

The Long and Winding Road

Remediation of ASHRAE 160

Samuel V. Glass, Christopher Schumacher, Kohta Ueno

Westford Symposium on Building Science XIX
August 5, 2015

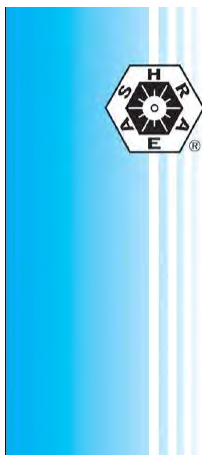


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1: Get Back

ANSI/ASHRAE Standard 160-2009



ASHRAE STANDARD

**Criteria for
Moisture-Control
Design Analysis in
Buildings**

1. PURPOSE

The purpose of this standard is to specify performance-based design criteria for predicting, mitigating, or reducing moisture damage to the building envelope, materials, components, systems, and furnishings, depending on climate, construction type, and HVAC system operation. These criteria include the following:

- a. Criteria for selecting analytic procedures
- b. Criteria for inputs
- c. Criteria for evaluation and use of outputs

Standard 160 contents

1. Purpose
2. Scope
3. Definitions, Abbreviations, and Symbols
4. Criteria for Design Parameters
5. Criteria for Selecting Analytical Procedures
- 6. Moisture Performance Evaluation Criteria**
7. Reporting
8. References

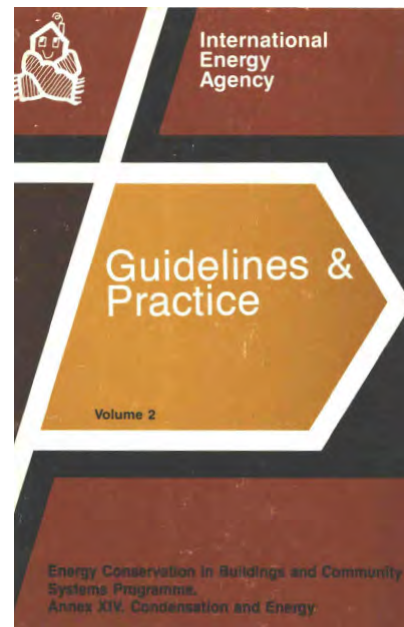
“6.1 Conditions Necessary to Minimize Mold Growth. In order to minimize problems associated with mold growth on the surfaces of components of building envelope assemblies, the following condition shall be met: a 30-day running average surface RH < 80% when the 30-day running average surface temperature is between 5°C (41°F) and 40°C (104°F).^{B-22}

“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 used in the evaluation shall be stated in the report.”

(Addendum a to Standard 160-2009)

“B-22 The source for the criteria for mold growth is *Annex 14, Condensation and Energy, “Guidelines and Practice”* (IEA 1991) ... with added temperature criteria.”

Conceptual incompatibility

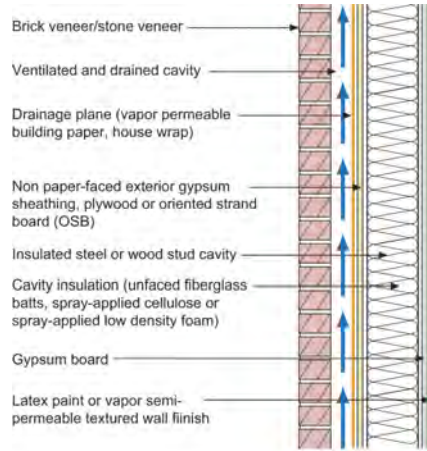


2: Help!



WUFI Hygrothermal Analysis: “Traditional” Brick Veneer Wall in Chicago, IL

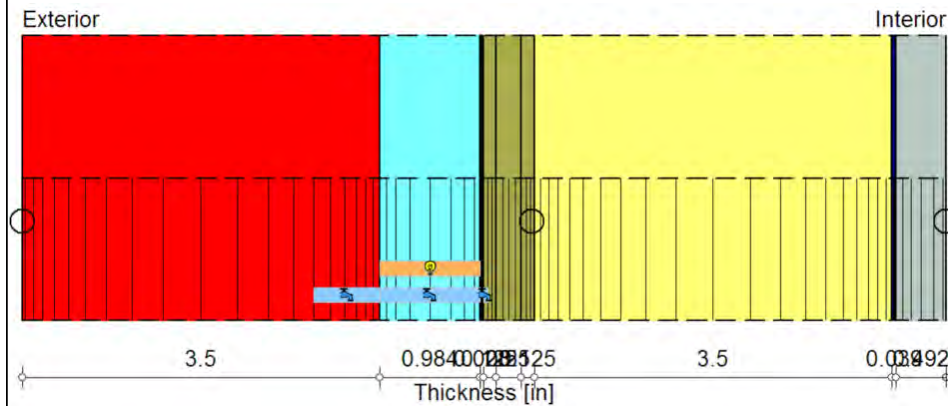
A "Traditional" Brick Veneer Wall



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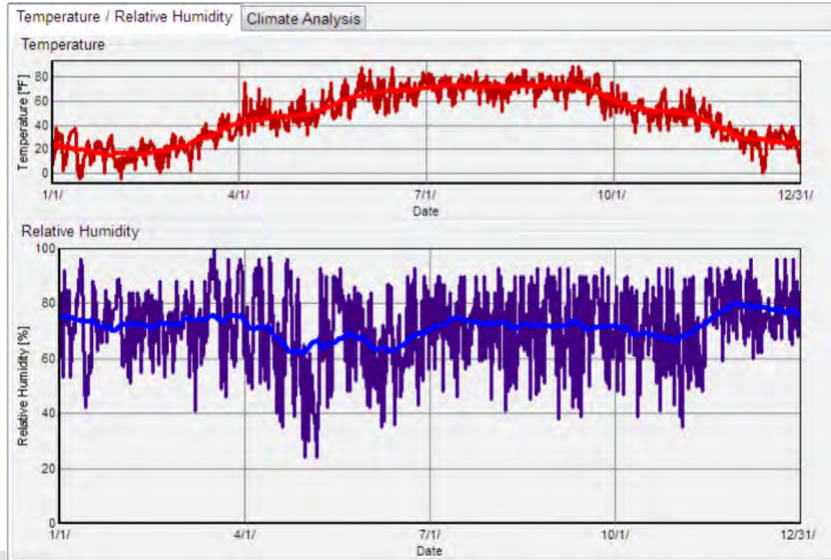
A "Traditional" Brick Veneer Wall



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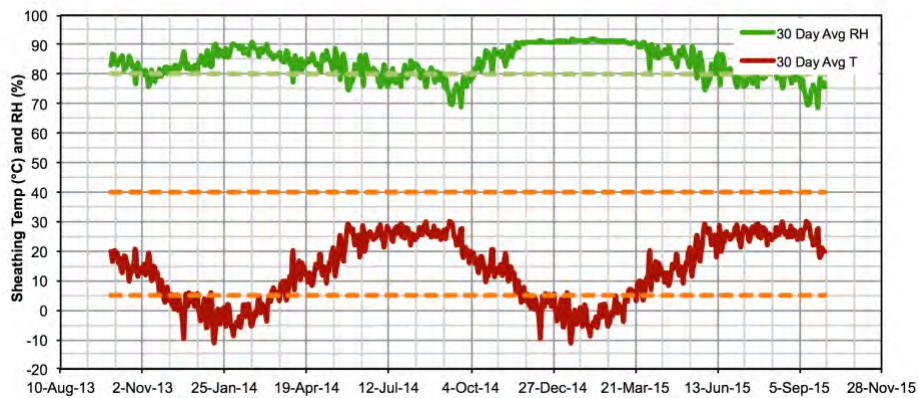
Chicago Outdoor Climate



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“Traditional” BV Wall assessment using Previous ASHRAE Mold Criteria

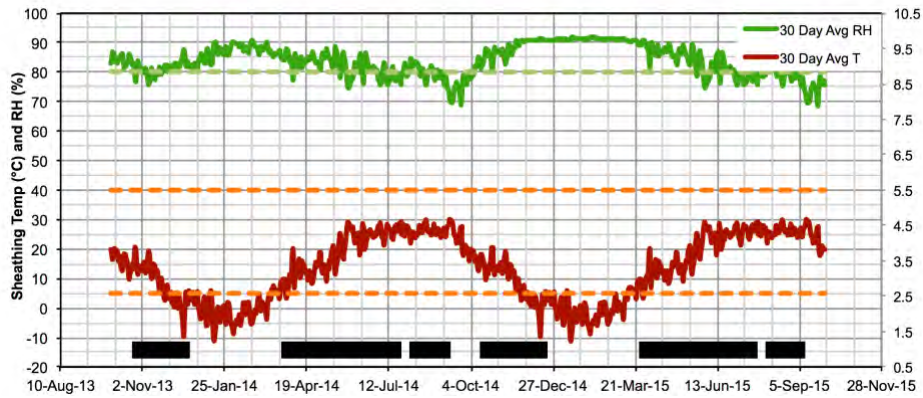


Assume conditions for mold growth: 30 Day Running Avg RH > 80%
30 Day Running Avg 5°C > Temp > 40°C

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“Traditional” BV Wall assessment using Previous ASHRAE Mold Criteria



Assume conditions for mold growth: 30 Day Running Avg RH > 80%
30 Day Running Avg 5°C > Temp > 40°C

“Traditional” Brick
clean
work in Chicago.

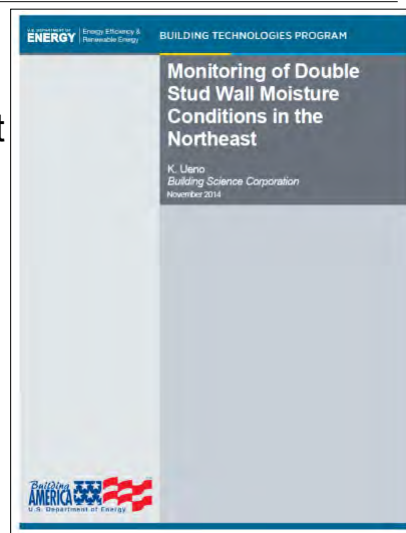
HELP!

3: Hello Goodbye



For the Full Story...

- BA-1501: Monitoring Double-Stud Wall Moisture Conditions in the Northeast
- <http://buildingscience.com/documents/bareports/ba-1501-monitor-double-stud-moisture-conditions-northeast/view>
- A monitoring study with disassembly at conclusion



Experimental Setup

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Wall Construction

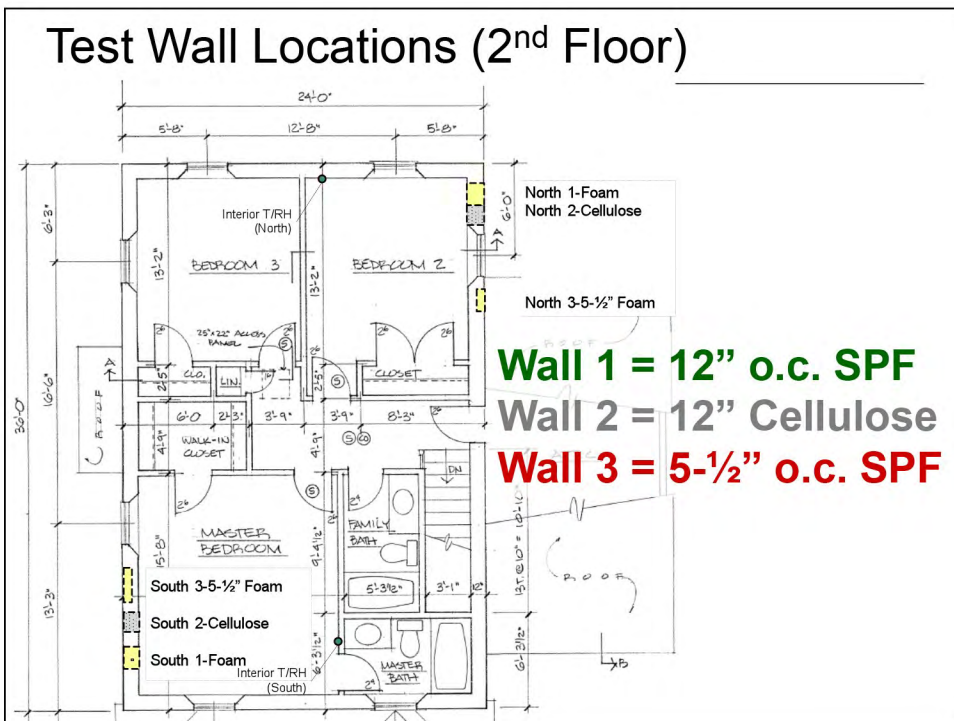
- Vinyl siding
- ZIP wall sheathing (OSB)
- 12" ocSPF, double stud
 - Considering cellulose
- Class III vapor control (latex paint) on GWB

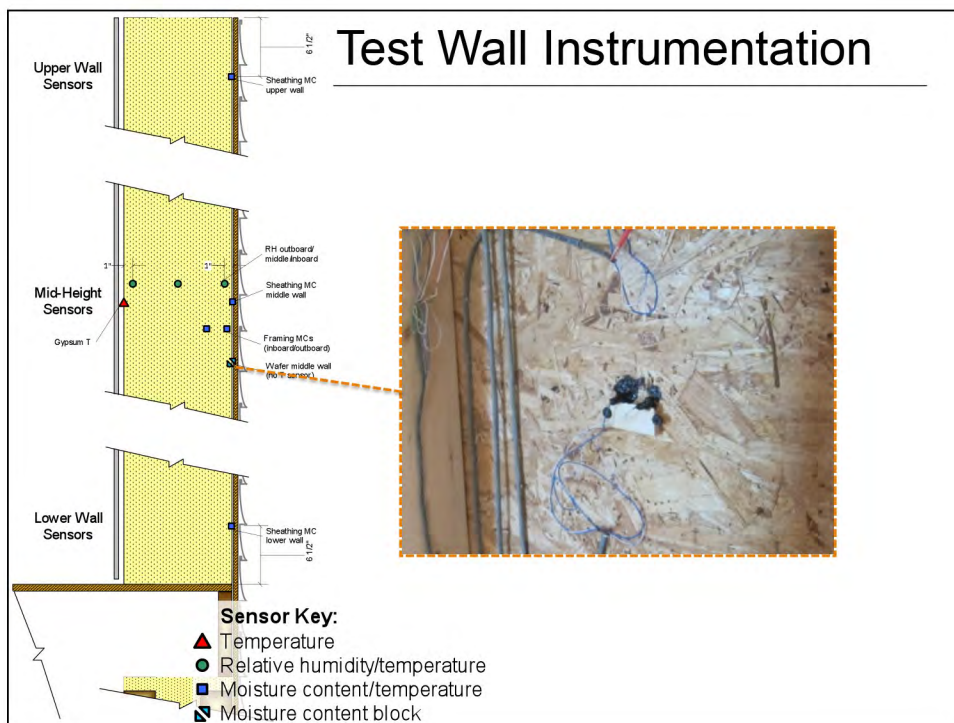
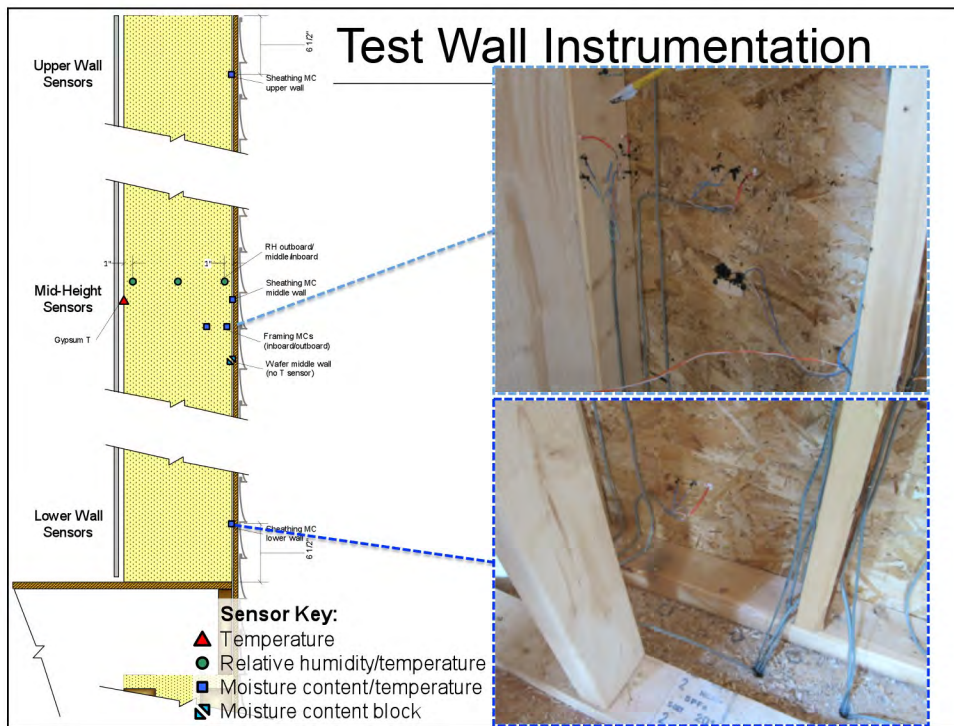


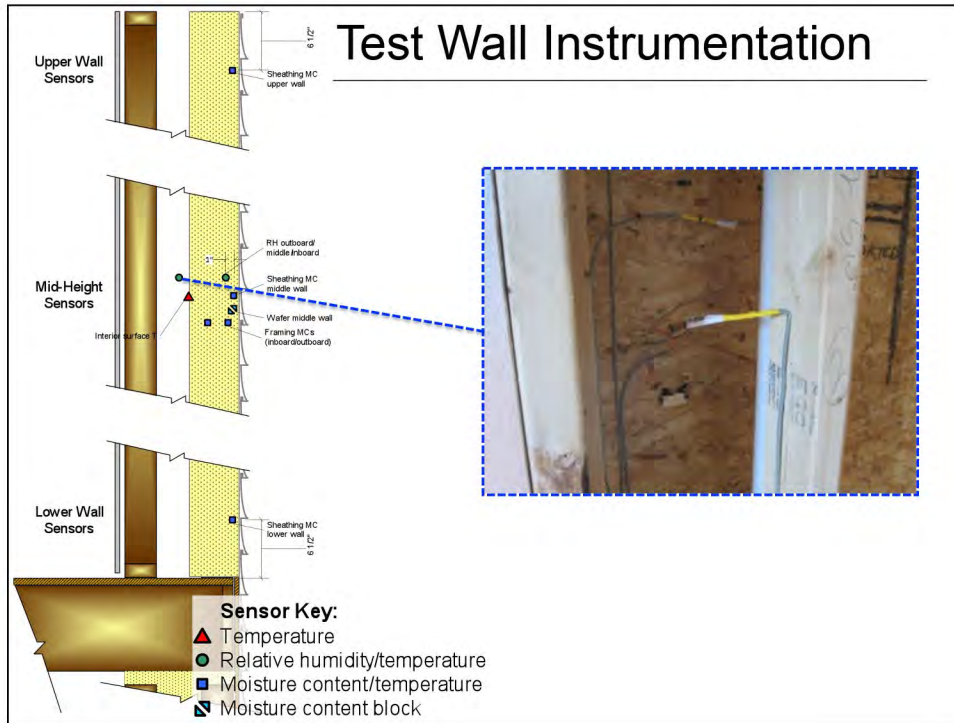
Site and Orientation



Test Wall Locations (2nd Floor)



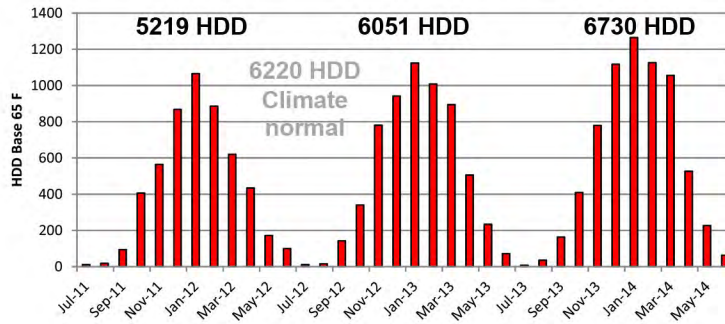




Results: Boundary Conditions

Data Collected

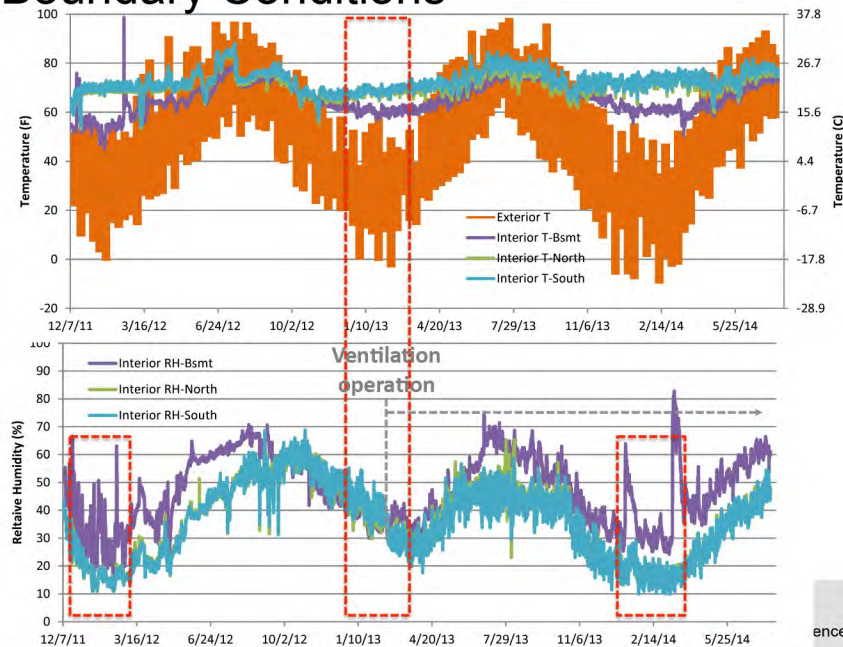
- December 2011 through July 2014 (32 months)
- Three winters collected (one partial)
- Warmer, normal, & colder winters



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Boundary Conditions



Boundary Conditions Takeaways

- First Winter (Partial)
 - Unoccupied conditions (no occupant moisture generation)
 - **Very low interior RH**
 - Wimpy winter (5220 HDD vs. 6220 HDD “normal”)
- Second Winter
 - Occupied family of four (2 adults, 2 children)
 - Ventilation system not running, ~1 ACH 50 → **High RHs**
- Third Winter
 - Winter of the “polar vortex”
 - Occupied conditions (same family)
 - Ventilation system running → **RHs ~15-30% (“normal”)**

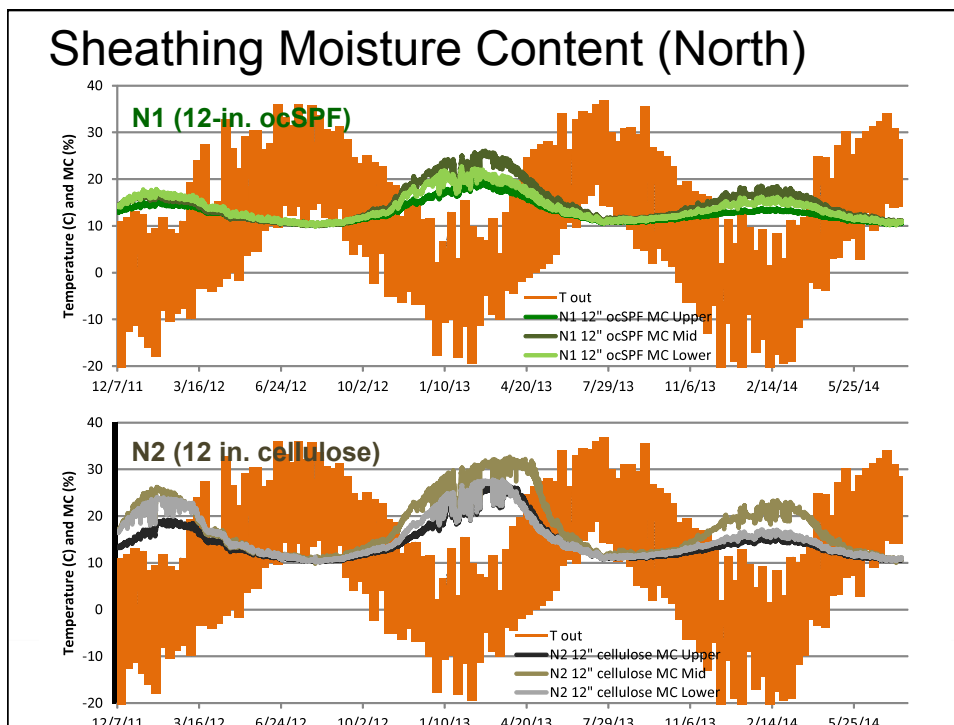
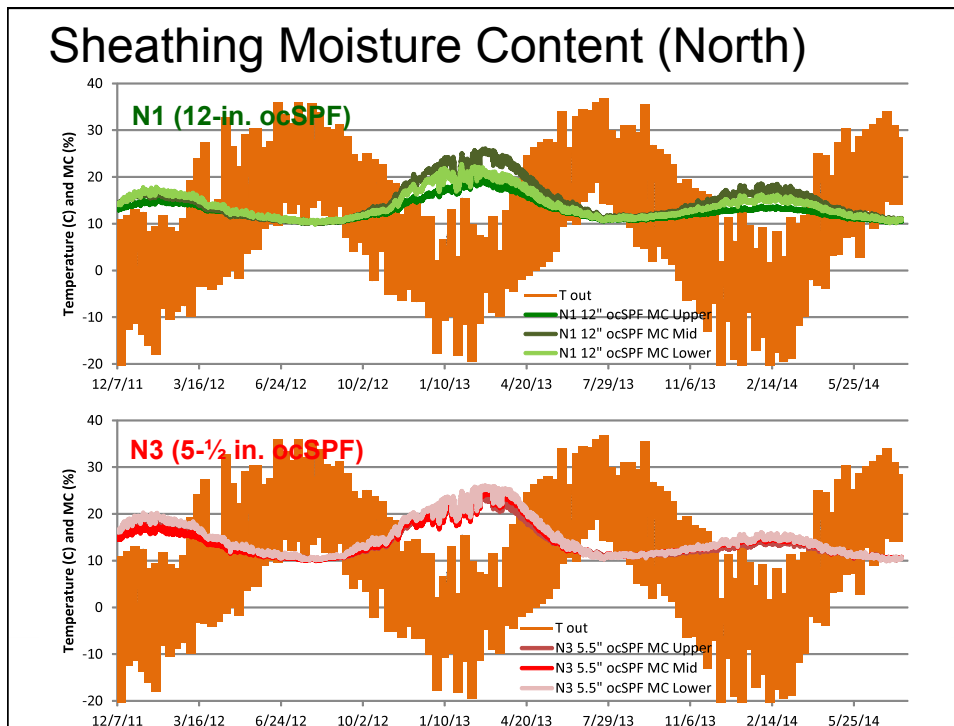
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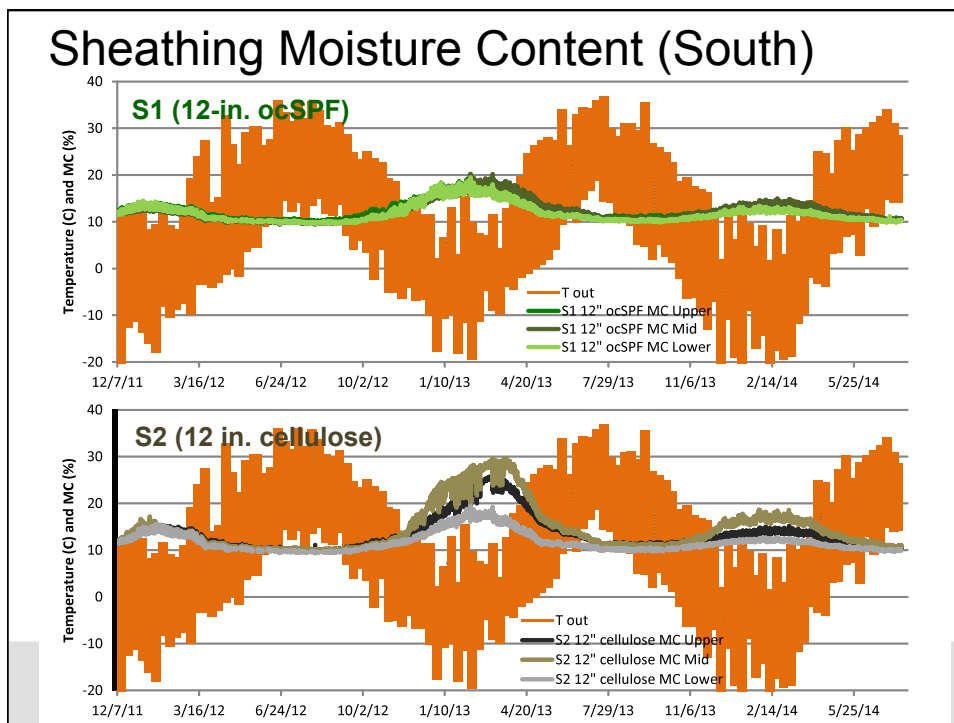
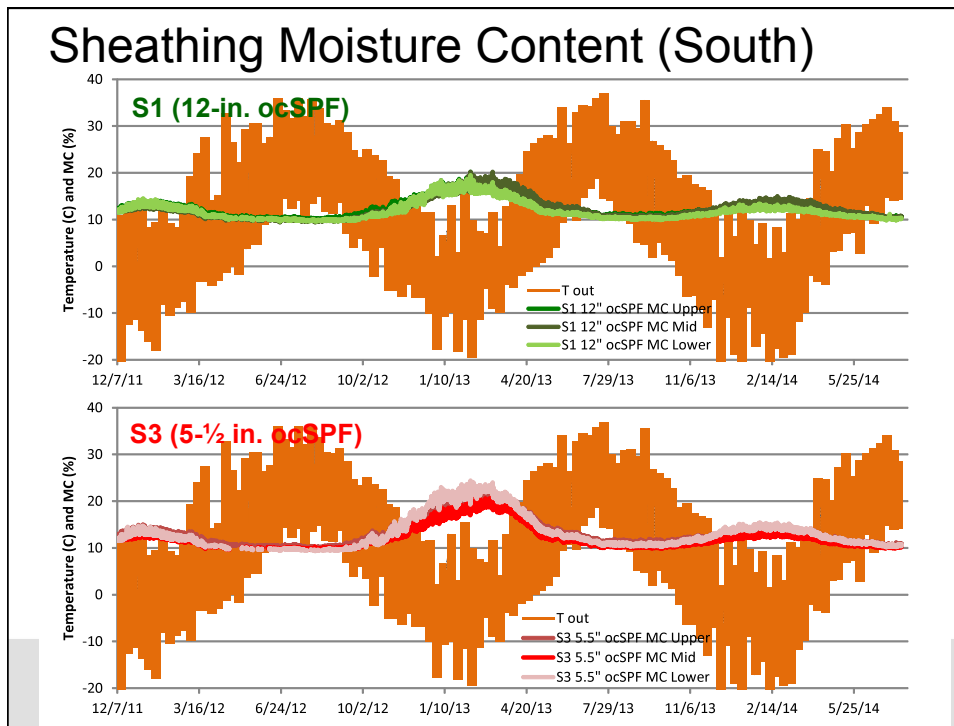
27
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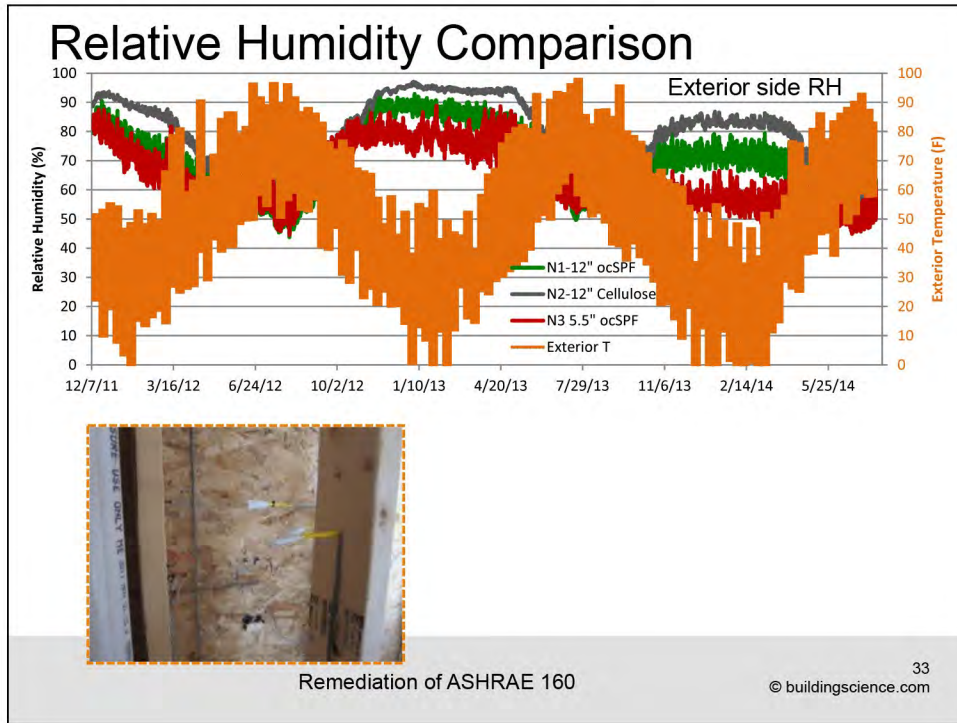
Results: Wall Monitoring

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Wall Disassembly

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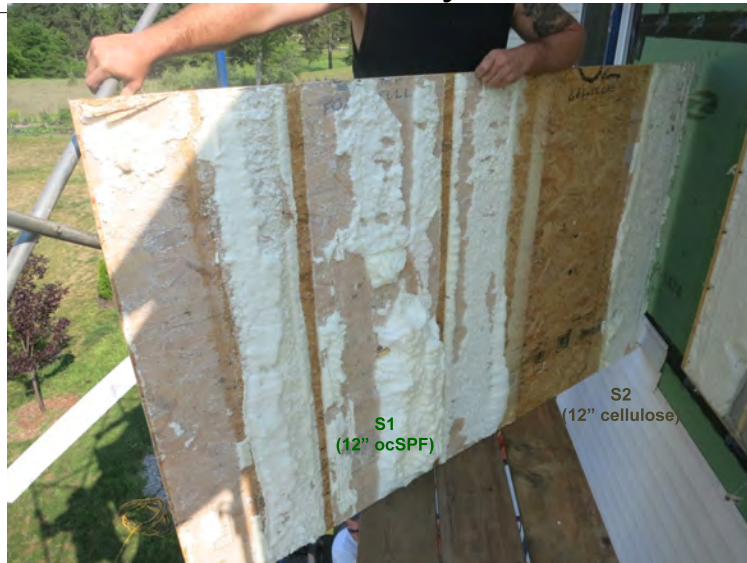
South Side Disassembly



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South Side Disassembly



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North Side Disassembly



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North Side Disassembly



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North Side Disassembly



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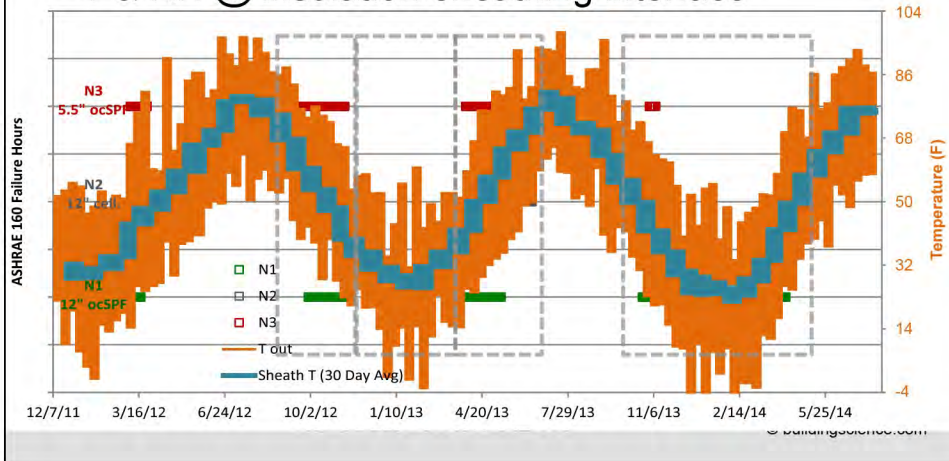
Analysis

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ASHRAE 160—Wet and Warm Enough?

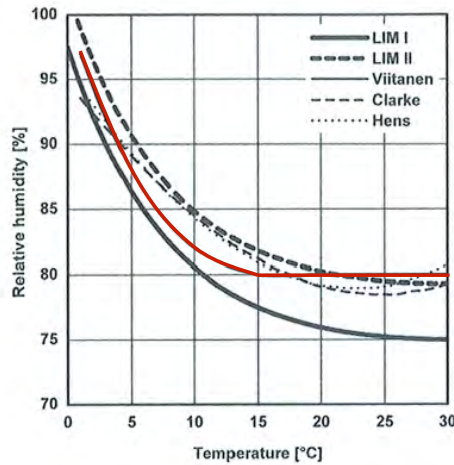
- 30 day running average
 - Relative humidity > 80% AND
 - Temperature between 41 F and 104 F
- T & RH @ insulation-sheathing interface



Why Aren't The Walls Oatmeal?

- 20% MC or lower—decay fungi inhibited
- Best growth 25-30% MC range
- All walls had MCs over 20% in winter 2; cellulose 30%+
- Condensation indicated—liquid water is kicker for decay activity

4: With A Little Help From My Friends



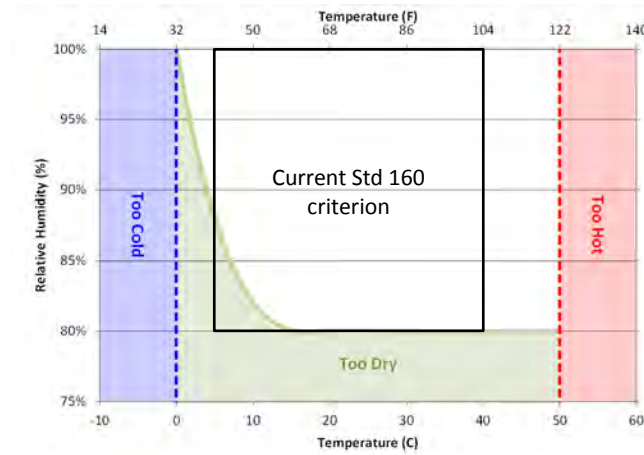
Ojanen, Viitanen, et al. (2010) Mold Growth Modeling of Building Structures Using Sensitivity Classes of Materials. [Buildings XI](#).

Mold index

Index	Description
0	No growth
1	Small amounts of mold on surface (microscope); initial stages of local growth
2	Several local mold growth colonies on surface (microscope)
3	Visual findings of mold on surface; <10% coverage
4	Visual findings of mold on surface; 10% - 50% coverage
5	Plenty of growth on surface; > 50% coverage
6	Heavy and tight growth; coverage about 100%

Based on Ojanen, Viitanen, et al. (2010)

Threshold conditions



Mold index model – key variables

Surface T, RH

Material sensitivity
(nutrient levels, chemical composition, pH)

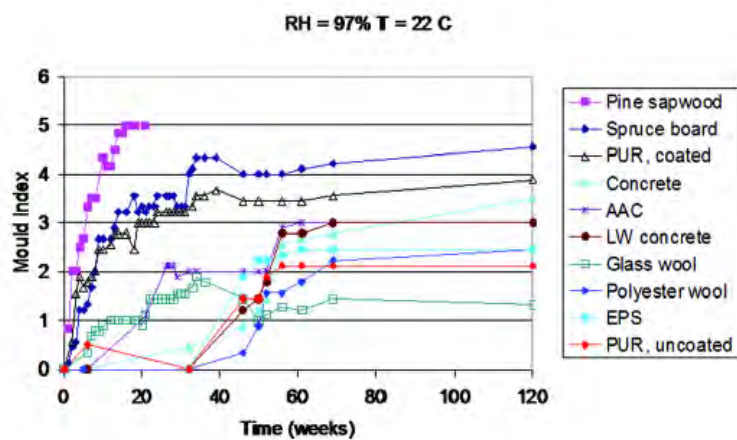


Measurements



Ojanen, Viitanen, et al. (2010)

Measurements



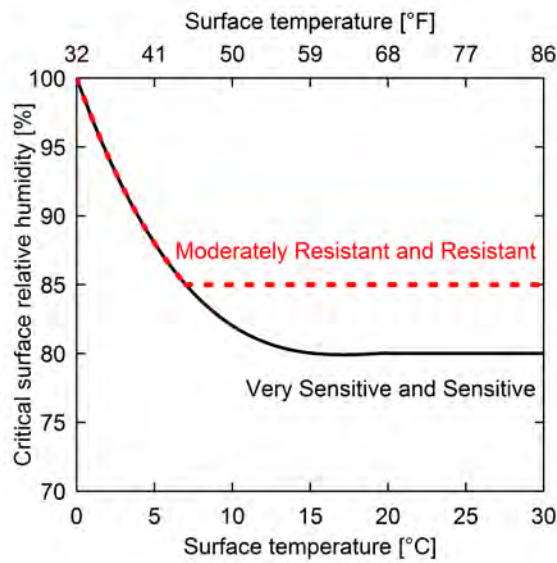
Ojanen, Viitanen, et al. (2010)

Material sensitivity classes

Sensitivity Class	Materials
Very Sensitive	Pine sapwood
Sensitive	Glued wooden boards, PUR with paper surface, spruce
Medium Resistant	Concrete, aerated and cellular concrete, glass wool, polyester wool
Resistant	PUR with polished surface

Based on Ojanen, Viitanen, et al. (2010)

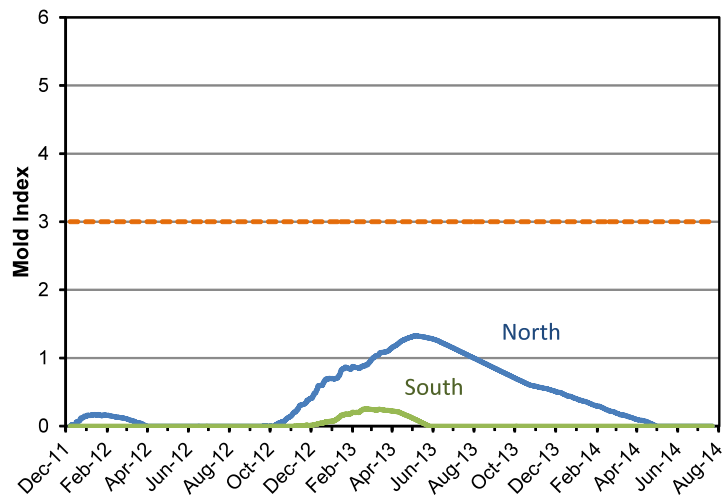
Model logic

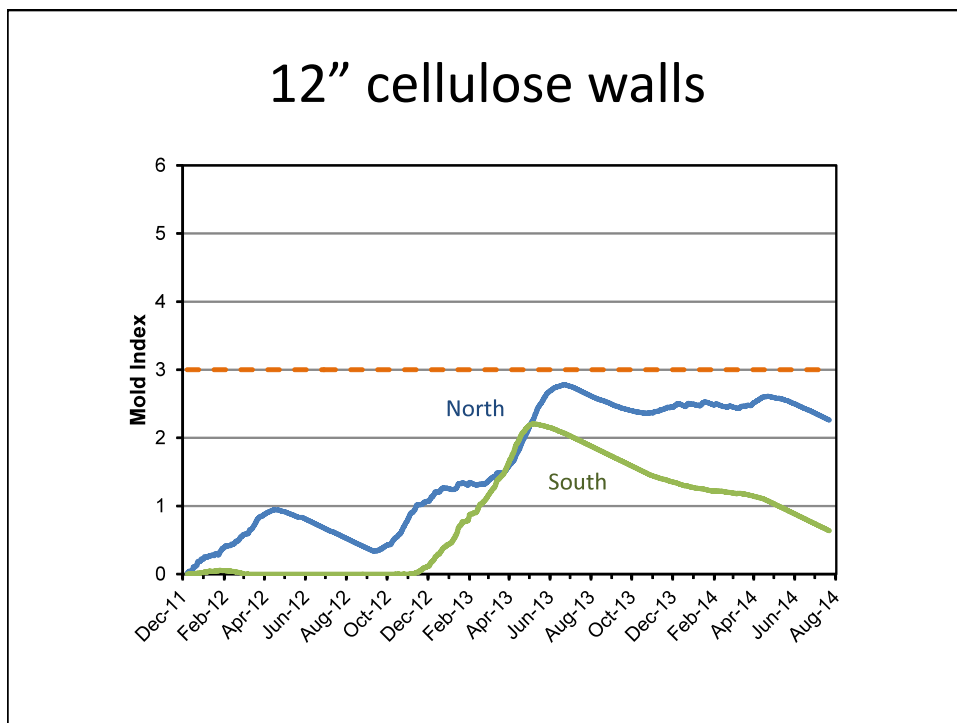
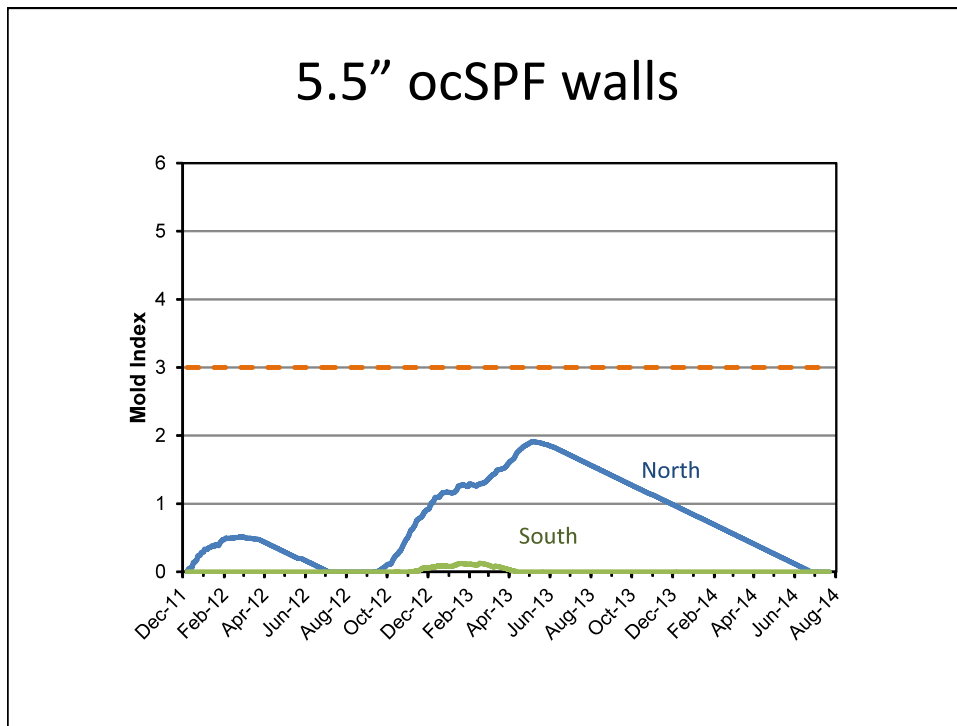


5: Don't Let Me Down

- Mold index is calculated based on measured surface temperature and relative humidity in double-stud walls
- OSB is modeled as Sensitive Class
- Mold index decline coefficient = 0.3

12" ocSPF walls



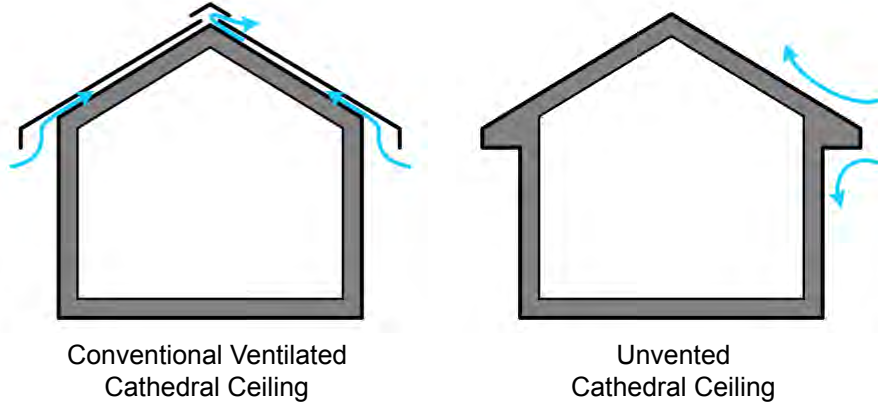


6: Here Comes the Sun



Vancouver, BC Unvented Cathedral Ceiling

Unvented Cathedral Ceilings (UCCs)



Conventional Ventilated Cathedral Ceiling

Unvented Cathedral Ceiling

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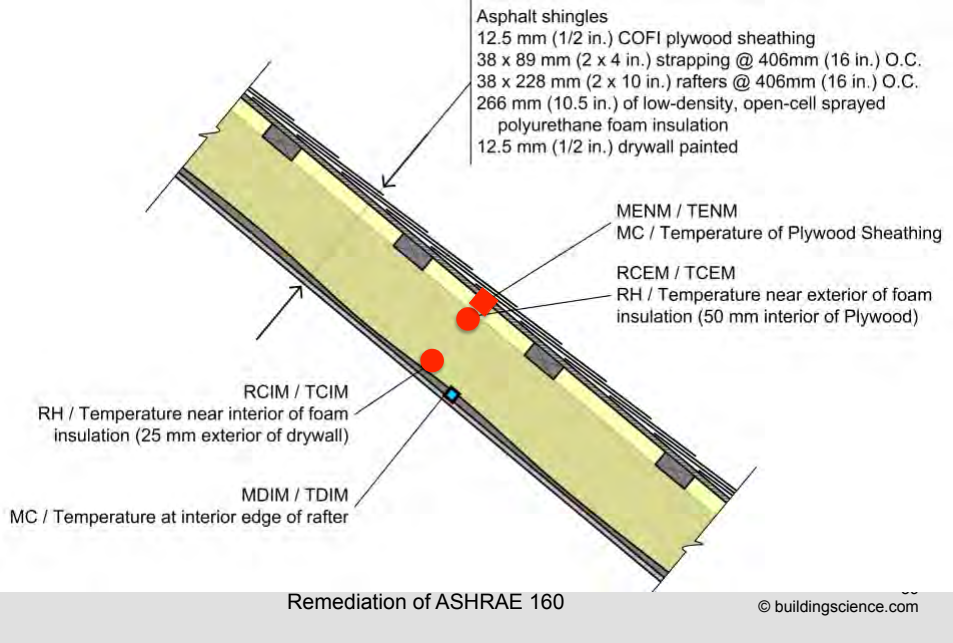
Vancouver, BC Unvented Cathedral Ceiling Study



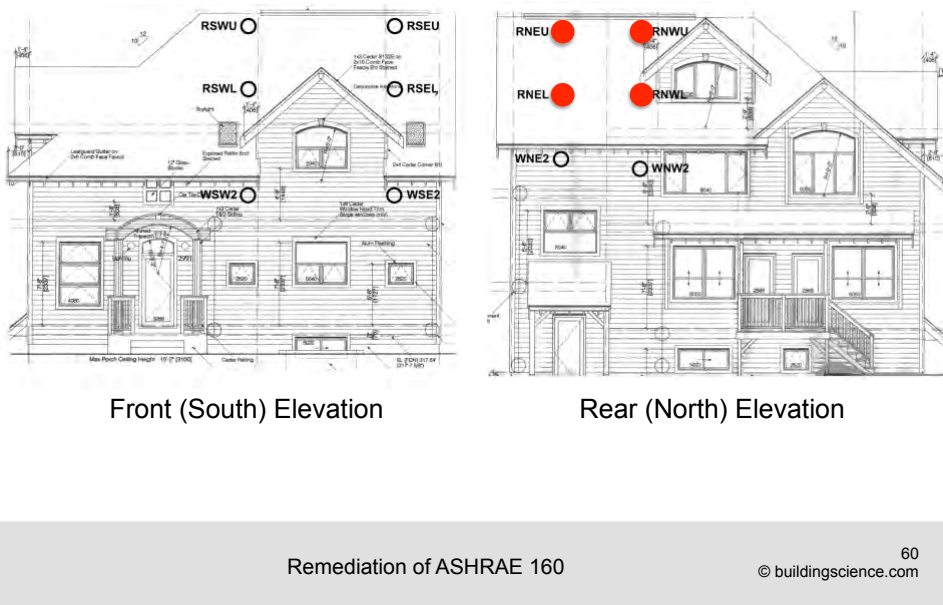
Remediation of ASHRAE 160

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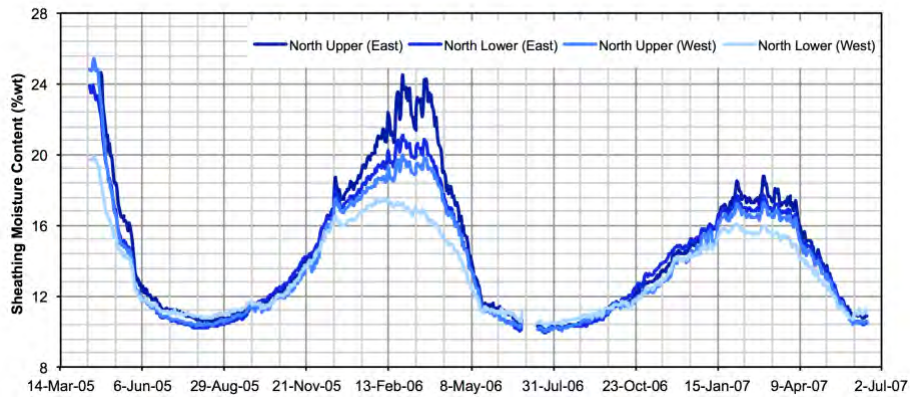
Unvented Cathedral Ceiling Assembly



Sensor Locations



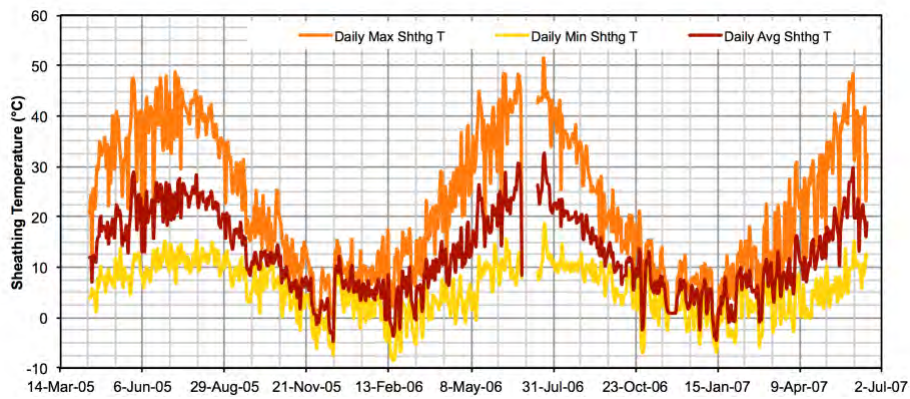
UCC Measured Moisture Contents



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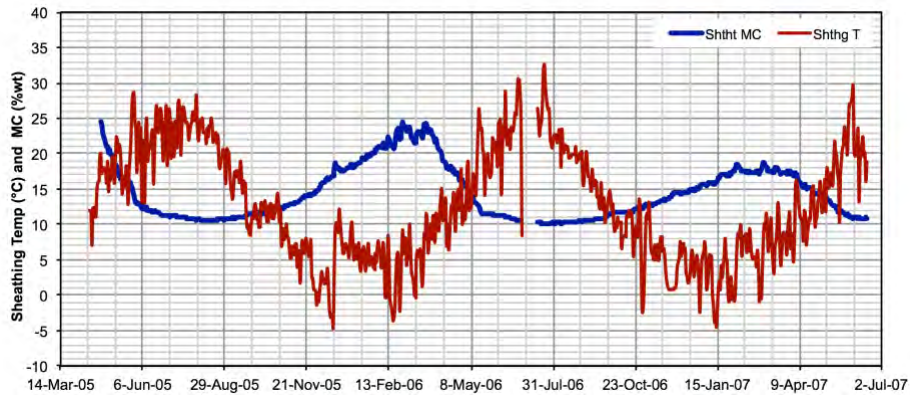
UCC Measured Temperatures



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Vancouver UCC assessment using Mold "Rule of Thumb"

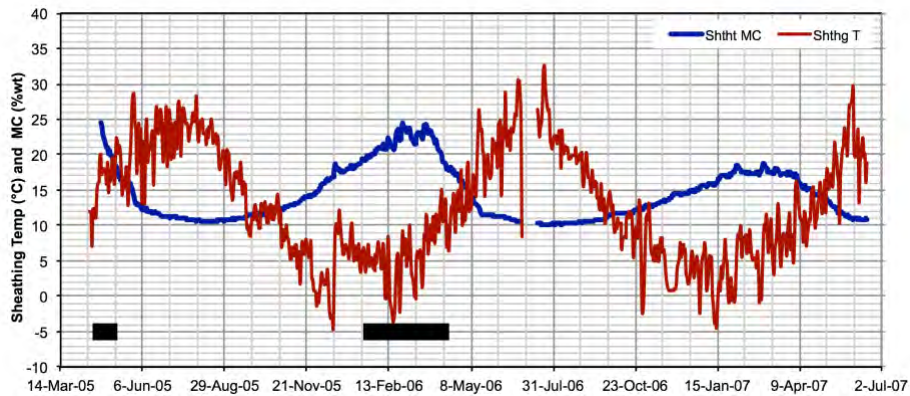


Assume conditions for mold growth: Moisture Content > 20%wt
& Temperature > 5°C

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Vancouver UCC assessment using Mold "Rule of Thumb"



Assume conditions for mold growth: Moisture Content > 20%wt
& Temperature > 5°C

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...but no mold was visible...

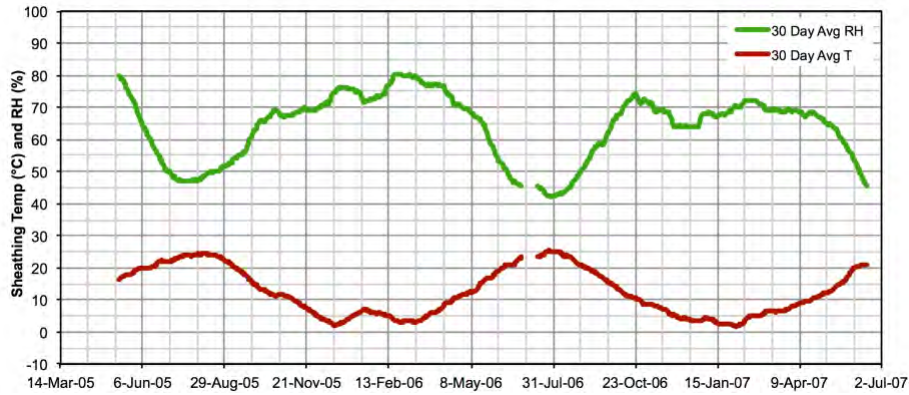


Remediation of ASHRAE 160

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Vancouver UCC assessment using Previous ASHRAE 160 Mold Criteria

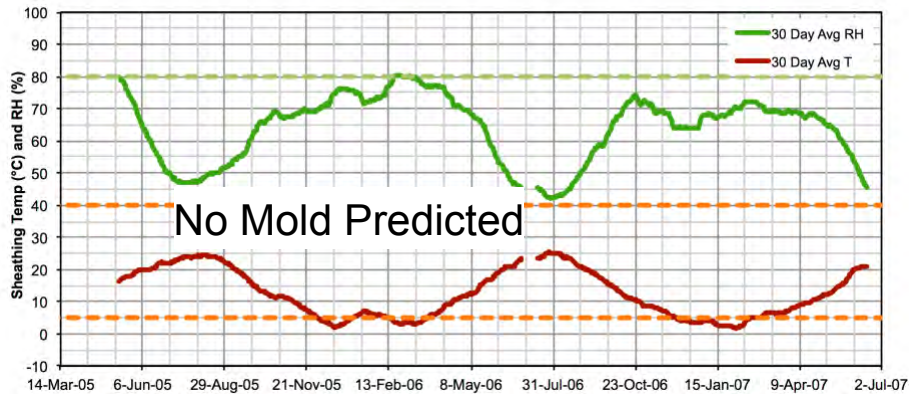


Assume conditions for mold growth: 30 Day Running Avg RH > 80%
 30 Day Running Avg 5°C > Temp > 40°C

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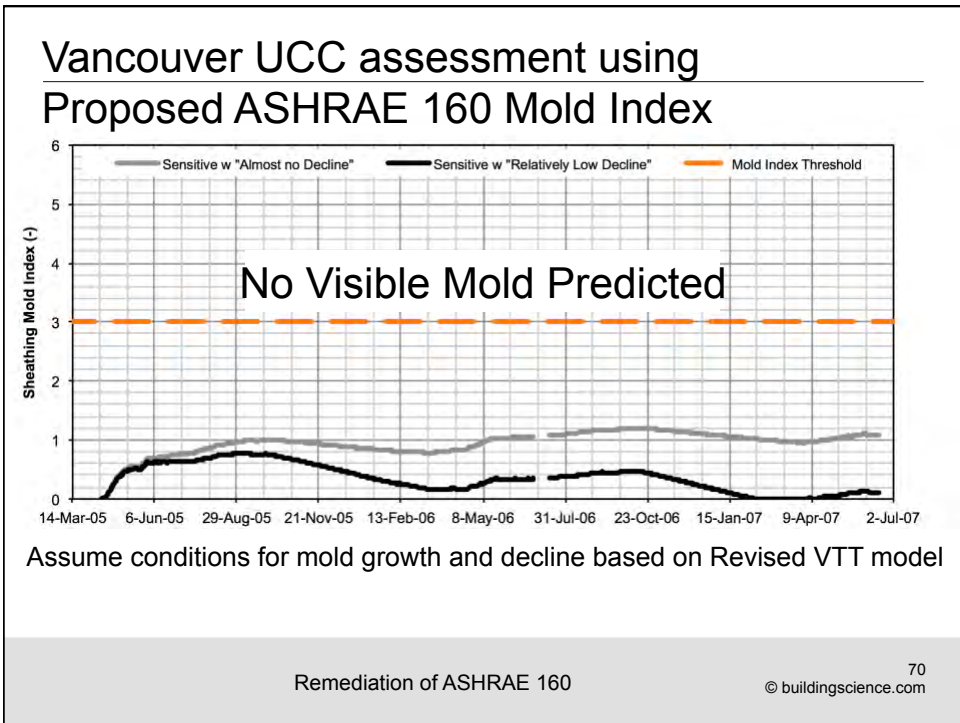
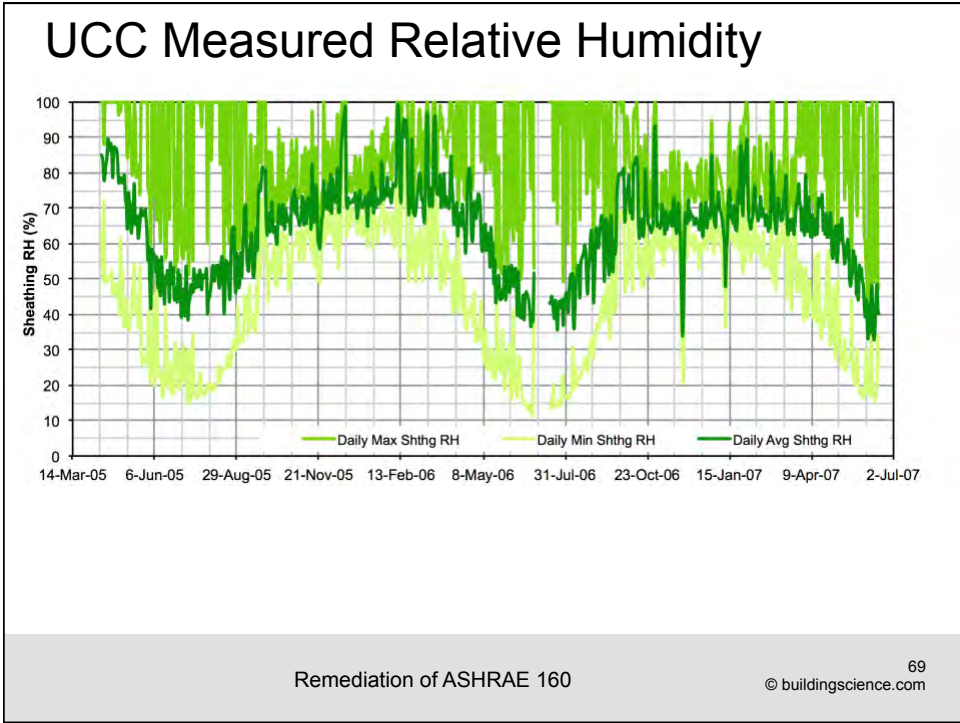
Vancouver UCC assessment using Previous ASHRAE 160 Mold Criteria






Assume conditions for mold growth: 30 Day Running Avg RH > 80%
 30 Day Running Avg 5°C > Temp > 40°C

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Vancouver UCC Research Summary

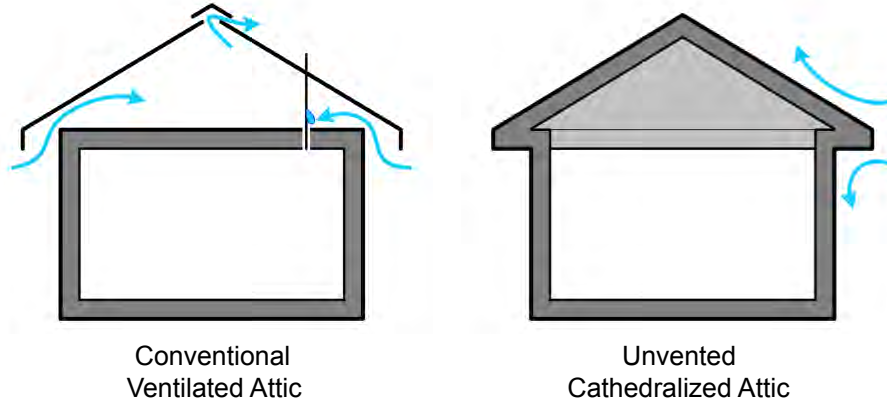
Performance Model	Agrees with Observation
“Rule of Thumb” (over 20% MC & 5°C)	
Previous ASHRAE 160 Mold Criteria (over 80% RH & between 5 and 40°C)	
Proposed ASHRAE 160 Mold Index (revised VTT Mold Index Model)	

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Coquitlam, BC Unvented Cathedralized Attics

Unvented Cathedralized Attics (UCAs)



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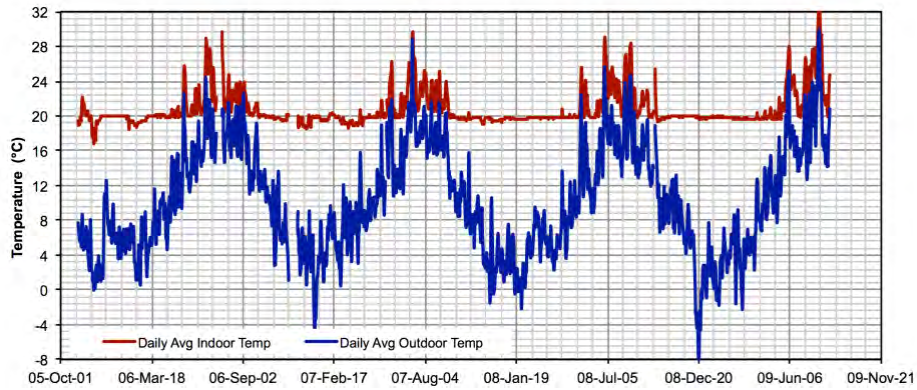
Coquitlam, BC Unvented Cathedralized Attic Study



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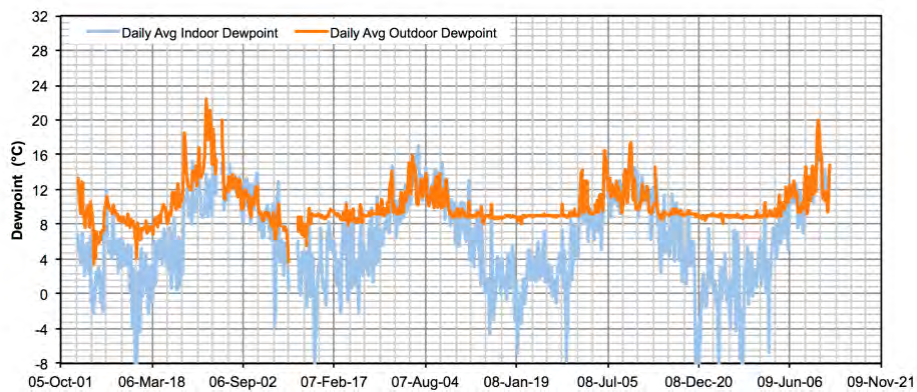
Coquitlam Hut Measured Indoor and Outdoor Temperatures



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Coquitlam Hut Measured Indoor and Outdoor Dewpoints



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Vented Attic Assembly

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

Remediation of ASHRAE 160 77
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Vented Attic Assembly

Remediation of ASHRAE 160 78
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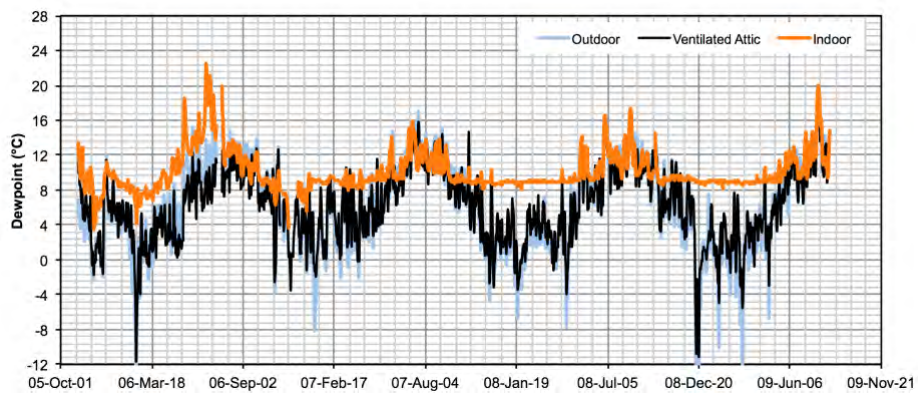
Vented Attic Assembly



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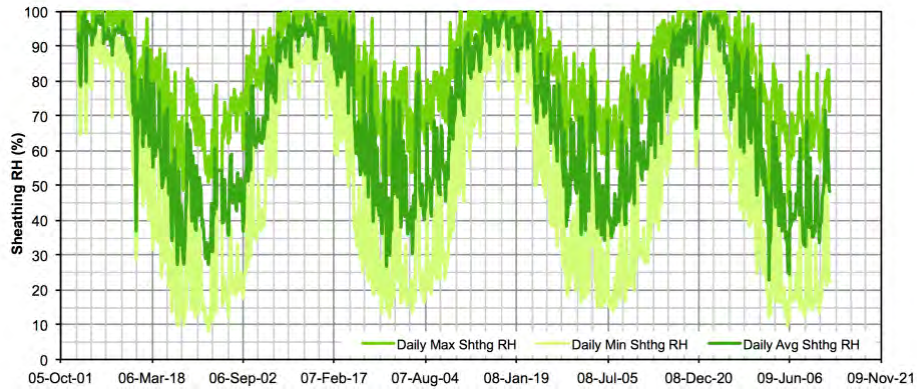
Vented Attic Measured Dewpoint



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80
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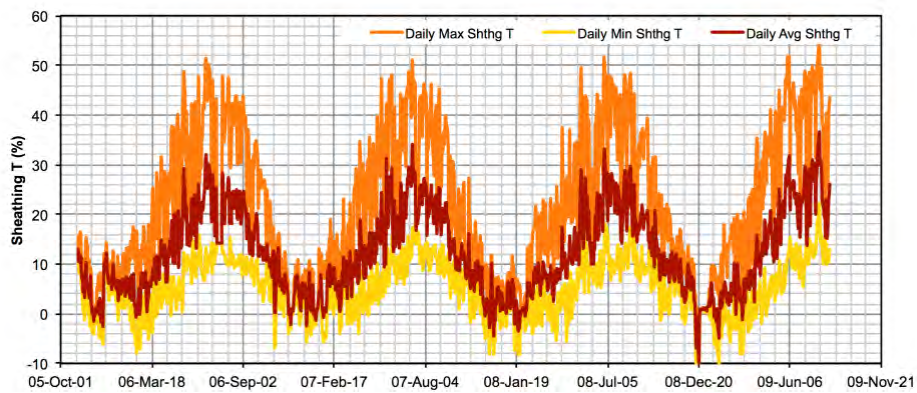
Vented Attic Measured RH



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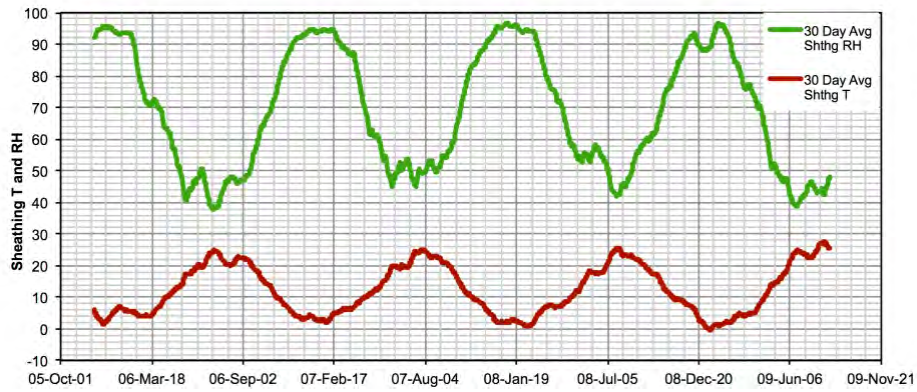
Vented Attic Measured Temperature



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Coquitlam Vented Attic assessment using Previous ASHRAE 160 Mold Criteria

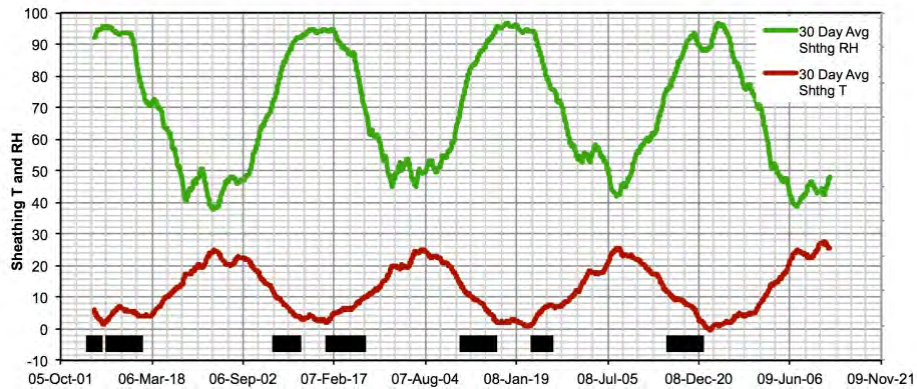


Assume conditions for mold growth: 30 Day Running Avg RH > 80%
30 Day Running Avg 5°C > Temp > 40°C

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Coquitlam Vented Attic assessment using Previous ASHRAE 160 Mold Criteria



Assume conditions for mold growth: 30 Day Running Avg RH > 80%
30 Day Running Avg 5°C > Temp > 40°C

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No Visible Mold @ 2 yrs



Remediation of ASHRAE 160

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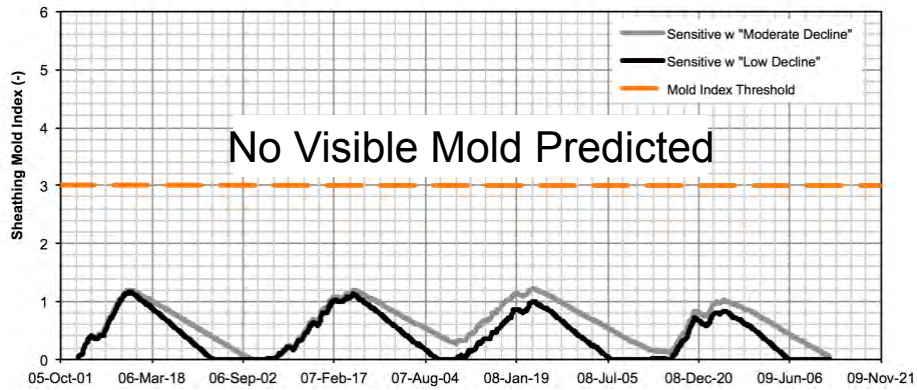
No Visible Mold @ 9 yrs



Remediation of ASHRAE 160



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Coquitlam Vented Attic assessment using Proposed ASHRAE 160 Mold Index



Assume conditions for mold growth and decline based on Revised VTT model

Coquitlam Hut Vented Attic Summary

Performance Model	Agrees with Observation
Previous ASHRAE 160 Mold Criteria (over 80% RH & between 5 and 40°C)	
Proposed ASHRAE 160 Mold Index (revised VTT Mold Index Model)	

Unvented Cathedralized Attic Assembly

The diagram shows a cross-section of a cathedralized attic. The roof structure consists of a 2x4 truss. The interior surface is finished with 1/2" drywall and paint. Below the drywall is a vapour/air barrier, followed by thermal insulation (sprayed poly ISO). The exterior sheathing is 1/2" OSB, and the exterior cladding is asphalt shingles. The diagram labels various material layers and components with abbreviations: MENU + TENU, MENM + TENM, RCCEM + TCEM, THEM, MENL + TENL, RCIM + TCIM, TBEM, MVNM + TVNM, and ?? + ??.

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
 Exterior Sheathing: (top chord truss) 1/2" OSB
 Air/Weather Barriers: n/a
 Exterior Cladding: asphalt shingles

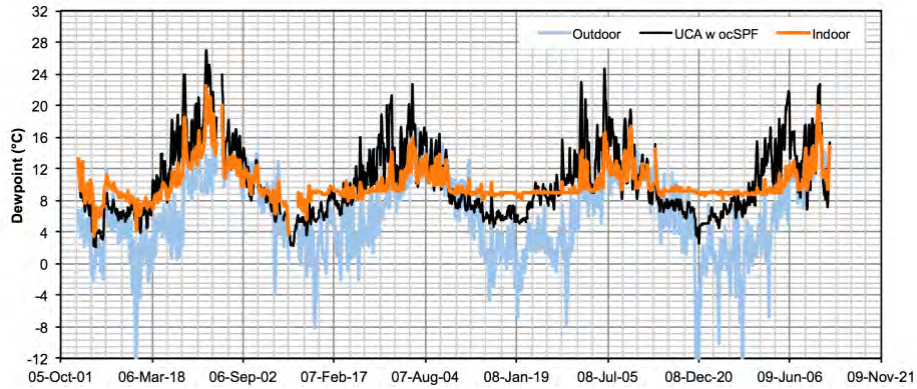
Remediation of ASHRAE 160 89
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Unvented Cathedralized Attic Assembly

The photograph shows the interior of a cathedralized attic. The wooden trusses are visible, and the spaces between them are filled with spray foam insulation. The insulation is a light tan color and appears to be applied in a thick, textured layer. The floor below the trusses is visible, and there is a dark object with the word "Boston" partially visible on the right side.

Remediation of ASHRAE 160 90
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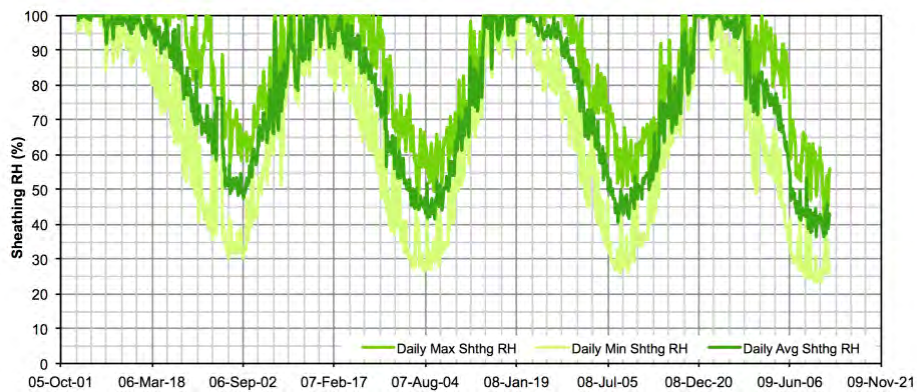
UCA Measured Dewpoint



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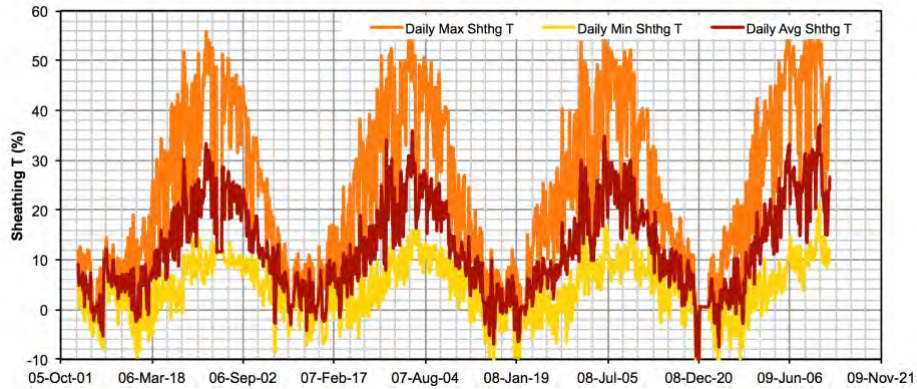
UCA Measured RH



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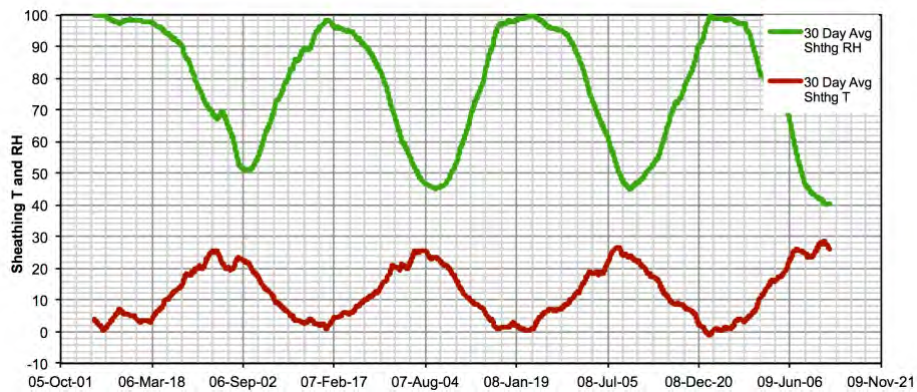
UCA Measured Temperature



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Coquitlam UCA assessment using Previous ASHRAE Mold Criteria

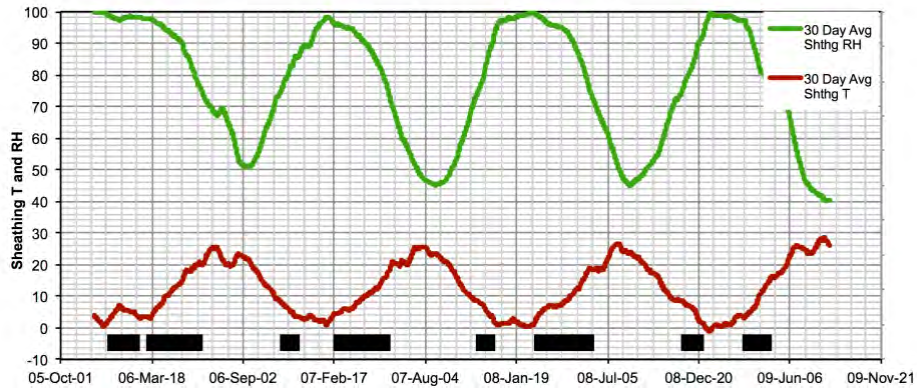


Assume conditions for mold growth: 30 Day Running Avg RH > 80%
30 Day Running Avg 5°C > Temp > 40°C

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Coquitlam UCA assessment using Previous ASHRAE Mold Criteria



Assume conditions for mold growth: 30 Day Running Avg RH > 80%
 30 Day Running Avg 5°C > Temp > 40°C

Remediation of ASHRAE 160

95
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No Visible Mold @ 9 yrs



Remediation of ASHRAE 160

96
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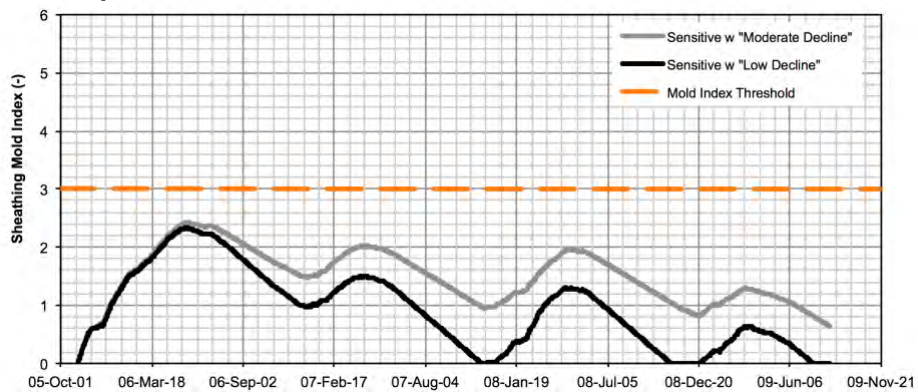
No Visible Mold @ 9 yrs



Remediation of ASHRAE 160

97
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Coquitlam UCA assessment using Proposed ASHRAE Mold Index



Remediation of ASHRAE 160

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Coquitlam Hut Unvented Cathedralized Attic Summary

Performance Model	Agrees with Observation
Previous ASHRAE 160 Mold Criteria (over 80% RH & between 5 and 40°C)	
Proposed ASHRAE 160 Mold Index (revised VTT Mold Index Model)	

Remediation of ASHRAE 160

99
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7: Come Together

- Mold index model is a big improvement over the previous Std 160 mold criterion
- Test cases using measurements show that model agrees with observations
- Need to run more test cases **with** visible mold growth
- Addendum to Std 160 coming soon for public review

Questions?



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Remediation of ASHRAE 160

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