Unvented Roofs

• Background
  – Desire for unvented roofs
  – Code R-values are increased and enforced
  – IRC/IBC now have different rules for vapor control and unvented roofs

• Computer-model study
  – Focus on vapor control
  – Consider impacts of air leakage
In practice, attics are usually well-ventilated.
Accommodate small mistakes in ceiling air leaks and roofing rain leaks.

Ventilated Cathedral Ceiling

Increased R-value w/interior insulation
Hard to Vent

Vented Attics
- Ductwork placed in ventilated attics!
- Complex roof shapes hard to vent

Unvented Cathedral Ceilings
- Not absolutely necessary to vent if airtight and vapour tight material in framing,
  - e.g. spray foam
  - beware thermal bridges
- If no wetting, little drying required
  - Demands high performance
- Or warm surfaces
  - E.g. air impermeable insulation on exterior
  - Air impermeable insulation in framed cavity

Unventilated Cathedral Ceiling

Unventilated Cathedral Roof

Example of Pitched and unventilated Cathedral Ceiling Roof

Unvented-vented hybrid

Example of Pitched, Ventilated, Exterior Insulated Cathedral Ceiling Roof

IRC Required R-values

- Must meet the code minimum's
- Installed R-value
  - Zones 1-3: R30
  - Zones 4-5: R38
  - Zones 6-7: R49

Vented cathedral
Simple gable roofs
Is it airtight enough?

Unvented roof for more complex roof lines
Moisture Study

- Investigate vapor and air control requirements of unvented roofs in all climate zones
- Hybrid insulation of particular interest
- WUFI 4.0 Modeling

Simulation Matrix

<table>
<thead>
<tr>
<th>DOE Zone &amp; City (12)</th>
<th>Code Required Value (4)</th>
<th>Roofing Type</th>
<th>Insulation Type (9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Miami</td>
<td>30</td>
<td>Dark asphalt</td>
<td>Spray fiberglass (1.8 pcf)</td>
</tr>
<tr>
<td>2A Houston</td>
<td>30</td>
<td>Tile (ventilated)</td>
<td>1&quot; osPF + spray fiber</td>
</tr>
<tr>
<td>2B Phoenix</td>
<td>30</td>
<td>Light metal</td>
<td>1&quot; osPF + spray fiber glass</td>
</tr>
<tr>
<td>3A Atlanta</td>
<td>30</td>
<td>Cedar shakes</td>
<td>2&quot; osPF + spray fiber glass</td>
</tr>
<tr>
<td>3B San Francisco</td>
<td>30</td>
<td></td>
<td>Full-depth osPF</td>
</tr>
<tr>
<td>4A Kansas City</td>
<td>38</td>
<td></td>
<td>Full-depth osPF</td>
</tr>
<tr>
<td>4A Boston</td>
<td>38</td>
<td></td>
<td>Kraft-faced bat</td>
</tr>
<tr>
<td>4C Seattle</td>
<td>38</td>
<td></td>
<td>Full-depth cellulose</td>
</tr>
<tr>
<td>5A Chicago</td>
<td>38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5B Denver</td>
<td>38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6A Minneapolis</td>
<td>49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 International Falls</td>
<td>49</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Geometry

- 3-in-12 roof pitch
- North-facing
  - worst case, least solar
- Roofing
  - Dark color shingles
  - Light colored metal
  - Tiles: dk red, back ventilated
  - Cedar Shakes: Store rainwater!
Interior RH Levels

• Very important!
• Depends on ventilation, occupancy, and exterior conditions
• Chose EuroNorm 15026
  – More straight forward
  – Matches our field experience
• High moisture level is normal for maritime

Material Properties

• Mostly choose default values from WUFI database
• Specific properties of spray fiberglass and open and closed cell foam from manufacturers

Interpretation

• Choose Moisture Content of inside 1 mm (1/16”) of OSB sheathing
  – Extreme case
  – Framing always drier
• Classes of moisture performance were selected

<table>
<thead>
<tr>
<th>Class</th>
<th>OSB MC Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Below 16% all year</td>
</tr>
<tr>
<td>1</td>
<td>Above 16% 1 week or more</td>
</tr>
<tr>
<td>2</td>
<td>Above 16% 4 weeks or more</td>
</tr>
<tr>
<td>3</td>
<td>Or above 28% 1 week or more</td>
</tr>
<tr>
<td></td>
<td>Above 28% 4 weeks or more</td>
</tr>
</tbody>
</table>
### Results

#### Diffusion Only

<table>
<thead>
<tr>
<th>Location</th>
<th>Zone</th>
<th>Type</th>
<th>Insulation</th>
<th>Thickness</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>4-5</td>
<td>Flat</td>
<td>ccSPF spray foam</td>
<td>6&quot;</td>
<td>R38</td>
</tr>
<tr>
<td>AZ</td>
<td>6-8</td>
<td>Flat</td>
<td>ccSPF spray foam</td>
<td>8&quot;</td>
<td>R49</td>
</tr>
<tr>
<td>MA</td>
<td>4-5</td>
<td>Flat</td>
<td>cellulose/fiberglass</td>
<td>3.5&quot;</td>
<td>R49</td>
</tr>
<tr>
<td>WA</td>
<td>6-8</td>
<td>Flat</td>
<td>cellulose/fiberglass</td>
<td>4&quot;</td>
<td>R49</td>
</tr>
</tbody>
</table>

Note: rafters insulated on the inside

### Full ccSPF Roof

- Zone 4-5: 6"
- Zone 6-8: 8"

- 6" (R38) - 8" (R48) ccSPF spray foam
- Gypsum board
- 2x6 wood frame
- Drainage plane
- 3.5" spray cellulose/ fiberglass
- 2" HD spray foam

### Hybrid Code R & Fire Protection

- Cold Climate R38: Zone 4/5
- R49: Zone 6/7/8

### Air Leakage

- It's not all about diffusion
- Air leakage is more important
  - But level of leakage varies
- Design value is zero leakage
  - But we know roofs leak some air.
  - How much?
  - What paths?
Air Leaks – cathedral ceilings

- Cool exterior (no sun)
- Air leaks via accidental openings or intentional vents
- Air flows through ventilation gaps, air permeable insulation or accidental gaps
- Condensation forms on cool roof sheathing
- Warm interior - higher air pressure than exterior

Some Condensation occurs, but risk is moderate

- Potential hours of condensation

Hourly: Denver, Normal Load

- Building Science.com

Air Leaks: Monthly Calculation

- Compare interior air dewpoint to exterior sheathing temperature

- Mean monthly outdoor temperature

- Find condensing surface temperature (bottom of roof sheathing) if R-value of roof insulation is measured over roof deck

Air leakage condensation

- Potential hours of condensation

<table>
<thead>
<tr>
<th>Zone</th>
<th>City</th>
<th>DA (ft²)</th>
<th>1 1/2 ccSPF</th>
<th>2 ccSPF</th>
<th>Kraft-faced batt</th>
<th>3 ccSPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Kansas City</td>
<td>2000</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>2A</td>
<td>Austin</td>
<td>1800</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>3A</td>
<td>Phoenix</td>
<td>1800</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>4A</td>
<td>New York City</td>
<td>1800</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>5A</td>
<td>Detroit</td>
<td>1800</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>6A</td>
<td>Boston</td>
<td>1800</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>7A</td>
<td>Miami</td>
<td>1800</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>8A</td>
<td>San Francisco</td>
<td>1800</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Legend:
- N/I - not installed
- N/S - not sufficient
- Less than 100 hrs per year
- Less than 1000 hrs per year
- Over 1000 hrs per year

Recommend 3" ccSPF in Zones 4/5, 4" in 6/7, more if high RH

Building Science.com
Hybrid Roof Insulation IRC

• IRC 2009

### TABLE IB8.6.4

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>MINIMUM RIGID BOARD OR AIR-IMPERMEABLE INSULATION R-VALUE</th>
<th>CCSPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2A, 2B, 2A, 2B, 2C</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>3A, 3B</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>4</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>5</td>
<td>3.0</td>
<td>2.5</td>
</tr>
<tr>
<td>6</td>
<td>3.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>

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

… or all air impermeable insulation

Conclusions

• Unvented cathedral ceilings can be used in all climates
• Full-depth ccSPF works in all climates
• Pure spray fiberglass/cellulose not in most climates
• Hybrid (fibrous+foam) can work well in all climates
• More air impermeable insulation R-value needed as climate is colder

Thanks & Questions

• Johns Manville sponsor

Potential Backup Slides
Moisture-Safe Unvented Wood Roof Systems

Warmer climates

Building Science.com

Building Science.com

Building Science.com

BEST2-Portland, OR

© buildingscience.com
Vented vs. unvented shingle temperatures

South-facing shingle temperatures
Jacksonville, FL 16-Sep to 18-Nov 2000

Cathedral 5C/9F hotter than attic
Vented cathedral is same as Unvented

Enough ventilation can provide cooling
Hybrid: Air, thermal, fire

Warm Climate Zone!

- 1" CC spray foam
- 2x6 top chord

R6+R30
- Cellulose or spray fiberglass, 8" nominal
- Gypsum board

R6+R16
- 2x6 frame wall
- 4½" cellulose or spray fiberglass
- 1" CC spray foam