Thermal Performance of the Exterior Envelopes of Whole Buildings XIII
Workshop 5 – How to Evaluate the Risk of Mold Using the Mold Growth Index
December 4, 2016
Clearwater Beach, Florida, USA

Comparison of Mold Index Model Predictions with Field Observations in North America

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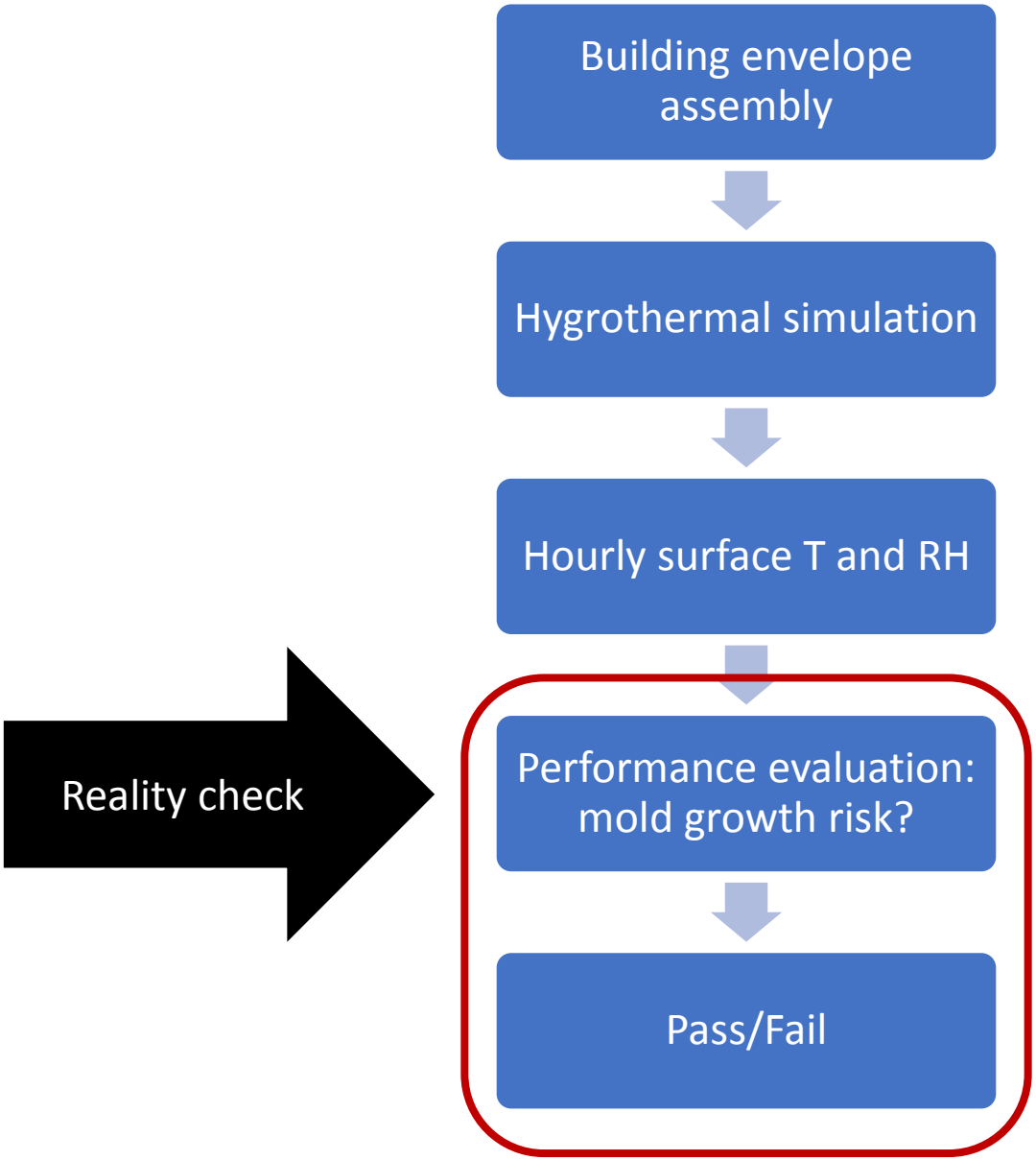
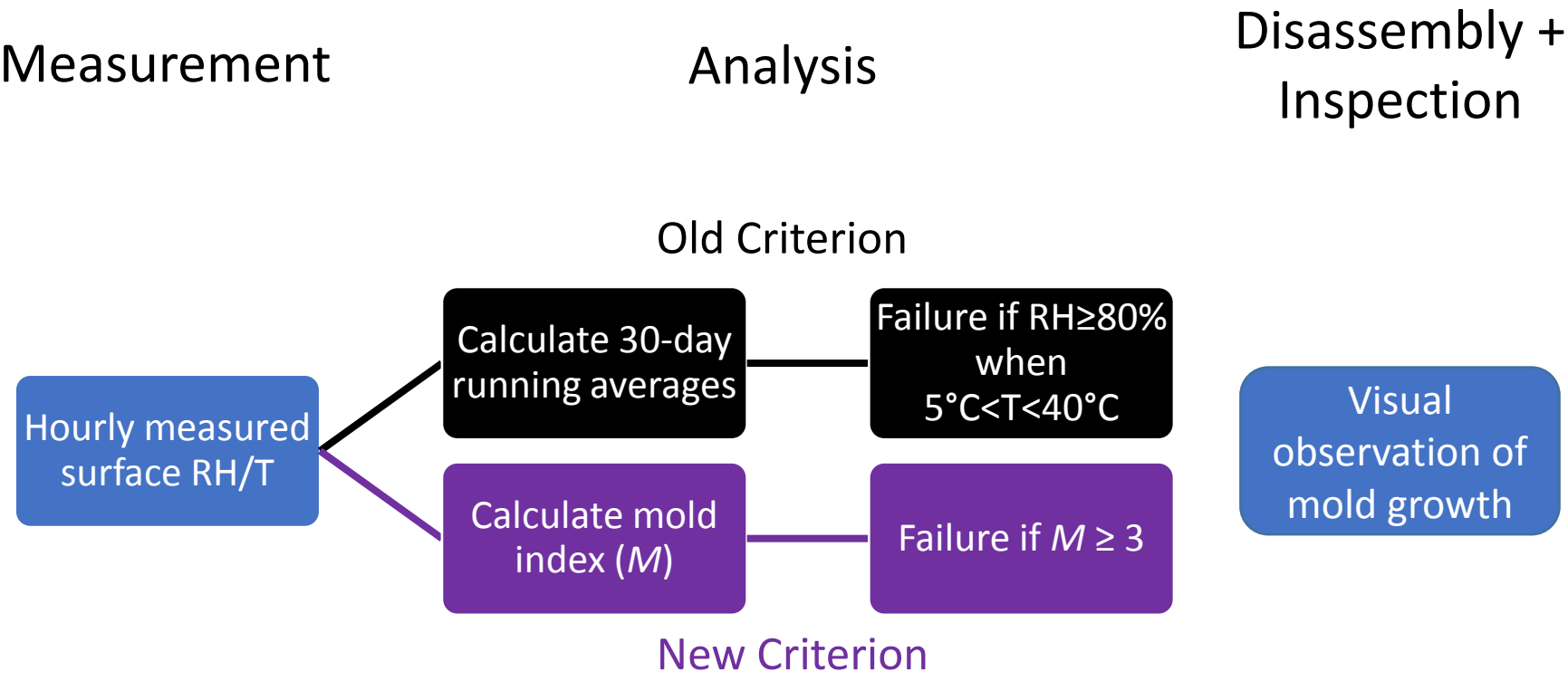
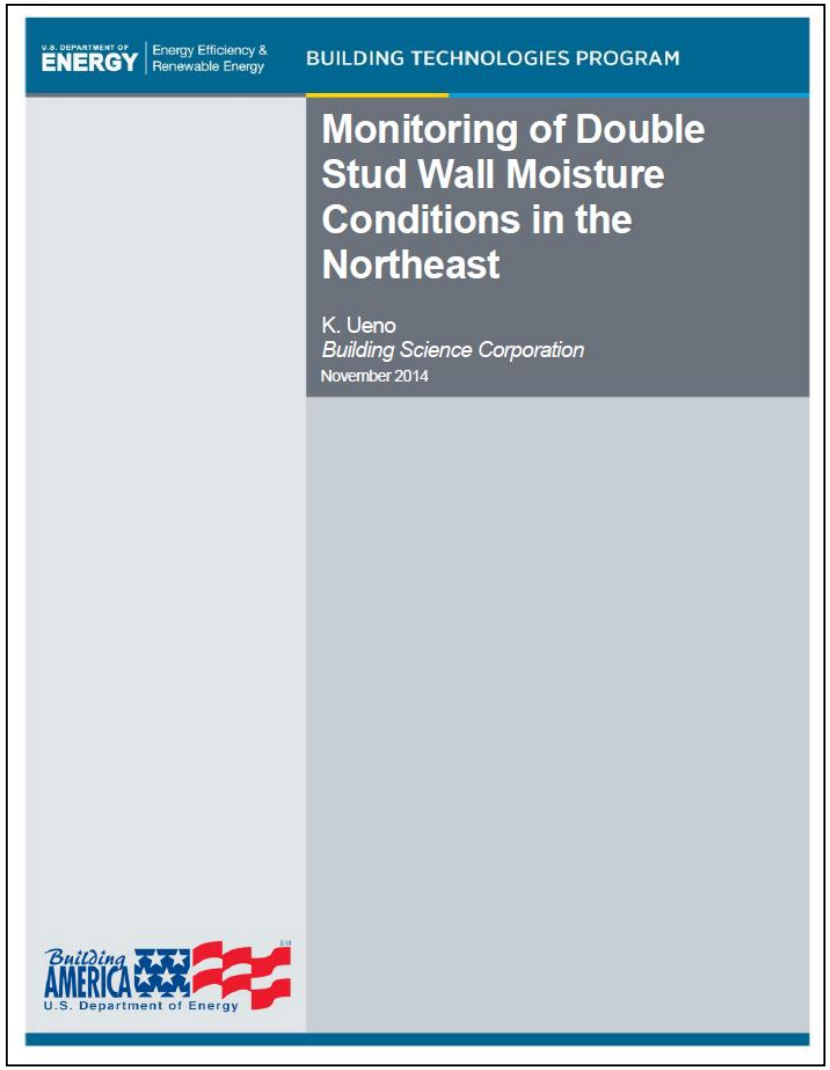

Building envelope assembly
Hygrothermal simulation
Hourly surface T and RH
Performance evaluation: mold growth risk?
Pass/Fail
Reality check

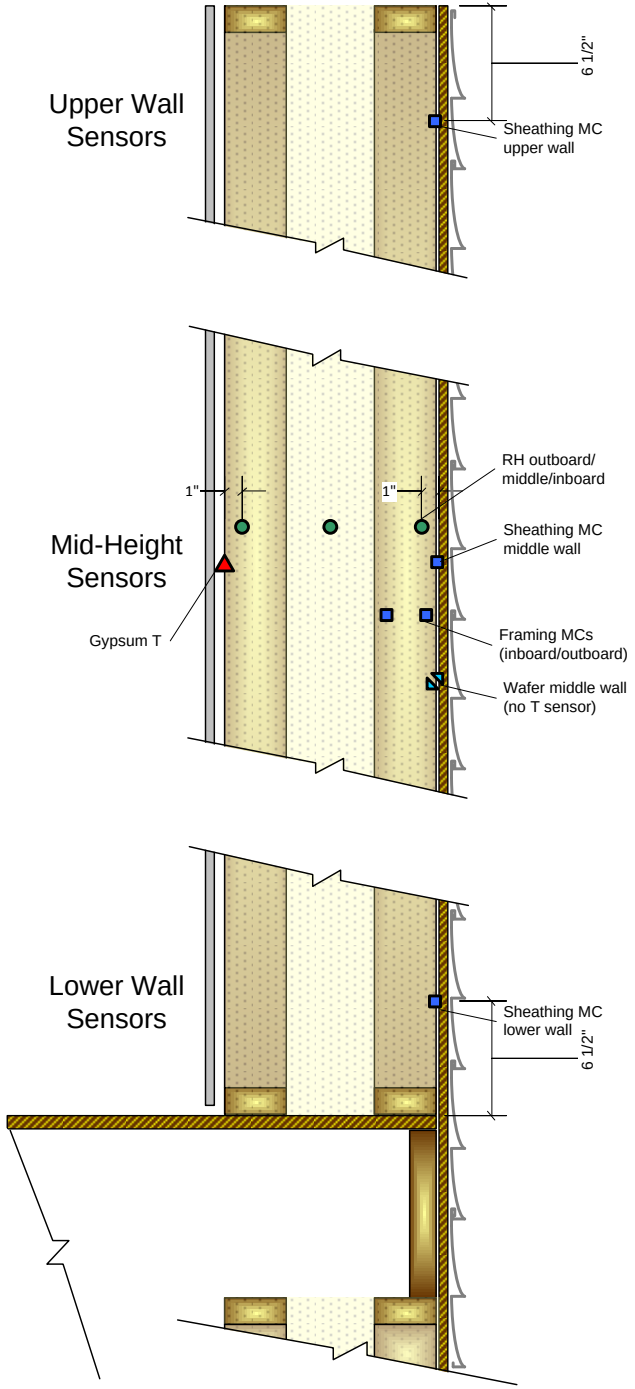
Methodology



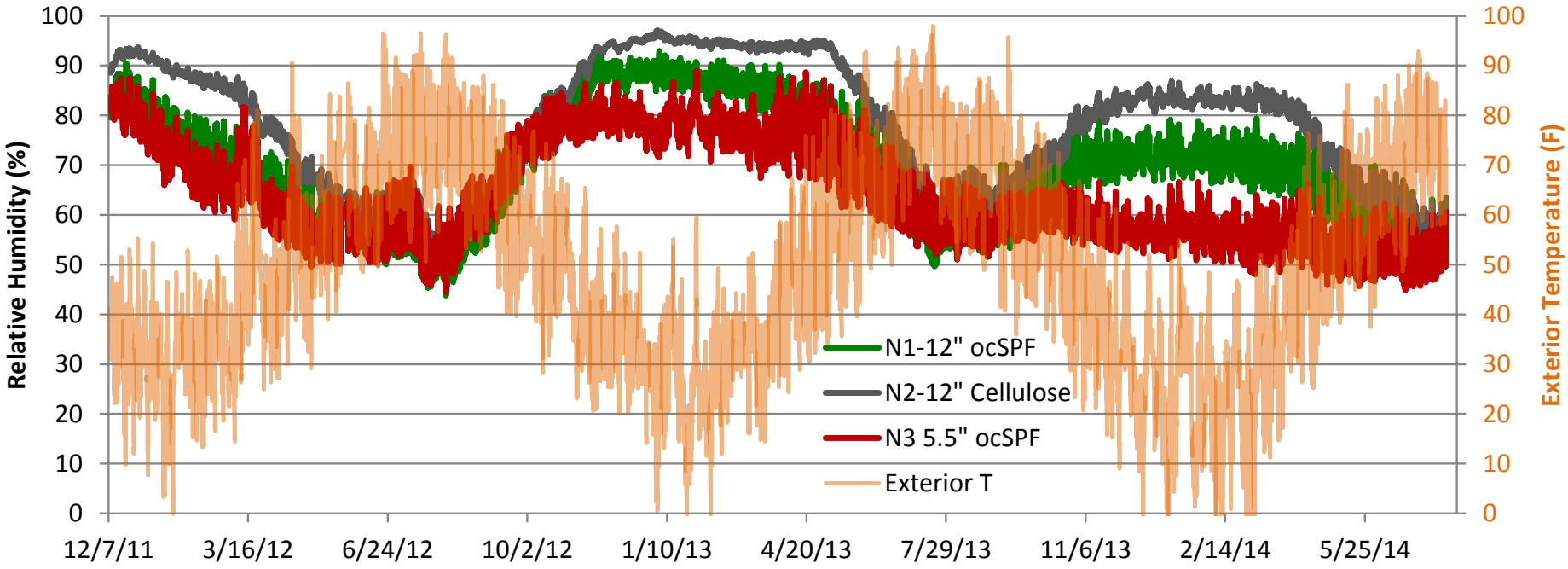
Occupied home near Boston



Double stud walls



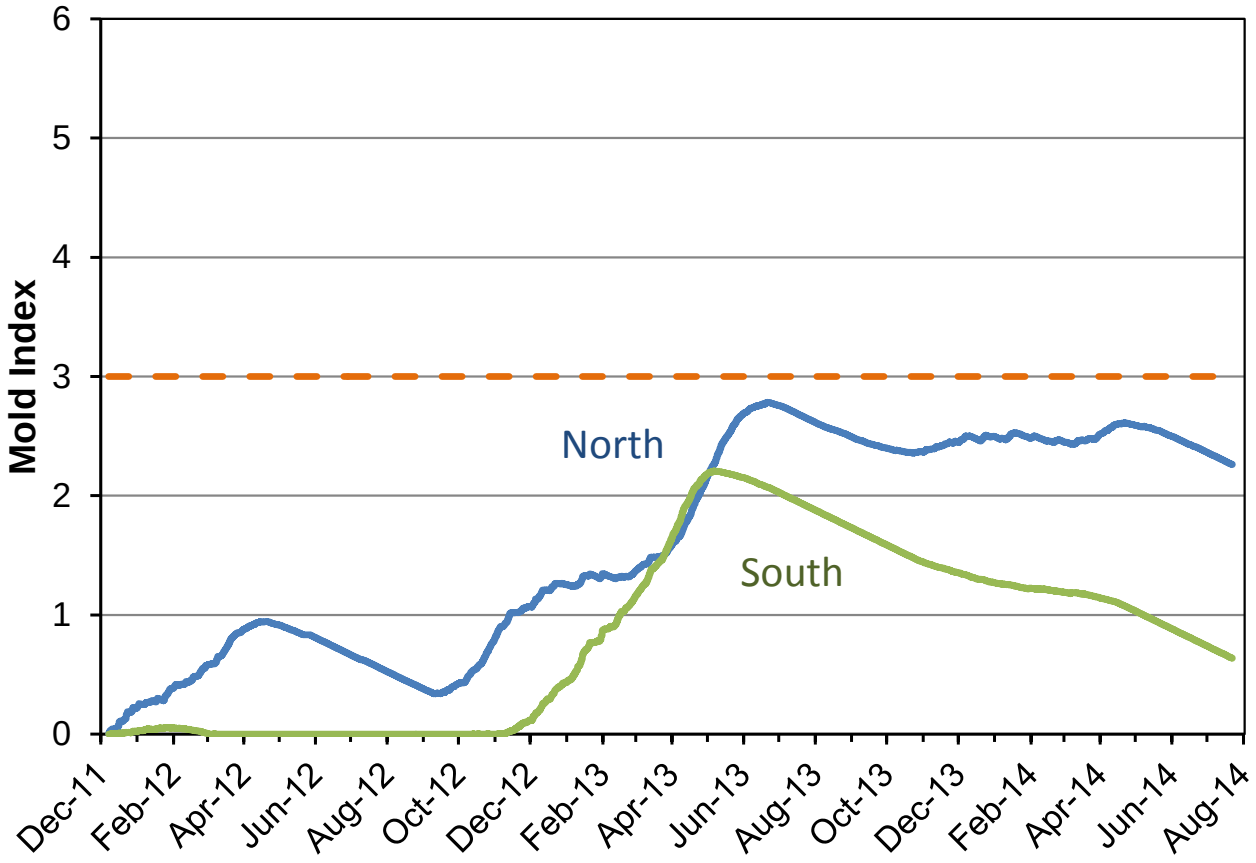
RH measurements at OSB surface



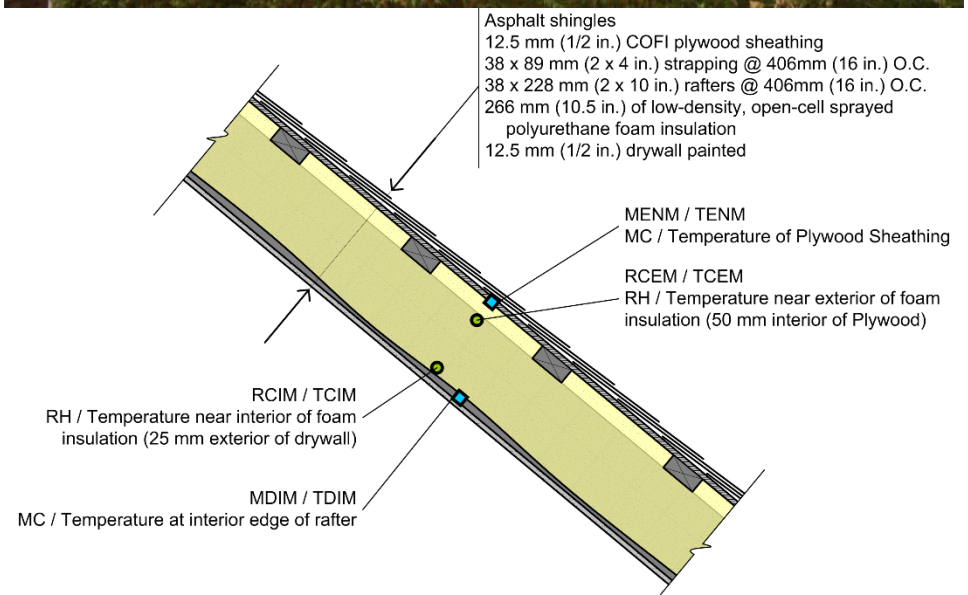
North wall disassembly

North wall disassembly

Model predicts no visible mold growth



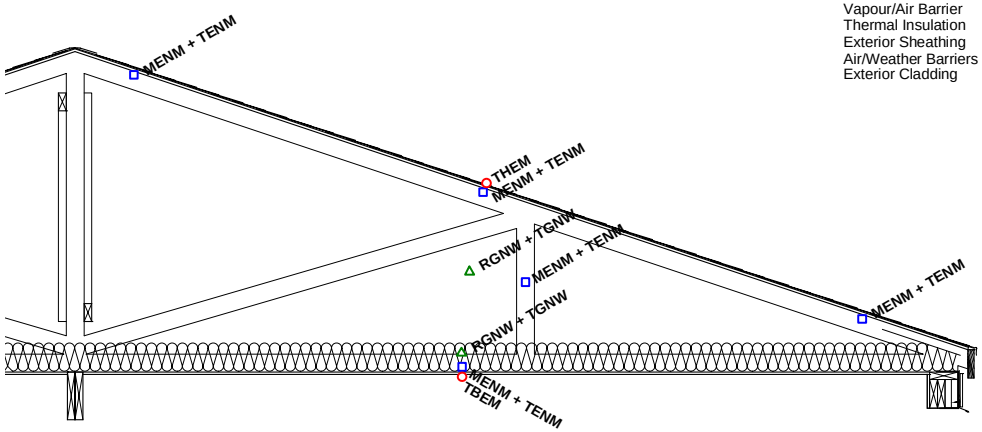
Vancouver unvented cathedral ceiling



Coquitlam vented attic

Roof Panel 1
Vented Attic *(fiberglass batt)*

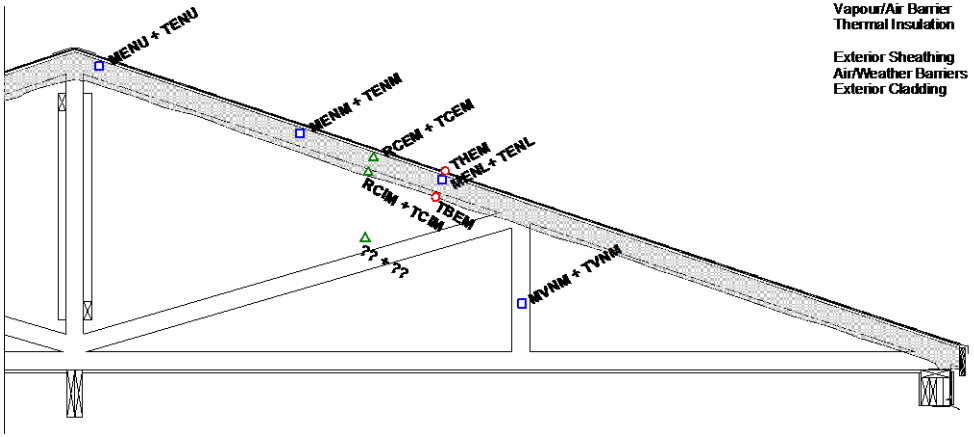
Frame:	2 x 4 truss
Interior Surface/Finish:	1/2" drywall + paint
Vapour/Air Barrier	6 mil poly at ceiling
Thermal Insulation	R-32 friction fit batt
Exterior Sheathing	1/2" OSB
Air/Weather Barriers	n/a
Exterior Cladding	asphalt shingles



Coquitlam unvented cathedralized attic

Roof Panel 3
Unvented Attic *(sprayed foam)*

Frame:	2 x 4 truss
Interior Surface/Finish:	1/2" drywall + paint
Vapour/Air Barrier	latex paint on ceilings
Thermal Insulation	sprayed poly ISO (top chord truss)
Exterior Sheathing	1/2" OSB
Air/Weather Barriers	n/a
Exterior Cladding	asphalt shingles



Analysis summary

Assembly type	Location	Visible mold growth?	30-day criterion	Mold index model
Double-stud walls	Devens, MA	No	**Mold risk**	$M < 3$
Unvented cathedral ceiling	Vancouver, BC	No	No mold risk	$M << 3$
Vented attic	Coquitlam, BC	No	**Mold risk**	$M << 3$
Unvented cathedralized attic	Coquitlam, BC	No	**Mold risk**	$M < 3$

What about cases **with** visible mold growth?

Seattle wall assemblies

Natural Exposure Test Facility
Washington State University
Puyallup, Washington

The Hygrothermal Performance of Wood-Framed Wall Systems Using a Relative Humidity-Dependent Vapor Retarder in the Pacific Northwest

Stanley D. Gatland, II
Member ASHRAE

Achilles N. Karagiozis, PhD

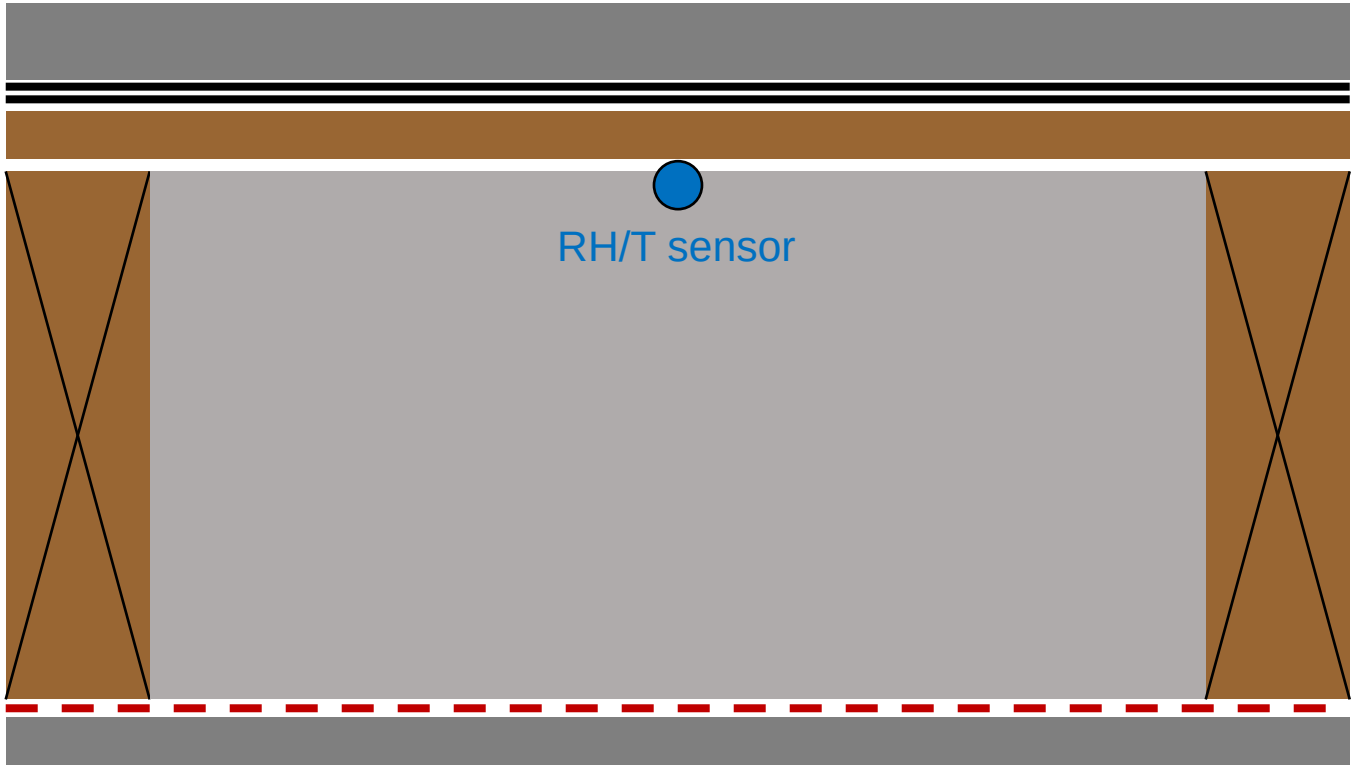
Charles Murray

Kohta Ueno
Associate Member ASHRAE

Thermal Performance of the Exterior Envelopes of Whole Buildings X International Conference, Clearwater Beach, FL, 2007

Test walls

stucco/lath
2 layers building paper
oriented strand board



wood framing

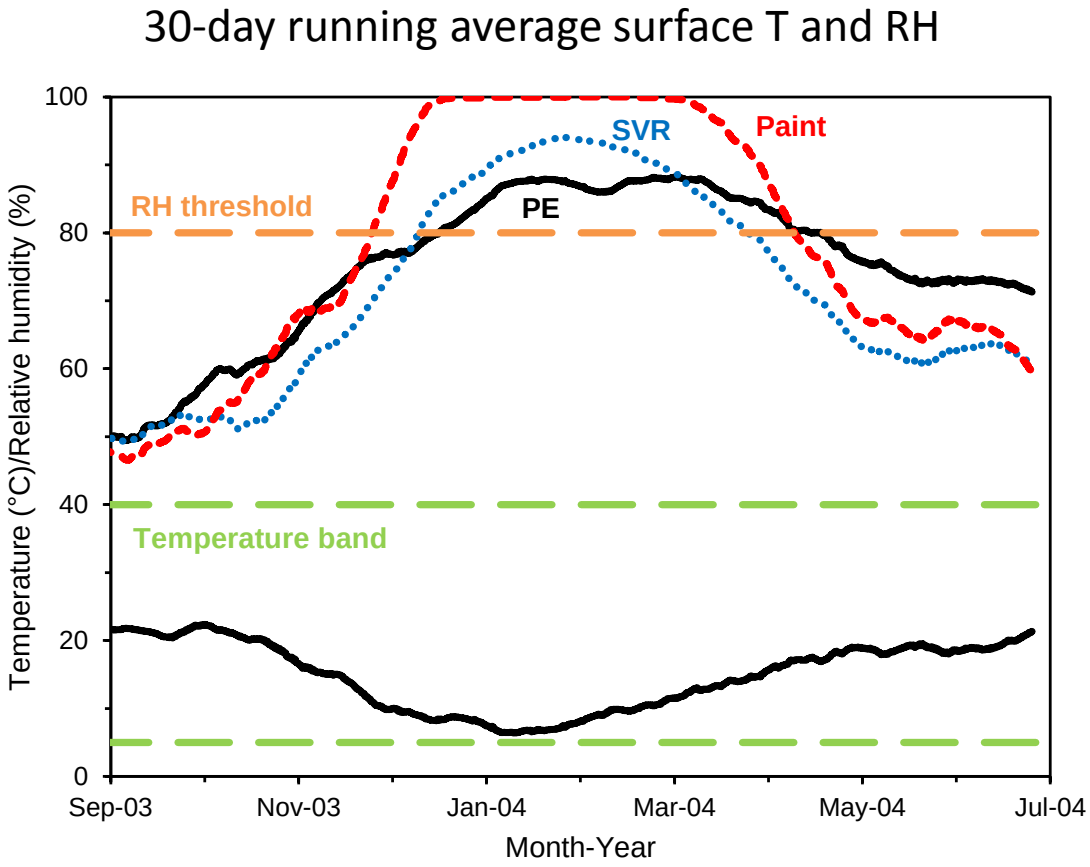
batt insulation

Polyethylene (PE),
Polyamide (SVR),
or no vapor retarder

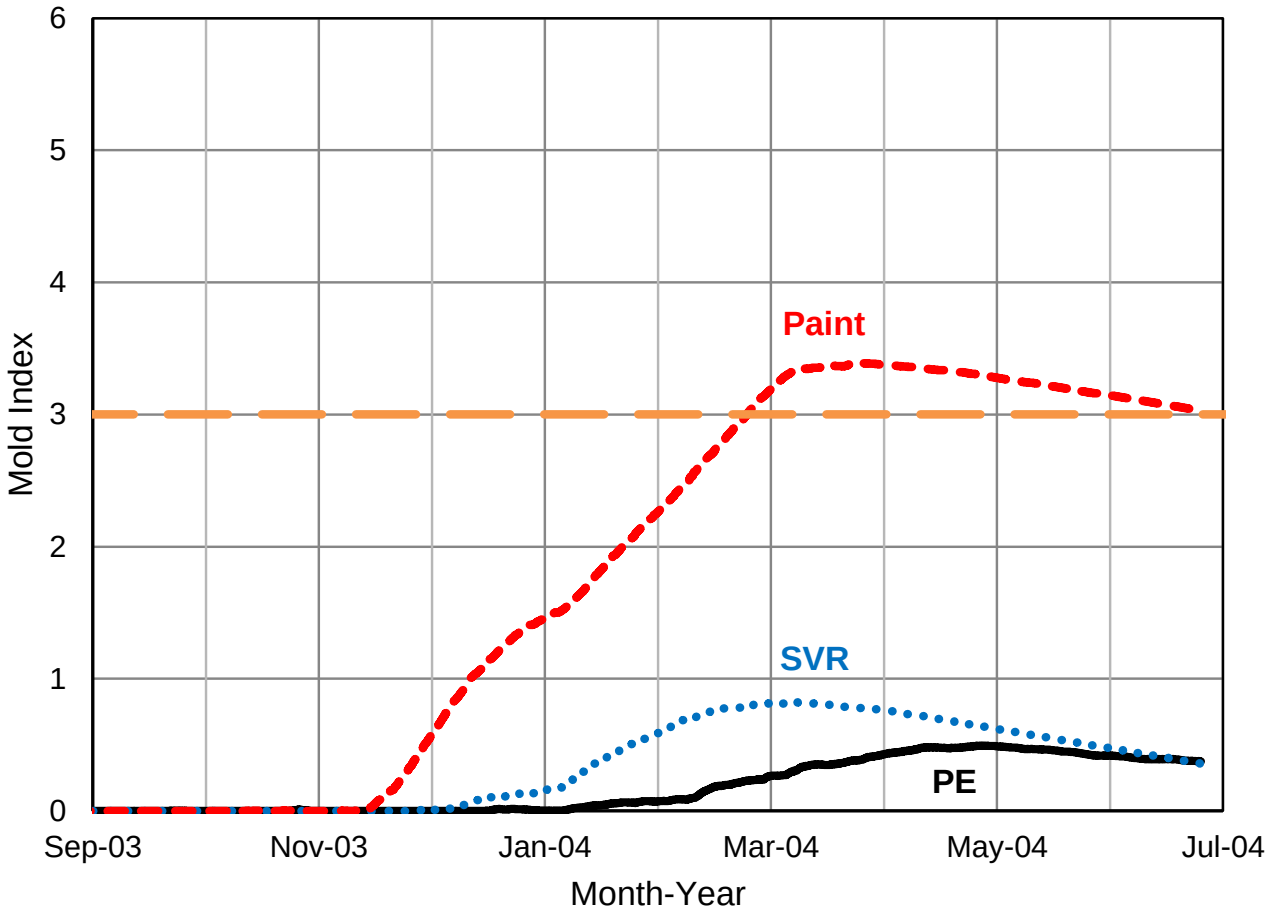
gypsum board
primer and latex paint

Each wall fails 30-day mold criterion

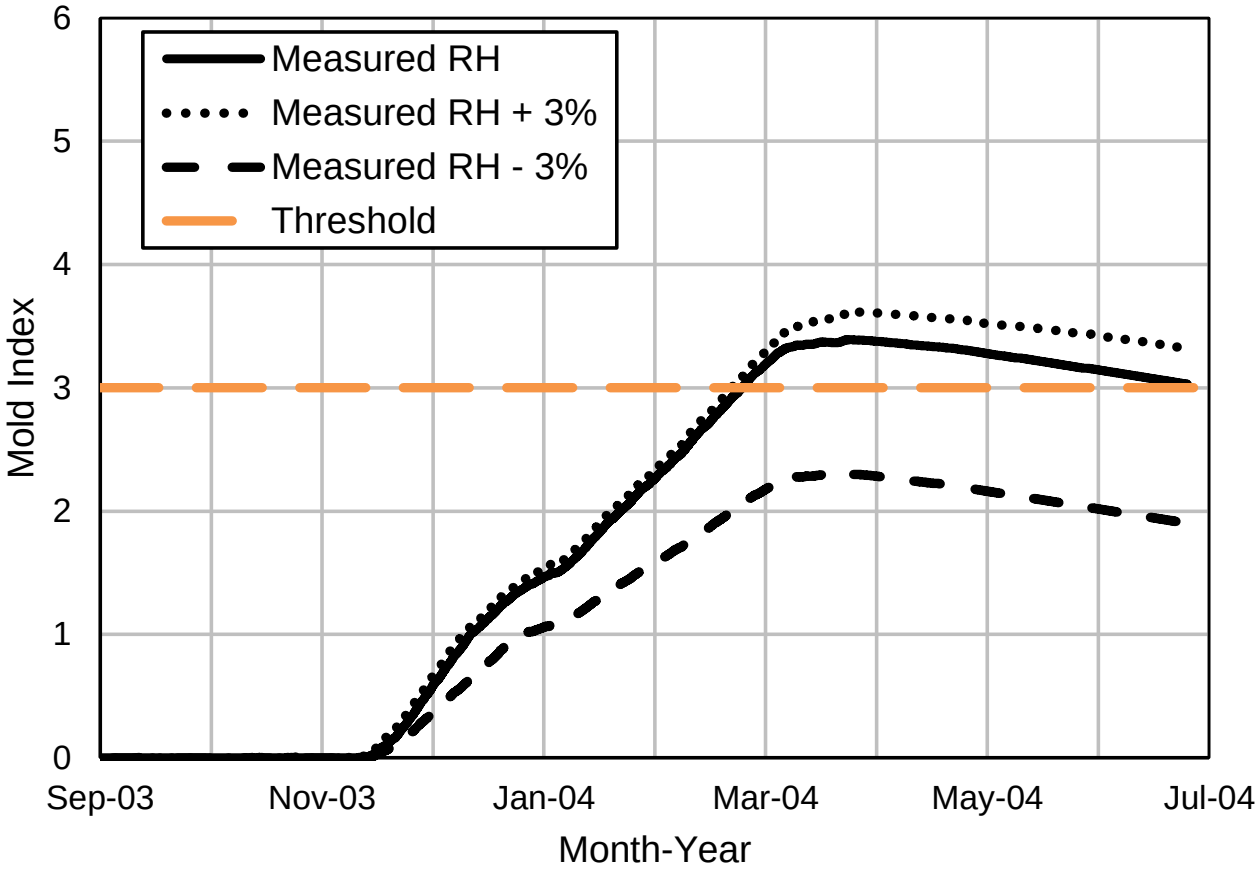
But visible mold was found only in the “Paint” wall



Mold index model gets it right



Model sensitivity



Chicago roof assemblies

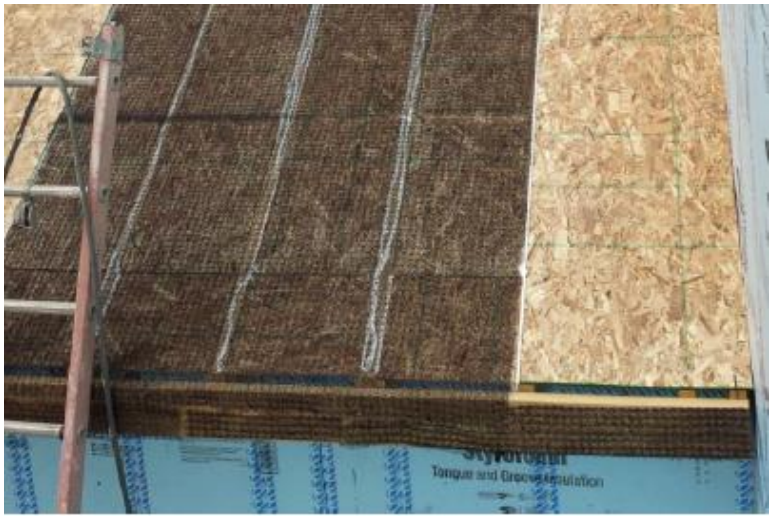
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

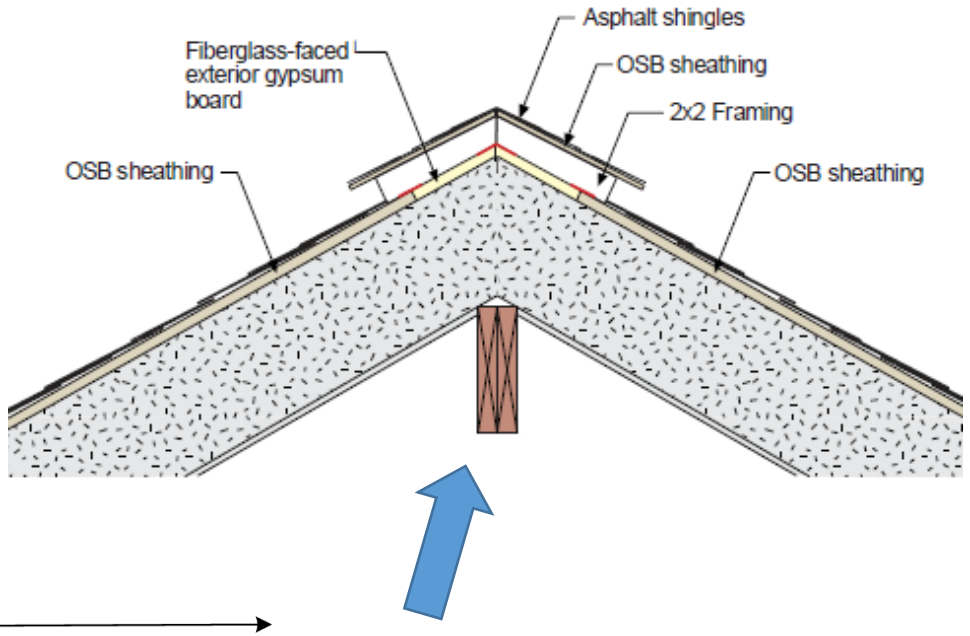
Field Testing Unvented Roofs with Asphalt Shingles in Cold and Hot-Humid Climates

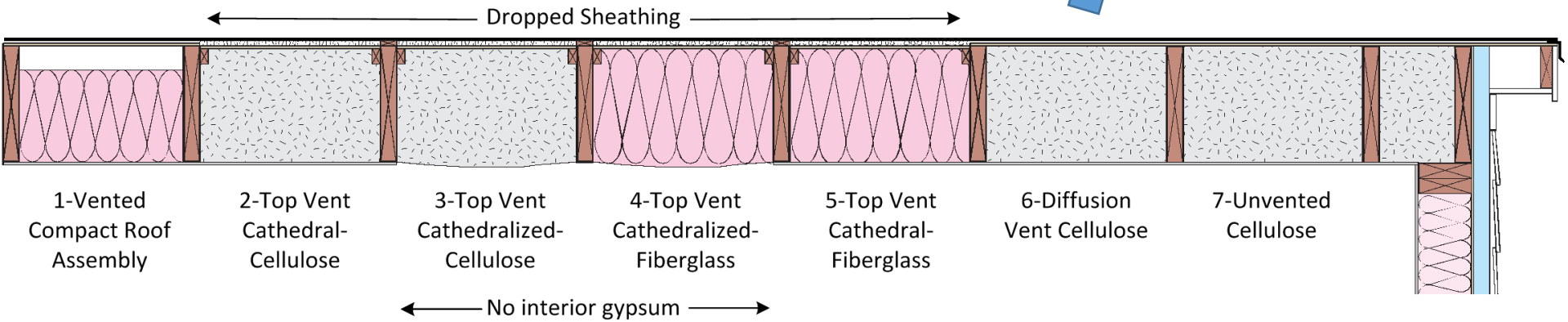
K. Ueno, J.W. Lstiburek
Building Science Corporation

June 2015

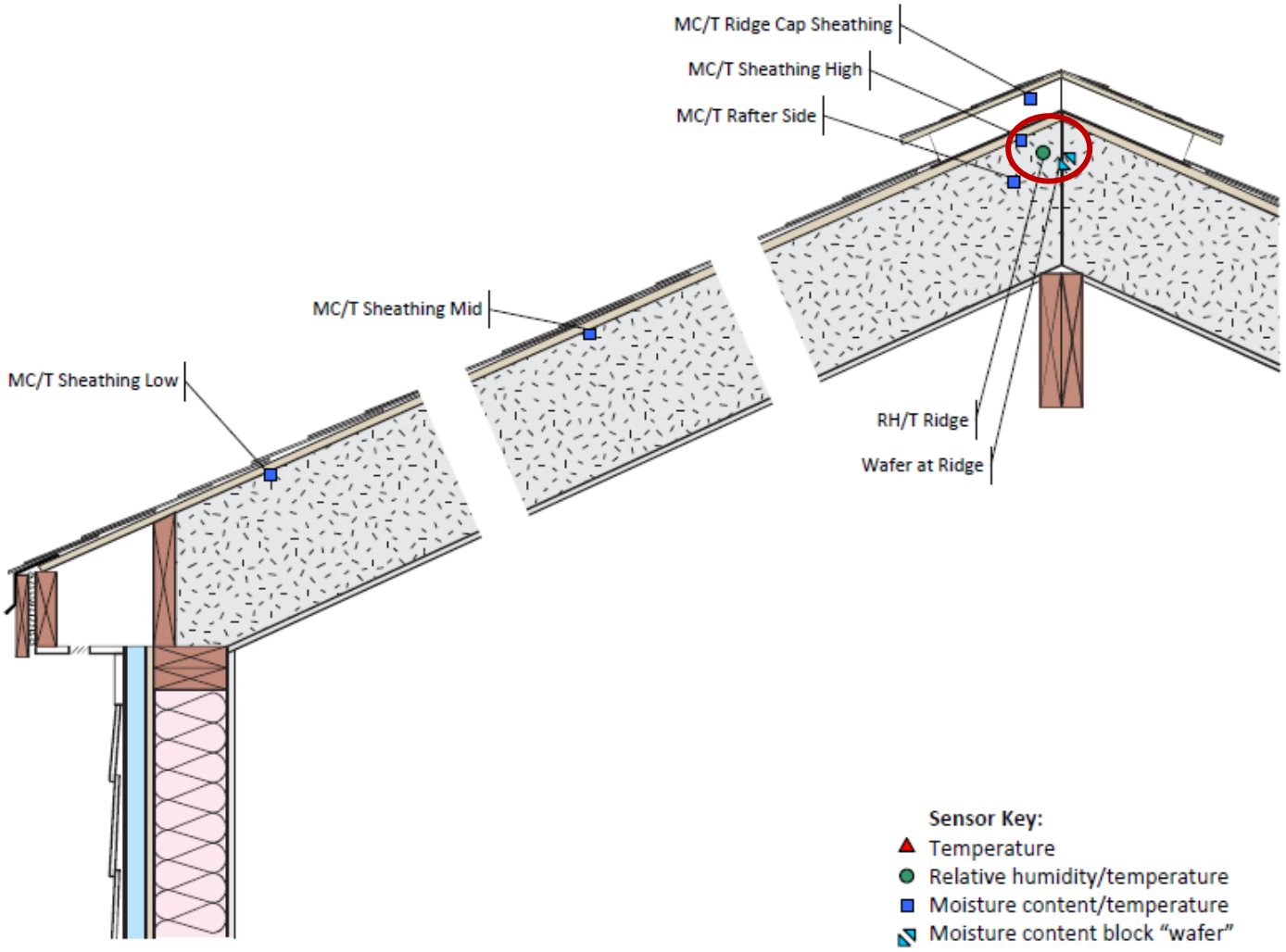
Building AMERICA U.S. Department of Energy

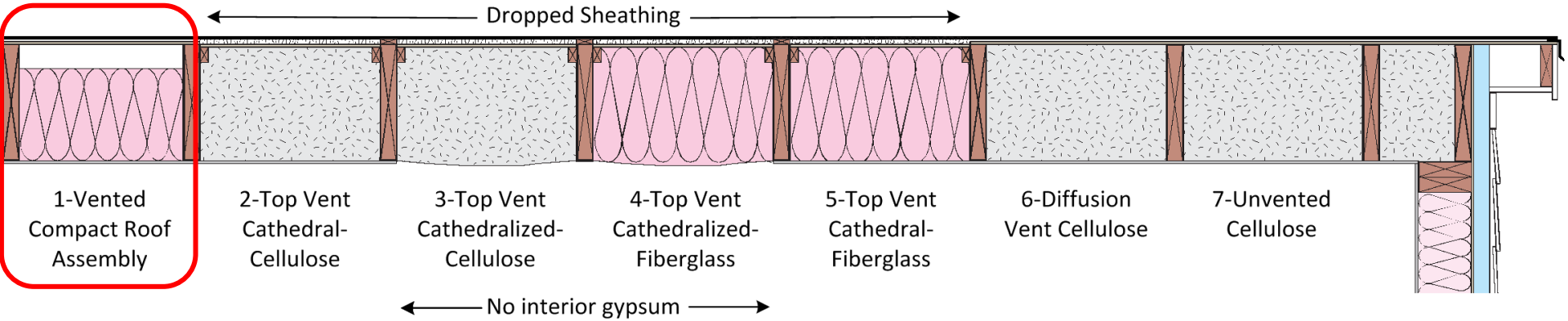


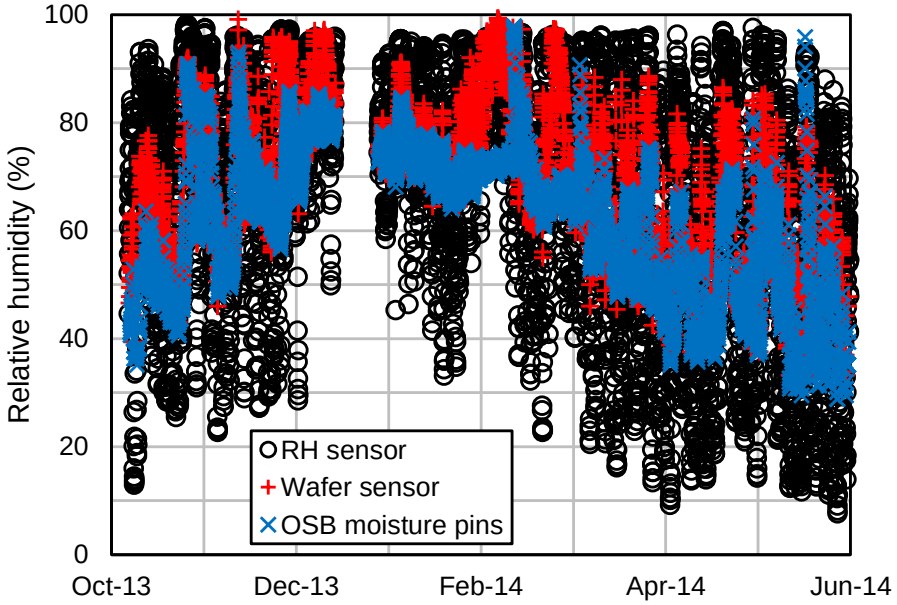

Asphalt shingles
Fiberglass-faced exterior gypsum board
OSB sheathing
2x2 Framing
OSB sheathing
OSB sheathing

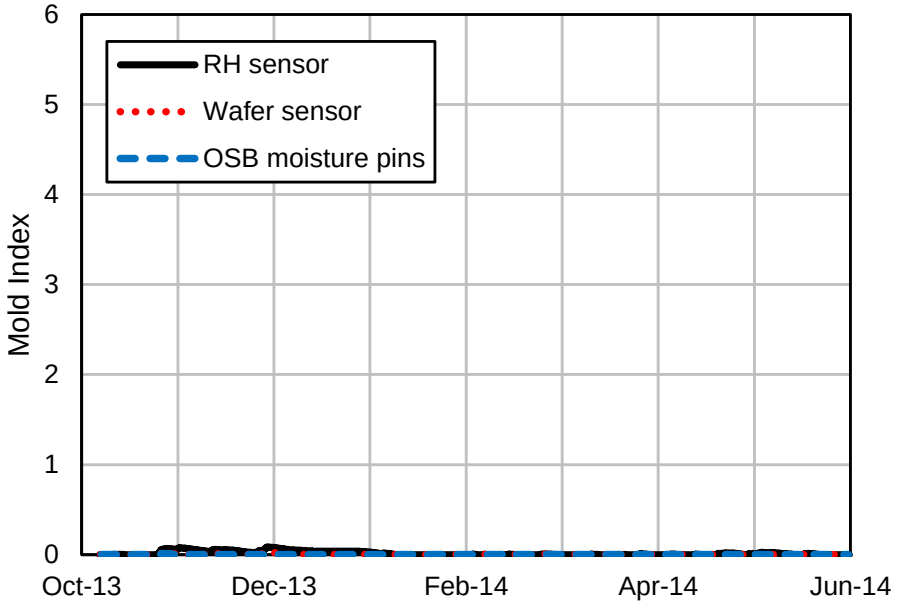

Dropped Sheathing
1-Vented Compact Roof Assembly
2-Top Vent Cathedral-Cellulose
3-Top Vent Cathedralized-Cellulose
4-Top Vent Cathedralized-Fiberglass
5-Top Vent Cathedral-Fiberglass
6-Diffusion Vent Cellulose
7-Unvented Cellulose
No interior gypsum

Sensors

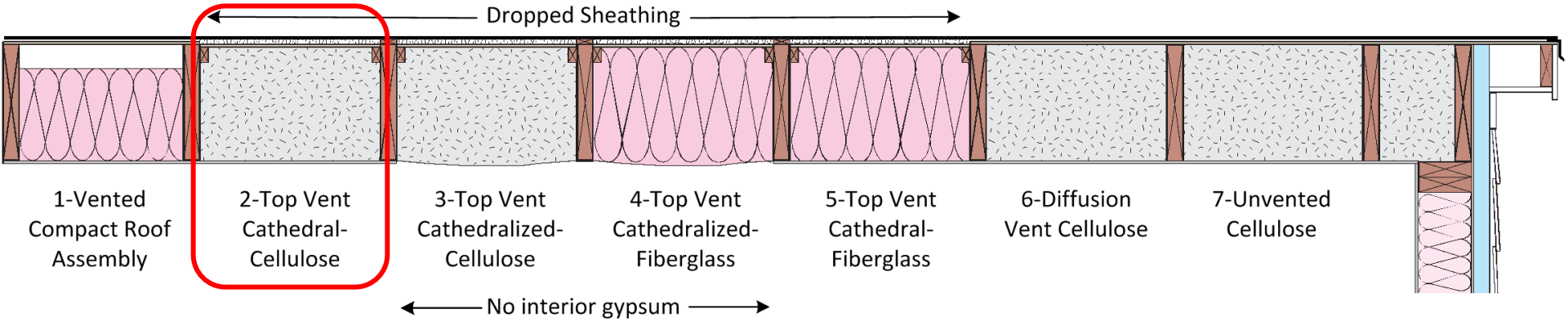

MC/T Ridge Cap Sheathing
MC/T Sheathing High
MC/T Rafter Side
MC/T Sheathing Mid
MC/T Sheathing Low
RH/T Ridge
Wafer at Ridge
Sensor Key:
Temperature
Relative humidity/temperature
Moisture content/temperature
Moisture content block "wafer"

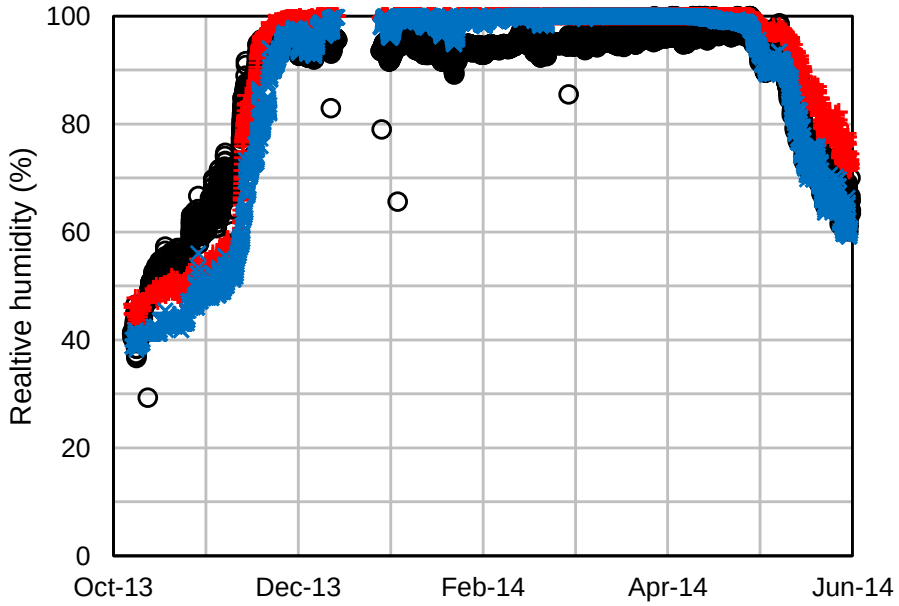


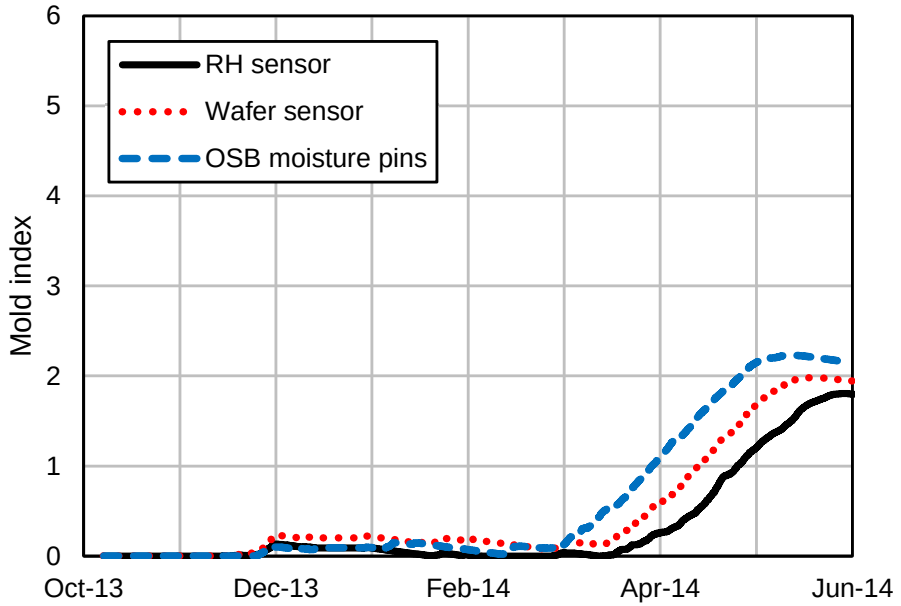




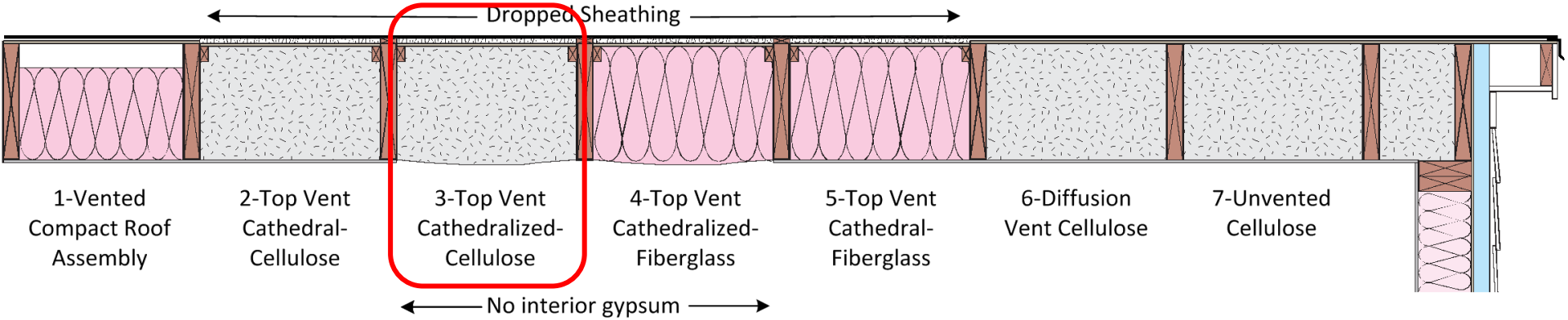
Visible mold growth?	30-day criterion	Mold index model
No	No mold risk	$M << 3$

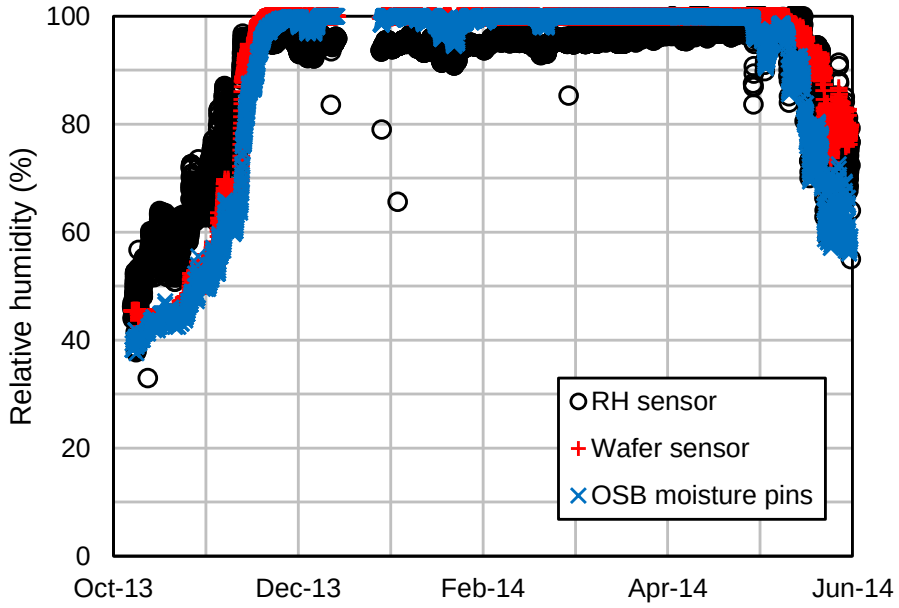


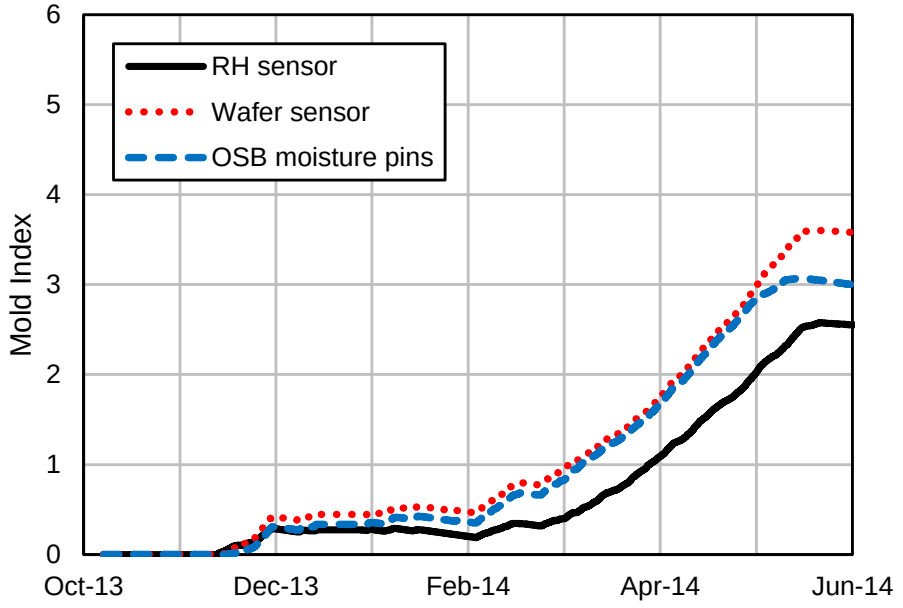




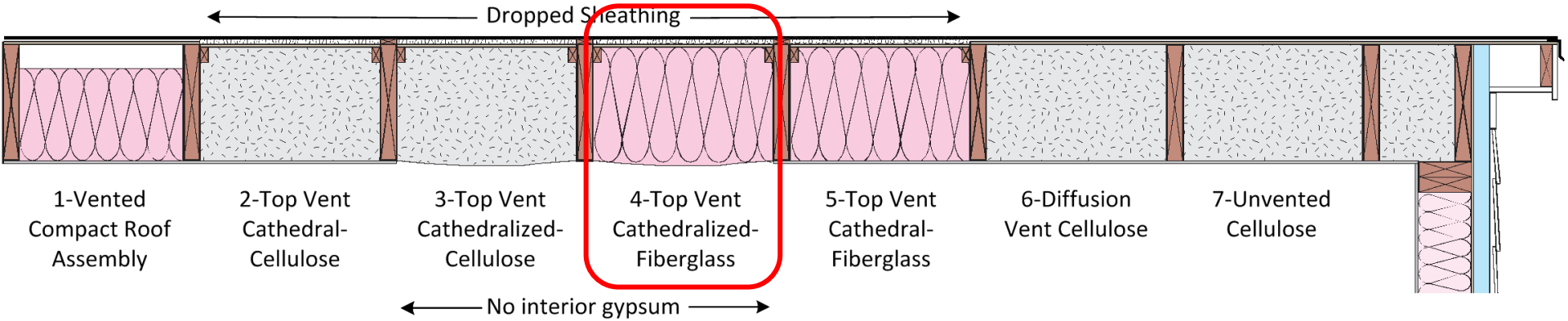
Visible mold growth?	30-day criterion	Mold index model
No	**Mold risk**	$M < 3$

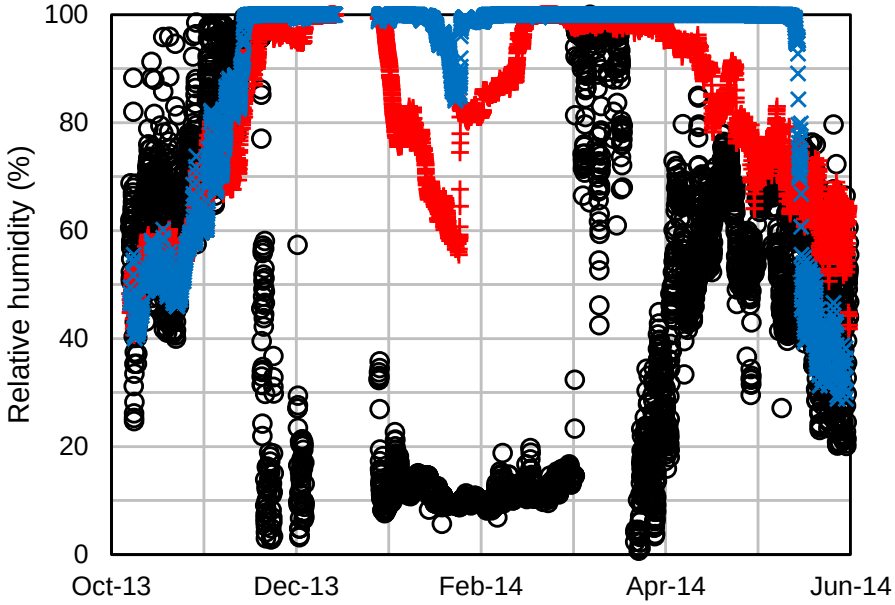


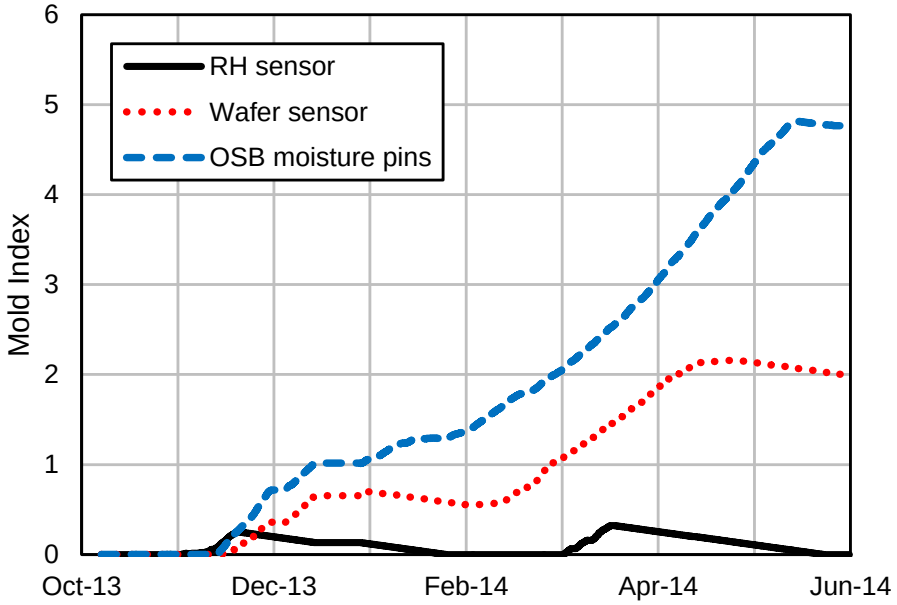




Visible mold growth?	30-day criterion	Mold index model
No	**Mold risk**	$M \approx 3$

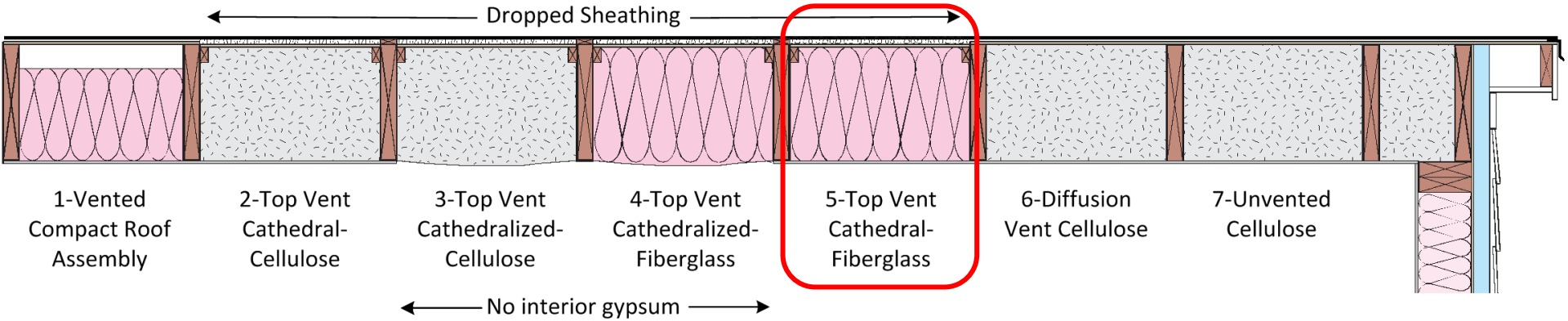


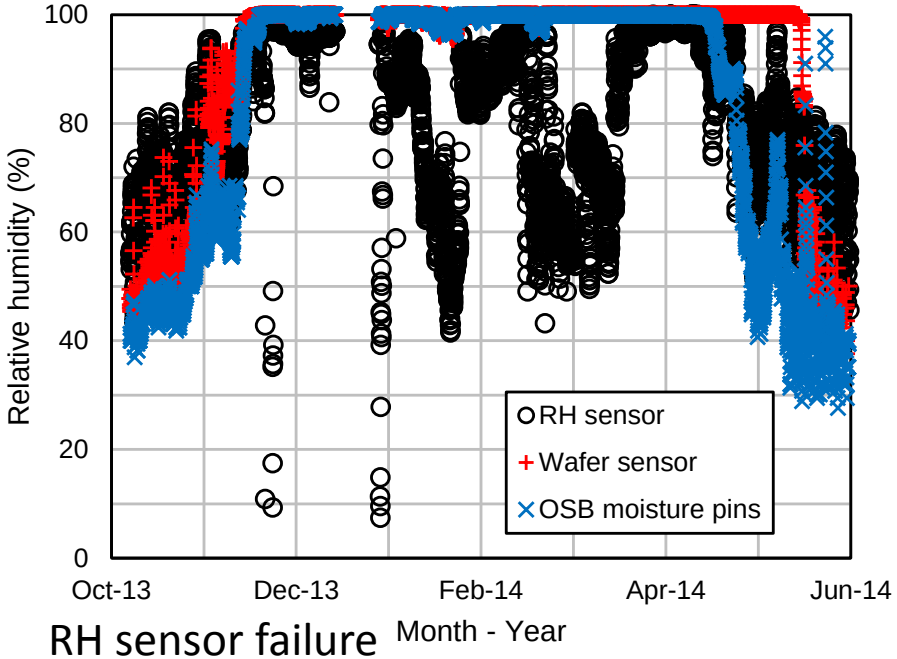




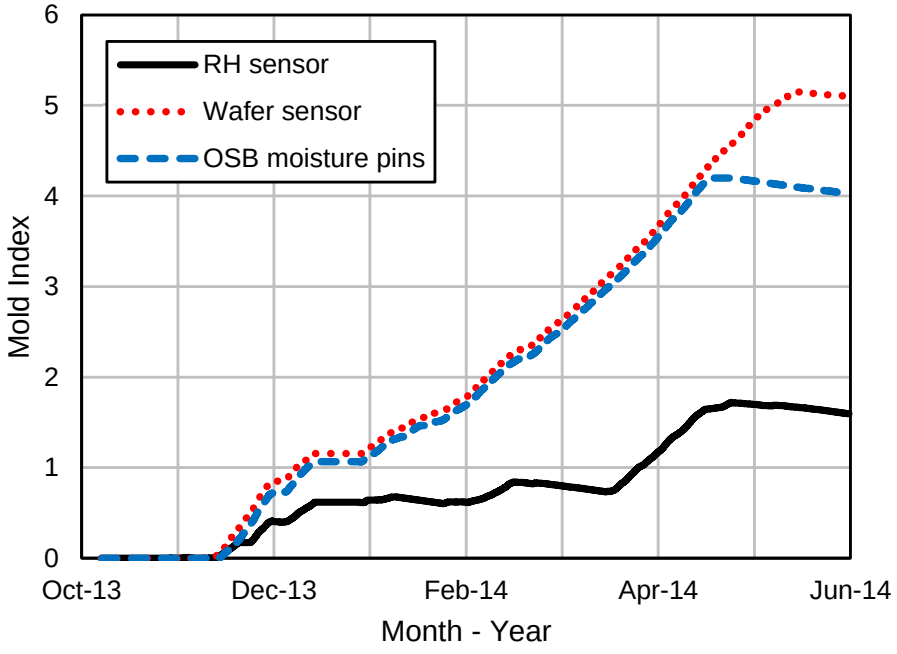
RH sensor and wafer sensor failure

Visible mold growth?	30-day criterion	Mold index model
Yes	**Mold risk**	*Sensor-dependent*

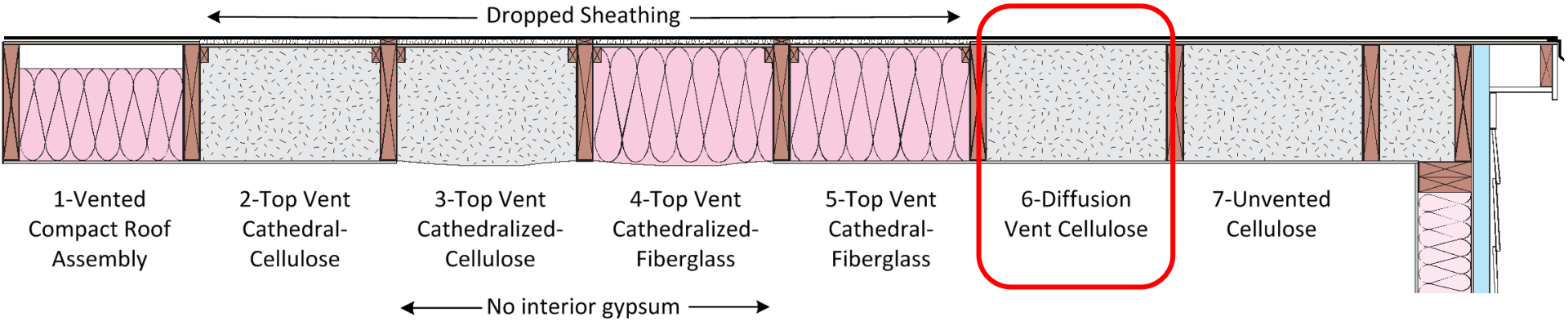


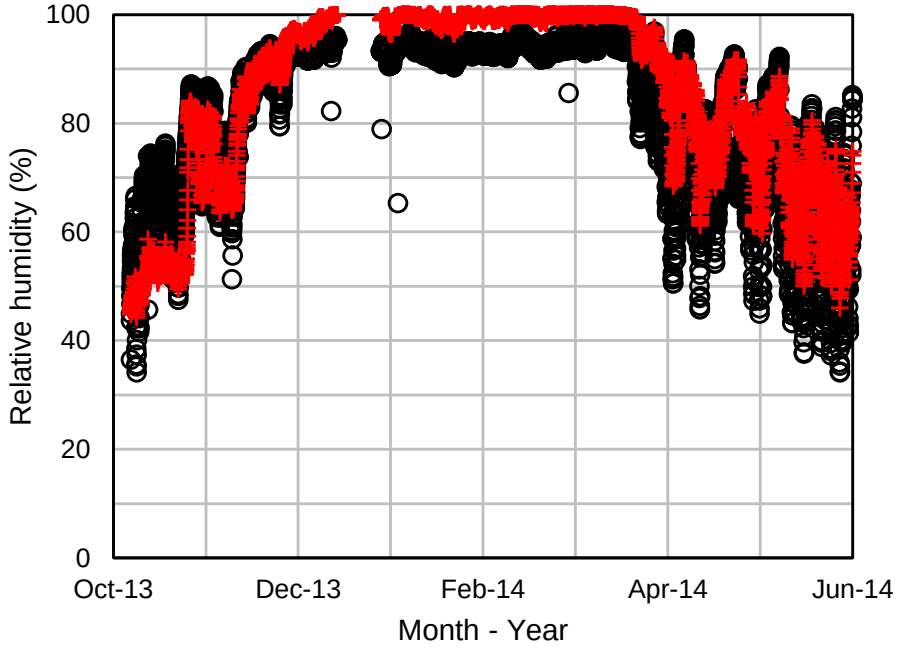


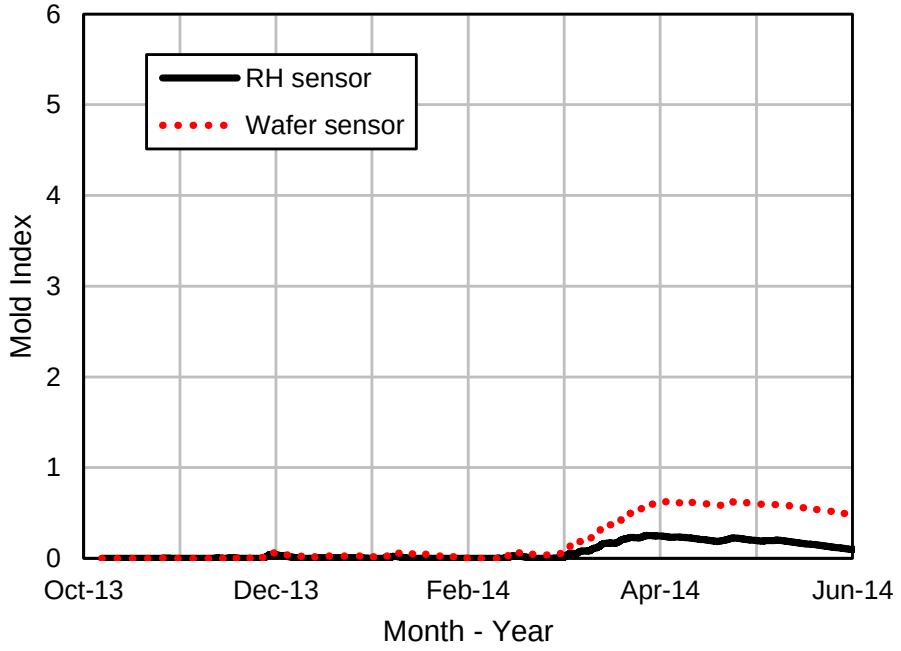
RH sensor failure



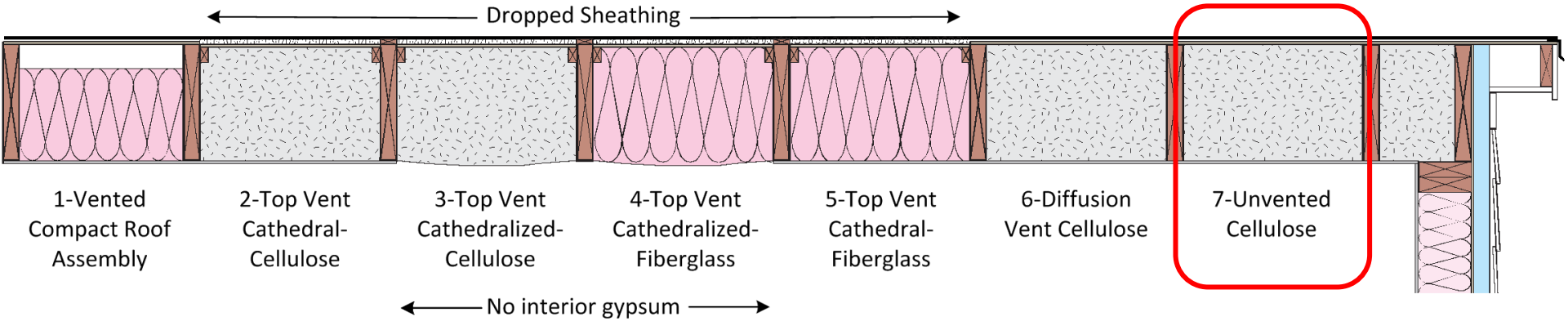
Visible mold growth?	30-day criterion	Mold index model
Yes	**Mold risk**	*Sensor-dependent*

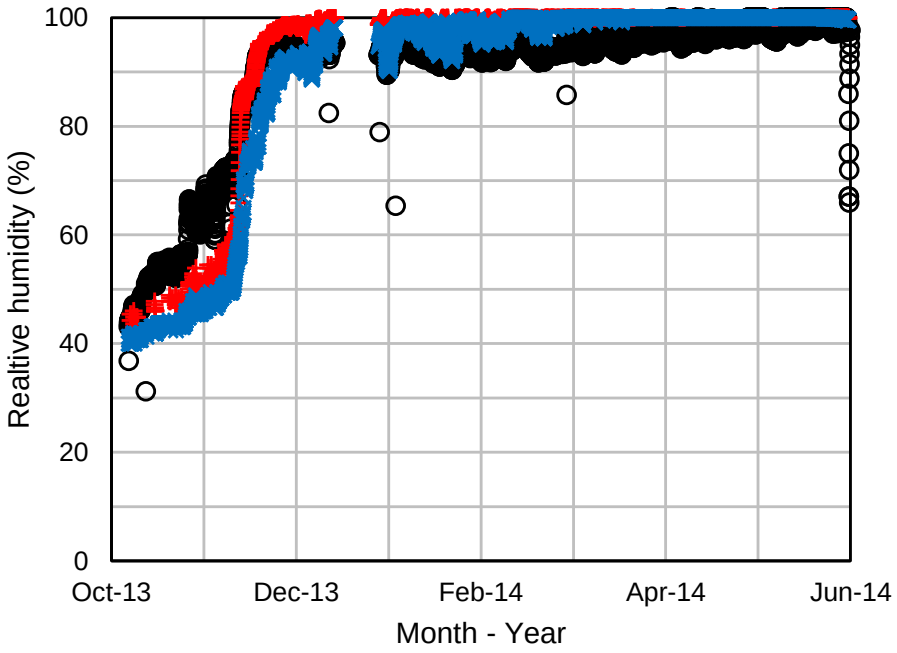


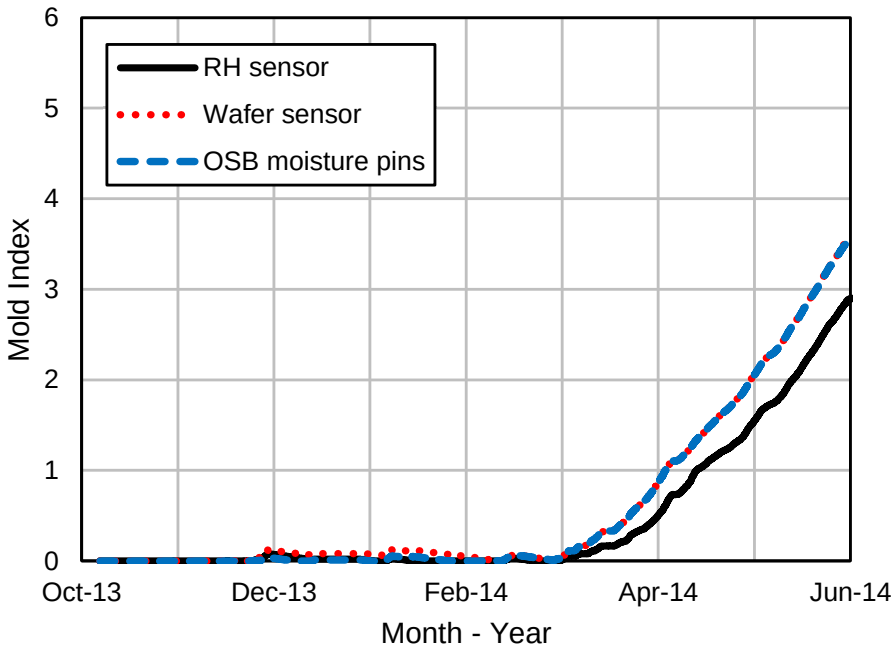




Visible mold growth?	30-day criterion	Mold index model
No	**Mold risk**	$M << 3$







Visible mold growth?	30-day criterion	Mold index model
No	**Mold risk**	$M \approx 3$

Adoption into ASHRAE Standard 160

ANSI/ASHRAE Addendum e to
ANSI/ASHRAE Standard 160-2009

Criteria for Moisture-Control Design Analysis in Buildings

Addendum e to Standard 160-2009

Revise Section 6.1 as follows.

6.1 Conditions Necessary to Minimize Mold Growth. In order to minimize problems associated with mold growth on the surfaces of components of building envelope assemblies, ~~the following condition shall be met: a 30-day running average surface RH < 80% when the 30-day running average surface temperature is between 5°C (41°F) and 40°C (104°F)~~ the mold index, calculated in accordance with Equations 6-1 through 6-7, shall not exceed a value of three (3.00)[B-22].

The building material surface under analysis shall be assigned to one of the following four sensitivity classes: Very Sensitive, Sensitive, Medium Resistant, or Resistant. ~~Materials that are naturally resistant to mold or have been chemically treated to resist mold growth may be able to resist higher surface relative humidities and/or to resist for longer periods as specified by the manufacturer.~~ The ~~criteria~~ sensitivity class used in the evaluation and the rationale for its selection shall

Summary

- Mold index model is a big improvement
  - Less stringent (does not fail assemblies that work)
  - Based on empirical measurements of mold growth
  - Test cases using measurements show that model mostly agrees with observations
- Model includes influence of …
  - Material sensitivity
  - Surface temperature
  - Surface relative humidity
  - Time
  - Decline of mold index when conditions are unfavorable
- Performance limit = visible mold growth rather than germination