

Thermal Performance of the Exterior Envelopes of Whole Buildings XIII

Sealed Attics Exposed to Two Years of Weathering in a Hot and Humid Climate

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Principles: Attic and Roof Performance

Session 5, Tuesday 1:30 PM

Chair: Bill Rose



Objectives

1. Conduct attic ventilation field studies in hot, humid climate of Charleston SC

Partners

- GAF
- Owens Corning Fiberglass

2. Document temperature and moisture management in attics sealed with spray polyurethane foam insulation

Climate: Hot and Humid
Air leakage

Sealed attics

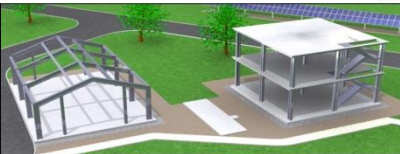
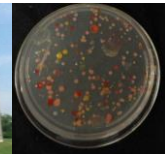
- Closed-cell foam
- Open-cell foam
- Durability

Natural Exposure Test (NET) facility



ASHRAE STANDARD

Criteria for
Moisture-Control
Design Analysis in
Buildings



Natural Exposure Test Facility in Charleston, SC

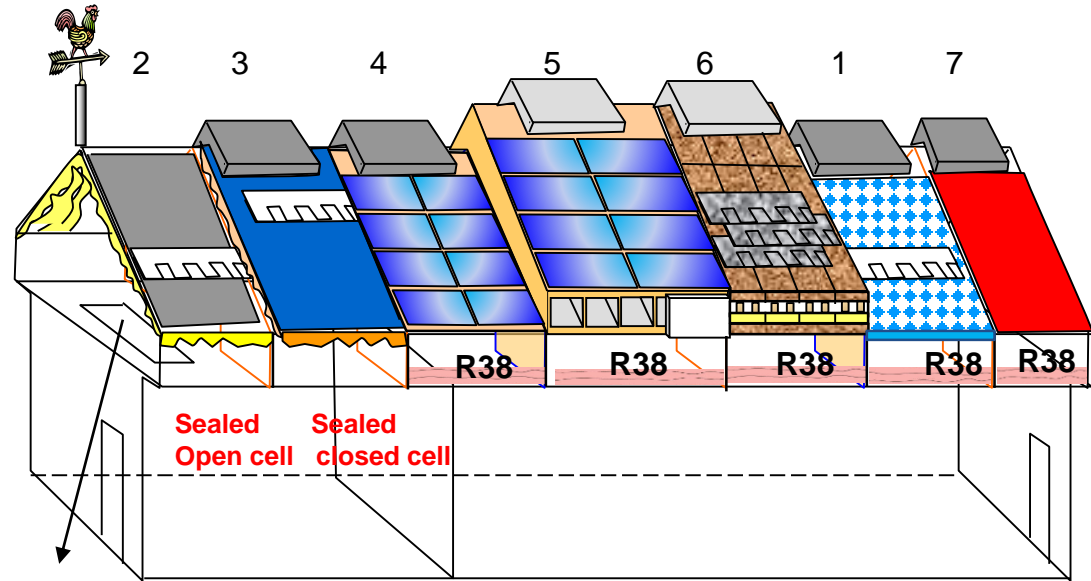


Permeance:

material < 0.1 perm vapor impermeable

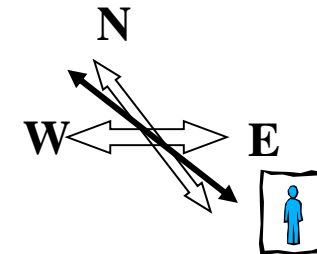
material between 1.0 and 10.0 perm vapor semi permeable

Attic Cavity	Acronym
Attic 01	CTRL (16 Perm) Vapor permeable underlayment
Attic 02	SLD (8 Perm) Semi permeable
Attic 03	NB (0.04 Perm) Vapor impermeable
Attic 04	CC (0.04 Perm) Vapor impermeable
Attic 05	ASV (8 Perm) Semi permeable
Attic 06	RB (8 perm) Semi permeable
Attic 07	FF (0.10 Perm) Vapor semi impermeable



Access door

Each bay width ~ 11 ft

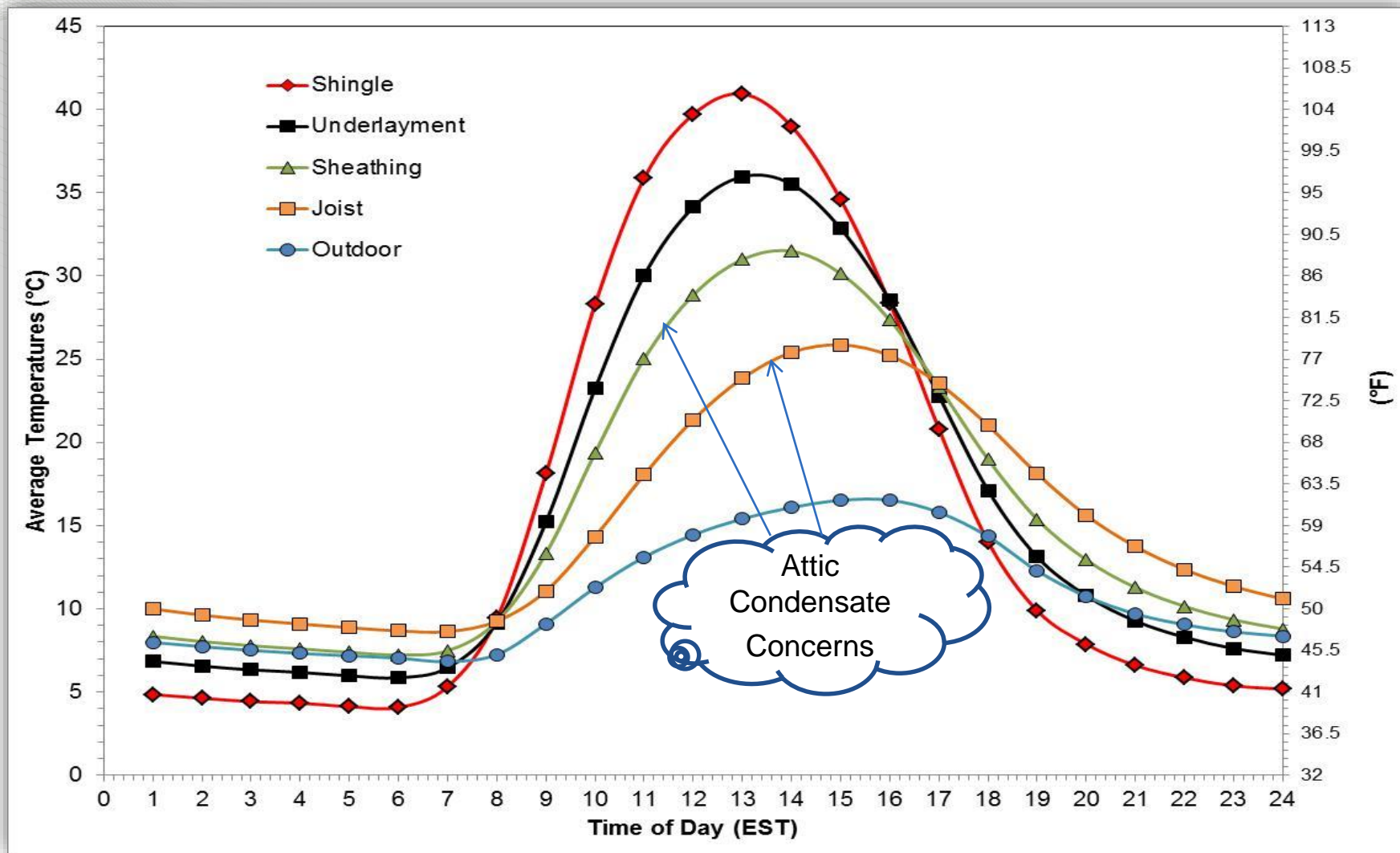


Established Benchmarks heat flux crossing roof decks
and attic floor for all 7 Attics

Winter Data: January – April 2011



Ventilated Attics: Potential for Condensation occurs $\leq 5\%$ of 5760 hrs



Attic 01 Vent 1:300, Vapor permeable underlayment (16 perm)

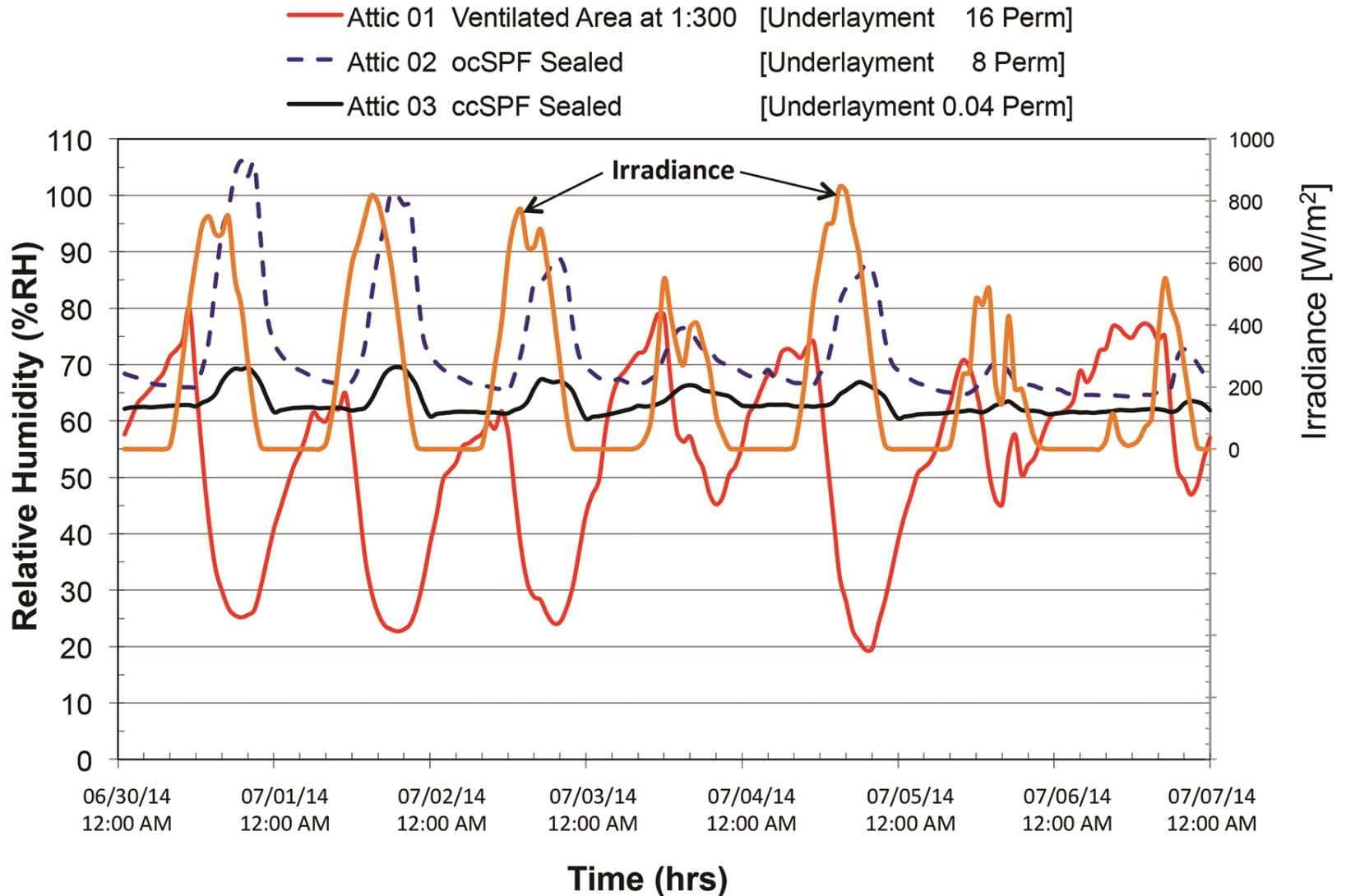
Condensation Potential Least for ASV Roof and Attic

● Charleston Field Data Jan through March 2011

Attic	Hours $T_{\text{sheath}} < T_{\text{dp}}$ (2015 total)	% Time for Condensation on Sheathing	Hours $T_{\text{joist}} < T_{\text{dp}}$ (2015 total)	% Time for Condensation on Joist
03 – Low perm	110	5.46%	72	3.57%
04 – Irr Shingle	103	5.11%	62	3.08%
01 - CTRL	102	5.06%	48	2.38%
06 - RB	83	4.12%	26	1.29%
07 – 1:150	75	3.72%	32	1.59%
05 - ASV	20	0.99%	10	0.50%

Sealed attic assembly shows evidence of moisture intrusion

● Moisture Intrusion trend not observed in winter months

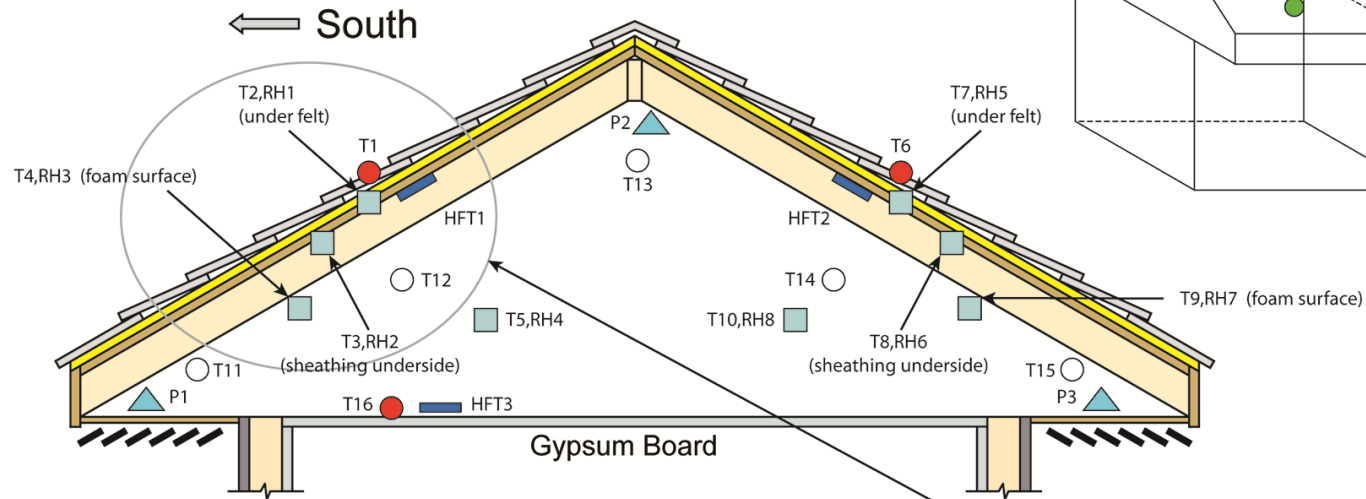
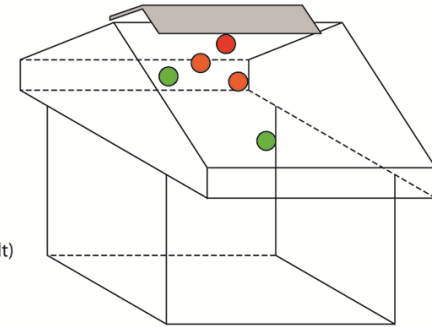


Instrumentation for Sealed Attics

- Temp Thermistor
- Temp/Rh Absolute humidity probe
- ▬ Heat flux Roof decks, attic floor
- Temp Air
- ▲ Pressure Air

Single Bay

- Footprint: 12-ft by 21-ft
- Roof pitch: 3/12

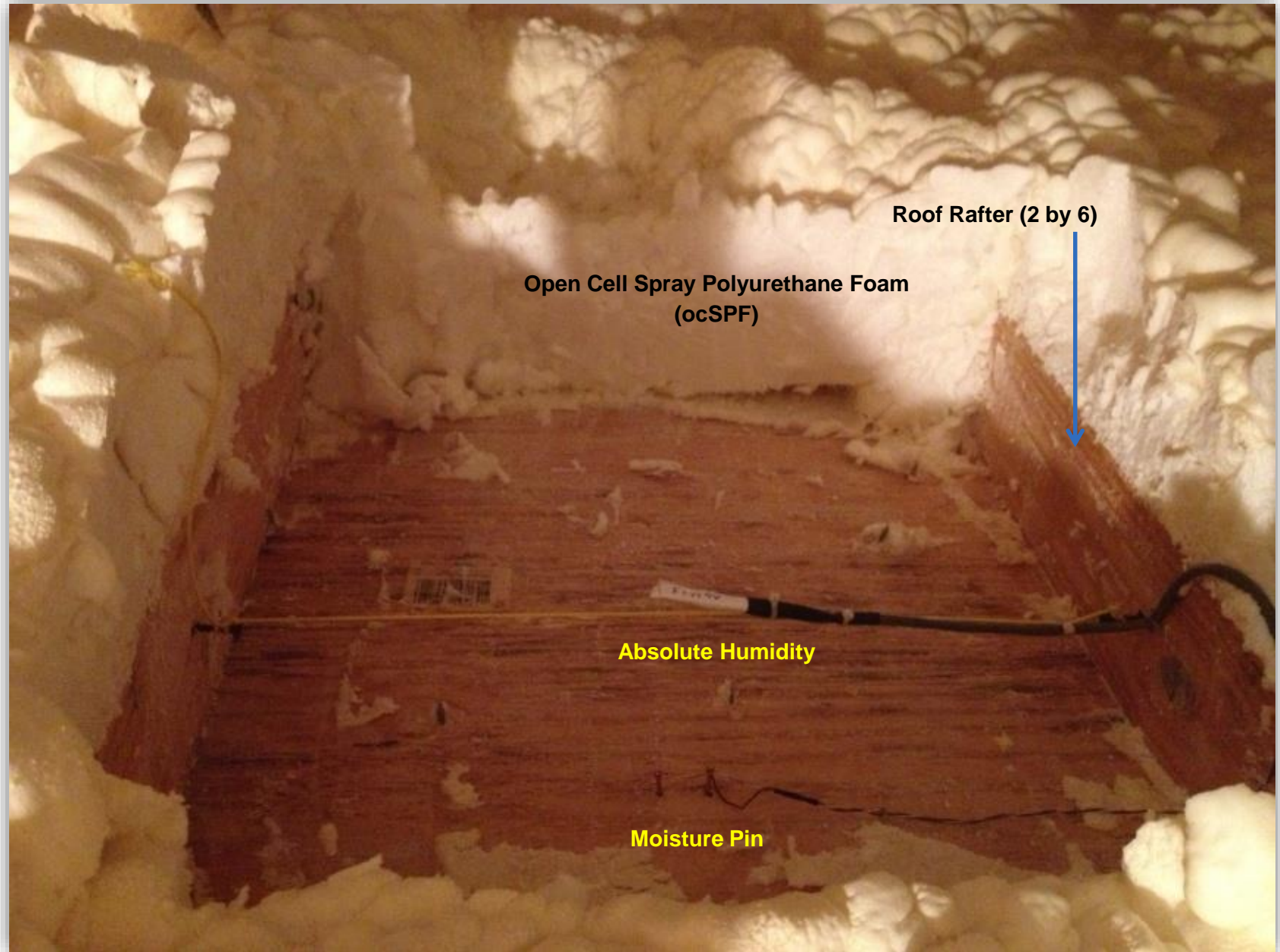


These sensors are all in the same vertical plane, both sides

In each attic

- Thermistors (16), Rh sensors (8), Heat flux sensors (3)
- Total 27 sensors per bay

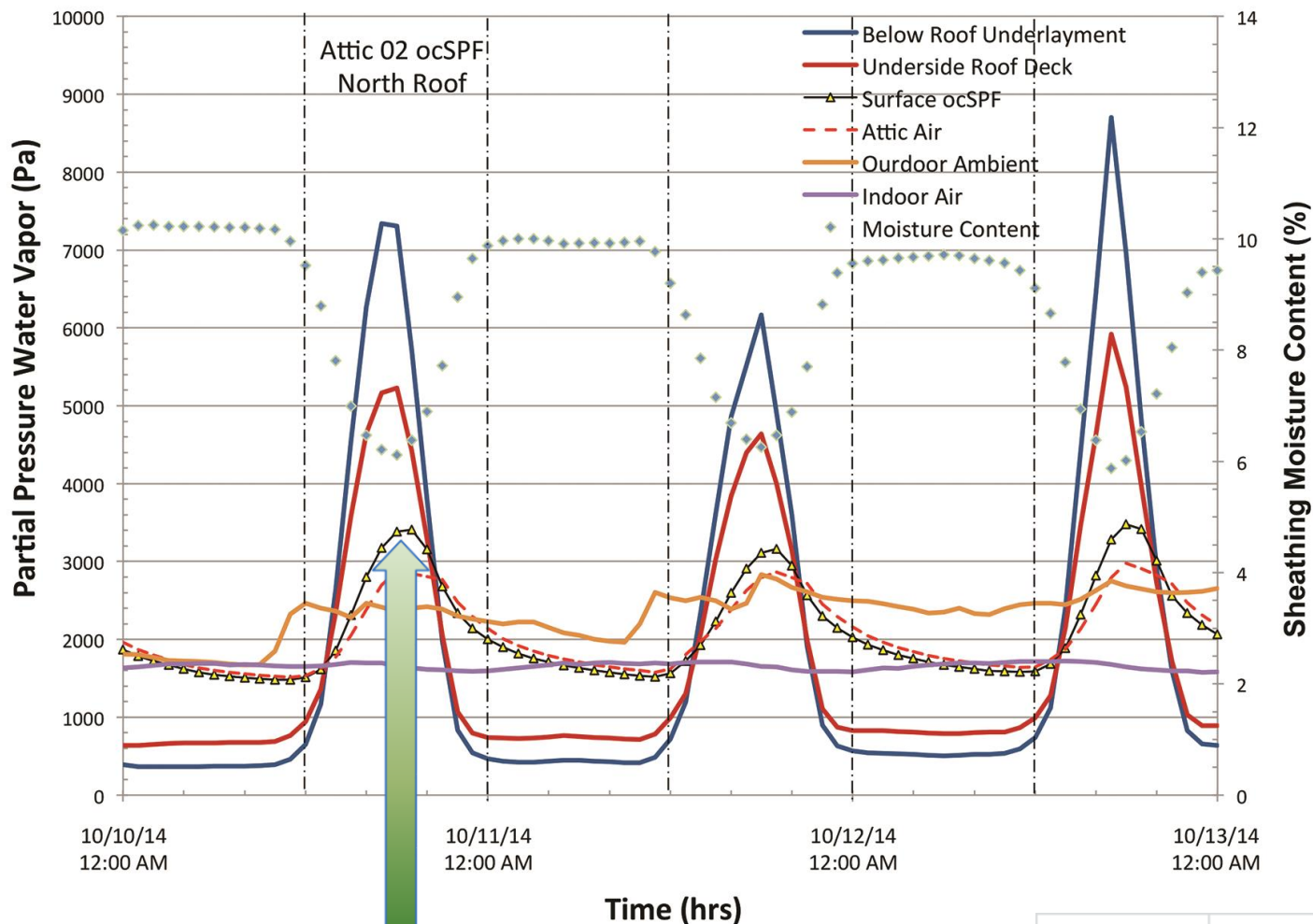
Attic 02 Data for Oct 2014 [sealed with ocSPF]



Attic O2 Data for Oct 2014 [sealed with ocSPF]



No Internal Moisture Load. No Occupants in NET facility.



Vapor is moving from ocSPF to Attic Air

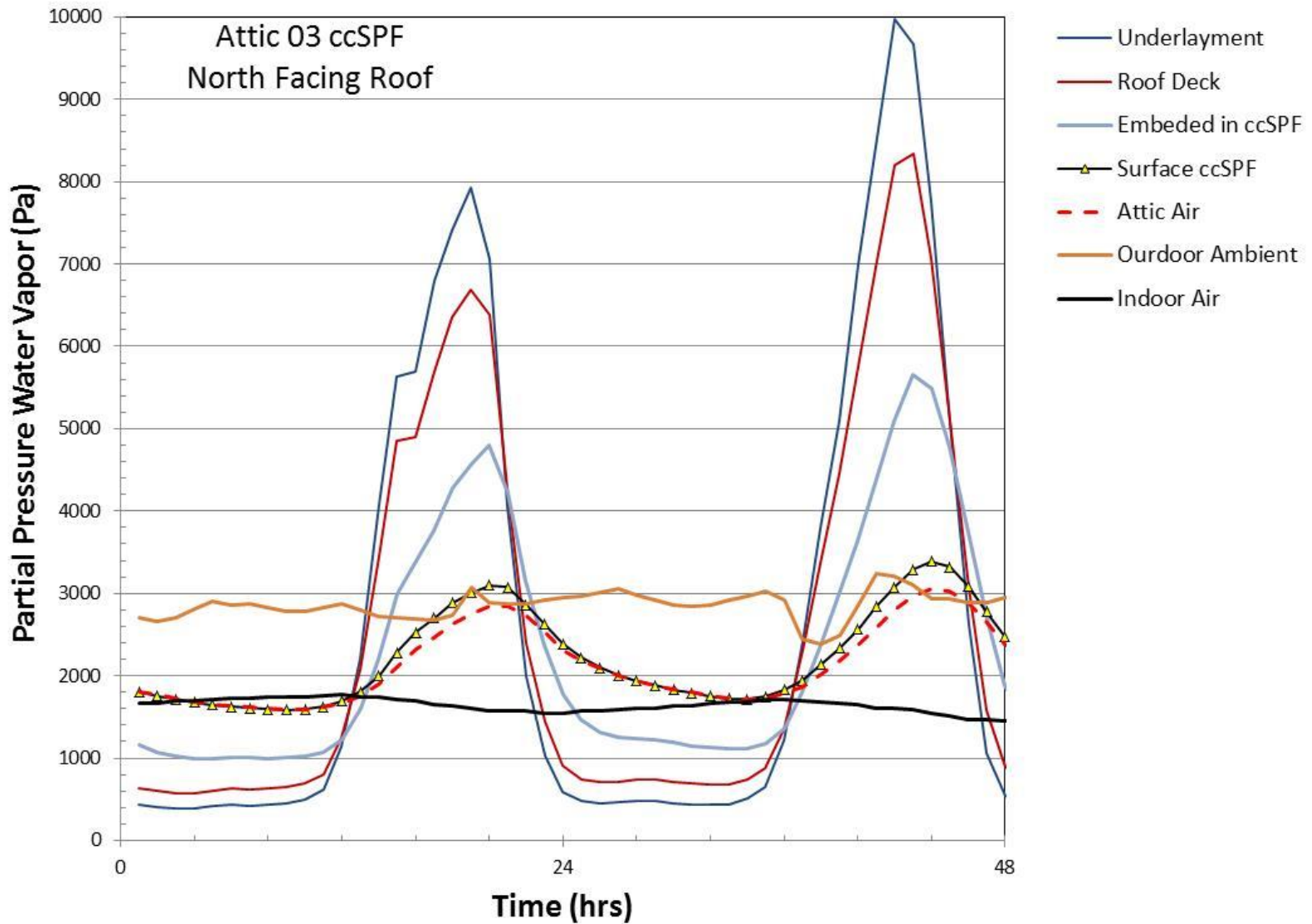
	ocSPF
R_{US}	3.6 per inch
Permeance	16 Perm per 3 inches
Cost	\$0.50 per board foot

Plywood deck (½-in) shows moisture damage after 2 years of exposure to hot, humid climate and ocSPF insulation

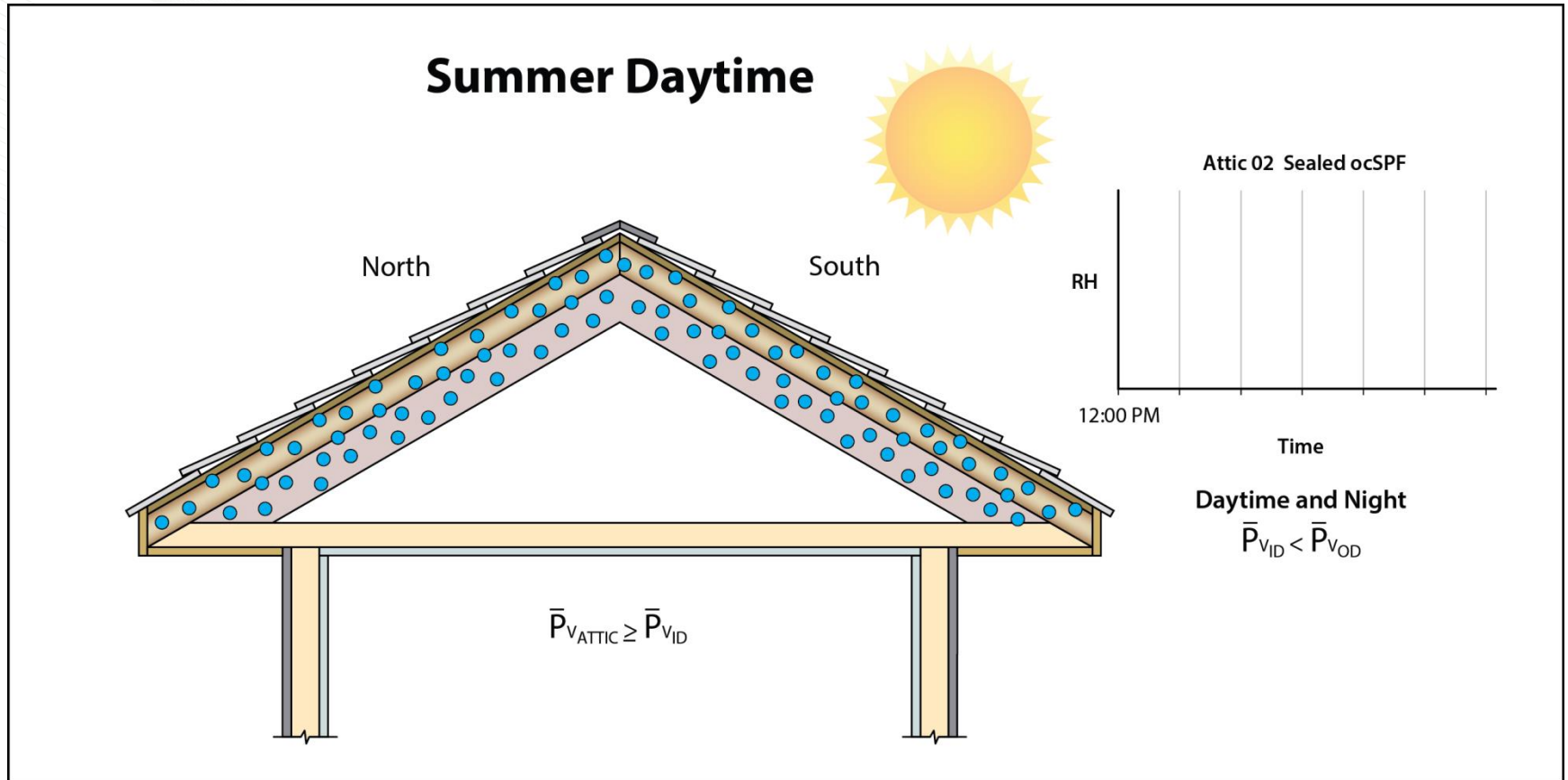
- Delmhorst measures showed south- and north-decks dry
Moisture damage comes from attic interior



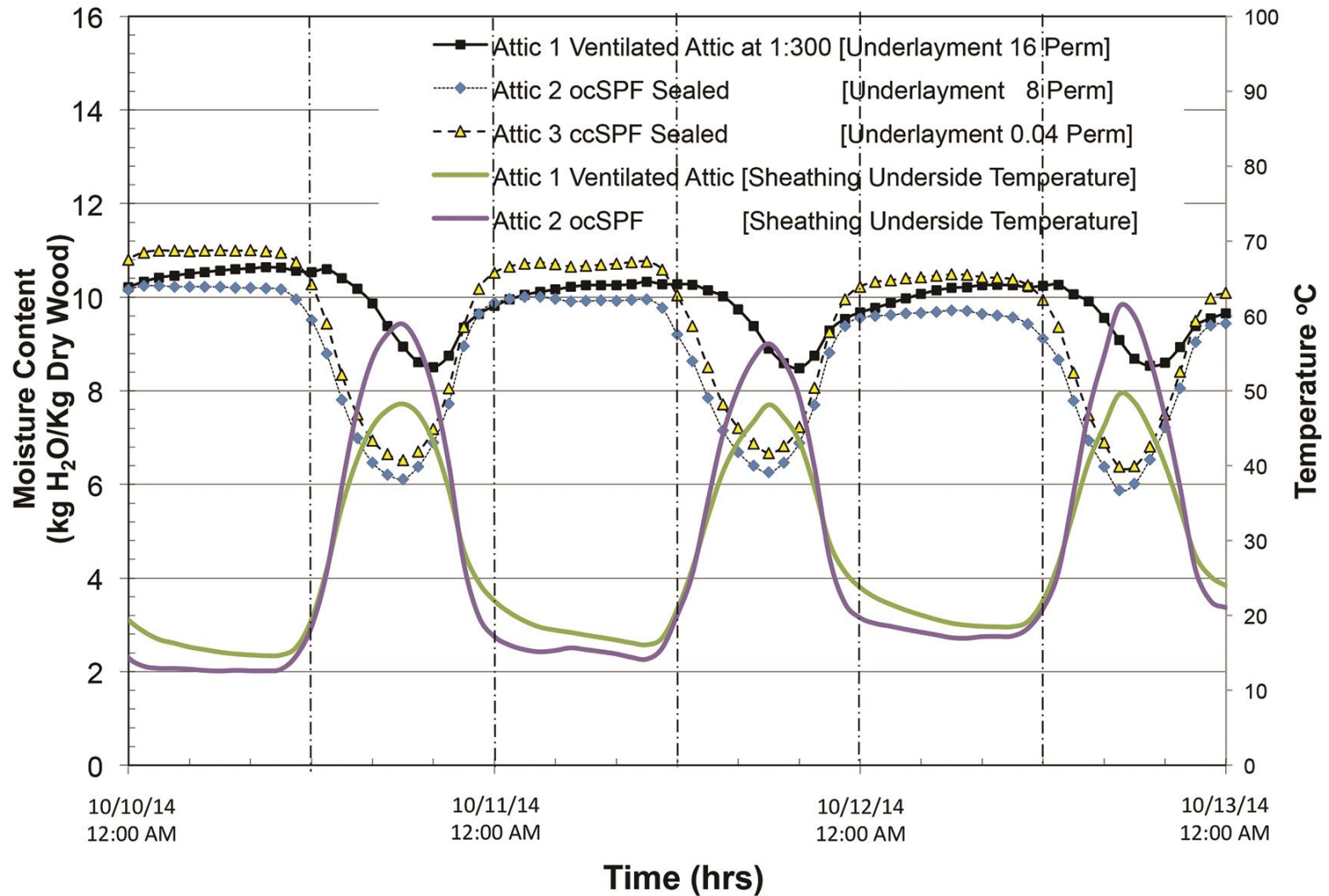
Attic 03 Data for Oct 2014 [sealed with ccSPF]



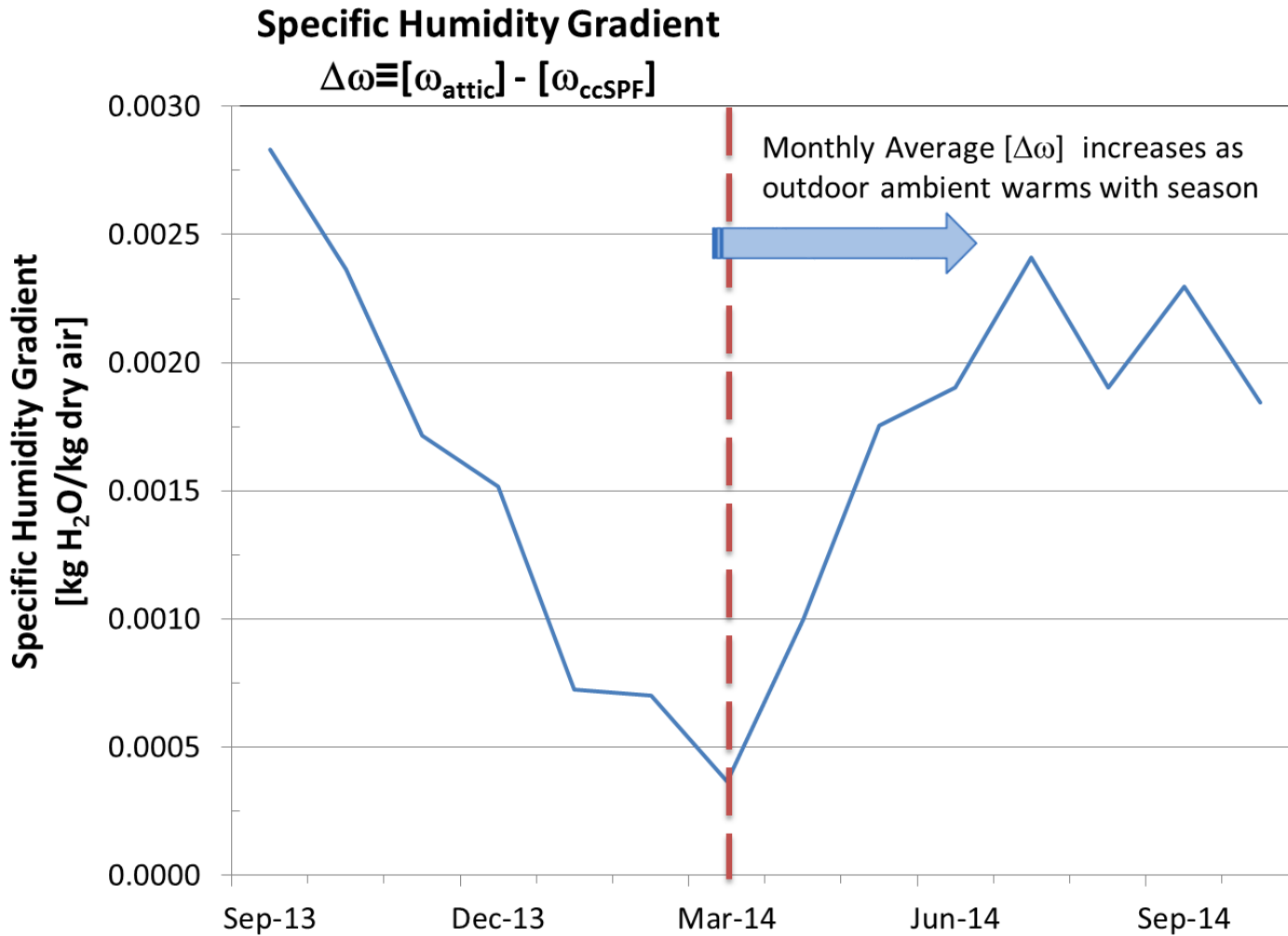
Sealed Attic Moisture Intrusion



Cyclic Effect of Moisture Content in Roof Deck not as Severe if Attic Ventilated



Monthly Average Specific Humidity of Attic Exceeds Specific Humidity in the ccSPF



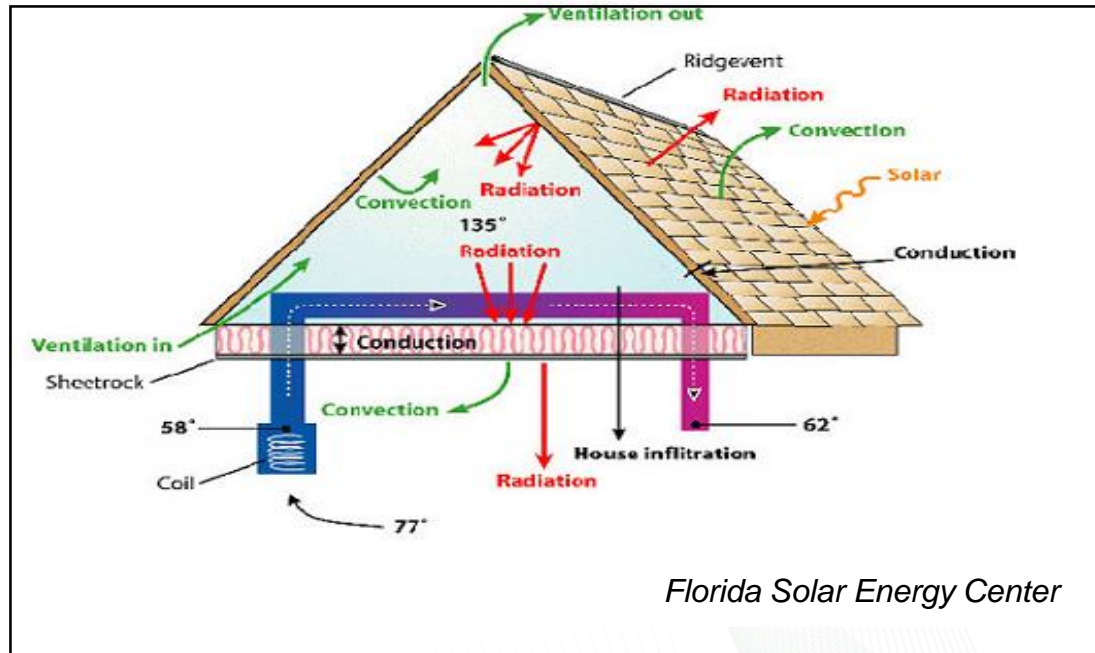
AtticSIM Simulation Model

FORTRAN 90

Estimating Heat Gain and Loss Through Ceilings Under Attics



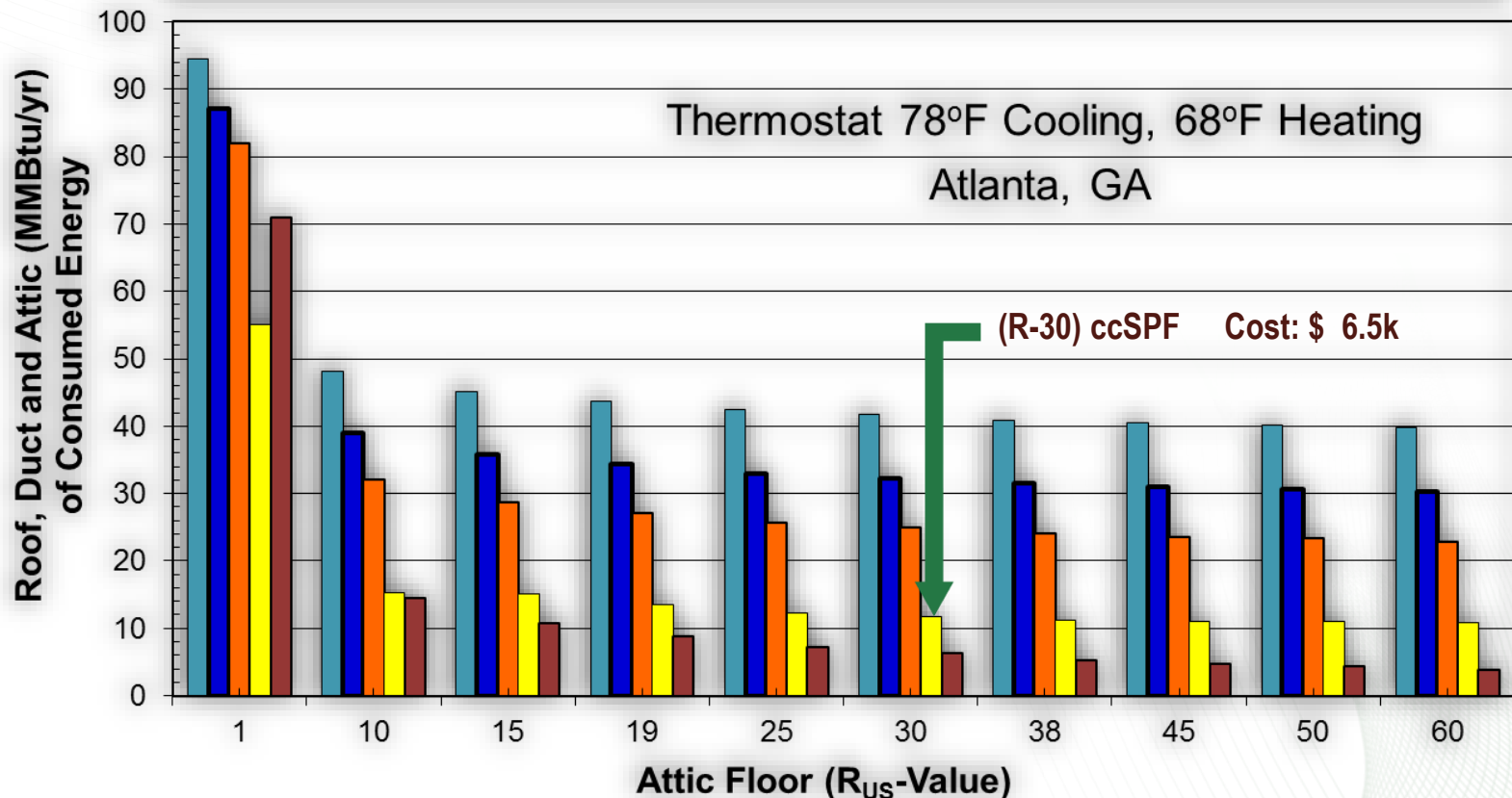
**Roof Energy
Balance**



Petrie, T., Wilkes K., "Effect of Radiant Barriers and Attic Ventilation on Residential Attics and Attic Duct Systems," ASHRAE Trans., June 1998

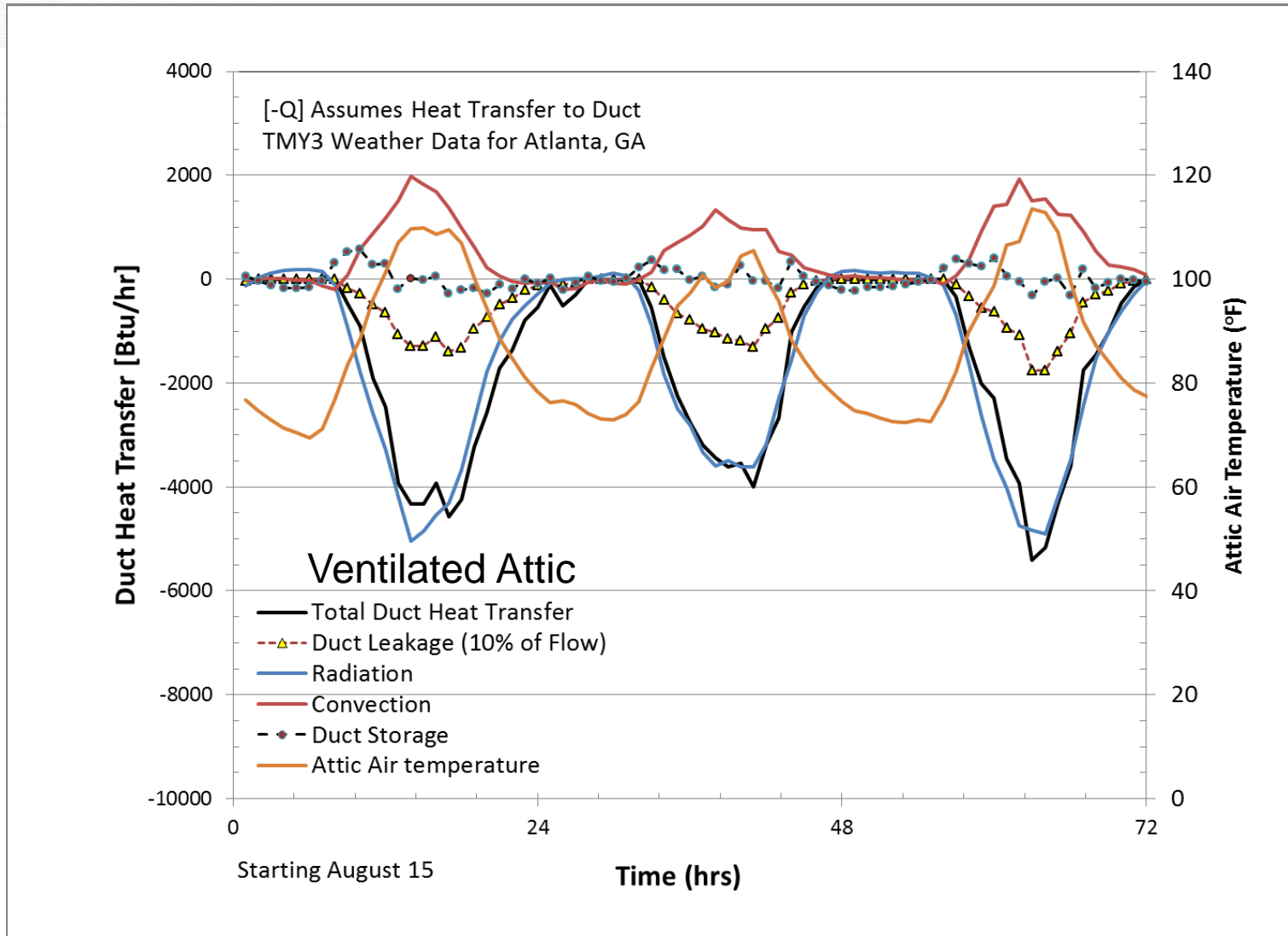
Diminishing Returns for Adding Ceiling Insulation (Leaky Duct Losses ☠)

- Dark Shingle roof, attic contains 20% leaky ducts; attic floor is not sealed
- Dark Shingle roof, attic contains 10% leaky ducts; attic floor is not sealed
- Dark Shingle roof, attic contains 4% leaky ducts (R-8 insulation); attic floor is sealed
- Dark Shingle Roof with Sealed Attic, 10% leaky duct; attic floor is not sealed
- Dark Shingle but with ducts removed from attic; attic floor sealed



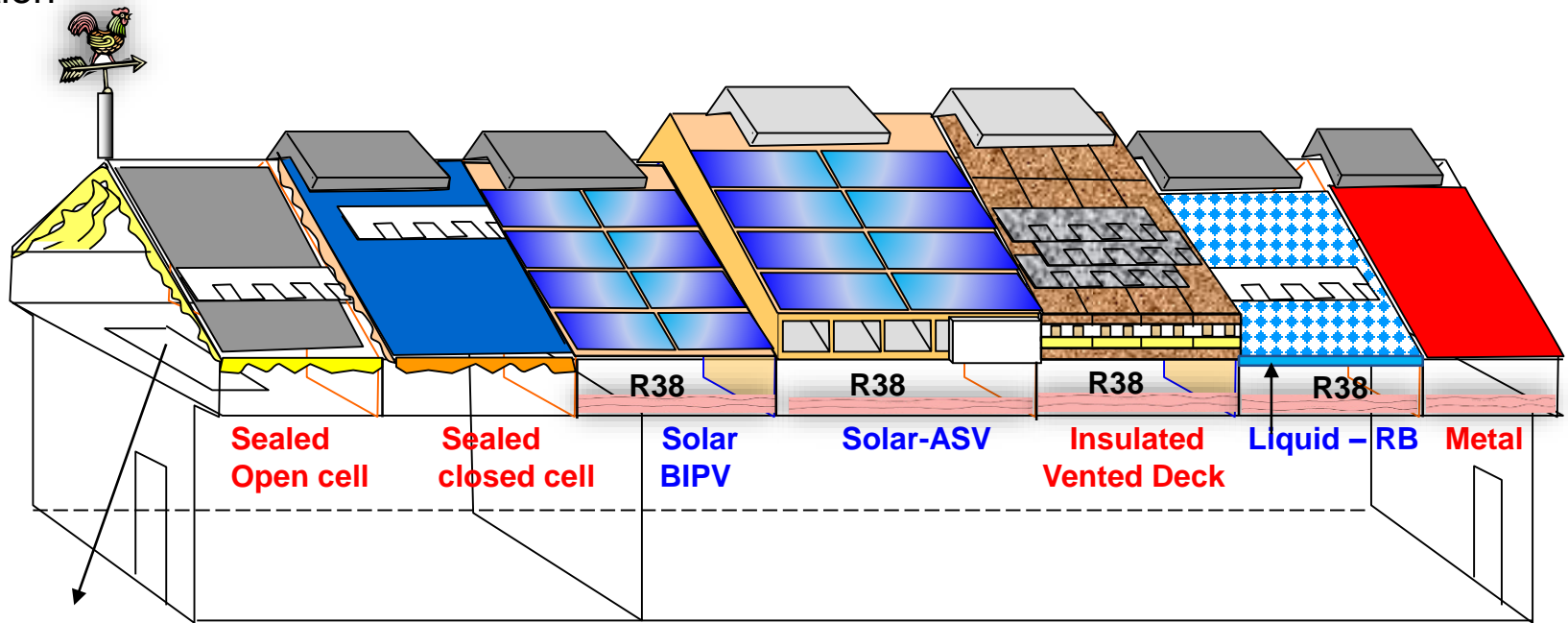
R_{US} thermal resistance to heat transfer

Summer Operation of HVAC Duct in ASHRAE Climate Zone 3

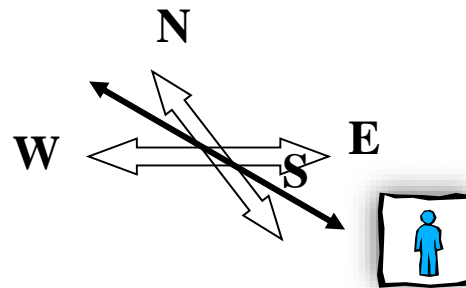


NET Field Experiments Sealed Attics Insulated to R-22

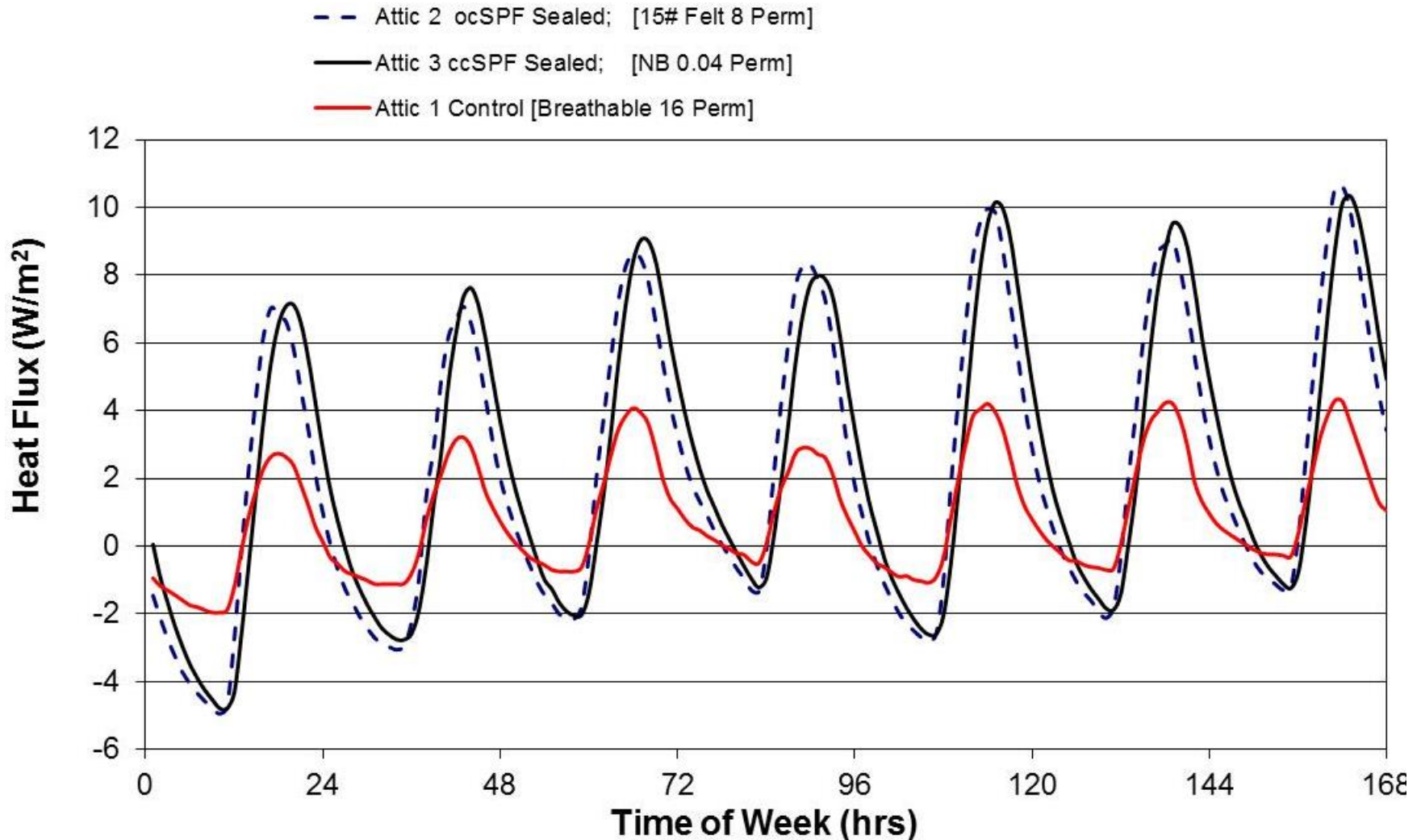
Weather
station



Access door



Ceiling Flux Crossing Sealed Attics Insulated to R-22 at Roof Deck is at Least Double that of R-38 Blown Fiber on Ceiling in Ventilated Attic



Conclusions

1. The attics sealed with ocSPF and ccSPF showed higher moisture movement during the warmer months of the year than observed in the colder months.
2. Moisture transfer crossing the ccSPF was much less than that for the ocSPF because of the difference in permeance of the two foams.
3. Moisture was physically observed along the 2 by 6 rafters of the attic sealed with ocSPF. Water damage to plywood deck was observed about 1.6 meters up from the soffit.
4. The field study did not show evidence of moisture marks or damage near the ridge, rather water marks were observed along the rafters about mid span of the roof.
5. Sealed attic insulated with spray polyurethane foam that is less than code level of insulation will have significantly higher heat flows crossing the attic floor.
 - difference in thermal resistances of bare drywall as compared to an insulated ceiling predominates over the benefit of the reduced attic air temperature

Questions and/or Discussions

1.



Contact information

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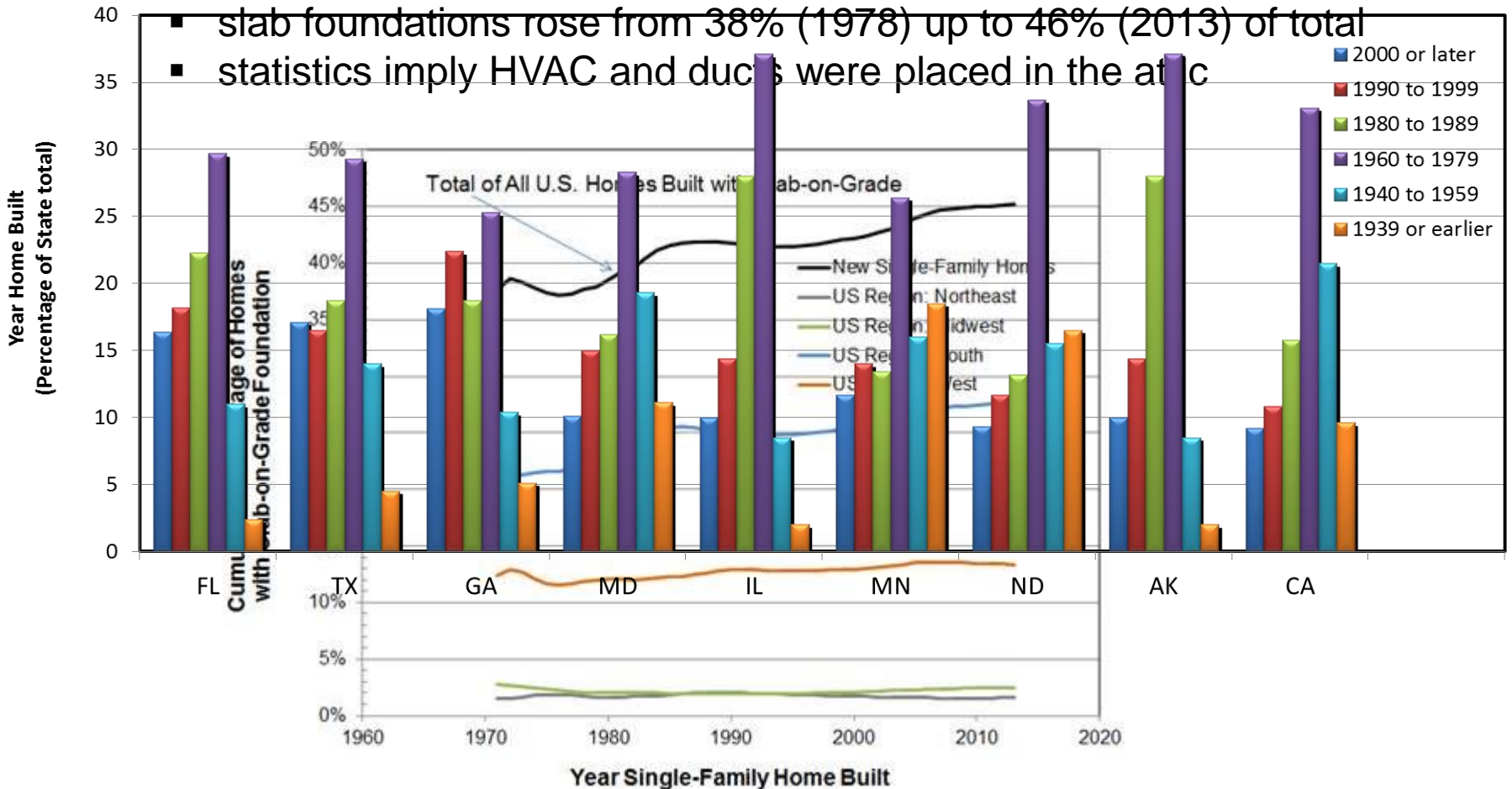
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US Census Bureau Demographics

~50% of the 114 Million U.S. homes built 1940 to 1979

Census Bureau 2013 data reveals (mostly the south)



ORNL Roofs and Attics project has been and continues as a highly leveraged public-private partnership



COSELLA DÖRKEN



Building Solutions



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