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Monitoring of Two Unvented Roofs with Air-Permeable Insulation in Climate Zone 2A

bsc Building Science Corporation

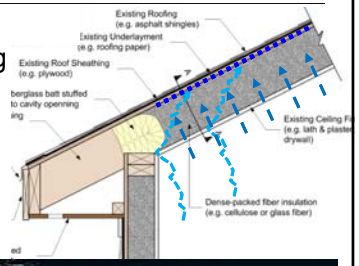
Unvented Roofs: Background

Unvented/Cathedralized Roofs

- Insulation at roof deck, rather than attic floor
  - Brings HVAC ductwork/equipment into conditioned space
  - Can improve airtightness (ceiling plane vs. roof)
  - Wind driven rain, hurricane roof tear-off
- Moisture risks with unvented roofs (vs. vented)
  - Condensation of interior moisture at roof sheathing
  - Code-compliant (IRC § R806.4) roofs—"air impermeable insulation" (spray foam/SPF, exterior insulation)
- Current research: air permeable insulation, CZ 2A
  - Lower cost, environmental impacts of SPF
  - Houston and Orlando test houses
  - Can moisture risk be managed?

Why Unvented + Fibrous 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



2000's Cathedralized Roofs-TX & FL

- Houston climate (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)
- Possible solution: allowing release of moisture at ridge?

Test Site & Instrumentation Setup

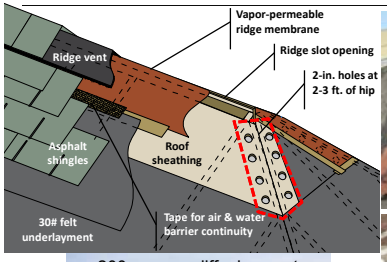
Unvented Roof Test Houses

- Houston: asphalt shingle, #30 paper
  - Unoccupied model, humidified in winter 3 of 3
- Orlando: concrete tile, self-adhered membrane
  - Occupied by family of 4, 2 winters of data

Unvented Roof Test Houses-Insulation

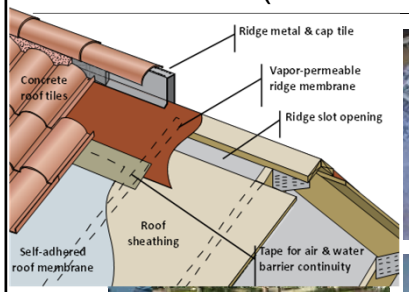
- Houston: adhered fiberglass, R-38/RSI 6.7
- Orlando: netted/blown fiberglass R-38/RSI 6.7
- Vapor open insulation: 120 perm-in. or 170 ng/(Pa·s·m)); no interior vapor control layer

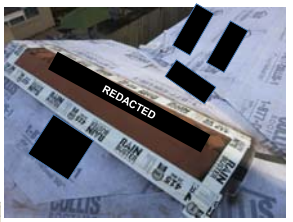
Diffusion Vent (Houston)



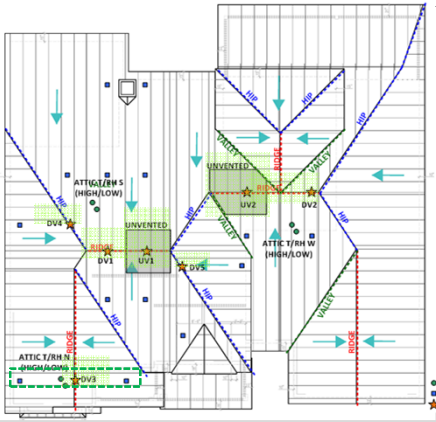
200+ perms diffusion vent

Diffusion Vent (Orlando-Tile)



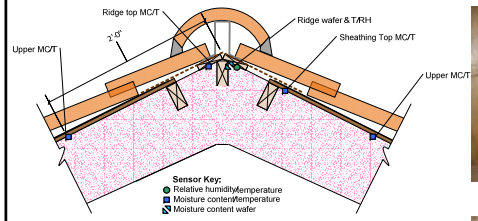


Roof Instrumentation (Houston)



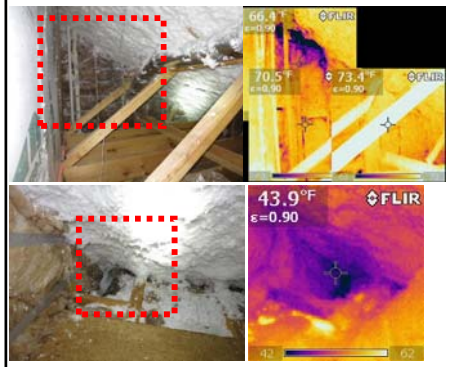
- Unvented (membrane) control vs. diffusion vent experimental
- Ridge packages
- Hip packages
- "Downhill" sensors
- Interior T/RH

Roof Instrumentation



- Temperature, relative humidity (RH), wood moisture content (MC)
- "Wafer" sensors

Air Leakage Testing

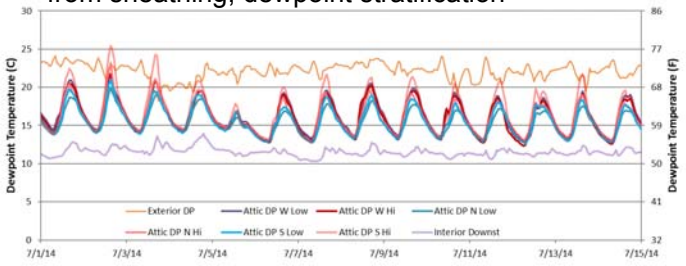


- Guarded testing: some attics tight, others noticeably leaky
- Depressurization w. infrared
- Air leakage occurs at roof-wall connections, not field of roof

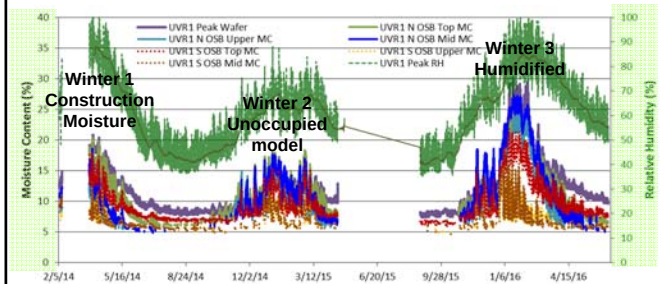
Results: Houston (Asphalt Shingle)

Houston Attic Conditions (Summer)

- Temperature tracks interior main space T
  - Warmer summer, cooler winter (ΔT 5-7 F/3-4 C)
- Temperature high-low stratification
- Dewpoint shows diurnal adsorption/desorption from sheathing, dewpoint stratification

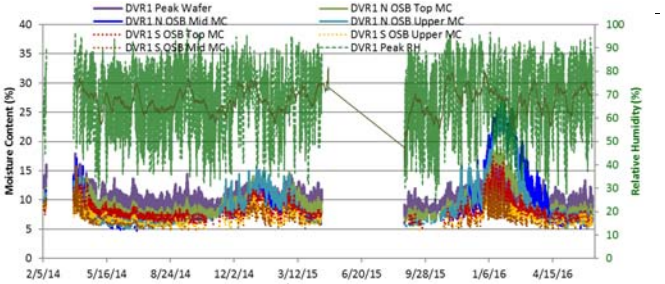


Houston Unvented Peak Conditions



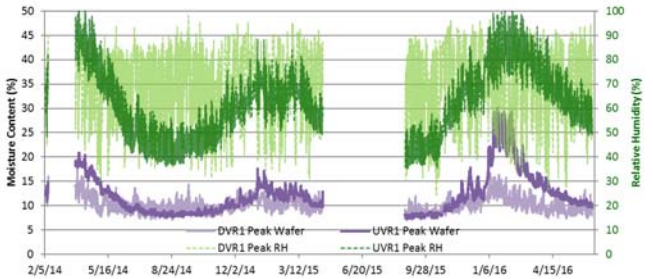
- Strong seasonal swing in moisture levels
- Wet in winter, dries out in summer
- Interior humidification→major effect, high risk

Houston Diffusion Vent Peak Conditions



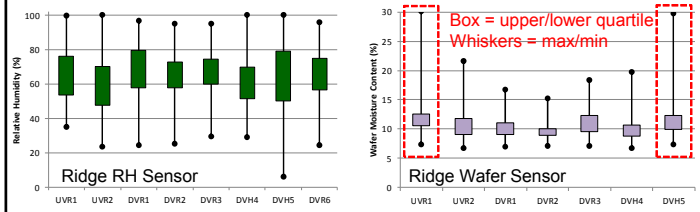
- MCs only risky in 3rd humidified winter, drier than UV
- Ridge RH shows minimal seasonal swing → coupled to exterior conditions
- Humidified winter ~40-65% RH interior attic

Houston UVR vs. DVR Comparison



- Diffusion vent wetter in summer, but well within safe range
- Wintertime diffusion vent prevents accumulation

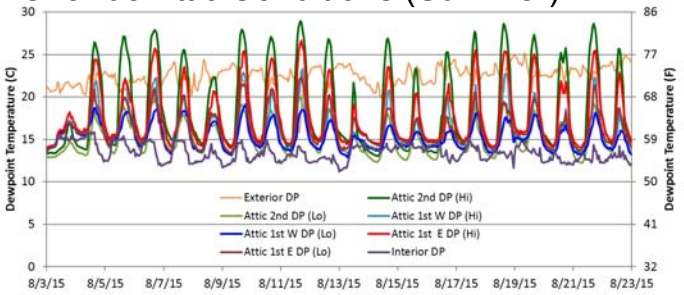
Houston Ridge RH and Wafer Box Plots



- RHs all have peaks 95-100%; diffusion vent roofs higher RHs in summer
- Wafer sensor shows long-term accumulation
- UVR1 & DVH5 wafer wettest outliers

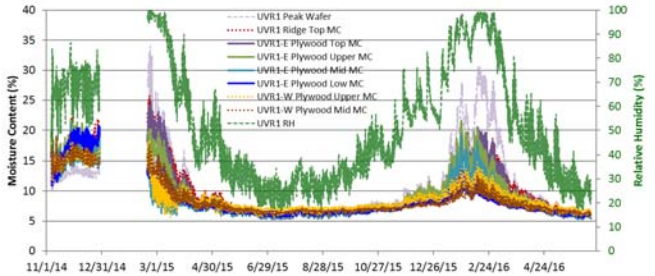
Results: Orlando (Concrete Tile)

Orlando Attic Conditions (Summer)



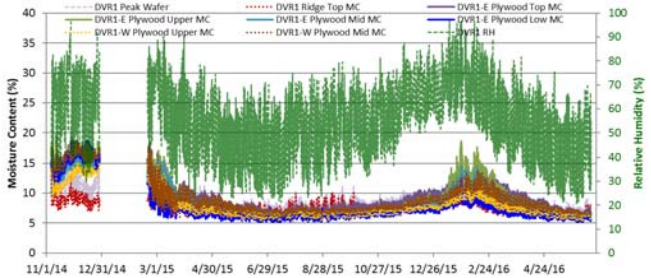
- Dewpoint diurnal cycling
- Highest dewpoints consistently at "high" locations
- Interior DP higher than exterior DP at peaks

Orlando Unvented Peak Conditions



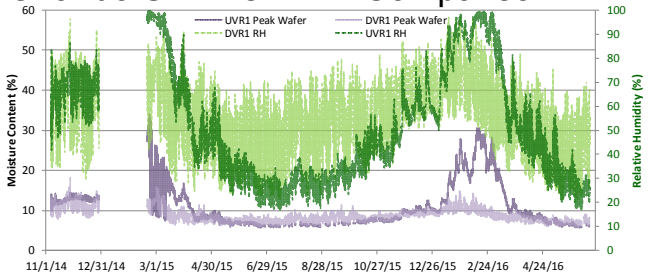
- Very high RHs and MCs first winter (construction moisture); missing data after drywalling
- Second winter—100% RH peaks, but sheathing MCs not as concerning

Orlando Diffusion Vent Peak Conditions



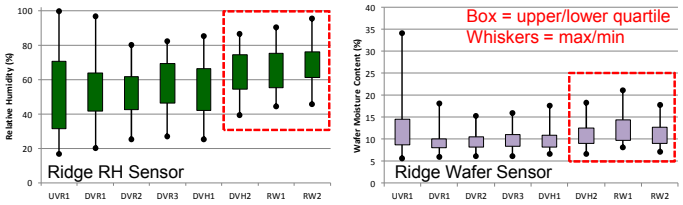
- Diffusion vent: lower MCs, RH peaks
- "Smear" RH data at ridge vs. unvented

Orlando UVR vs. DVR Comparison



- Again, wafer and ridge RH patterns show safer behavior with diffusion vent, less accumulation

Orlando Ridge RH and Wafer Box Plots



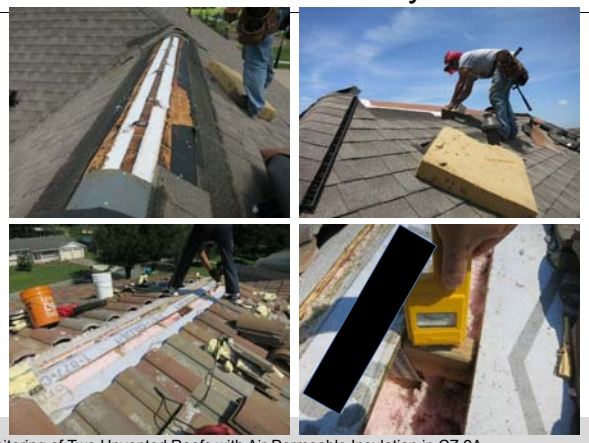
- Unvented roof (UVR1) outlier, 100% RH; 35% MC
- Diffusion vent roofs higher RHs in summer
- Wafer sensor shows long-term accumulation
- DVH2, RW1, RW2 wetter than other DVs

Orlando Roof Shading Patterns

- Higher RH areas in shade (DVH2, RW1, RW2)

Decommissioning & Disassembly

Unvented Roof Disassembly/DV Retrofit



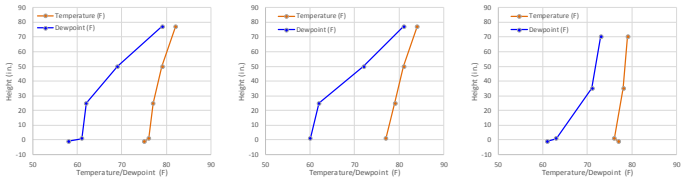
Houston Hip Diffusion Vent

- Monitored results showed low drying—closer to unvented behavior vs. diffusion vent
- Limited drying available at 2" hole "diffusion ports"
- Covered up by asphalt shingles
- Shingles cut back-retrofit

Orlando Roof Peak Conditions

- Spotting on netting near ridge, ~4 ft./1.2 m down
- Worst issues at unvented (not diffusion vent):
  - Spotting on truss vertical member/king post
  - Spotting on upper T/RH sensor jacket, not lower
  - Water stains on ceiling drywall under ridge
- First winter construction moisture condensation

Orlando Attic Vertical Measurements



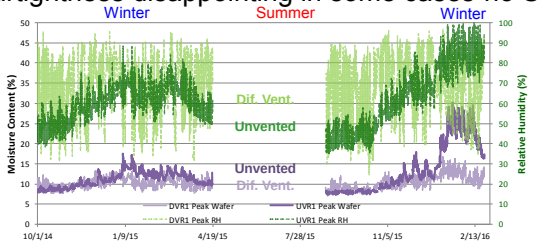
Upper Attic | Upper Attic | Lower Attic

- Handheld T/RH probe
- Late afternoon June 2016
- Temperature and dewpoint differences w. height

Conclusions & Recommendations

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



Questions?

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Project Partners/Sponsors: Cosella Dörken, David Weekley Homes, DuPont Building Innovations, Johns Manville, and Owens Corning

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