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- See Building Science Digest
  - BSD-134 Ice Dams
  - BSD-115 Wood Roofs
  - BSD-102 Understanding Attic Ventilation
  - BSD-104 Understanding Air Barriers
  - BSD-106 Understanding Basements
Complexity
Air Leaks – cathedral ceilings

- Cold 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 cold roof sheathing
- Warm moist interior air leaks into roof via accidental crack or opening
- Warm interior – higher air pressure than exterior

Unvented Cathedral Ceilings

- Not absolutely necessary to vent if airtight and vapour tight material,
  - e.g. spray foam.
  - Or insulated sheathing
- May be practical in retrofit
- If no wetting, little drying required
  - Demands very high performance
  - >R40, no penetrations
  - spray foam is a practical solution
  - beware thermal bridges

Unvented Solutions

Spray foam

- Airtight!

Typical Construction Materials

1. Wood or metal siding
2. Asphalt shingles
3. Slate or tile
4. Plywood
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Ice Dams

1. Snow insulates roof membrane
2. Low thermal insulation level allows heat to flow to roof sheathing
3. Snow melts and runs down roof
4. Cold air removes heat from underside
5. Ice dams and icicles form

**Figure 2: The Process of Ice Dam Formation Caused by Poor Insulation**
1. Sun warms shingles where little or no snow cover exists
2. Snow melts and runs down roof
3. Snow insulates roof membrane
4. Cold air removes heat from underside
5. Ice dam and icicles form

Figure 5: Ice Dam Formation Process Due to Uneven Snow Thickness
Shingles
Roofing paper
R-40 rigid insulation (6 inches of R-6.5/inch rigid insulation) in two or three layers with horizontal and vertical joints staggered
Nail base for shingles (plywood or OSB) screwed through rigid insulation to wood decking or timber rafters
Air barrier membrane (sheet polyethylene, membrane roofing in very cold and cold climates; houseswraps, building paper in all other climates)
Wood decking
Timber rafter or exposed joist

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Underside of roof sheathing is typically the “first condensing surface” as it tends to be the first surface below the dewpoint temperature of the interior air-vapor mixture with sufficient thermal mass to support condensation during cold weather. Additionally, it also tends to be the first surface below the dewpoint temperature of the interior air-vapor mixture that is also relatively impermeable compared to the insulation layer beneath it.
Vented vs. unvented shingle temperatures

Cathedral Ceilings

- What vapor control is needed to be safe for unvented SPUF roofs?
  - Similar to wall study
- Will roof be hotter than ventilated cathedral?
  - We know this answer already
- Is ice damming a bigger concern?
- the need for venting to remove moisture and the impact of venting on roofing temperature
- the risk of roof leaks caused by the different drying strategies applied.
Proposed field testing

- Five different roofs: Each type faced one direction at a 3:12 pitch.
- R30 of 2 pcf SPUF between the rafters.
- R30 of 0.5 or 2 pcf SPUF between the rafters below a 2” ventilation space formed with an EPS baffle.
- R30 of 0.5 pcf open cell SPUF.
- R30 of 0.5 pcf open cell SPUF with a vapor retarding paint finish as supplemental vapor retarder.
- Standard 8” R30 fiberglass batt insulated 2” space (vent chutes at the soffits) leading to a mushroom vent.