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Unvented Roof Research:

Research and Reality

March 10, 2016

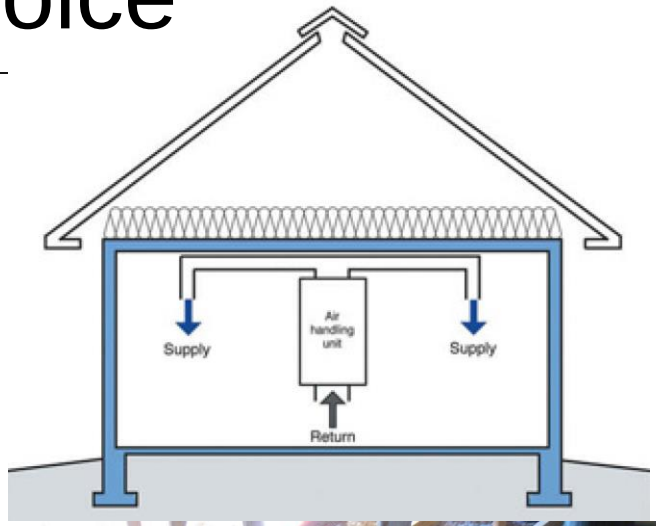
BUILDINGENERGY

Online Community of Northeast Sustainable Energy Association

Unvented Roofs: Background

Ventilated Attics—Best Choice

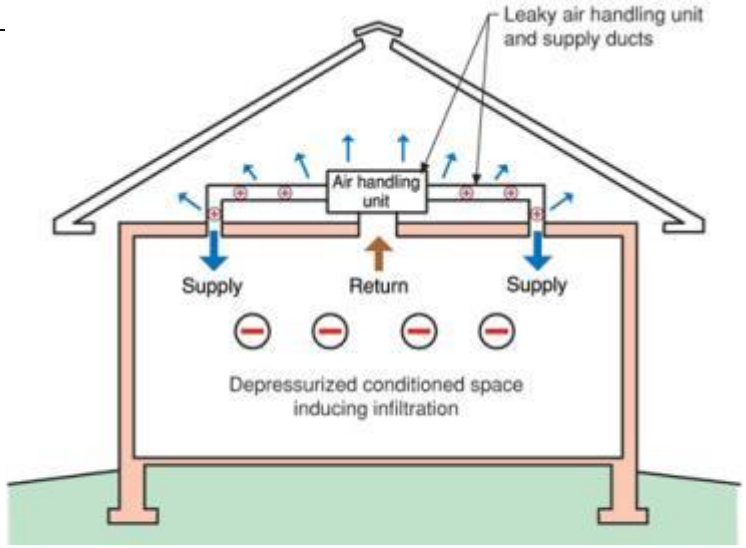
- Roof sheathing dries to ventilated attic-moisture safe
- Interior moisture (air leaks) ventilated away in winter
- Air sealing at ceiling critical for best performance (e.g., spray foam air barrier, detail with sealant)

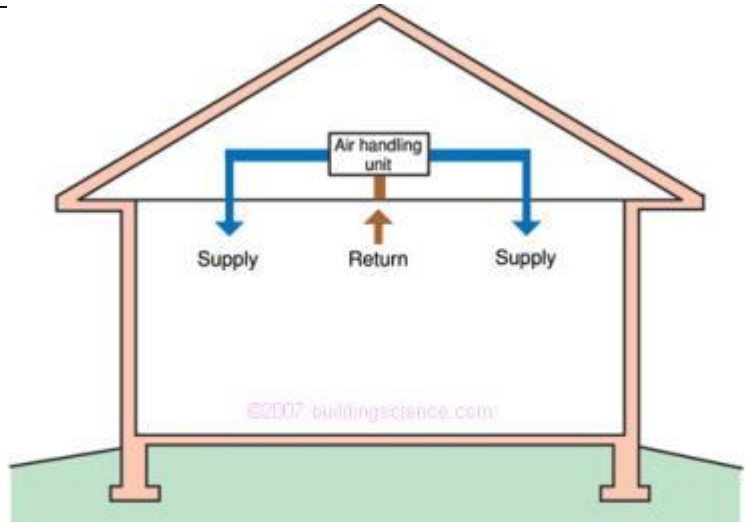


Then Why Unvented Roofs?

- Living space built into roof
- Vented cathedral assemblies—often poor performance
- Complicated rooflines, hip geometries—how to vent?
- Unworkable air barrier at ceiling line
- Blown-in rain (coastal)
- Hurricane tear-off
- HVAC in vented attic

Unvented Roofs & HVAC Placement





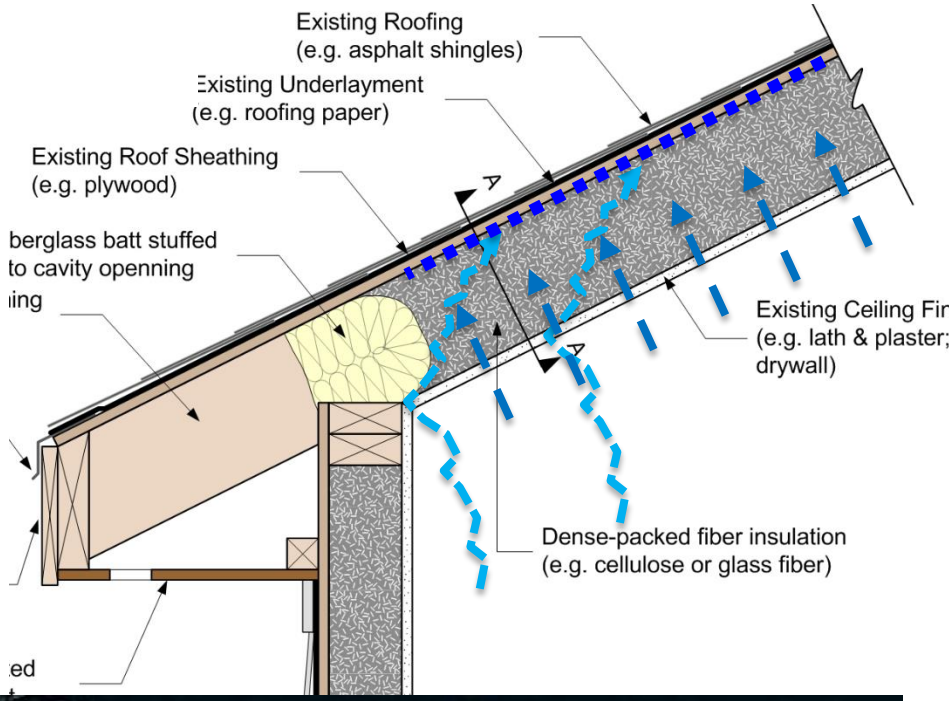
- Ducts in unconditioned attic = huge energy losses
  - Industry reluctant to move ducts out of attic
  - Ice dam issues due to duct losses
- Solution: bring ducts into conditioned space
- Unvented/conditioned attic—keeps ductwork in conditioned space, duct leak issues eliminated

Fibrous Insulation Unvented Roofs

- Dense pack insulation of unvented roofs common in cold-climate retrofits
  - Moisture risks (see BSI-043 “Don't Be Dense—Cellulose and Dense-Pack Insulation”)—2 in 10 failure?
  - Violates I-codes (see IRC § R806.4)
  - “Ridge rot”—localized problems (SIPS same problem)

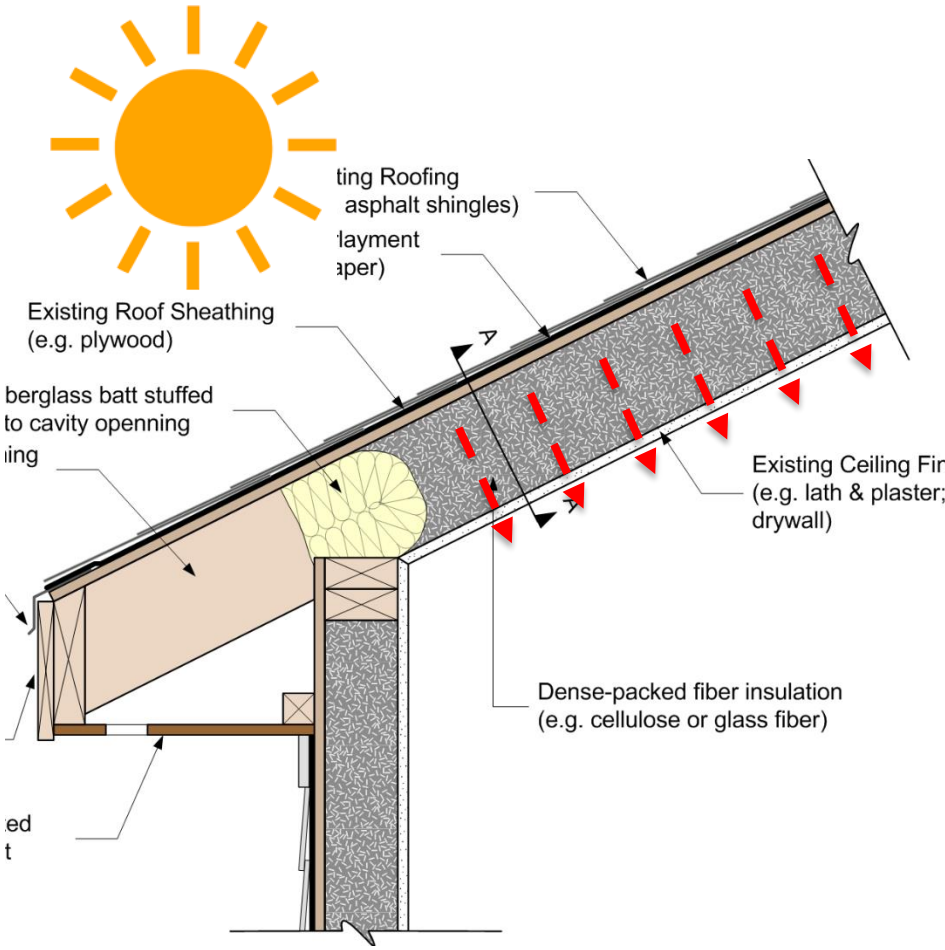
Why Unvented + Loose Fill Risky?

- Different than walls?
- Moisture risks at sheathing
  - Interior-sourced air leakage
  - Vapor contributing too?
  - Zero-perm exterior (“wrong side perfect vapor barrier”)
  - Night sky radiation cooling
  - Stack effect in winter
  - “Ridge rot” (thermal and moisture buoyancy)

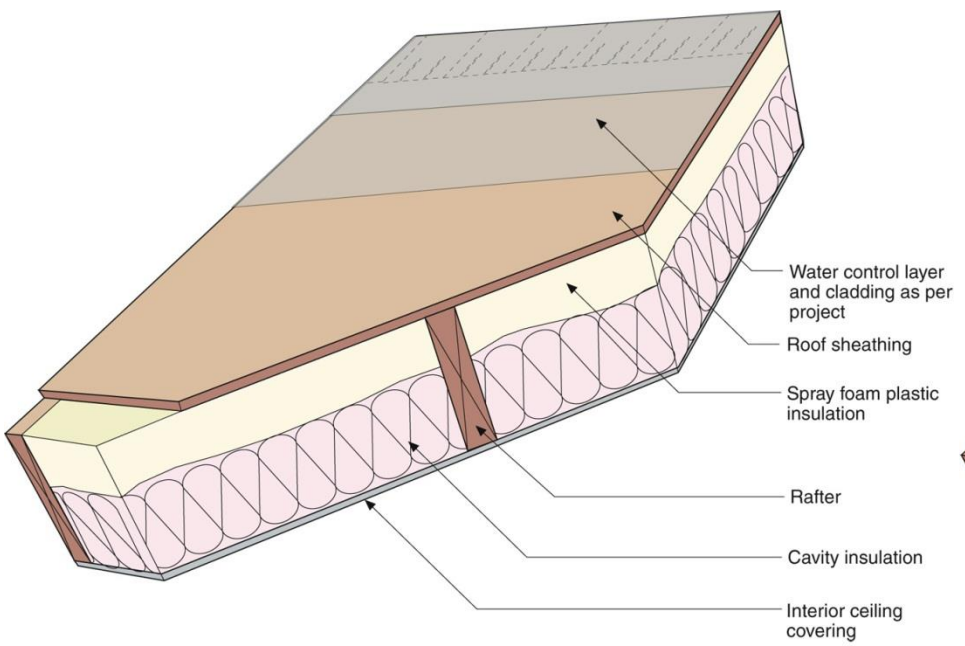


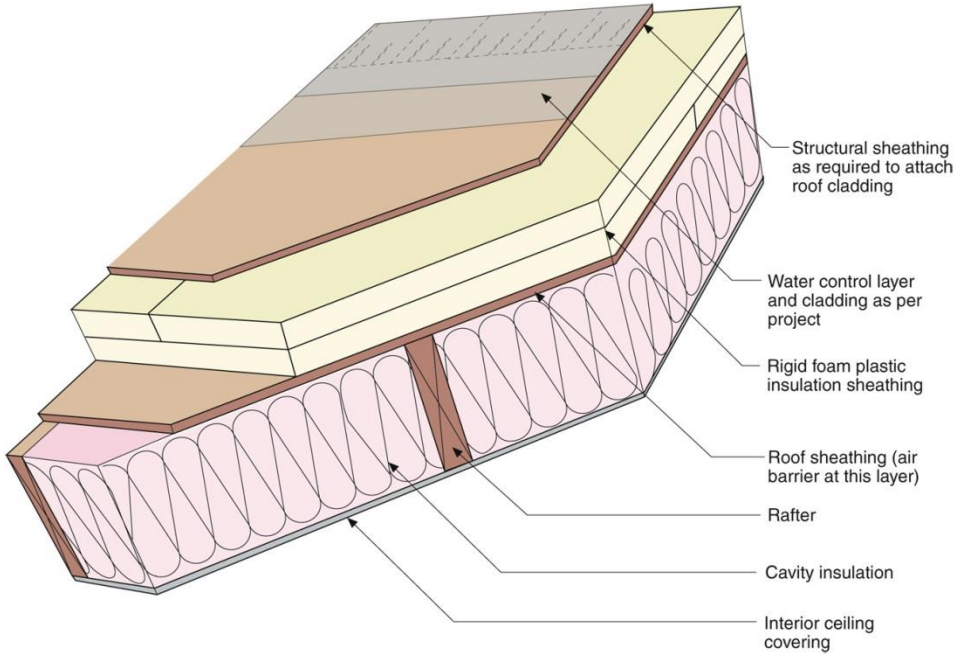
Why Unvented + Loose Fill Risky?

- Risk reduced by:
  - Airtightness of ceiling
  - Dense insulations-less airflow
  - Solar drive
    - But white roofs, shading
  - Lower interior RH (winter)
    - Why many of them work?
  - Lower permeance interior
    - Assumes good airtightness—vapor retarder not bypassed
- Moisture accumulation: what gets in vs. gets out



Spray Foam/Exterior Insulation Roofs





- 2006 IRC: R806.4 Unvented attic assemblies
- Minimum R-value of “air impermeable insulation”
  - Not ratio of R-values… don’t get me started…
- Nail base needed with rigid foam on roof deck

Why Fibrous Fill Unvented Roofs?

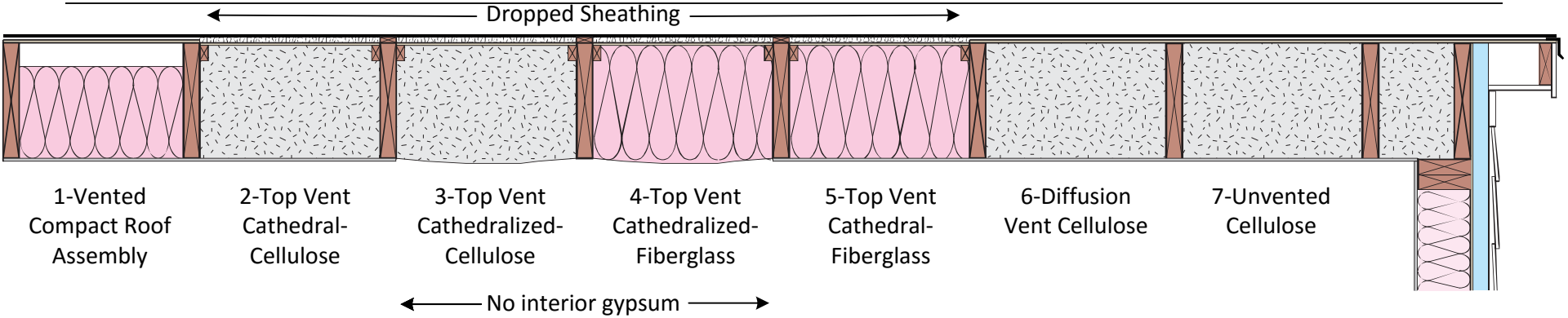
- Unvented roofs without spray/board foams could reduce costs and increase market penetration… IF moisture damage risks are addressed
- Retrofit opportunities (existing uninsulated living space at roof line, without removing finishes)

Chicago Experiment

Experimental Design

- Seven roof bays (east-west pairs) in test garage attic in Chicago, IL (5A) area
- **72 F/50% RH interior** conditions through winter: stressing assemblies to failure

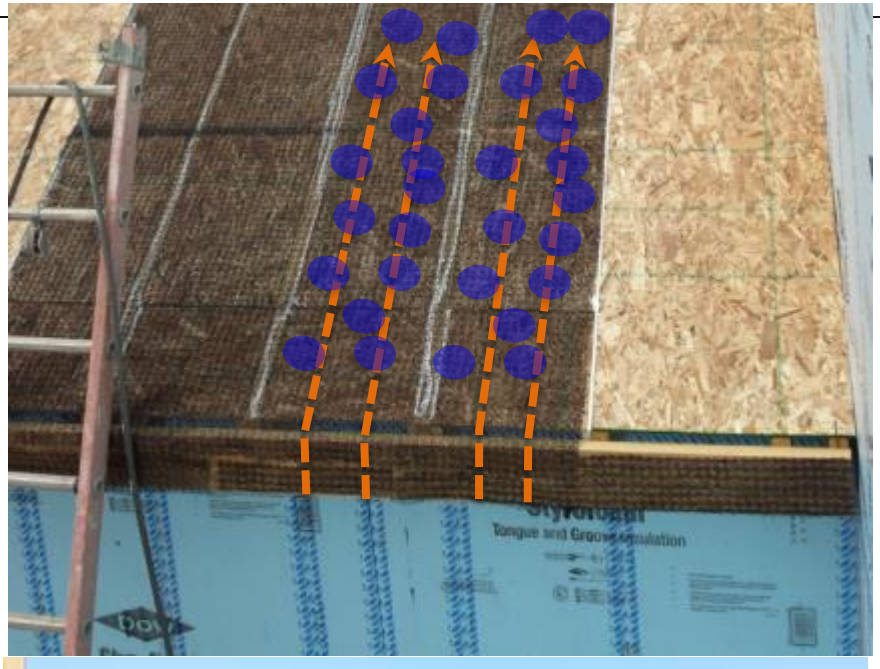
Experimental Design



#	Name	Venting	Insulation	Interior
1	Vented	Vent space (2")	Fiberglass	Gypsum Bd
2	Top Vent Cathedral-Cellulose	Cedar Breather (~½")	Cellulose	Gypsum Bd
3	Top Vent Cathedralized-Cellulose	Cedar Breather (~½")	Cellulose	Open
4	Top Vent Cathedralized-FG	Cedar Breather (~½")	Fiberglass	Open
5	Top Vent Cathedral-FG	Cedar Breather (~½")	Fiberglass	Gypsum Bd
6	Diffusion Vent Cellulose	Diffusion Vent	Cellulose	Gypsum Bd
7	Unvented Cellulose	None	Cellulose	Gypsum Bd

- **All assemblies vapor open inside**
  - Latex paint on GWB or no GWB)

Top Vent Details



Monitoring Result Takeaways

- Vented roof=great performance—even @50% RH!
- Unvented cellulose assembly driven to failure (high RHs, high sheathing MCs, condensation)
- Cellulose + diffusion vent helps, but not enough
- Top venting not enough to save roofs in:
  - Zone 5A climate, 50% RH interior
  - With a small (~1/2” vent space)
  - With OSB sheathing
- In top vent roofs, fiberglass roof much worse than cellulose

Sheathing Ridge Condition

Sheathing Ridge Condition

Top Vent Fiberglass Ridge Conditions

Diffusion Vent & Unvented

Sheathing Further from Ridge-East

Chicago Experiment Conclusions

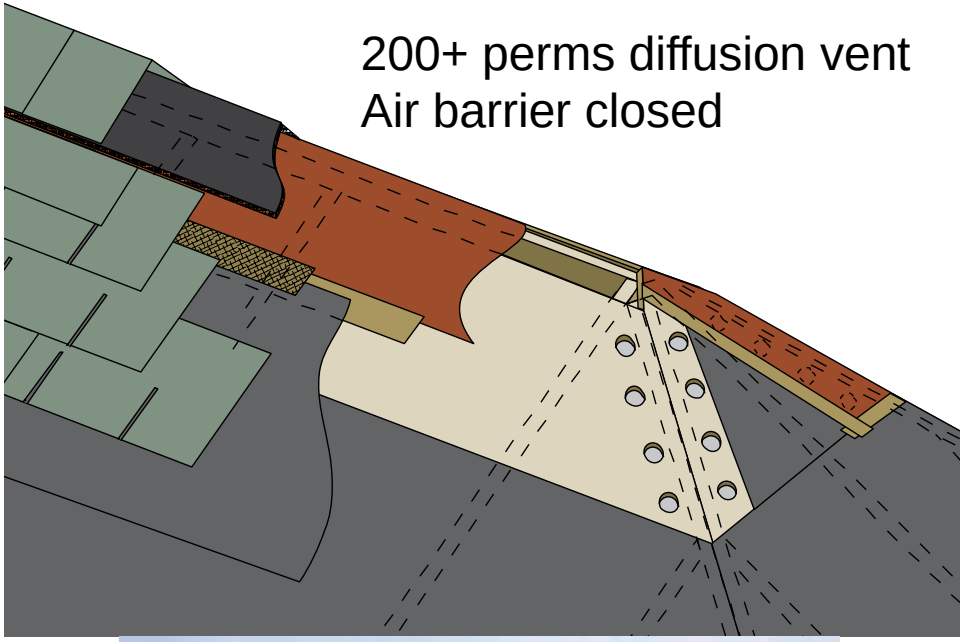
- No roof except for “control” vented roof showed “safe” performance in Zone 5A @ 50% RH
- Cellulose roofs generally showed lower MCs than fiberglass roofs, less damage to structure
- “Top vent” configuration not effective
  - OSB too restrictive for diffusion drying, even with outward thermal gradient? (part of the time)
  - Ventilation space too small?
- Diffusion vent: “helpful, but not enough”
  - Allowed greater drying than conventional unvented
  - But still higher MCs than generally considered safe

Houston Research (Diffusion Vent Ridge)

1990's Cathedralized Roofs-Houston

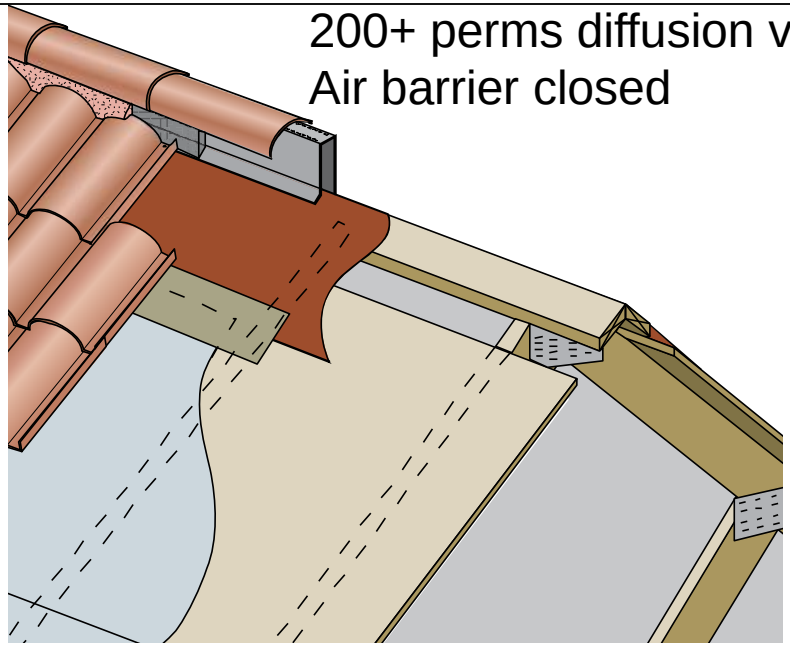
- Even in Houston (CZ 2A), had moisture at ridge
- Concentrated only at ridge—rest of roof OK
- Similar problems in Jacksonville FL (CZ 2A)
- No interior air/vapor control (not practical)
- How about letting the moisture out at ridge?

Diffusion Vent Prototype (Houston)



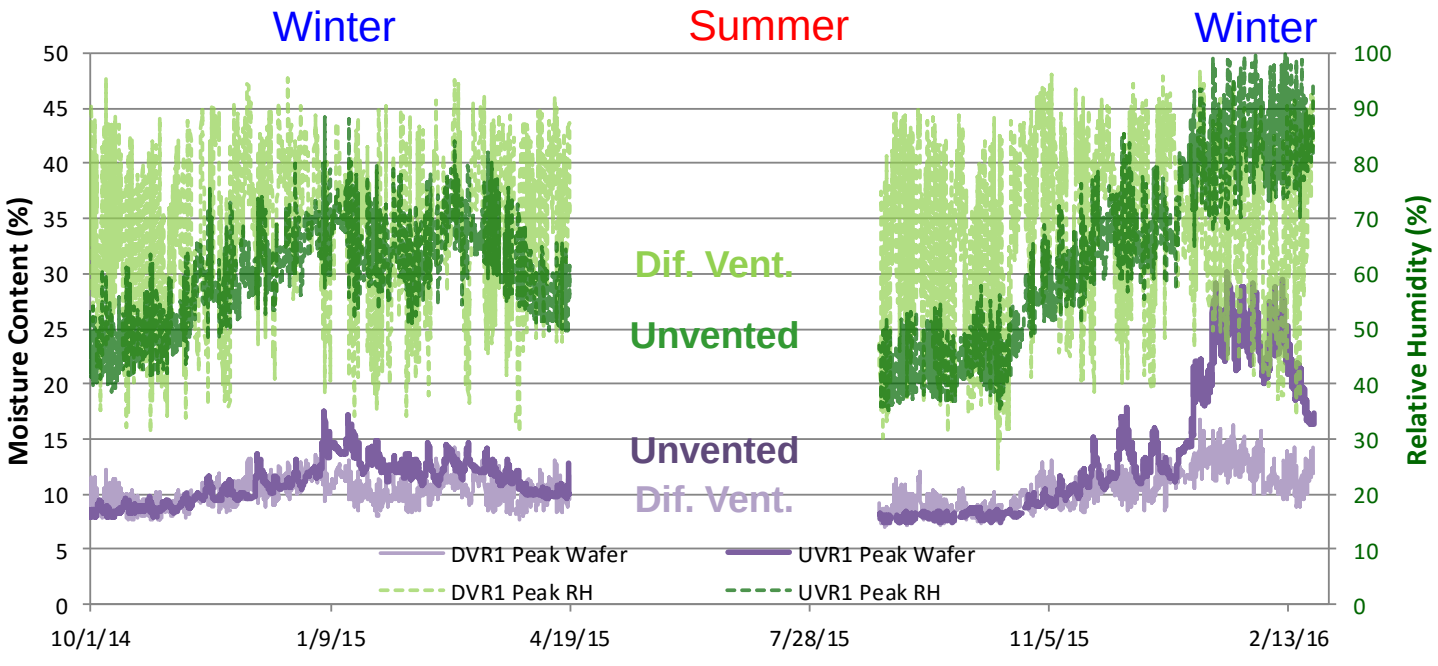
Diffusion Vent Prototype (Orlando-Tile)

200+ perms diffusion vent
Air barrier closed



Houston/Orlando Results

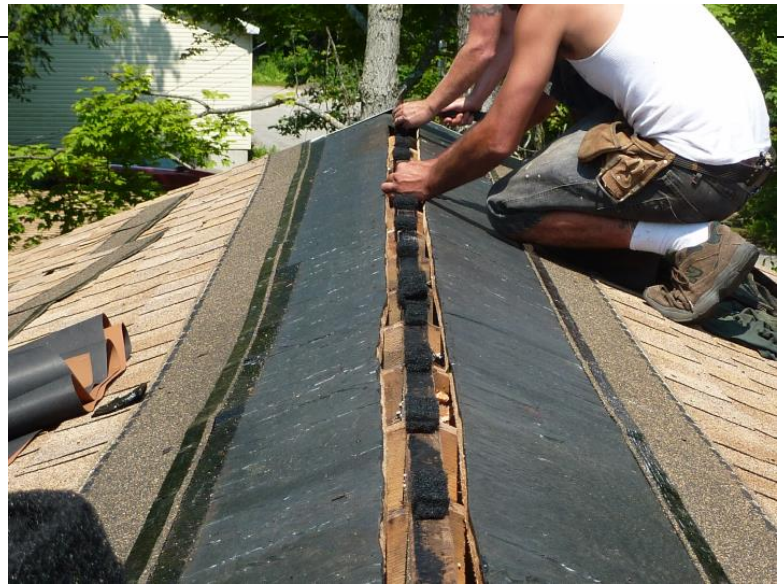
- Diffusion vent avoids wintertime ridge accumulation problems (ridge peak RHs/MCs)
- No failures at low interior RH, bigger difference at higher RH (interior humidification)
- Airtightness disappointing in some cases-no SPF

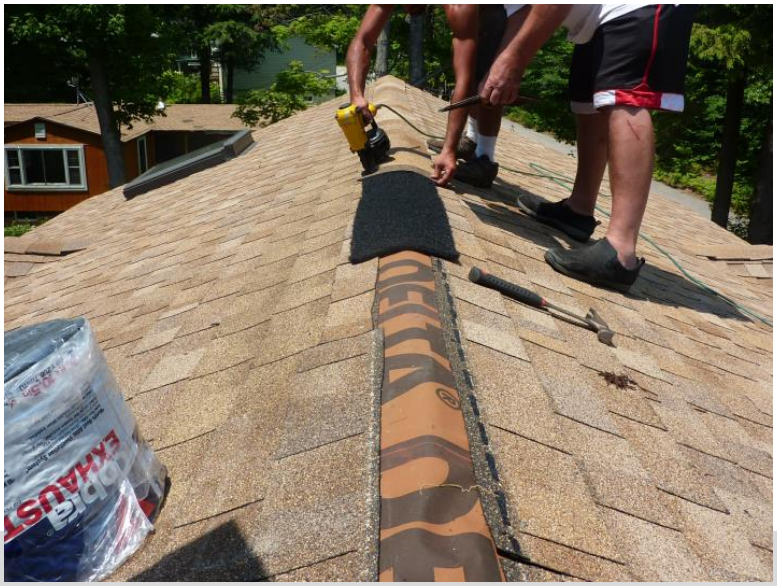


Cut & Cobble Unvented Roof (Diffusion Vent)

Cut & Cobble Roof, Central MA

Diffusion Vent Retrofit





Monitoring Results

- Not ideal experiment (with & w/o DV comparison)
  - (Trying to fix friends' houses, not rot them)
- Still worrying high wood MCs ~30% peaks
- Peaks occur in spring (May), not winter—???
- What goes in vs. what comes out
  - In via air leakage/out via vapor diffusion→hard
  - Airtightness was ~6 ACH 50; air leaks to roof evident
  - Trapped moisture—foil-faced polyiso below?
  - Small diffusion vent surface area
- Return trip in spring 2016

Working Unvented Cellulose Assemblies

Variable-Perm Membrane Unvented Roof

- Roof assembly:
  - Gypsum board, strapping
  - Intello plus membrane
  - 14” dense packed I joist
  - 3/4 AdvanTech (OSB)
  - Grace Ice and Water HT
  - Standing seam galvalume roof nailed thru sheathing

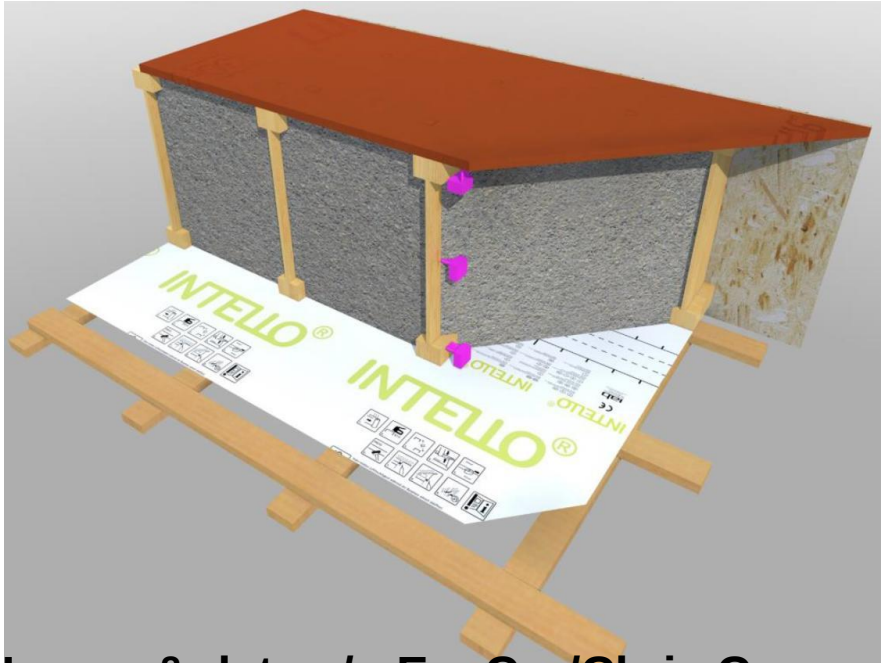
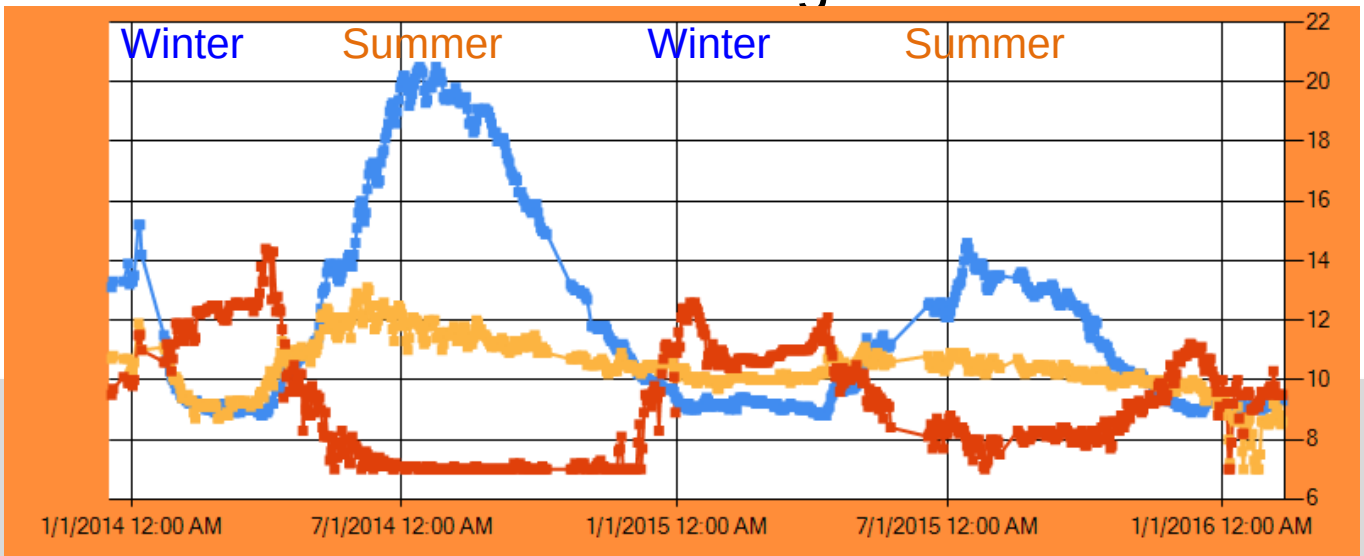


Image & data c/o EcoCor/Chris Corson



TJI MCs:
- Inboard
- Middle
- Outboard

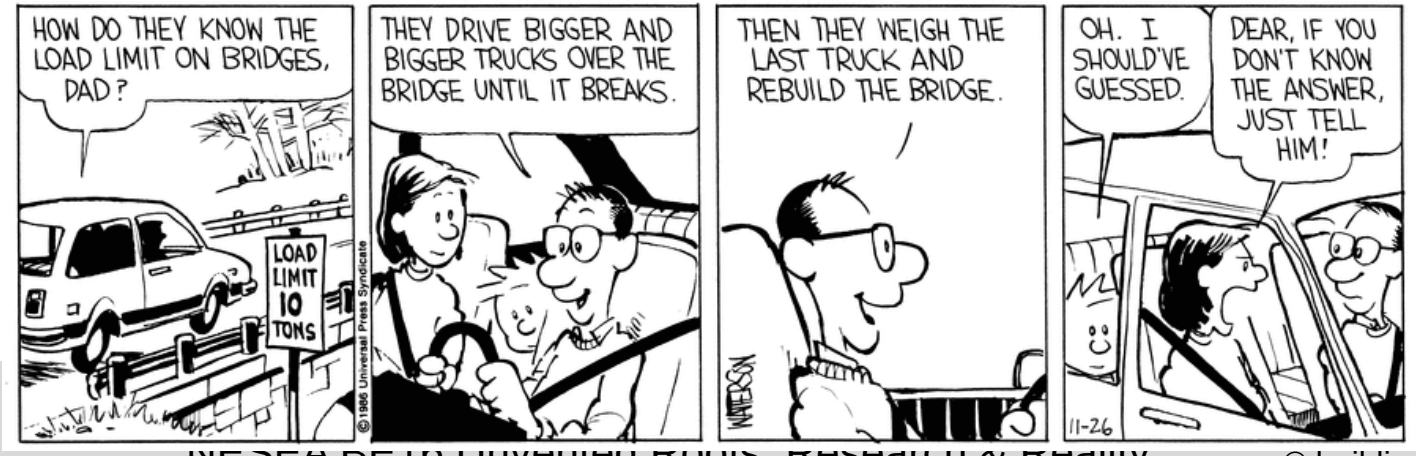
DIBt/475 Guidance on “Hot Roofs”

- Vapor variable permeance membrane on interior side of roof assembly
- Testing of airtightness
- Low MCs when closed (construction moisture)
- No permanent shading (e.g., solar panels)
- No sustained high interior RH
- Dark roof membrane (α>0.80)

- I trust PassivHaus and other 1 ACH 50 builders with this idea, but…

Further Research

- Ideal experiment: build hundreds, and see if/how many fail! ¯_(ツ)_/¯ [sarcasm]
- Further Building America research in CZ 5A
  - Includes variable-permeability interior vapor retarders, with and without ridge diffusion vent
  - First winter low interior RH
  - Second winter high interior RH
  - Third winter add controlled interior air leakage



Questions?

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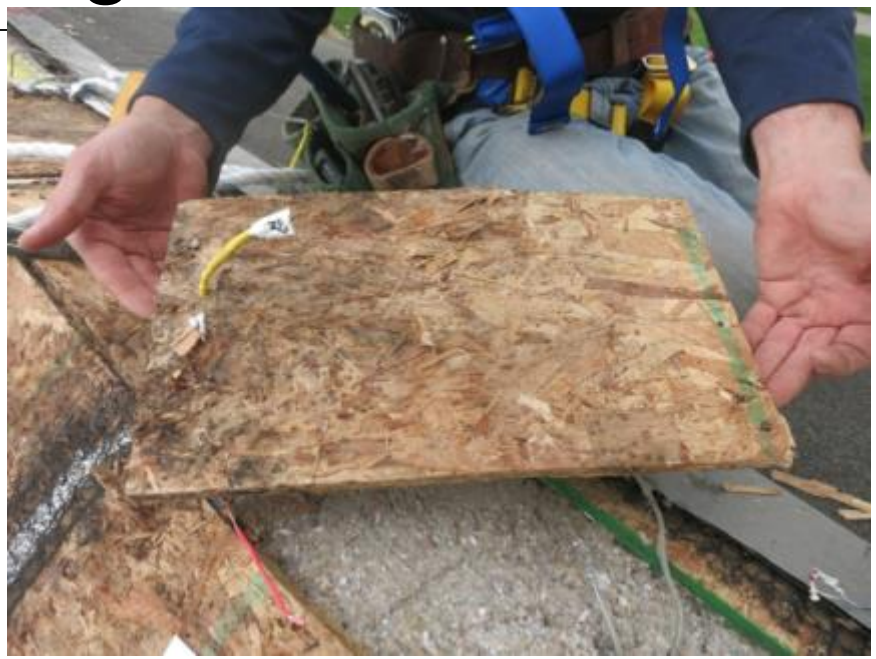
Document Resources

- Building Science Digest 149: Unvented Roof Assemblies for All Climates
  http://buildingscience.com/documents/digests/bsd-149-unvented-roof-assemblies-for-all-climates
- Building Science Insight 043: Don't Be Dense—Cellulose and Dense-Pack Insulation
  http://buildingscience.com/documents/insights/bsi-043-dont-be-dense
- Building Science Insight 088: Venting Vapor
  http://buildingscience.com/documents/insights/bsi-088-venting-vapor
- Building America Report 1511: Field Testing of an Unvented Roof with Fibrous Insulation, Tiles, and Vapor Diffusion Venting
  http://buildingscience.com/documents/building-america-reports/ba-1511-field-testing-unvented-roof-fibrous-insulation-tiles-and
- Building America Report 1409: Field Testing Unvented Roofs with Asphalt Shingles in Cold and Hot-Humid Climates
  http://buildingscience.com/documents/building-america-reports/ba-1409-field-testing-unvented-roofs-asphalt-shingles-cold-and
- Building America Report 1001: Moisture-Safe Unvented Wood Roof Systems
  http://buildingscience.com/documents/bareports/ba-1001-moisture-safe-unvented-wood-roof-systems/view
- Building America Report 1308: Moisture Control for Dense-Packed Roof Assemblies in Cold Climates: Final Measure Guideline
  http://buildingscience.com/documents/bareports/ba-1308-moisture-control-dense-packed-roof-assemblies-cold-climates/view
- INTELLO & DB+ Approved by DIBt for Use in Unvented Hot Roof Assemblies
  https://foursevenfive.com/intello-db-approved-by-dibt-for-use-in-unvented-hot-roof-assemblies/

Instrumentation, Insulation, Finishes…

Top Vent Cellulose Ridge Conditions



Disassembly Takeaways

- Results consistent with monitoring data
- Sheathing stained but not punky/structural damage
- Damage concentrated/severe at ridge
- Fiberglass sheathing & framing: extensive damage & staining, possible mold growth
- Cellulose sheathing: some delamination, adhesions, and rusty fasteners—not as bad
- Cellulose did not settle over one winter
- Fiberglass batts leave lots of air leakage paths