Slag)
 - R/inch = 2.8 to 3.7
 - Air Permeable
 - Vapor Permeable
 - No moisture storage capacity
 - Even Cavity Fill (net/adhesive holds fibers in place)

Performance

- Mineral Fiber Batts (Glass/Rock/Slag)
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 - Vapor Permeable
 - No moisture storage capacity
 - Even Cavity Fill (net/adhesive holds fibers in place)



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Performance

- Blown/Spray Cellulose
 - R/inch = 3.0 to 3.7
 - Air Permeable (higher density = some resistance to air flow)
 - Vapor Permeable
 - Some moisture storage capacity
 - Even Cavity Fill (net/adhesives hold fibers in place)
- Cotton
 - R/inch = 3.0 to 3.7
 - Air Permeable (Some resistance to air flow)
 - Vapor Permeable
 - Some Moisture Storage Capacity
 - Even Cavity Fill



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Performance

- Open Cell Spray Polyurethane
 - R/inch = 3.6 to 3.8
 - Air Impermeable (good air barrier <math><0.01\text{ lps/m}^2</math> @ 75 Pa, controls convective loops)
 - Vapor Permeable
 - Moisture Resistant
 - Even Cavity Fill (expands to fill voids)
- Closed Cell Spray Polyurethane
 - R/inch = 5.8 to 6.8
 - Air Impermeable (good air barrier <math><0.01\text{ lps/m}^2</math> @ 75 Pa, controls convective loops)
 - Vapor Semi-impermeable (1 – 2 perms for 2" thickness)
 - Moisture Resistant
 - Even Cavity Fill (expands to fill voids)



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Performance

- Medium Density Mineral Fiber (Glass/Rock/Slag)
 - R/inch = 4.0 to 4.4
 - Air Permeable (resistance to wind washing)
 - Vapor Permeable
 - Moisture Resistant (good drainage for rock/slag)
- Expanded Polystyrene
 - R/inch = 3.6 to 4.4
 - Air Impermeable (air barrier if joints taped?)
 - Vapor Semi-impermeable (3 – 4 perms)
 - Moisture Resistant



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Performance


- Extruded Polystyrene
 - R/inch = 5.0
 - Air Impermeable (air barrier if joints taped?)
 - Vapor Semi-impermeable (0.5 perms for 2" thickness)
 - Moisture Resistant
- Polyisocyanurate
 - R/inch = 6.0 to 6.5
 - Air Impermeable (air barrier if joints taped?)
 - Vapor Semi-Impermeable or Impermeable (<1 glass fiber faced, 0.03 perms for foil faced)
 - Moisture Resistant

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Performance

- Closed Cell Spray Polyurethane
 - R/inch = 5.8 to 6.8
 - Air Impermeable (good exterior air barrier system <0.01 lps/m2 @ 75 Pa)
 - Vapor Semi-impermeable (1 - 2 perms for 2" thickness)
 - Moisture Resistant (can act as a drainage plane behind a cladding system)

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Wall Assemblies



Wall Assemblies

- How much insulation?
- Comfort & moisture –
 - **True** R-10 is usually enough in Zone 6, but
- For energy / environment / economics
 - as much as *practical*
- Practical constraints likely the limit
 - How much space available in studs?
 - Moisture concerns
 - Fastening, windows: exterior sheathing of 1.5"/4"
- Increased insulation can reduce HVAC purchase/install cost as well as operating!



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Wall Assemblies

- Add up the R-values of the layers to get the total R-value of the assembly
- **BUT** the actual thermal resistance of an assembly is affected by
 - **Thermal Bridges**
 - **Thermal Mass**
 - **Air Leakage**



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True R-value

- Includes realistic framing factors
 - 3D heat loss
 - Realistic framing factors
 - (16% advanced framing, 25% normal)
- Should include airtightness
 - But we don't have a metric yet
- Durability also matters
 - No one metric will work

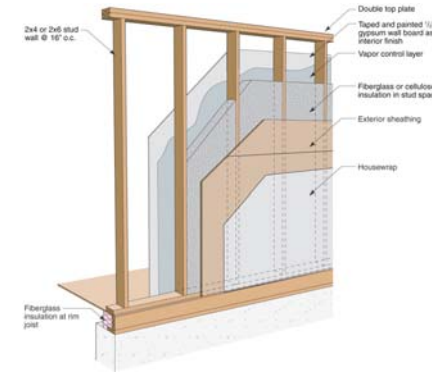
Durability


- Condensation occurs on cold surface
- Drying occurs slowly when cold
- Ergo... Insulating makes things wetter!
- Air & water vapor moves through fiberglass and cellulose
- Foam stops air and slows vapor


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Wall Assemblies


- Wood framed wall with cavity insulation





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Wall Assemblies

- Cavity Insulation Options
 - Fiberglass/Cellulose/Cotton/Open Cell SPF/Closed Cell SPF
 - Combinations?
- Retrofits change the dynamic of the wall assembly
 - How is the moisture balance affected?
- Building operation is changing to meet peoples comfort needs
 - Can't guarantee interior environmental conditions
 - Look for more resistant/robust assemblies


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Wall Assemblies




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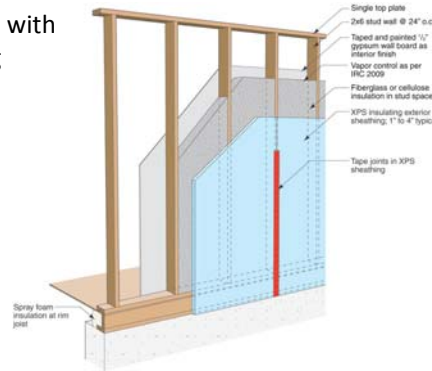
Wall Assemblies


- Retrofits?
 - Address water management concerns – required for all
 - How will it affect the drying of the assembly?
 - Will it reduce wetting?
 - What about built in moisture?
 - Cladding impacts?
 - Other elements?


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Wall Assemblies

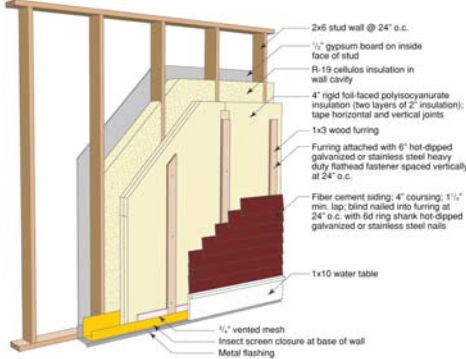
- Wood framed wall with exterior insulating sheathing




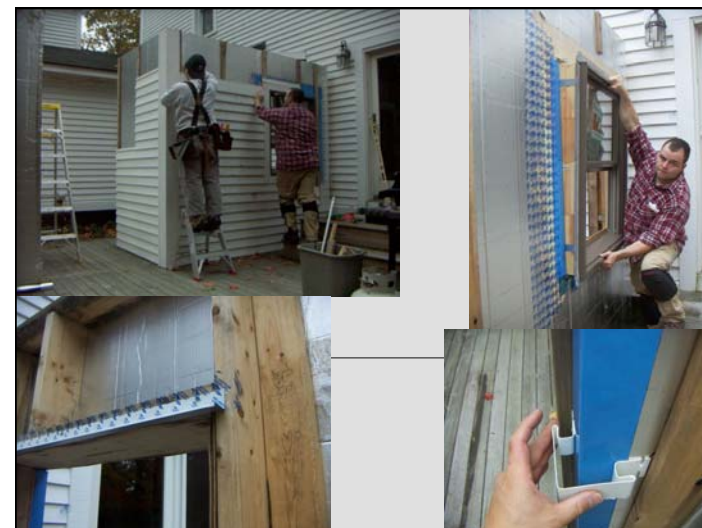

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Wall Assemblies

- Wood framed wall with thick exterior insulating sheathing



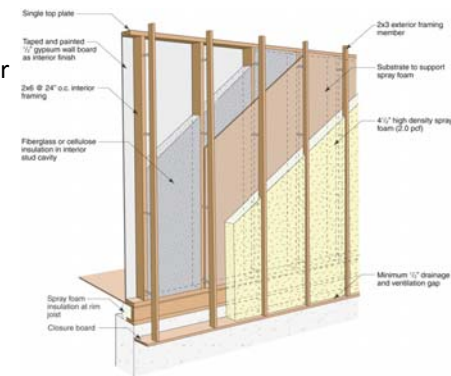

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Wall Assemblies

- Wood framed wall with exterior closed cell spray foam insulation and drainage plane



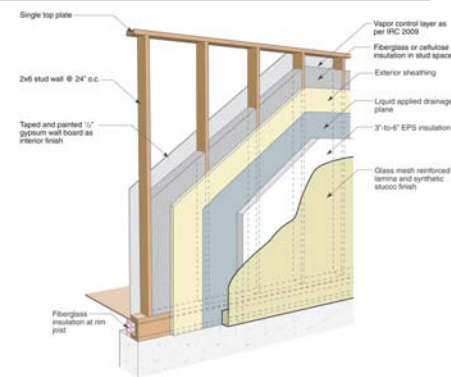
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Wall Assemblies

- Wood framed wall with EIFS cladding



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Wall Assemblies

- Wood framed wall with interior horizontal strapping

Labels in diagram:

- Single top plate
- 2x6 stud wall @ 24" o.c.
- Fiberglass or cellulose insulation in stud space
- OSB exterior sheathing
- Housewrap
- Fiberglass insulation at rim joist
- Housewrap is wrapped around rim joist for air barrier continuity
- 6 mil polyethylene air and vapor barrier between framing and strapping
- 2x3 horizontal strapping
- R-8 fibrous insulation between strapping
- Taped and painted 1/2" gypsum wall board as interior finish

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Wall Assemblies

- Double stud wall

Labels in diagram:

- Single top plate
- 2x4 exterior wall @ 16" o.c.
- Cellulose insulation in 2x4 exterior wall stud spaces
- OSB exterior sheathing
- Housewrap
- Cellulose insulation in gap between framing
- 6 mil polyethylene air and vapor barrier on outside of interior wall
- Cellulose insulation in 2x3 interior wall stud spaces
- 2x3 interior wall
- Taped and painted 1/2" gypsum wall board as interior finish
- Board foam blocking sealed airtight
- Cellulose insulation at rim joist

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Construction issues

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Wall Assemblies

- Larsen truss wall

Labels in diagram:

- Double top plate
- 2x4 exterior framing member
- Cellulose insulation in wall cavity
- OSB exterior sheathing
- Housewrap
- Fiberglass insulation at rim joist
- Capillary break
- Ledger board
- 2x4 interior framing member @ 16" o.c.
- 6 mil polyethylene air and vapor barrier between 2x4 framing and gypsum wall board
- Taped and painted 1/2" gypsum wall board as interior finish
- Physed cavity closure at each floor

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Wall Assemblies

- SIP wall

Labels in diagram:
Vertical stiffener
Taped and painted 1/2" gypsum wall board as interior finish
OSB interior panel
EPS insulation core
OSB exterior panel
Housewrap

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Wall Assemblies

- Mass Wall

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Roof Assemblies

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Roof Assemblies

- How much insulation?
- For energy / environment / economics
 - as much as *practical*
- Practical constraints likely the limit
 - How much space available?
 - Rafter depth
 - Moisture concerns
 - Vented/Unvented – material deterioration?
- Increased insulation can reduce HVAC purchase/install cost as well as operating!



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Vented Attics

- Why ventilate?
 - Remove excess heat and moisture
 - Prolong service life of shingles
 - Control ice damming



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Vented Attics

- Retrofits
 - Can re-roof whenever, with whatever
 - Deal with moisture, then add insulation
 - Rain leaks, air leaks
 - If possible, keep ventilated attic
 - Inspect ceiling plane, plug all holes with caulking and foam
 - Consider 1" of spray foam air barrier
 - Blow in minimum R60 cellulose, R75-R100 sensible

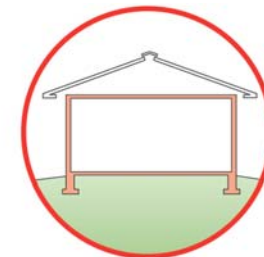


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Roof Assemblies

- Common assembly
- Easy to get higher levels of insulation
- Need to provide an air seal the ceiling plane

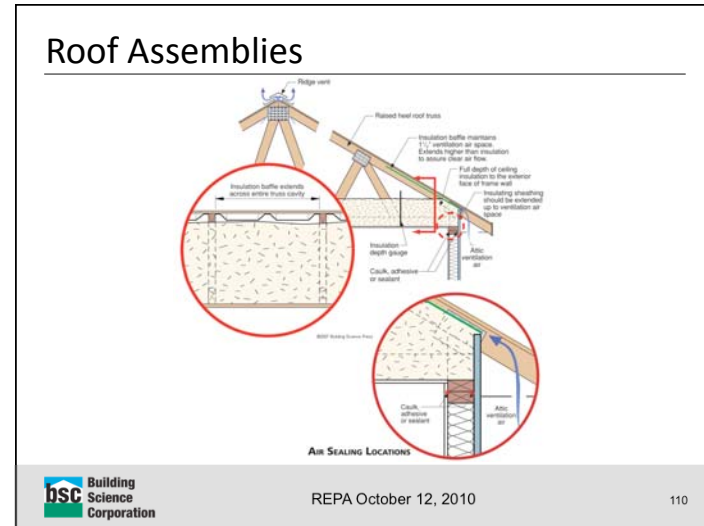
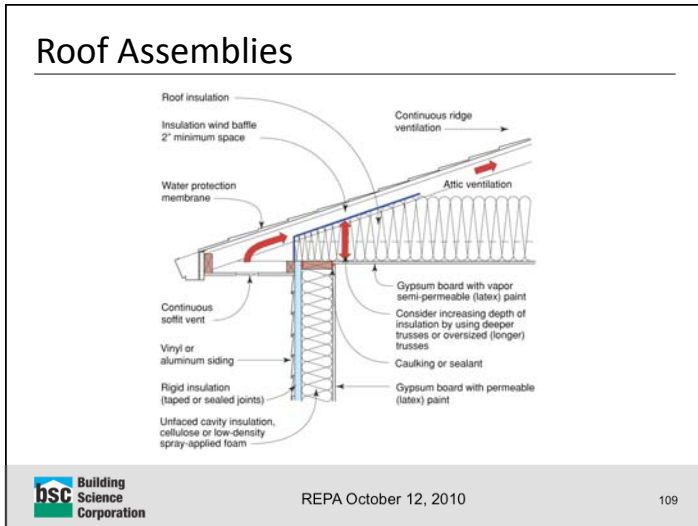


Vented attic with insulation at ceiling;
mechanical equipment should be located
inside the conditioned space; can
also have a tray ceiling



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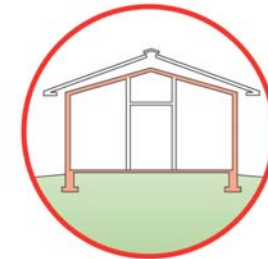
108





Roof Assemblies

- Cathedral ceilings are common in New England
- Rafter depth can create a challenge for insulation thickness while still providing ventilation
- Air sealing occurs at the ceiling plane



Vented attic with cathedral ceiling; mechanical equipment should be located inside the conditioned space

Roof Assemblies

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Roof Assemblies

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Roof Assemblies



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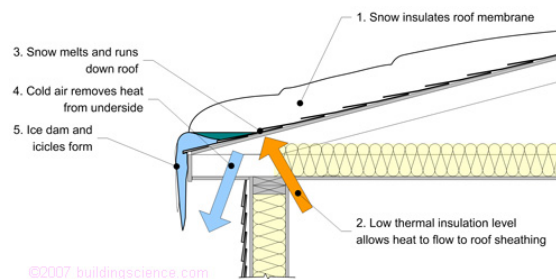
117



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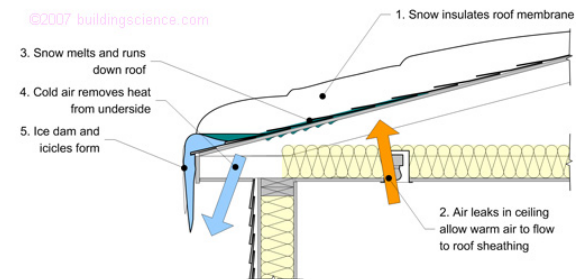
Ice Damming



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Ice Damming



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Ice Damming



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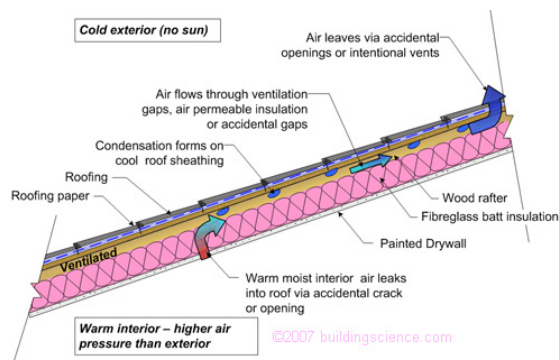
Ice Damming



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Condensation



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Condensation




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Unvented Roof

- Why use a hot roof?
 - Mechanical in the attic
 - Complicated ceiling geometry make air sealing difficult
 - Control ice dams?

- Why not to use a hot roof?
 - Control of ice dams?
 - Reduced shingle life?

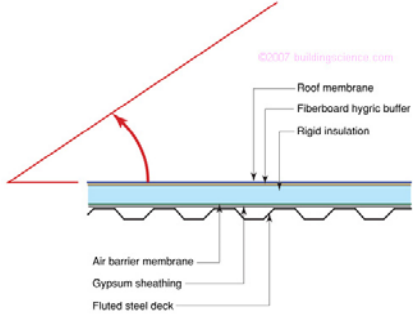



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Unvented Roof

- Long history of performance





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Unvented Roof

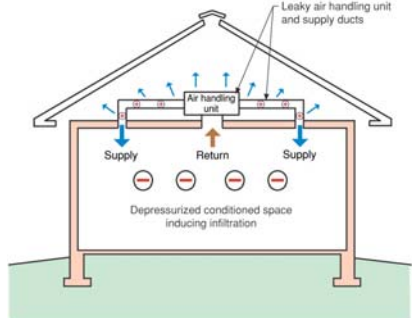





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Unvented Roof



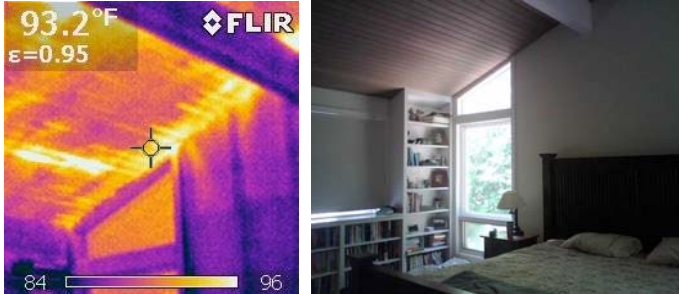
Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.



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Why an Unvented Roof?



93.2°F
ε=0.95

FLIR


84 96

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Why an Unvented Roof?



84.6°F
ε=0.95

FLIR


84 103

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Why an Unvented Roof?



87.8°F
ε=0.95

FLIR

84 104

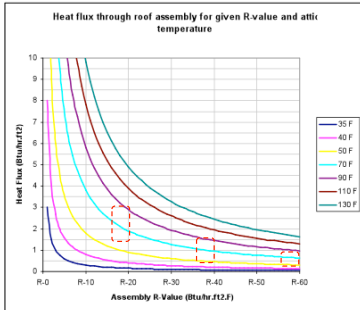
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Unvented Roof

- Ice Damming
 - Function of rate of heat loss through thermal insulation – Heat Flux
 - Cannot prevent snow melt – can reduce the rate to the point where ice dams will not form
 - Empirical evidence has demonstrated good success



Heat flux through roof assembly for given R-value and attic temperature

Heat Flux (Btu/hr·ft²)

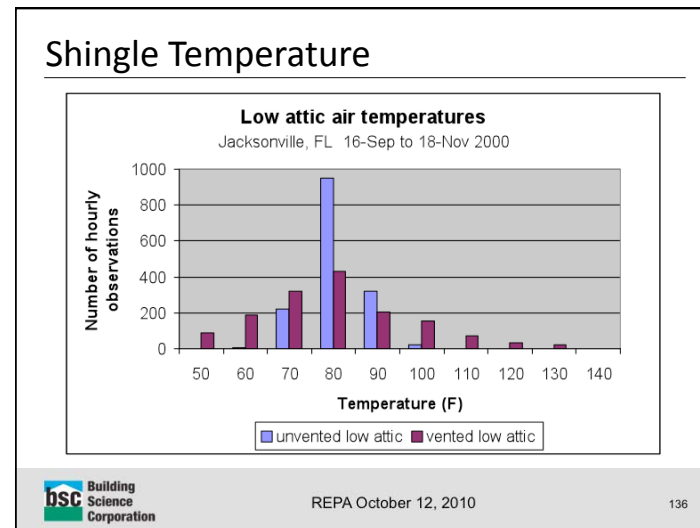
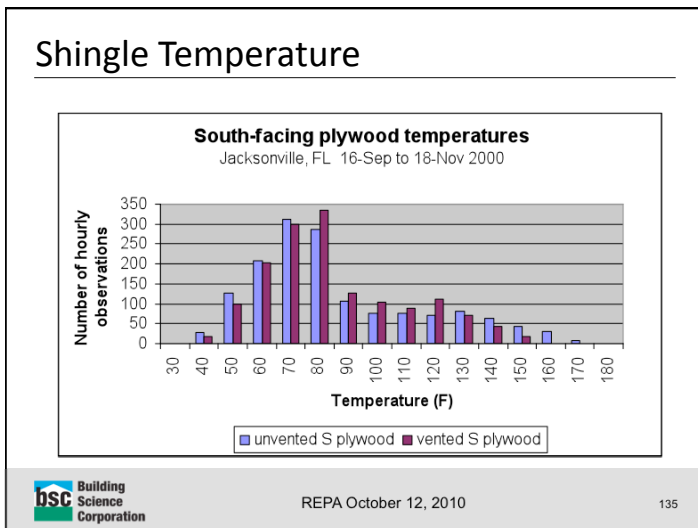
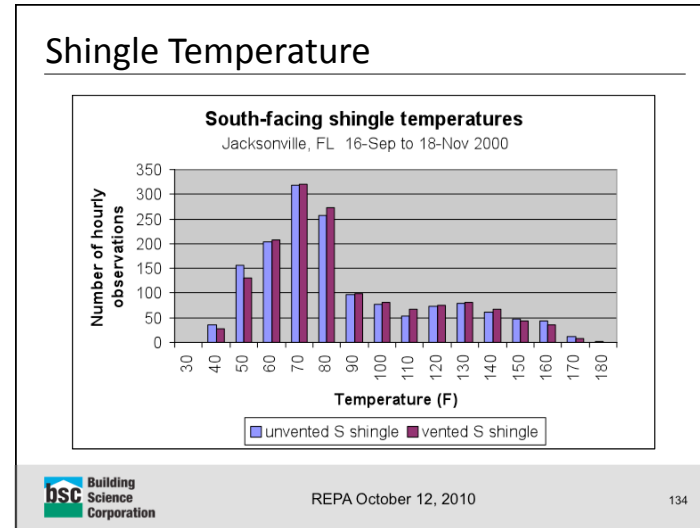
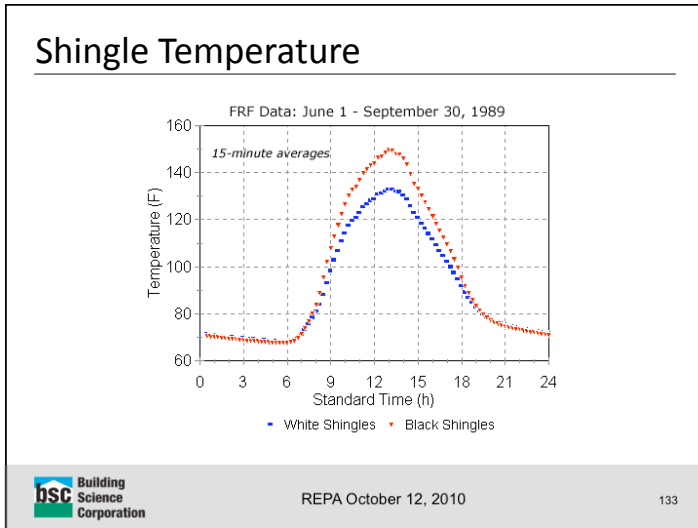
Assembly R-Value (ft²·h/F)

35 F
40 F
50 F
70 F
90 F
110 F
130 F

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Building Code

Excerpt from 2006 IRC

SECTION R806 ROOF VENTILATION

R806.1 Ventilation required. Enclosed attics and enclosed rafter spaces formed where ceilings are applied directly to the underside of roof rafters shall have cross ventilation for each separate space by ventilating openings protected against the entrance of rain or snow. Ventilating openings shall be provided with corrosion-resistant wire mesh, with 1/4 inch (3.2 mm) minimum to 1/4 inch (6 mm) maximum openings.

R806.2 Minimum area. The total net free ventilating area shall not be less than 1/150 of the area of the space ventilated except that reduction of the total area to 1/300 is permitted, provided that at least 50 percent and not more than 80 percent of the required ventilating area is provided by ventilators located in the upper portion of the space to be ventilated at least 3 feet (914 mm) above the eave or cornice vents with the balance of the required ventilation provided by eave or cornice vents. As an alternative, the net free cross-ventilation area may be reduced to 1/300 when a vapor barrier having a transmission rate not exceeding 1 perm (5.7×10^{-11} kg/s · m² · Pa) is installed on the warm-in-winter side of the ceiling.

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Building Code

Excerpt from 2006 IRC

R806.4 Conditioned attic assemblies. Unvented conditioned attic assemblies (spaces between the ceiling joists of the top story and the roof rafters) are permitted under the following conditions:

1. No interior vapor retarders are installed on the ceiling side (attic floor) of the unvented attic assembly.
2. An air-impermeable insulation is applied in direct contact to the underside/interior of the structural roof deck. "Air-impermeable" shall be defined by ASTM E 283.

Exception: In Zones 2B and 3B, insulation is not required to be air impermeable.

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Building Code

Excerpt from 2006 IRC

4. In Zones 3 through 8 as defined in Section N1101.2, sufficient insulation is installed to maintain the monthly average temperature of the condensing surface above 45°F (7°C). The condensing surface is defined as either the structural roof deck or the interior surface of an air-impermeable insulation applied in direct contact with the underside/interior of the structural roof deck. "Air-impermeable" is quantitatively defined by ASTM E 283. For calculation purposes, an interior temperature of 68°F (20°C) is assumed. The exterior temperature is assumed to be the monthly average outside temperature.

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Building Code


Excerpt from 2007 IRC Supplement

R806.4 Unvented attic assemblies. Unvented attic assemblies (spaces between the ceiling joists of the top story and the roof rafters) shall be permitted if all the following conditions are met:

1. The unvented attic space is completely contained within the building thermal envelope.
2. No interior vapor retarders are installed on the ceiling side (attic floor) of the unvented attic assembly.
3. Where wood shingles or shakes are used, a minimum 1/4 inch (6 mm) vented air space separates the shingles, or shakes, and the roofing underlayment above the structural sheathing.
4. In climate zones 5, 6, 7 and 8, any air-impermeable insulation shall be a vapor retarder, or shall have a vapor retarder coating or covering in direct contact with the underside of the insulation.
5. Either items a, b or c shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.
 - a. Air-impermeable insulation only. Insulation shall be applied in direct contact to the underside of the structural roof sheathing.
 - b. Air-permeable insulation only. In addition to the air-permeable installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing as specified in Table R806.4 for condensation control.
 - c. Air-impermeable and air-permeable insulation. The air-impermeable insulation shall be applied in direct contact to the underside of the structural roof sheathing as specified in Table R806.4 for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

CLIMATE ZONE	MINIMUM RIGID BOARD OR AIR-IMPERMEABLE INSULATION R-VALUE *
2B and 3B tie roof only	0 (none required)
1, 2A, 2B, 3A, 3B, 3C	R-5
4C	R-10
4A, 4B	R-15
5	R-20
6	R-25
7	R-30
8	R-35

a. Contributes to but does not supersede Chapter 11 energy requirements.



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Building Code


Excerpt from 7th Edition Mass Code for 1 and 2-family dwellings

**SECTION 5806
ROOF VENTILATION**

5806.1 Ventilation required. Enclosed attics and enclosed rafter spaces formed where ceilings are applied directly to the underside of roof rafters shall have cross ventilation for each separate space by ventilating openings protected against the entrance of rain or snow. Ventilating openings shall be provided with corrosion-resistant wire mesh, with 1/4 inch (3.2 mm) minimum to 3/4 inch (6.4 mm) maximum openings.

Exceptions:

1. Roof assemblies where an expanding spray foam insulation material, providing at least 40 percent of the total R-value of the required insulation, is in direct contact with the underside of the roof deck and adjacent framing members. If the permeability of the foam material is less than 2 perm-inch, no vapor barrier is necessary.
2. Roof assemblies where a board foam plastic insulation material, providing at least 40 percent of the total R-value of the required insulation, is placed on top of the roof deck. If the permeability of the foam material is less than 2 perm-inch, no vapor barrier is necessary.



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Building Code

Excerpt from 2006 IRC

R314.5.3 Attics. The thermal barrier specified in Section 314.4 is not required where attic access is required by Section R807.1 and where the space is entered only for service of utilities and when the foam plastic insulation is protected against ignition using one of the following ignition barrier materials:

1. 1.5-inch-thick (38 mm) mineral fiber insulation;
2. 0.25-inch-thick (6.4 mm) wood structural panels;
3. 0.375-inch (9.5 mm) particleboard;
4. 0.25-inch (6.4 mm) hardboard;
5. 0.375-inch (9.5 mm) gypsum board; or
6. Corrosion-resistant steel having a base metal thickness of 0.016 inch (0.406 mm).

The above ignition barrier is not required where the foam plastic insulation has been tested in accordance with Section R314.6.




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Building Code

Excerpt from 2006 IRC

R314.6 Specific approval. Foam plastic not meeting the requirements of Sections R314.3 through R314.5 shall be specifically approved on the basis of one of the following approved tests: NFPA 286 with the acceptance criteria of Section R315.4, FM4880, UL 1040 or UL 1715, or fire tests related to actual end-use configurations. The specific approval shall be based on the actual end use configuration and shall be performed on the finished foam plastic assembly in the maximum thickness intended for use. Assemblies tested shall include seams, joints and other typical details used in the installation of the assembly and shall be tested in the manner intended for use.

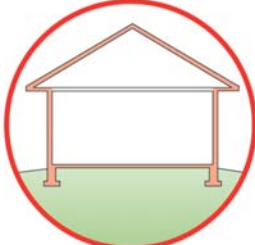


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Roof Assemblies

- Insulation at the roof plane
- Thickness is not a function of the rafter depth
- Material type may have other requirements for ignition, thermal barrier, or vapor control

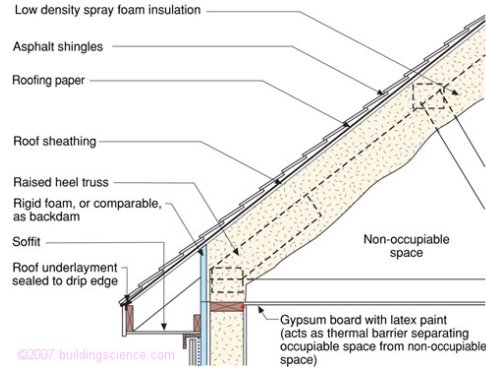


Un-vented attic; mechanical equipment can be located inside the conditioned attic.

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Roof Assemblies



- Low density spray foam insulation
- Asphalt shingles
- Roofing paper
- Roof sheathing
- Raised heel truss
- Rigid foam, or comparable, as backdam
- Soffit
- Roof underlayment sealed to drip edge
- Non-occupiable space
- Gypsum board with latex paint (acts as thermal barrier separating occupiable space from non-occupiable space)

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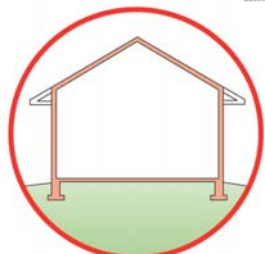
Roof Assemblies



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Roof Assemblies

- Insulation at the plane of the roof deck
- Interior insulation thickness limited by rafter depth – though possible for additional insulation to be added to the interior of the framing
- Exterior insulation is possible



Un-vented cathedral ceilings; can also have knee walls, a raised heel truss, or use scissor trusses.

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Roof Assemblies

Thickness varies according to local building code

Insulation

Heel height should be at least half of the insulation depth

Glue and screw all gypsum board

Rigid insulation should be extended up to the underside of the roof sheathing

Caulk or adhesive

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Roof Assemblies

Exposed structure

Finish layer to be 15 min. fire barrier

Stagger joints in both horizontal and vertical displacement

Rigid insulation (extruded or isocyanurate), thickness varies by code and climate

Air seal all joints to prevent convection and condensation of moisture

Fiberglass insulation

Extend foam board sheathing to underside of roof deck

Caulk or adhesive

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Roof Assemblies

Roof sheathing

Spray foam plastic insulation

Rafter

Cavity insulation

Interior ceiling covering

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Roof Assemblies

Rigid foam plastic insulation sheathing

Roof sheathing

Rafter

Cavity insulation

Interior ceiling covering

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SIP Roofs

0.5" 20" ALUMINUM - CONTINUOUS
GROOVE WITH PANEL OVERLAP AND
TO WALLS LAP OVER BY ONE INCH,
WITH GASKET

FILL JOINT WITH FLAM
RESISTANT, CONTINUOUS ROOF
SEALANT

OVERLAP HEADS
OF GASKET SEALANT

SEAL JOINT WITH
FLAM RESISTANT, CONTINUOUS ROOF
SEALANT

INTERIOR BRICKWALL

CONTINUOUS SEALANT AT
LOWER PANEL JOINT

SECTION

SEALANT
IN LAP

CLIP PROTRUDING
BETWEEN
PANEL EDGES

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SIP Roofs

RIDGE

EAVE

CENTER OF PANELS
NOT AFFECTED

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SIP Roofs

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SIP Roofs

Cold air falls toward
bottom of joint

Rising air cools and
vapor condenses on
underside of top layer

Warm air rises toward
cold side of SIP

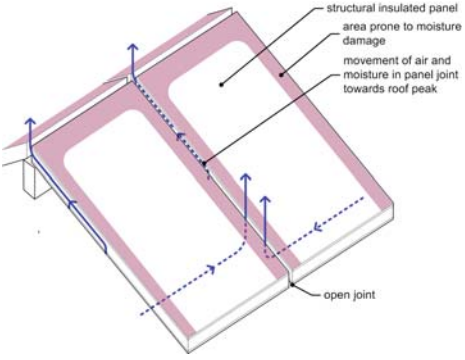
Air returns to interior
through accidental opening

Accidental opening on
inside of joint allows warm
moist air to enter

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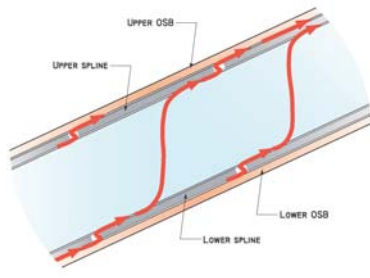
SIP Roofs



structural insulated panel
area prone to moisture
damage
movement of air and
moisture in panel joint
towards roof peak
open joint

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SIP Roofs



UPPER OSB
UPPER SPLINE
LOWER OSB
LOWER SPLINE

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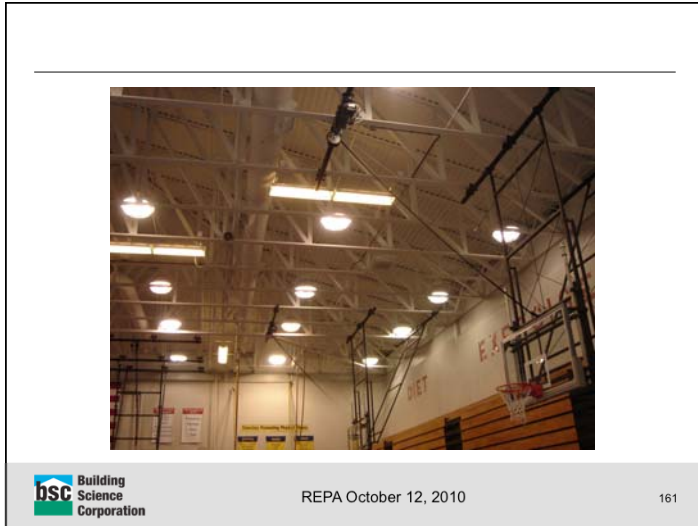
SIP Roofs

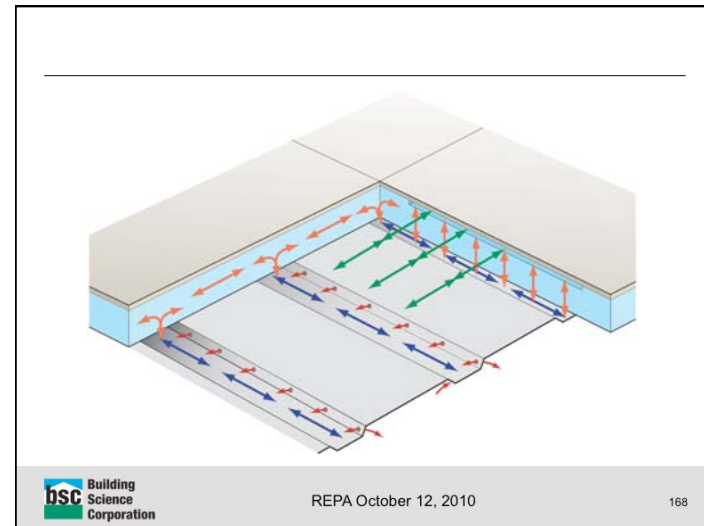
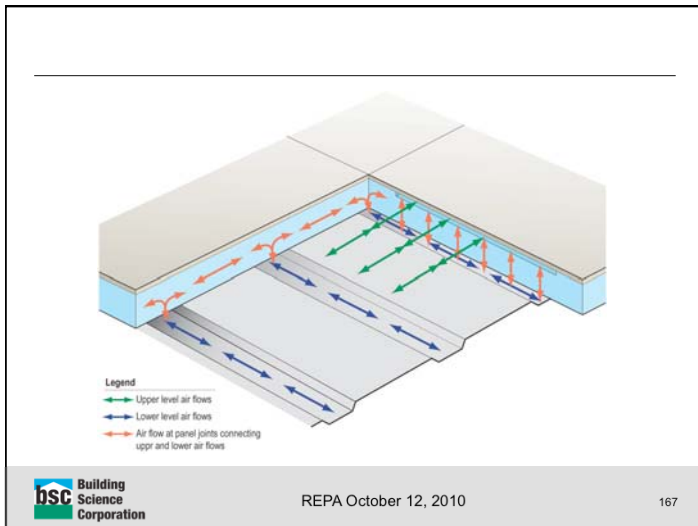
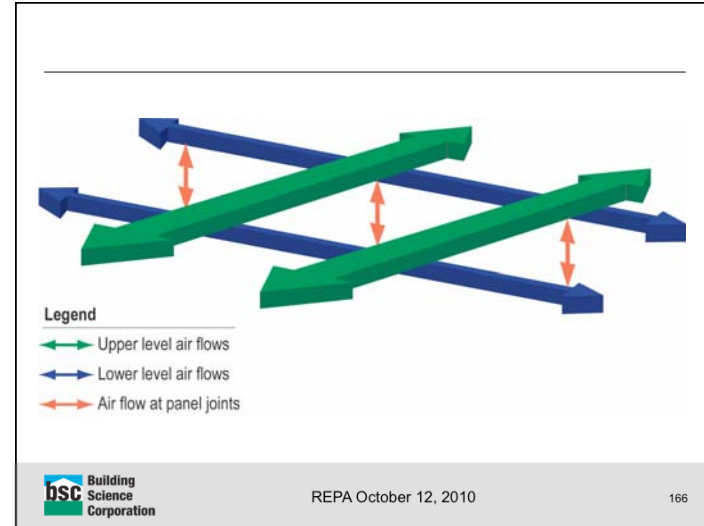
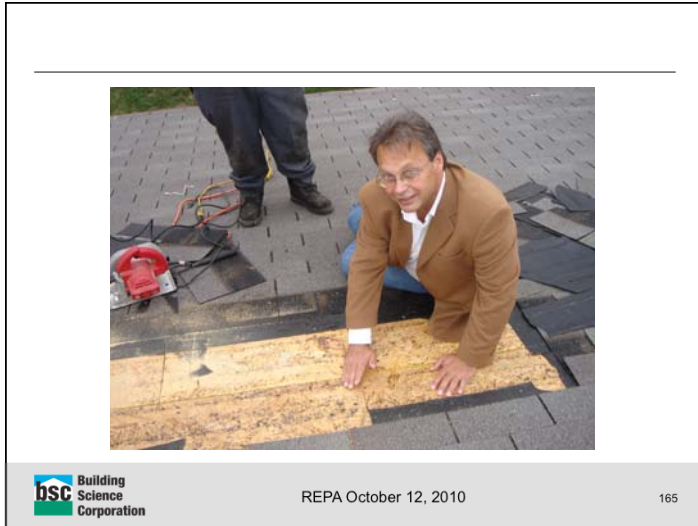


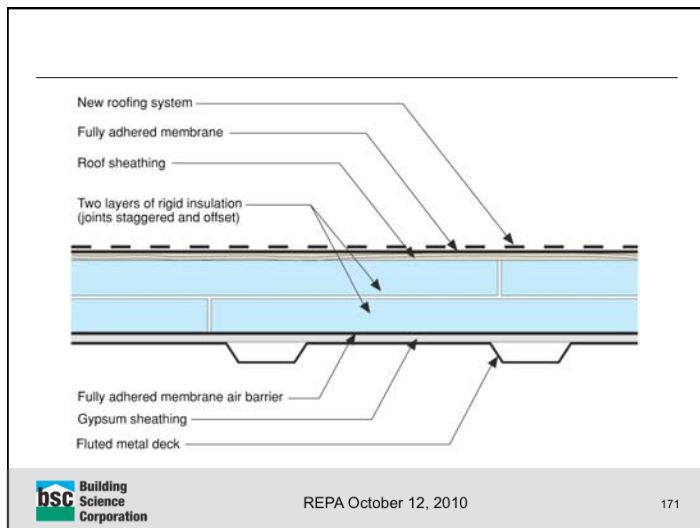
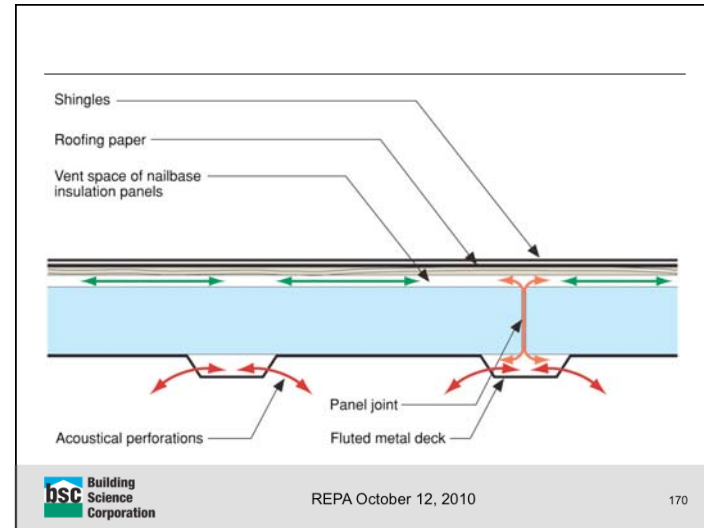
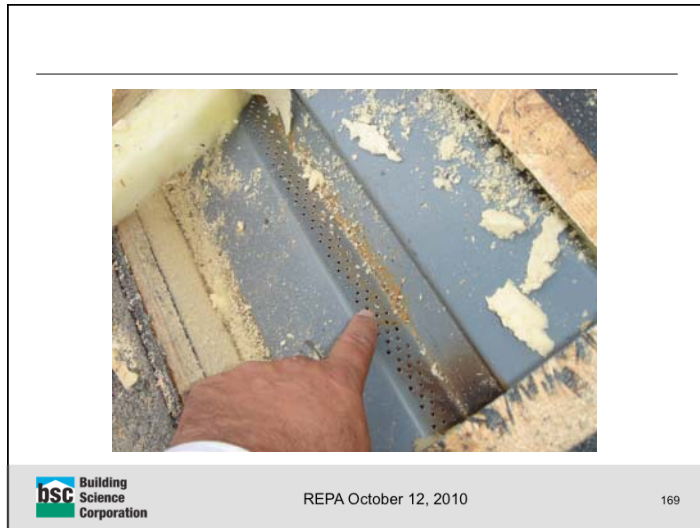
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Questions?

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