Building a Better Thermal Envelope

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Bruce Harley, Technical Director
Conservation Services Group

Goals of Session

Understand the key roles in building performance
- Insulation
- Air sealing materials
- Installation quality

Explore design details and installation practices
Address boundary issues in building cavities
- Moisture
- Airflow

Disclaimer

The emphasis in content of this presentation and the details shown exhibit a bias towards cold climates

That's the author's primary experience

An attempt has been made to identify such places

Thermal Envelope Priorities

Achieve desired R-values
- Based on design intent

Resist moisture damage
- Keep moisture out
- Promote or allow drying

Control air flow
- Reduce energy loads
- Support moisture control objectives

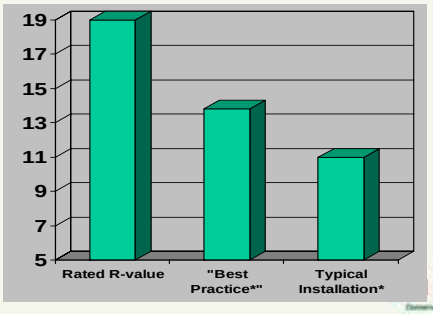
Insulation Priorities

Achieve full R-value
- Installation practices--material itself
- Context (surrounding environment)

Key Properties
- R-value per thickness
- Air permeability
- Vapor permeance

Applications
- Preferences / Limitations / Availability

Insulation performance (Real World)



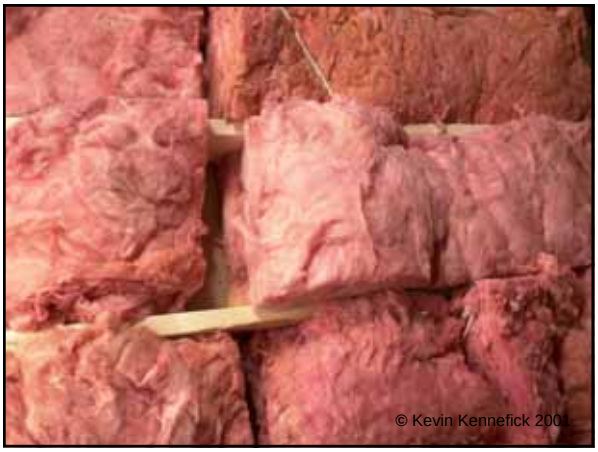
Why is it So Bad?

The gaps and spaces dominate the heat loss

- No matter how much insulation you pile up next to a gap, the heat loss through the gap is not reduced at all

Larger initial R-value = greater effect

- R-38 design, exposed 2x4 truss @24 o.c.
  - Net = R-24.4
  - Add 2% gap, net = R-19




Blown-in Blanket (BIB) Fiberglass
CSG


Damp spray cellulose

Targeted Spray Foam

Band joist area
Rafter / ceiling joist / wall intersection
Difficult areas
- Dormers
- Odd framing bays
- Unvented roofs

Ducts in attic

Key Insulation Properties

All fiber products are air and vapor permeable

- Must control wind washing (both sides, esp. exterior)
- Must pay attention to vapor control (in most climates)
- Must pay attention to air barrier alignment and enclosure

Most foams need to have 15-minute thermal barrier

- "Ignition barrier" in attics that have HVAC access

High density foam provides vapor control

Even foam only seals where it is

Eave baffles

Pre-cut for 16 o.c. or 24 o.c.

Staple in place fast

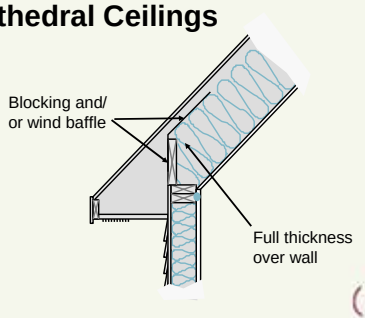
Help prevent wind washing

Prevent filling of soffit area

No need for "propa-vents"

Spray Foam at Eaves

Cathedral Ceilings



Cantilever Solutions

(from EPA thermal bypass checklist guide)

Key Moisture Control Strategies

Prevent water getting in from outside
- Roof – walls - foundation

Limit air flow
- – Spray foams; air sealing

Keep vapor barrier warm w/ proper insulation

Exterior rigid foam insulation
- – Keeps sheathing warm
- – Adds R-value with vapor control

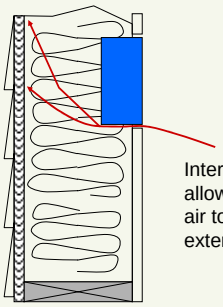
Air barriers

What do they have to do with moisture?

- **Cold climate**

Interior and Exterior Air Barriers

• Cold climate (reversible)

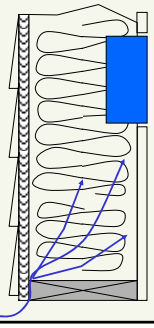


Interior air leaks allow warm humid air to reach the exterior sheathing

Interior and Exterior Air Barriers

• Cold climate (reversible)

Exterior air leaks allow wind washing and chilling of interior vapor barrier



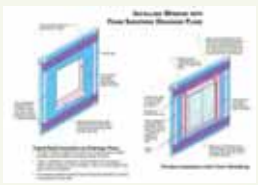
Keeping water out

www.buildingscience.com

Click on “Homeowner resources”

www.eeba.org

Water Management Guide

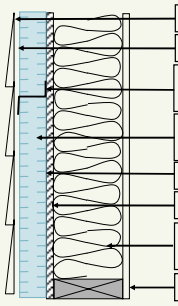


CSG

“Rain Screen” Wall

From *Fine Homebuilding* February/March 2001

Moisture-resistant Wall (any climate)



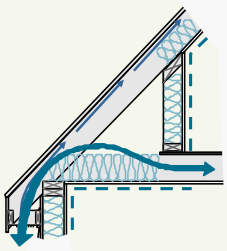
- Exterior cladding
- Air space for drainage (furring)
- Z-flashing at horizontal joints (optional); Pan flashings at window/door openings
- 1.5-2" Extruded polystyrene, seal edges. Horizontal joints *not* staggered.
- **Ridged** sheathing wrap (“drain wrap”)
- Exterior structural sheathing
- 2x4 structural wall, R-11 batt or blown insulation
- Gypsum wallboard with latex paint

Air barriers

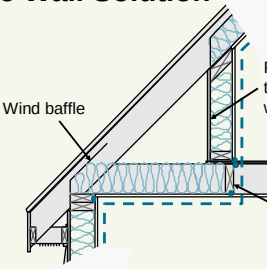
How?

- **Cold climate**

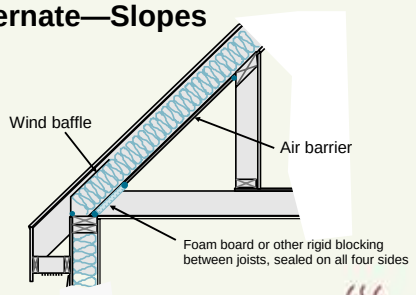
Attic Knee Wall



Knee Wall Solution



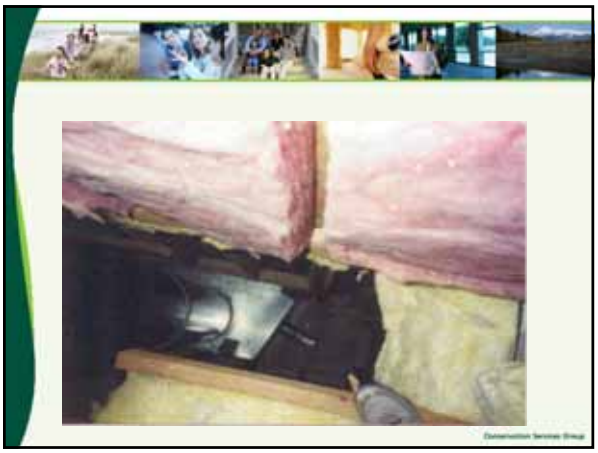
Alternate—Slopes



2.6 Wall Adjoining Porch Roof

- "Air barrier is installed at the intersection of the porch roof and exterior wall"


Images courtesy of Energy Services Group



R602.8 Fireblocking required. Fireblocking shall be provided to cut off all concealed draft openings (both vertical and horizontal) and to form an effective fire barrier between stories, and between a top story and the roof space.

R1001.16 Chimney fireblocking. All spaces between chimneys and floors and ceilings through which chimneys pass shall be fireblocked with noncombustible material securely fastened in place.

Roof Moisture Control

Conventional Strategies:
Ventilate roof
- Ridge, soffit
- "Propa-vents"

Vapor barrier
- Polyethylene
- Kraft faced batts

Moisture control in roof spaces

Vent it when you can—it's a good idea
Much more important:
- Continuous insulation well installed
- Continuous air barrier

Venting loses effectiveness when there's good insulation and air barrier
Also, interior humidity control helps (cold climates)

Strategies to reduce roof moisture risk

Seal air leaks
- Manually or w/ cavity foam insulation

Reduce vapor drive from interior
- Mechanical ventilation in building / moisture control
- Class III vapor retarder (Zones 4-5) = latex paint
- Class II VR (Zone 6-7) = kraft facing, VR paint, 1" XPS

Keep sheathing warm with rigid foam
- Expensive on roof

Limit vapor drive and air flow by spraying foam
- Low density foam needs vapor control in some climates

Insulated sloped ceilings:

Air barrier required except if closed cell spray foam

2004 IRC Supplement

Section R806.4 Add new section as shown: (EC48-03/04)

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.

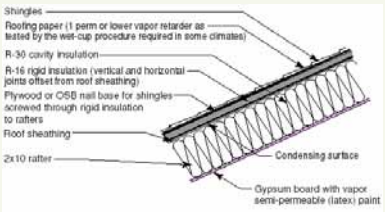
3. In the warm humid locations as defined in Section N1101.2.1:
   a. For asphalt roofing shingles: A 1-perm (57.4 mg/s · m^2 · Pa) or less vapor retarder (determined using Procedure B of ASTM E 96) is placed to the exterior of the structural roof deck; i.e., just above the roof structural sheathing.
   b. For wood shingles and shakes: a minimum continuous 1/4-inch (6 mm) vented air space separates the shingles/shakes and the roofing felt placed over the structural sheathing.

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 to 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.

The following detail drawings are from:

http://www.buildingscience.com

→"Technical Resources"
→"Building Science Information Resources"
→"Roofs"



R-46 Unvented Roof Assembly

- Two layers of R-6.5/inch rigid insulation yielding a total combined thickness of 2.5 inches
- Layers of rigid insulation have staggered joints to facilitate air tightness; two layers are preferable to one layer due to increase in air flow resistance

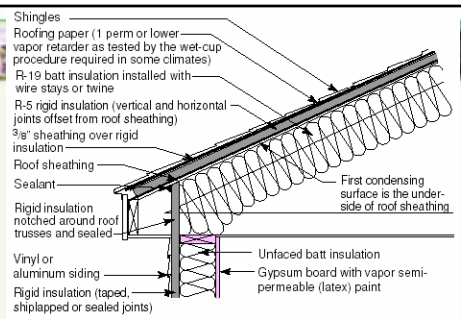


Figure 2
Rigid Insulation Used to Control Condensing Surface Temperatures

- Rigid insulation installed above roof deck
- Ratio of R-value between rigid insulation and batt insulation is climate-dependent

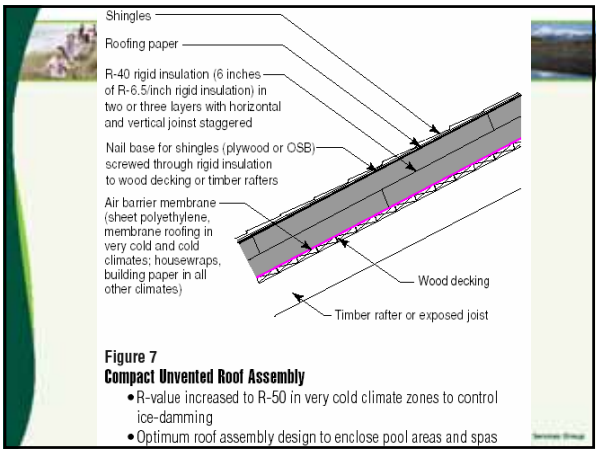


Figure 7
Compact Unvented Roof Assembly

- R-value increased to R-50 in very cold climate zones to control ice-damming
- Optimum roof assembly design to enclose pool areas and spas

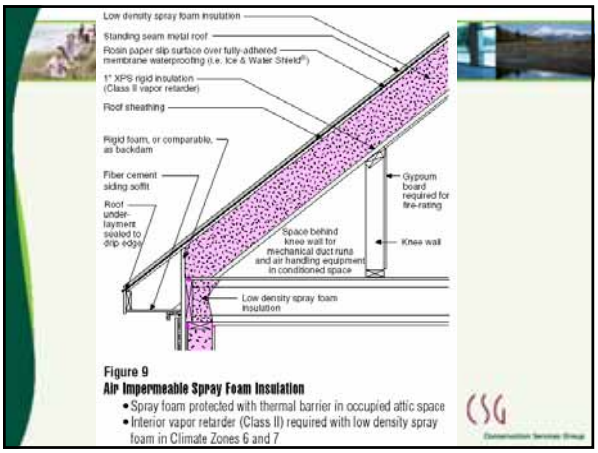


Figure 9
Air Impermeable Spray Foam Insulation

- Spray foam protected with thermal barrier in occupied attic space
- Interior vapor retarder (Class II) required with low density spray foam in Climate Zones 6 and 7

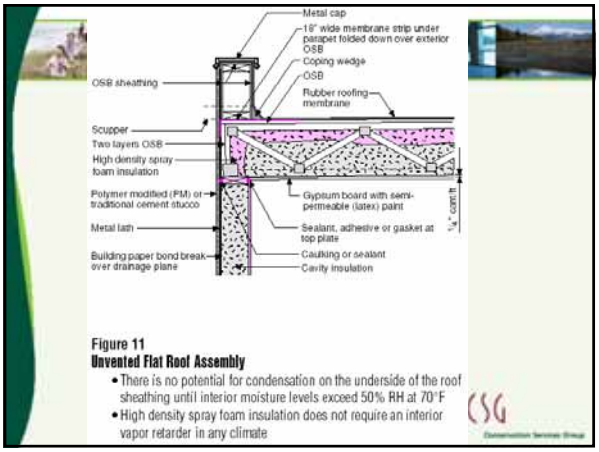


Figure 11
Unvented Flat Roof Assembly

- There is no potential for condensation on the underside of the roof sheathing until interior moisture levels exceed 50% RH at 70°F
- High density spray foam insulation does not require an interior vapor retarder in any climate

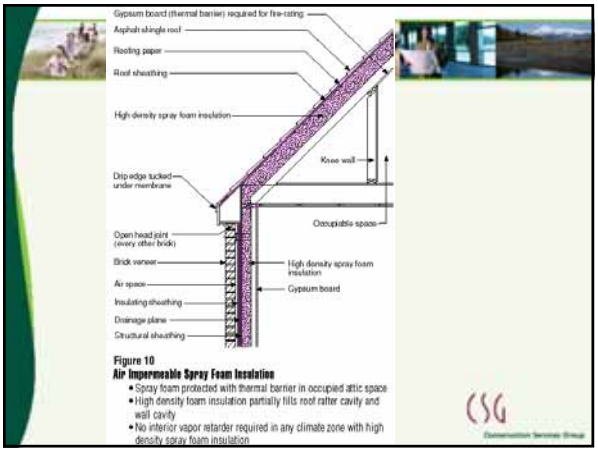


Figure 10
Air Impermeable Spray Foam Insulation

- Spray foam protected with thermal barrier in occupied attic space
- High density foam insulation partially fills roof rafter cavity and wall cavity
- No interior vapor retarder required in any climate zone with high density spray foam insulation