



Encouraging Building Air Tightness

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BUILDING AIR LEAKAGE GUIDELINES



Building Air Leakage And Air Barrier Requirements

State of Vermont Energy Code 2019/ 2020

Commercial:

Materials – Air permeability not greater than 0.004 cfm/ft² at 75 Pa pressure difference (ASTM E2178)

Assemblies – not greater than 0.04 cfm/ft² at 75 Pa pressure difference (ASTM E 2357, ASTM E E1677, ASTM E238)

NEW Whole Building Air Tightness - Not greater than **0.3** cfm/ft² at **75** Pa (ASTM E779 or E1827)

Vermont Commercial Building Energy Standards 2015



Building Air Leakage And Air Barrier Requirements

State of Vermont Energy Code 2019/2020

Residential:

Whole Building Air Tightness - Less Than 3 air changes per hour at 50 Pa pressure difference (ASTM E1827 or E779)

Vermont Residential Building Energy Code 2015



Building Air Leakage And Air Barrier Requirements

My Recommendations:

Whole Building Air Tightness - Not greater than 0.25 cfm/ft² at 75 Pa (ASTM E779, ASTM E1827)

-OR-

Whole Building Air Tightness – 1.0 ACH at 50 Pa, (ASTM E779, ASTM E1827)

Depending!



A Little Bit About The Building That Is The Focus Of This Presentation And It's Owners

Bangor Savings Bank Environmental Commitments

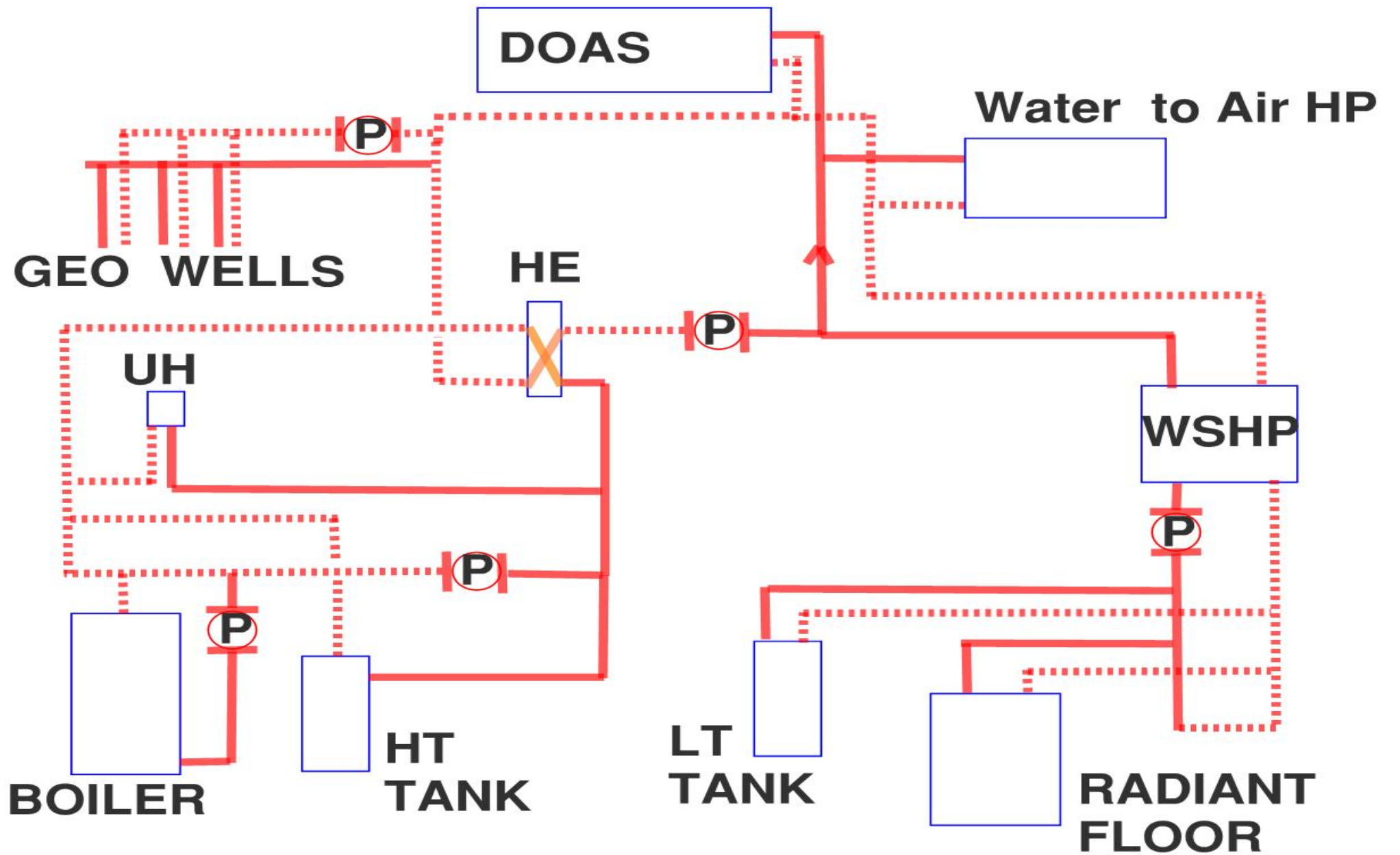


Bangor Savings Bank Environmental Commitments



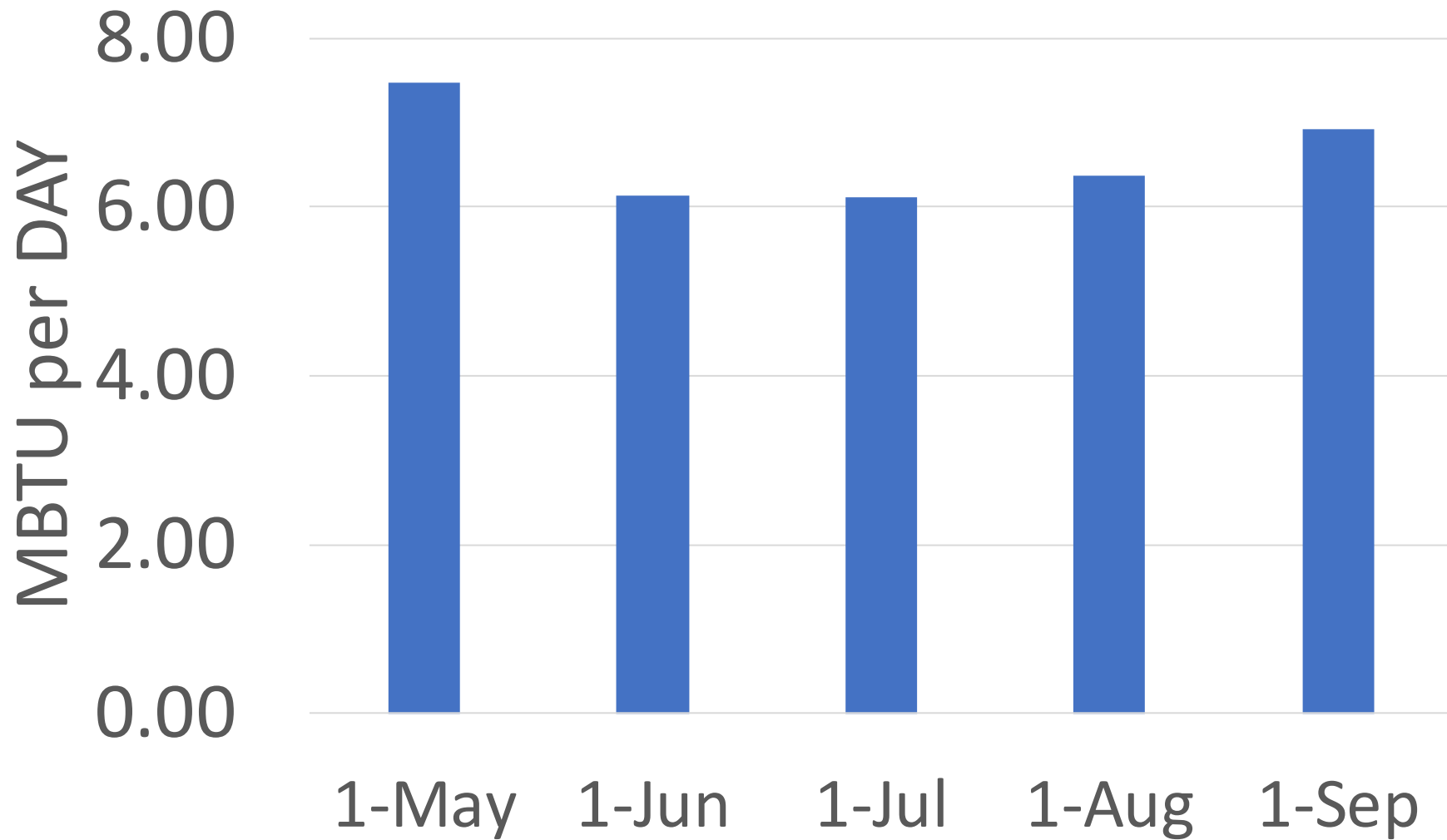
BSB Commitment To Low Energy Use Systems



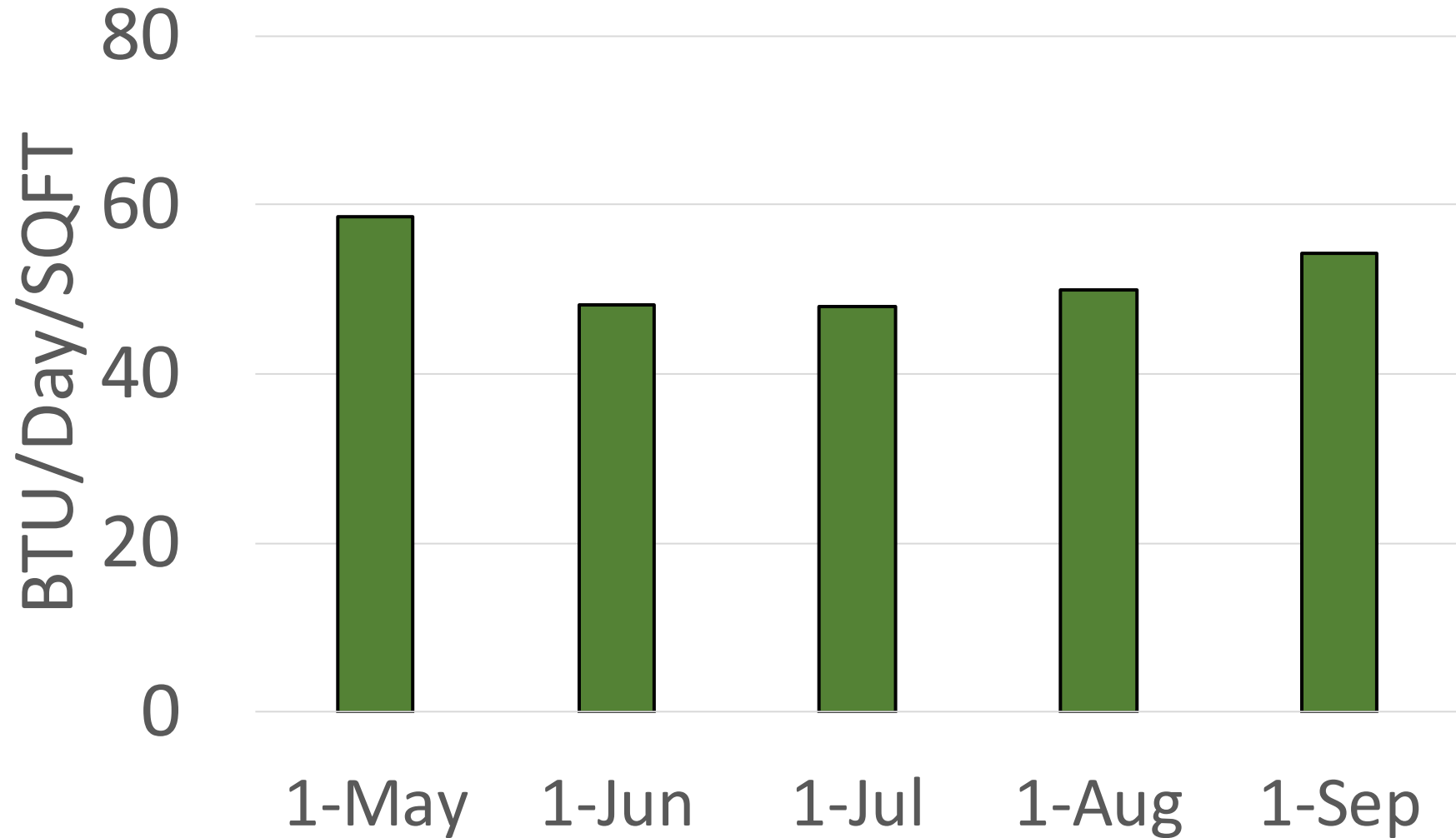


Natural Gas Use

BSB Office Mid Year 2019



BTU per Day per SQFT BSB Office Mid Year 2019



BSB Commitment To Low Energy Use Systems 280 kW Array



BSB Server Room Is A Large Heat Generator, About 22 kw Steady Use



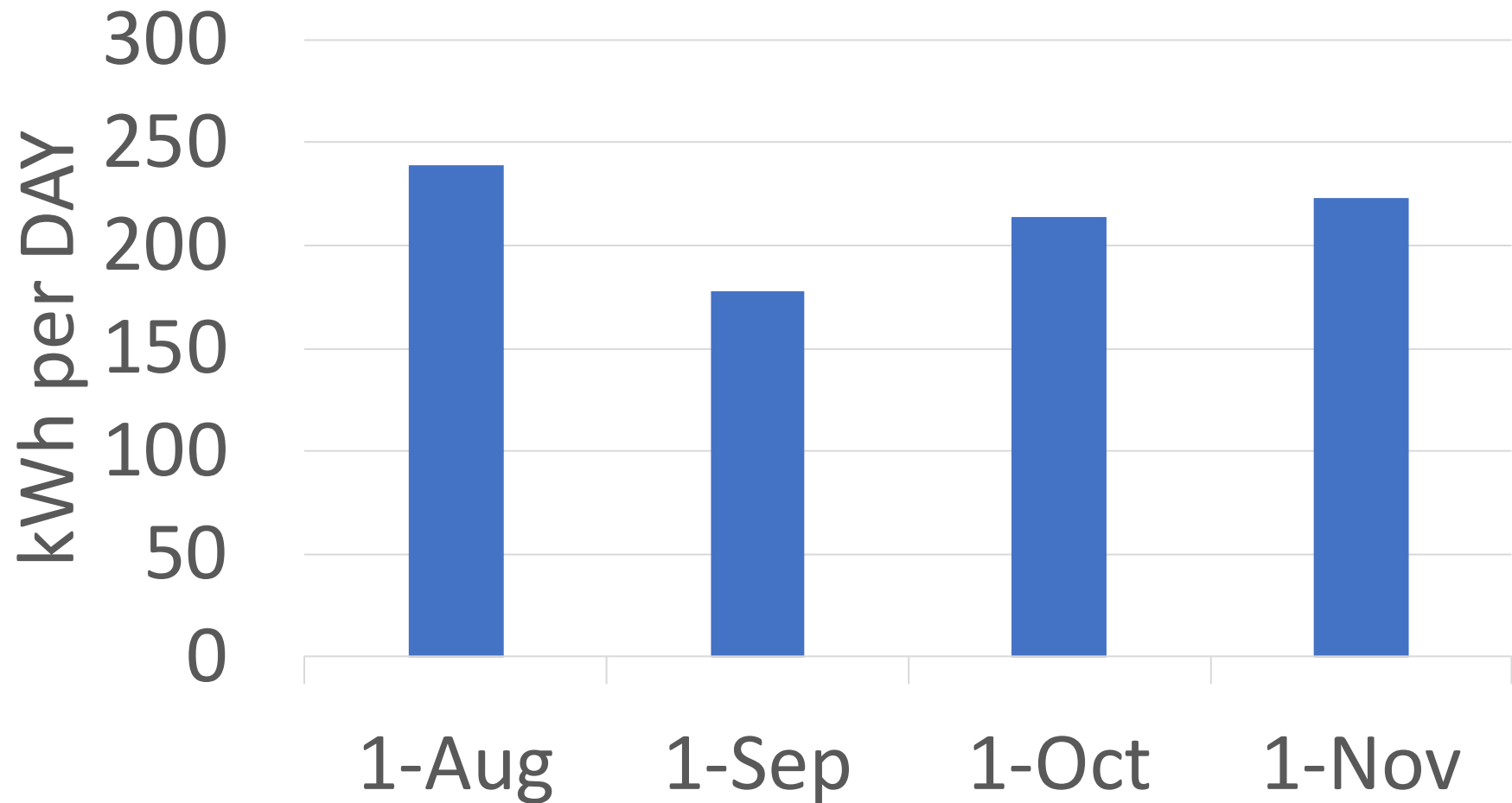
Most Of The Building Is Office Space





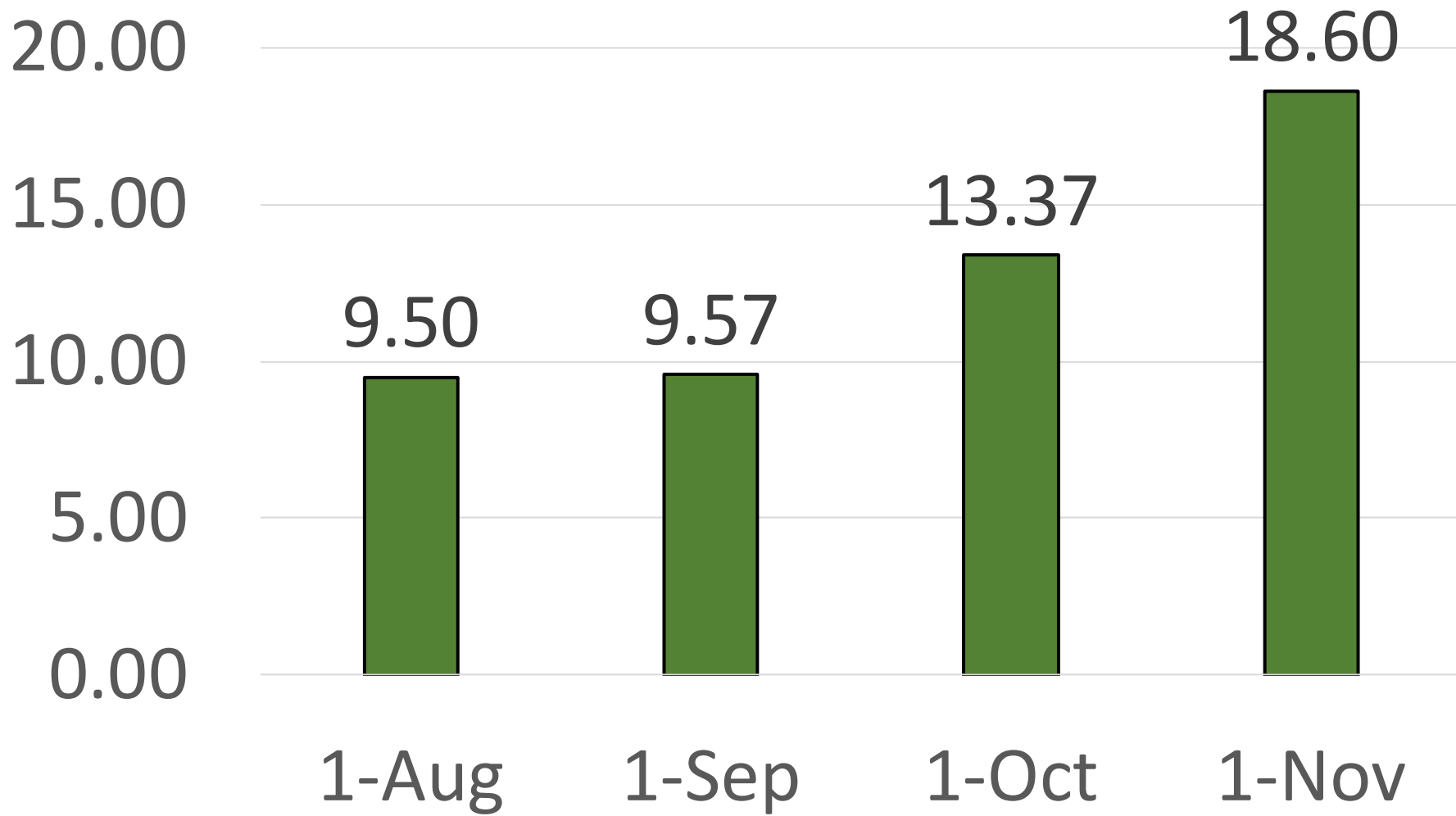
Electrical Power Use

BSB Office Last Part of 2019



Watts Per Day Per SQFT

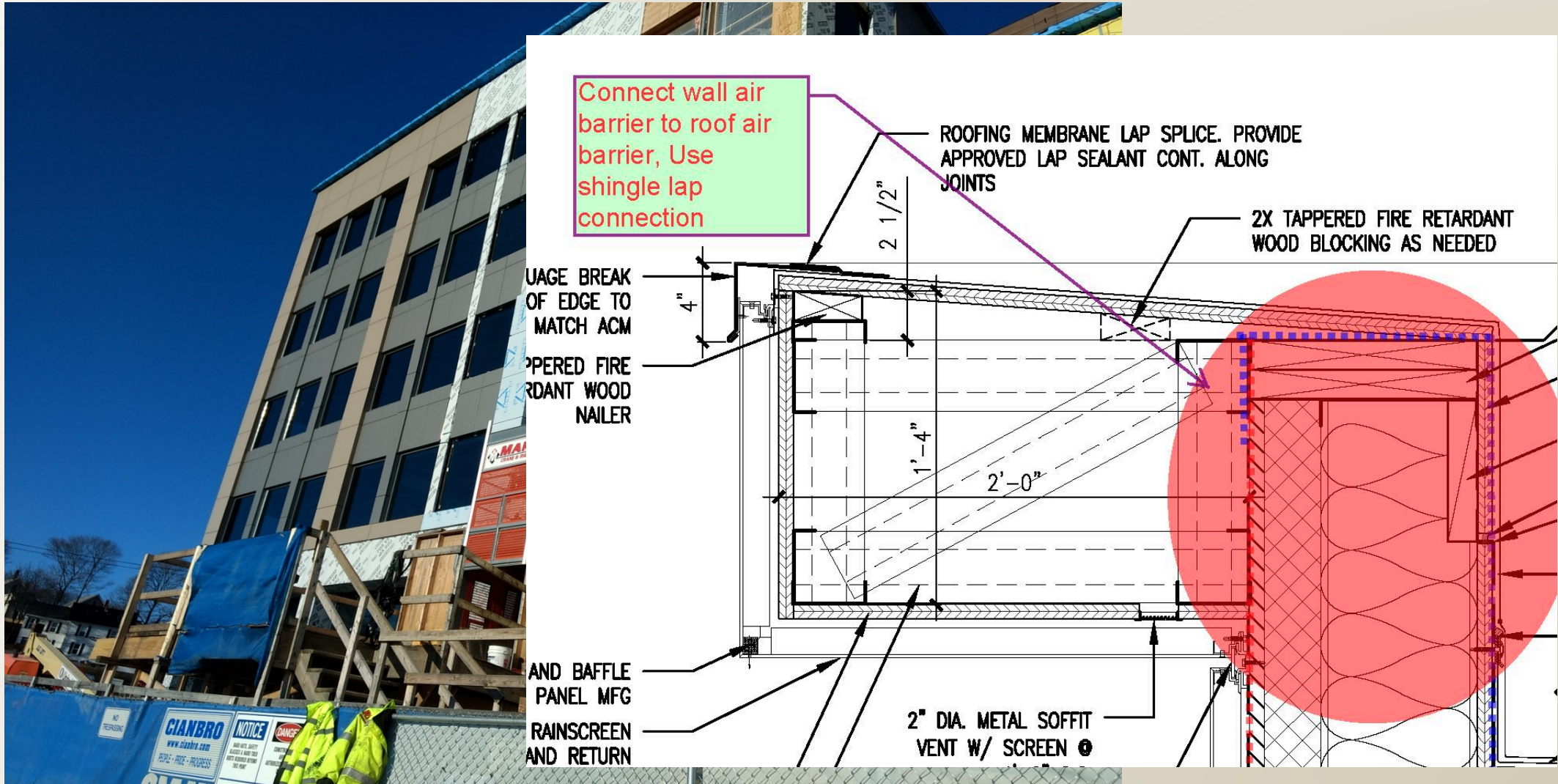
BSB Office Last Part Of 2019



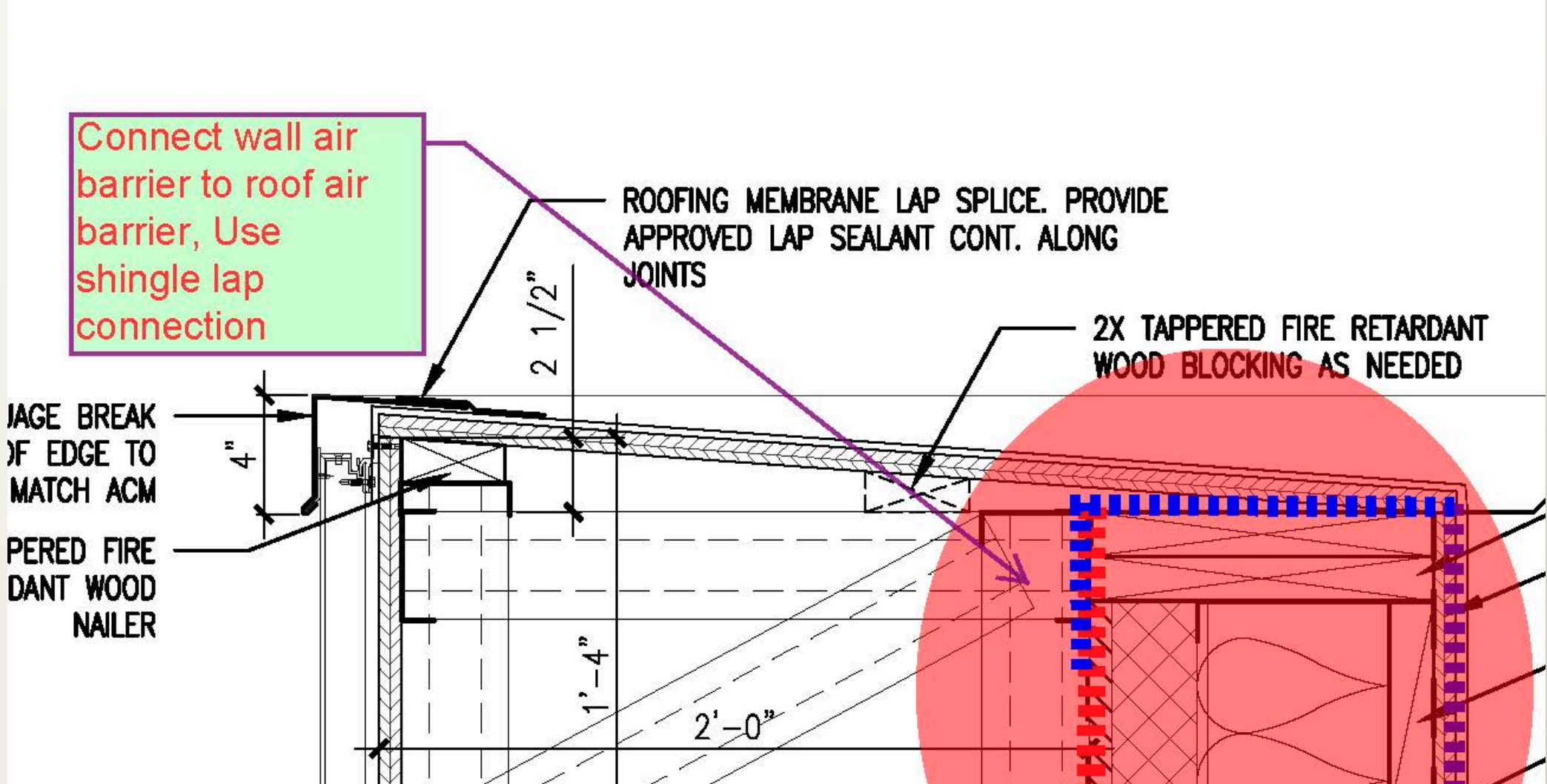


**AN AIR BARRIER IS NOT AN AIR BARRIER
UNLESS ITS CONTINUOUS**

Design Review Of Wall, Roof, Foundation Assemblies



Design Review



Termination Of Air Barriers At Existing Structure And Penetrations Of The Structure



Column Penetrations Thru The Slab And Related Assemblies



Connection Of Roof AVB To Wall AVB



Slab assembly to Wall Assembly



Minimize Site Made Edges (Cuts)



Wall With Minimum Number Of Non Factory Edges



Sealing interior gypsum walls to floor / roof decks everywhere



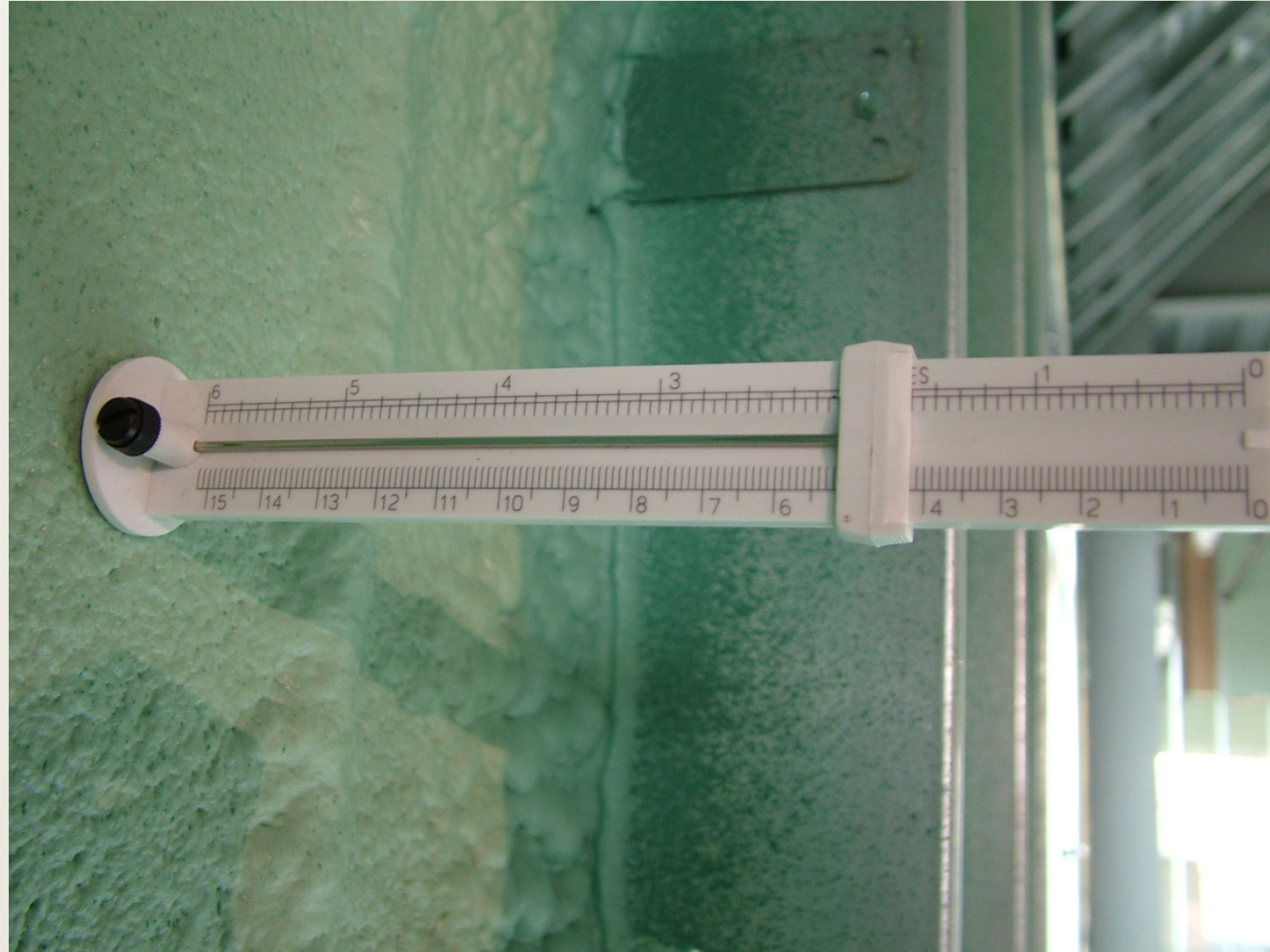




Verifying The Proper Installation Of An Air Barrier Assembly

**TESTING MATERIALS DURING INSTALLATION,
ADHESION,
THICKNESS
DENSITY**

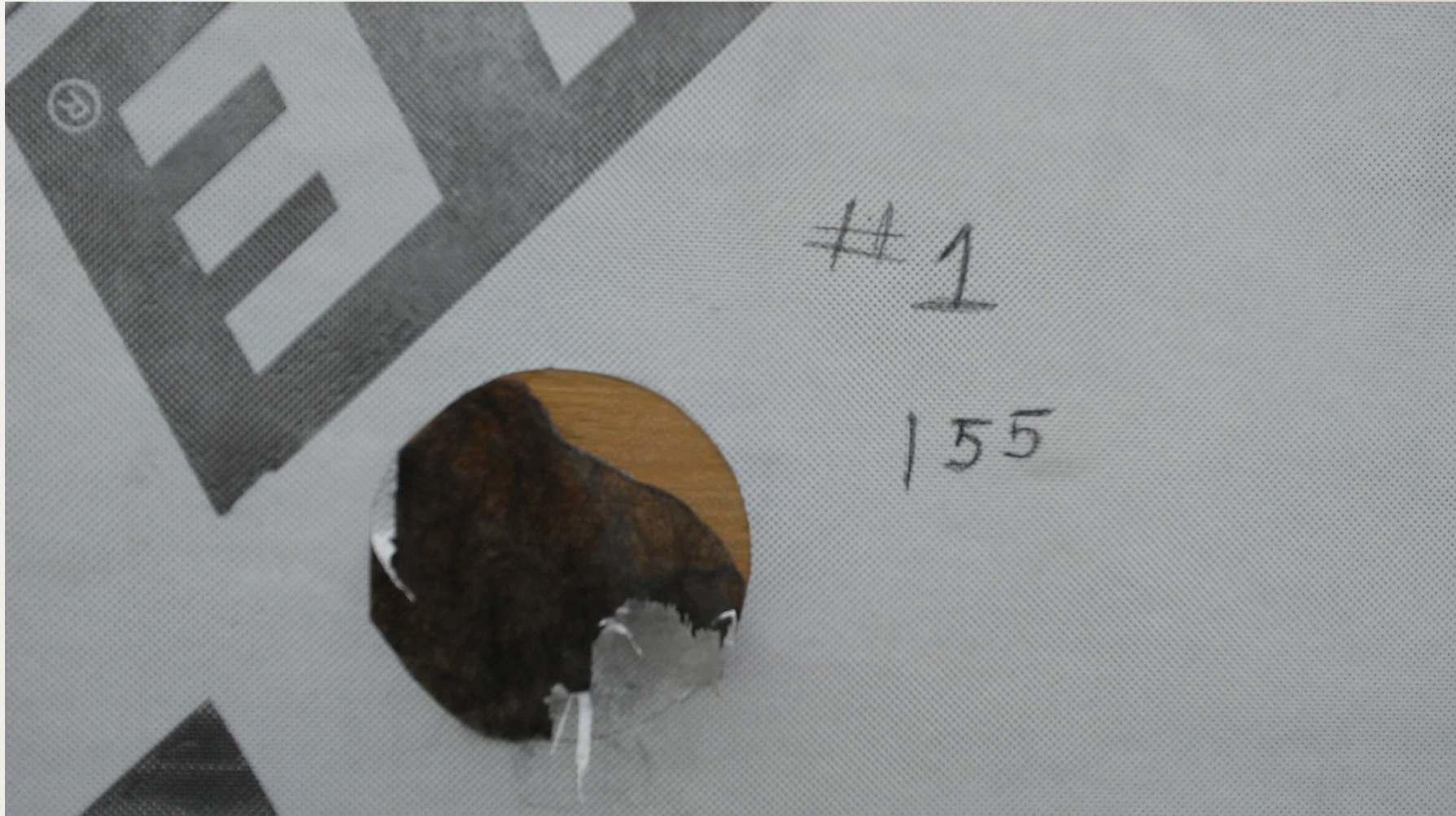
Thickness Testing



Thickness Testing -Fluid Applied



Adhesion Testing ASTM D4541 Self Adhered



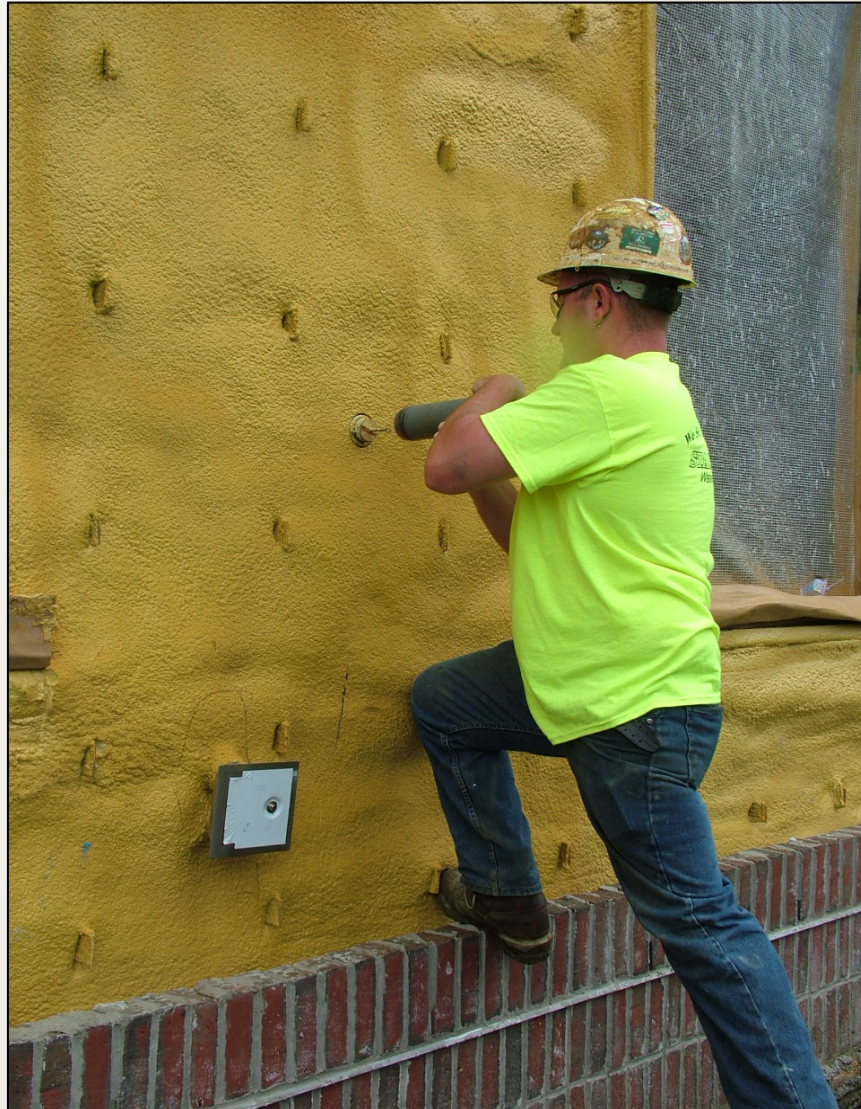
Adhesion Testing Self Adhered



Visual Successful Adhesion Tests



Adhesion test Spray Polyurethane Foam (ASTM D4541)



Location of Adhesion Failure, Thickness



Spray On Foam Density Testing

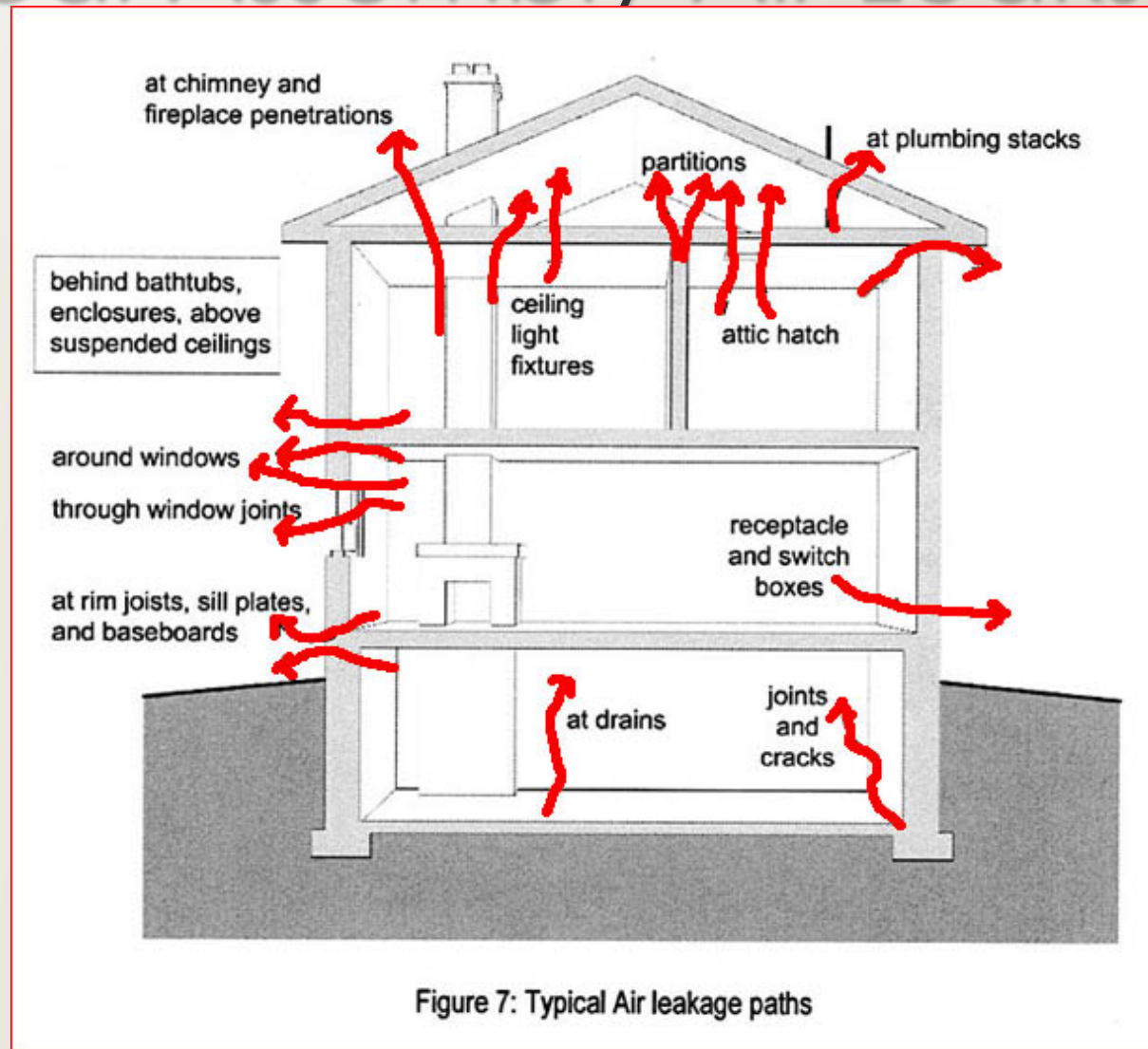




FINAL AIR TIGHTNESS TESTING

WHOLE BUILDING AIR TIGHTNESS TEST

Typical Assembly Air Leaks

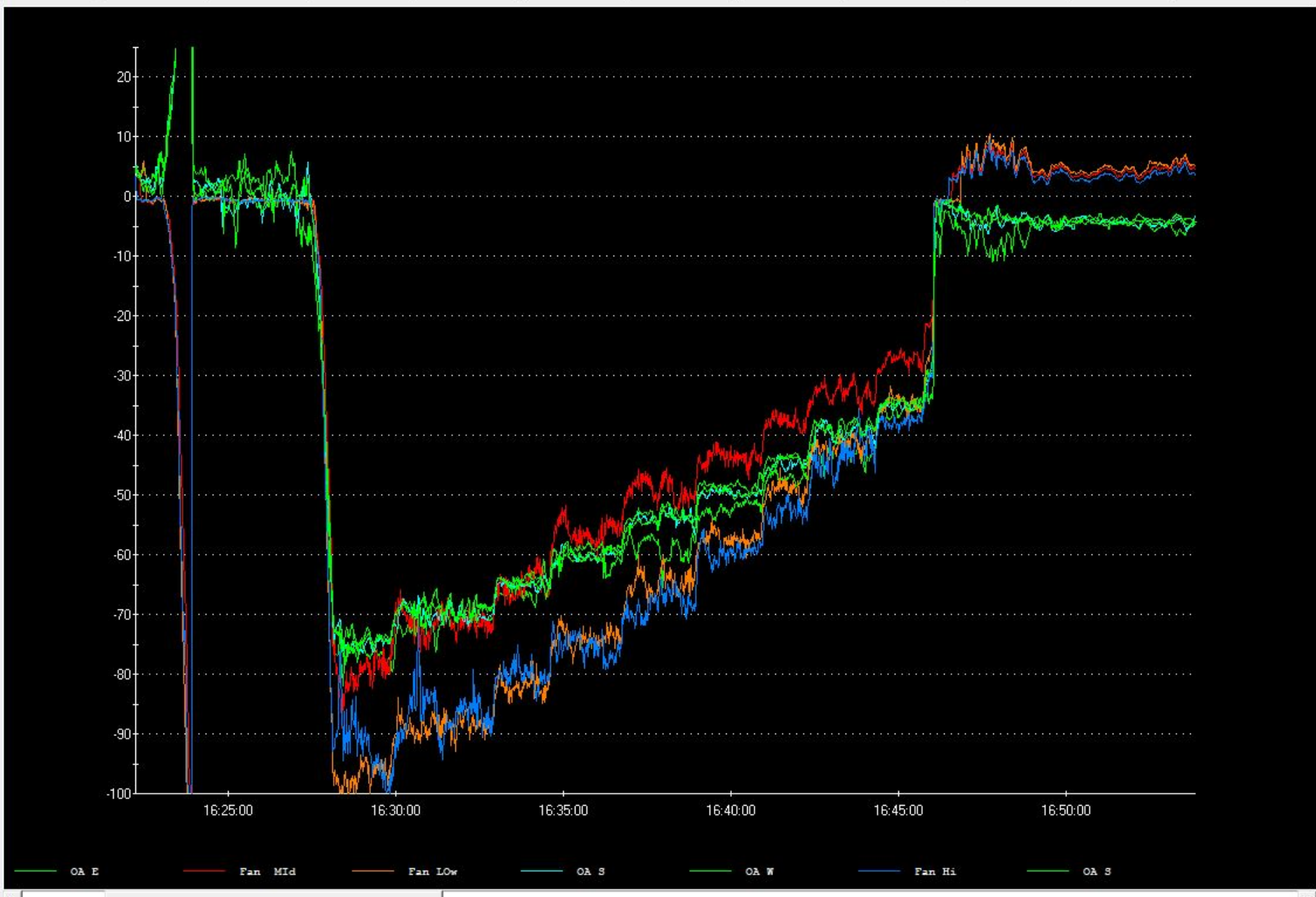


Courtesy of Building Science Inc

Multiple Blower Doors For Larger Buildings



Event Baseline POR Fan-On POR Auto T Auto Y Devices MASTER Edit Test Details Results



Obs #:

Viewing File:
Hartford FS DP test

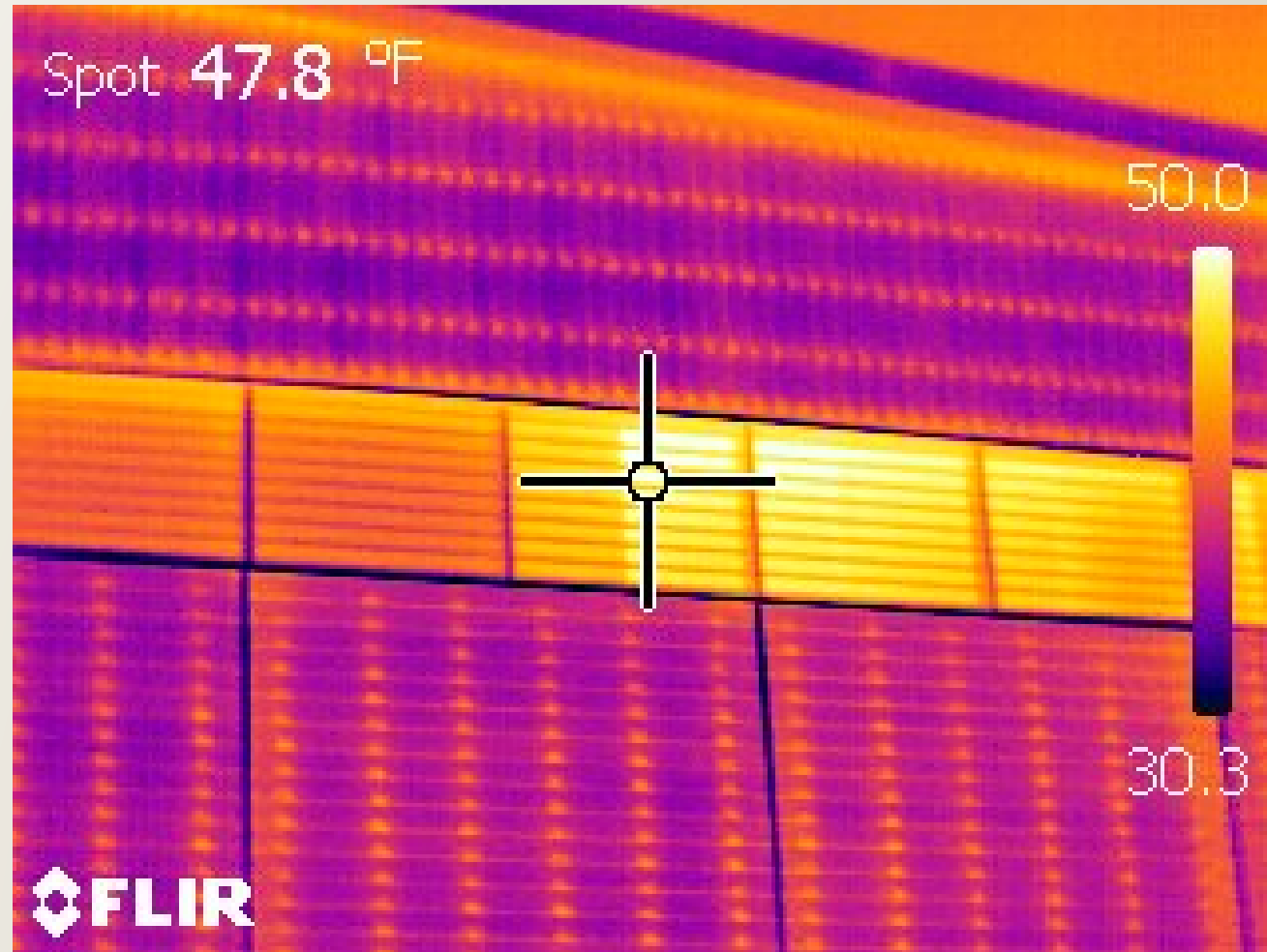
- OA E
- OA S
- OA W
- OA S
- Fan Mid
- Ring ▾
- Flow
- Fan LOw
- Ring ▾
- Flow
- Fan Hi
- Ring ▾
- Flow

— OA E — Fan Mid — Fan LOw — OA S — OA W — Fan Hi — OA S

Finding Leaks



And To No Ones Surprise, Other Stuff As Well



BSB Building Statistics

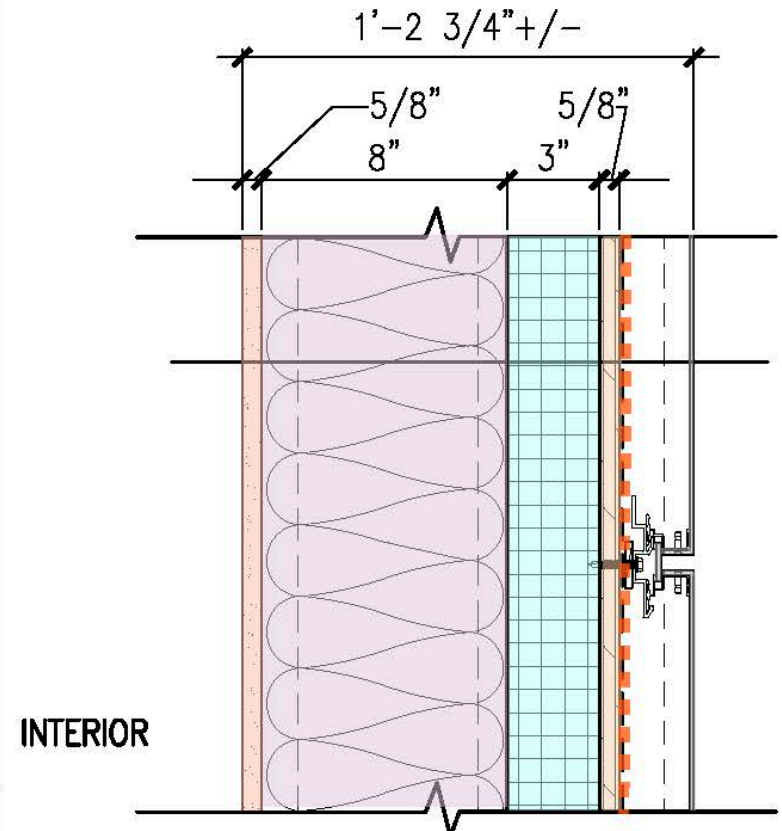


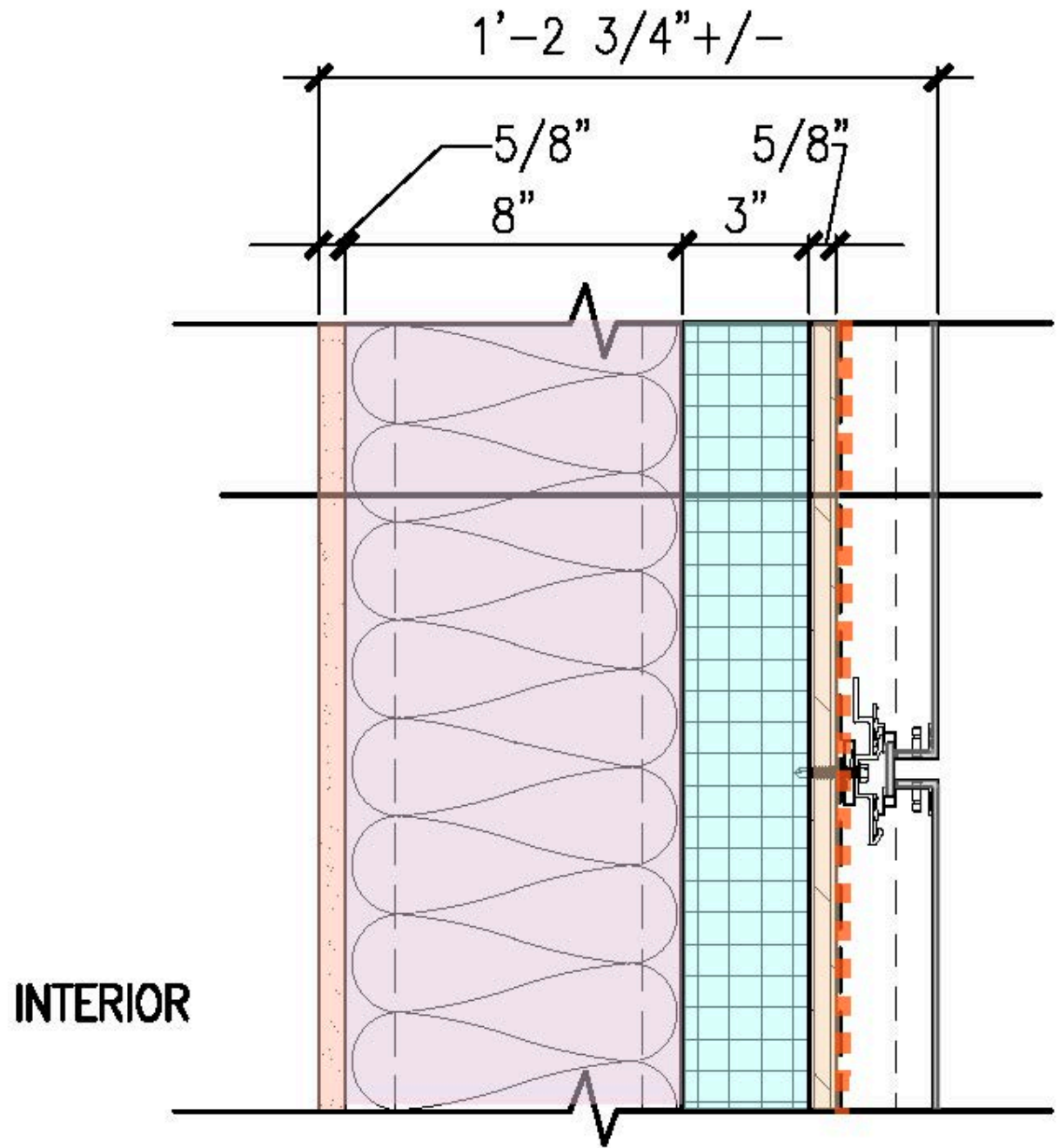
Typical Wall Assembly

TYPICAL EXTERIOR ACM PANEL WALL ASSEMBLY
NFPA 285 COMPLIANT

Composite Panel
Water Resistive VP Air Barrier
3" Thick Insulated 5/8" Hunter
Panel R17.7
6" Metal studs 24" OC
with R21 Batt insulation
5/8" Gypsum Board

Courtesy of CWS Architects



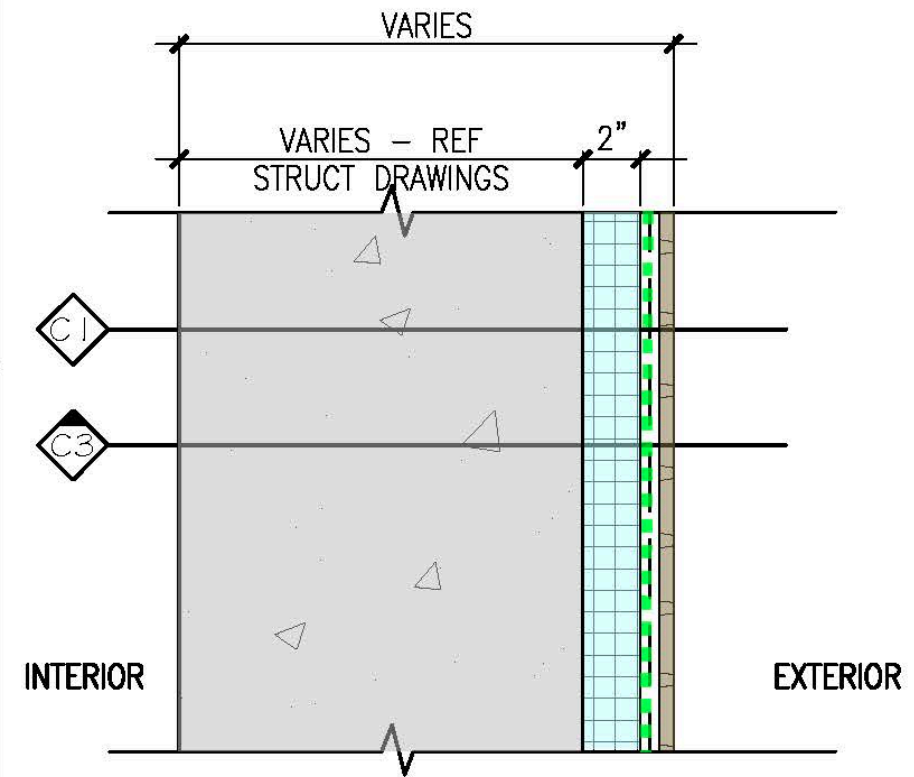


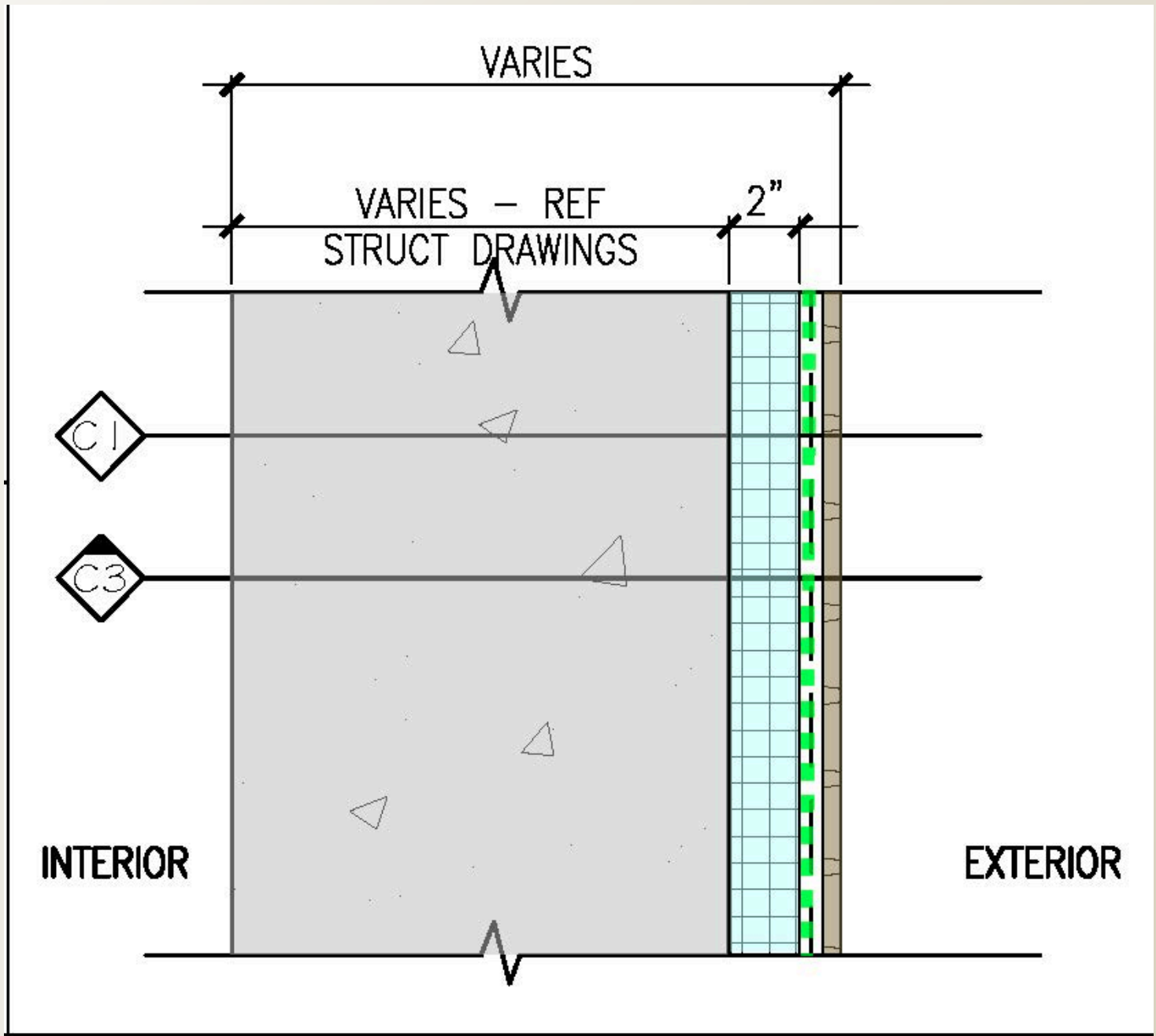
Typical Foundation ASSEMBLY

TYPICAL FOUNDATION WALL ASSEMBLY @ OCCUPIED BASEMENT

Poured Concrete
2" XPS Insulation R10
Waterproofing Membrane
Drainage Board

Courtesy of CWS Architects



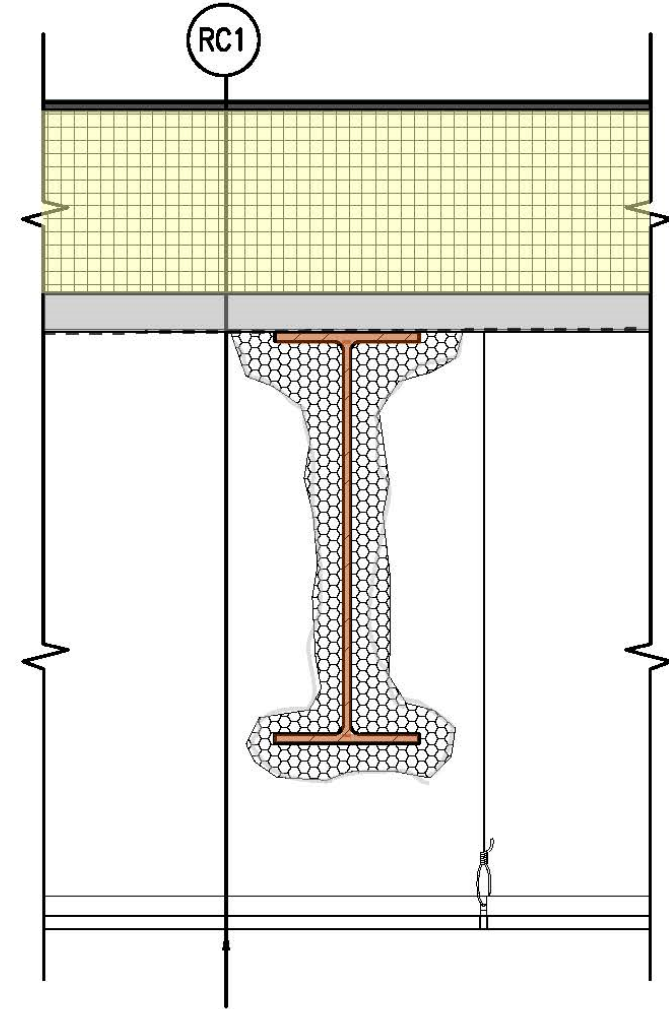


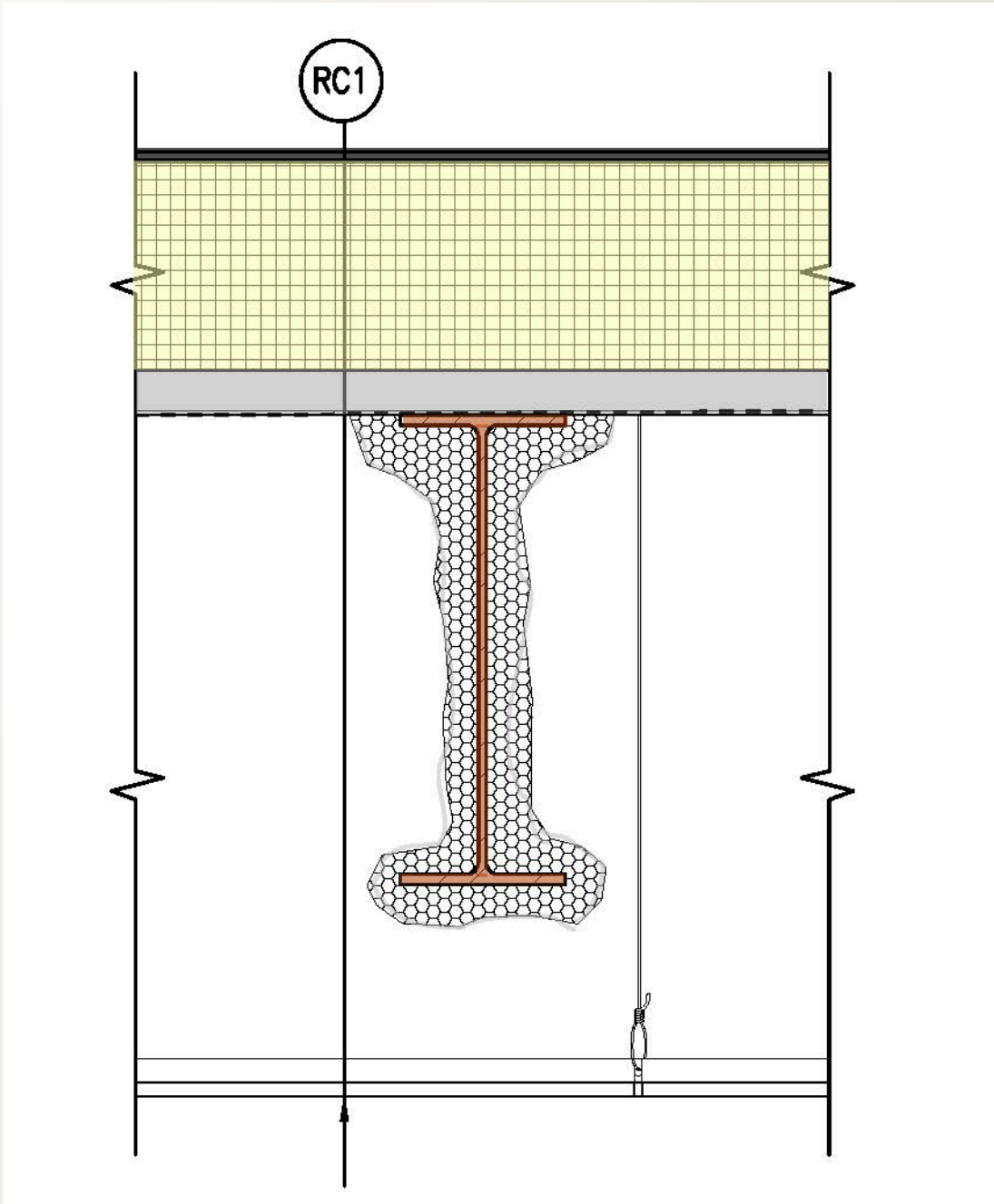
TYPICAL ROOF ASSEMBLY Nominal R49

1 HOUR FIRE RATED
TYPICAL METAL JOIST ROOF / CEILING ASSEMBLY
EQUAL TO U.L. DESIGN P304

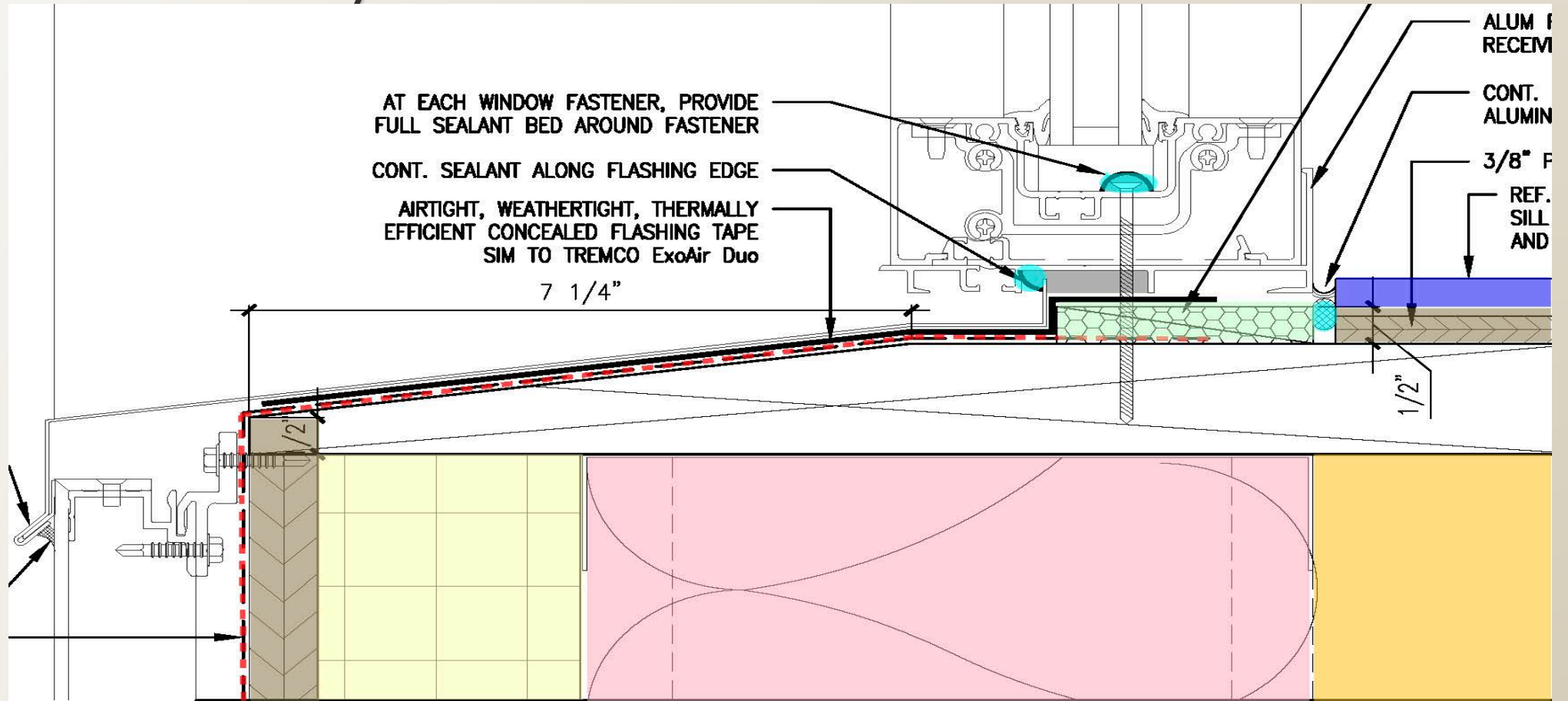
EPDM Membrane
7" Polyiso R49
Steel Deck
Fire Protected Steel

Courtesy of CWS Architects



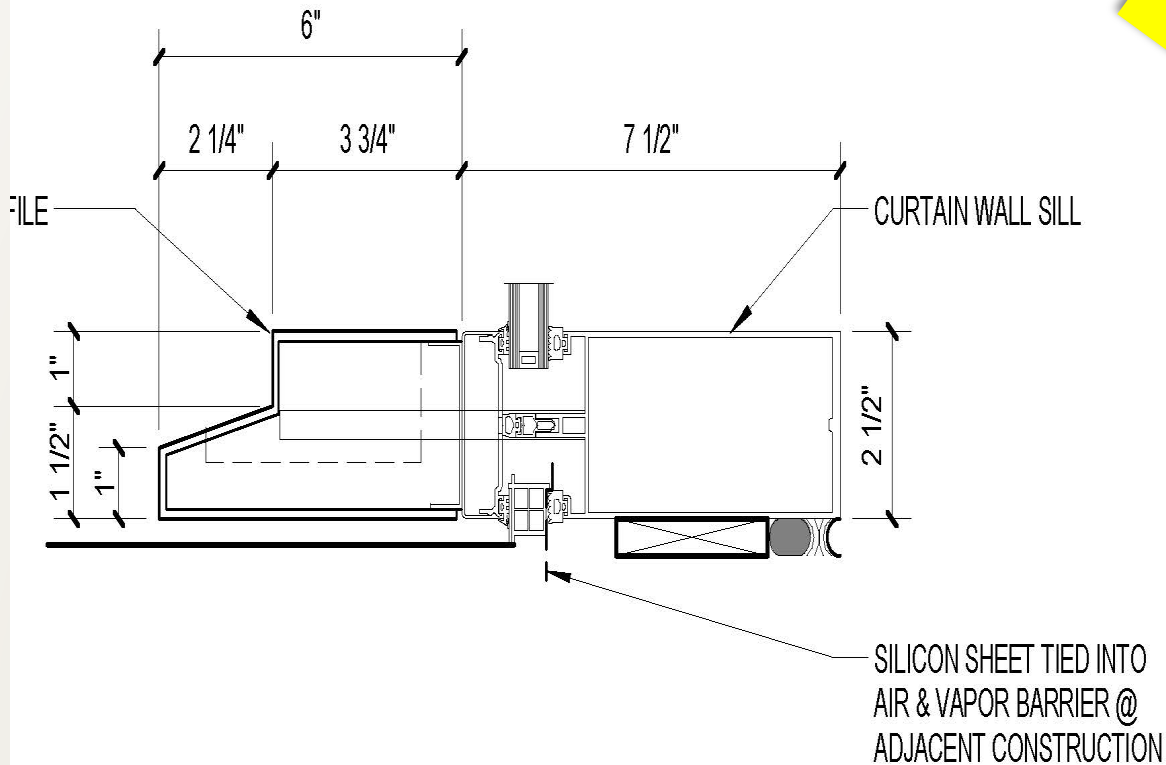


Typical Window Connection To Wall Assembly



Courtesy of CWS Architects

My Favorite Window Connection To Wall Assembly



Courtesy of SLAM Collaborative



WBAT Test

Testing Parameters
Set up Calculations

Test Set Up

Minimum Test Pressures For Conditions

Calculating Air Density ASTM E779

Imperial

$$\text{Eq x1.1 } r_{in} = 1.2041 \{1 - ((0.0065 * E) / 293)\}^{5.2553} \{293 / (T_{in} + 273)\}$$

$$\text{Eq x1.2 } r_{out} = 1.2041 \{1 - ((0.0065 * E) / 293)\}^{5.2553} \{293 / (T_{out} + 273)\}$$

Metric

$$\text{Eq XI.3 } r_{in} = 0.07517 \{1 - ((0.0035666 * E) / 528)\}^{5.2553} \{528 / (T_{in} + 460)\}$$

$$\text{Eq XI.4 } r_{out} = 0.07517 \{1 - ((0.0035666 * E) / 528)\}^{5.2553} \{528 / (T_{out} + 460)\}$$

Air Density Calculations

Inputs		Imperial	Metric	Standard conditions	
		Imperial	Metric	Imperial	Metric
E	elevation	185 ft	56 m	0 ft	0 m
T _{in}	temperature inside	70 °F	21.1 °C	68 °F	20 °C
T _{out}	temperature outside	20 °F	-6.7 °C		
		Results		Results	
r _{in}	air density inside	0.07 lbm/ft ³	1.19 kg/m ³	0.08 lbm/ft ³	1.20 kg/m ³
r _{out}	air density outside	0.08 lbm/ft ³	1.32 kg/m ³	r _{std}	r _{std}

Stack Pressure Calc Air Barrier Association of America, Standard Method for Building Enclosure Airtightness Compliance Testing

Eq1: $P_{\text{stack}} = \text{abs}(\rho_{\text{out}} - \rho_{\text{in}}) * g * h = 32.9 \text{ kg/m}\cdot\text{s}^2$

Where:

ρ_{in} = Inside air density (kg/m³) from ASTM E779-2010 equation X1.1

1.20 kg/m³

ρ_{out} = Outside air density (kg/m³) from ASTM E779-2010 equation X1.2

1.32 kg/m³

g = acceleration Due to gravity as 9.81 m/s²

9.81 m/s²

h = height of building (m), measured from grade up to highest portion of the test enclosure.

26.9 m

Note: 1Pa=1/N/m² \equiv 1kg/m \cdot s²

Minimum Allowable Test Pressure Air Barrier Association of America, Standard Method for Building Enclosure Airtightness Compliance Testing

Eq2: $P_{\text{induced, min}} \geq \text{Max} (|P_{\text{base,pre}}| + 10 * \text{STDev}(P_{\text{base,pre}}), P_{\text{stack}} / 2, 10 \text{ Pa})$

25.5 Pa Minimum
40 pa actual used

Where:

$P_{\text{induced, min}}$	= the minimum induced enclosure pressure that may used in the test analysis	
$P_{\text{base,pre}}$	= the pre-test baseline enclosure pressure	18 Pa
P_{stack}	= the total calculated stack pressure given by equation (1)	32.9 Pa

Building Surface Area

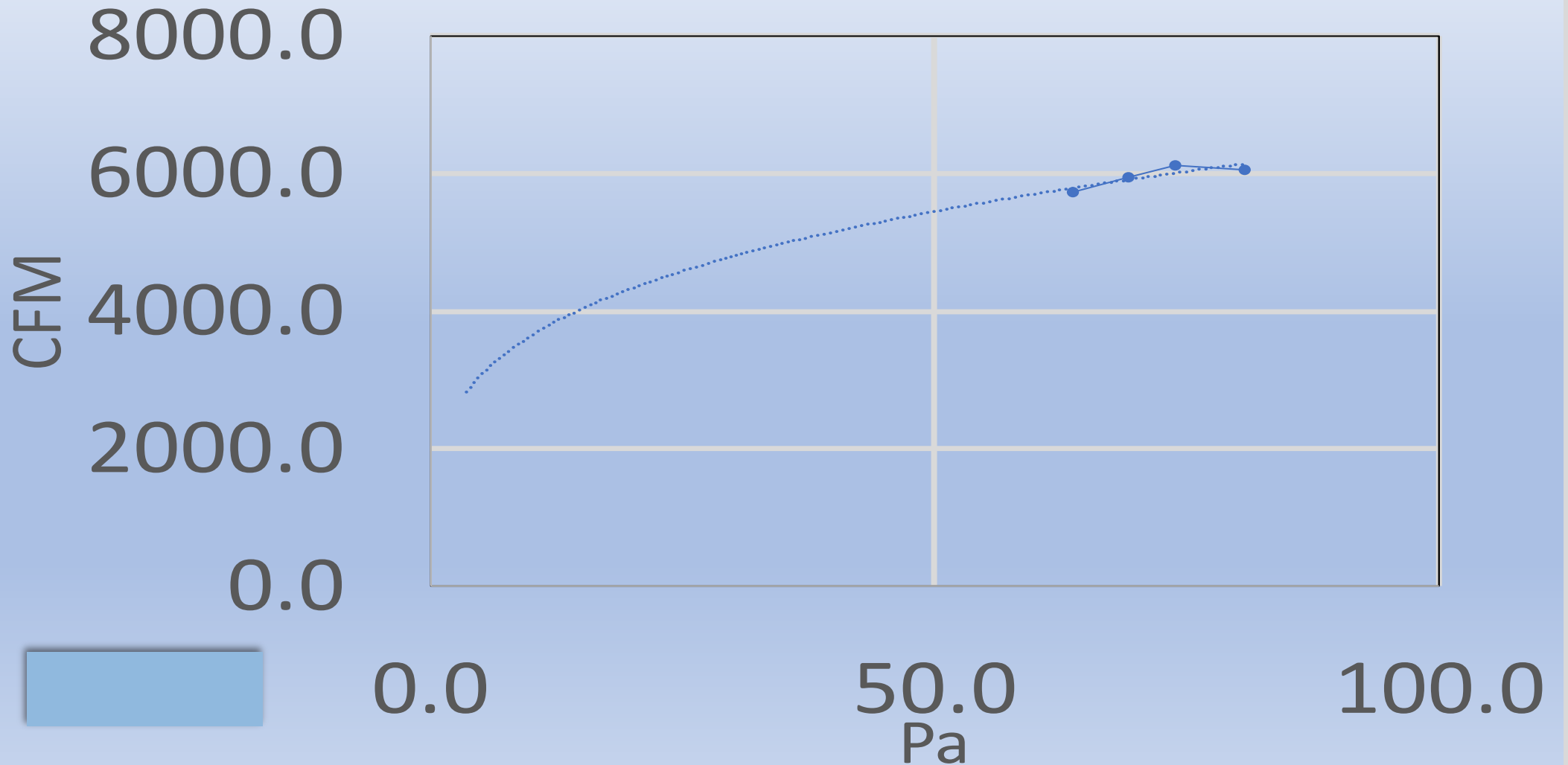
BSB 11 Hamlin Way									
Building areas	Below		Above					total ft ²	
	ceiling	ceiling	area 1	area 2	area 3	area 4	area 5		
	height	width							
Walls			50334.6	13252.4					63,587.0
								sub total	63,587.0
Roof			22050		622				22,672.0
Floor			22050						22,050.0
								sub total	44,722.0
								total ft²	108,309.0

Sizing Fan Capacity Based On Surface Area

Fan Sizing Base On Surface Area

CFM/sqft goal:	0.25
Total expected air flow: CFM	27,077
Number of fans required:	5

Avg Fan Flow CFM At Induced Pressure Difference





Results Using ASTM E779 Test Methodologies

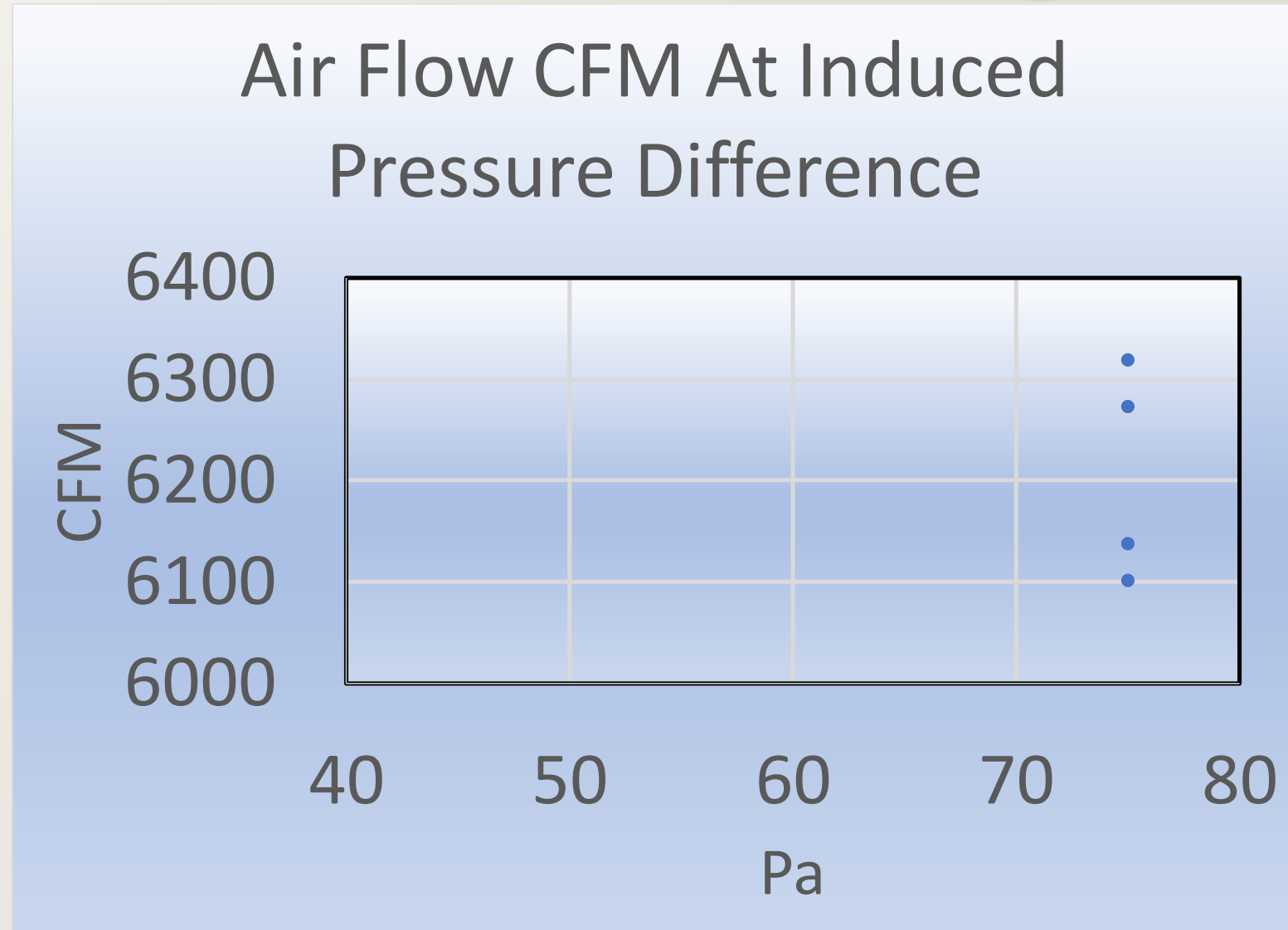
Building surface area = 108,309 sqft

Avg Test Flow at 75Pa = 6032 CFM

Building Enclosure Tightness

Value 0.06 CFM/sqft @ 75 Pa IPD

Plan B Use ASTM E1827 Single Point



Enclosure Leakage Rate

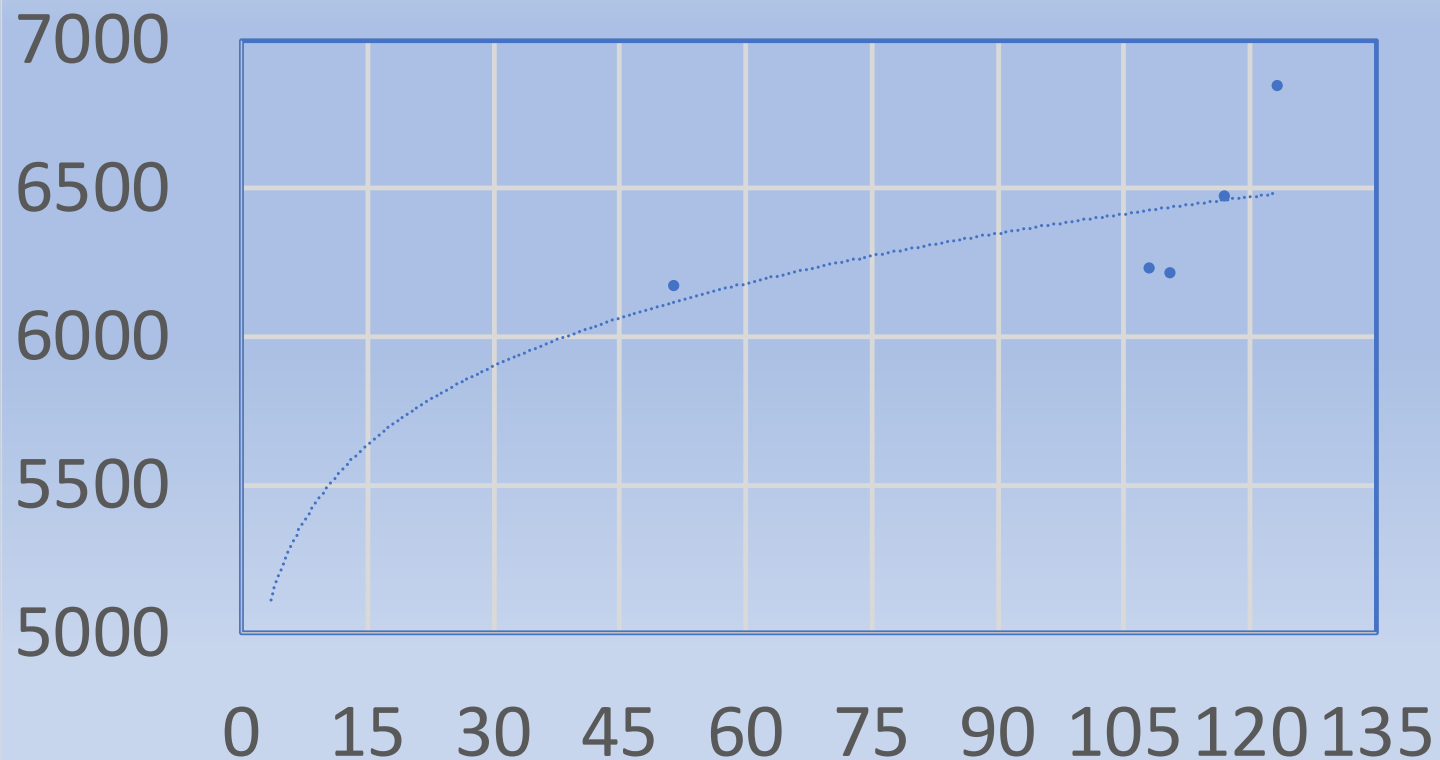
Bangor Savings Bank, 11 Hamlin Way

Bangor, ME

Depressurized Runs	Enclosure Pressure Difference Pa	Enclosure Air Leakage CFM	Air Leakage CFM/ft² Surface
A	75	6273	0.06
B	75	6138	0.06
C	75	6319	0.06
Pressurized Runs			
D	75	6101	0.06
Average	75	6208	0.06

Plan C ASTM E779 At Pressures Above 75 Pa ?@##%!!

Avg Fan Flow CFM at Induced Pressure Difference





Results Using ASTM E779 Test Methodologies

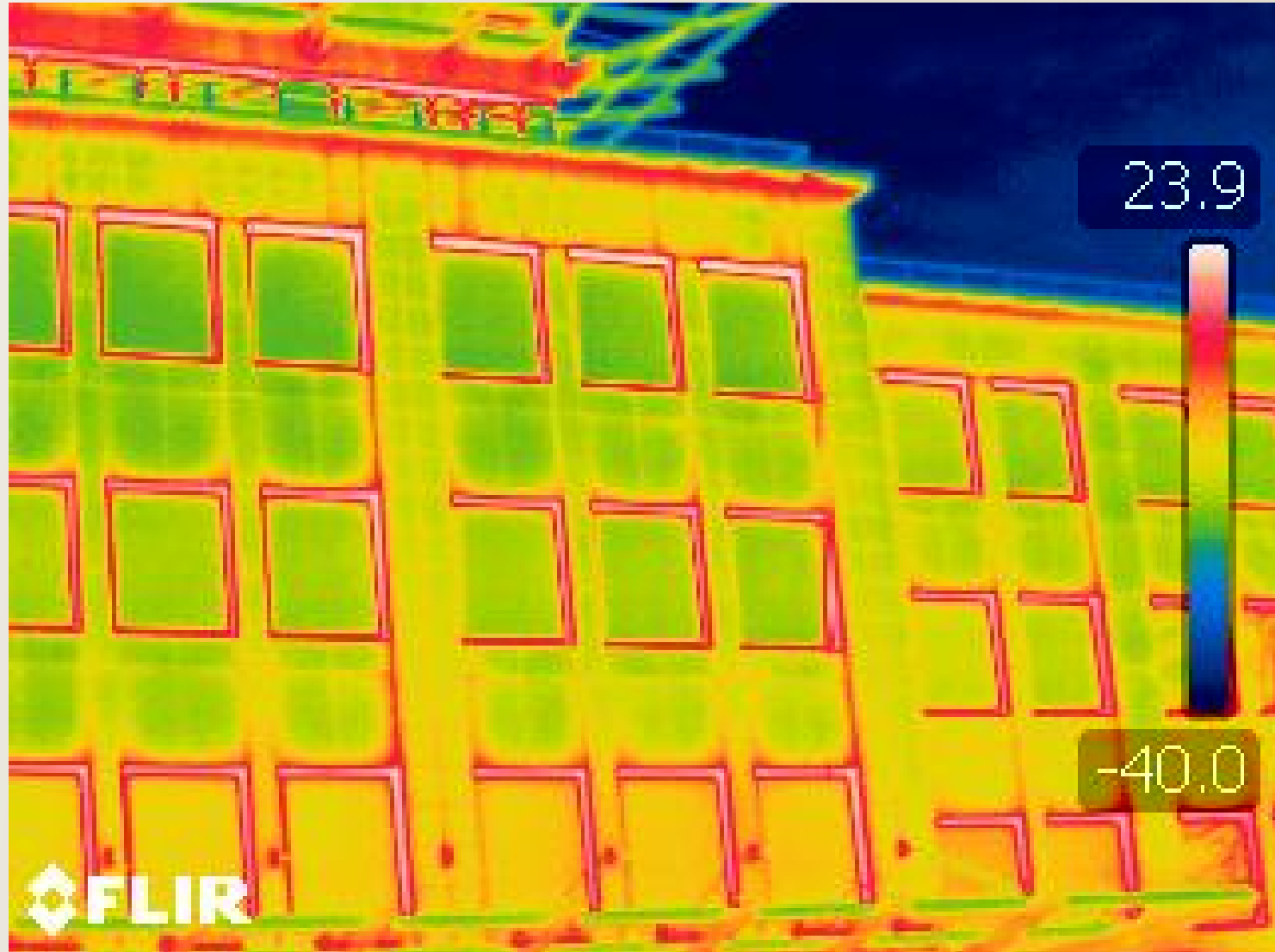
Building surface area = 108,309 sqft

Avg Test Flow at 75Pa = 6273 CFM

Building Enclosure Tightness

Value 0.06 CFM/sqft @ 75 Pa IPD

Documenting The Air Leakage Sites





Thanks For Listening
Enjoy Your Day

