BUILDING ENERGY 15

MARCH 3-5, 2015 AT THE SEAPORT WORLD TRADE CENTER

AIA Provider: Northeast Sustainable Energy Association

Provider Number: G338

Super Insulated Walls and Moisture: Does Bad Stuff Happen?

Course Number

Chris Corson and Kohta Ueno

March 4, 2015

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Course Description

High-R or super-insulated walls are a common component of high performance housing. However, in cold climates, these walls run the risks of cold-weather condensation, and general durability issues due to reduced heat flow. Two practitioners have been monitoring the moisture performance of several high performance walls, and will share their results. Chris Corson has been examining highly vapor-open walls based on classic European Passive House designs, without the use of plastic foams. Kohta Ueno has been monitoring double stud walls insulated with cellulose and open-cell spray foam for three winters. His monitoring study was followed by disassembly of the walls, to examine conditions in the cavities. The two will talk about their data, whether various assemblies fall on the safer or riskier side, and how to make design choices. Keeping these walls buildable and cost-effective will be another aspect of the discussions.

Learning Objectives

At the end of the this course, participants will be able to answer:

1. What are the risks associated with high-R or superinsulated walls, relative to conventional/code construction?

2. What are some of the options for constructing high-R walls in cold climates?

3. How does a vapor-open high-R wall behave in a very cold climate (Maine), in terms of moisture risks?

4. What moisture conditions and resulting damage are seen at double stud wall sheathing after experiencing high interior humidity conditions?

Kohta Ueno

Super Insulated Walls and Moisture: Does Bad Stuff Happen? (Double Stud)

NESEA BuildingEnergy 2014
March 4, 2015

Building Science Corporation

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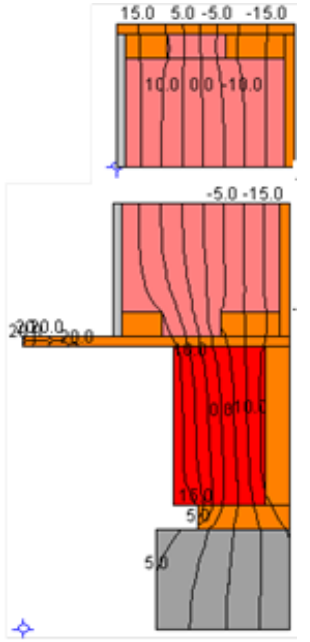
Background

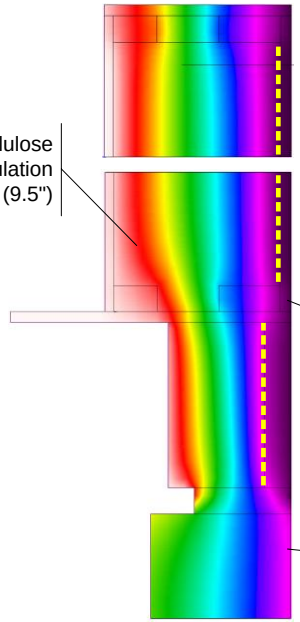
Double Stud Wall Monitoring

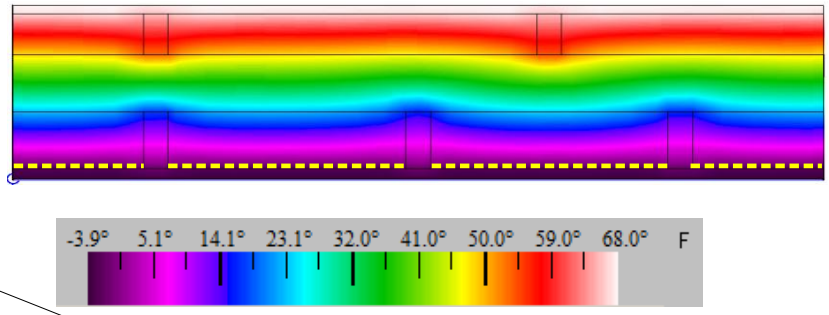
- Double stud wall advantages:
  - High R values
  - Simplifies exterior detailing (few changes to standard practice)
  - Lower cost vs. other high-R walls?
- Moisture risks due to interstitial condensation?
  - Most common failure, after rain control issues
  - Air barrier imperfections—increase risk
  - Air permeable low-density insulations—increase risk (including convective looping)
  - Air impermeable insulations—decrease risk
  - Reduce risk with “skim” of spray foam at sheathing?

Wall Condensation Potentials

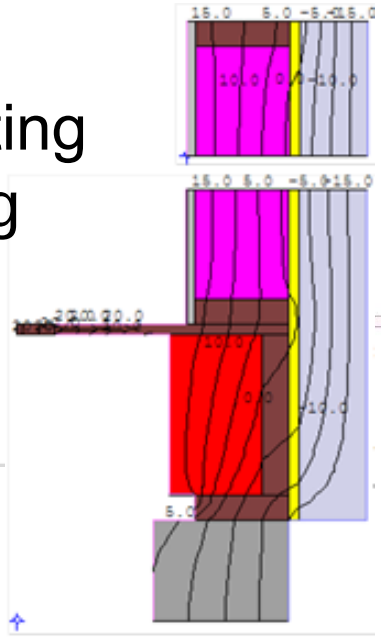
Double stud wall

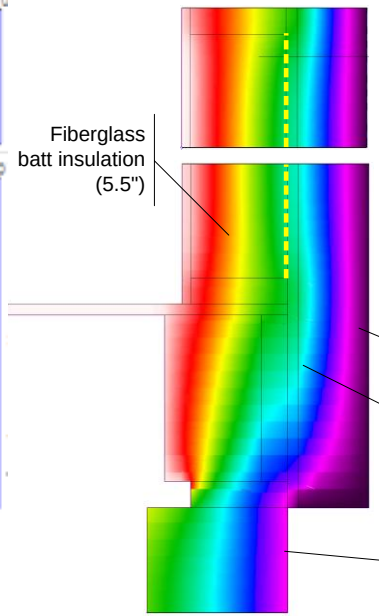


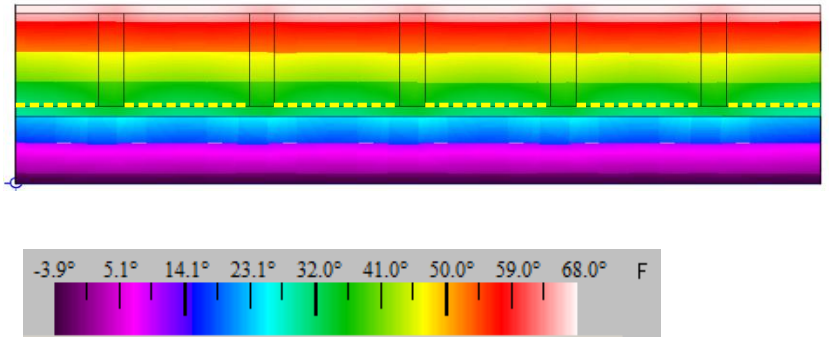




4” insulating sheathing (on 2x6)





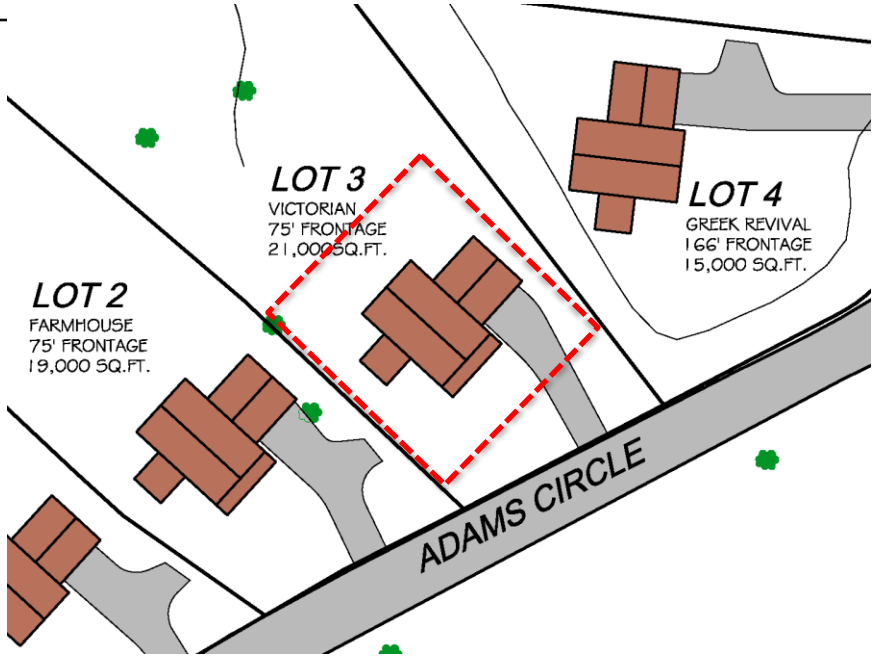


Experimental Setup

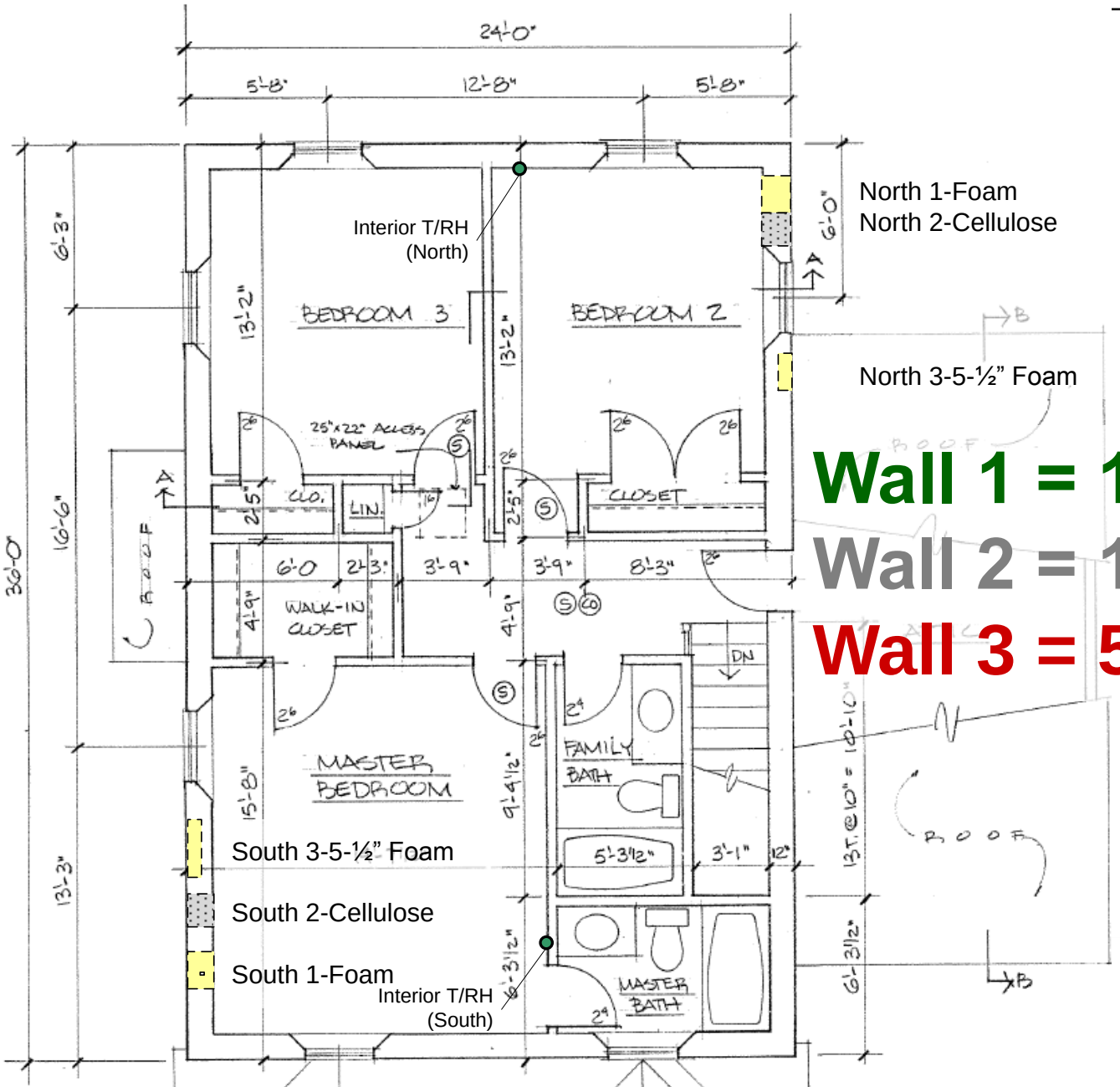
Wall Construction

- Vinyl siding
- ZIP wall sheathing (OSB)
- Class III vapor control (latex paint)
- IRC R601.3.1—vented cladding over OSB

Site and Orientation



Test Wall Locations (2nd Floor)

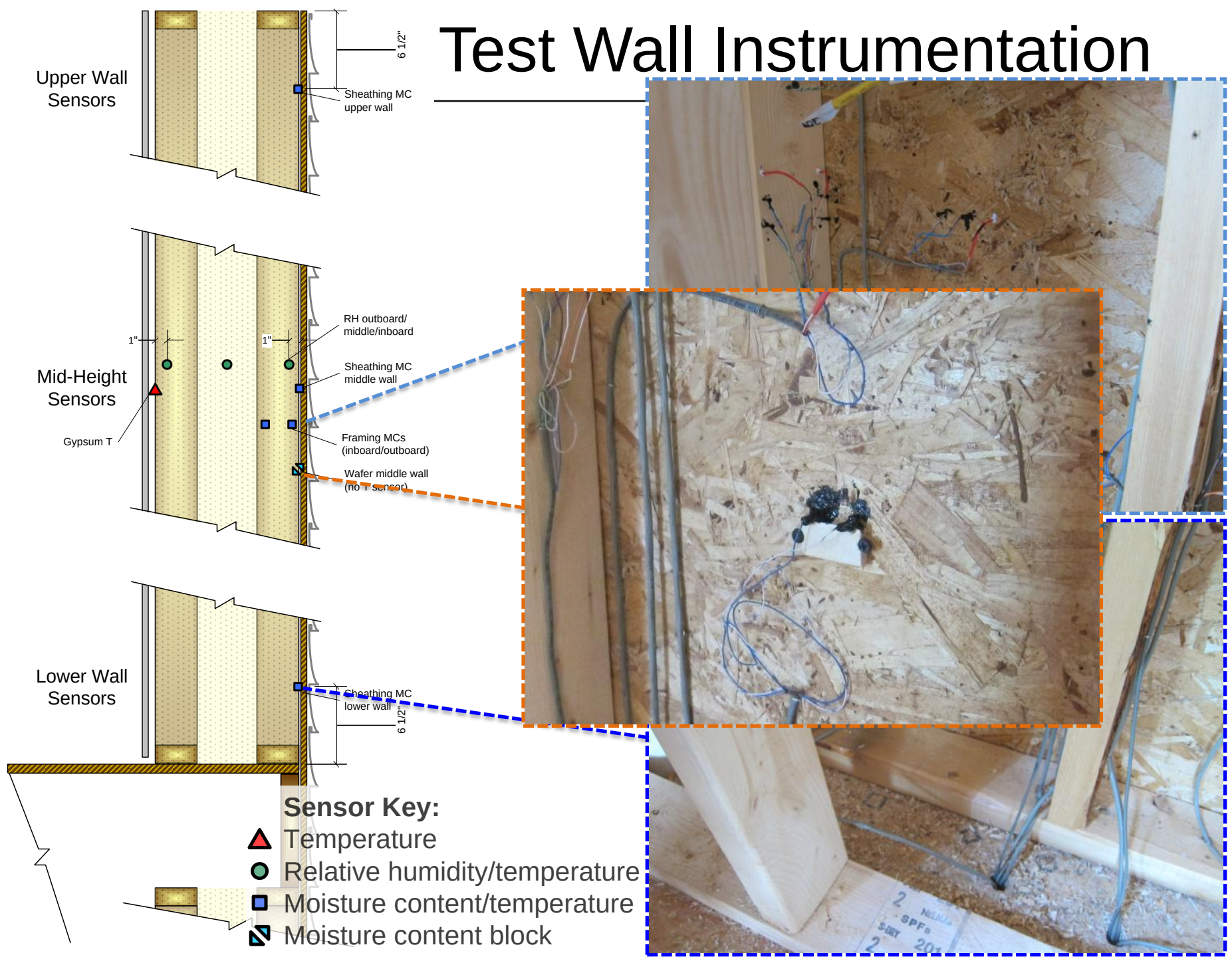


Wall 1 = 12" o.c. SPF

Wall 2 = 12" Cellulose

Wall 3 = 5-½" o.c. SPF

Test Wall Instrumentation



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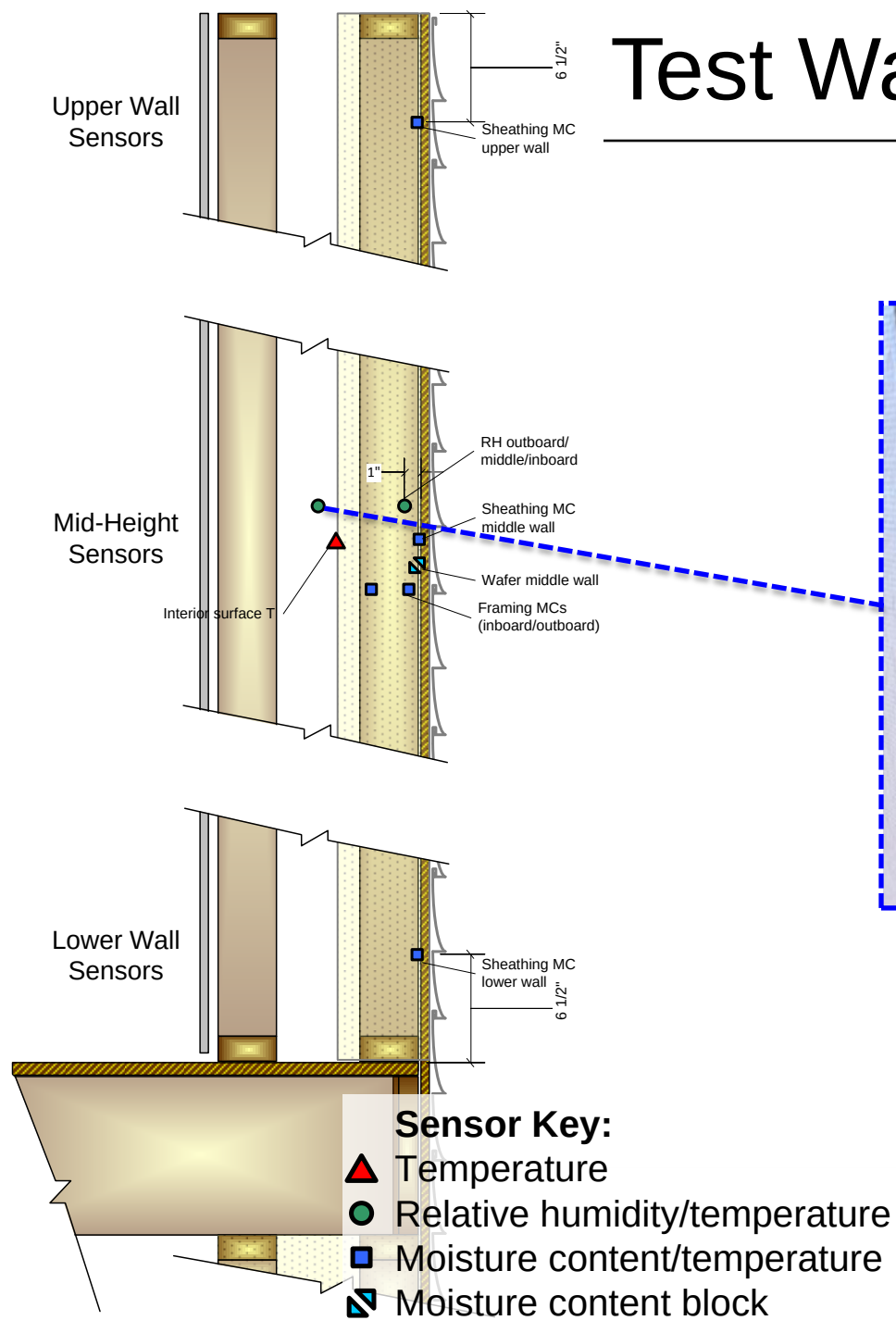
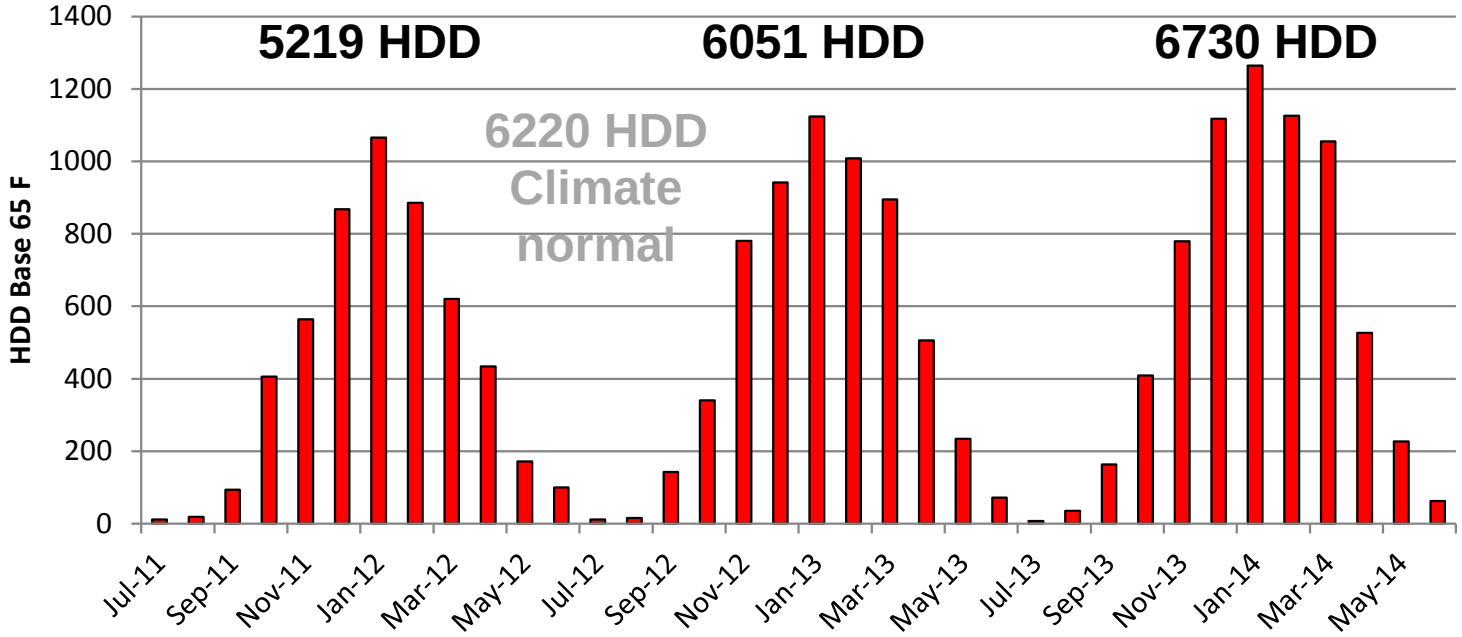


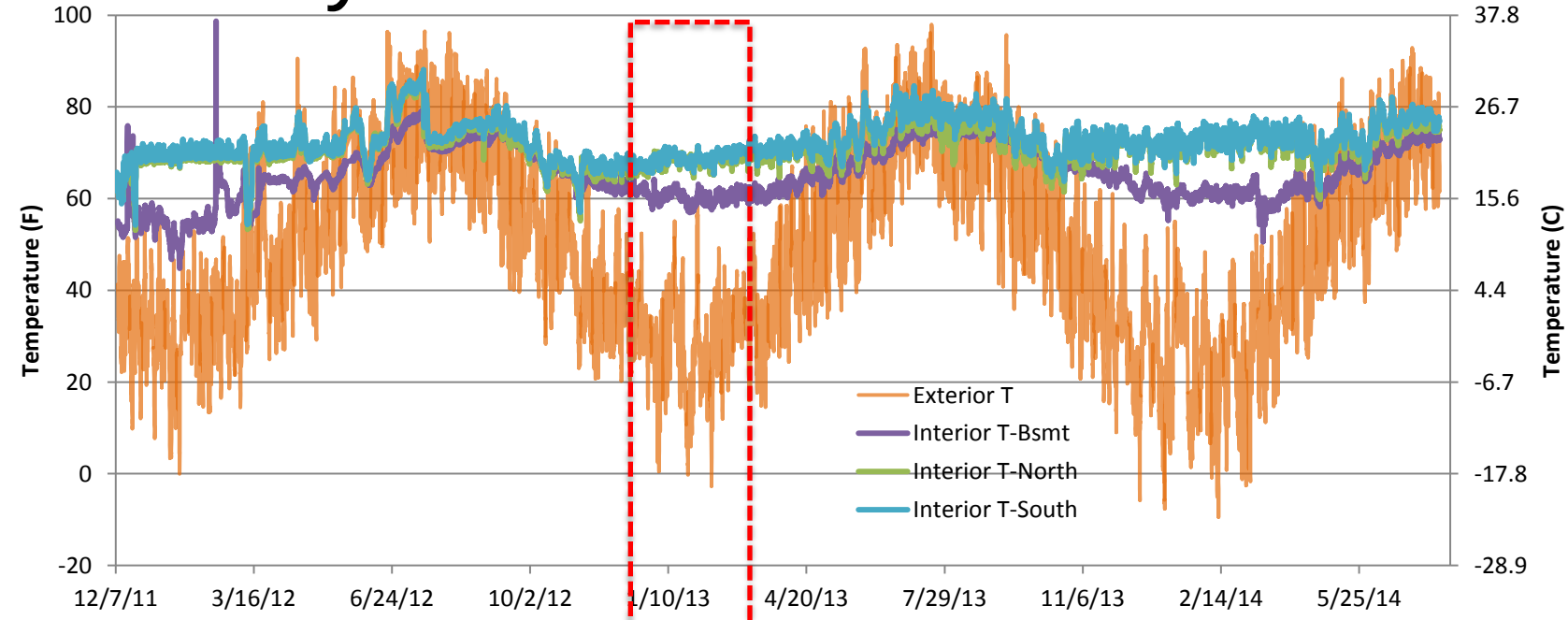
Results: Boundary Conditions

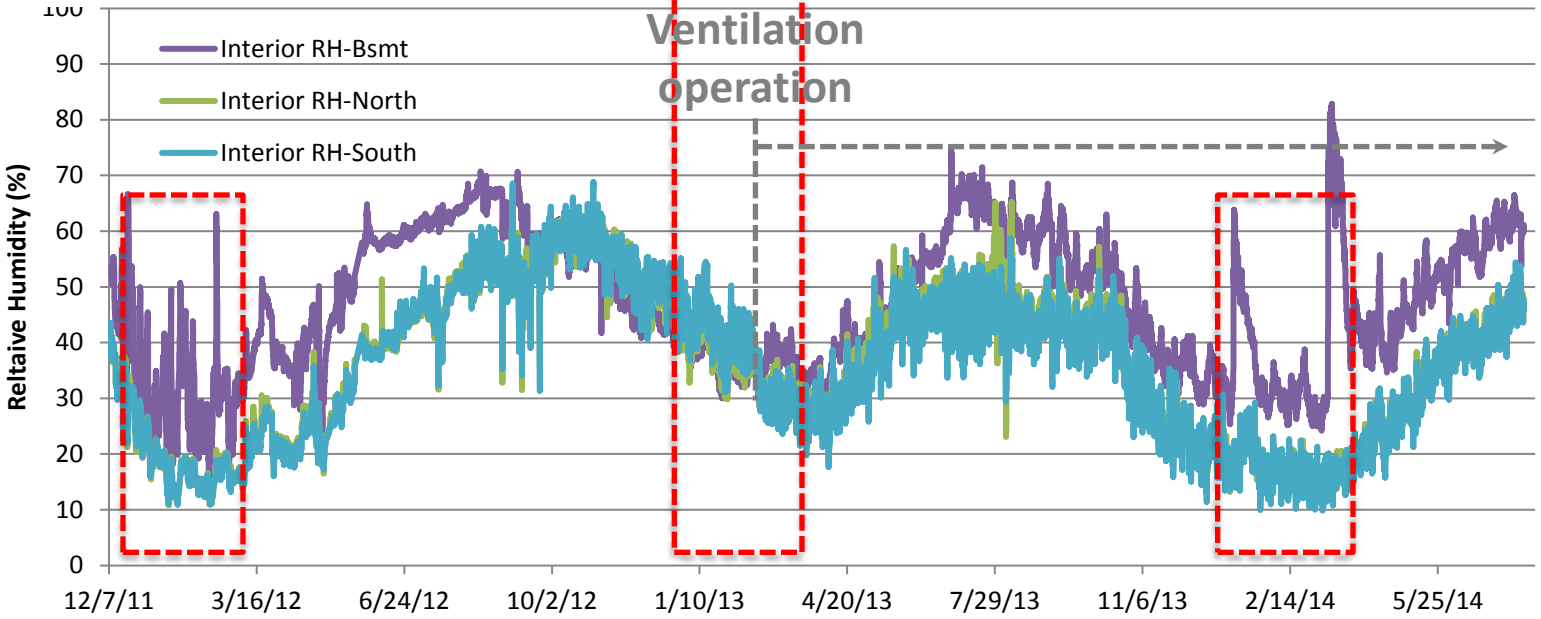
Data Collected

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



Boundary Conditions



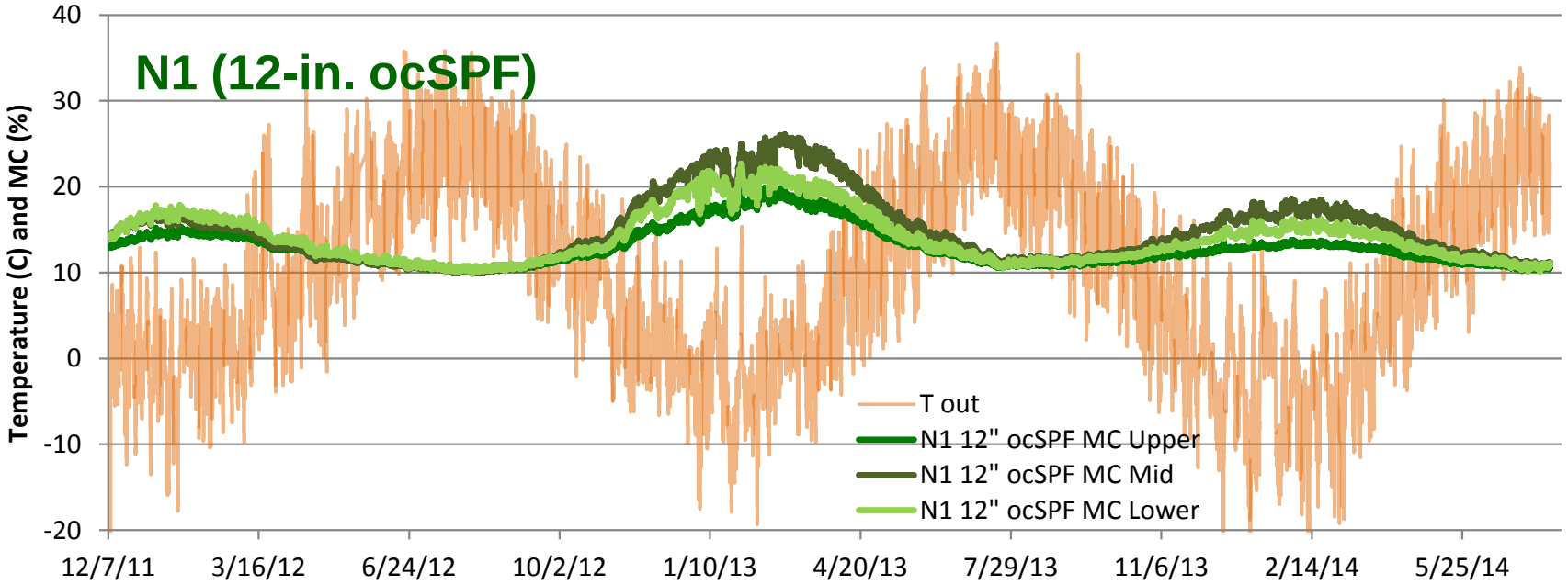


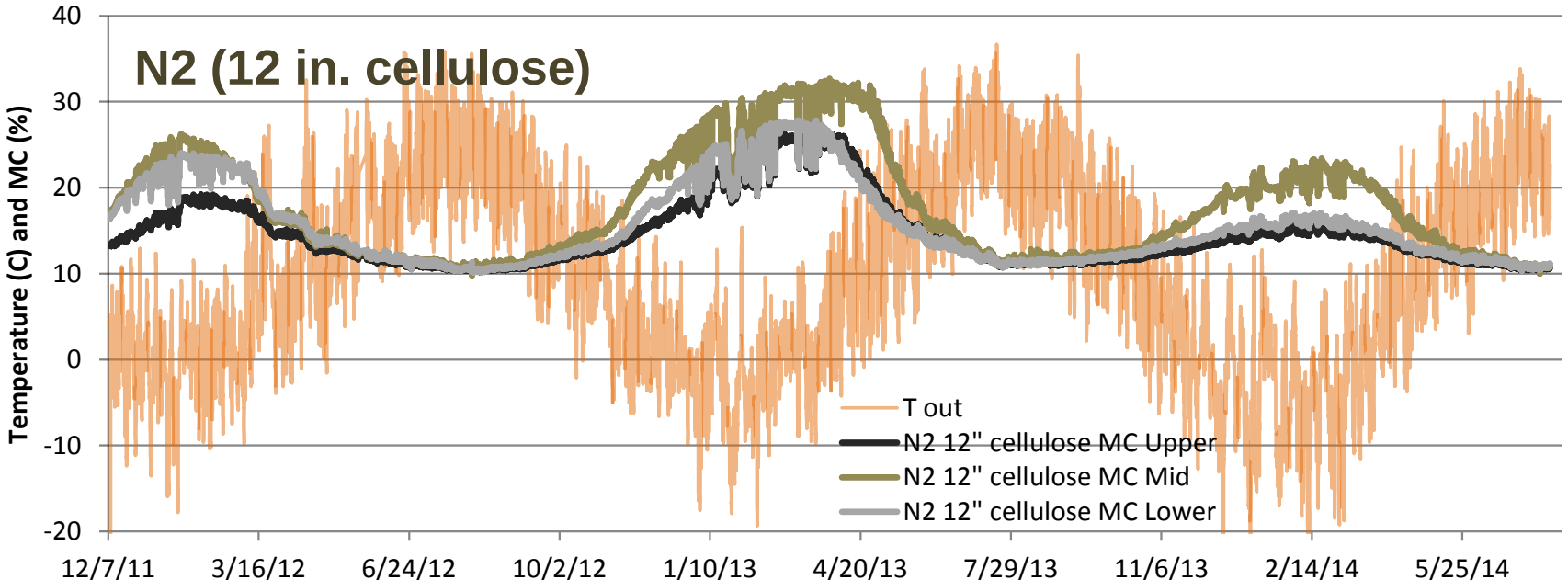
Boundary Conditions Takeaways

- First Winter (Partial)
  - Unoccupied conditions (no occupant moisture generation)
  - Very low interior RH
  - 5220 HDD Base 65 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%

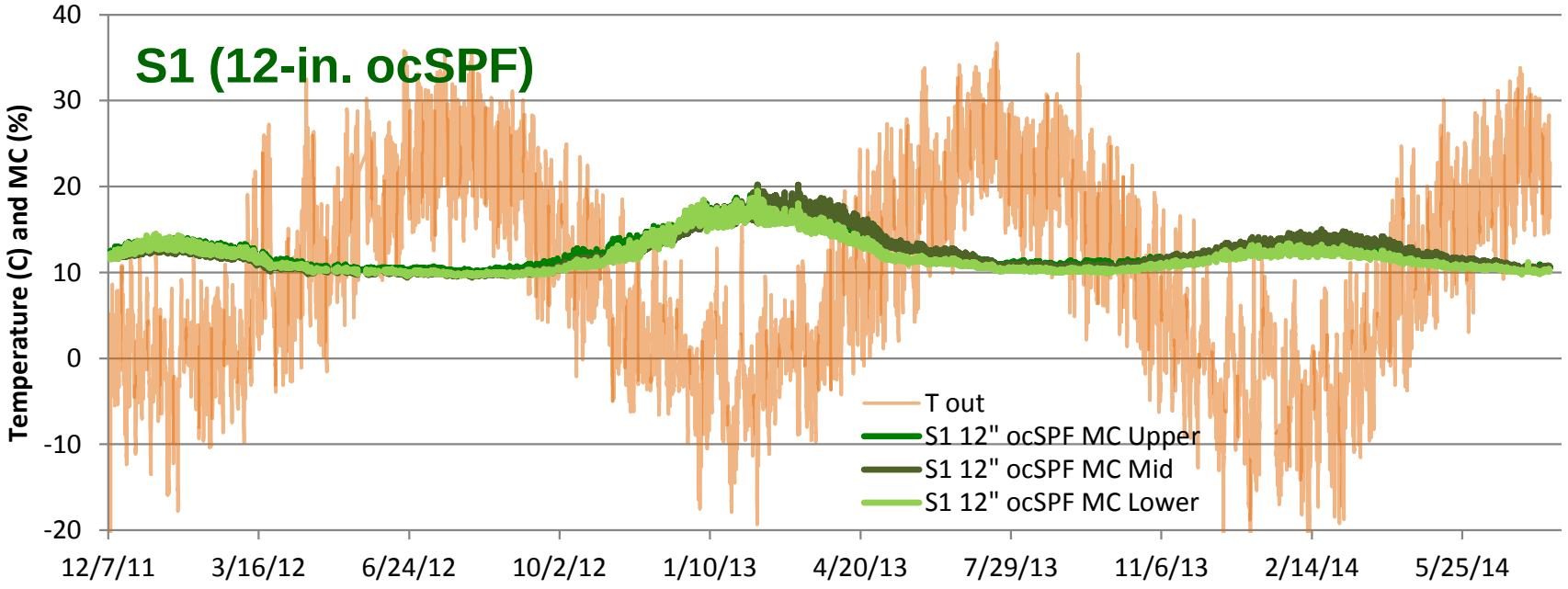
Results: Wall Monitoring

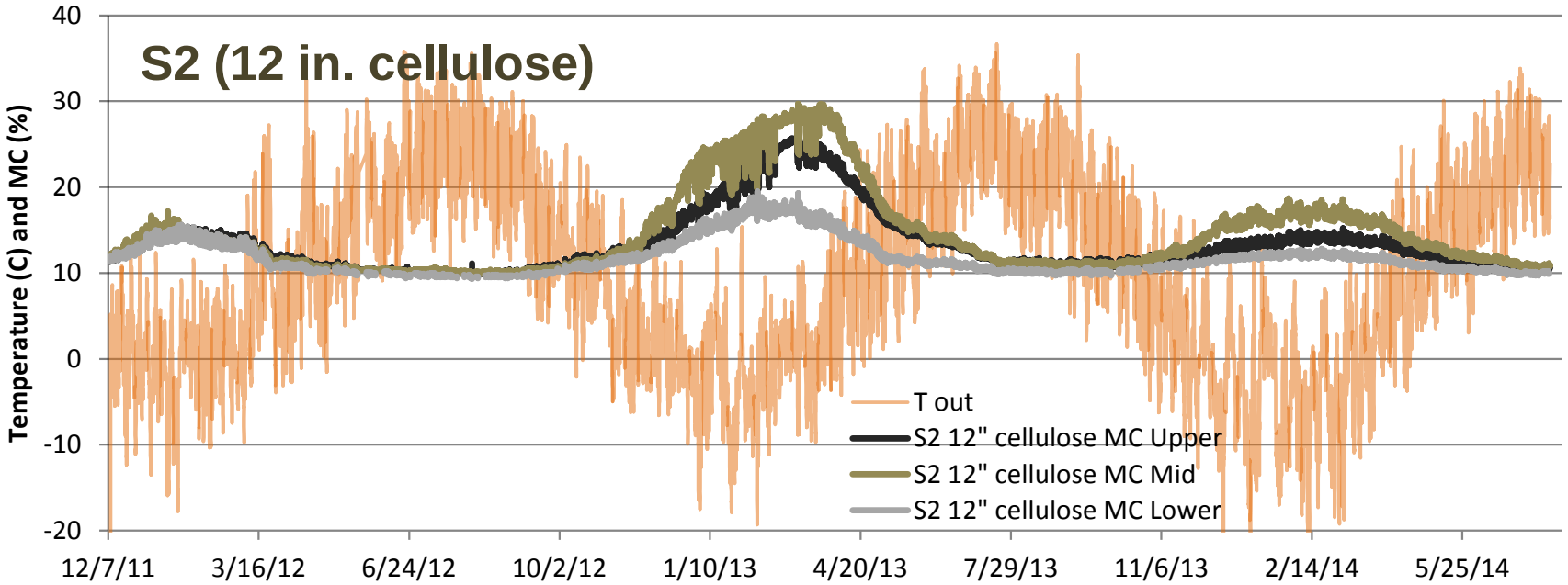
Sheathing Moisture Content (North)



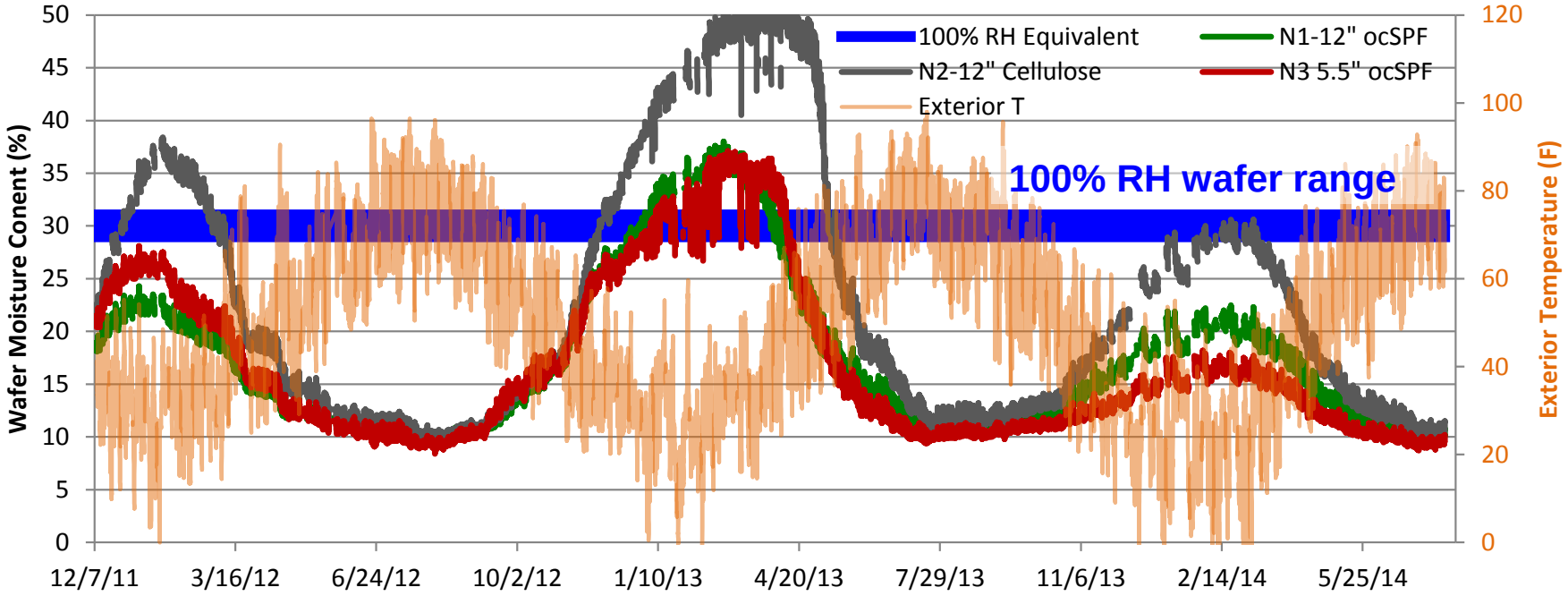


Sheathing Moisture Content (South)



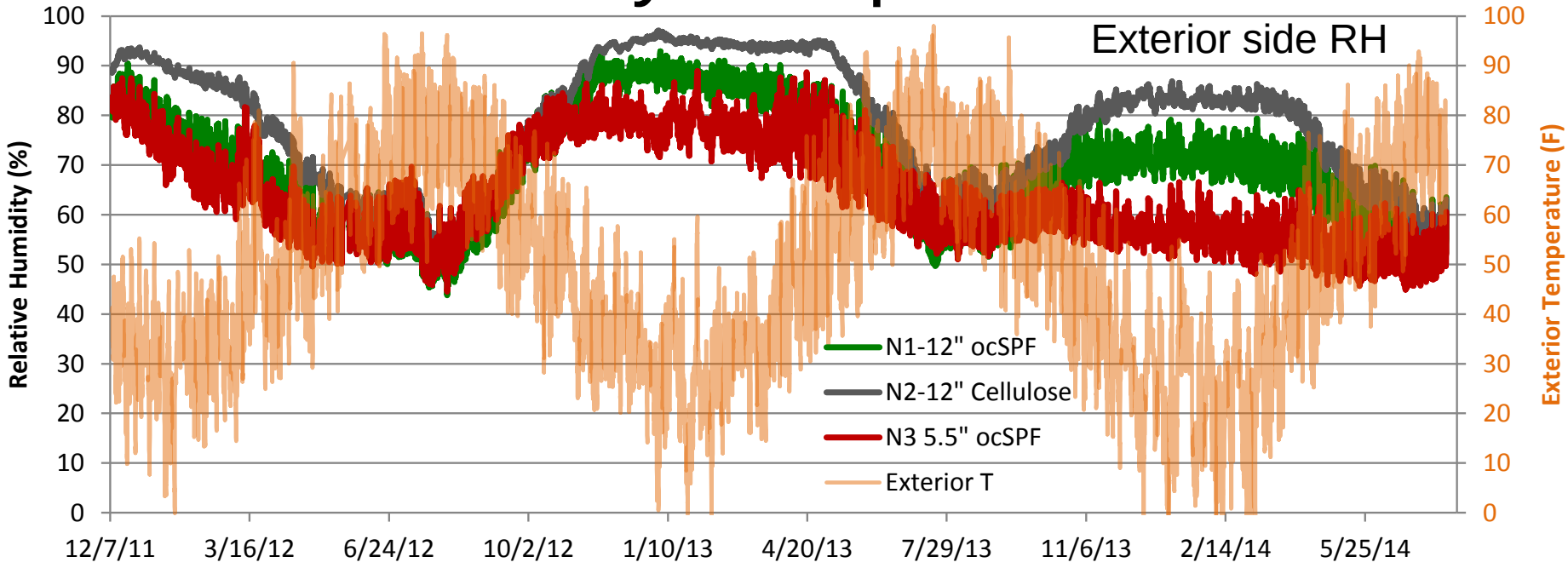


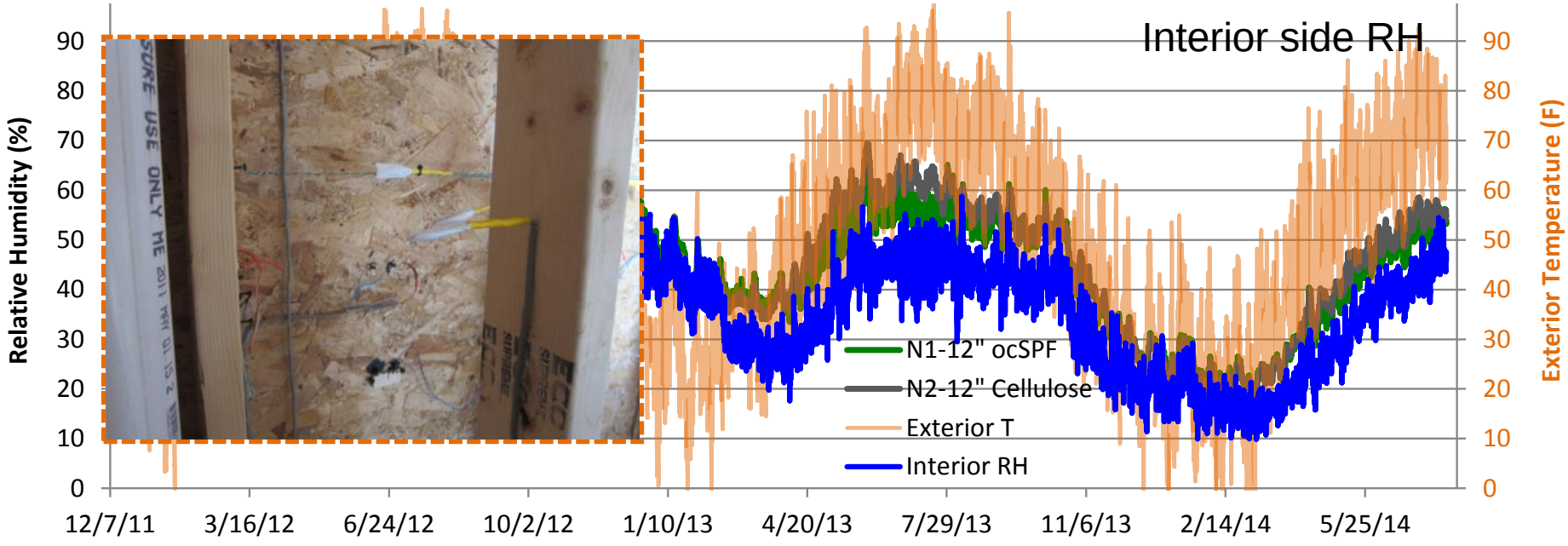
Sheathing “Wafer” Moisture Contents



- 00% RH
- → liquid water immersion
- n condensation at sheathing
- condensation on south side

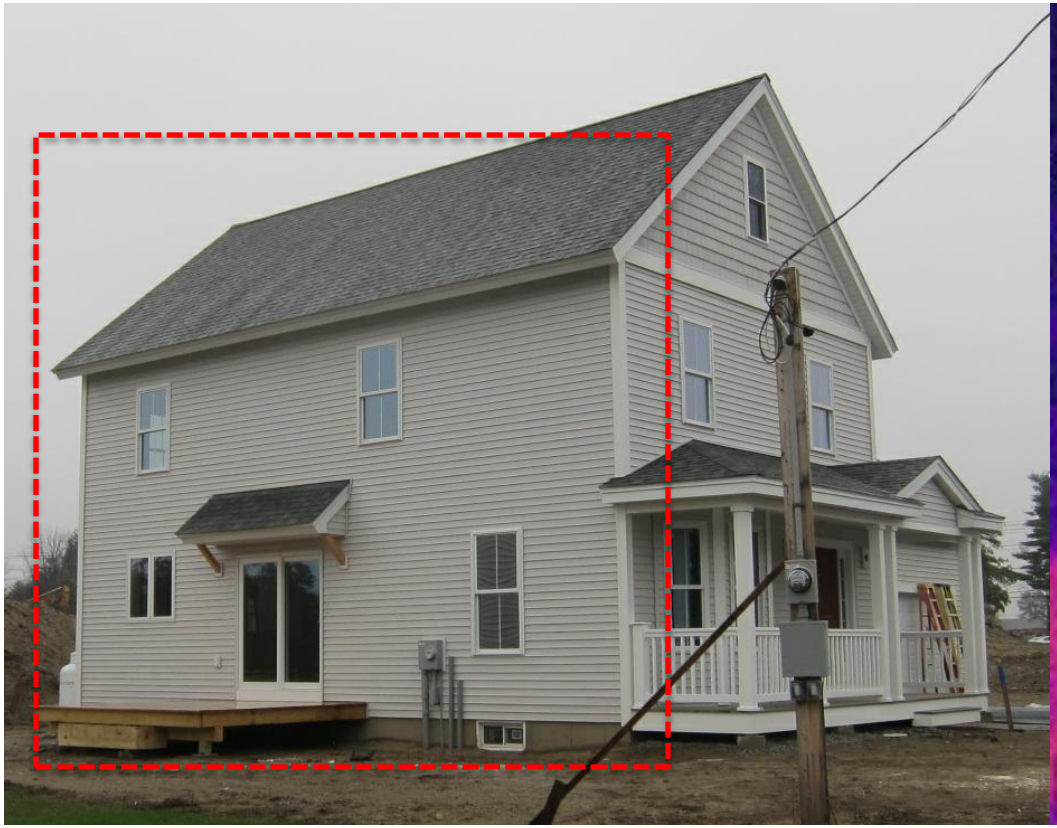
Relative Humidity Comparison

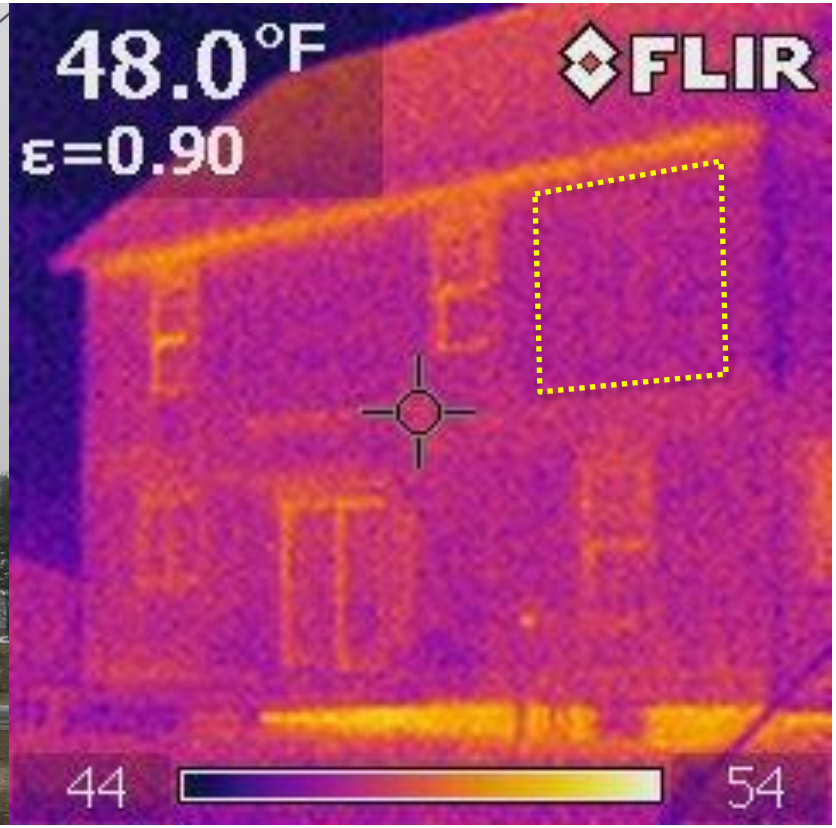




Sheathing Temperature

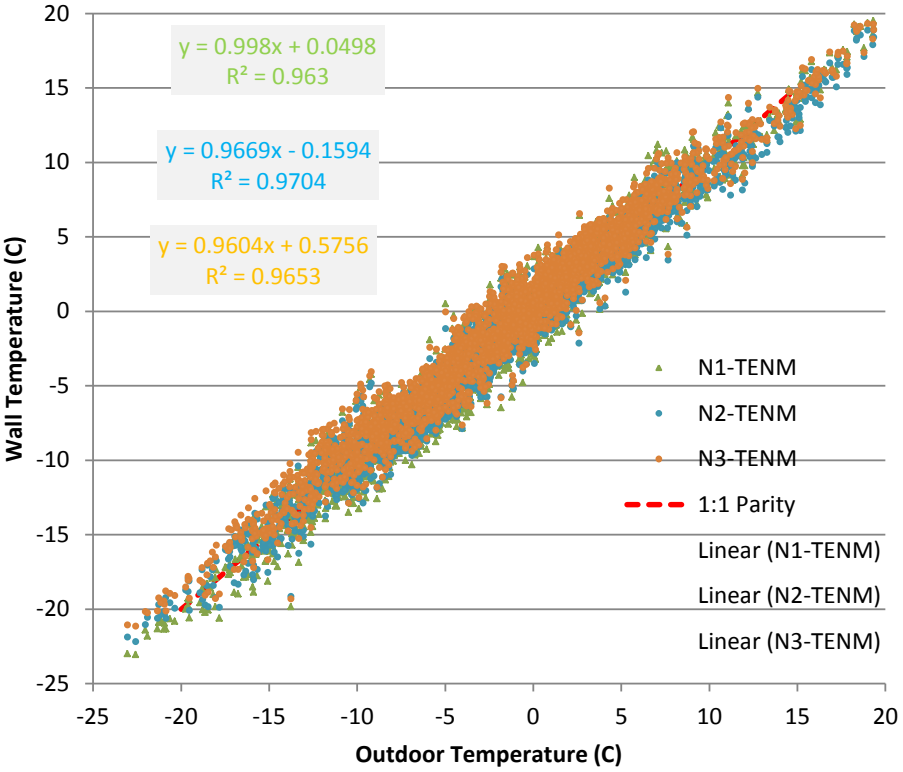
Colder Sheathing with More Insulation?

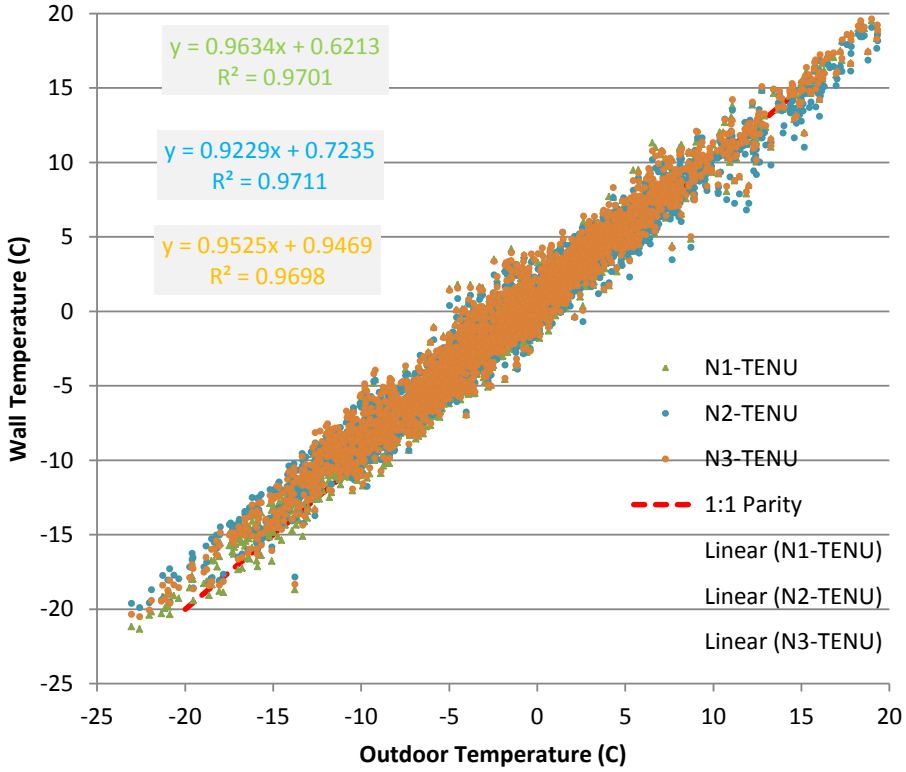




- Outdoor temperature 50 F (10:30 AM)

Colder Sheathing with More Insulation?



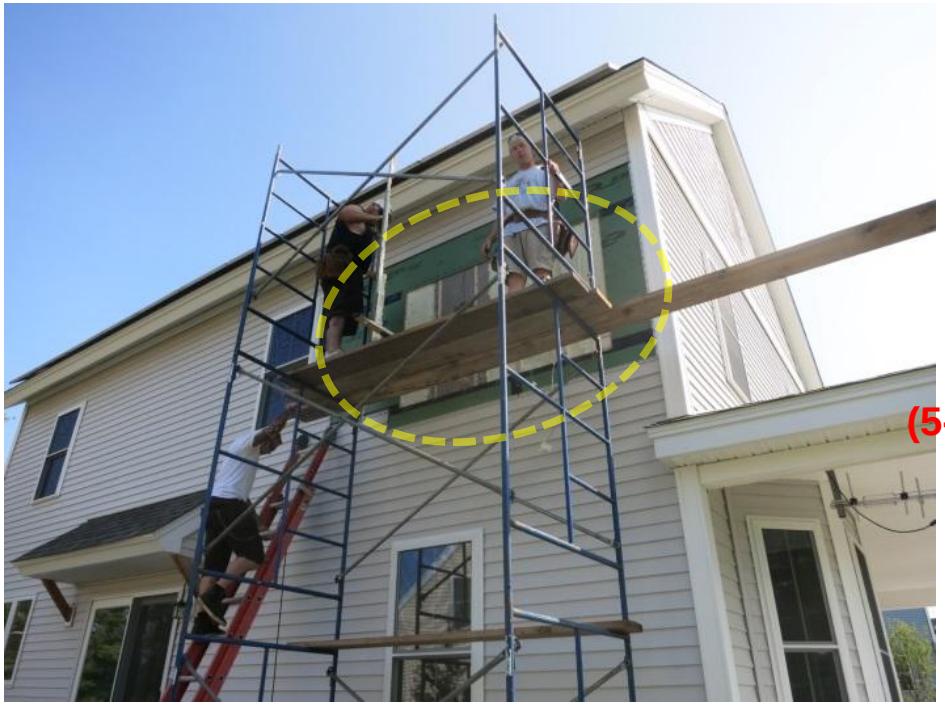


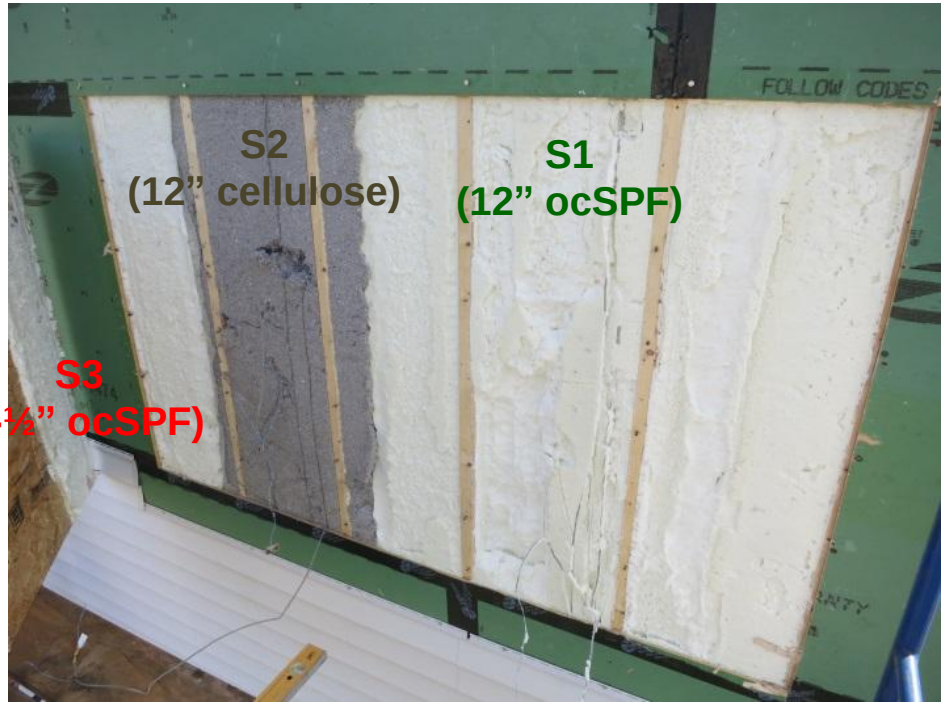
Colder Sheathing with More Insulation?

- Double stud wall sheathing maybe ~1 F or less colder at coldest conditions
- Steady state analysis predicts 0.8 F difference @ 7 F outdoors
- Wintertime energy/Btu's through sheathing possibly more important (drying energy): doubling insulation = halving heat flow
- 12" vs. 5.5" cavity insulation different than cavity vs. exterior insulation!

Wall Disassembly

South Side Disassembly





South Side Disassembly

North Side Disassembly

North Side Disassembly

North Side Disassembly

Analysis

Vapor Permeability of Insulation Layer

Wall ID	Insulation Material	Vapor Permeability (Insulation Only)	Vapor Permeability (Add 10 Perm Class III Vapor Retarder)
N1/S1	12 in. 0.5 PCF foam	1.8–2.5 perms	1.5–2.0 perms
N2/S2	12 in. cellulose	7.0–10 perms	4.0–5.0 perms
N3/S3	5-½ in. 0.5 PCF foam	4.0–5.5 perms	2.9–3.5 perms

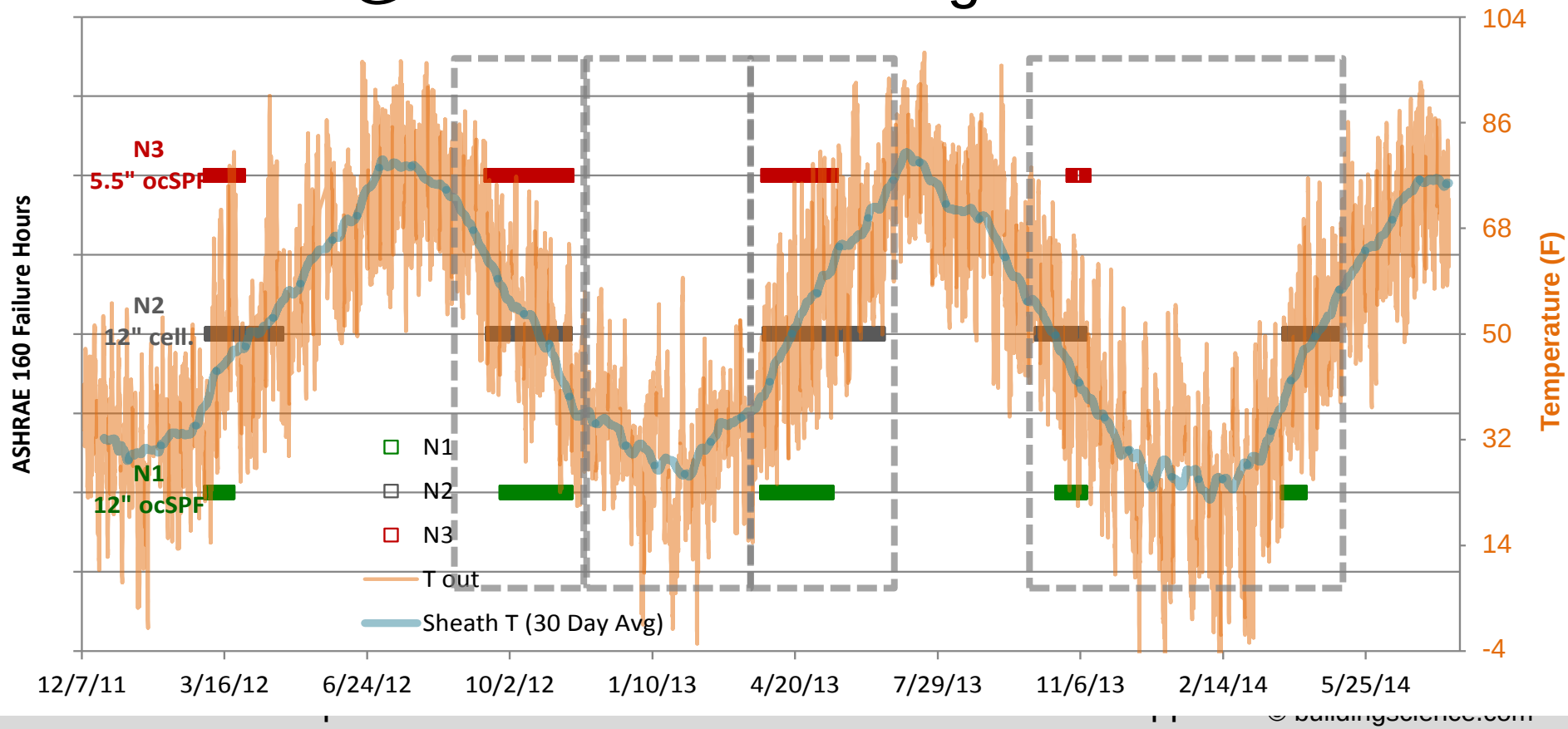
- Insulation-only, vs. adding 10 perm Class III vapor retarder (latex paint)
- 12” of ocSPF (brand used here) provides reasonable interior vapor control

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

ASHRAE 160—Wet and Warm Enough?

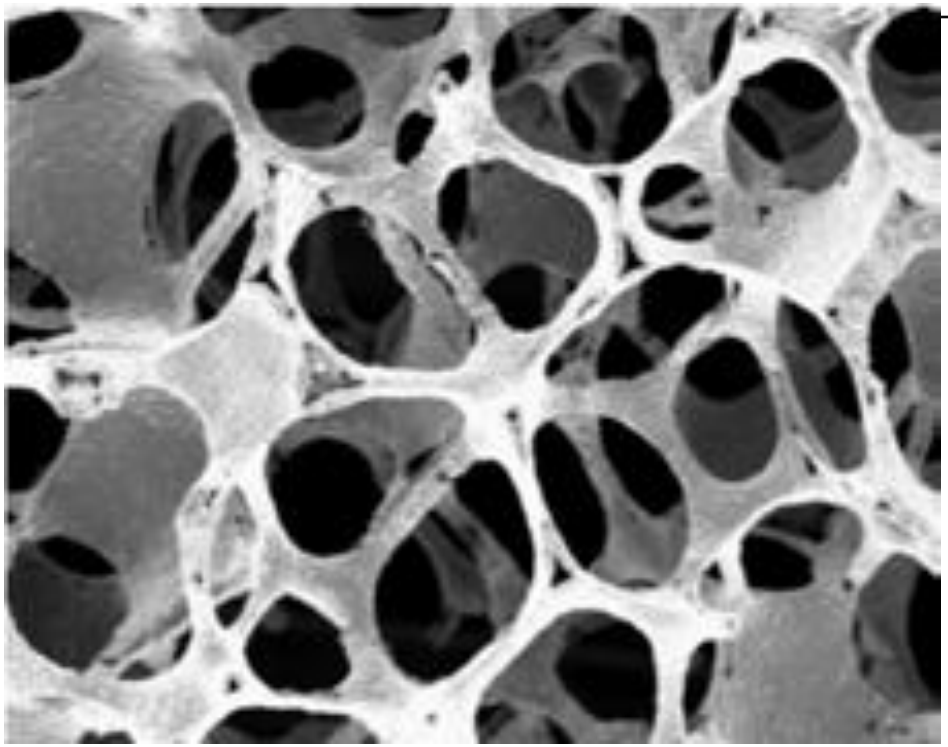
- 30 day running average
  - Relative humidity > 80% AND
  - Temperature between 41 F and 104 F
- T & RH @ insulation-sheathing interface



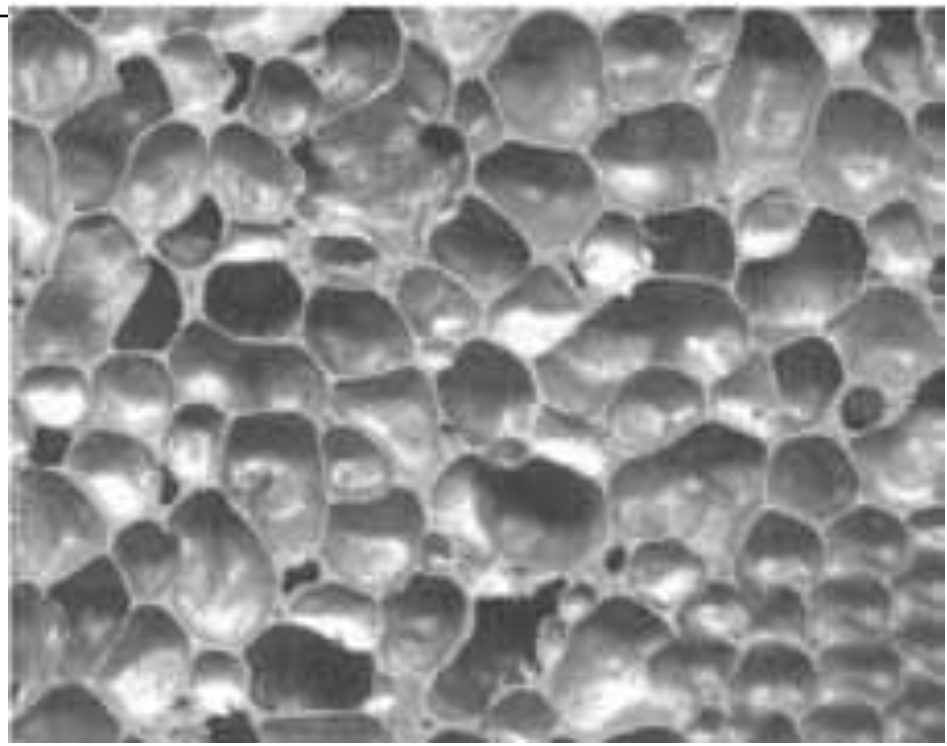
Protective Mechanisms

- OSB Sheathing—all MDI adhesive
- Cellulose fiber insulation
  - Borate preservative/fire retardant—also leaches into adjacent materials
  - Moisture storage in cellulose
  - Airflow retarding qualities
- Open cell polyurethane spray foam
  - Oxygen restriction?

ocSPF Protective Mechanisms



Open-cell SPF



Closed-cell SPF

Images c/o SPFA

- Food science literature—oxygen needs to be in PPM range before inhibiting mold growth. Mold can get oxygen from substrate.

Protective Mechanisms

- OSB Sheathing—all MDI adhesive (no PF)
- Cellulose fiber insulation
  - Borate preservative/fire retardant—also leaches into adjacent materials
  - Moisture storage in cellulose
  - Airflow retarding qualities
- Open cell polyurethane spray foam
  - Oxygen restriction?
  - “Flash heating”? Hot enough long enough?
  - Surface treatment (film formation)?
  - Capillary redistribution (through ocSPF pores)?

Conclusions

Monitoring Conclusions

- "Normal" interior RH conditions:
  - ocSPF walls stayed below 20% MC—SAFE
  - Cellulose > 20% MC on north—WORRYING, BUT…
- High interior RH conditions
  - ocSPF walls peaked in 18-25% MC range
  - Cellulose >30% MC, condensation indicated
- Each summer, walls dried to safe conditions
- ASHRAE 160 and mold isopleths say these walls have failed
- Disassembly showed all walls look okay
  - Sheathing reinstalled

Construction Recommendations

- Based on Zone 5A Climate
- Cellulose walls
  - Class III (latex paint) risky
  - Class II (VR paint, variable-permeability membrane safer)
  - Class I (polyethylene) NOT recommended
- ocSPF walls
  - ocSPF seems to provide sufficient vapor control
  - Class II possible option on conservative side
- Mechanical ventilation system vital
- Exterior insulated walls much more moisture-safe!

This concludes The American Institute of Architects
Continuing Education Systems Course

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Questions?

Kohta Ueno (kohta [at sign] buildingscience [dot] com)

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http://www.buildingscienceconsulting.com/presentations/recent.aspx?PresentationsYear=2015

The full Building America report on this research:
http://www.buildingscience.com/documents/bareports/ba-1501-monitor-double-stud-moisture-conditions-northeast/view

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