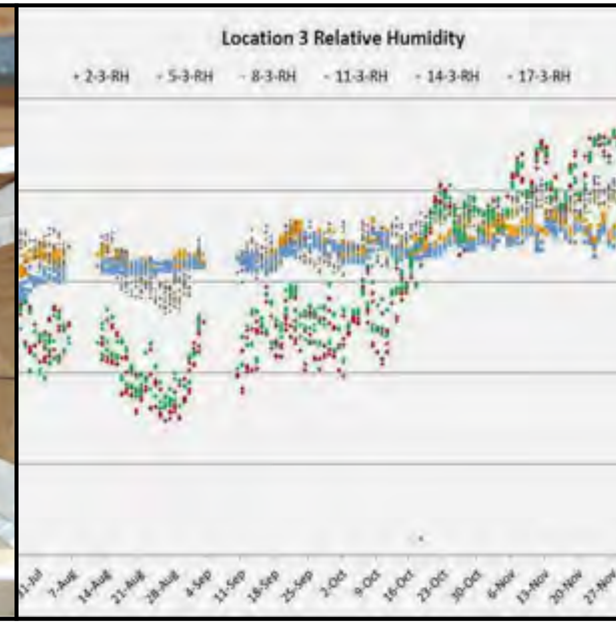
Cantilevered Floor Research:



Comfort and Moisture Findings at 6 Months

- In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

  "This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1 hour** of credit toward **Building Official and Residential Contractors** continuing education requirements."

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A cantilevered floor extends beyond a supporting wall and supports an exterior wall at its projected edge.

This building feature has also been identified as:

- a floor over unconditioned space
- an extended rim joist
- an overhang
- a garrison style floor overhang
- an overhanging floor
- a jettied floor

Single family home designs use overhanging floors to:

- Add floor space to rooms
- Add visual interest to walls
- Add visual interest to roof geometry

Multi-family housing also incorporates cantilevered floors as architectural design features that:

- Break up large expanses of wall
- Increase square footage
- Increase curb appeal

Related building features identified as floors over unconditioned space include:

Attached sunrooms on piers

Rooms over garages (bonus rooms)

Shanxi province, China

Gisling, 2007

Fugong Temple Wooden Pagoda
Oldest wooden tower in China
Constructed 1056 AD

Lincolnshire, England

Dunn, 2004

Medieval building with a double-jettied timber floor

Green Lake, Wisconsin

Reproduction of a Scandinavian style timber building

Timber construction is strong and durable, but…

. . . solid wood provides limited resistance to heat loss, resulting in cold floors.

Engineered and composite building materials. . .

. . . create cavities for insulation but are more susceptible to damage from trapped moisture

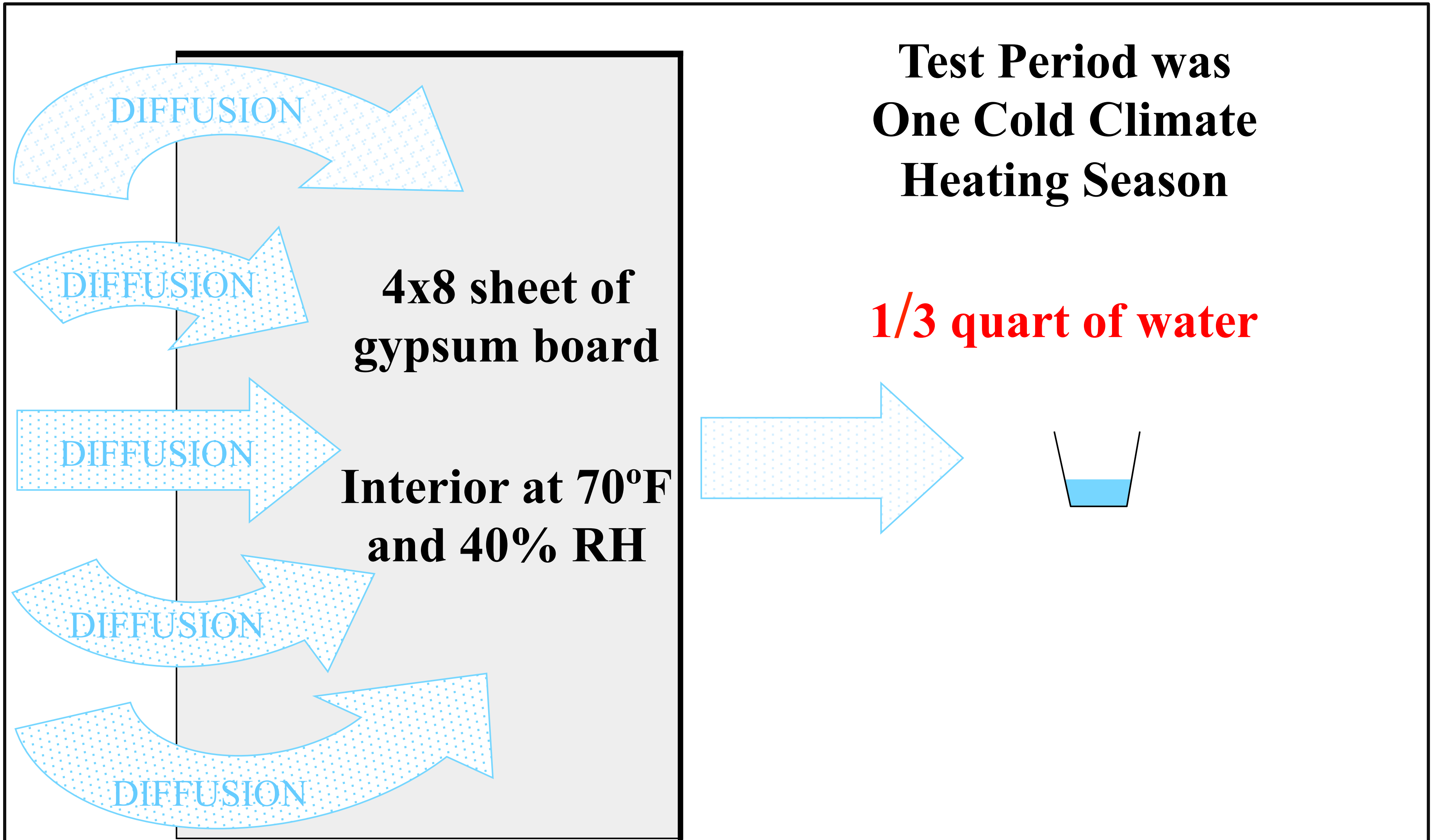
Adding thermal insulation in building cavities. . .

. . . can create dewpoint temperature issues at interior surfaces of exterior sheathing

Structural damage can result if wood products:

- get wet too easily
- and stay wet too long

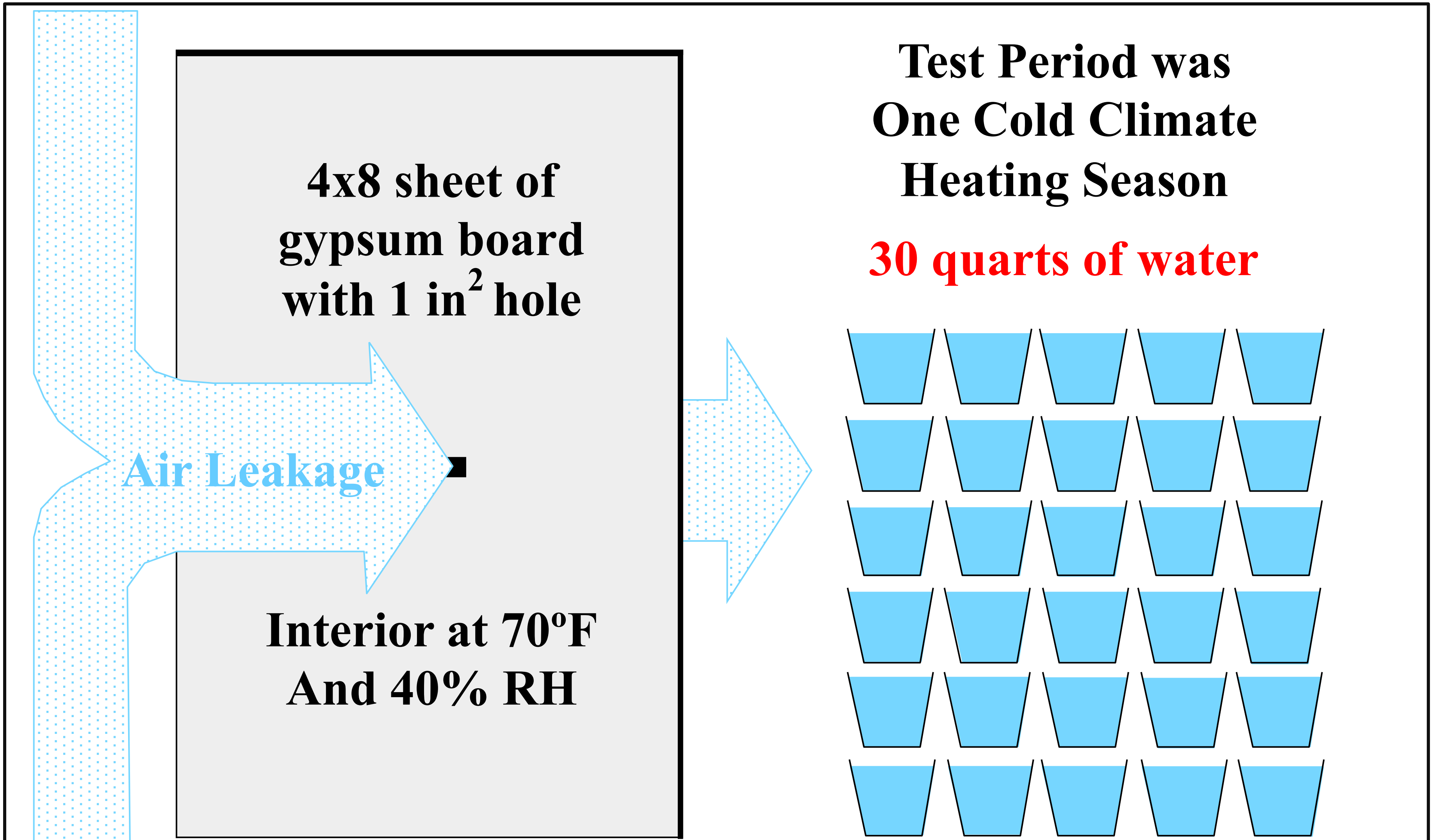
. . . when used to construct enclosed building cavities



Adapted from: Lstiburek, J. 2004. *Builder's Guide to Cold Climates.* Building Science Corporation

Wetting building cavities through Diffusion

Water Vapor Molecules move through a Solid Material



Adapted from: Lstiburek, J. 2004. *Builder's Guide to Cold Climates*. Building Science Corporation

Building cavities wetted by Air Transported Moisture

Unsealed holes increase the potential for moisture damage to homes

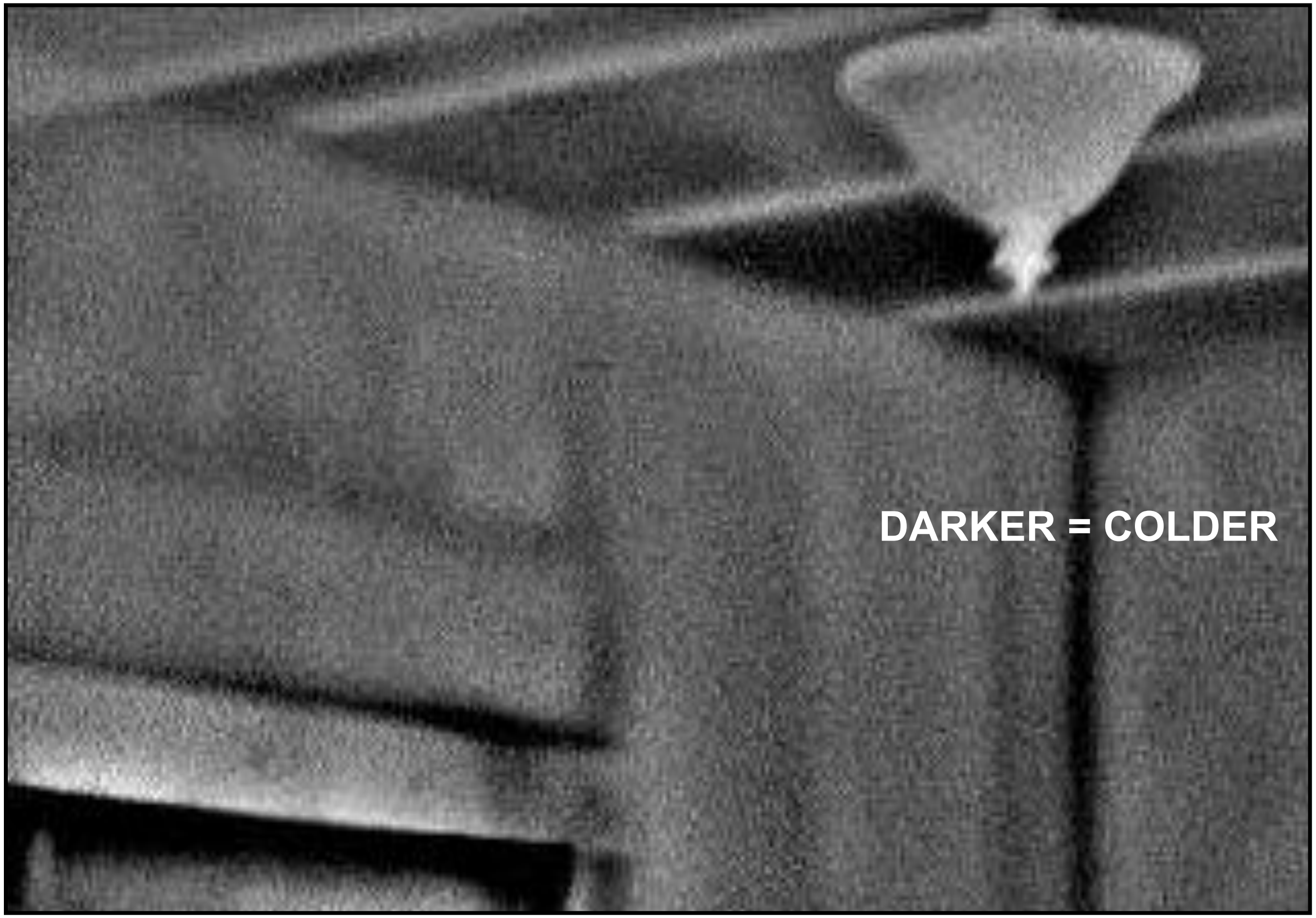
New homes look good on the outside. . .

. . . but all the details under the surface need to be done right

Design and execution of critical construction details can be tested using:

- Blower door depressurization to expose thermal bypasses and air-leakage pathways through the framing
- Thermal imaging using Infra-red to identify changes in surface temperature resulting from bypasses and air-leakage

Thermal imaging exposes cold surfaces. . .



. . . caused by thermal bypasses and air leakage through building cavities

A variety of practices have been used to. . .

. . . frame and finish residential cantilevered floor assemblies





- Different insulation products are used
- Different levels of insulation are used
- Some are not insulated or poorly insulated
- Some are blocked and air-sealed
- Some are not blocked or not air-sealed





What is working? What is not? How can we know which practice is the best?

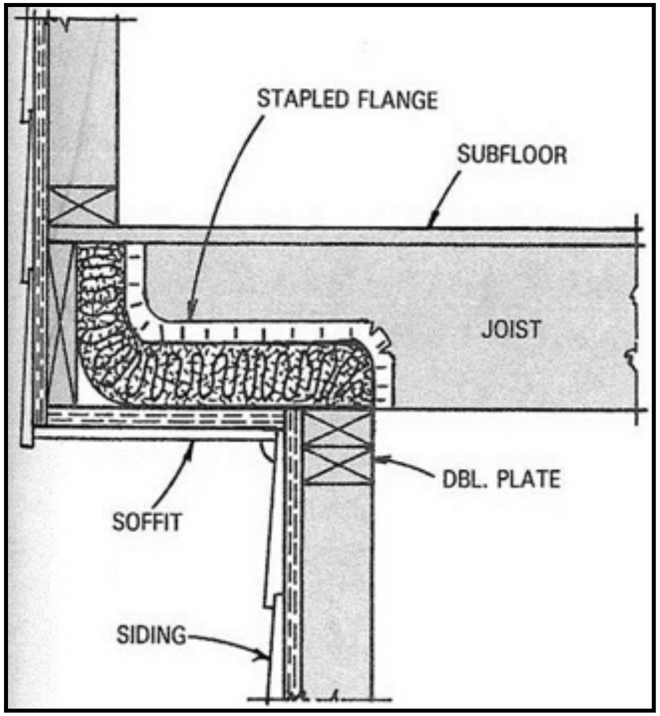
We can compare them through testing!

Three representative methods of insulating cantilevered floors were selected:

- R-19 fiberglass batt with the cavity open to the inside
- R-30 fiberglass batt (completely filled), blocked, and air-sealed
- R-30 closed cell spray-applied plastic foam insulation

R-19 fiberglass batt

Cavity open to the inside

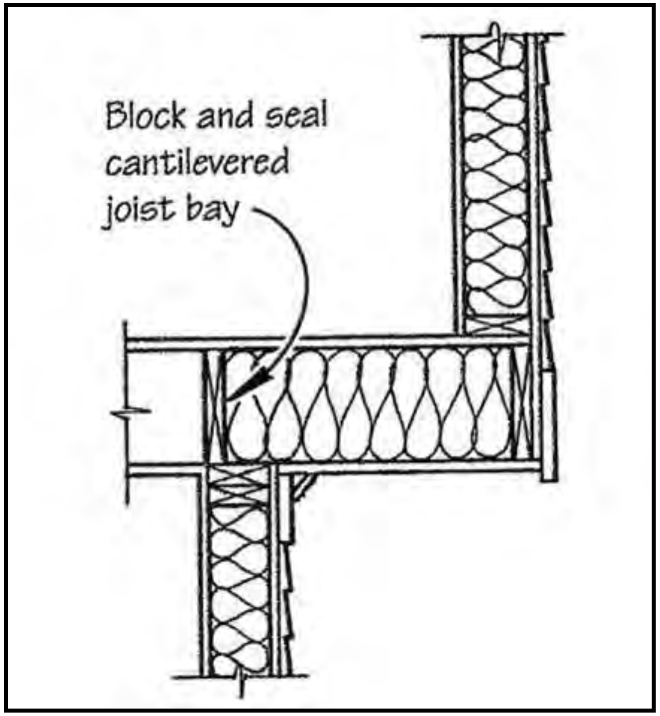


Wagner, 1992

- Many older homes with insulated cantilevered floors used this method
- Wide variation in product and quality control is seen

R-30 fiberglass batt

Completely filled, blocked, and air-sealed

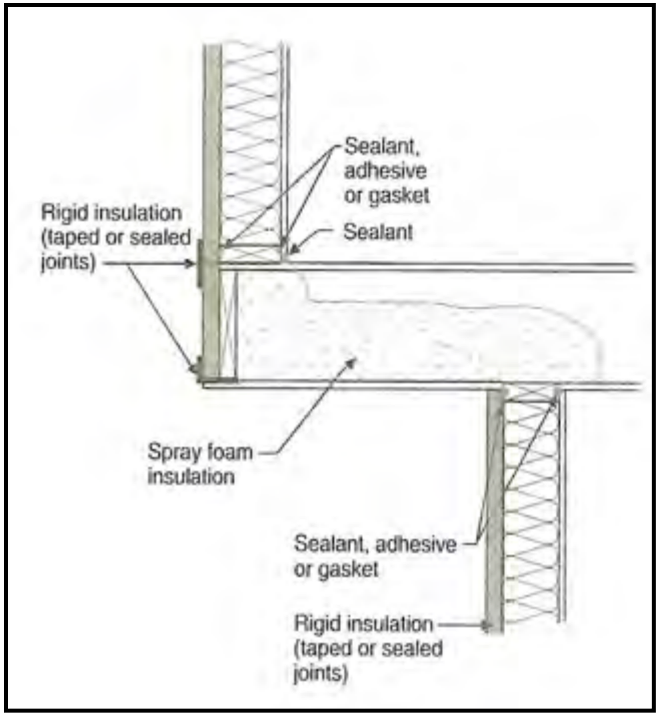


Legg, 1997

- Became common following the 80's energy crisis and code updates
- Wide variety of blocking and sealing strategies is seen

R-30 closed cell foam

Spray-applied plastic insulation



Lstiburek, 2004

- Most recently introduced method in residential buildings
- Closed cell foam acts as vapor retarder and air-barrier

Roseville, Minnesota home used as research site

1971 2x4 framed walls with trussed roof framing – no foundation insulation

24 inch Cantilever on North Elevation

Extended floor has 2x10 fir joists at16 inches on center

Cantilevered floor in “as found” condition

Variety of fiberglass batts “stuffed” into cavities in varying configurations

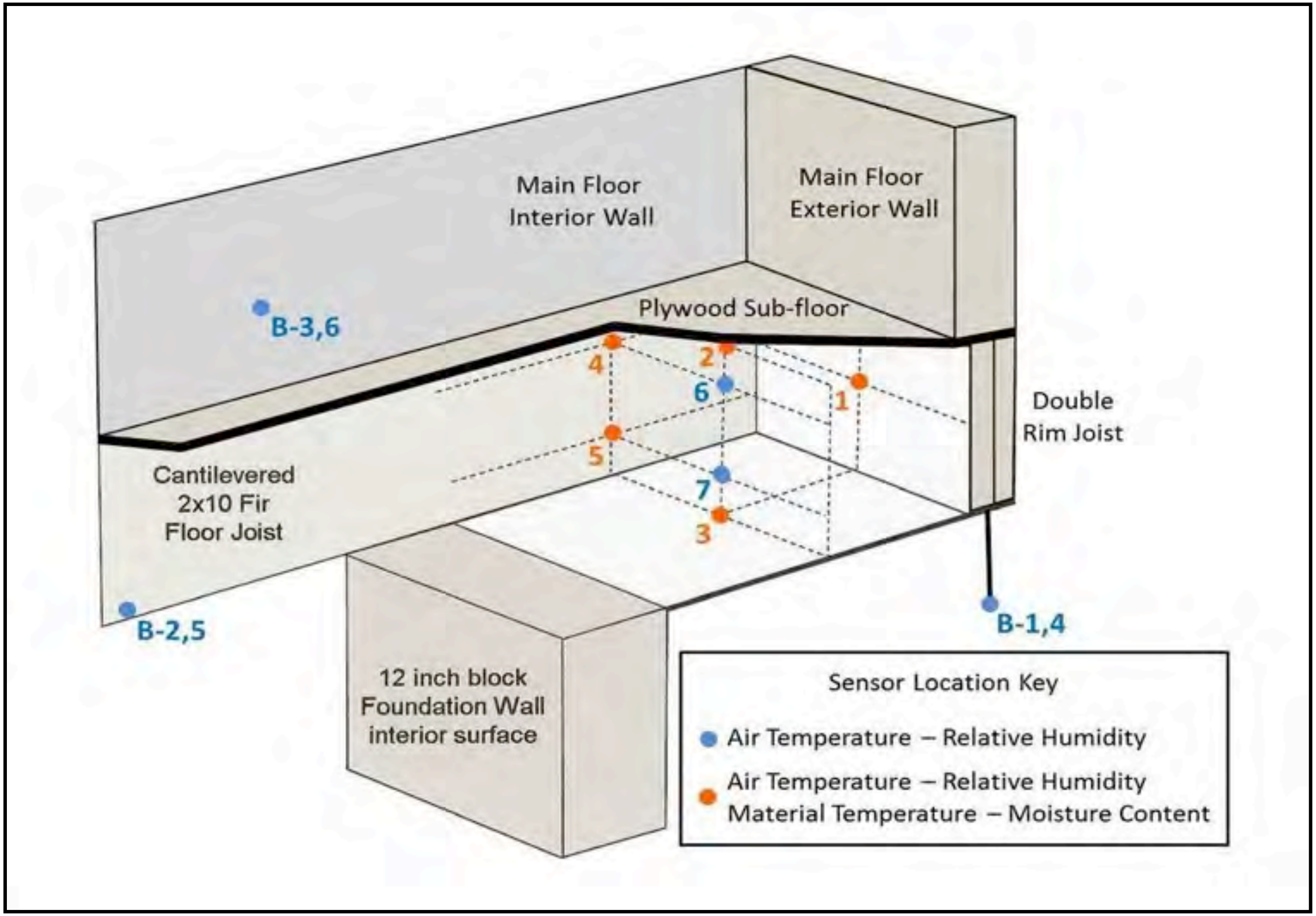
Interior conditions maintained at 68-75 degrees F. and at approximately 35% R.H.

Natural gas forced air heating, central air conditioning, and dehumidification

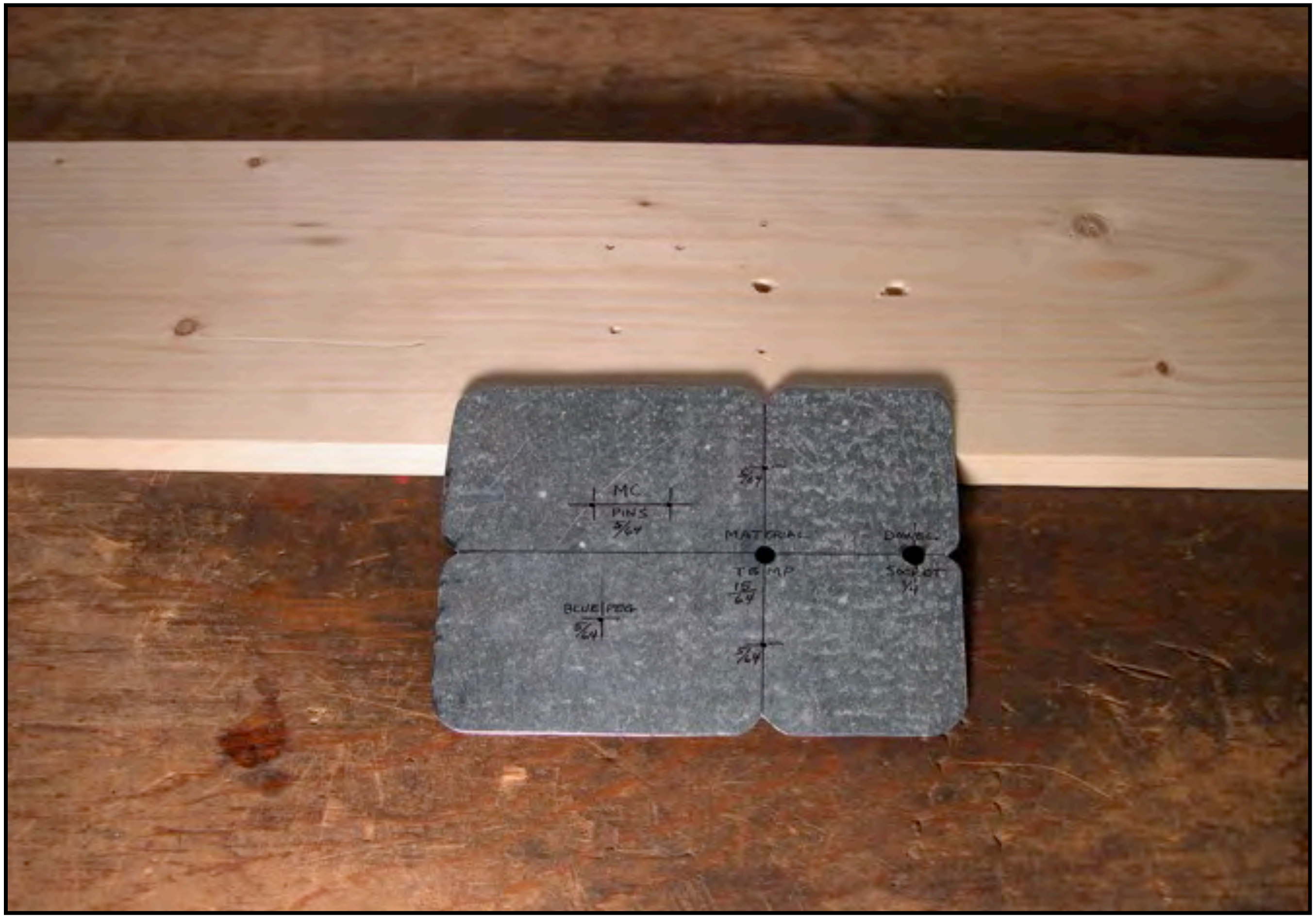
Proposed layout for the west half with a guard cavity on each side of test cavities

Test cavity layout for the east half would be reversed in a “bookend” fashion

Temperature and moisture sensor locations

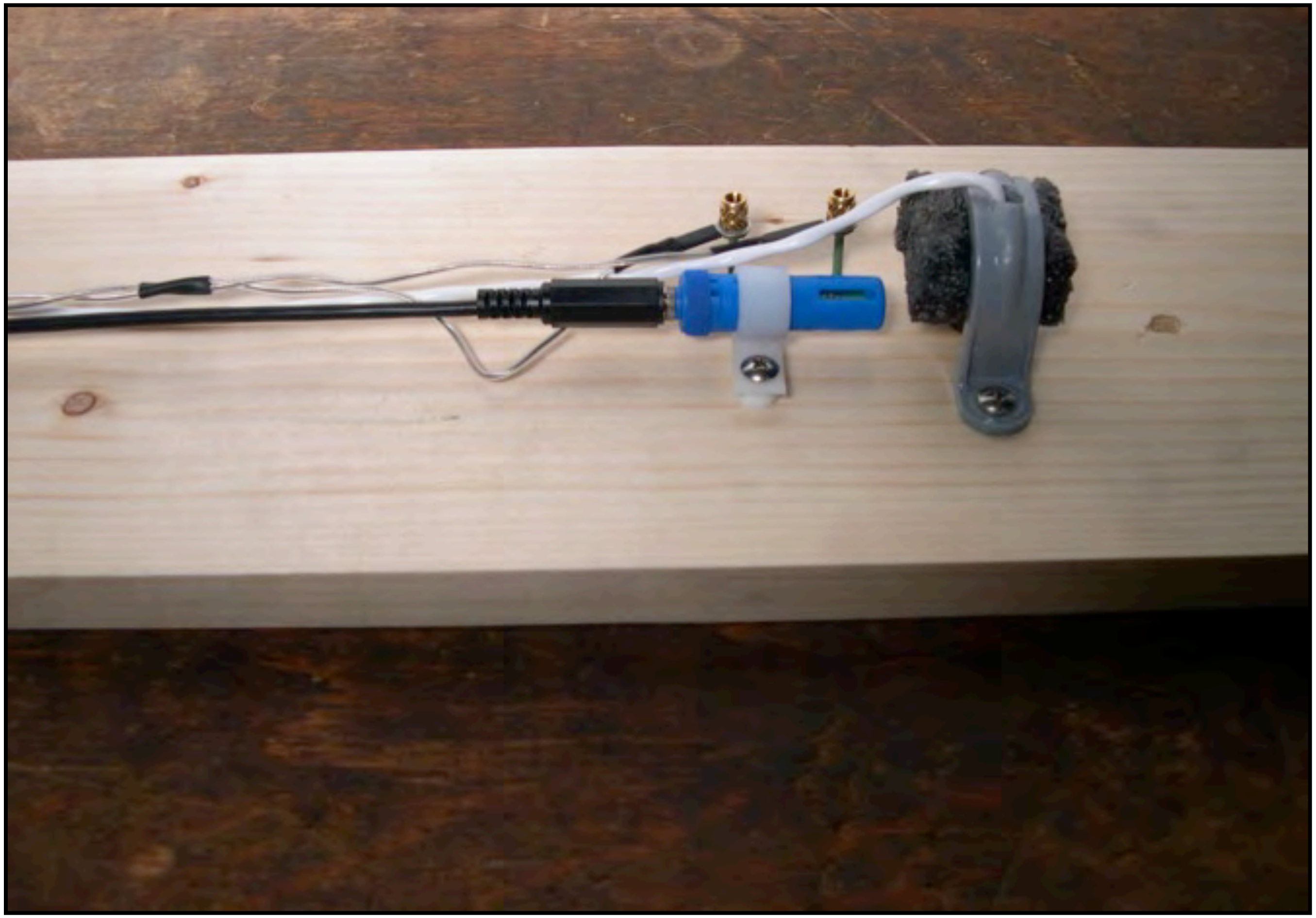


Sensor placement uniformity was maintained. . .



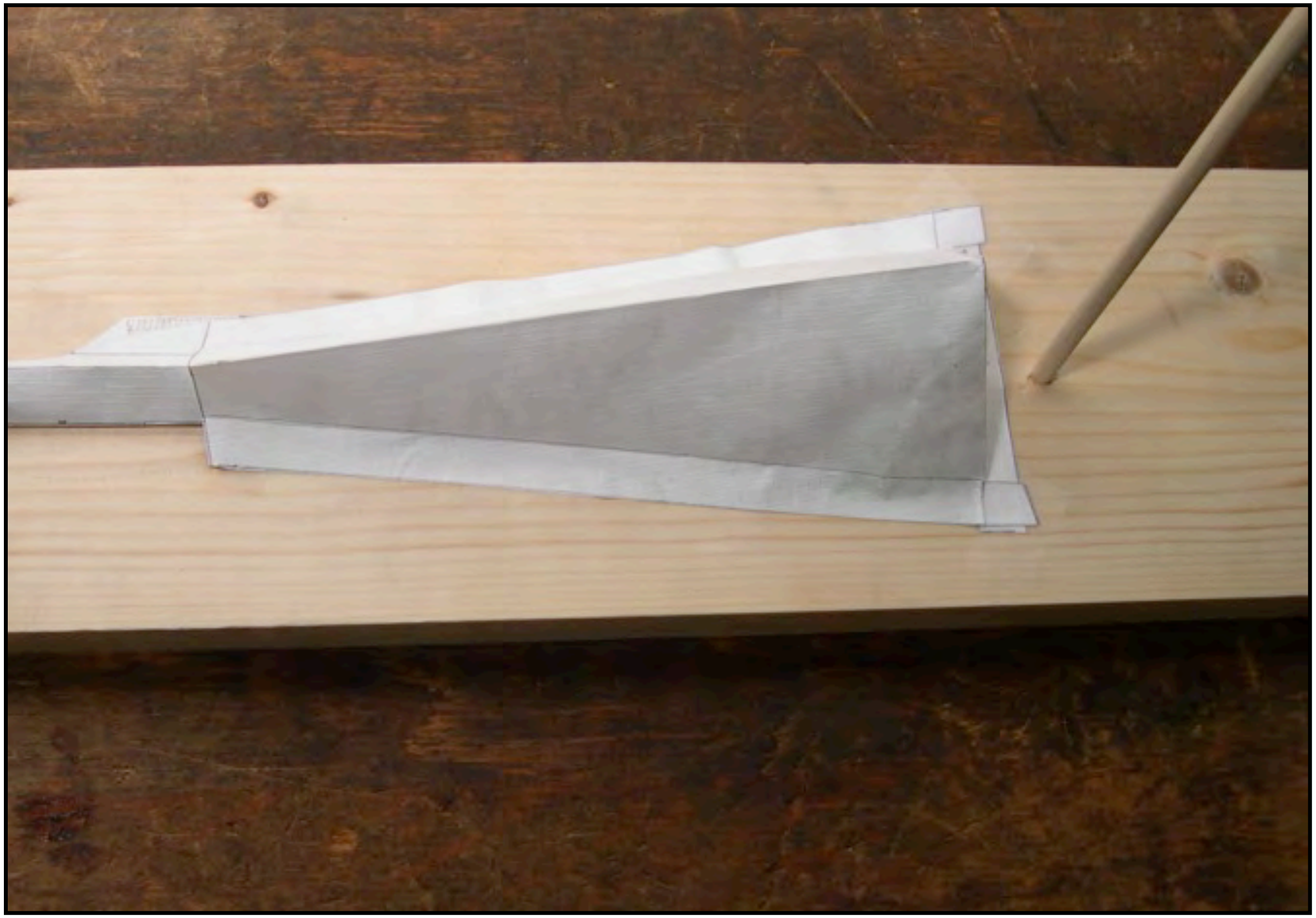
. . . by use of templates and a standard grid layout in all test cavities

A mock-up sensor group was assembled. . .



. . . to assure that mounting brackets and cables had necessary clearances

Housewrap enclosures were designed. . .



. . . to protect cables and sensors without restricting heat or moisture movement

Existing insulation was removed from the cantilever. . .

. . . and all dirt and debris was removed from all of the cavities

More dirt (evidence of infiltration) was found. . .

. . . on the fiberglass batts where air leakage paths were present

Temporary protection from the weather. . .

. . . was created by first installing foam weather-stripping

1 inch poly-isocyanurate insulation board blocking. . .

. . . was held against the weather-stripping in each cavity with spring wires

Old water stains were present in all cavities. . .

. . . but all components of the cantilevered floor were still sound

The fir plywood soffit panels were removed. . .

. . . and also showed evidence of water staining and infiltration

Fiber-board had been installed above the plywood . . .

. . . and when removed, showed evidence of water staining but not decay

The cantilever assembly was opened completely. . .

. . . for inspection, retrofit, and installation of research components

It was found that insulation had never been installed. . .

. . . in the corner cavities that extended beyond the foundation walls

The cantilevered floor and workspace was enclosed. . .

. . . so the research retrofit build-out could continue into the winter

Cantilever joists varied as much as 3/8 inch. . .

. . . so shims were created to even out cantilever dimensions at the bottom

Enclosures for exterior boundary condition sensors. . .

. . . were fabricated for installation below the outer edge of the cantilever

Installation of sensor enclosures was completed. . .

. . . and cables were routed and secured inside a guard cavity

The cable pathway was sealed. . .

. . . at the inside of the cavity and the outside of the PVC conduit

Shims and blocking were installed. . .

. . . to provide fastener support for the individual plywood soffit panels

Air-sealing of the cantilevered floor cavities. . .

. . . was completed with silicone sealant at seams and closed cell foam gaskets

20 Plywood soffit panels were cut to fit. . .

. . . and temporarily installed using spacers and fastened with screws

The unfinished soffit panels were removed. . .

. . . for the installation of six sensor panels and for painting

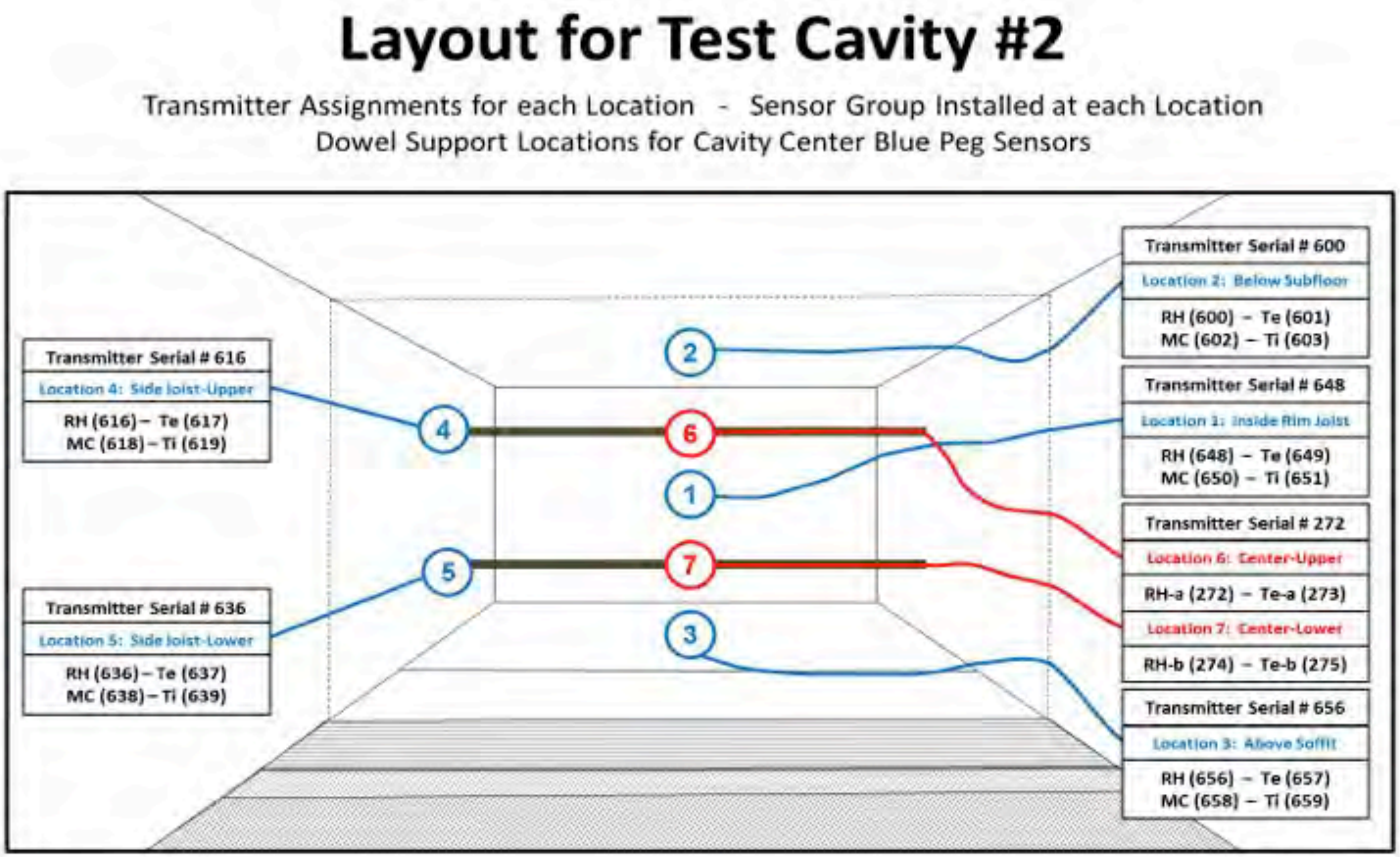
Clear vertical grain Douglas Fir sensor panels. . .

. . . were fabricated and inserted into the six test cavity plywood soffit panels

Sensor performance will be enhanced. . .

. . . by wood species uniformity and panel thickness and R-value

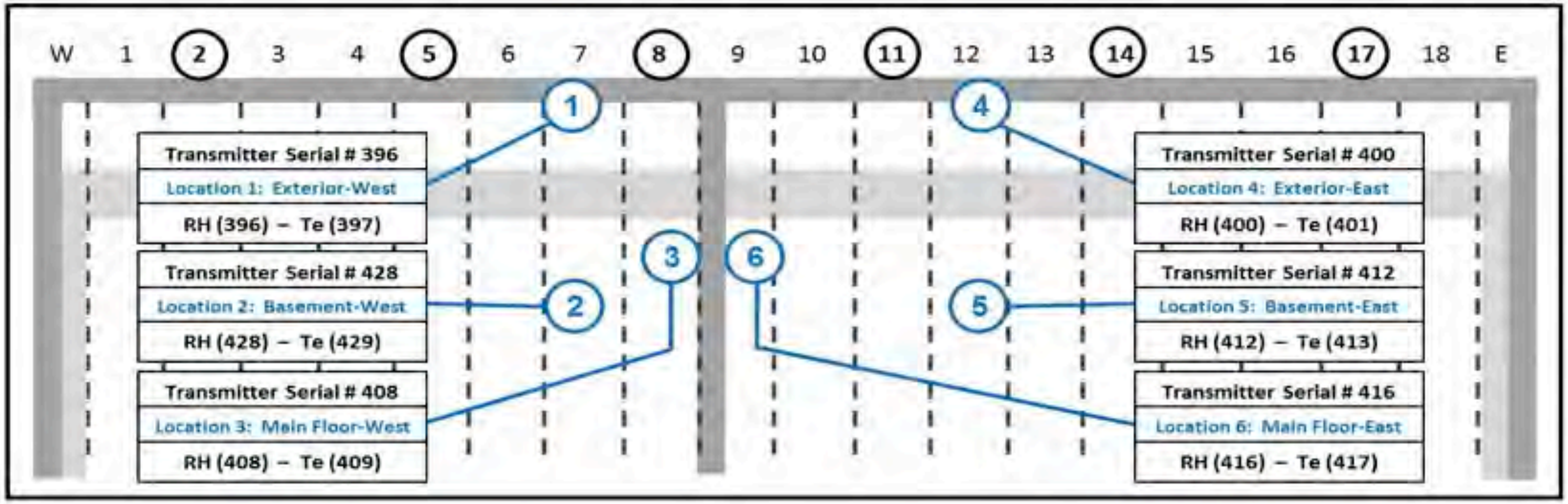
Sensor Group Layout and ID Example



- *Sensor Group 1 is centered vertically and horizontally and sensor Groups 2 and 3 are centered in both directions horizontally*
- *Sensor Groups 4 and 5, and Sensors at 6 and 7 are centered horizontally and at quarter points vertically*

Layout for Boundary Conditions Sensors

Transmitter Assignment for each Blue Peg Sensor - Cavity Identification
Location of Main Floor Walls, Floor Joists, and Basement Walls



- *Blue Peg Sensors 1 and 4 are mounted outside and 12 inches below the outer (north) edge of the cantilever soffit*
- *Blue Peg Sensors 2 and 5 are mounted in the basement, 2 feet in from the cantilever cavities, and at the bottom edge of the vertical sides of the floor joists*
- *Blue Peg Sensors 3 and 6 are mounted 6 inches above the main floor and 1 inch off the east and west sides of the interior wall between the two bedrooms above the interior (south) side of the top of the cantilever cavities.*

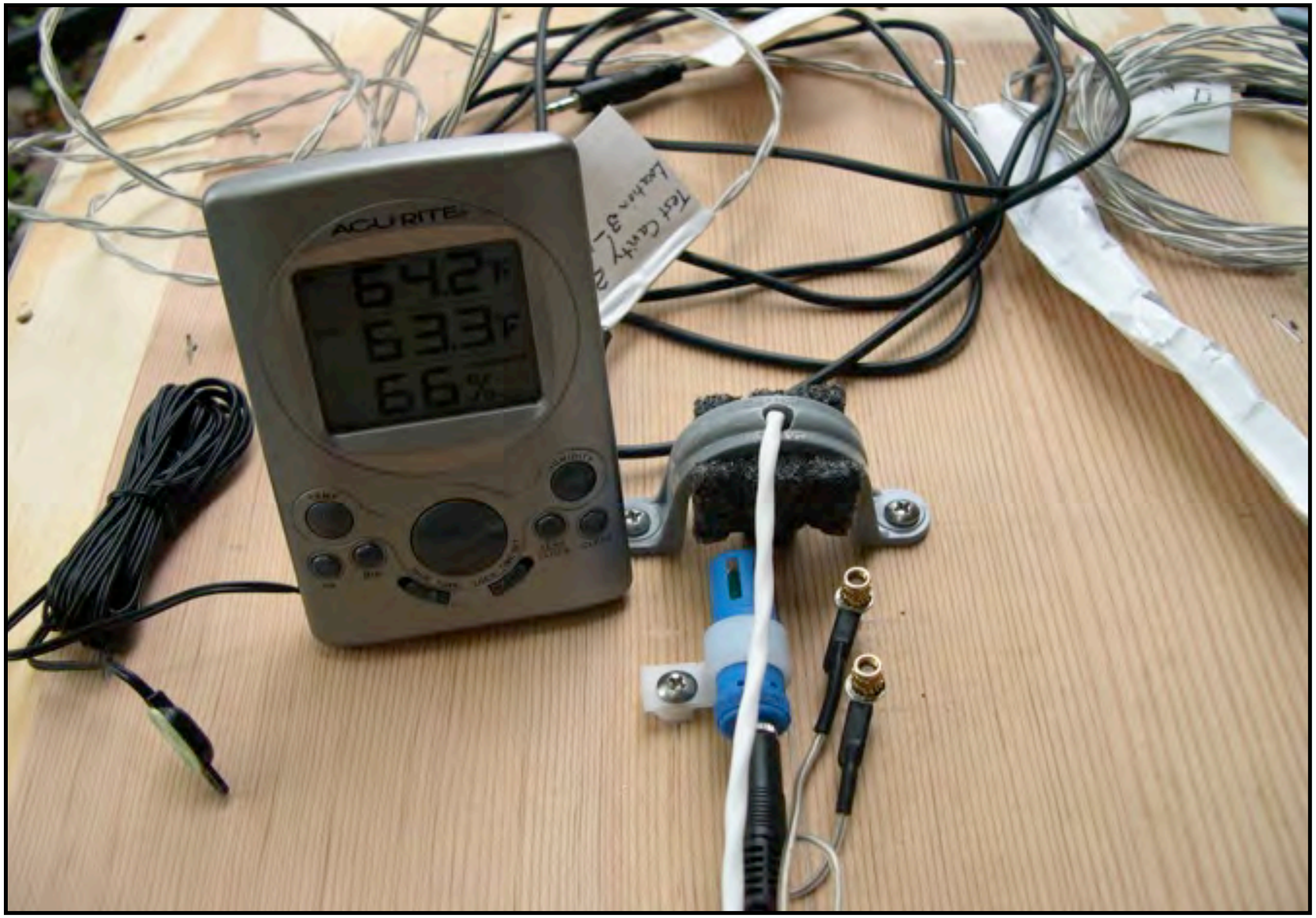
Sensor groups installed in cavity locations. . .

. . . before testing and installation of sensor enclosures

Sensor group installed on soffit panel. . .

. . . before testing and installation of sensor enclosures

Air temperature and relative humidity (RH). . .

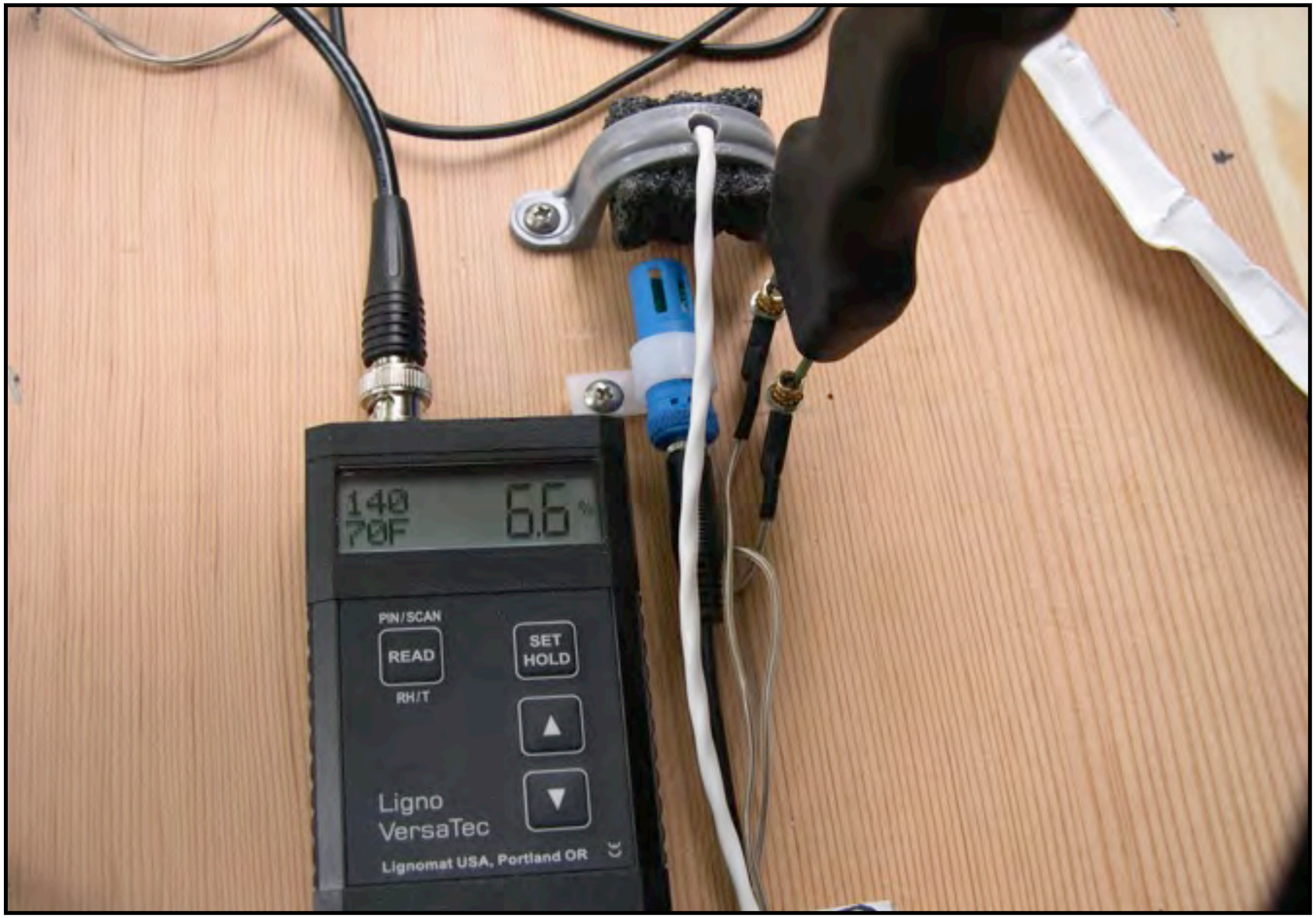


. . . values from a digital hygrometer were recorded for comparison

RH and air temperature from the sensors. . .

. . . were recorded and compared to the recorded hygrometer values

Wood moisture content (MC). . .

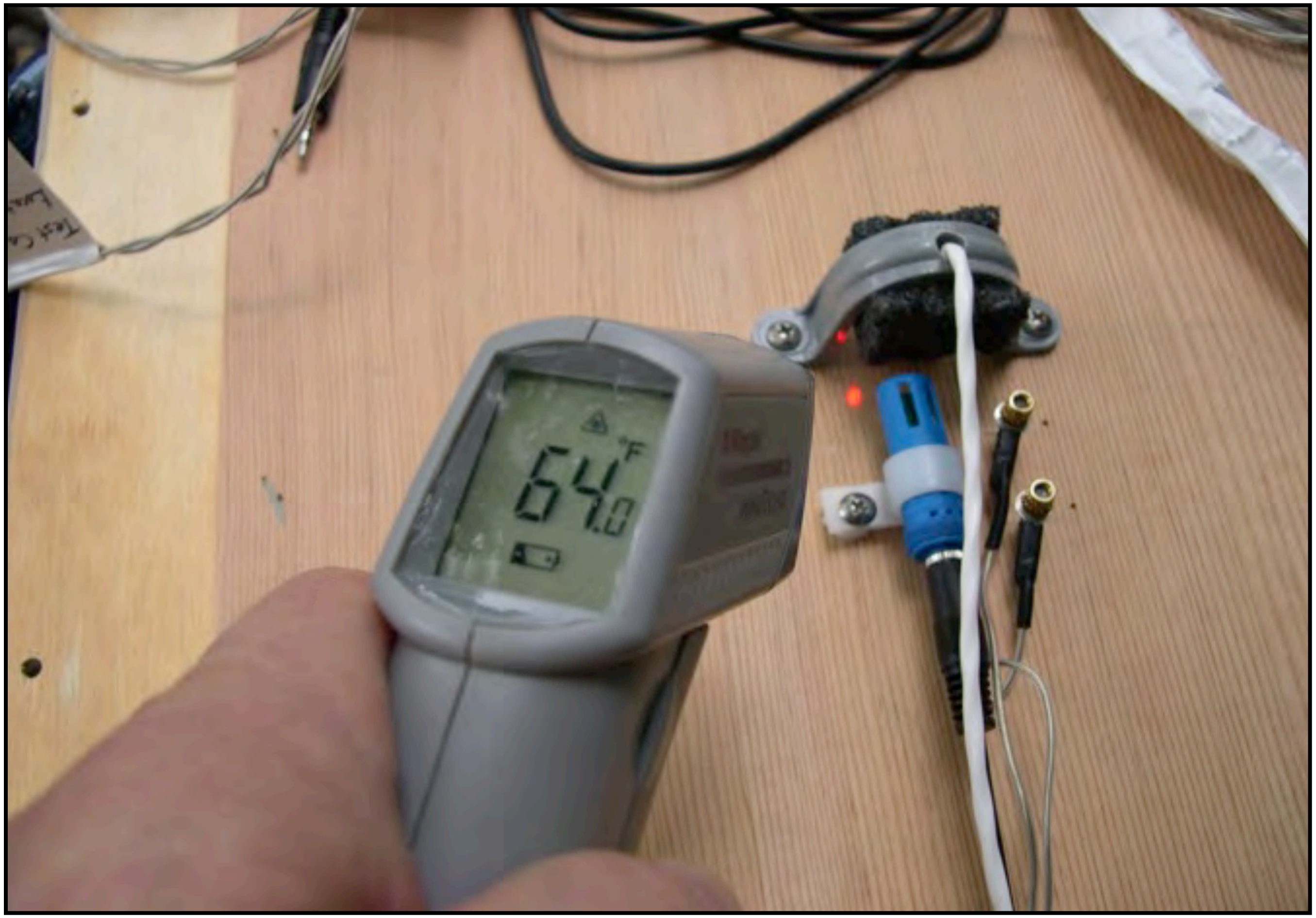


. . . values were recorded at the pins in the sensor group

MC measurements were taken at cable ends. . .

. . . to assure proper cable performance in areas that would be enclosed

Temperature of the wood was measured. . .



. . . to compare with the value transmitted by the sensor in the wood

A record of values measured during installation. . .

Test Cavity 5 - Sensor Installation Checklist	Degrees F / Percent RH or MC	DATE	TIME	AM/PM
Location 1				
Using Ligno VersaTec - Blue Peg Temp (in degrees F)	70	4/30	10:30	am
Using ACURITE Desktop Unit - Blue Peg Temp (in degrees F)	72.1			
Online via Transmitter - Blue Peg Temp (in degrees F)	70.3°F	4/30	12:44	pm
Using Ligno VersaTec - Blue Peg RH (percent)	53.8			
Using ACURITE Desktop Unit - Blue Peg RH (percent)	52			
Online via Transmitter - Blue Peg RH (percent)	45.5% RH	4/30	12:44	pm
Using Ligno VersaTec - MC with E14C on Test Block (percent)	12/10.4 20/19.2			
Using Ligno VersaTec - MC with E14C in wood (percent)	7.7			
Using Ligno VersaTec - MC with E14C at pins (percent)	9.0			
Using Ligno VersaTec - MC with E14C at cables (percent)	9.0			
Using Ligno VersaTec - MC with E14C on Test Block (percent)	10.4/12 20/19.2			
Online via Transmitter - MC (percent)	6.4% MC	4/30	12:44	pm
Online via Transmitter - Material Temp (degrees F)	70.2°F	4/30	12:44	pm
Using RayTec MT4 - Material Temp (degrees F)	72			
Location 2				
Using Ligno VersaTec - Blue Peg Temp (in degrees F)	72.1			
Using ACURITE Desktop Unit - Blue Peg Temp (in degrees F)	71.8			
Online via Transmitter - Blue Peg Temp (in degrees F)	70.3°F	4/30	12:44	pm
Using Ligno VersaTec - Blue Peg RH (percent)	48.8			
Using ACURITE Desktop Unit - Blue Peg RH (percent)	51			
Online via Transmitter - Blue Peg RH (percent)	46.1% RH	4/30	12:44	pm
Using Ligno VersaTec - MC with E14C on Test Block (percent)	10.5/12 19.3/20			
Using Ligno VersaTec - MC with E14C in wood (percent)	8.8			
Using Ligno VersaTec - MC with E14C at pins (percent)	11.2			
Using Ligno VersaTec - MC with E14C at cables (percent)	11.3			
Using Ligno VersaTec - MC with E14C on Test Block (percent)	10.5 19.2			
Online via Transmitter - MC (percent)	7.9% MC	4/30	12:44	pm
Online via Transmitter - Material Temp (degrees F)	70.2°F	4/30	12:44	pm
Using RayTec MT4 - Material Temp (degrees F)	73.5		10:45	am
Location 3				
Using Ligno VersaTec - Blue Peg Temp (in degrees F)	74.5			
Using ACURITE Desktop Unit - Blue Peg Temp (in degrees F)	72.3			
Online via Transmitter - Blue Peg Temp (in degrees F)	72.7°F	4/30	12:44	pm
Using Ligno VersaTec - Blue Peg RH (percent)	43.4			
Using ACURITE Desktop Unit - Blue Peg RH (percent)	51			
Online via Transmitter - Blue Peg RH (percent)	37.8% RH	4/30	12:44	pm
Using Ligno VersaTec - MC with E14C on Test Block (percent)	10.4 19.2			
Using Ligno VersaTec - MC with E14C in wood (percent)	6.3			
Using Ligno VersaTec - MC with E14C at pins (percent)	6.3			
Using Ligno VersaTec - MC with E14C at cables (percent)	6.3			
Using Ligno VersaTec - MC with E14C on Test Block (percent)	10.4 19.2			
Online via Transmitter - MC (percent)	3.8% MC	4/30	12:44	pm
Online via Transmitter - Material Temp (degrees F)	72.1°F	4/30	12:44	pm
Using RayTec MT4 - Material Temp (degrees F)	74.0		10:52	

. . . at every sensor in every location was compared to values recorded online

Sensor group enclosures were installed. . .

. . . after testing of all sensors during the installation process

Masking was installed to protect the interior side. . .

. . . of the cantilevered floor area during the sprayed foam application

Closed cell polyurethane foam installation. . .

. . . was completed in compliance with the manufacturer's recommendations

After allowing time for the foam to cure. . .

. . . the masking in the cantilever area was removed

Additional masking had been applied. . .

. . . to sensor enclosures not imbedded in the closed cell foam insulation

Sensors open to the interior of the house. . .

. . . and their enclosures were protected during the spray foam application

R-19 fiberglass batts were installed. . .

. . . at the cavity bottom and against the double rim joist

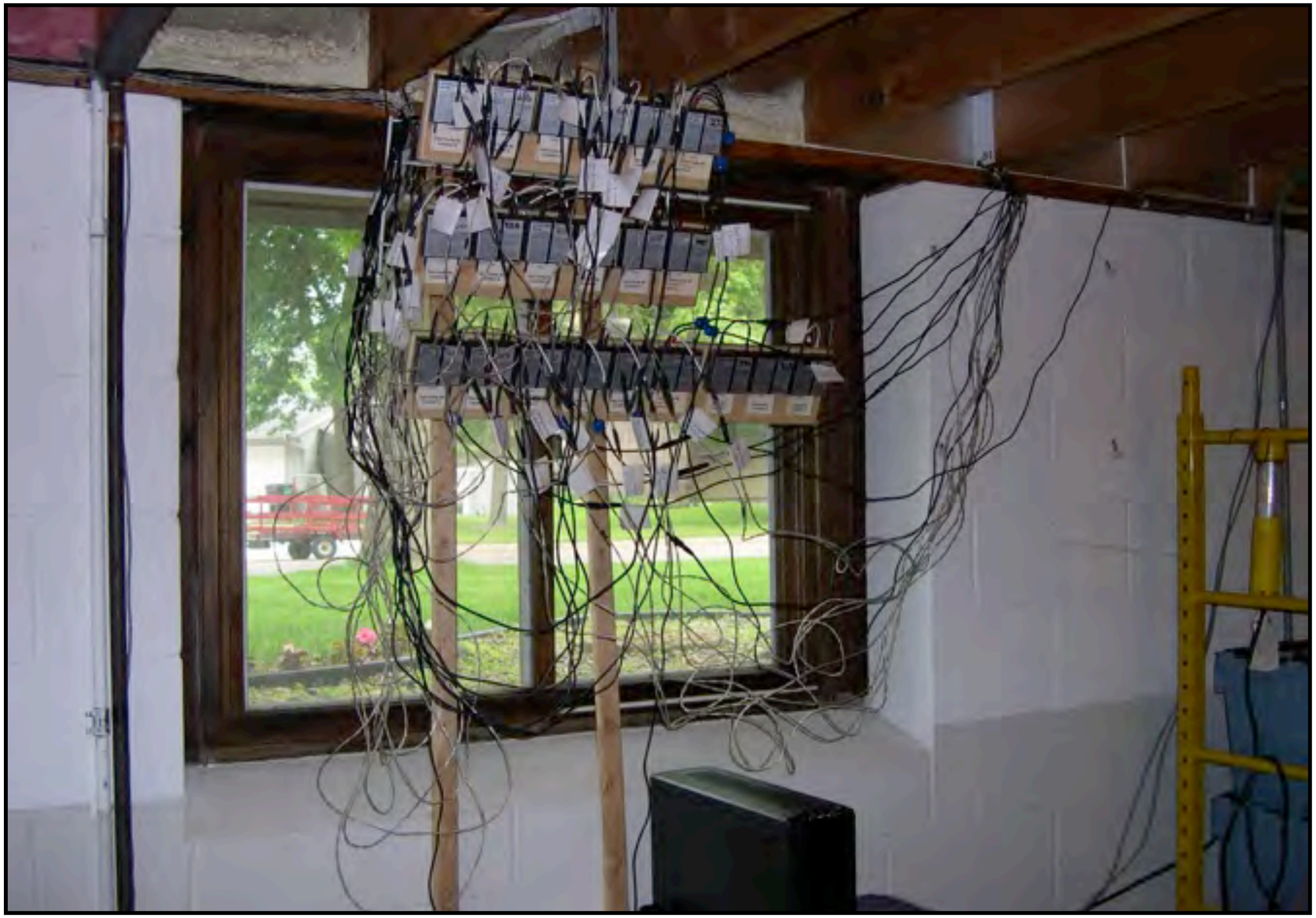
R-30 fiberglass batts were filled completely. . .

. . . trimming around sensor group enclosures

One inch insulation board blocking was installed. . .

. . . enclosing the fiberglass fill and then sealed with silicone sealant

Sensor cables were sorted and bundled. . .



. . . while still connected to the temporary transmitter arrays

Sensor cable sorting was completed. . .

. . . for both halves of the cantilever and routed to the final transmitter locations

Cavities and cables were labeled. . .

. . . to allow easy identification of all components of the research project

Cable bundles were anchored to the sill plate. . .

. . . and all extension cables and connections checked for continuity

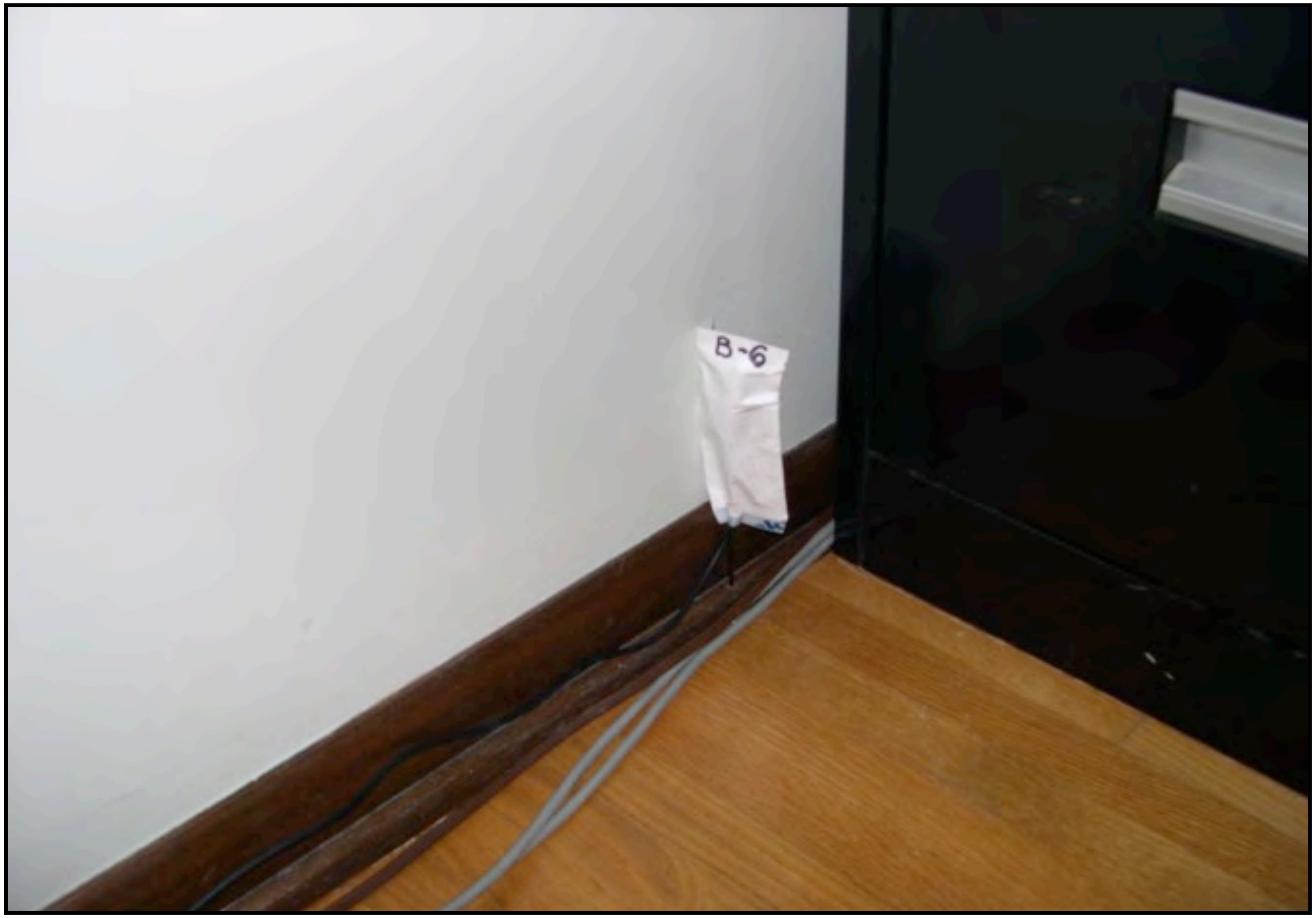
Boundary condition and Internet cables. . .

. . . were also routed to the transmitter arrays and data logger location

Boundary conditions were monitored. . .

. . . by sensors at the bottom of floor joists two feet inside the cantilever

Main floor boundary condition sensors. . .



. . . on either side of the interior wall above the center of the cantilever

A Housewrap enclosure was added. . .

. . . around the exterior boundary sensors inside of the plastic shields

The data logger and Internet connection. . .

. . . was located between the two transmitter arrays

The first air temperature/RH sensor failure. . .

. . . occurred above the soffit in a foam insulated cavity

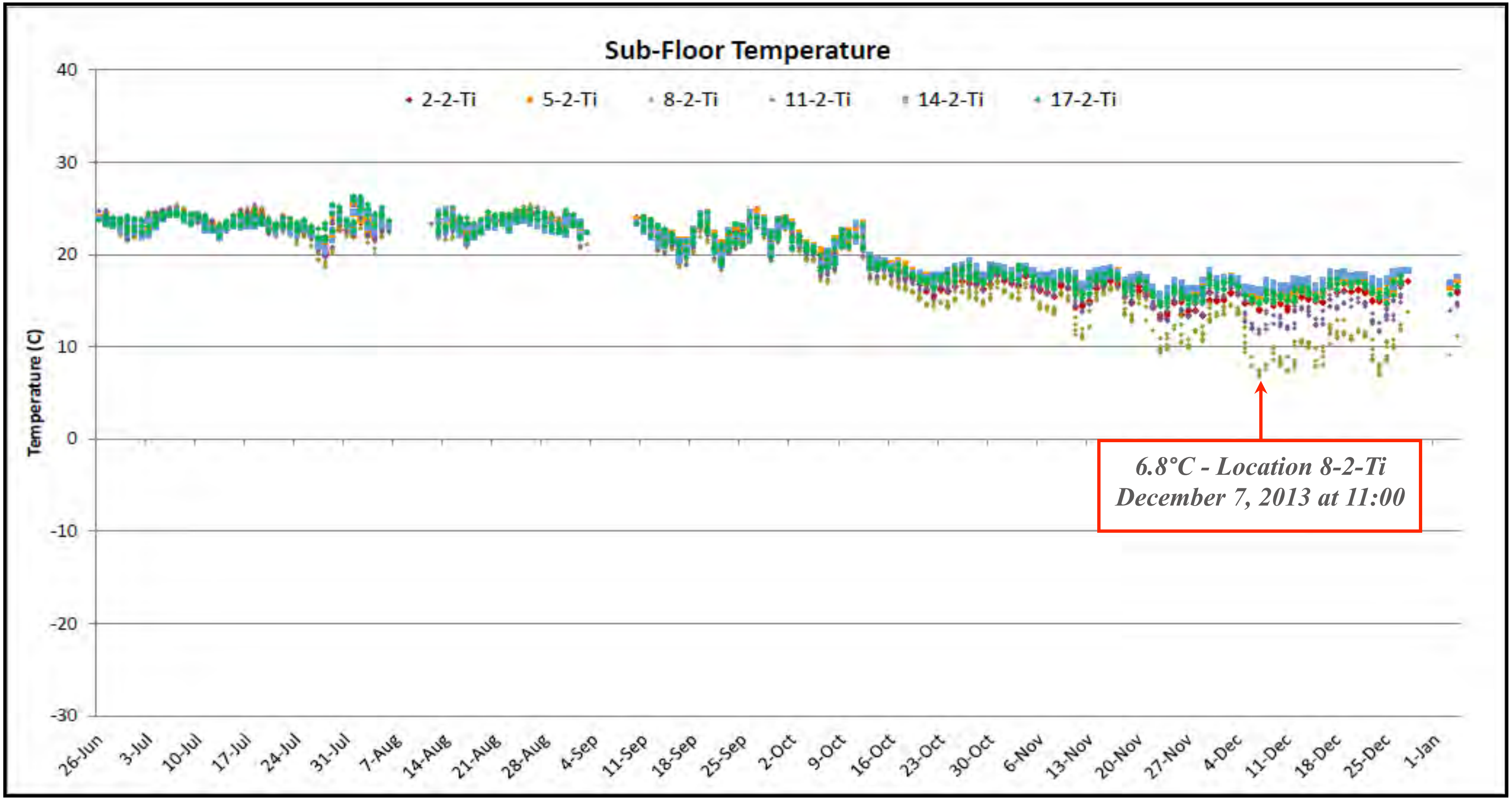
The sensor was removed and replaced. . .

. . . after testing to confirm the issue and the soffit was then re-sealed

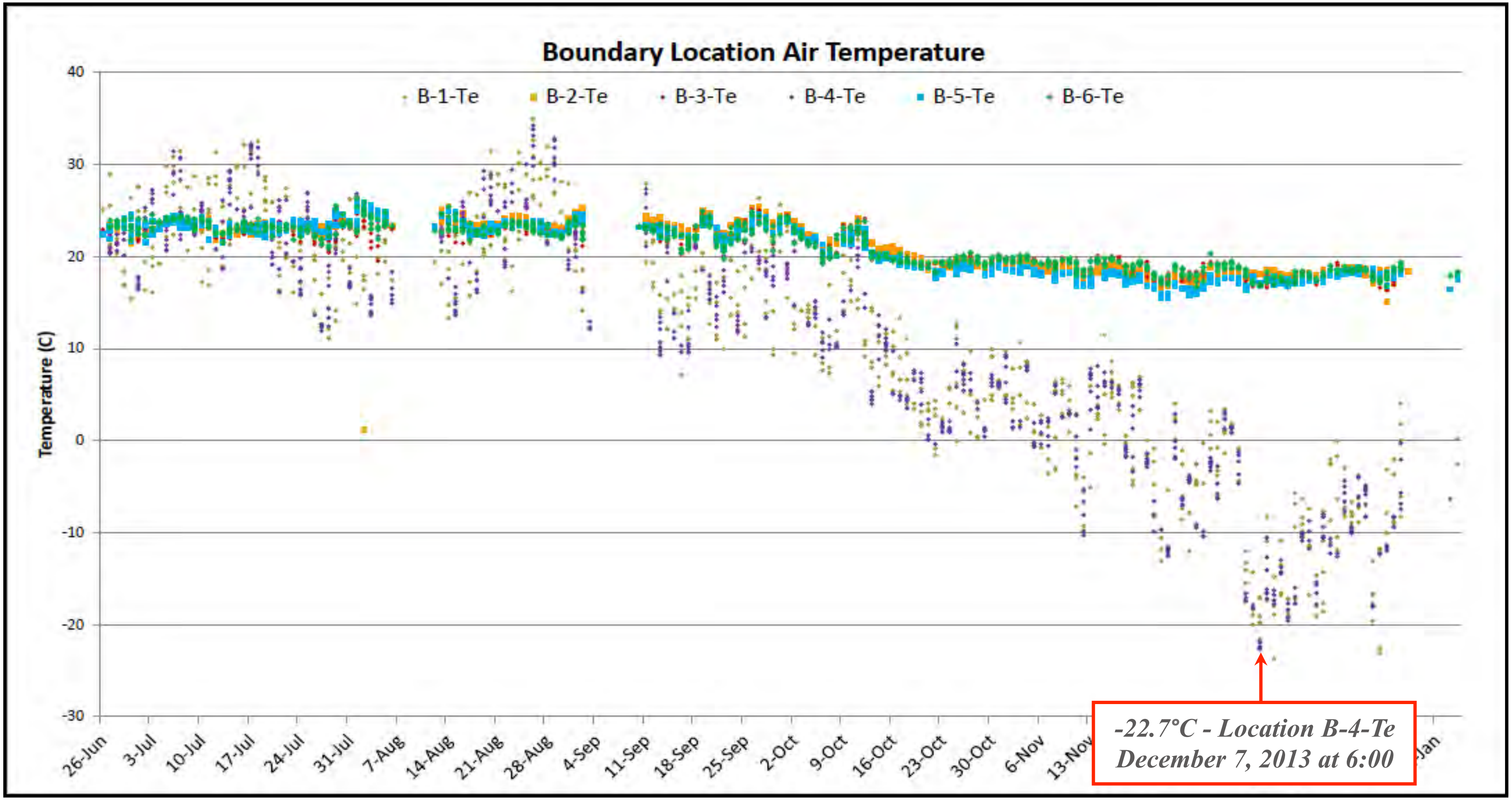
A section from the DATA SET

	A	B	GA	GB	GC	GD	GE	GF	GG	GH	GI	GJ
1	Date / Time		Test Cavity #8 - Location 1: Inside Rim Joist									
2	**ALWAYS Use Daylight Time**		8-1-RH	8-1-Te	8-1-MC	8-1-Ti	8-1-P_{WVSAT}	8-1-P_{WV}	8-1-W	8-1-t_{DP}	8-1-EMC	8-2-RH
3	PDT	CDT	Relative Humidity %	Air Temperature °C	Wood Moisture Content %	Material Temperature °C	H20 Vapor Pressure	H20 Vapor Pressure (Partial)	Humidity Ratio gWV /KgDA	Dew Point Temperature	Equilibrium Moisture Content	Relative Humi %
4	Portland, OR	Roseville, MN	676	677	678	679	mmHg Calculated	mmHg Calculated	Calculated	°C Calculated	% Calculated	640
310	7/9/2013 3:00	7/9/2013 5:00	61.6	24.3			22.8	14.0	12.1	16.5	11.2	
311	7/9/2013 4:00	7/9/2013 6:00			7.1							
312	7/9/2013 5:00	7/9/2013 7:00										[illegible]
313	7/9/2013 6:00	7/9/2013 8:00										
314	7/9/2013 7:00	7/9/2013 9:00	62.3	23.9			22.3	13.9	12.0	16.3	11.3	
315	7/9/2013 8:00	7/9/2013 10:00			7.1							
316	7/9/2013 9:00	7/9/2013 11:00										[illegible]
317	7/9/2013 10:00	7/9/2013 12:00										
318	7/9/2013 11:00	7/9/2013 13:00	63.4	23.9			22.3	14.1	12.2	16.6	11.5	
319	7/9/2013 12:00	7/9/2013 14:00			7.1	24.3						
320	7/9/2013 13:00	7/9/2013 15:00										[illegible]
321	7/9/2013 14:00	7/9/2013 16:00										
322	7/9/2013 15:00	7/9/2013 17:00	64.5									
323	7/9/2013 16:00	7/9/2013 18:00			7.1	25.8						
324	7/9/2013 17:00	7/9/2013 19:00										[illegible]
325	7/9/2013 18:00	7/9/2013 20:00										
326	7/9/2013 19:00	7/9/2013 21:00	63.5	26.5			26.0	16.5	14.3	19.0	11.4	
327	7/9/2013 20:00	7/9/2013 22:00			7.1	26.4						[illegible]
328	7/9/2013 21:00	7/9/2013 23:00										
329	7/9/2013 22:00	7/10/2013 0:00										
330	7/9/2013 23:00	7/10/2013 1:00	61.6	25.6			24.6	15.2	13.1	17.7	11.1	
331	7/10/2013 0:00	7/10/2013 2:00			7.1	25.3						[illegible]
332	7/10/2013 1:00	7/10/2013 3:00										
333	7/10/2013 2:00	7/10/2013 4:00										
334	7/10/2013 3:00	7/10/2013 5:00	60.4	23.5			21.7	13.1	11.3	15.4	11.0	
335	7/10/2013 4:00	7/10/2013 6:00			7	22.8						[illegible]
336	7/10/2013 5:00	7/10/2013 7:00										
337	7/10/2013 6:00	7/10/2013 8:00										
338	7/10/2013 7:00	7/10/2013 9:00	61.9									
339	7/10/2013 8:00	7/10/2013 10:00			6.9	21.4						
340	7/10/2013 9:00	7/10/2013 11:00										
341	7/10/2013 10:00	7/10/2013 12:00										
342	7/10/2013 11:00	7/10/2013 13:00	64.3	22.5			20.4	13.1	11.3	15.5	11.8	[illegible]
343	7/10/2013 12:00	7/10/2013 14:00			7	22.85						
344	7/10/2013 13:00	7/10/2013 15:00										
345	7/10/2013 14:00	7/10/2013 16:00										
346	7/10/2013 15:00	7/10/2013 17:00	64.9									[illegible]
347	7/10/2013 16:00	7/10/2013 18:00			7.1	24.3						
348	7/10/2013 17:00	7/10/2013 19:00										
349	7/10/2013 18:00	7/10/2013 20:00										
350	7/10/2013 19:00	7/10/2013 21:00	63.3	24.6			23.2	14.7	12.7	17.2	11.5	

Floor temperature and thermal comfort



Temperatures at boundary locations



Boundary Locations - Air Temperature *Recorded on December 7, 2014 - Coldest Sub-Floor Series of the 6 Month Test Period*						
Location-Type of Sensor	B-1-Te	B-2-Te	B-3-Te	B-4-Te	B-5-Te	B-6-Te
Temperature °C	-21.6	18.1	16.7	-22.7	17.1	16.8
Temperature °F	-6.9	64.6	62.1	-8.9	62.8	62.2

Test Cavity Locations - Sub-Floor Temperature *Recorded on December 7, 2014 - Coldest Sub-Floor Series of the 6 Month Test Period*						
Location-Type of Sensor	2-2-Ti	5-2-Ti	8-2-Ti	11-2-Ti	14-2-Ti	17-2-Ti
Temperature °C	13.9	15.4	6.8	11.4	15.8	14.9
Temperature °F	57.0	59.7	44.2	52.5	60.4	58.8
Insulation Type	*R-19 Batt w/o Blocking*	*4 1/2" SPF w/o Blocking*	*R-30 Batt Blocked & Sealed*	*R-30 Batt Blocked & Sealed*	*4 1/2" SPF w/o Blocking*	*R-19 Batt w/o Blocking*
Floor Profile	*Carpet with pad 3/4" Oak Hardwood Flooring 3/4" Fir Plywood Sub-Floor*			*3/4" Oak Hardwood Flooring 3/4" Fir Plywood Sub-Floor*		

Cavity #8 - Under Carpeted Floor December 7, 2013 ~11:00am At B-1-Te, outside temperature is -21.6°C		
Insulation Type: R-30 Batt Blocked & Sealed	R-Value	Temp °C
B-3-Te - Boundary-Main Floor-West		16.7
Air Film - top of carpeted floor	0.92	
3/4 inch carpet with rebonded urethane pad	2.38	
3/4 inch Oak hardwood flooring	0.60	
3/4 inch Douglas Fir Plywood Sub-floor	1.08	
Air Film - bottom of sub-floor	0.92	
8-2-Ti - material temperature at bottom of subfloor		6.8
8-2-Te - air temperature below sub-floor		7.8
B-2-Te - Boundary-Basement-East		18.1
TOTAL R-Value	5.90	
Calculated temperature at top of carpet		15.3
Calculated temperature at bottom of sub-floor		9.2
Measured temperature compared to calculated temperature at bottom of sub-floor		-2.4

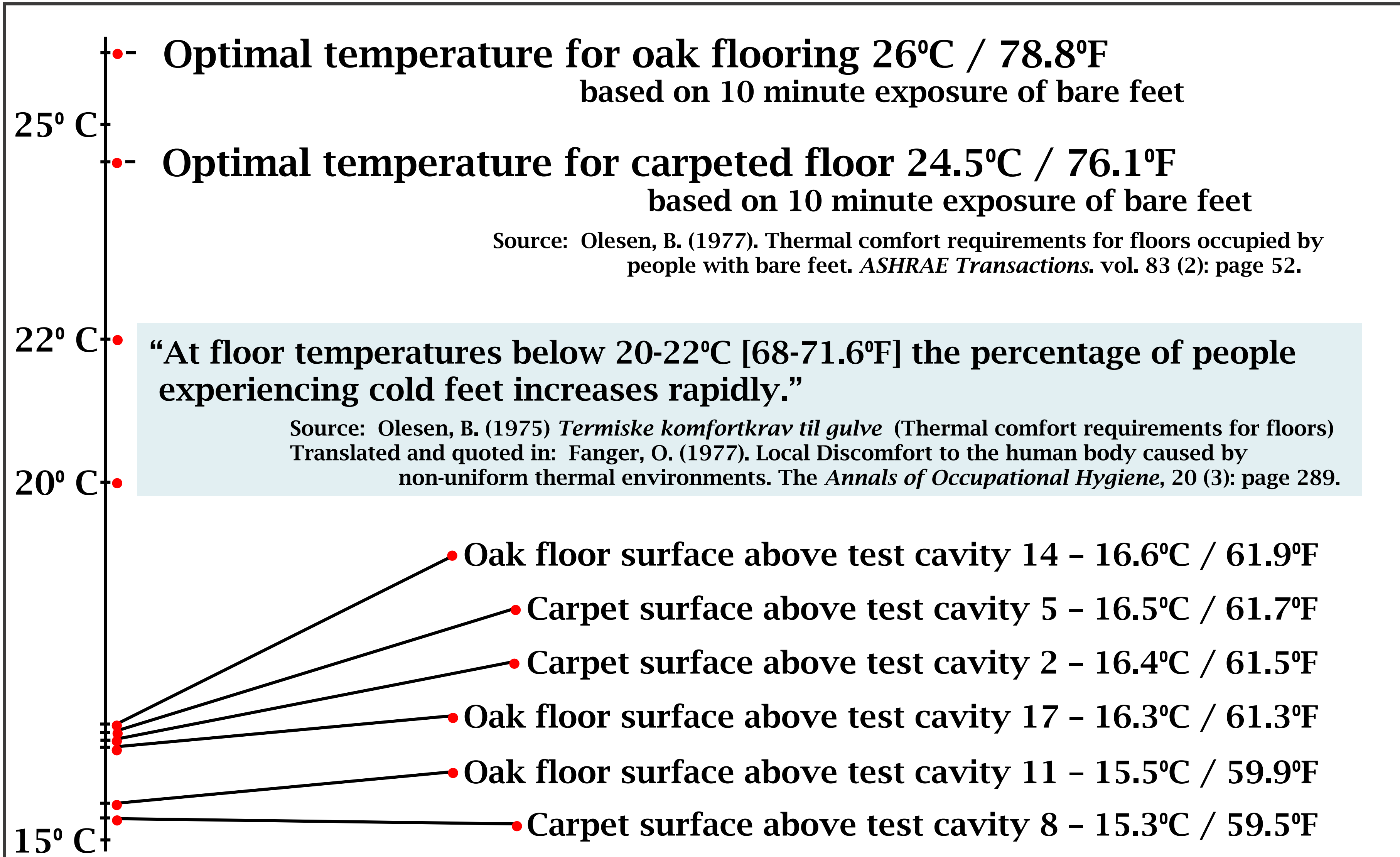
Cavity #14 - Under Hardwood Floor		
December 7, 2013 ~11:00am At B-4-Te, outside temperature is -22.7°C		
Insulation Type: 4 1/2" SPF w/o Blocking	R-Value	Temp °C
B-6-Te - Boundary-Main Floor-East		16.8
Air Film - top of hardwood floor	0.92	
3/4 inch Oak hardwood flooring	0.60	
3/4 inch Douglas Fir Plywood Sub-floor	1.08	
Air Film - bottom of sub-floor	0.92	
14-2-Ti - material temperature at bottom of subfloor		15.8
14-2-Te - air temperature below sub-floor		16.0
B-5-Te - Boundary-Basement-East		17.1
TOTAL R-Value	3.52	
Calculated temperature at top of hardwood floor		16.6
Calculated temperature at bottom of sub-floor		16.2
Measured temperature compared to calculated temperature at bottom of sub-floor		-0.4

Temperature Profiles of the Floor above Test Cavities

*December 7, 2013 ~11:00am * At B-1-Te, outside temperature is -21.6°C (-6.9°F) * At B-4-Te, outside temperature is -22.7°C (-8.9°F)*

	Cavity #2	Cavity #5	Cavity #8	Cavity #11	Cavity #14	Cavity #17
Air Temperature (measured) 6 inches above the Surface of the Main Floor	16.7°C 62.1°F	16.7°C 62.1°F	16.7°C 62.1°F	16.8°C 62.2°F	16.8°C 62.2°F	16.8°C 62.2°F
Material Temperature (calculated) at the Surface of the Main Floor *(Carpet or Hardwood)*	16.4°C 61.5°F	16.5°C 61.7°F	15.3°C 59.5°F	15.5°C 59.9°F	16.6°C 61.9°F	16.3°C 61.3°F
Material Temperature (measured) at the bottom of the Plywood Sub-floor	13.9°C 57.0°F	15.4°C 59.7°F	6.8°C 44.2°F	11.4°C 52.5°F	15.8°C 60.4°F	14.9°C 58.8°F
Material Temperature (calculated) at the bottom of the Plywood Sub-floor	15.1°C 59.2°F	15.9°C 60.6°F	9.2°C 48.6°F	13.2°C 55.8°F	16.2°C 61.2°F	15.3°C 59.5°F
Air Temperature (measured) 1/4 inch below the Plywood Sub-floor	14.8°C 58.6°F	15.7°C 60.3°F	7.8°C 46.0°F	11.9°C 53.4°F	16.0°C 60.8°F	14.8°C 58.6°F
Air Temperature (measured) at Basement Boundary Locations near bottom of Floor Joists	18.1°C 64.6°F	18.1°C 64.6°F	18.1°C 64.6°F	17.1°C 62.8°F	17.1°C 62.8°F	17.1°C 62.8°F
Insulation Type	*R-19 Batt w/o Blocking*	*4 1/2" SPF w/o Blocking*	*R-30 Batt Blocked & Sealed*	*R-30 Batt Blocked & Sealed*	*4 1/2" SPF w/o Blocking*	*R-19 Batt w/o Blocking*
Floor Profile	*Carpet with pad 3/4" Oak Hardwood Flooring 3/4" Fir Plywood Sub-Floor*			*3/4" Oak Hardwood Flooring 3/4" Fir Plywood Sub-Floor*		

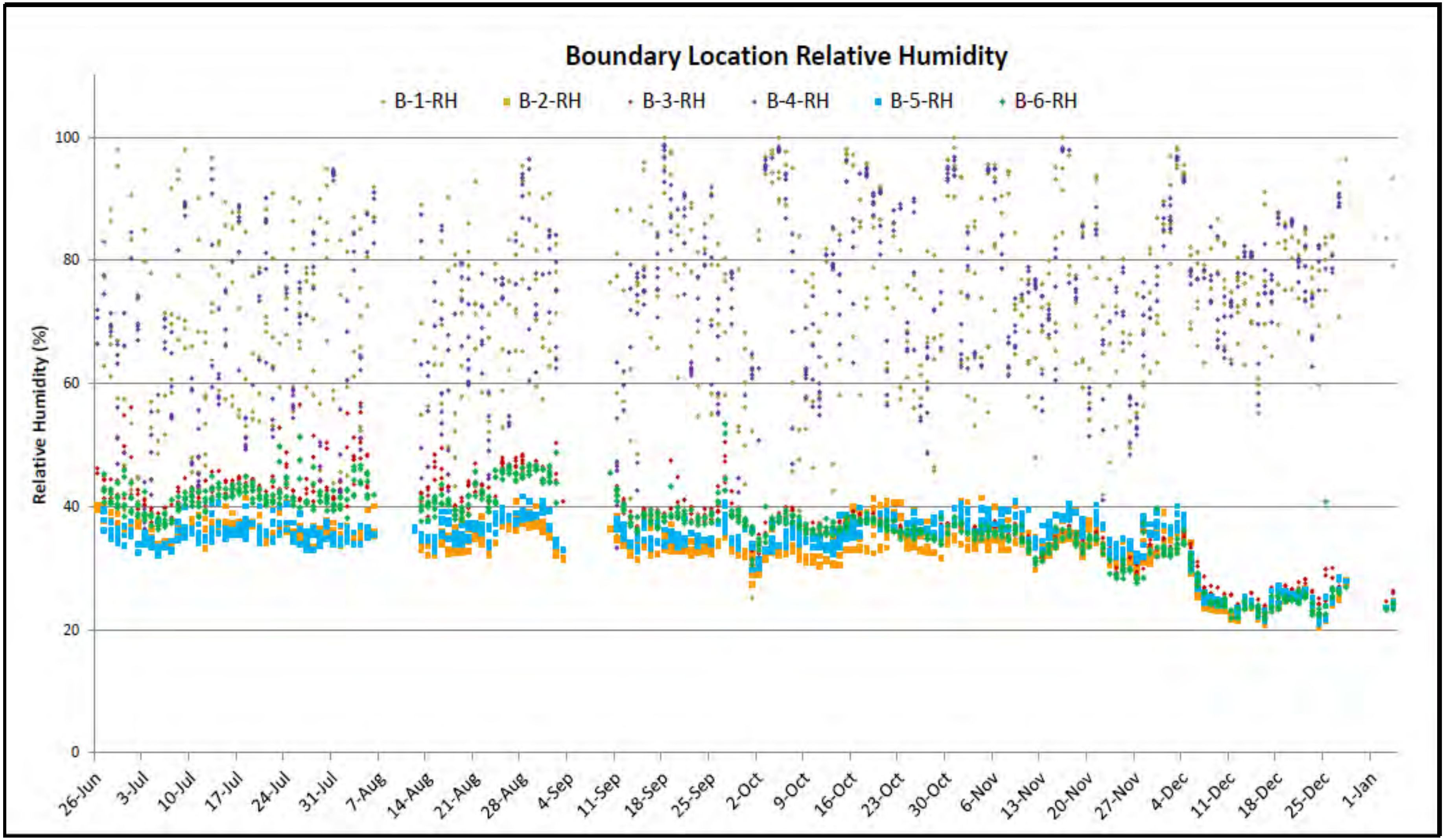
Actual Floor Temperature vs Optimal Floor Temperature



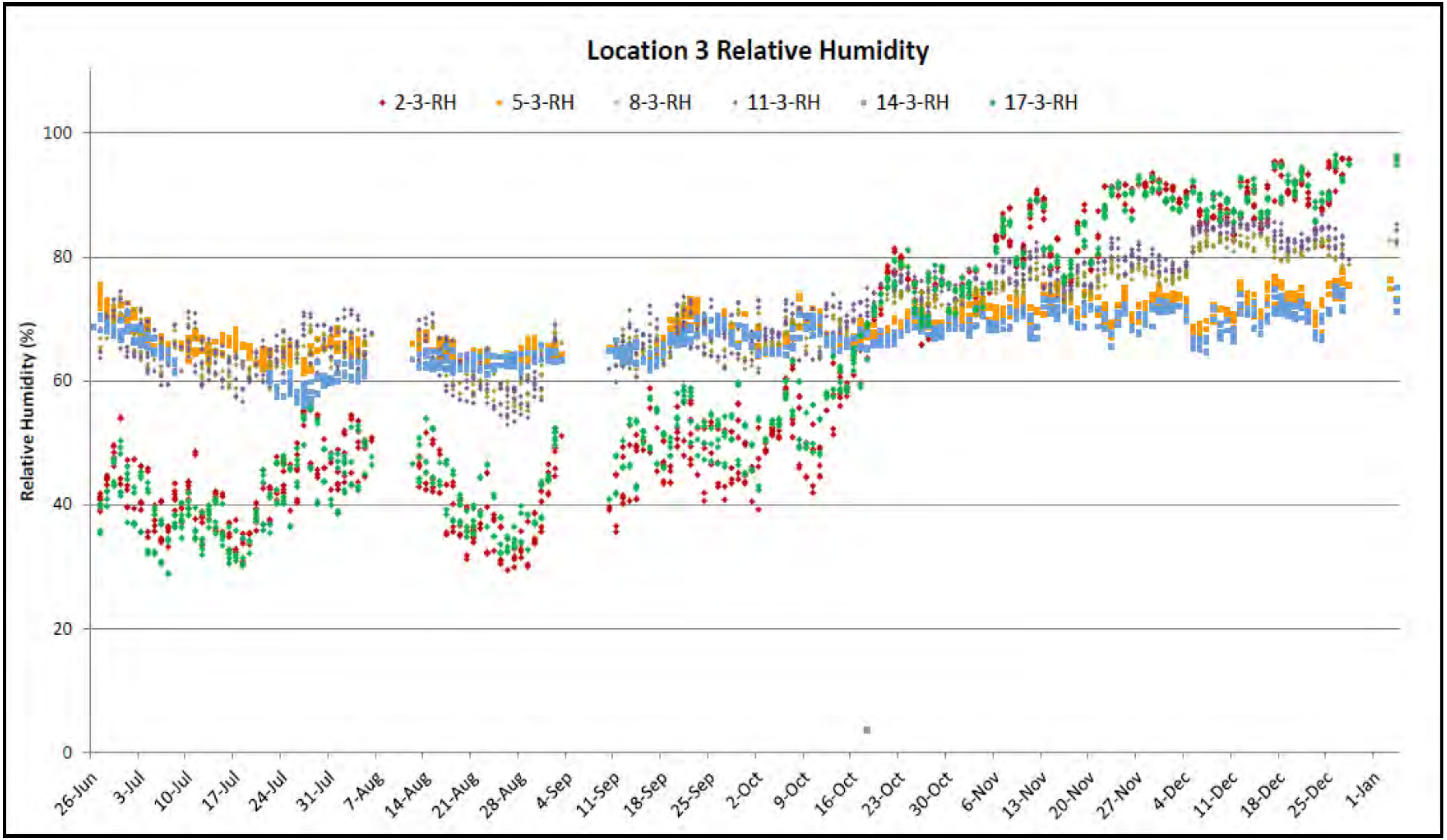
Wood Moisture Content - Equilibrium Moisture Content - Relative Humidity - Wetting Trend					
June 26, 2013 to January 4, 2014		Highest Value Recorded			
Location	Insulation Type	%MC	%EMC	%RH	Wetting Trend
2-1 Inside Rim Joist	R-19 - Open	10.4	22.0	92.0	Slight Increase
2-3 Above Soffit	R-19 - Open	16.3	25.1	95.9	Increasing
5-1 Inside Rim Joist	Foam - Open	5.9	12.3	64.8	No Increase
5-3 Above Soffit	Foam - Open	10.9	15.1	77.6	Slight Increase
8-1 Inside Rim Joist	R-30 - Blocked	9.3	15.1	76.1	Slight Increase
8-3 Above Soffit	R-30 - Blocked	10.9	17.9	85.4	Slight Increase
11-1 Inside Rim Joist	R-30 - Blocked	8.6	15.5	78.7	Slight Increase
11-3 Above Soffit	R-30 - Blocked	11.4	19.0	87.3	Slight Increase
14-1 Inside Rim Joist	Foam - Open	6.4	11.5	60.8	No Increase
14-3 Above Soffit	Foam - Open	10.8	14.9	75.1	Slight Increase
17-1 Inside Rim Joist	R-19 - Open	9.7	20.5	88.8	Slight Increase
17-3 Above Soffit	R-19 - Open	19.6	25.5	96.4	Increasing

No Concern about Durability	Potential Concern about Durability	Active Concern about Durability

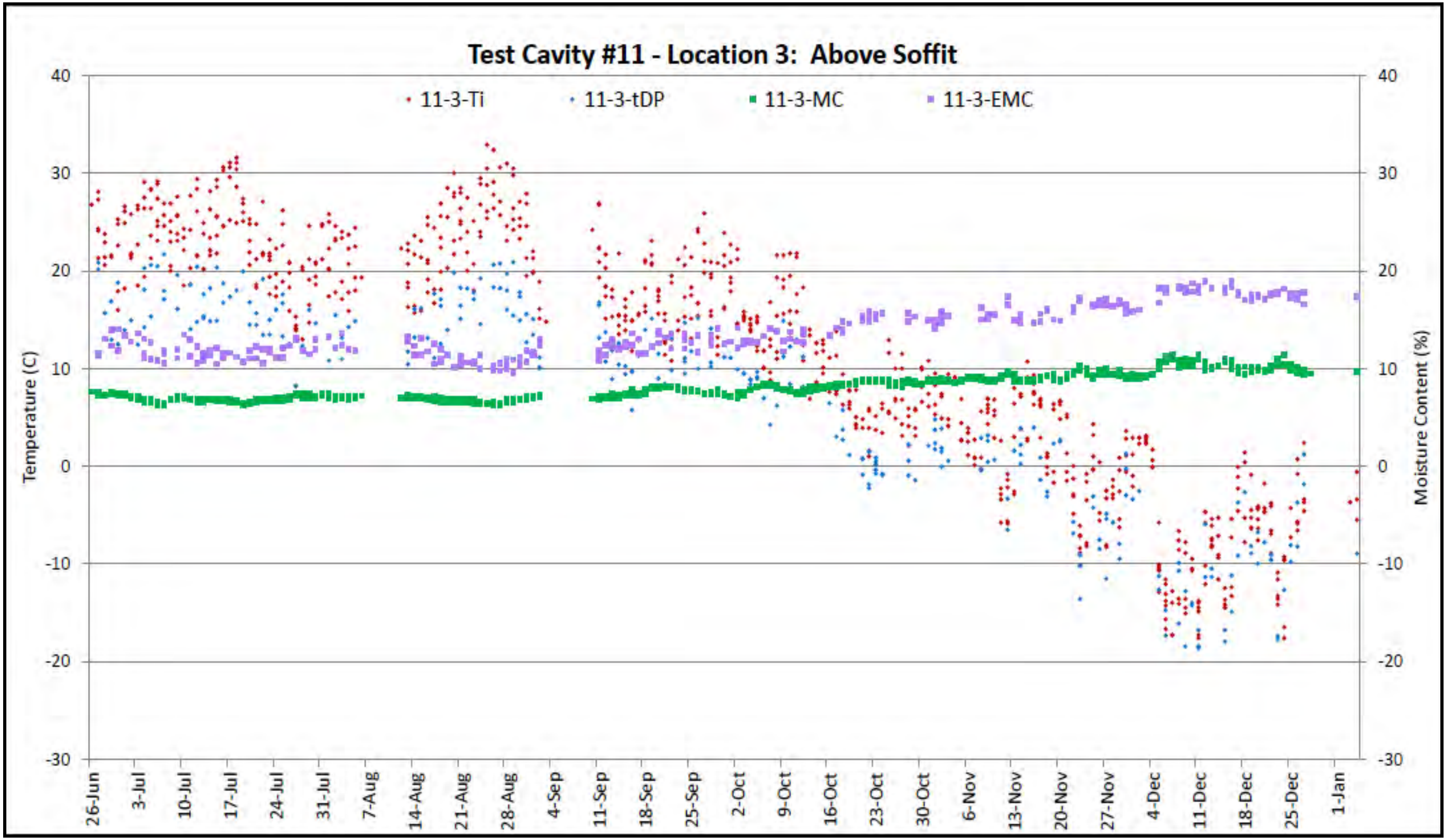
Boundary location RH comparisons



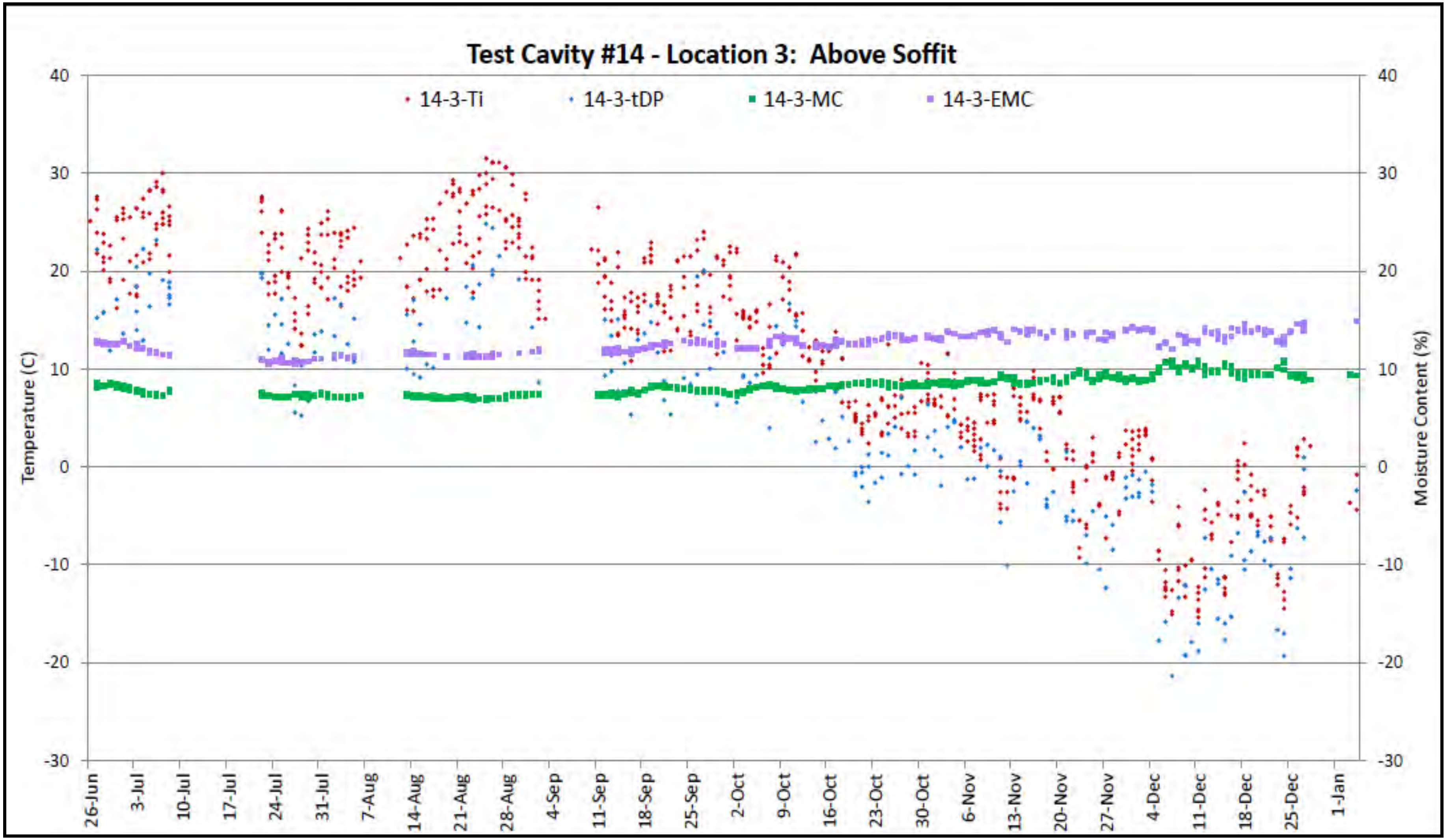
Soffit location RH comparisons



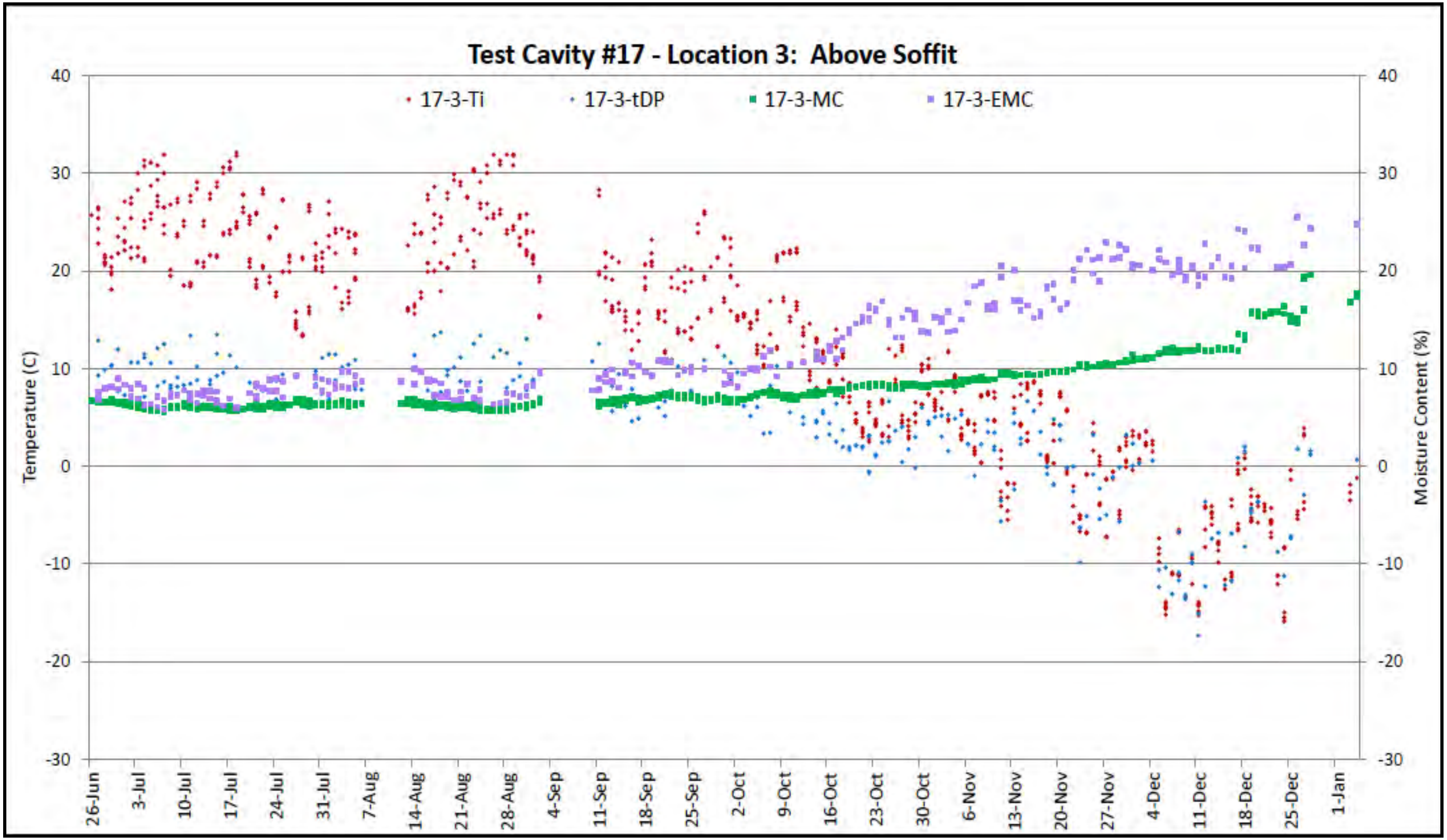
Moisture behavior at soffit in R-30/sealed cavity



Moisture behavior at soffit in R-30/ foamed cavity



Moisture behavior at soffit in R-19/open cavity



Questions and Discussion

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