Moisture-Safe Unvented Wood Roof Systems

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www.buildingscience.com
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
The old faithful

Pitched and Ventilated Attic Roof

1. Rafter
2. Exterior cladding
3. Cavity insulation
4. Vapour Retarder (opt)
5. Water resistant membrane & drainage gap
6. Air barrier/Interior Finish
• In practise, attics are usually well-ventilated.
• Accommodate small mistakes in ceiling air leaks and roofing rain leaks.
Ventilated Cathedral Ceiling

1. Rafter
2. Exterior cladding
3. Cavity insulation
4. Vapour Retarder (opt)
5. Water resistant membrane & drainage gap
6-8. Air barrier/Interior Finish
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

1. Rafter
2. Exterior cladding
3. Water resistant membrane & drainage gap
4. Vapour Retarder (opt)
5. Air impermeable cavity insulation
6. Interior Finish

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Unvented-vented hybrid.
Vented cathedral
Simple gable roofs
Is it airtight enough?

Unvented roof for more complex roof lines
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
Ottawa/Toronto/Montreal: 6
Calgary/Edmonton/Quebec: 7
Vancouver / Windsor: 5
Halifax/St Johns: 6

All of Alaska in Zone 7 except for the following Boroughs in Zone 8: Bethel, Dillingham, Fairbanks, N. Star, Nome North Slope, Northwest Arctic, Southeast Fairbanks, Wade Hampton, and Yukon-Koyukuk

Zone 1 Includes: Hawaii, Guam, Puerto Rico, and the Virgin Islands
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 R-value</th>
<th>Roofing Type (4)</th>
<th>Insulation Type (8)</th>
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<td>Dark asphalt</td>
<td>Spray fiberglass (1.8 pcf)</td>
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<td></td>
<td></td>
<td>1&quot; ocSPF + spray fiber glass</td>
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</tr>
<tr>
<td>7 International Falls</td>
<td>49</td>
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</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
Interior RH Levels

![Graph showing the relationship between exterior temperature (F) and interior RH (percent), with lines for High Moisture Level and Normal Moisture Level.](BuildingScience.com)
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

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<tr>
<td>1</td>
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<tr>
<td>2</td>
<td>Above 16% 4 weeks or more</td>
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<td>Or above 28% 1 week or more</td>
</tr>
<tr>
<td>3</td>
<td>Above 28% 4 weeks or more</td>
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Building Science.com
## RESULTS

### Diffusion Only

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<th>DOE Zone</th>
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<th>R-value</th>
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<th>Spray fiberglass (1.8 pcf)</th>
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<th>Kraft-faced fiberglass batt</th>
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<td>3/1-</td>
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</table>

**Legend**

- OSB Moisture Content, Inner layer
- **Results are for High moisture interior conditions if a single number is given.**
- **1 - Above 16% 1 week**
- **2 - Above 16% 4 weeks**
- **- Above 28% 1 week**
- **- Above 28% 4 weeks**
- NA means simulations were not conducted - color represents estimated extrapolation
- **Indicates danger of convective-air-movement-induced condensation at normal moisture level**

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Full ccSPF roof

Zone 4-5: 6”
Zone 6-8: 8”

Note: rafters insulated on the inside

6” (R38) - 8” (48) ccSPF spray foam
Gypsum board
2x6 wood frame
3.5” spray cellulose/fiberglass
2” HD spray foam

OSB/plywood sheathing
Drainage plane
Hybrid Code R & fire protection

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

Roof cladding

Roof underlayment
3” ccSPF (R18)
4” (R24)

5.5” ccSPF (R20)
7” (R25)
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

Cold exterior (no sun)

Air leaves via accidental openings or intentional vents

Air flows through ventilation gaps, air permeable insulation or accidental gaps

Condensation forms on cool roof sheathing

Roofing paper

Roofing

Wood rafter

Fibreglass batt insulation

Painted Drywall

Ventilated

Warm moist interior air leaks into roof via accidental crack or opening

Warm interior – higher air pressure than exterior
Air Leaks: Monthly Calculation

Compare interior air dewpoint to exterior sheathing temperature

![Graph showing temperature variations over months with dew point temperature and outdoor temperature notes.](image-url)
Hourly: Denver, Normal Load

Some Condensation occurs, but risk is moderate
Air leakage condensation

- **Potential** hours of condensation

<table>
<thead>
<tr>
<th>Zone</th>
<th>City</th>
<th>Roofing</th>
<th>1&quot; ccSPF</th>
<th>2&quot; ccSPF</th>
<th>Kraft-faced batt</th>
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**Legend**

- Less than 100 hrs per year
- Less than 1000 hrs per year
- N/S - not simulated
- Over 1000 hrs per year

Recommend 3” ccSPF in Zones 4/5, 4” in 6/7, more if high RH
Hybrid Roof Insulation IRC

• IRC 2009

<table>
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<th>CLIMATE ZONE</th>
<th>MINIMUM RIGID BOARD OR AIR-IMPERMEABLE INSULATION R-VALUE</th>
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<td>R-35</td>
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a. Contributes 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
Warmer climates

- 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

Gypsum board with latex paint (acts as thermal barrier separating occupiable space from non-occupiable space)
Vented vs. unvented shingle temperatures

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

Temperature (F)
Number of hourly observations
Ventilation & Roof Temperature

Roof Surface Temperature Distribution - Comparison of Different Roof Strategies
(2005.04.11-2005.05.16)

- Cathedral 5C/9F hotter than attic
- Vented cathedral is same as Unvented
Enough ventilation can provide cooling
Hybrid: Air, thermal, fire

Warm Climate Zone!

R6+R30

1” CC spray foam
2x6 top chord

Cellulose or spray fiberglass; 8” nominal
Gypsum board
2x6 frame wall
4½” cellulose or spray fiberglass
1” CC spray foam

R6+R16

OSB/plywood sheathing
Drainage plane