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CONFERENCE
& TRADE SHOW
APRIL 18-20
2017
RESTON, VA
AIR BARRIER EDUCATION TRACKS FOR
THE CONSTRUCTION INDUSTRY

Energy Improvements to Existing Buildings Using Air Barriers and Insulation Upgrades

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Gale Associates, Inc.



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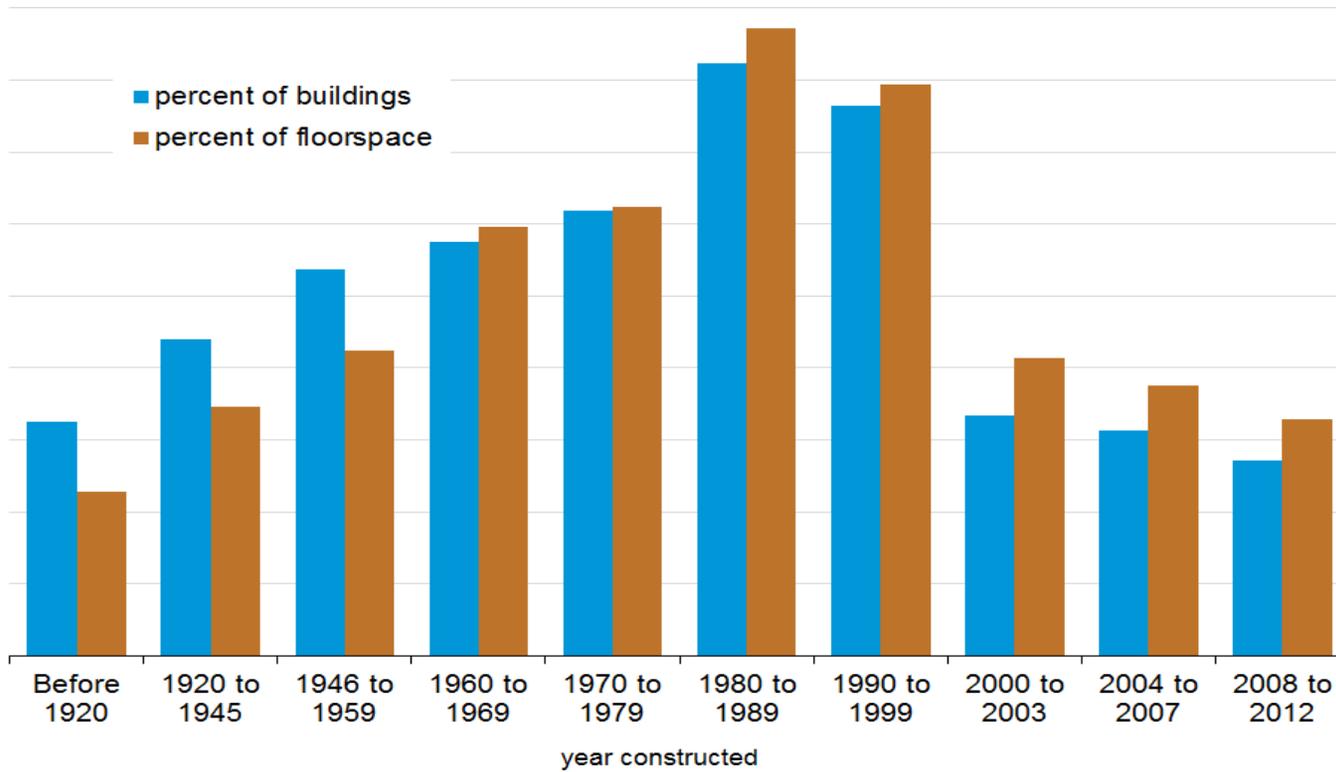
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2017

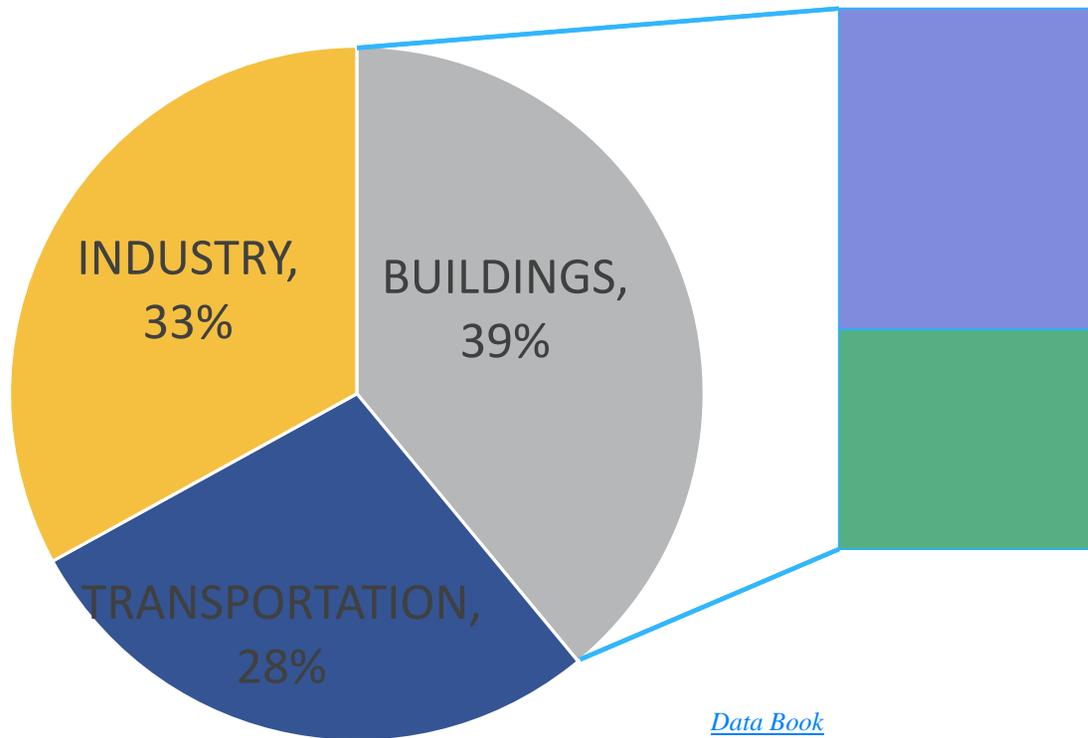
RESTON, VA

**AIR BARRIER EDUCATION TRACKS FOR
THE CONSTRUCTION INDUSTRY**

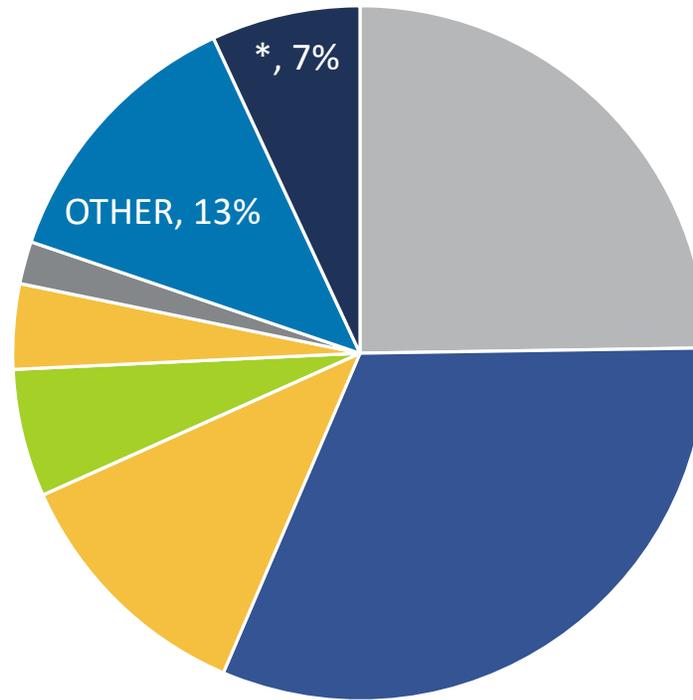
AGE OF BUILDING STOCK



US ENERGY CONSUMPTION



COMMERCIAL SECTOR ENERGY USE



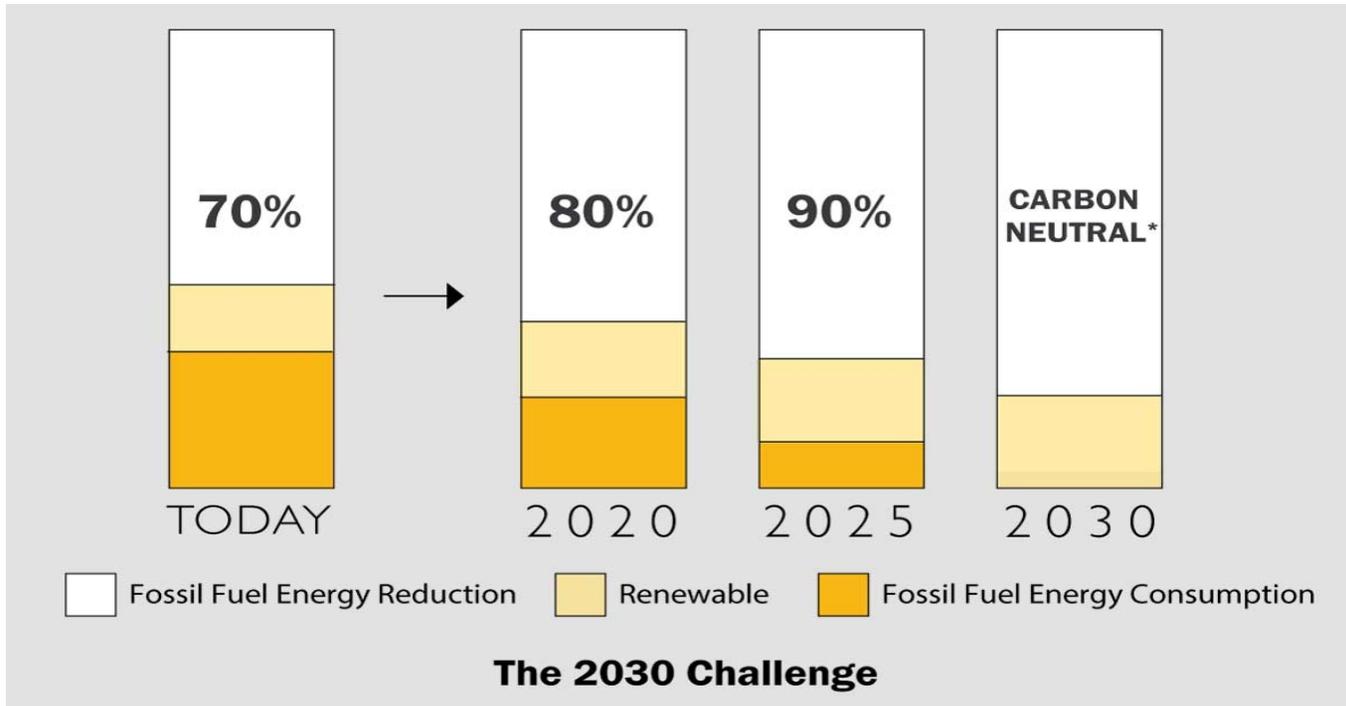
Source: DOE, [2008 Buildings Energy Data Book](#), Section 3.1.4, 2008.

Note: This pie chart uses an adjustment factor (*) used by the EIA to reconcile two datasets

2005 NIST STUDY

- An air barrier can reduce:
 - 85% of air leakage
 - 40% of savings in heat cost
 - 26% of saving in cooling cost

2030 CHALLENGE



Solid Masonry Wall



Precast Concrete Panels



Metal Stud Framed Wall



Wood Stud Frame Wall

Masonry

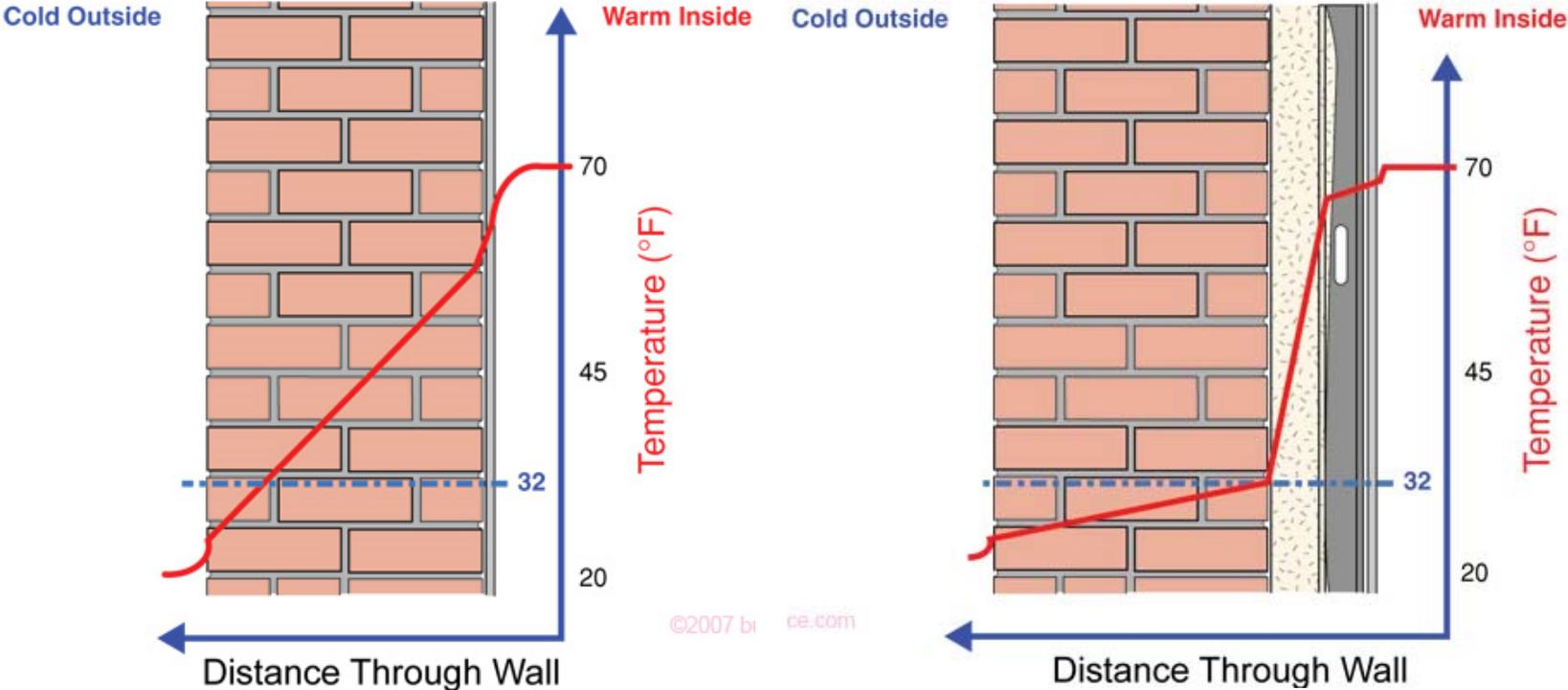
EXISTING WALL SUBSTRATES

- Configuration
- Condition
- Material Quality
- Installation Quality
- Weathering
- Maintenance

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CHANGE IN PERFORMANCE





Renovated Building-Type 1 (SPF):

- Basement and four floors
- Foot Print – 10,400 sf
- Assembly space, offices and 73 single dormitory rooms

Renovated Building-Type 2 (FG Batt):

- Basement and four floors
- Foot Print – 9,600 sf
- Assembly space, offices and 72 single dormitory rooms

Unrenovated Building:

- Basement and four floors
- Foot Print – 10,400 sf
- Assembly space, offices and 85 single dormitory rooms

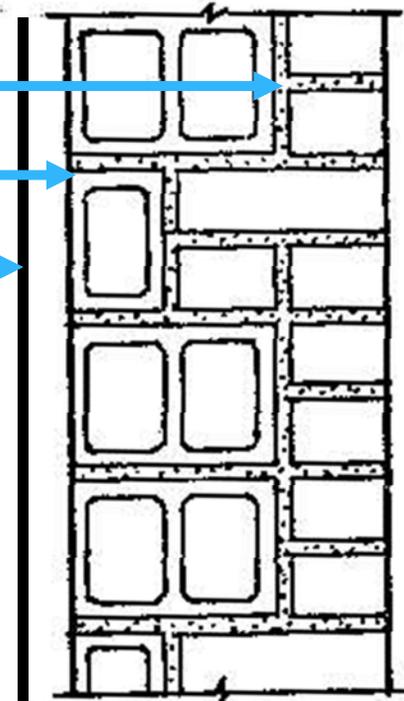
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	Unrenovated	Renovated SPF	Renovated FG Batt
Red Brick Exterior Wythe	P	P	P
Terra Cotta Block	P	P	P
Plaster	P	Removed	Removed
Insulation	—	1" closed cell polyurethane spray foam	3" fiberglass batt
Vapor Retarder	—	—	Polyethylene
Gypsum Sheathing	—		
Paint	Acrylic Latex	Acrylic Latex	Acrylic Latex

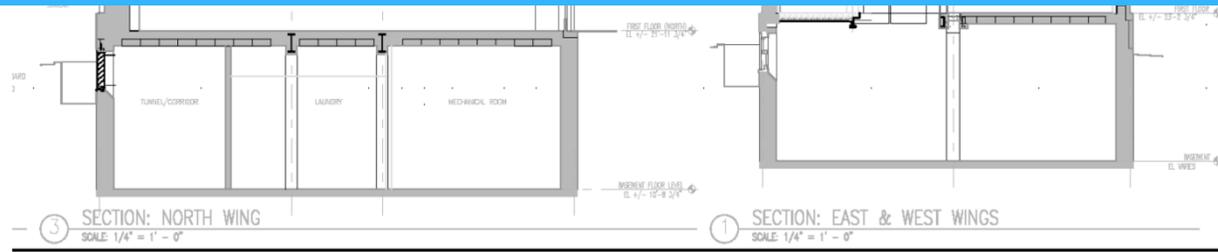
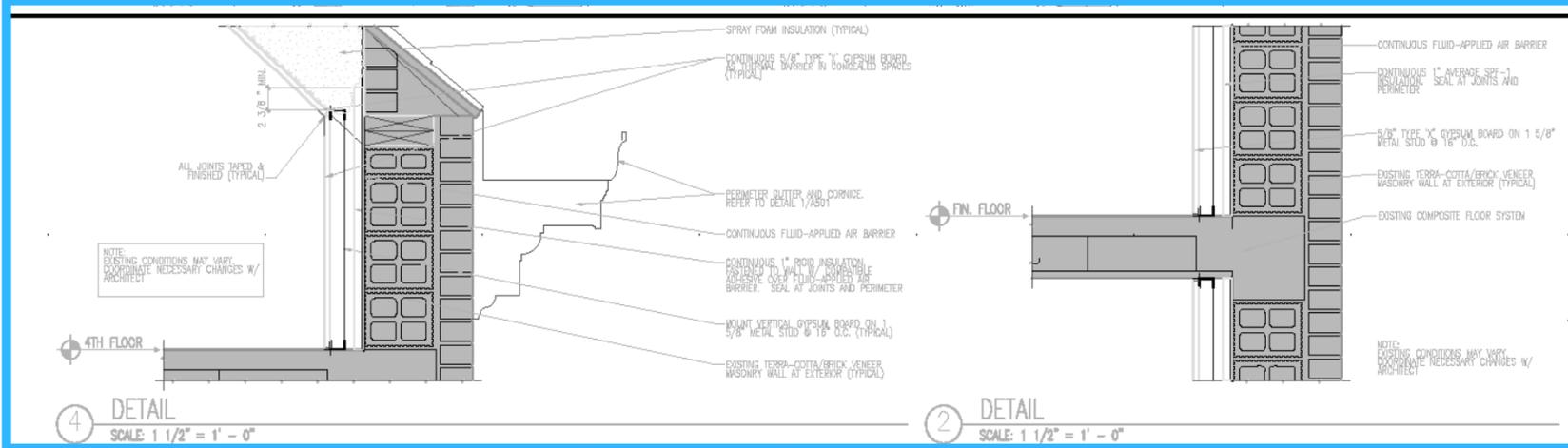
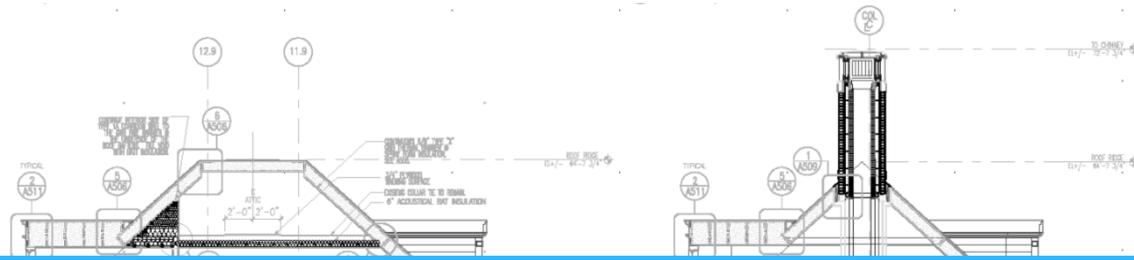
Original Building Construction

- Exterior Brick Masonry
- Terra Cotta Back Up Wall
- Interior Plaster Finish



Horizontal cells

Renovated



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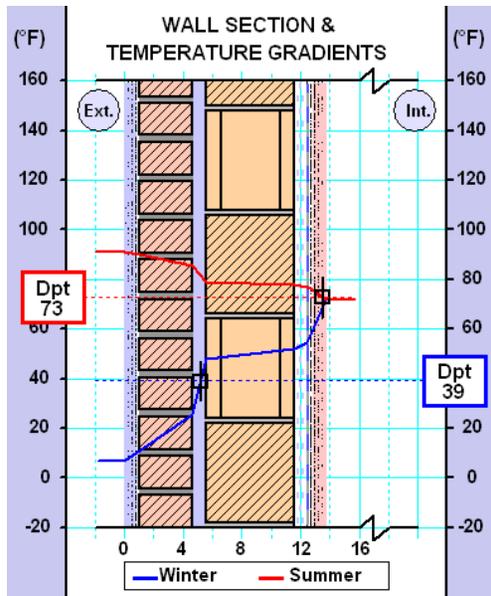


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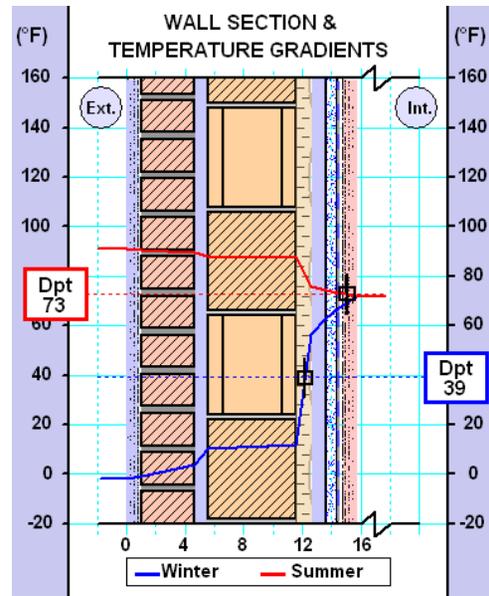
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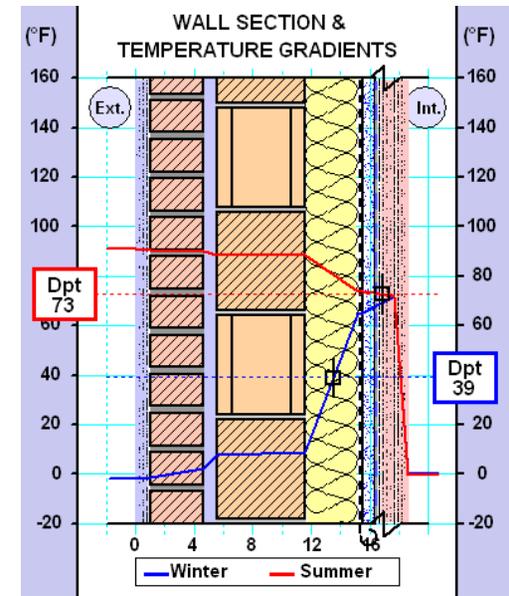
Static Dewpoint Analysis



Unrenovated

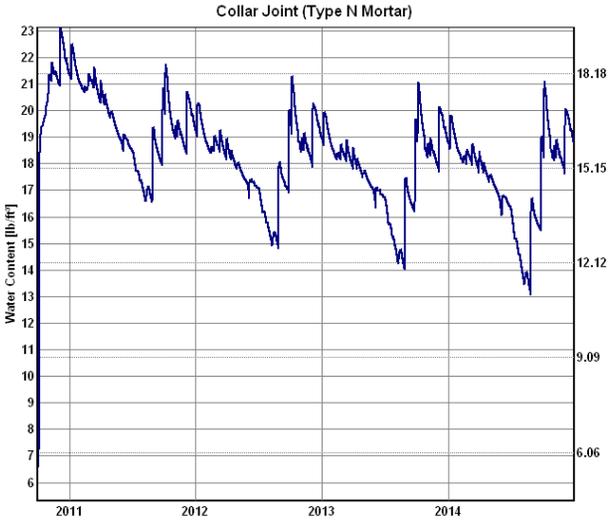


Renovated- SPF



Renovated- FG Batt

Comparison: Collar Joint



Unrenovated

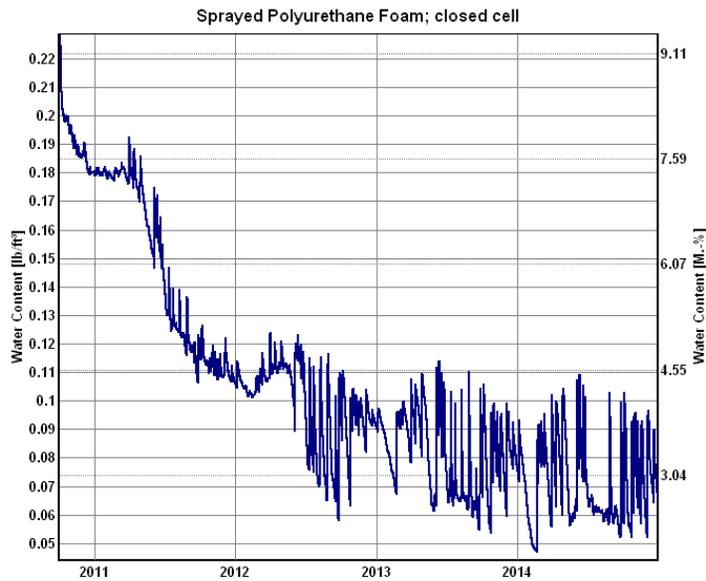


Renovated- SPF

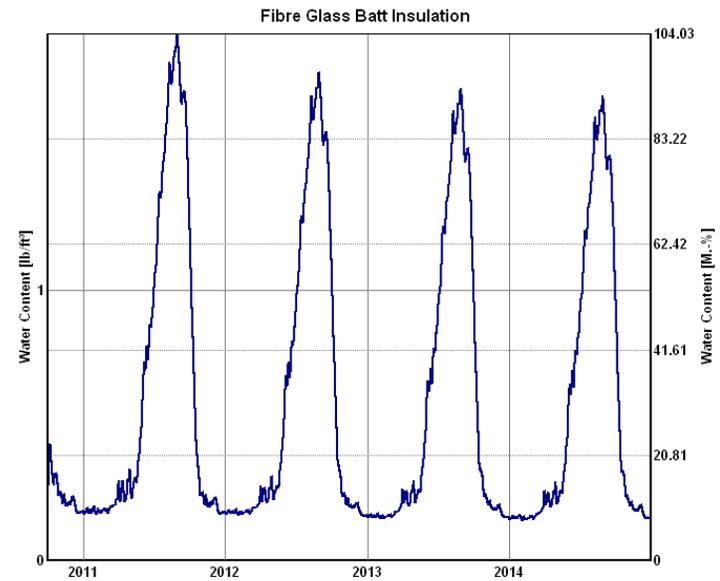


Renovated- FG Batt

Comparison: Insulation

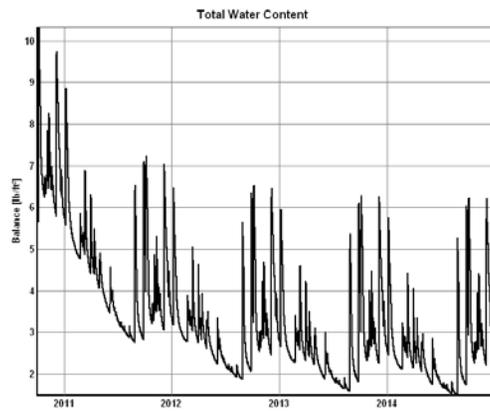


Renovated- SPF

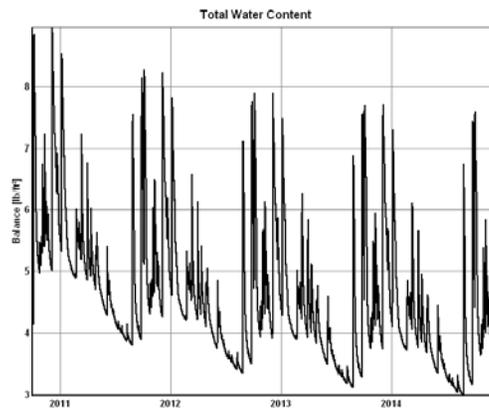


Renovated- FG Batt

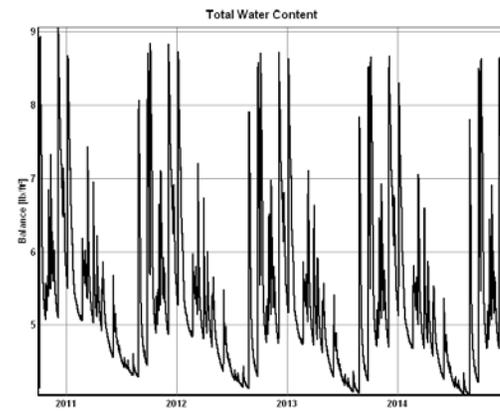
Water Content of Wall Assembly



Unrenovated



Renovated- SPF



Renovated- FG Batt

Comparison: North Elevation



Unrenovated

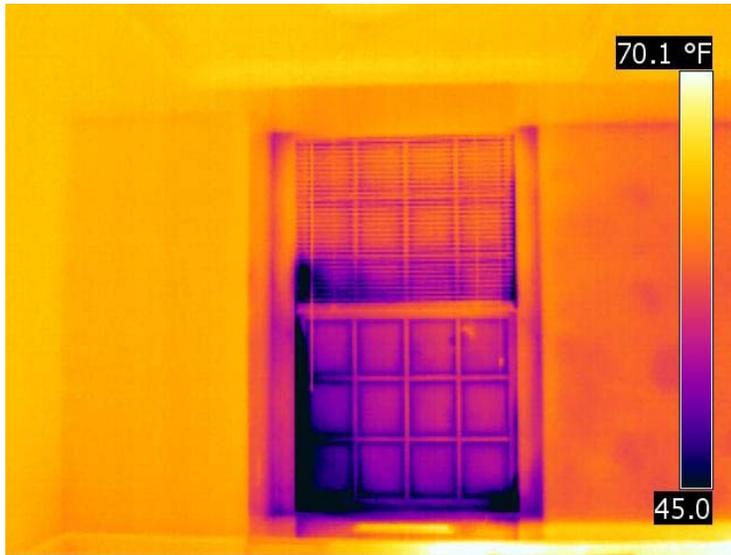


Renovated SPF

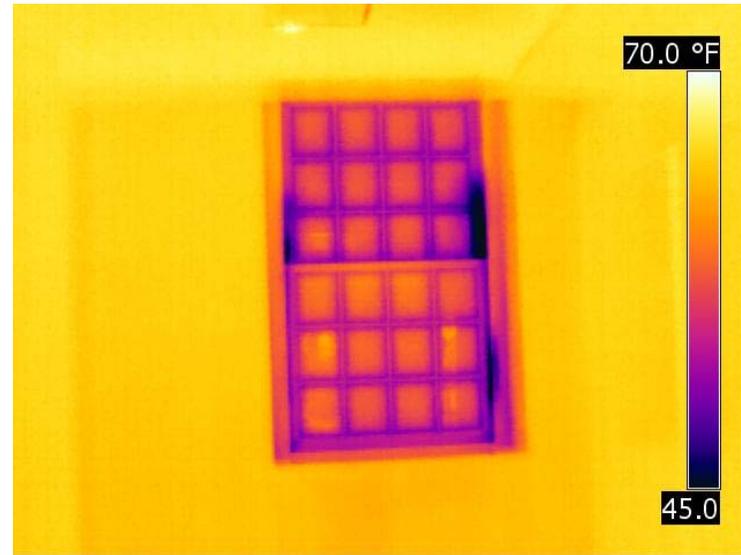


Renovated FG Batt

Unrenovated vs. Renovated SPF



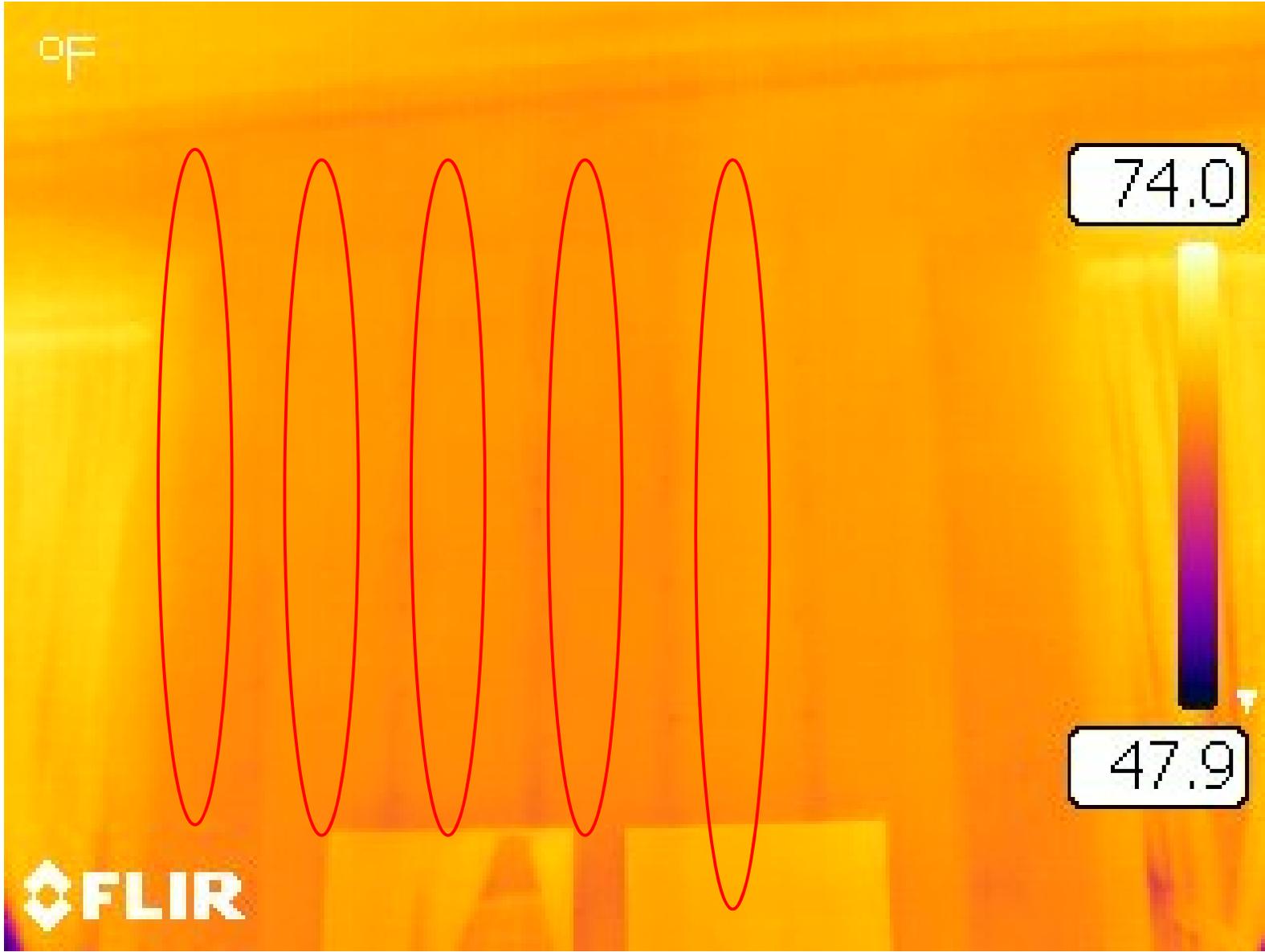
Room Temp: 69 °F
Wall Temp: 58.6 °F



Room Temp: 65.4 °F
Wall Temp: 64.5 °F

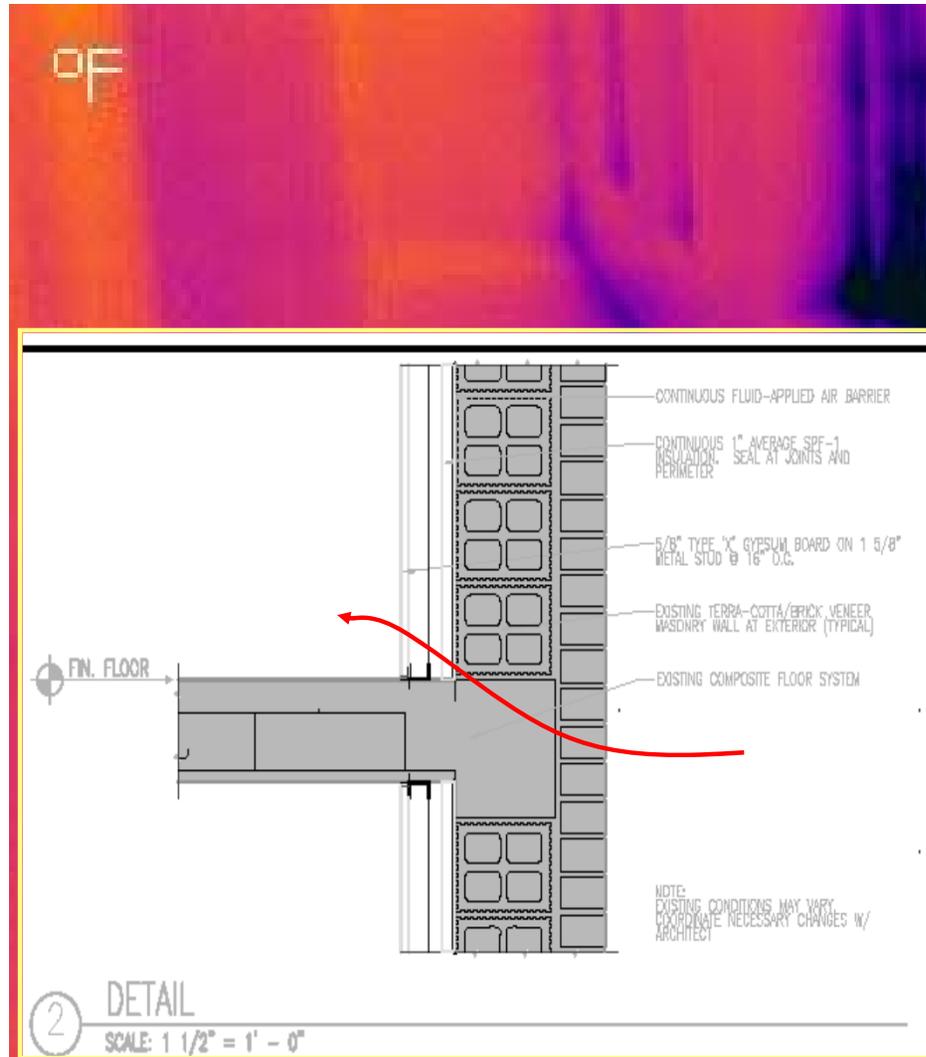
Renovated FG Batt

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Renovated SPF

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FLIR

70.1



47.9

Potential Effects of Accumulated Moisture

Corrosion of
embedded structural
and light gauge steel

Mold

Reduction of the
thermal performance
of insulation

Accelerated
freeze/thaw
deterioration in
masonry

Precast Concrete Walls



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Moisture Damages



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Condensation on exposed concrete



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Condensation on window system



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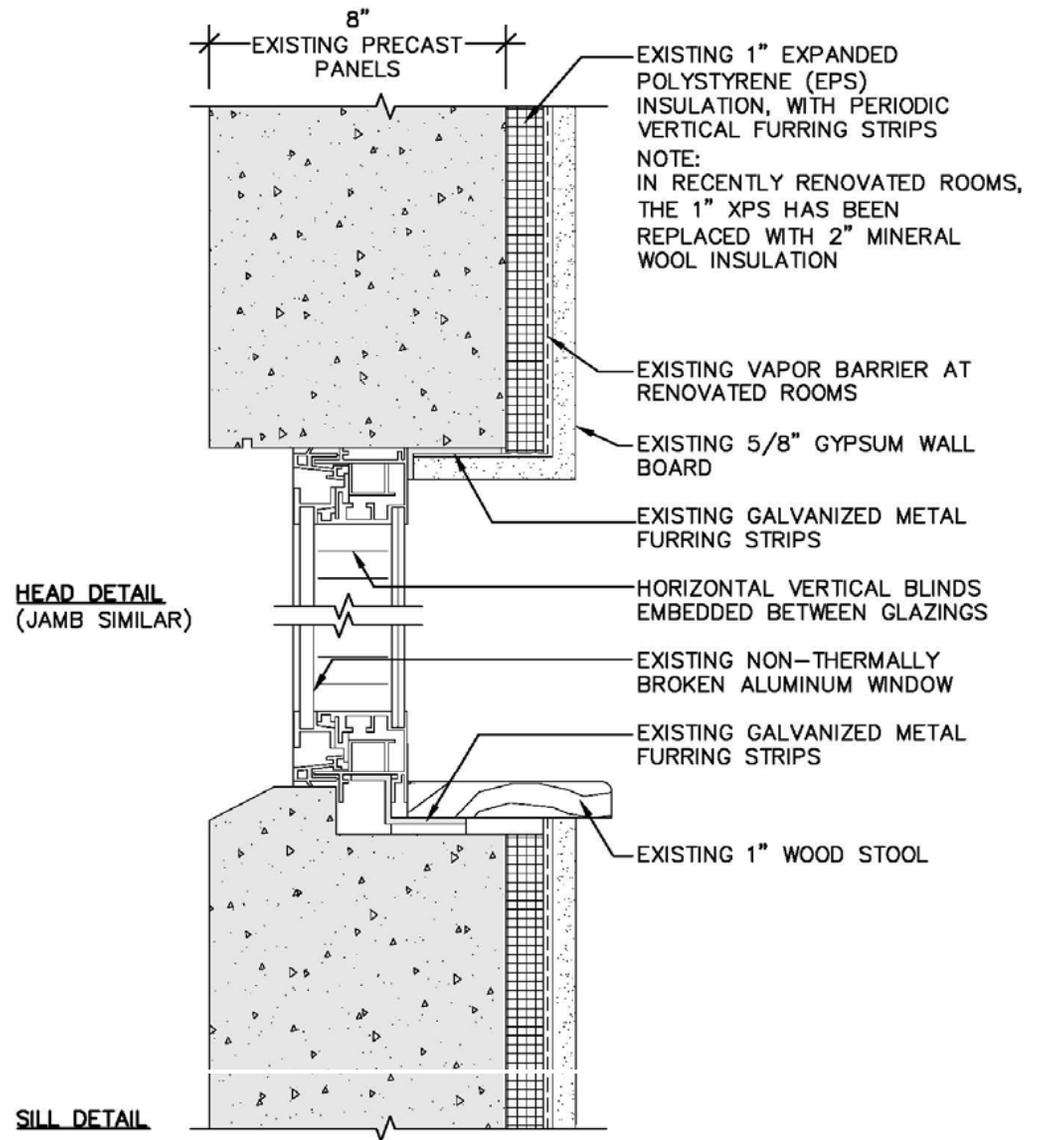
Non-continuous vapor barrier

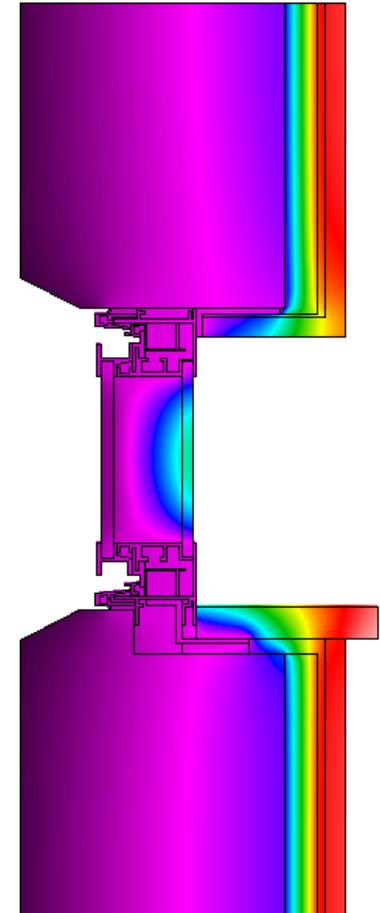
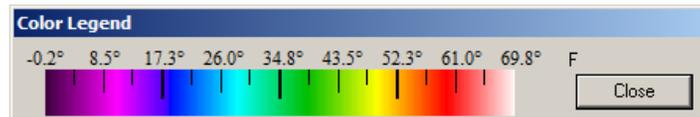
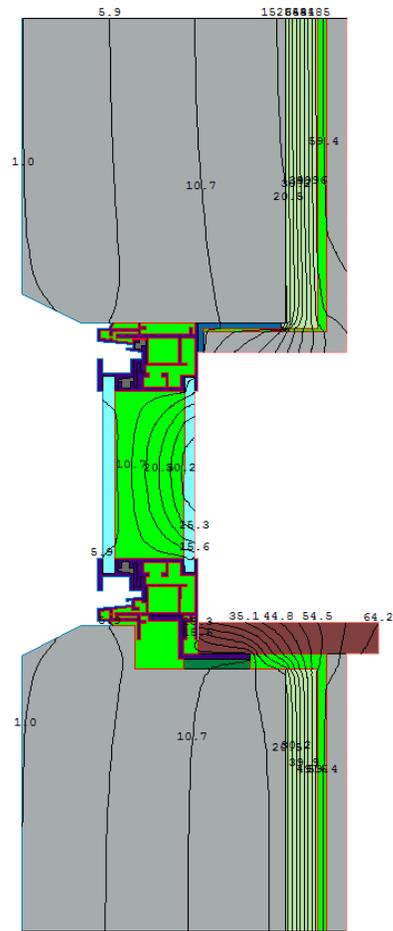


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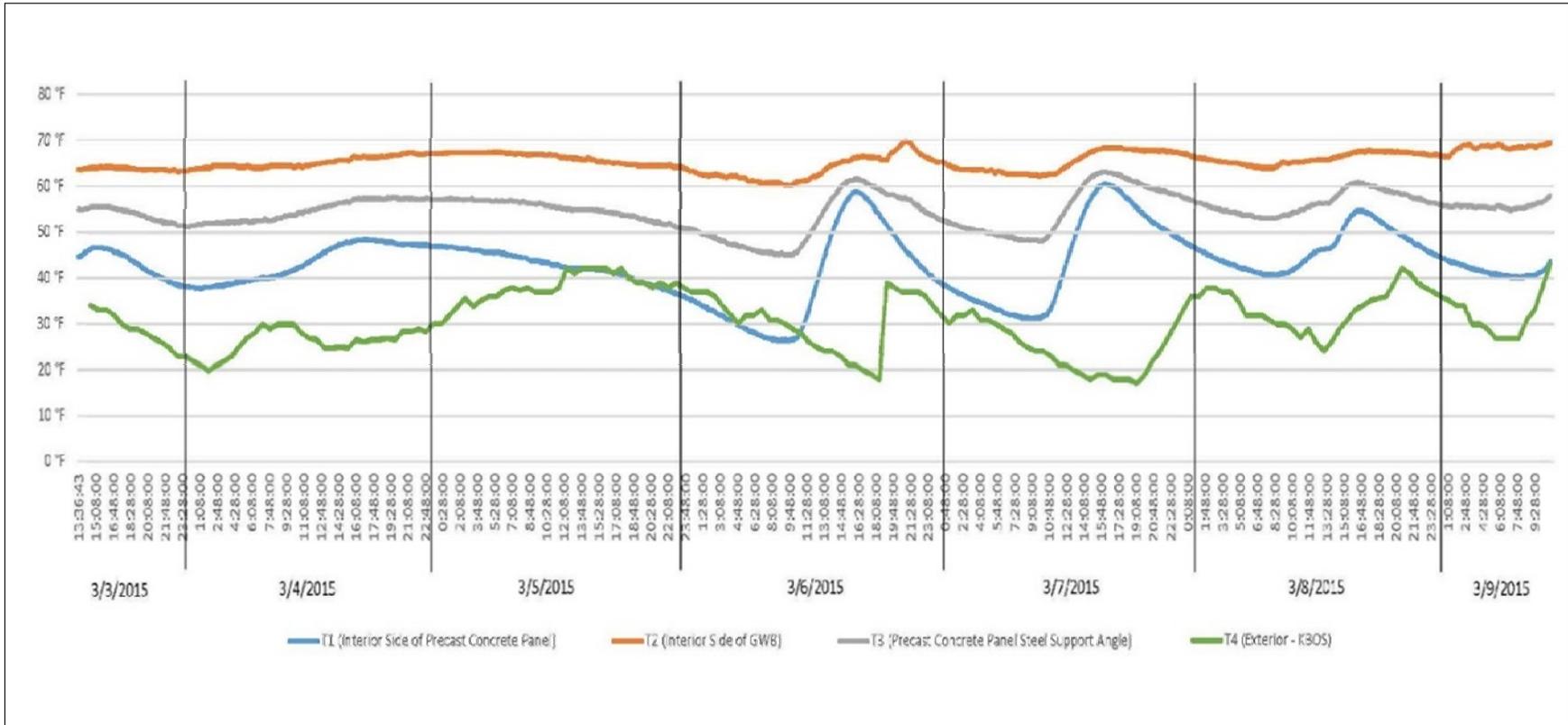
Condensation at exterior wall

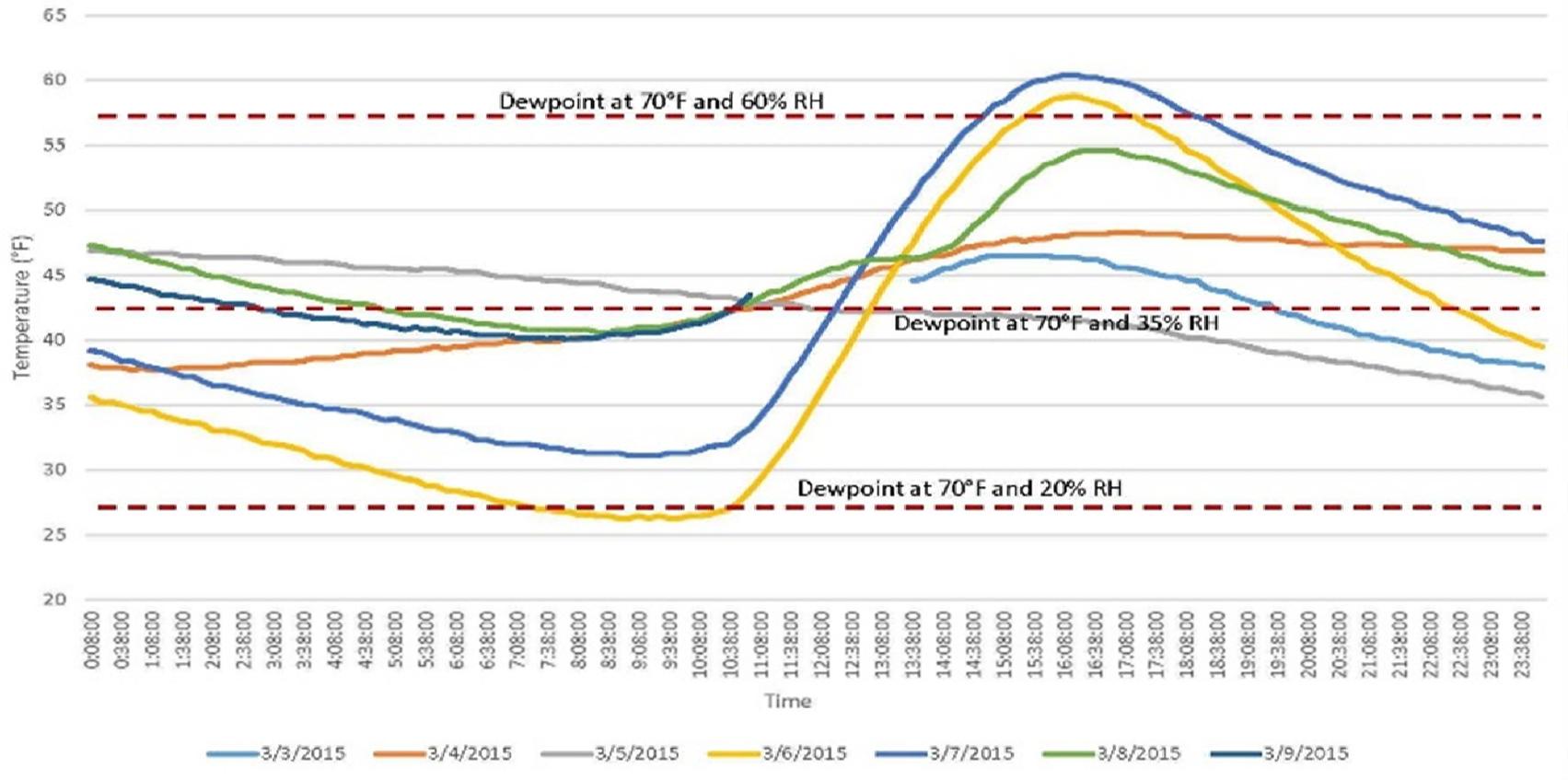
Existing Conditions

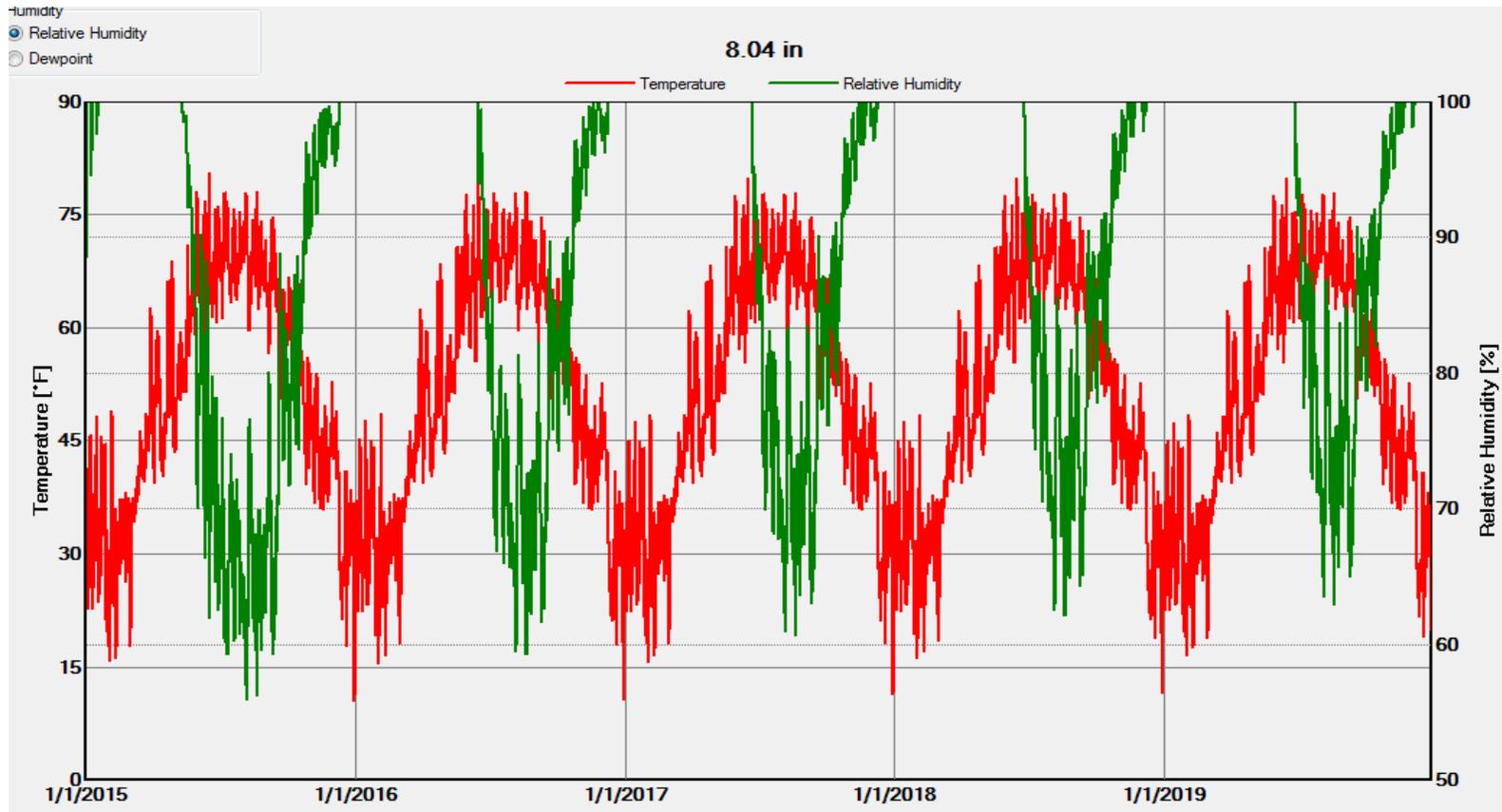




Existing Conditions

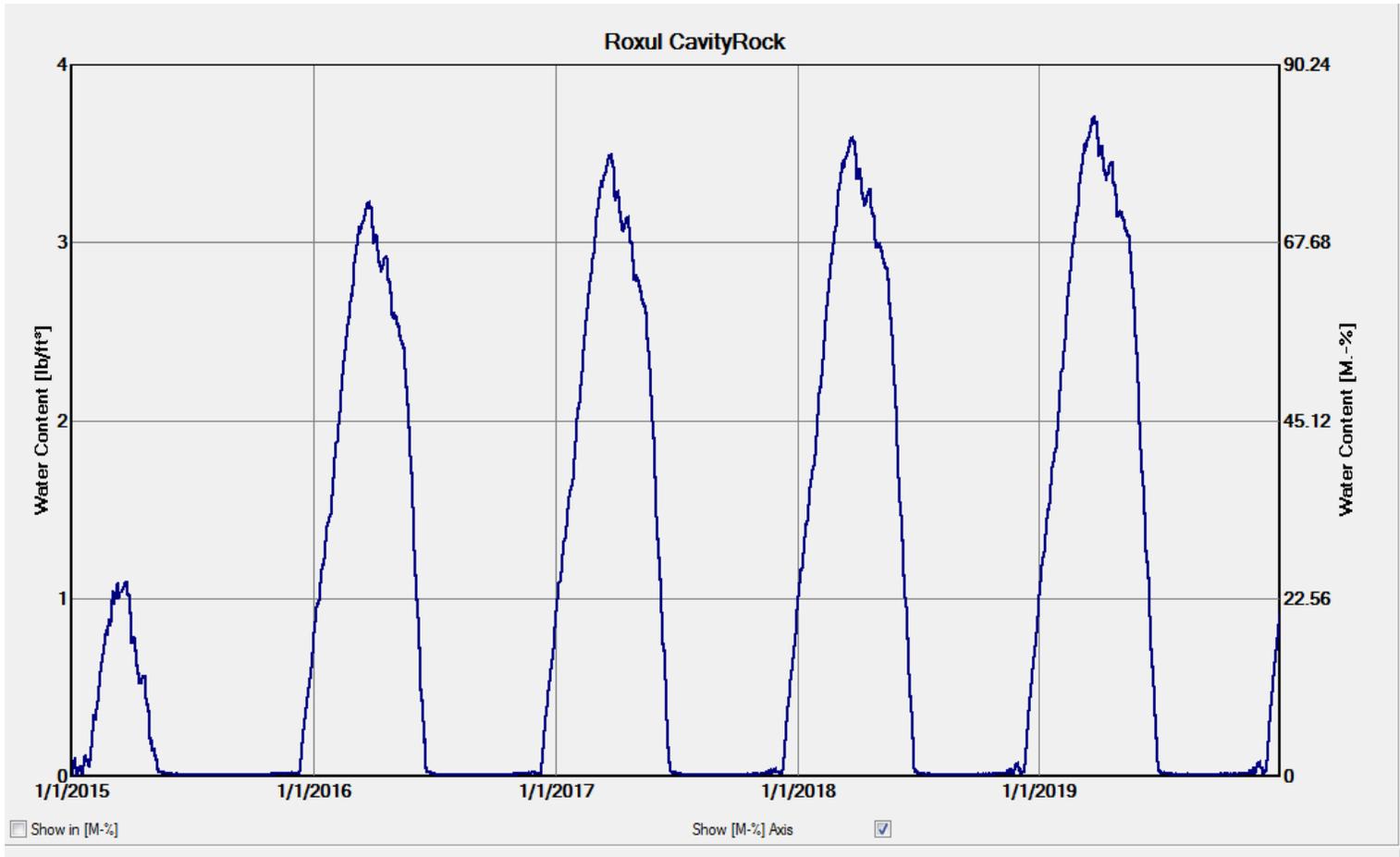






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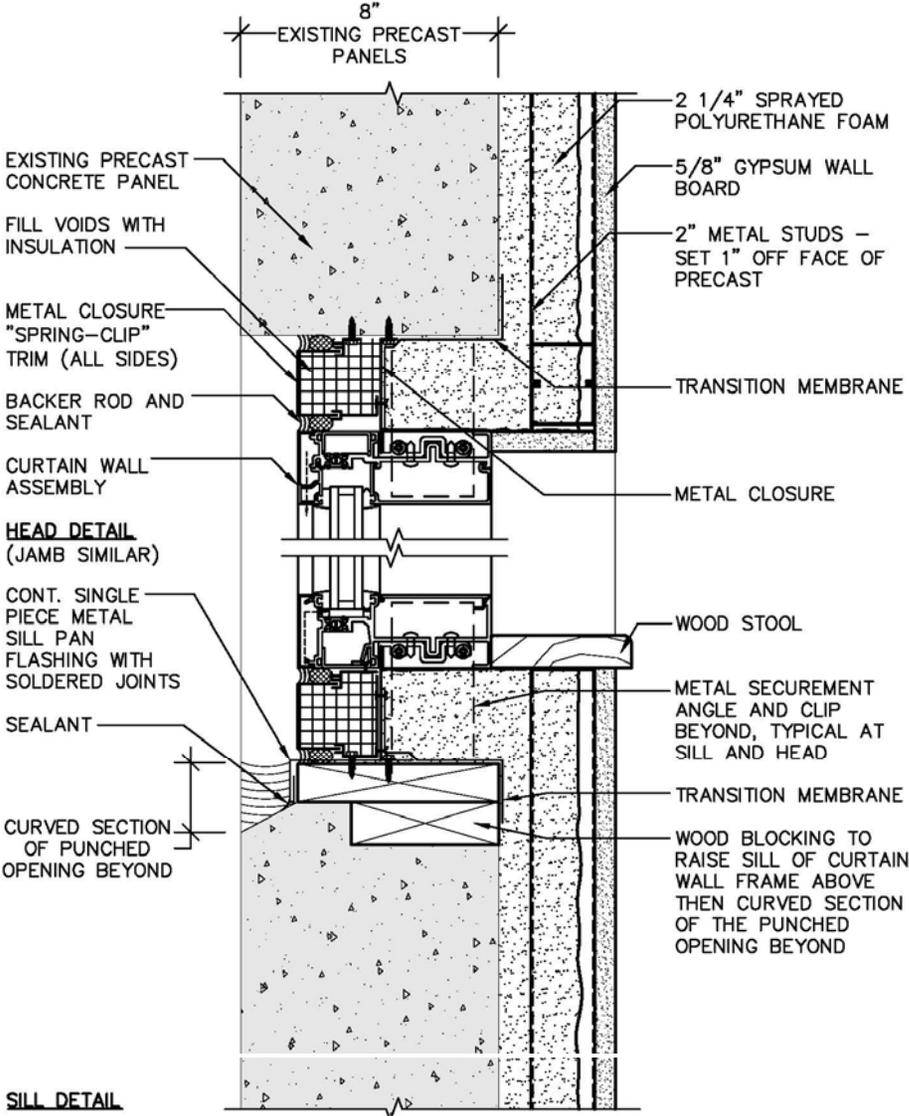
Temperature and humidity readings at the interior surface of the concrete wall. Condensation occurs when the green line tops out at the 100% RH mark.



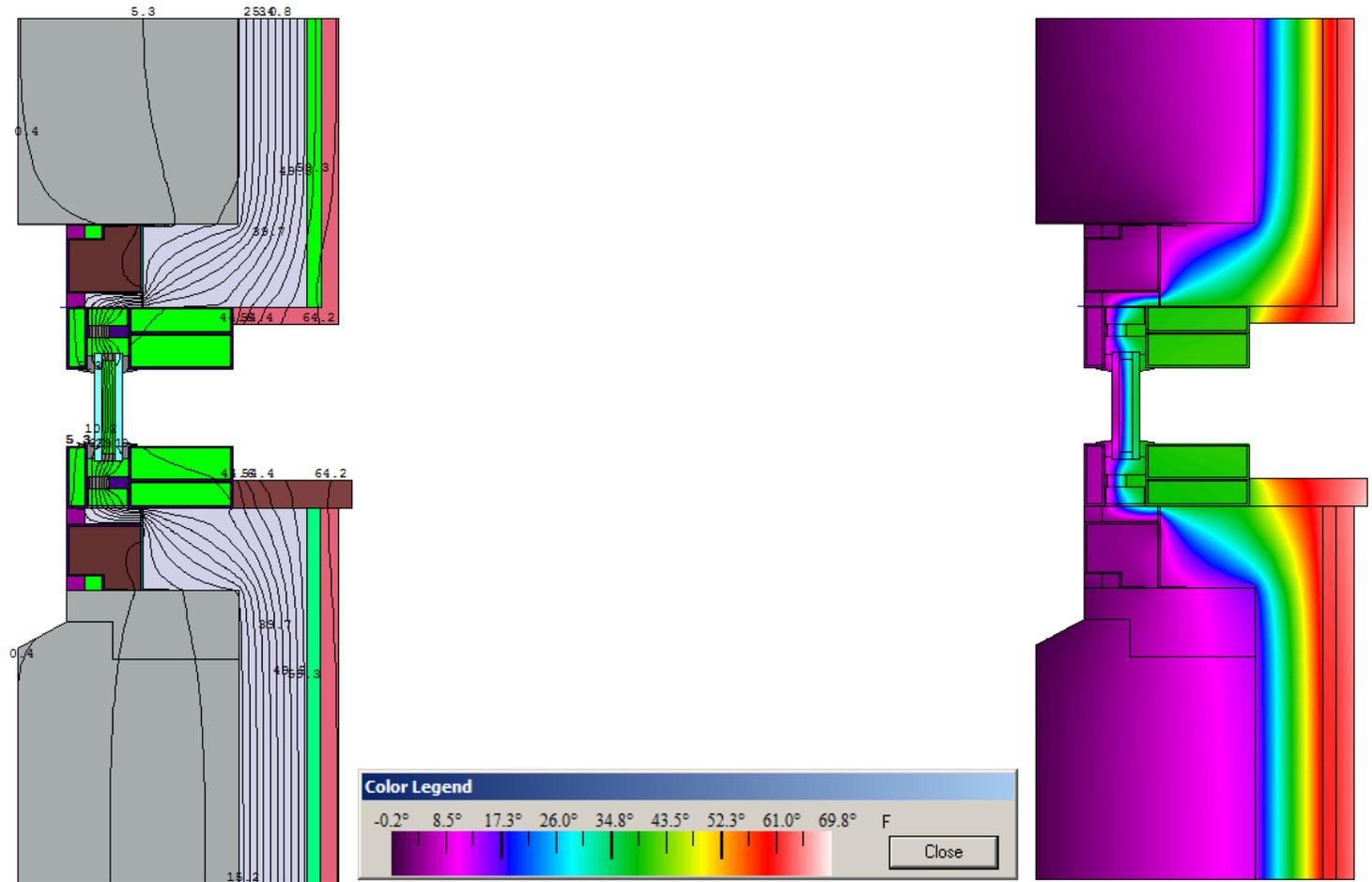
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**Increasing moisture content of the
 mineral wool each winter**

Proposed Wall Assembly



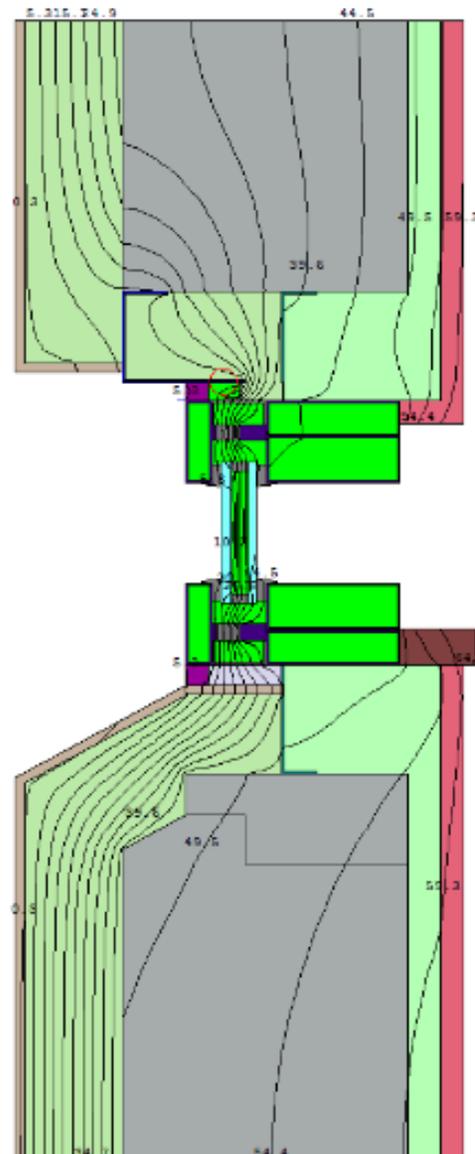
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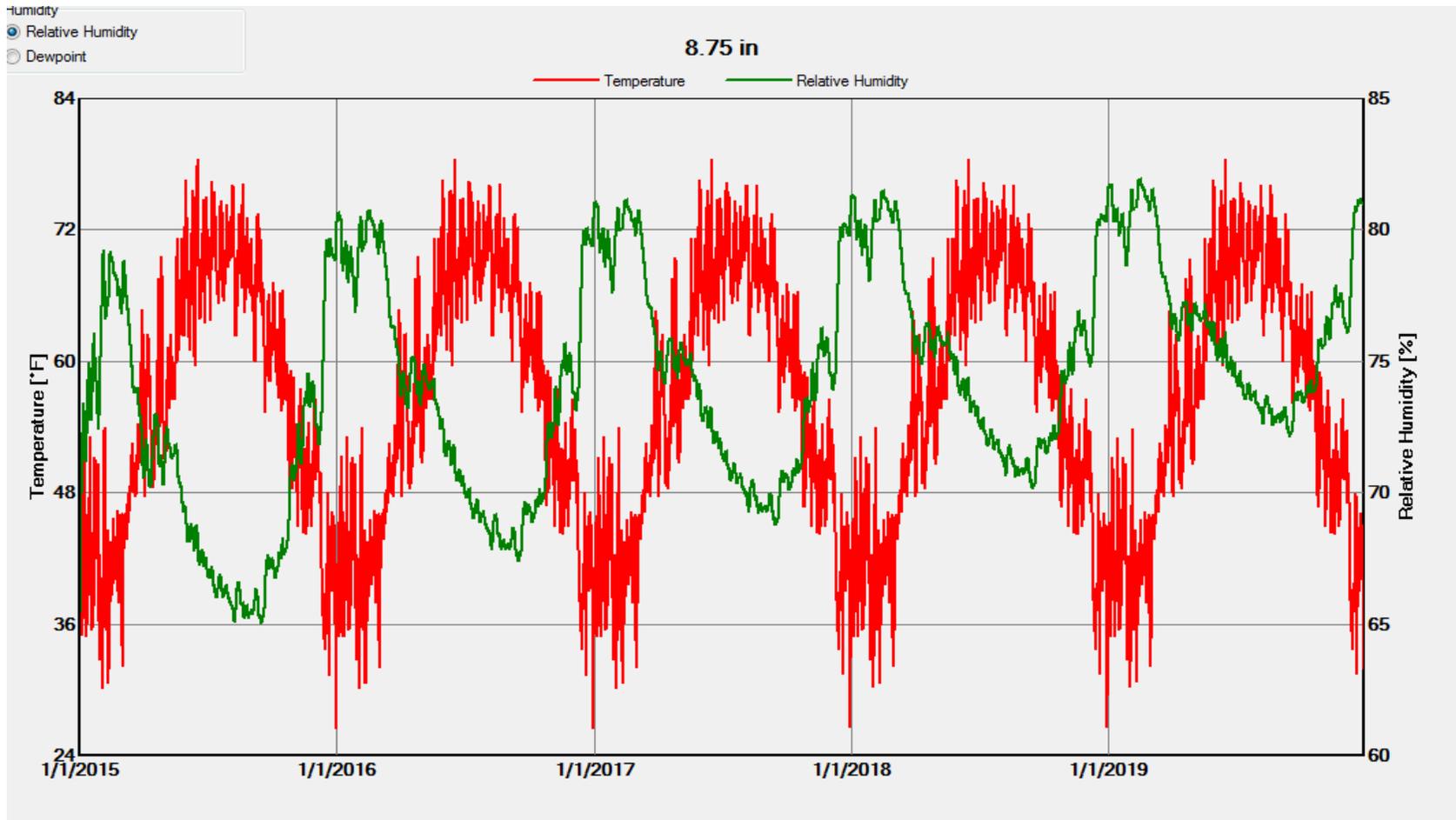


Proposed Wall Assembly

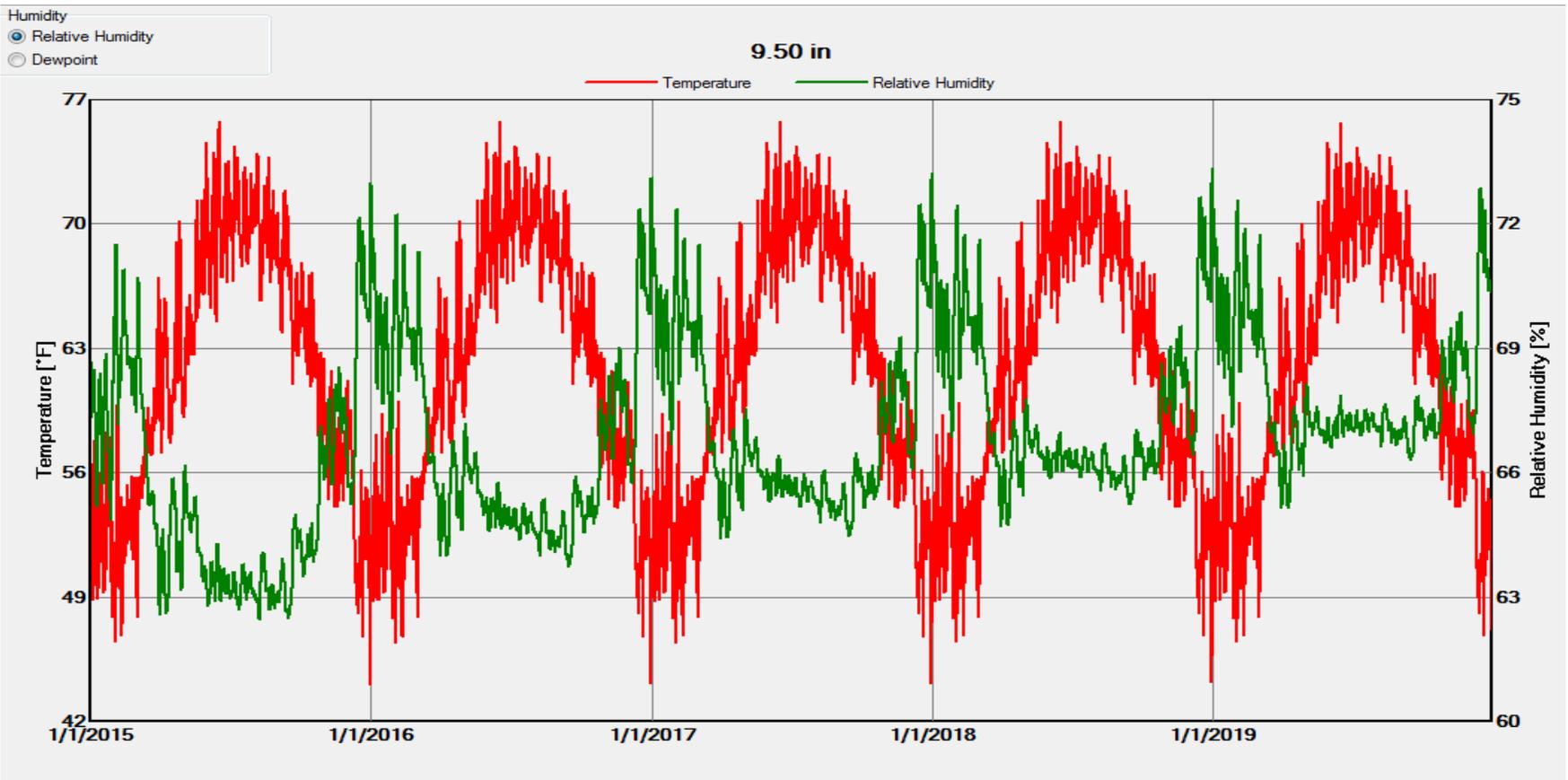
Alternate Wall Assembly

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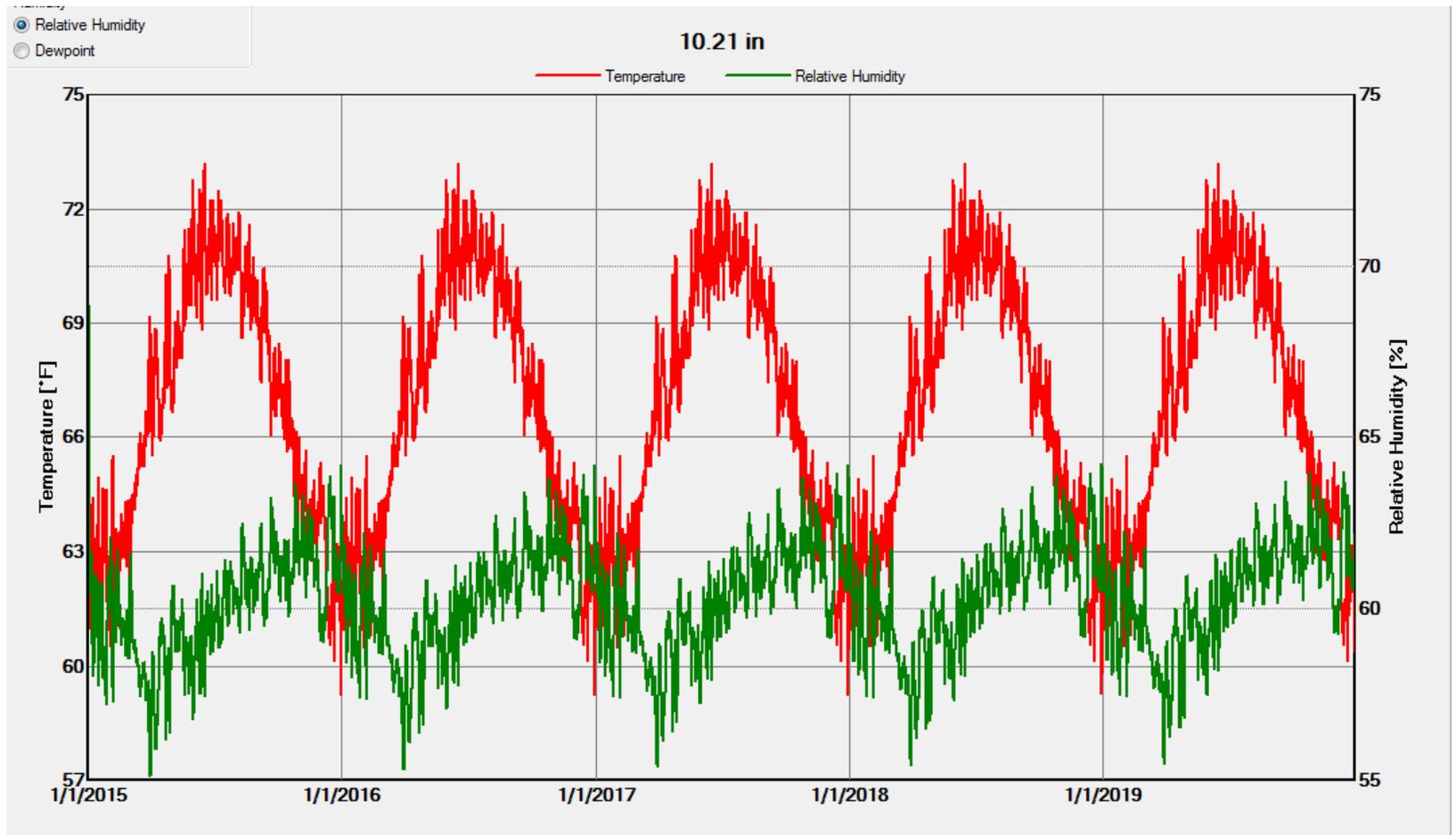


Temperature and humidity readings .75" into the SPF. Note several RH readings over 80%.

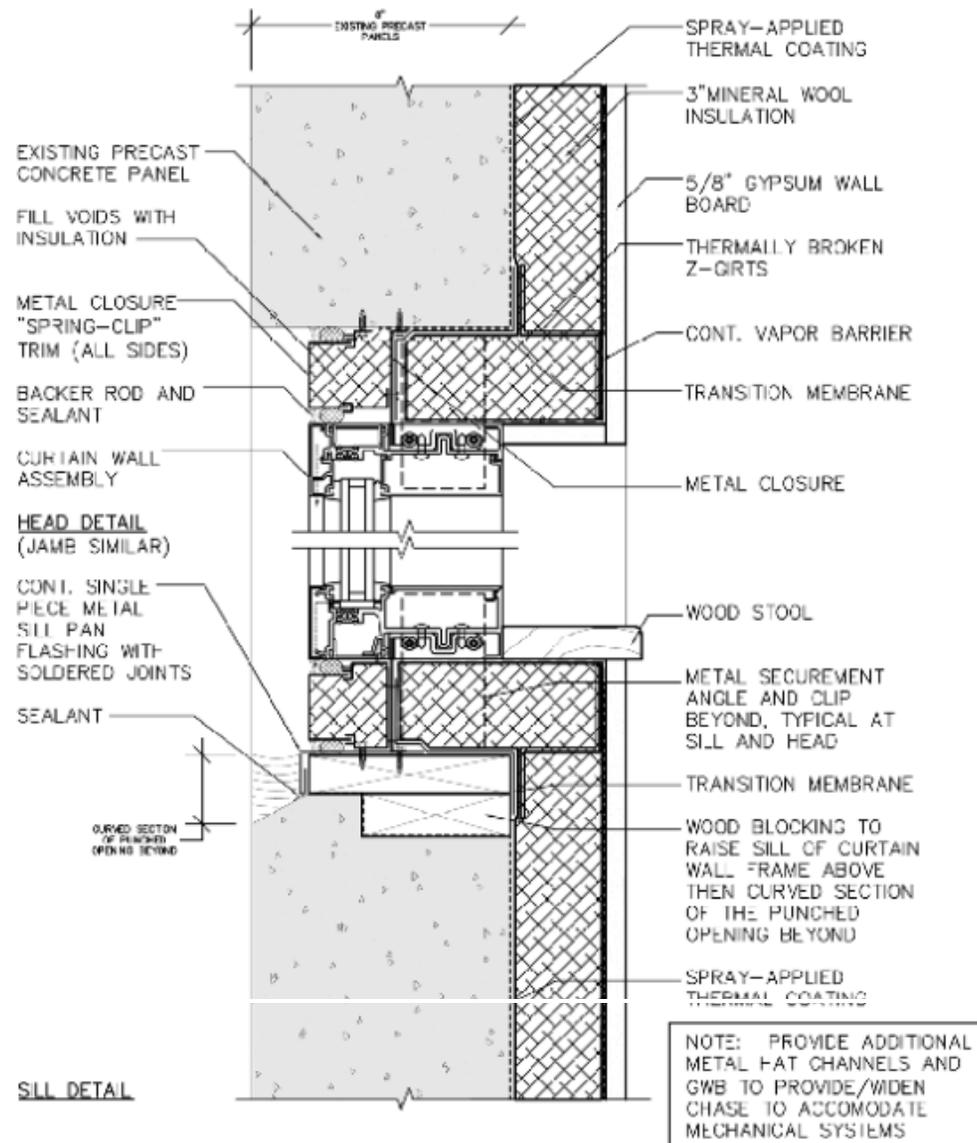


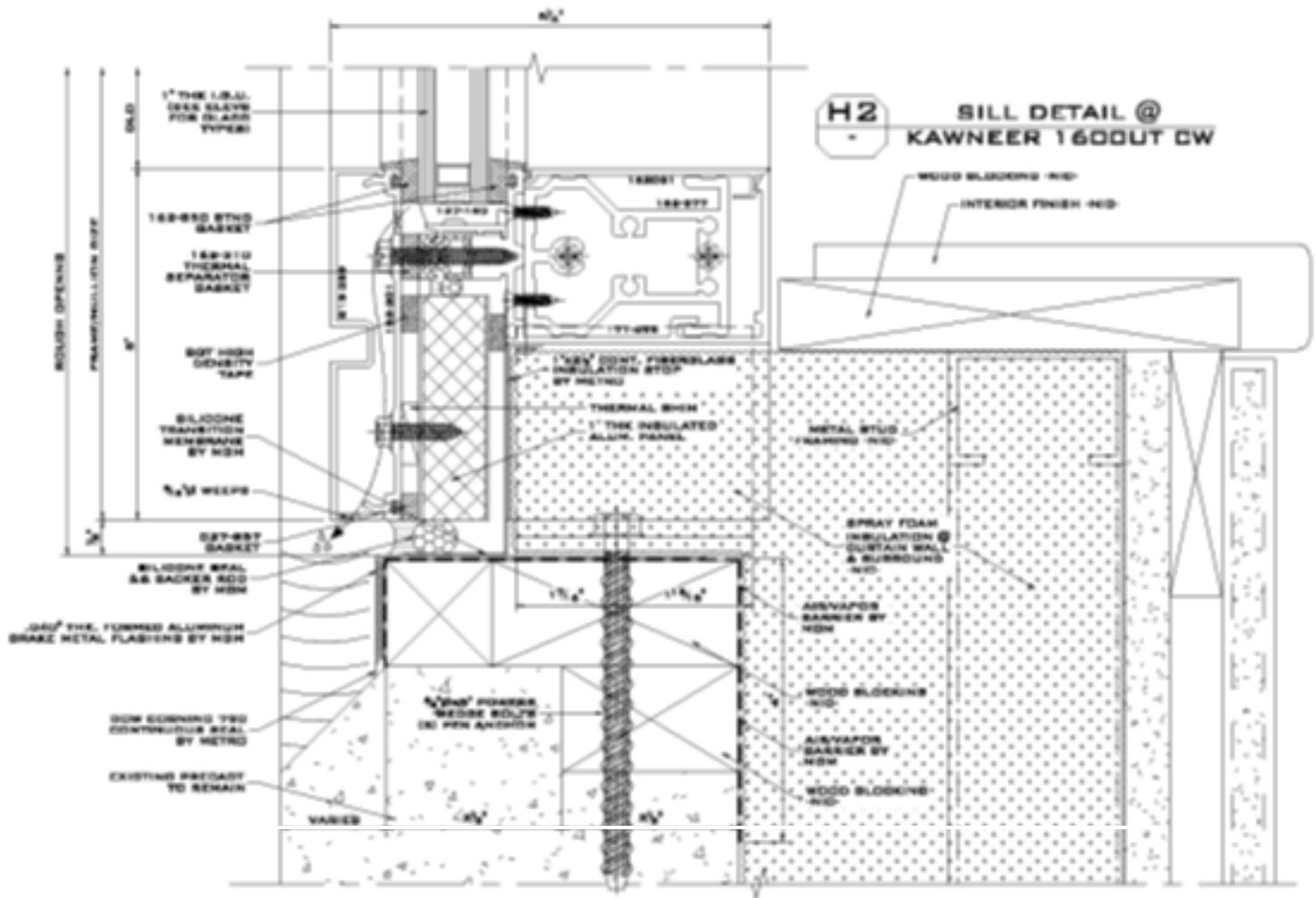
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Temperature and humidity readings 1.5” into the SPF.
 Note no RH readings over 80% and very few over 70%.



Temperature and humidity readings at interior face of the SPF. Note low RH readings close to baseline interior RH.





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Thermal Probe Locations

Interior surface of the precast concrete panel

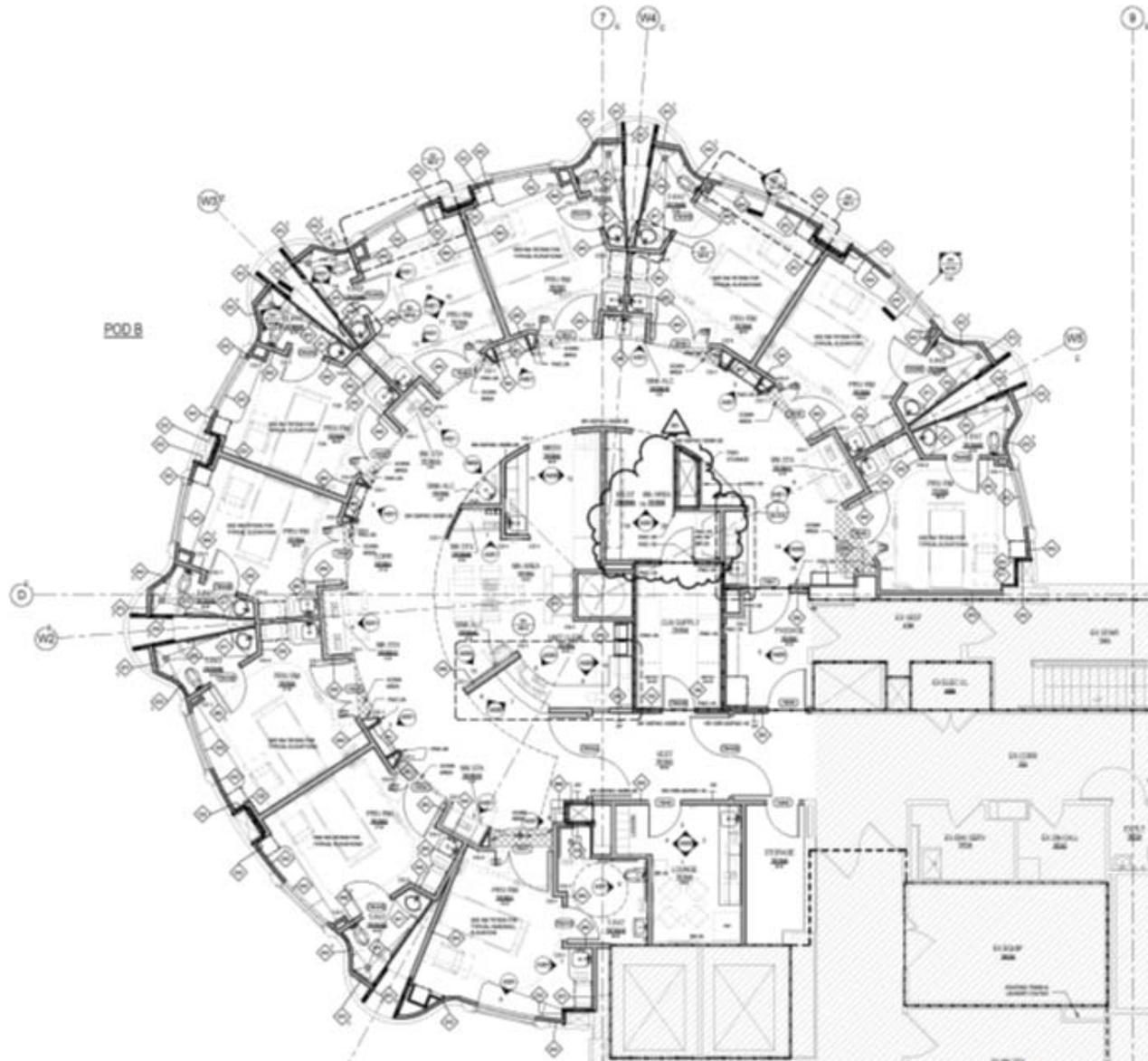
Logan International Airport Weather Station

Interior surface of the interior gypsum wall board

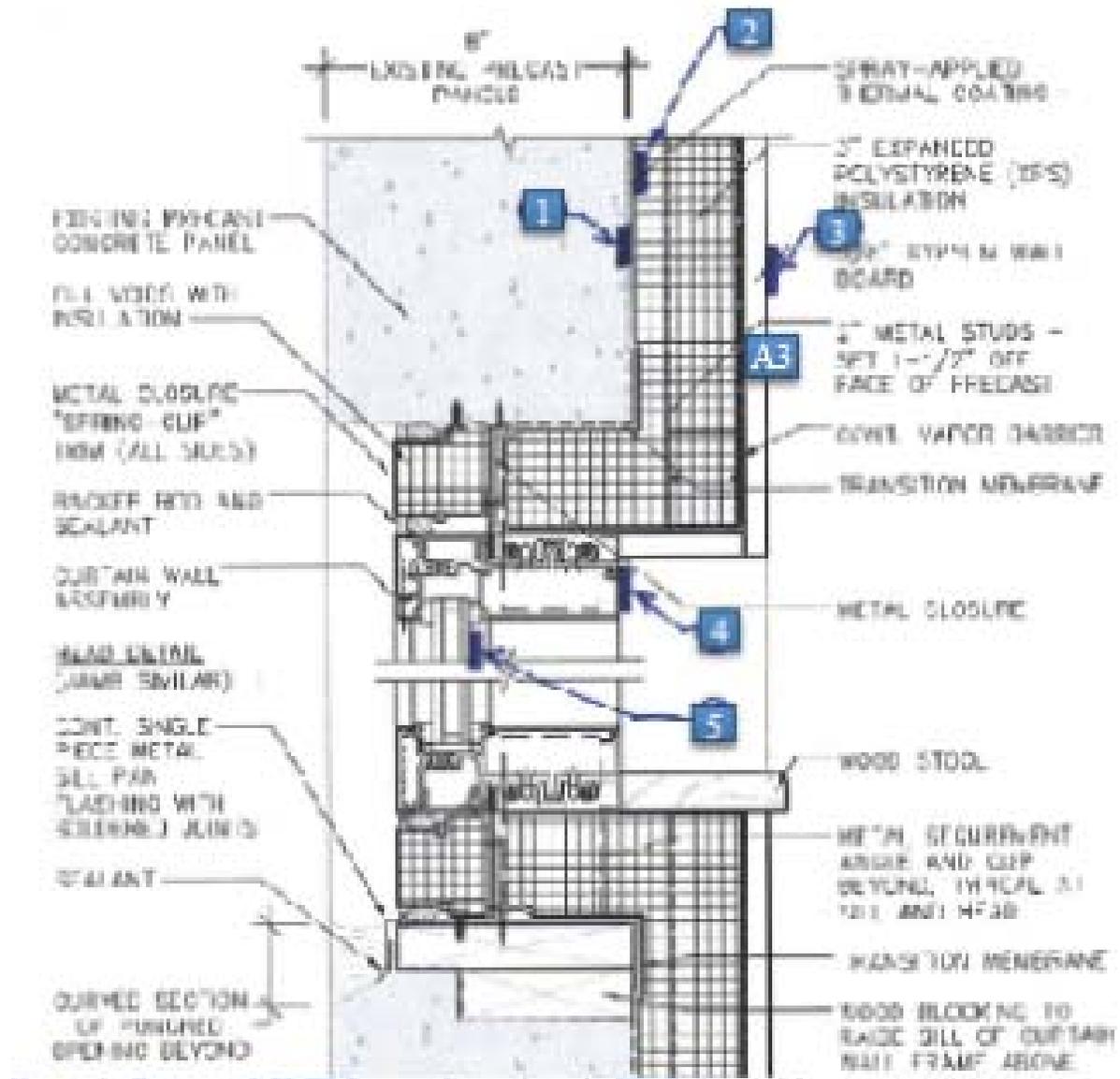
Interior surface of glazing

Surface of steel support angle for the precast panels at the floor above

Interior surface of metal frame



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Metal Stud Framed Walls



Image 9: Infrared image highlighting the thermal bridging caused by the metal studs

TABLE A3.3 Assembly U-Factors for Steel-Frame Walls

Framing Type and Spacing Width (Actual Depth)	Cavity Insulation R-Value: Rated (Effective Installed [see Table A9.2B])	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (Uninterrupted by Framing),																			
			Rated R-Value of Continuous Insulation																			
			R-1.00	R-2.00	R-3.00	R-4.00	R-5.00	R-6.00	R-7.00	R-8.00	R-9.00	R-10.00	R-11.00	R-12.00	R-13.00	R-14.00	R-15.00	R-20.00	R-25.00	R-30.00	R-35.00	R-40.00
Steel Framing at 16 in. on center																						
3.5 in. depth	None (0.0)	0.352	0.260	0.207	0.171	0.146	0.128	0.113	0.102	0.092	0.084	0.078	0.072	0.067	0.063	0.059	0.056	0.044	0.036	0.030	0.026	0.023
	R-11 (5.5)	0.132	0.117	0.105	0.095	0.087	0.080	0.074	0.069	0.064	0.060	0.057	0.054	0.051	0.049	0.046	0.044	0.036	0.031	0.027	0.024	0.021
	R-13 (6.0)	0.124	0.111	0.100	0.091	0.083	0.077	0.071	0.066	0.062	0.059	0.055	0.052	0.050	0.048	0.045	0.043	0.036	0.030	0.026	0.023	0.021
	R-15 (6.4)	0.118	0.106	0.096	0.087	0.080	0.074	0.069	0.065	0.061	0.057	0.054	0.051	0.049	0.047	0.045	0.043	0.035	0.030	0.026	0.023	0.021
6.0 in. depth	R-19 (7.1)	0.109	0.099	0.090	0.082	0.076	0.071	0.066	0.062	0.058	0.055	0.052	0.050	0.047	0.045	0.043	0.041	0.034	0.029	0.026	0.023	0.020
	R-21 (7.4)	0.106	0.096	0.087	0.080	0.074	0.069	0.065	0.061	0.057	0.054	0.051	0.049	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.022	0.020
Steel Framing at 24 in. on center																						
3.5 in. depth	None (0.0)	0.338	0.253	0.202	0.168	0.144	0.126	0.112	0.100	0.091	0.084	0.077	0.072	0.067	0.063	0.059	0.056	0.044	0.036	0.030	0.026	0.023
	R-11 (6.6)	0.116	0.104	0.094	0.086	0.079	0.073	0.068	0.064	0.060	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.035	0.030	0.026	0.023	0.021
	R-13 (7.2)	0.108	0.098	0.089	0.082	0.075	0.070	0.066	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.034	0.029	0.025	0.023	0.020
	R-15 (7.8)	0.102	0.092	0.084	0.078	0.072	0.067	0.063	0.059	0.056	0.053	0.050	0.048	0.046	0.044	0.042	0.040	0.034	0.029	0.025	0.022	0.020
6.0 in. depth	R-19 (8.6)	0.094	0.086	0.079	0.073	0.068	0.064	0.060	0.057	0.054	0.051	0.048	0.046	0.044	0.042	0.041	0.039	0.033	0.028	0.025	0.022	0.020
	R-21 (9.0)	0.090	0.083	0.077	0.071	0.066	0.062	0.059	0.055	0.052	0.050	0.048	0.045	0.043	0.042	0.040	0.038	0.032	0.028	0.024	0.022	0.020

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**Building Enclosure Function:
 base equal to 8.06; with CI, equivalent to R-16**



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IR Survey

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Test Cuts



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Test Cuts



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Construction

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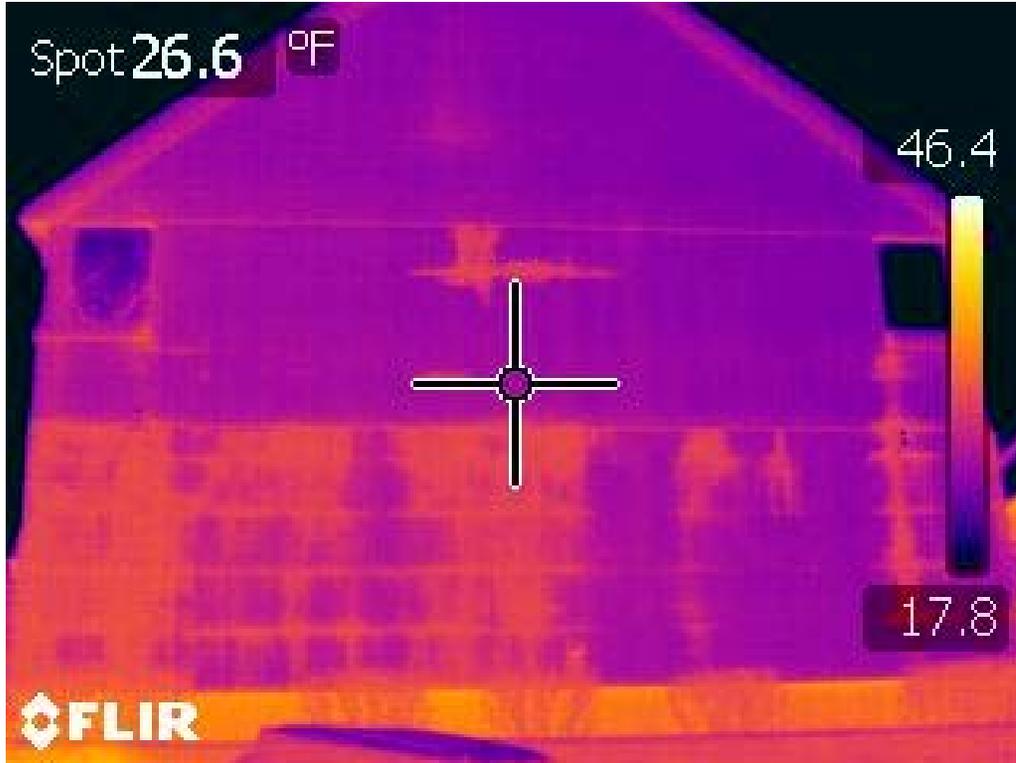
Wood Framed

Background – History

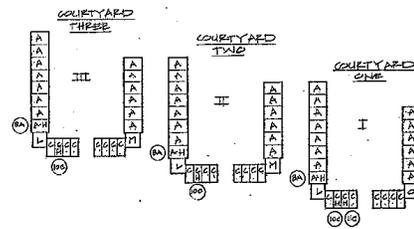
- Typical three story dorm building – east / courtyard elevation.
- Typical two story dorm buildings, photo shows the south elevation of the north wing.

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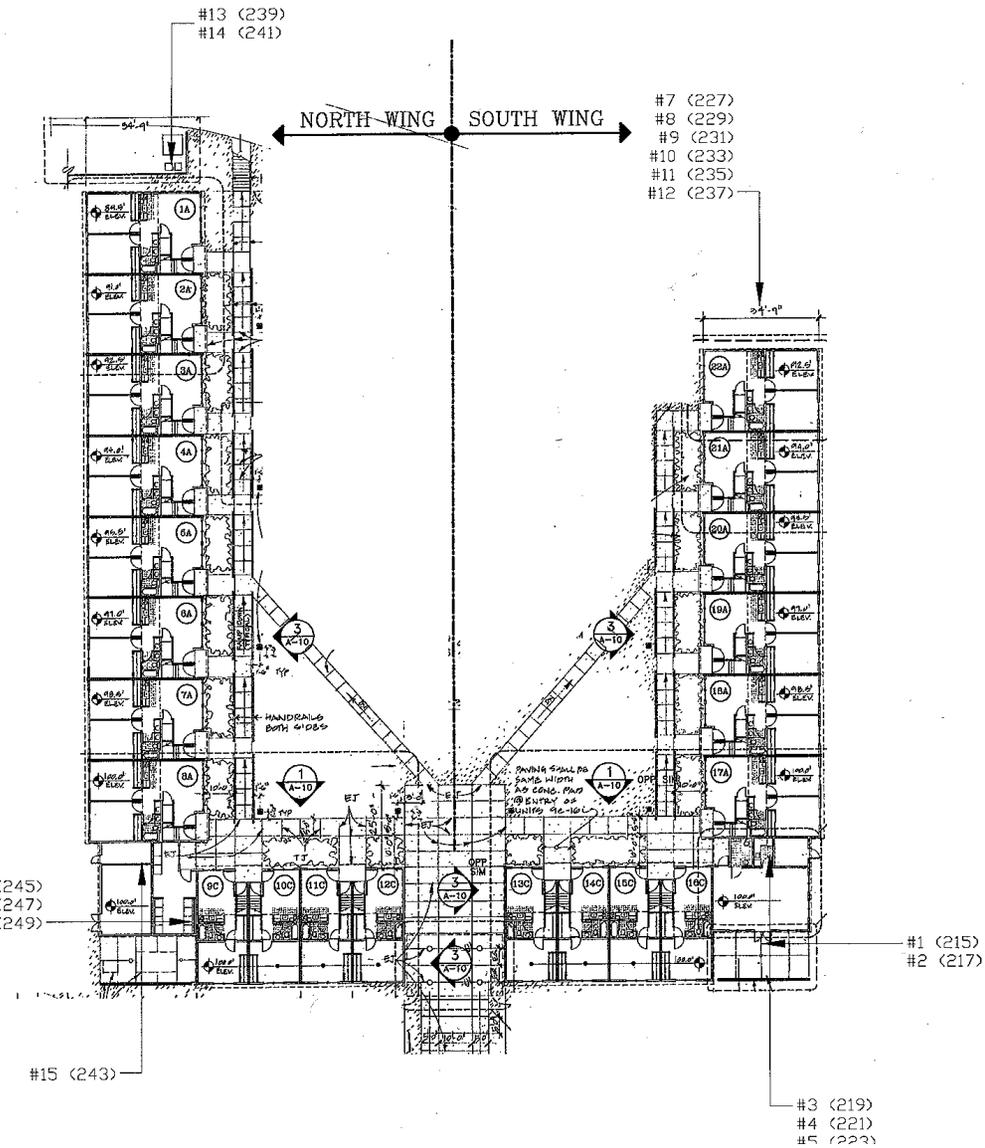


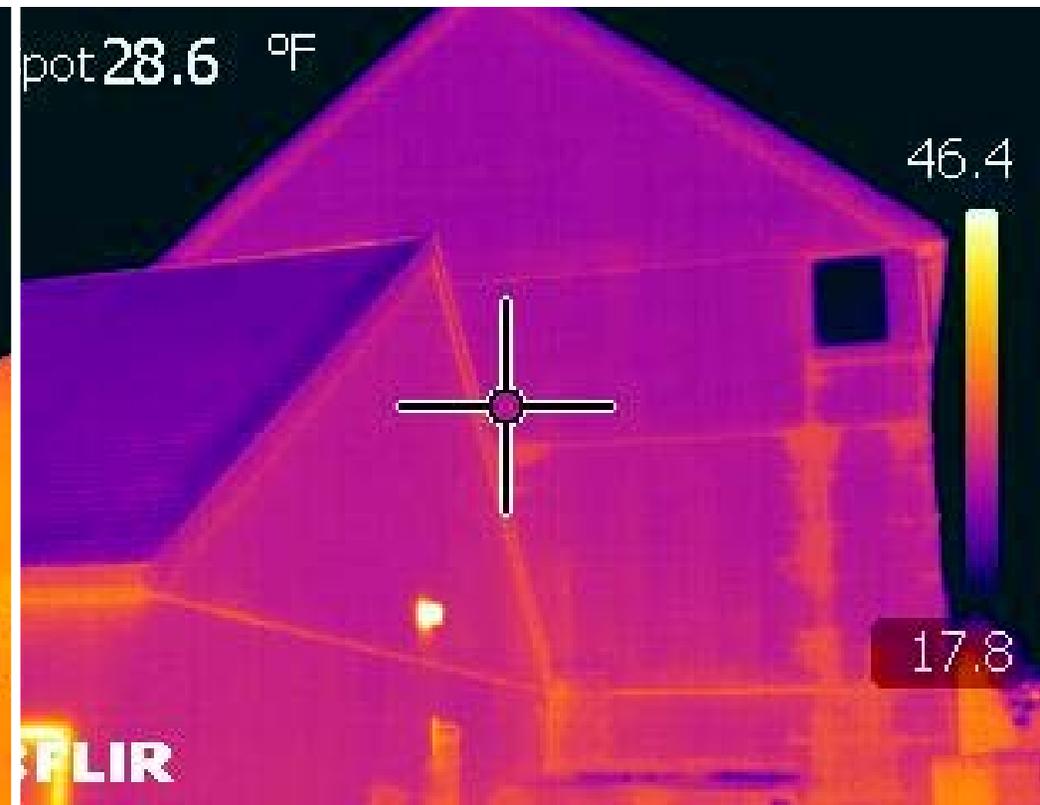


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#16 (245)
 #17 (247)
 #18 (249)





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Background – History

- The EIFS panels are cracked at the vertical joints and are bowing
- Staining of EIFS under the window.
- Open joints were observed at the horizontal sealant line.
- The EIFS is not adhered to the wall at the foundation which is wet, note water running down behind the EIFS.

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Background – History

- South wall of the south wing of Tidewater which blew off in the wind storm of April 15th and 16th, 2007.
- Prior to the storm, the EIFS wall was previously secured with fasteners by University staff.
- The EIFS is in direct contact with the shingles. Step flashing was observed behind the EIFS. The step flashing was not flashed or secured tightly to the substrate.

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Background – History

- Bowed EIFS Panel not adhered to the OSB substrate.
- Failed adhesive connections and wet substrates.

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Proposed Design

New plywood sheathing

Continuous air barrier from foundation to roof eave

Exterior insulation

Cementitious wood siding and trim

Air barrier and continuous rigid insulation on top of roof deck with vented nail board

Provide a “New England” aesthetic

Proposed Design

Budget limitations eliminated air sealing at ceiling

Air barrier tie in at eave line limited due to access

Air leakage between units not addressed

Insulation limited to 1" due to existing recessed entries

Performed under IBC 2009 (with state modifications)

Plywood installed as sheer wall to comply with current code requirements

Proposed Design

New cellulose insulation R-21 equivalent to R16.3 ci when framing taken into account

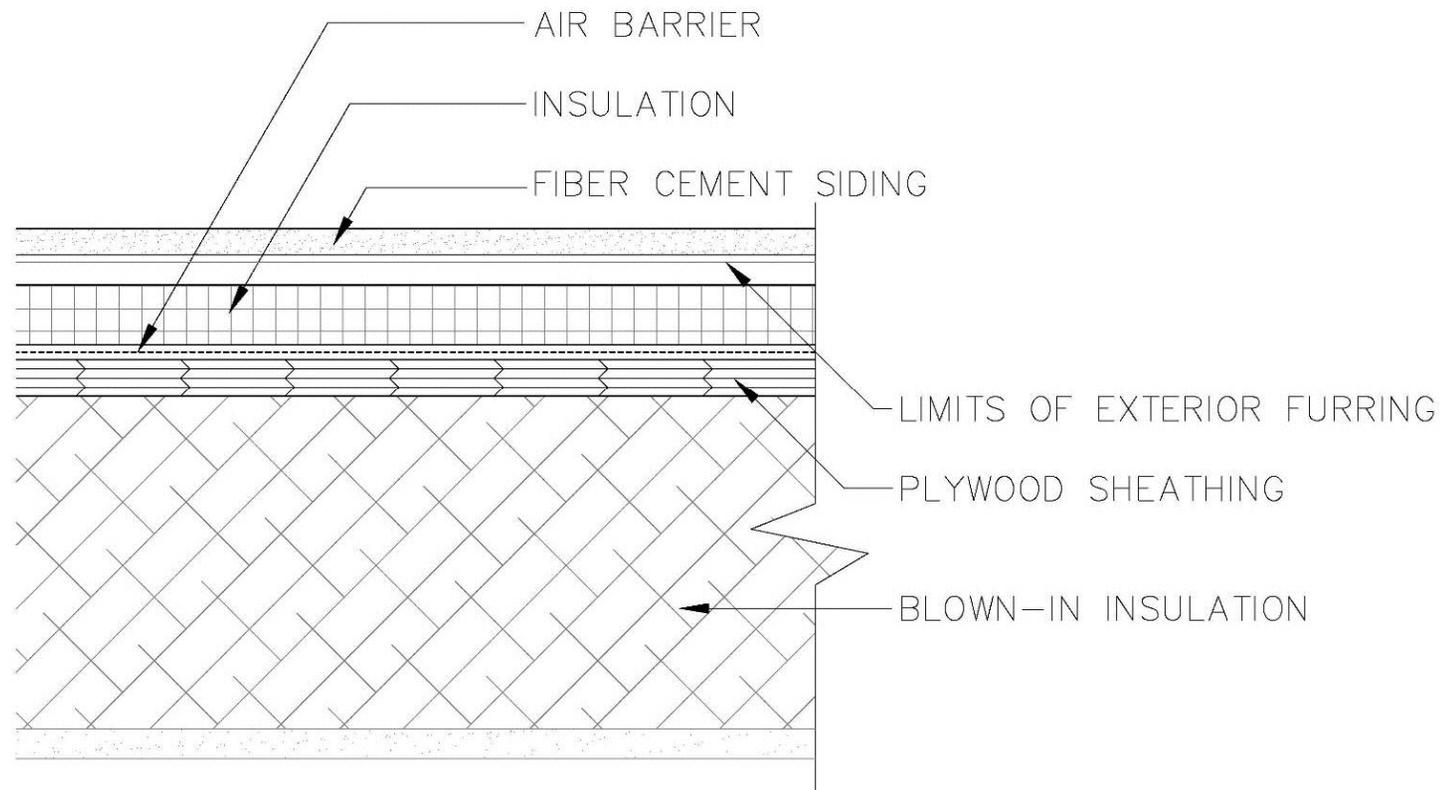
Insulation R-value of 6.5; wood furring with R-1.875 reduces total exterior R-value to approximately R-5.49

System R-value is 24.07 or U-value of 0.0415

Wall System Components	Existing Building	Existing Building	New Building	
Exterior Air Film	0.17	0.17	0.17	
Fiber Cement Siding	N/A	N/A	N/A	
2" EIFS Exterior	8	4	N/A	
1" Foil-Faced Polyisocyanurate (R6.5)	N/A	N/A	5.49	
Plywood Sheathing	0.94	0.94	0.94	
Air Barrier (negligible)	N/A	N/A	N/A	
6" Blown-in Cellulose Insulation	N/A	N/A	21	
6" Fiberglass Batt Insulation (R19)	15.3	15.3	N/A	
Gypsum Sheathing (5/8")	0.56	0.56	0.56	
Interior Air Film	0.61	0.61	0.61	
Total R Value	25.58	21.58	24.07	CODE
Total U Value (1/R)	0.039	0.046	0.042	0.064

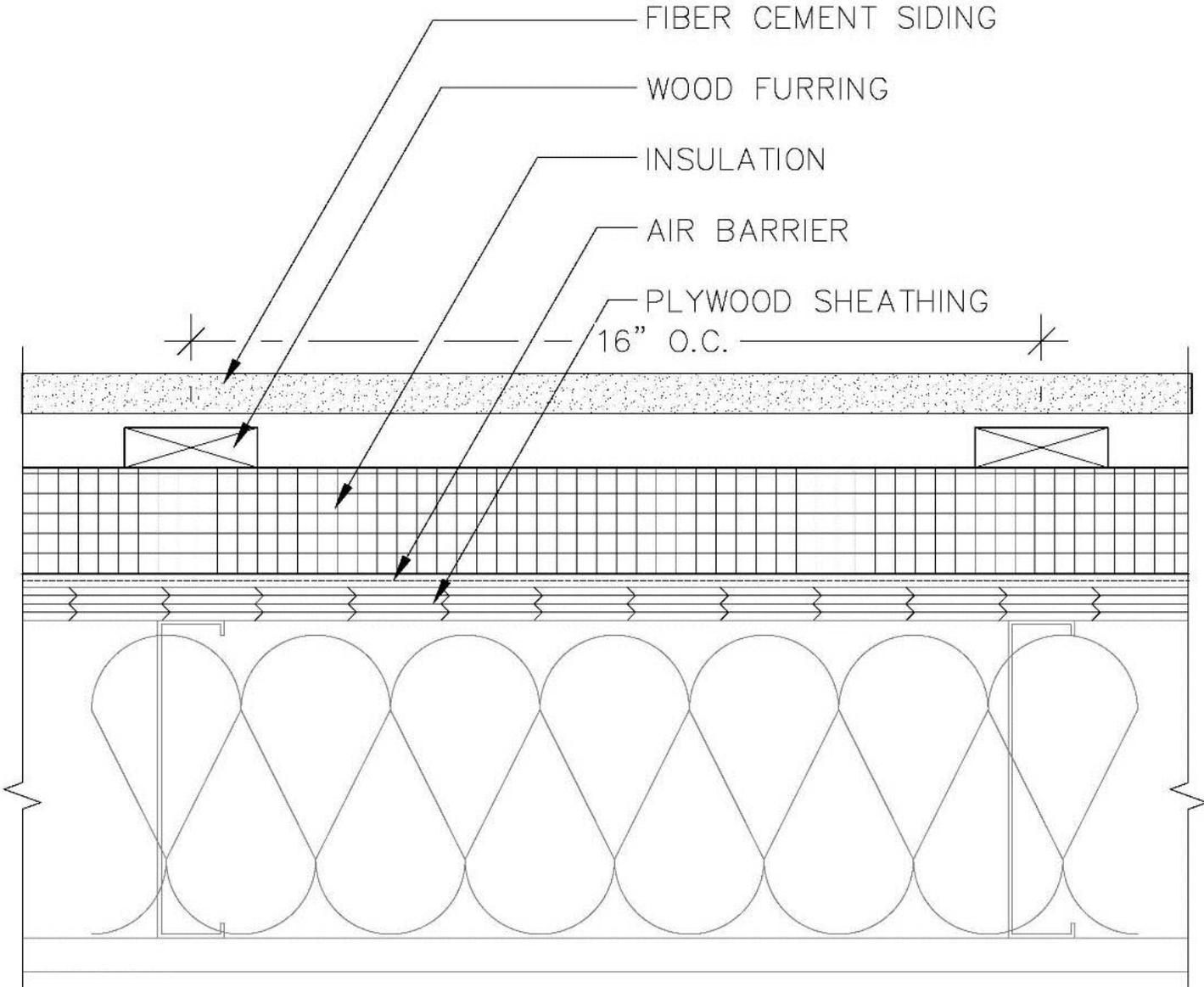
Wall System

- Siding attached through furring and into existing wood studs
- Insulation between furring members



Preferred Design

- Siding attached through furring and into existing wood studs
- Insulation continuous behind furring members



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Design Requirements

- State/Local Building Codes
- Product Manufacturers

		Recommended Fastener Spacing									
		Maximum Allowable Cladding Weight (psf) to be Supported									
		10	15	20	25	30	10	15	20	25	30
Stud Spacing	Foam Thickness	Fastener Spacing When Using $\frac{3}{4}$ " x 3- $\frac{1}{2}$ " Wood or WSP Furring					Fastener Spacing When Using $\frac{3}{8}$ " WSP Sheathing				
16	1										
	1.5		24 o.c.			16 o.c.					
	2				16 o.c.	12 o.c.		12 o.c.			
	3			16 o.c.	12 o.c.						8 o.c.
	4			12 o.c.	8 o.c.					8 o.c.	6 o.c.
24	1										
	1.5		24 o.c.			16 o.c.		12 o.c.			
	2					12 o.c.		8 o.c.			8 o.c.
	3			16 o.c.	12 o.c.	8 o.c.			8 o.c.		6 o.c.
	4	16 o.c.								6 o.c.	NA

Figure courtesy of Fastenmaster

Allowable Design Wind Pressure

Furring or WSP Installation Condition	Min. 1x4 Wood Furring at 16" o.c.				Min. 1x4 Wood Furring at 24" o.c.				Min. 3/8" WSP and 16" o.c. studs			Min. 3/8" WSP and 24" o.c. studs		
	24	16	12	8	24	16	12	8	12	8	6	12	8	6
HeadLok Fastener Spacing in Furring or Sheathing (in)	24	16	12	8	24	16	12	8	12	8	6	12	8	6
Connection Allowable Design Wind Pressure (PSF)	49	73	98	147	33	49	65	98	49	73	98	33	49	65

- 1) Wood framing and furring shall be minimum Spruce-Pine-Fir or any species with specific gravity, G, of 0.42 or greater.
- 2) Connection allowable design wind pressure applies to connection resistance only and shall meet or exceed design wind pressure.
- 3) Wood framing, furring, and sheathing shall be of adequate size, species, and grade to resist design loads and requirements in accordance with the applicable building code.
- 4) Where required by applicable building code, adequate resistance of connections and materials to seismic forces shall be provided based on local seismic ground motion hazard and the weight of the supported cladding system.

Figure courtesy of Fastenmaster



Manufacturer's design wind pressure requirements

Insulation Attachment

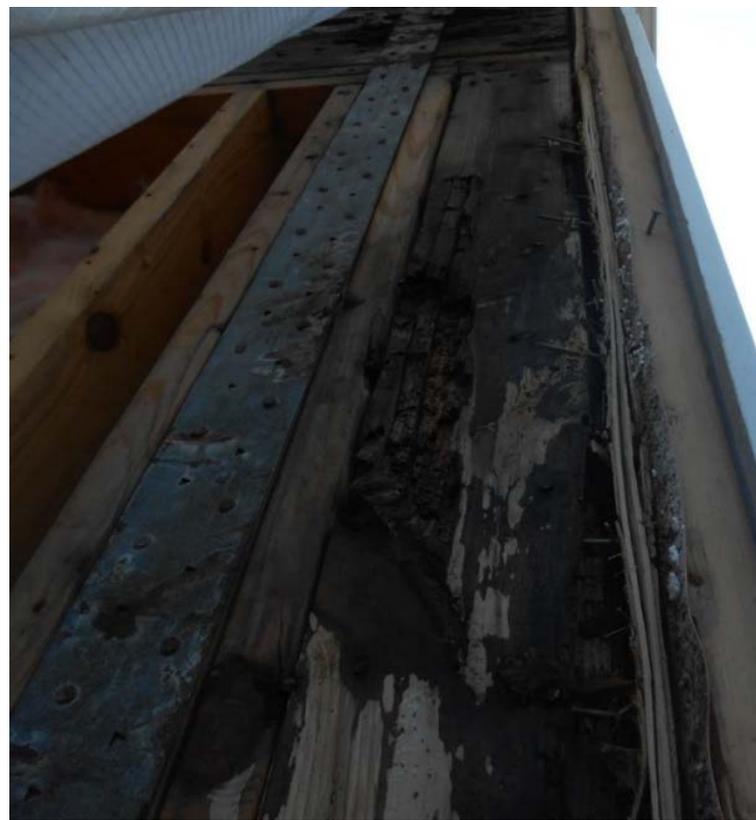
■ Design Requirements:

- Recent research indicates that installation of claddings of ≤ 5 psf through up to 8” thickness of insulation does not create short or long-term deflection or creep issues.
- Wood, metal, vinyl and fiber cement siding ≤ 5 psf typically
- Insulation between furring and exterior wall sheathing provides increased capacity for:
 - a) Rotational resistance
 - b) Vertical movement resistance

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Construction

Testing

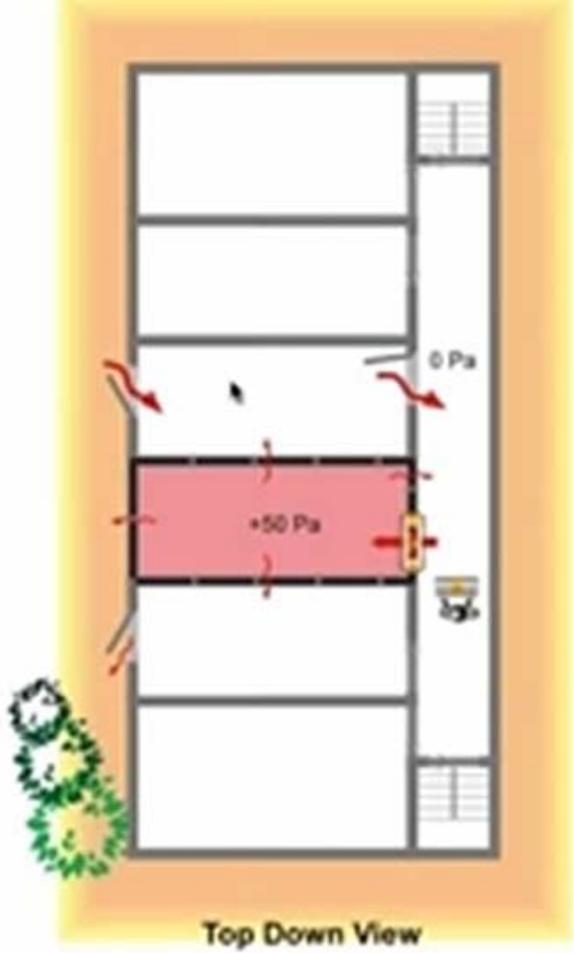
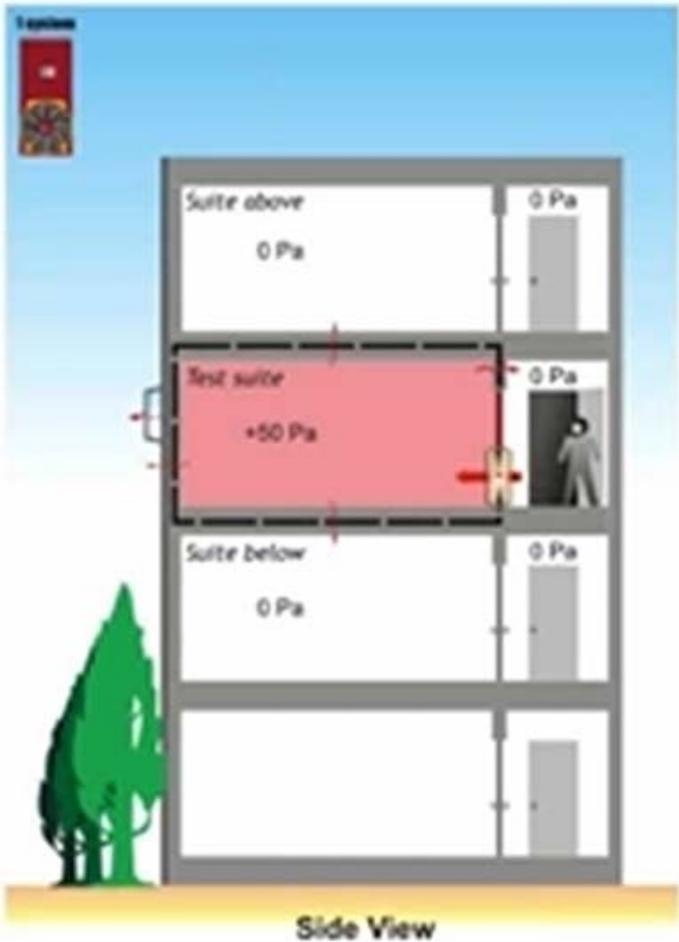
After Year 1 –
Phase 1

Complex 2
undergoing
renovations

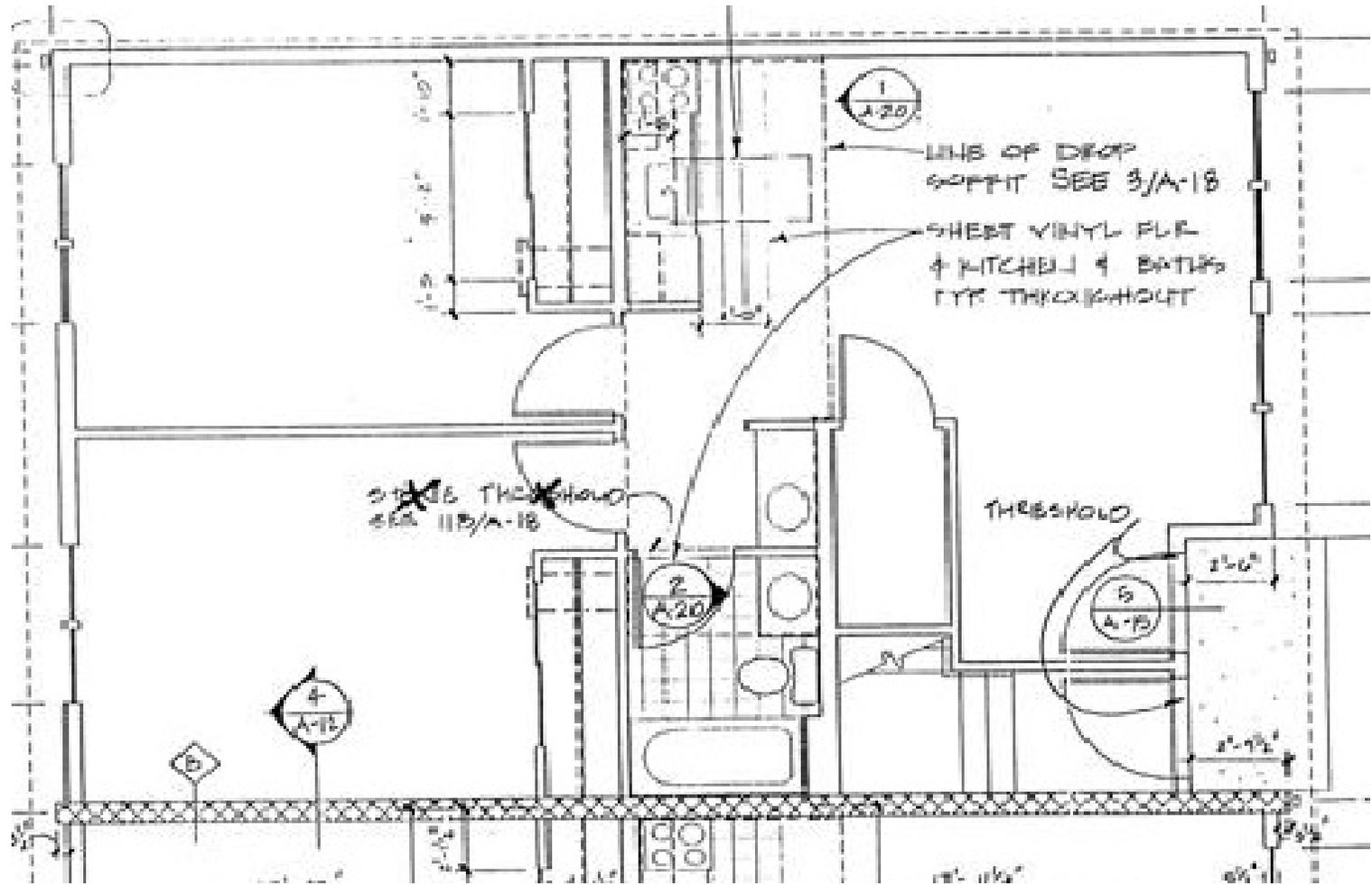
Complex 1
renovations
complete

Complex 3
awaiting
renovations

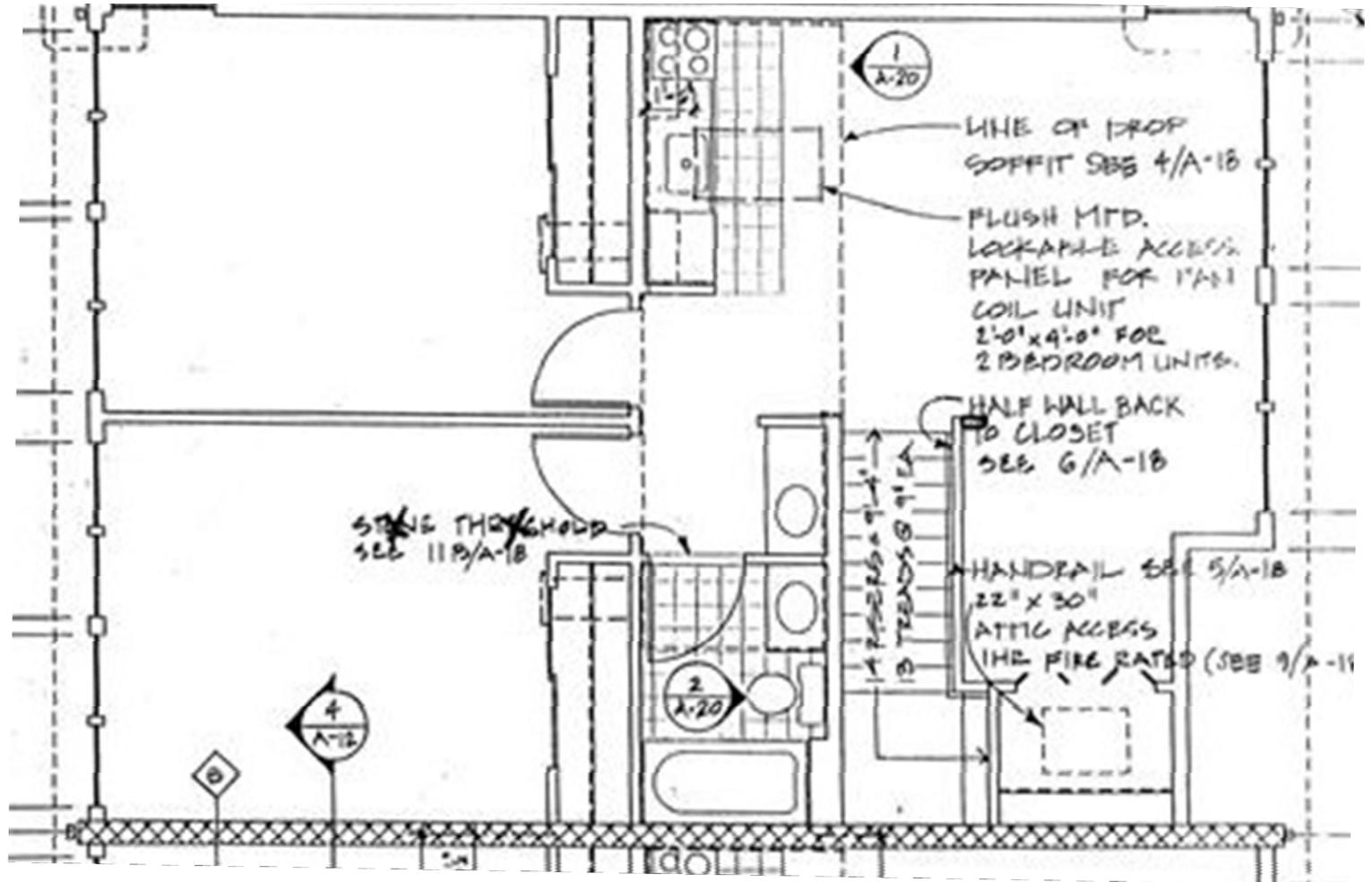
Testing ASTM 779-10



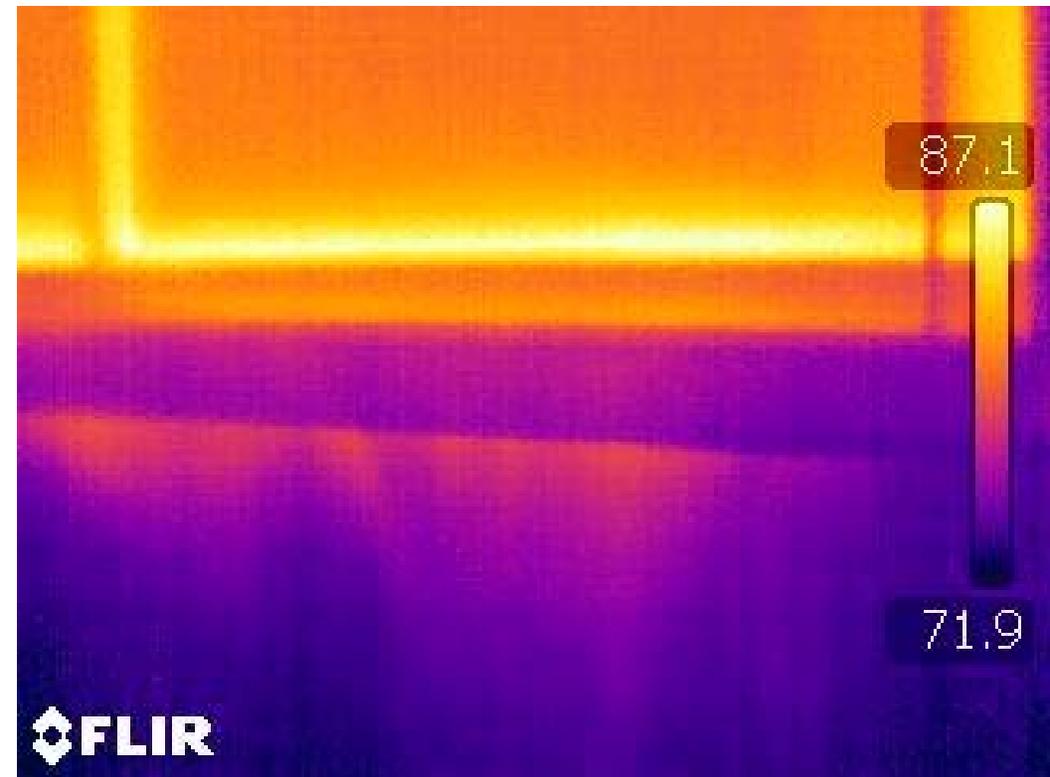
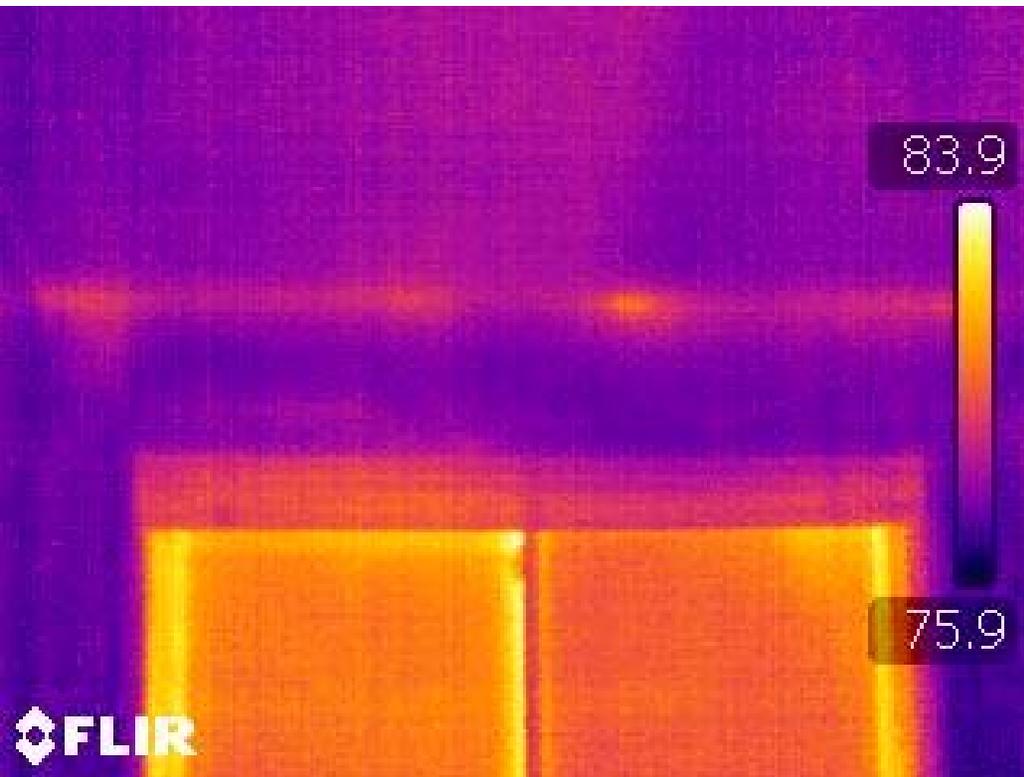
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Unit Plan 1st Floor

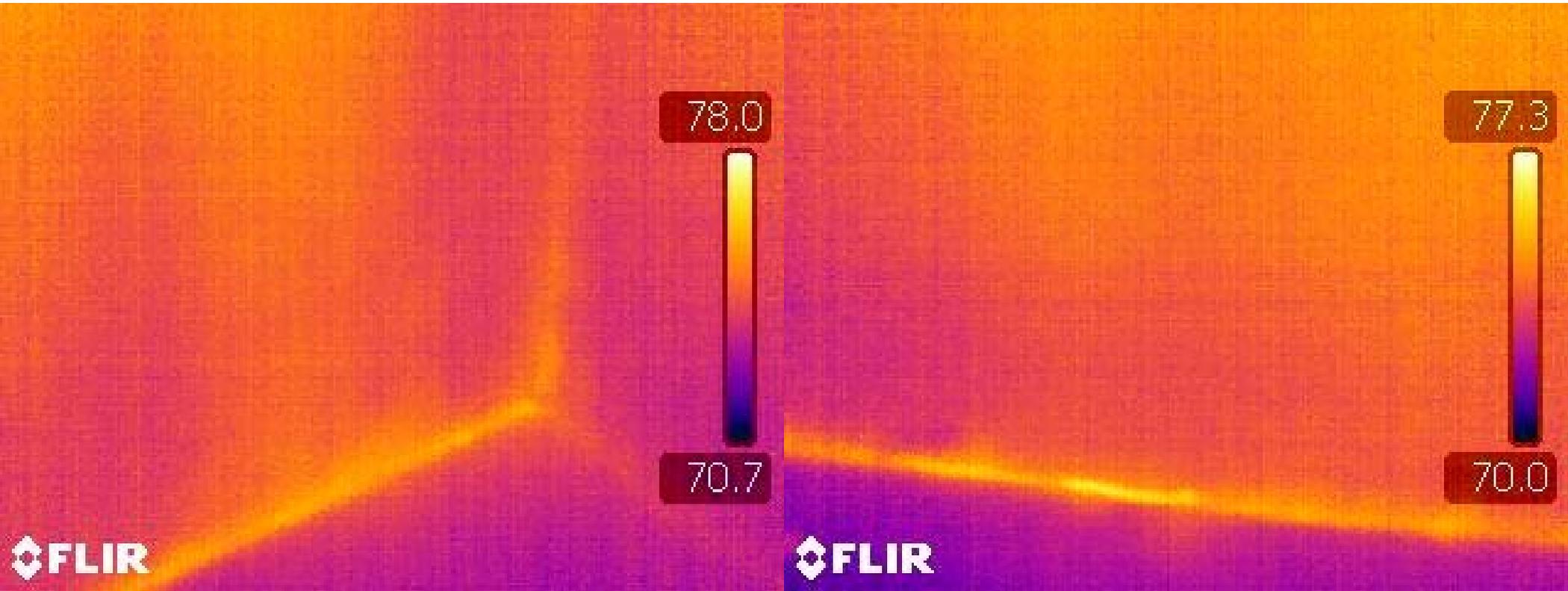


Unit Plan 2nd Floor



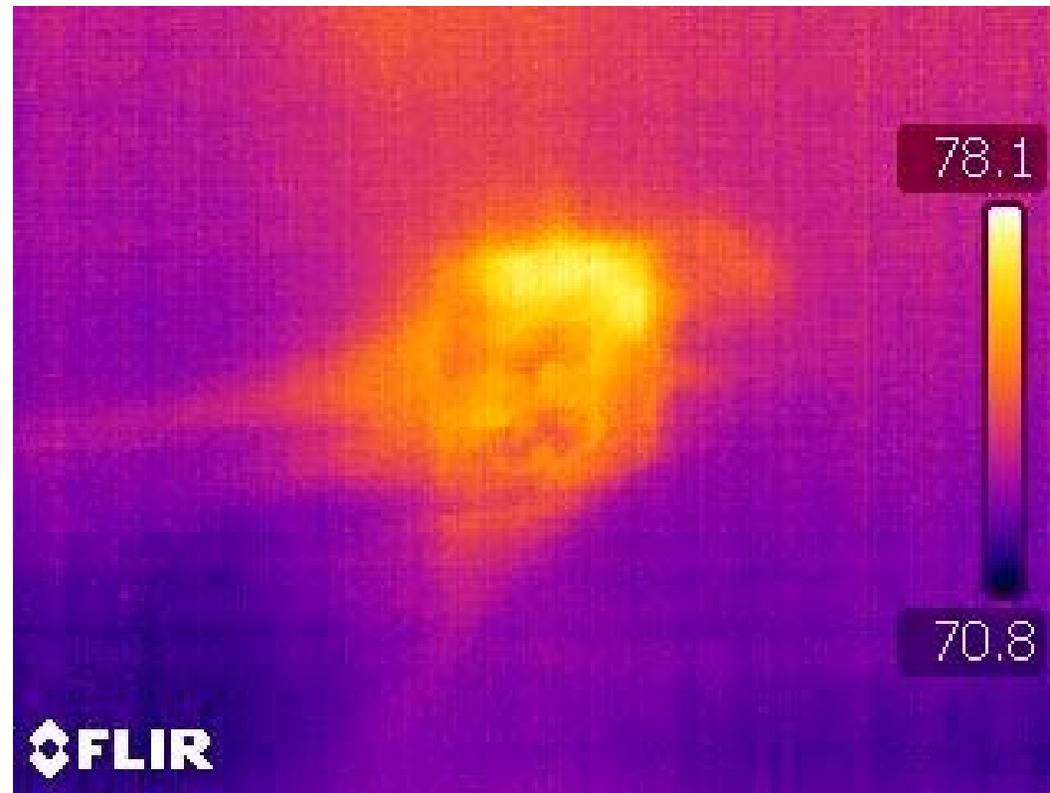
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Air Infiltration at Penetrations



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Air Infiltration at Floor



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Air Infiltration at Penetrations



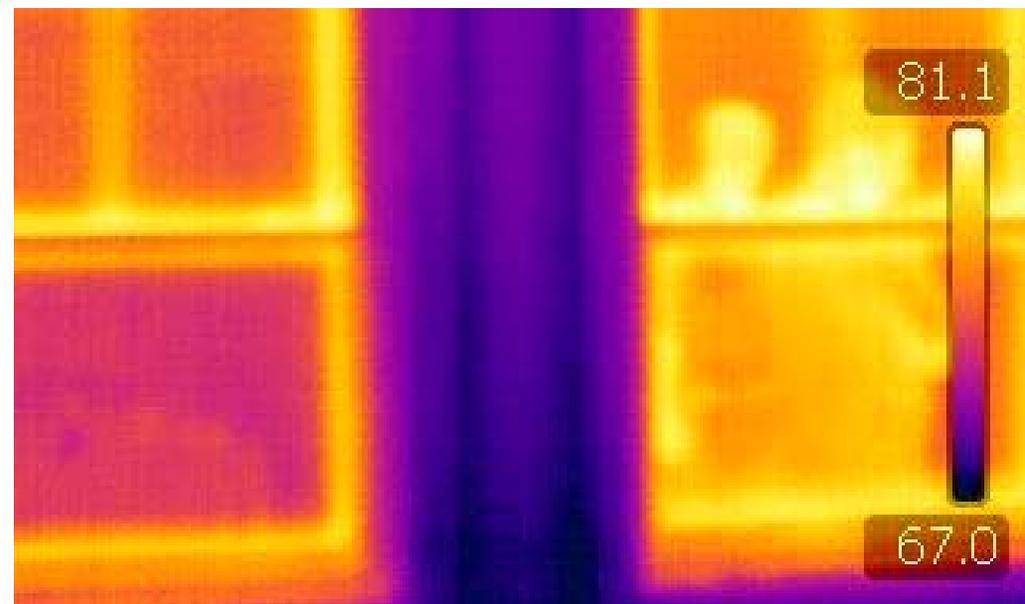
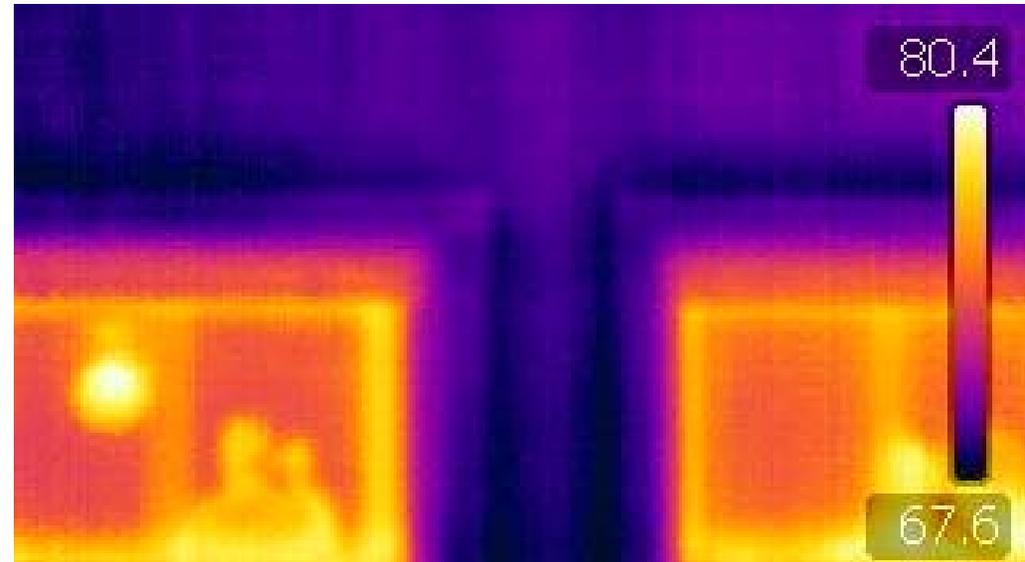
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Smoke Entry Under Wall Sill Plate

Testing

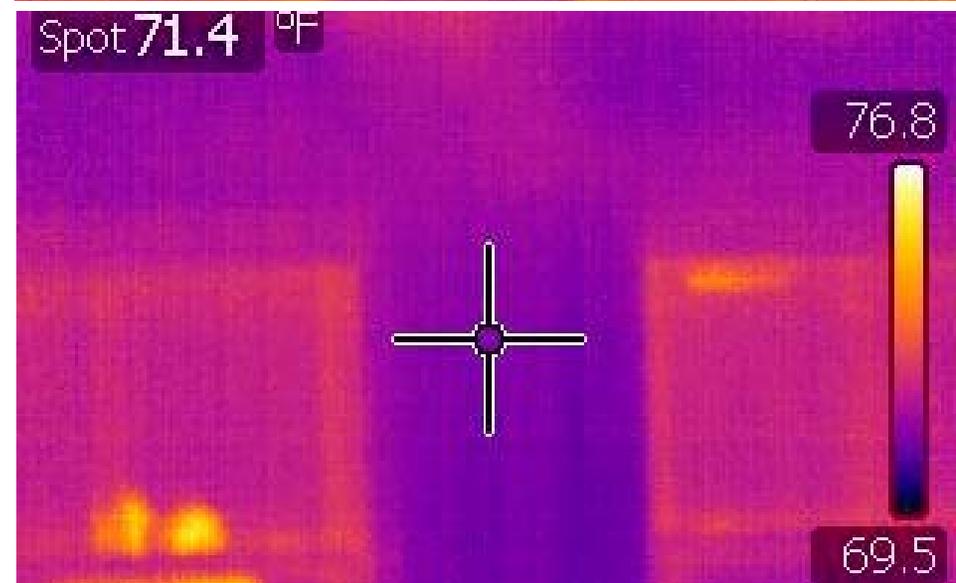
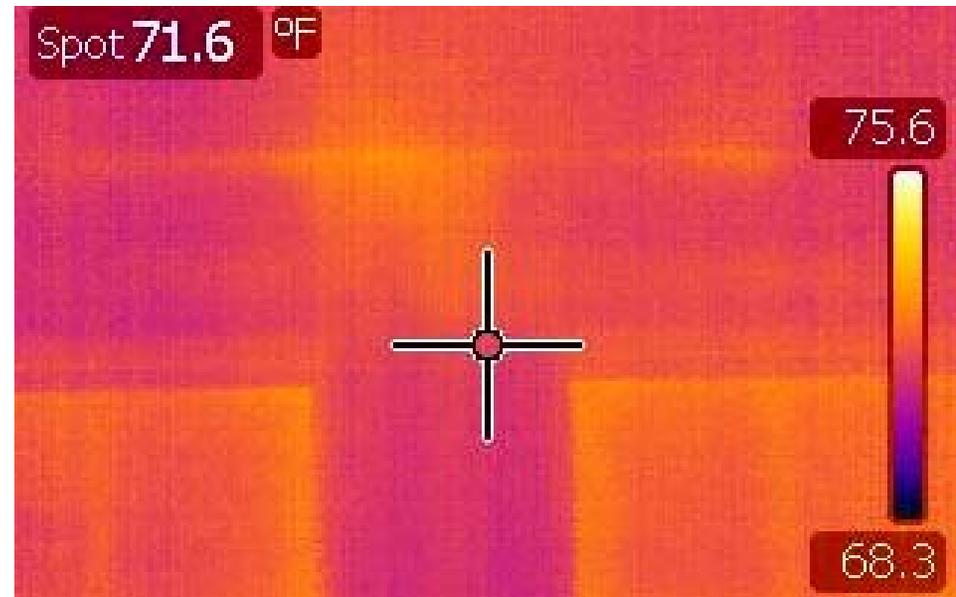
- ASTM 779-10 Blower Door Test
- Renovated Dorm

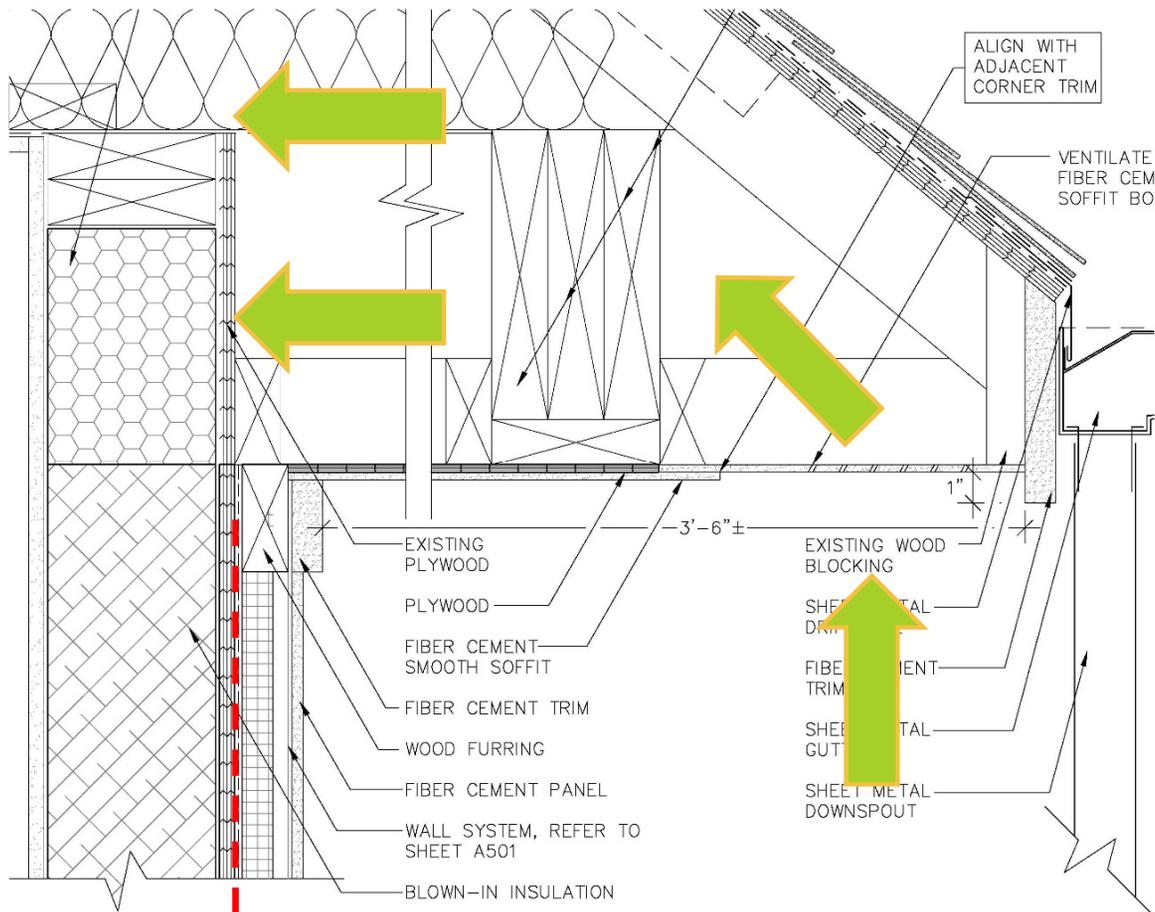
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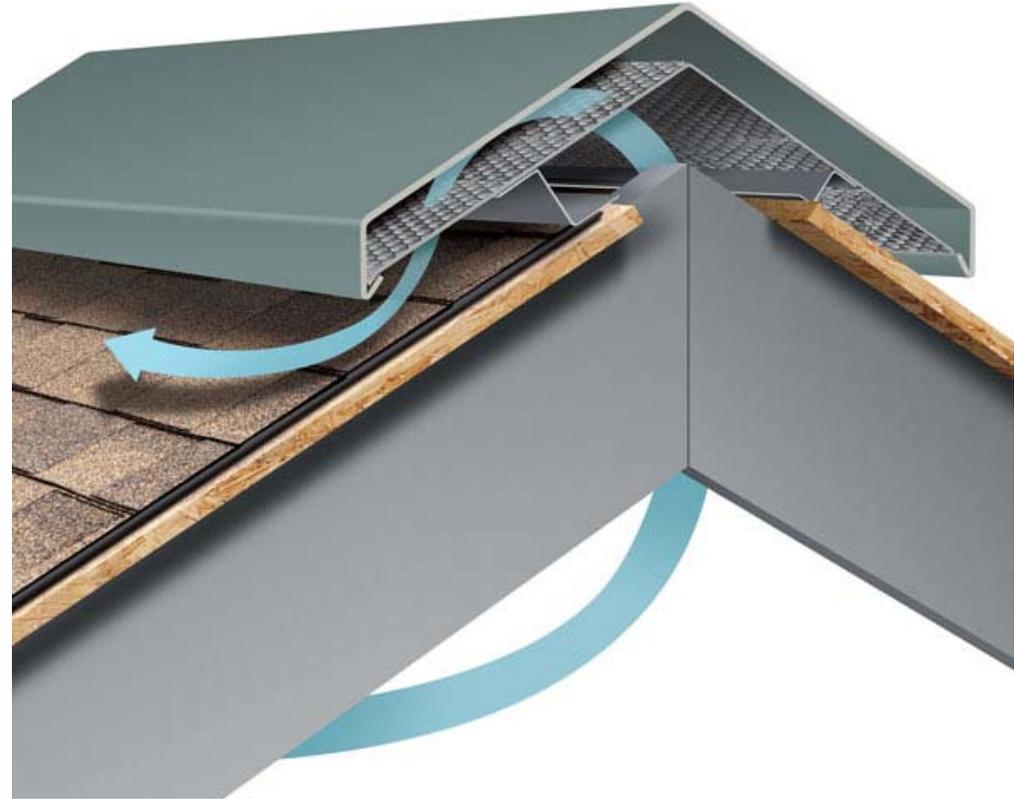
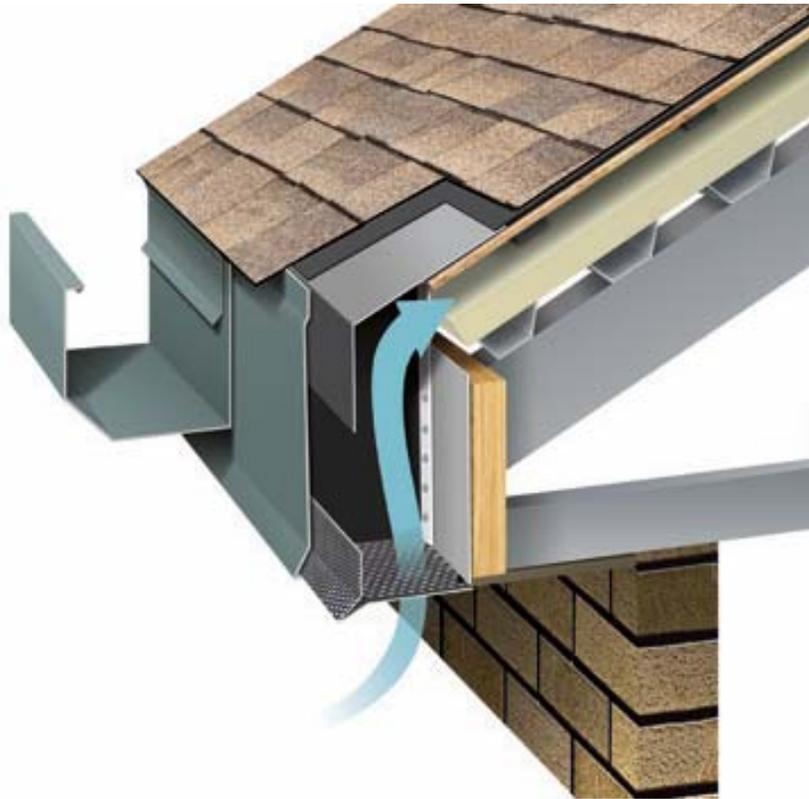
Testing

- ASTM 779-10 Blower Door Test
- Renovated Dorm





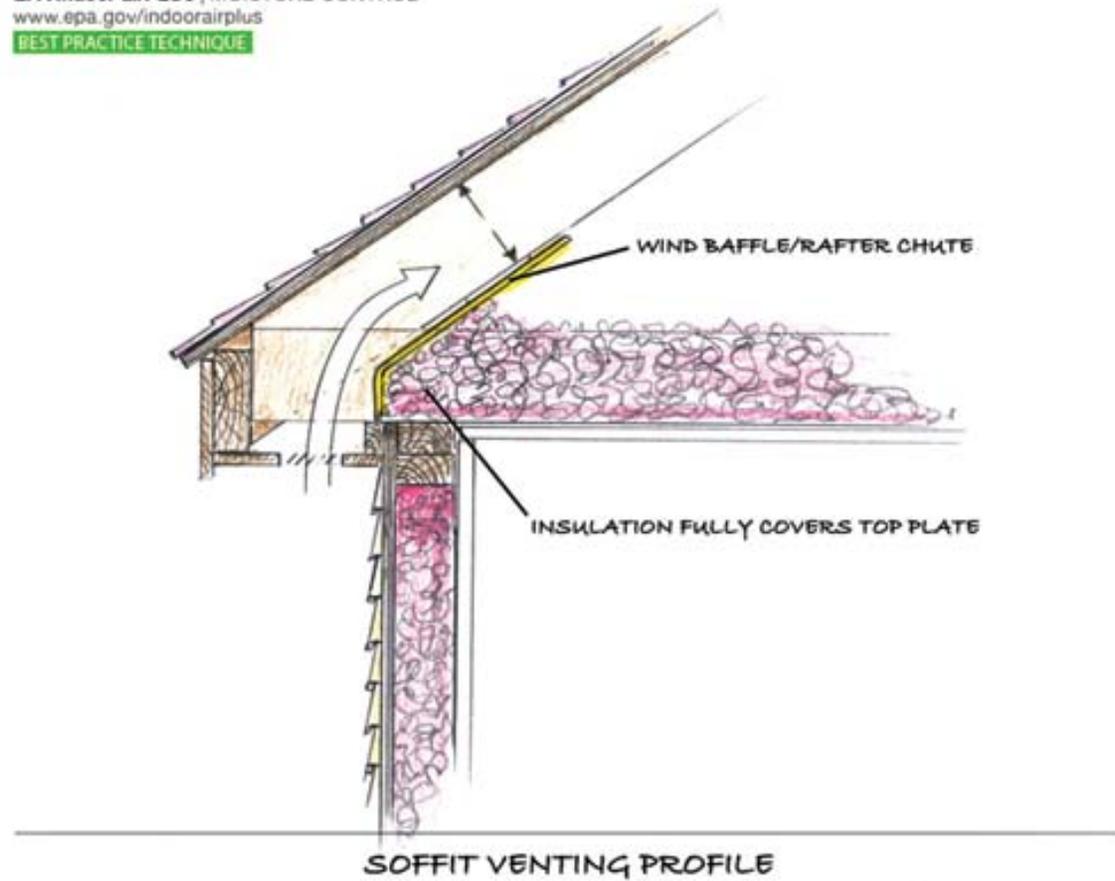
Potential Air Infiltration



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Preferred Design Detail

EPA Indoor airPLUS | MOISTURE CONTROL
www.epa.gov/indoorairplus
BEST PRACTICE TECHNIQUE



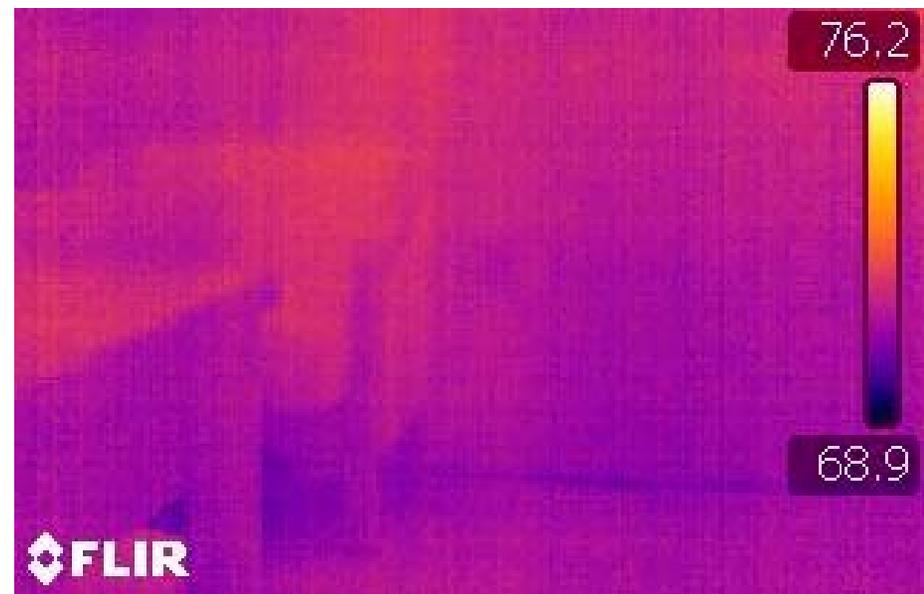
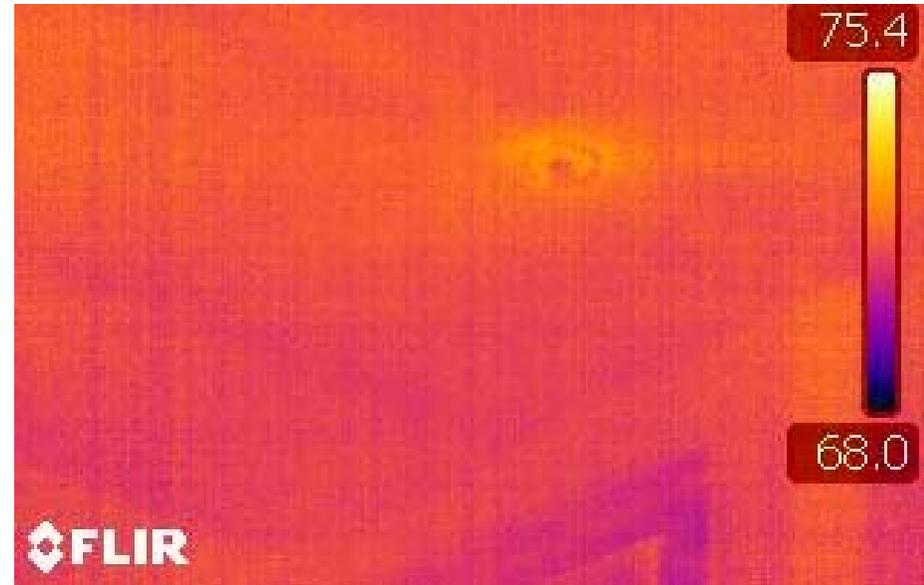
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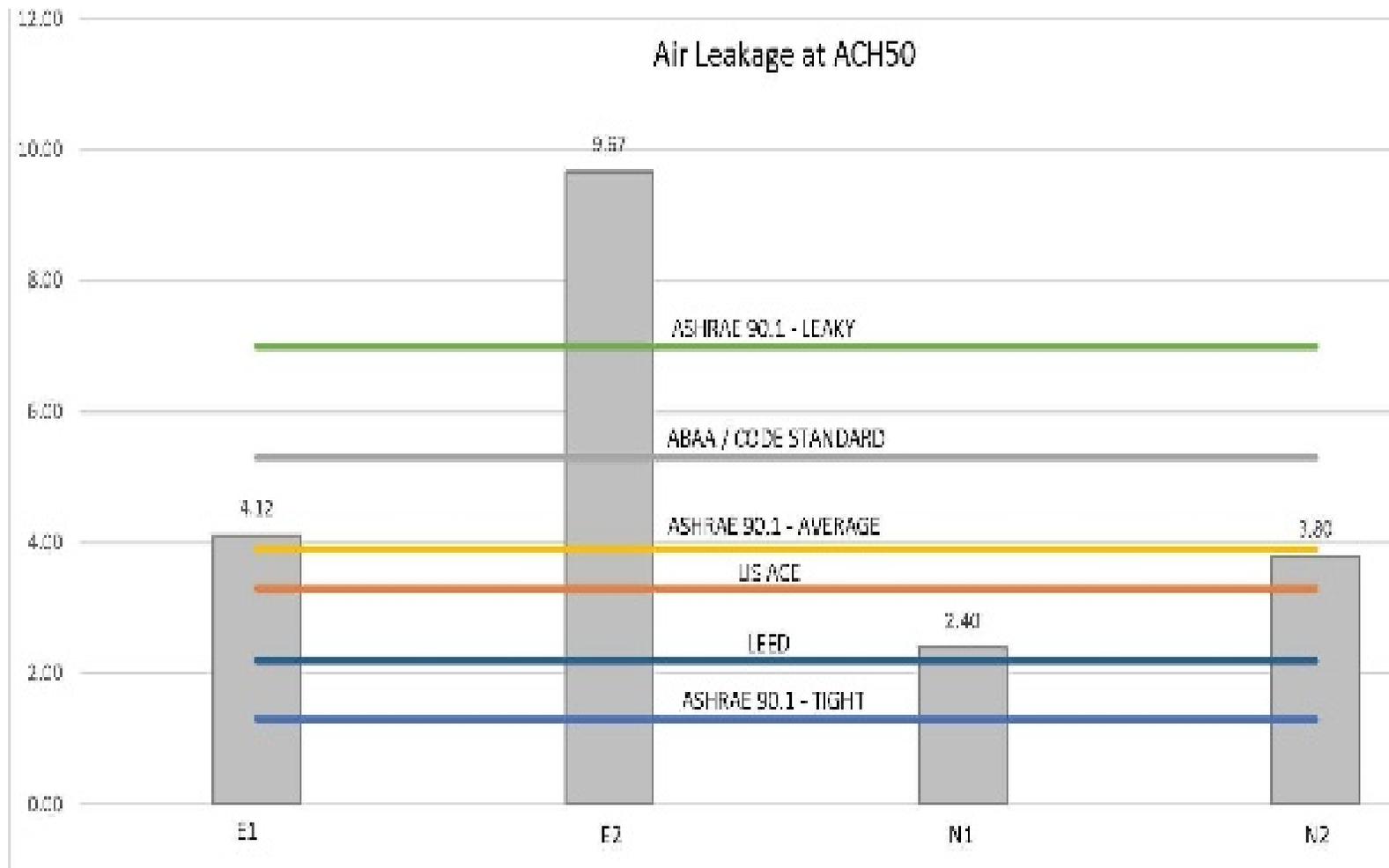
Preferred Design Detail

Testing

- ASTM E779-10 Blower Door Test
- Renovated Dorm

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QUESTIONS?

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Thank You!

