



Air Barrier & Continuous Insulation

Presented by:

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CEO & President, Senior Principal

Karim P. Allana, PE, RRC, RWC

- **Education:** B.S., Civil Engineering, Santa Clara University
- **Registration:** P.E., Civil Engineering, California, Washington, Nevada, and Hawaii
- **Certification:** Registered Roof Consultant (RRC), Roof Consultants Institute, and, Registered Waterproofing Consultant (RWC)
- **Overview:**
 - CEO and Senior Principal at Allana Buick & Bers.
 - Former Turner Construction Employee (Project Engineering and Superintendent)
 - Over 37 years experience providing superior technical standards in all aspects of building technology and energy efficiency.
 - Principal consultant in forensic investigations of building assemblies, failure analysis, evaluation and design of building infrastructure and building envelope evaluation and design.
 - Expert in all aspects of building envelope technology.
 - Completed numerous new construction, addition, rehabilitation, remodel and modernization projects for public and private sector clients.
 - Specialization in siding, roofing, cement plaster, wood, water intrusion damage, window assemblies, storefronts, below grade waterproofing, energy efficiency, solar engineering and complex building envelope and mechanical assemblies.





Presentation Overview

- ABBAE firm overview
- Air Barrier and Continuous Insulation
- Air barrier testing for enclosure performance



ABBAE Firm Overview

ABBAE Firm Overview

- Allana Buick & Bers (ABBAE) is an architectural engineering firm specializing in Building Envelope Systems
- ABBAE is one of the 5 largest building envelope consultants in the country
- ABBAE has over 31 years of experience with over 5,250 projects
- 45% of our work is new construction with over \$7B under construction. 55% of our work is building rehabilitation and repairs
- Office Locations – 12 offices across California, Oregon, Nevada, Washington, North Carolina, and Hawaii



ABBAE Building Expertise

- Building Envelope Expertise

- Windows and glazing systems
 - Punched windows
 - Curtain wall/window wall systems
 - Sliding glass doors
 - Skylights
- Exterior wall systems
 - Sheet metal flashings
 - Wall cladding/siding/GFRC/pre-cast
 - EIFS/stucco
- Roofing systems
 - High-slope/low-slope roofs
 - Green/garden roofs
 - Drainage systems
 - Pedestrian plazas

- Waterproofing systems
 - Deck/balcony/lanai waterproofing
 - Podium waterproofing
 - Pool/spa deck waterproofing
 - Below-grade waterproofing

- Mechanical/HVAC Expertise

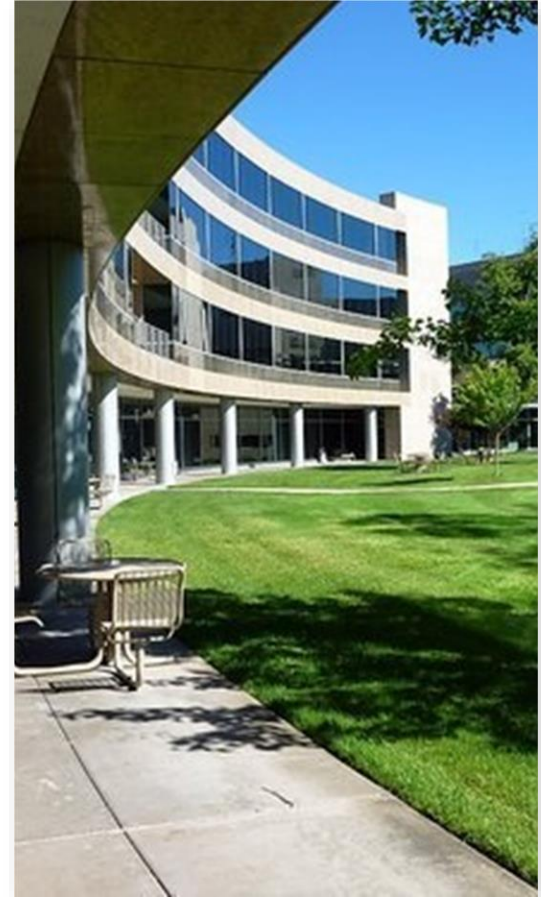
- HVAC design
- Plumbing systems
- Commissioning and testing

Qualified Staff & In-House Expertise

- Curtain wall and glazing testing
- (ABAA)Certified Air Barrier Testing
- Certified nuclear Troxler operators for non-destructive testing
- ICC certified inspectors
- Certified Exterior Insulation and Finish System (EIFS) inspectors
- Certified infra-red thermographers
- Registered Roof Observers (RROs)
- Licensed Professional Engineers – Civil, Structural, and Mechanical
- Registered Exterior Wall Consultant (REWCs)
- Quality assurance Monitors for exterior enclosure
- Certified Construction Contract Administrator (CCCA)
- Registered Building Envelope Consultant (RBEC)
- Registered Roofing Consultants (RRCs)
- Registered Waterproofing Consultants (RWCs)

ABBAE Core Services For Contractors

- Designer of record for design-build projects
- Third-party design review services
- Procurement and bidding phase consulting services
- Mock-up testing
- Construction observations, inspection & quality assurance
- Leak investigation and mitigation design
- Forensic litigation support and expert witness services
- Educational industry seminars



ABBAE Can Procure Materials For GC's

- Curtain wall systems
- Punched windows, skylights, sliding and folding doors
- Solar panels and inverters
- Chillers, boilers, pumps and other mechanical equipment
- LED lighting

Reducing Risk, Pre-construction

- Peer Review of Architect Enclosure
- Value Engineering Studies and Consultation
- Sub-Contractor Qualification Reviews
- Review design-build glazing proposals and shop drawings
- Pre-Construction Meetings with Key Enclosure Sub-Contractors
- Review shop drawings and submittals
- Mock-Up design and testing
- Early Enclosure RFI Consultation



Post Construction Phase Consulting Services

- Manufacturer warranty review and consultation
- Mediation/arbitration defense expert
- As-built drawing assistance
- Forensic investigation/enclosure defense expert



Air Barriers and Continuous Insulation Requirements

2006 IECC

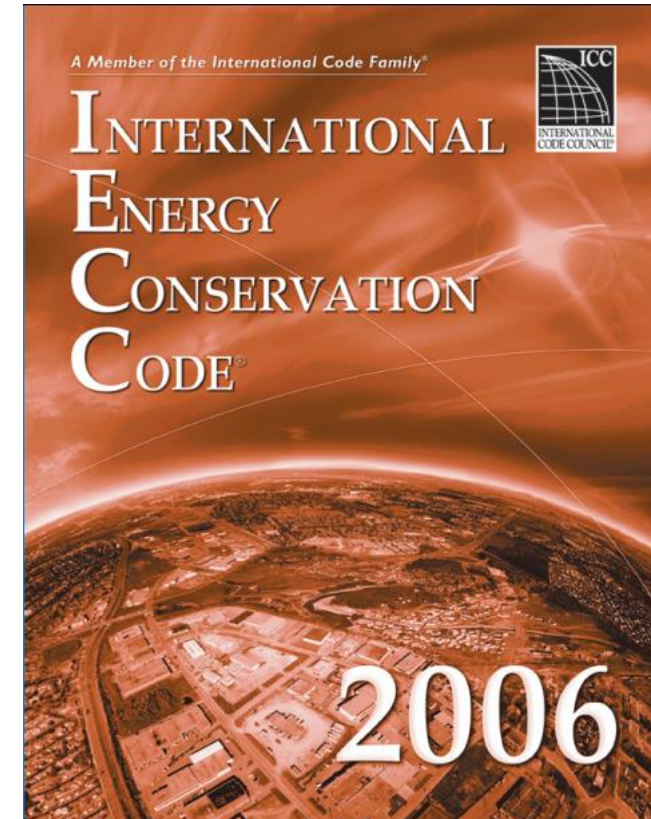
STATE ADOPTIONS

- ✓ *Alaska, Tennessee*
- ✓ *Maui County**
- ✓ *Honolulu County**
- ✓ *Hawaii County**

**Have independent and separate amendments*

Air Barrier Overall Requirements

1. *Residential vs. Commercial requirements*
2. *General, non-quantative building envelope requirements*
3. *Testing of the building envelope air barrier not required*
4. *Quantified air leakage limitations for fenestration and doors with testing requirements.*
5. *Not climate zone dependent*



2012 IECC Air Barrier/Leakage Rates

- Assemblies of materials and components that have an average air leakage not exceeding 0.04 cfm/sf, under a pressure differential of 1.57 psf, when tested in accordance with ASTM E2357, E1677, E1680, or E283; or
- Exception to Section CEC Section 14.3(a)9B if all joints are sealed and all of the materials are installed as air barriers in accordance with the manufacturer's instructions.
- Consistent with air leakage req in IECC (140.3(a)9B)

2015 IECC Code Adoption

- In March 2017 State of Hawaii Adopted the 2015 International Energy Conservation Code (IECC)
- Counties were provided a two year period to adopt
- Full adoption will occur in 2019
- Currently, most federal government projects require air barriers

Air Barriers are required in both Residential and Commercial Construction

Continuous Insulation Defined

- *Insulation that is continuous across assemblies that separate conditioned from unconditioned space. It is installed on the exterior or interior or is integral to any opaque surface of the building envelope and has no thermal bridges other than fasteners and necessary service openings.*
 - -2013 Title 24, Part 6
- *Insulation that is installed in such a that is continuous and is uninterrupted by framing members or other construction elements that would reduce the thermal resistance of the insulation.*
 - -2004 ASHRAE 90.1 User's Manual

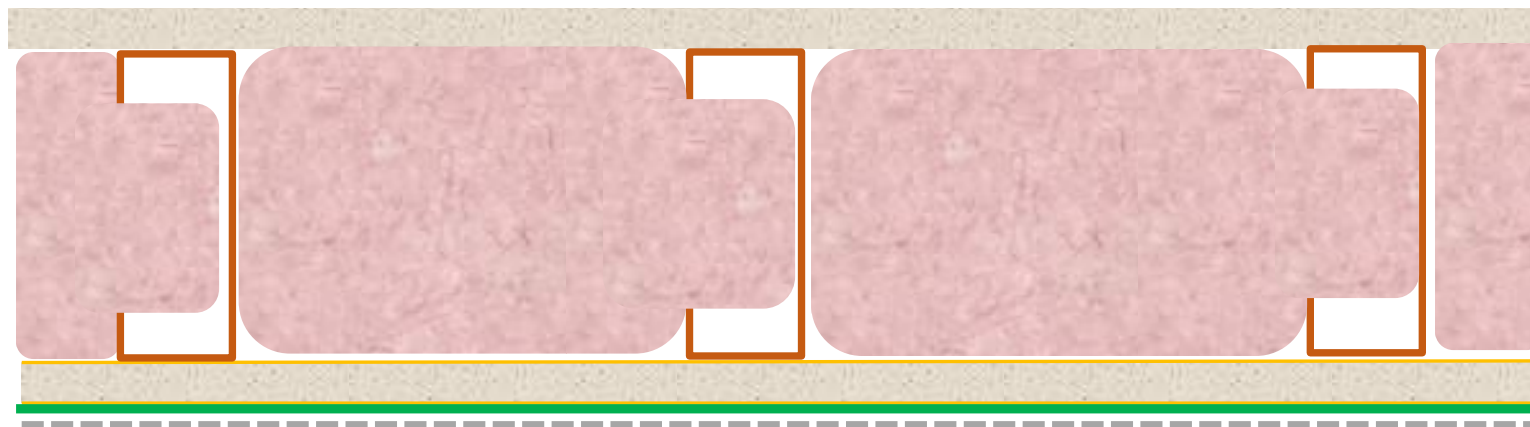
R Value Reductions; Why Code is Requiring It!

**TABLE A9.2-2 Effective Insulation/Framing Layer R-Values
for Wall Insulation Installed Between Steel Framing**

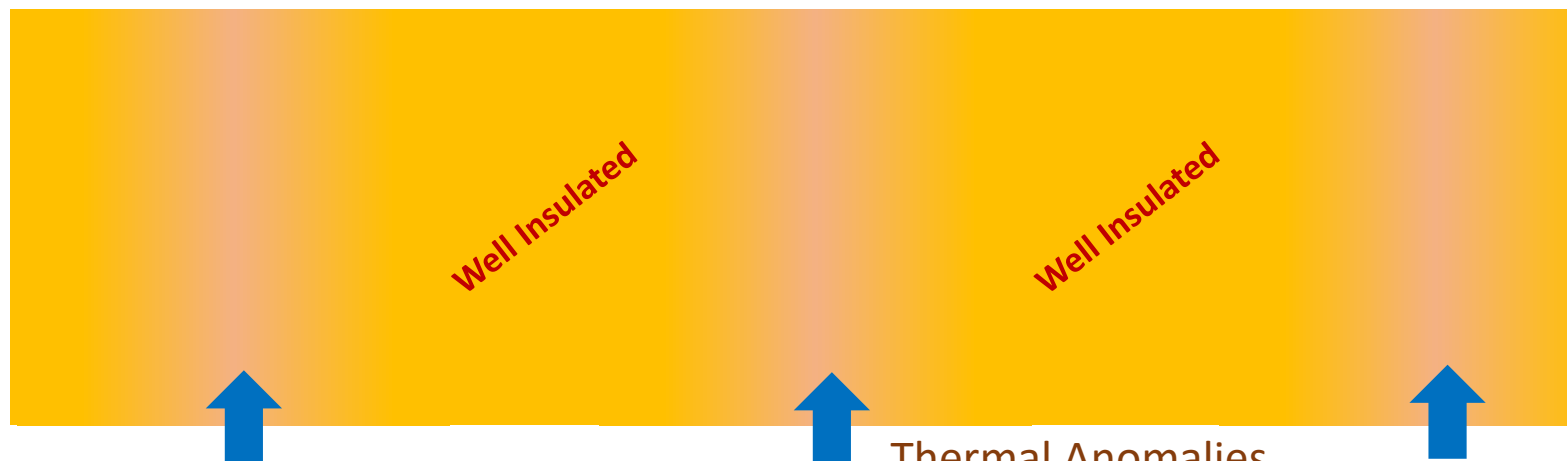
Nominal Depth of Cavity, in.	Actual Depth of Cavity, in.	Rated R-Value of Airspace or Insulation	Effective Framing/Cavity R-Value at 16 in. on Center	Effective Framing/Cavity R-Value at 24 in. on Center
Empty Cavity, No Insulation				
4	3.5	R-0.91	0.79	0.91
Insulated Cavity				
4	3.5	R-11	5.5	6.6
4	3.5	R-13	6.0	7.2
4	3.5	R-15	6.4	7.8
6	6.0	R-19	7.1	8.6
6	6.0	R-21	7.4	9.0
8	8.0	R-25	7.8	9.6

Metal framed wall assemblies require a reduction factor.

Typical Exterior Insulation

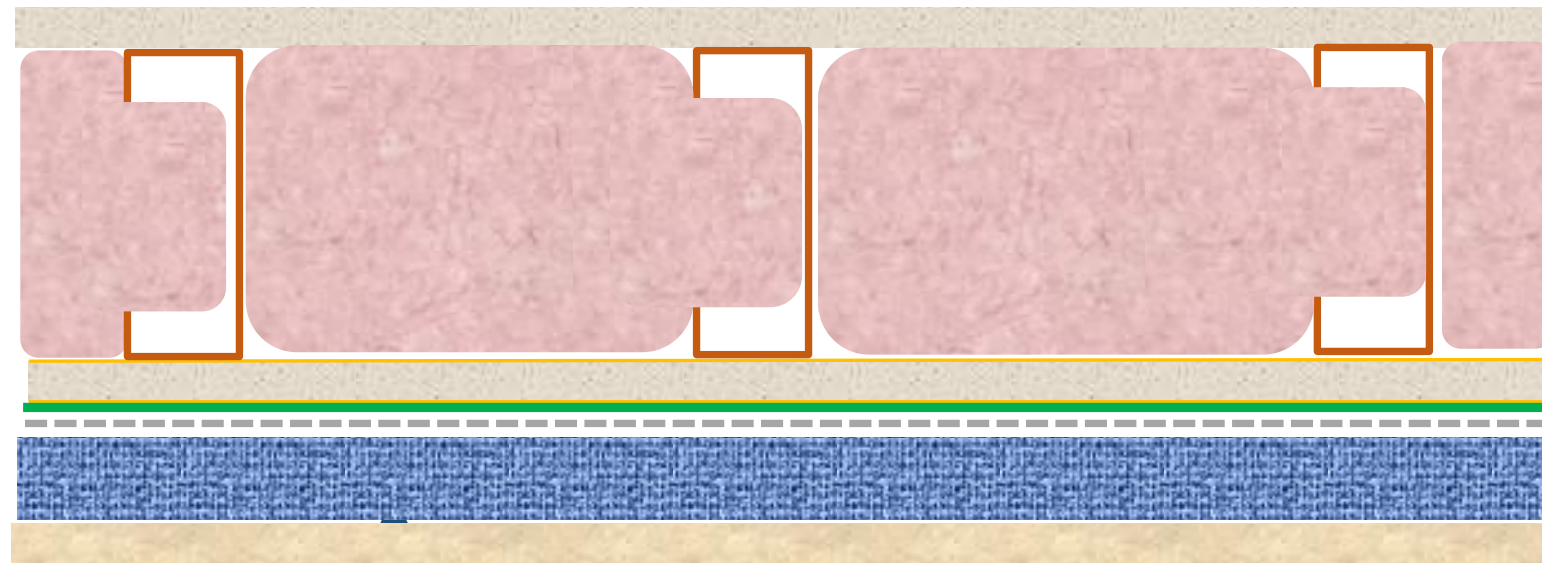


Traditional Insulated Wall Section

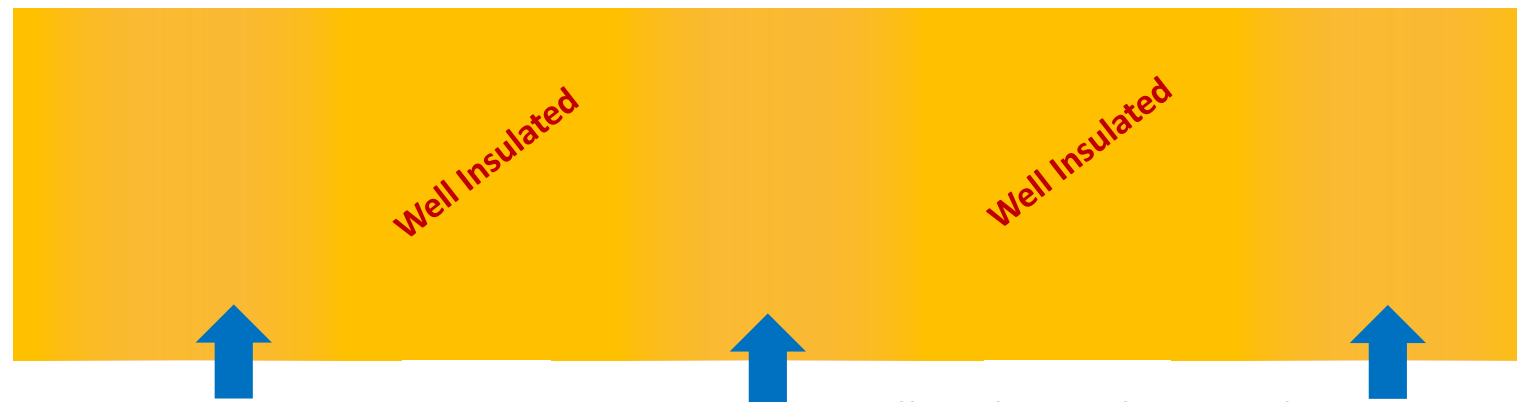


Thermal Anomalies

Typical Continuous Exterior Insulation

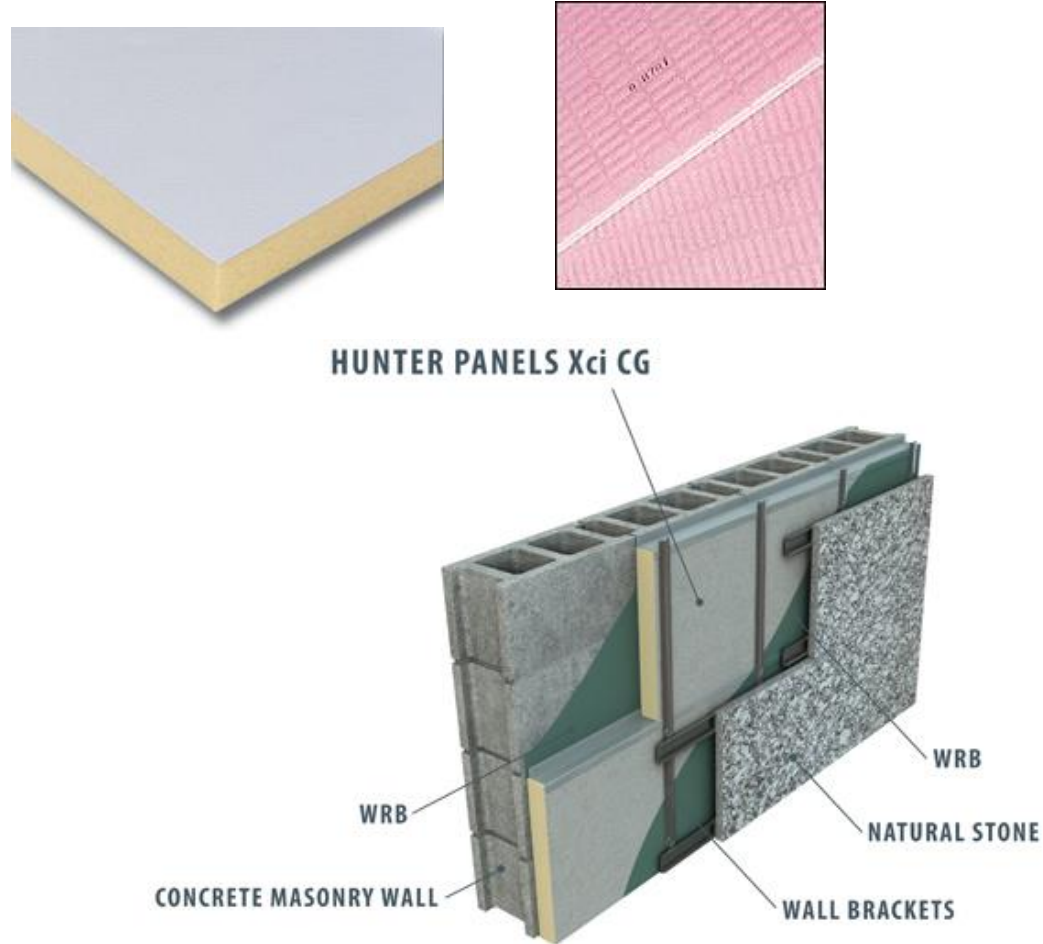


Continuous Insulated Wall Section



How do we solve the CI challenge?

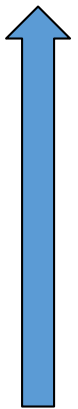
- Material Selection
- Design Consideration



Material Selection Considerations

- R-value
- Air and vapor permeability
- Moisture resistance
- Composite qualities (i.e. – integral cladding, weather resistant barrier, air barrier, interior vapor barrier)
- Fire Resistance
- UV Resistance (for open joint assemblies)
- Furring and Effective R Reductions

Continuous Insulation Options



R Value

- Insulation Panels and Materials
- ccSPF – Closed Cell Spray Polyurethane
- PolyIso – Polyisocyanurate
- XPS – Extruded Polystyrene
- Mineral Wool Insulation
- EPS – Expanded Polystyrene
- Insulation Panel Enhancements
- Foil Facing
- Plywood Facing
- Reinforced Cementitious Coating Faced

Insulation Panel Manufacturers

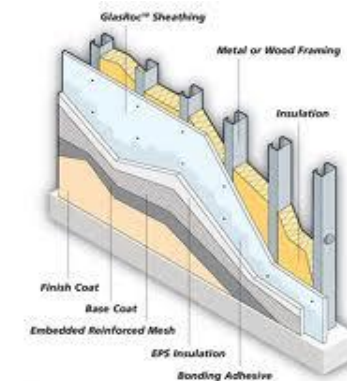
Manufacturer	Product Name	R / inch	Perms
R Max	Thermasheath-3 (Polyiso with facer)	6	< 0.3
DOW	Styrofoam (XPS)	5.0	1.5
	Thermax (Polyiso with facer)	6.5	< 0.3
Polyshield	Polyshield Sheathing (EPS)	3.85	> 2.0
Insulpink	OC Foamular XPS	5.2 *	1.5
Owens Corning	Insulating Sheathing (XPS)	5.0 *	0.2
Roxul	Cavity Rock DD (Stone Wool)	4.3	27.2
Therma Fiber	Rain Barrier (Rock Wool)	4.2	50
BASF	Spraytite (ccSPF)	6.62 **	1.39
Atlas	Energy Shield (PolyIso)	6.0 *	< 1.0
Hunter Xci	Xci CG (Polyiso)	6.0 *	< 1.0
* Based on LTTR			
** 6.62 – 6.9 Based of Formulation			

Insulation Assembly Manufacturers

Manufacturer	Product Name	R / inch	Perms
<u>EIFS – Exterior Insulating Foam System</u>			
Dryvit	(EPS)	3.6	Varies
STO	(EPS)	3.8	Varies
Senergy	(EPS)	N P	N P
Parex	(EPS)	N P	N P
<u>SIPS – Structural Insulated Panel</u>			
Insulspan	Insulspan SIPS	3.6	0.5
S Panels	R Control	3.5	< 1.0
Carlisle	Premier SIPS	4.2	< 1.0
<u>ICF – Insulated Concrete Forms</u>			
Quad Lock	Quad Lock ICF	5 - system	N P
Nudura	Nudura ICF	1.8 / 4 *	0.624
Arxx	Arxx Edge	N P	0.63
Amvic	Amvic ICF	2.4 / 3.8 *	2.3

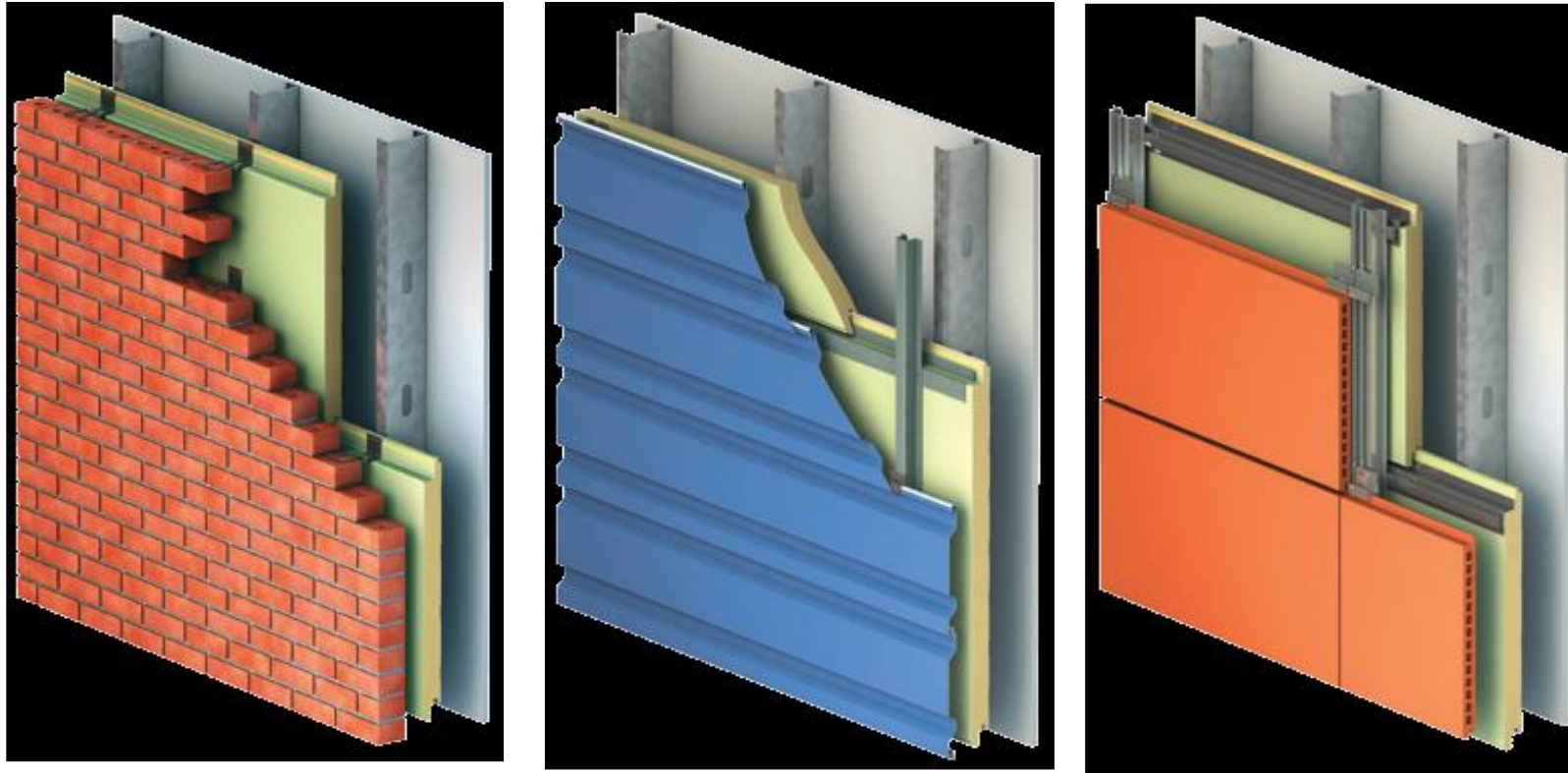
Continuous Insulation Composites

- Insulated Concrete Forms
- Structural Insulated Panel System
- Exterior Insulated Foam System



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Exterior Insulation and
Finish Systems (EIFS) Applications

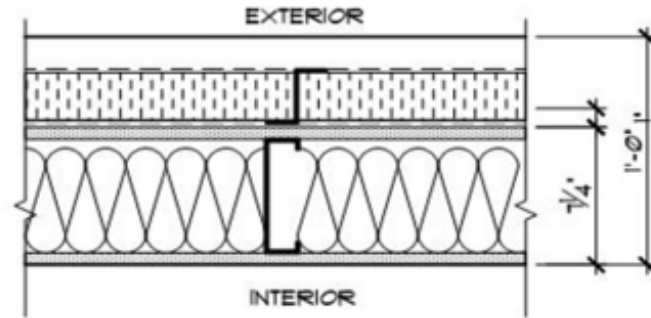
Metal Panels With Continuous Insulation



- These types of system requires clips and mechanical fasteners that bridges heat.
- Adhered Insulation like EIFS does not require fasteners.

Wall Section Real R Value

E4
EXTERIOR WALL
METAL SIDING
(TYPE 1A)



HORIZONTAL METAL SIDING
(A) AEP PRESTIGE METAL PANEL SYSTEM OR
(B) STANDING SEAM METAL SIDING,
3/4" VERTICAL FURRING CHANNELS @ 24" O.C. GALV. STEEL
2 1/2" (R-15) POLYISO RIGID INSUL
WEATHER BARRIER (PER SPEC)
5/8" TYPE 'X' GWB SHEATHING
6" STEEL STUD @16" O.C. WALL (PER STRUCTURAL)
R-21 BATT INSULATION
5/8" TYPE 'X' GWB
PVA PRIMER

E-4					
Material	Thickness	Perms	Pub. R-Value	Reduction	Eff. R-Value
Metal Cladding	1.5	0.01	0	0	0
Air Space	0.75	100	0.25	0	0.25
Foil Faced PolyIso with Z girts 16 inches on center *1	2.5	0.01	15	0.74	3.9
WRB/AB	0	23	0	0	0
Sheathing (Gyp)	0.625	50	0.5	0	0.5
Unfaced Batt with metal studs 16 inches on center *2	6	70	21	0.65	7.4
Sheathing (Gyp)	0.625	50	0.5	0	0.5
PVA Primer and Paint	0	0.5	0	0	0
Inside Air	0	0	0.68	0	0.68
	12		37.93		13.23
			Base Line		Base Line



San Diego International Airport

Continuous Insulation Mock-up

Contin

port





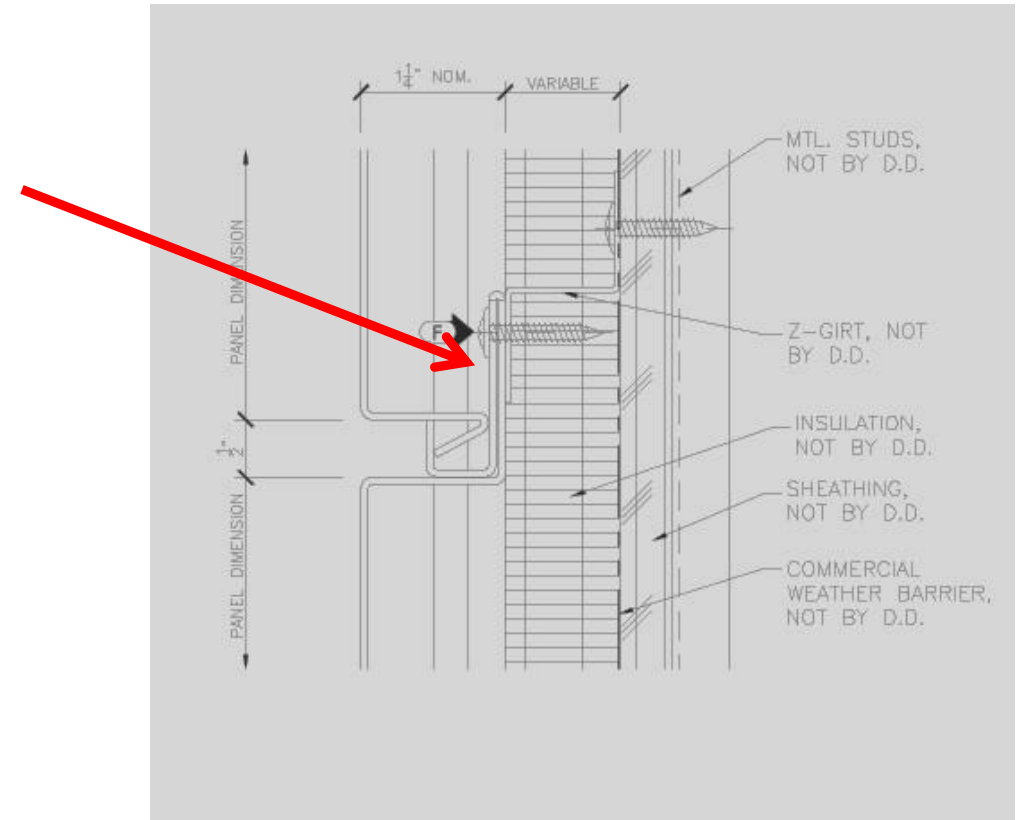




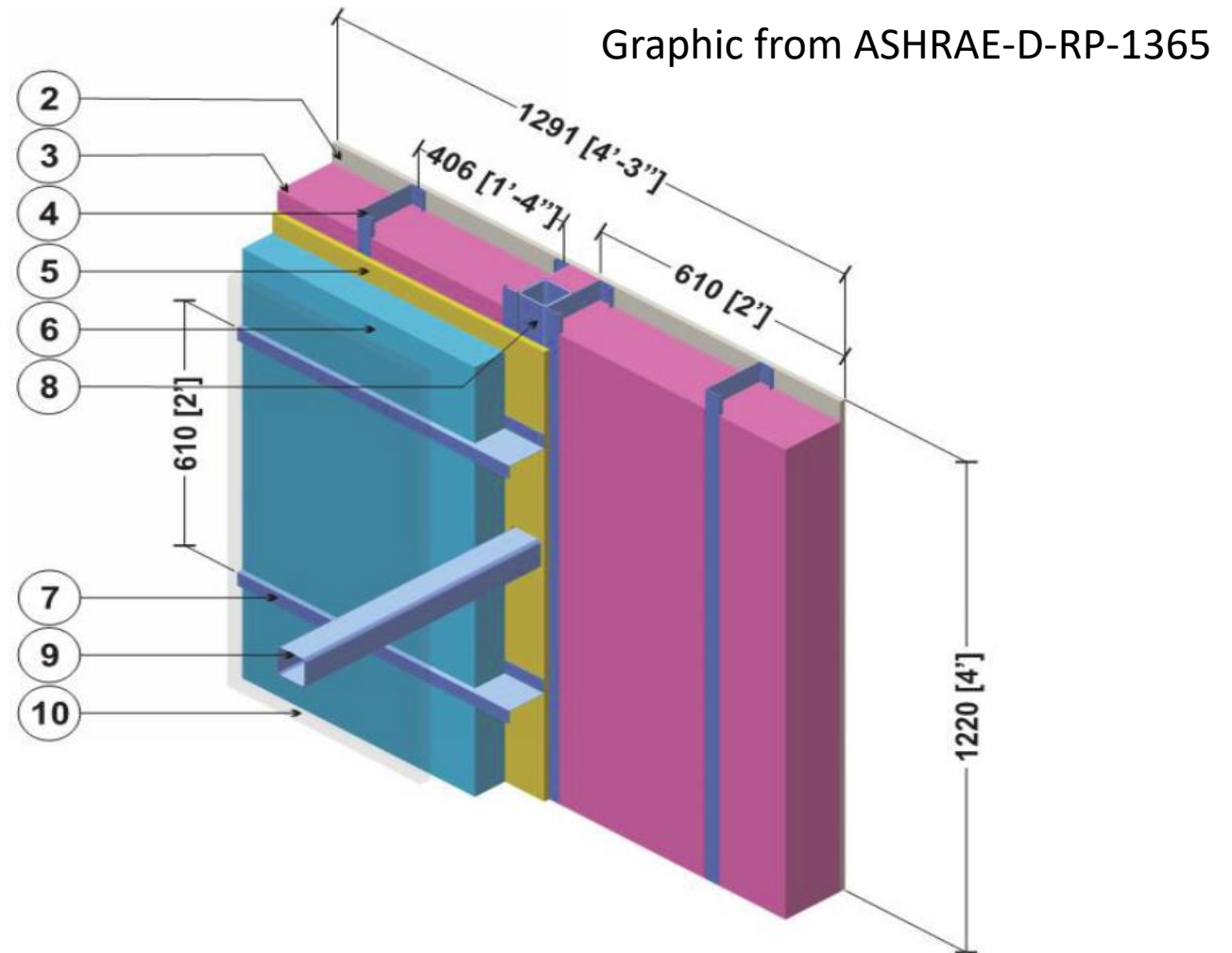


Thermal Bridges

- Because metal is a terrific conductor of heat, thermal bridges increase the U-value of an assembly
- In a side by side comparison, metal stud framing is 15 - 50% less efficient than wood framing
- Z-girts through continuous insulation assemblies increase the U-values of the assembly by 20-40%
- R-21 with Z-girts = R-15_{eff}



Z-Girt and Canopy Support





Air Barrier Basics

Air Barrier Defined

- “Materials assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material or a combination of materials.”
-2015 International Energy Conservation Code (IECC)
- A system of materials combined to form continuous control of the air leakage of a building.
-Air Barrier Association
- Air barriers define the location of the pressure boundary of the building enclosure.
-Joseph Lstiburek of the Building Science Corporation

How Does Air Leakage Occur

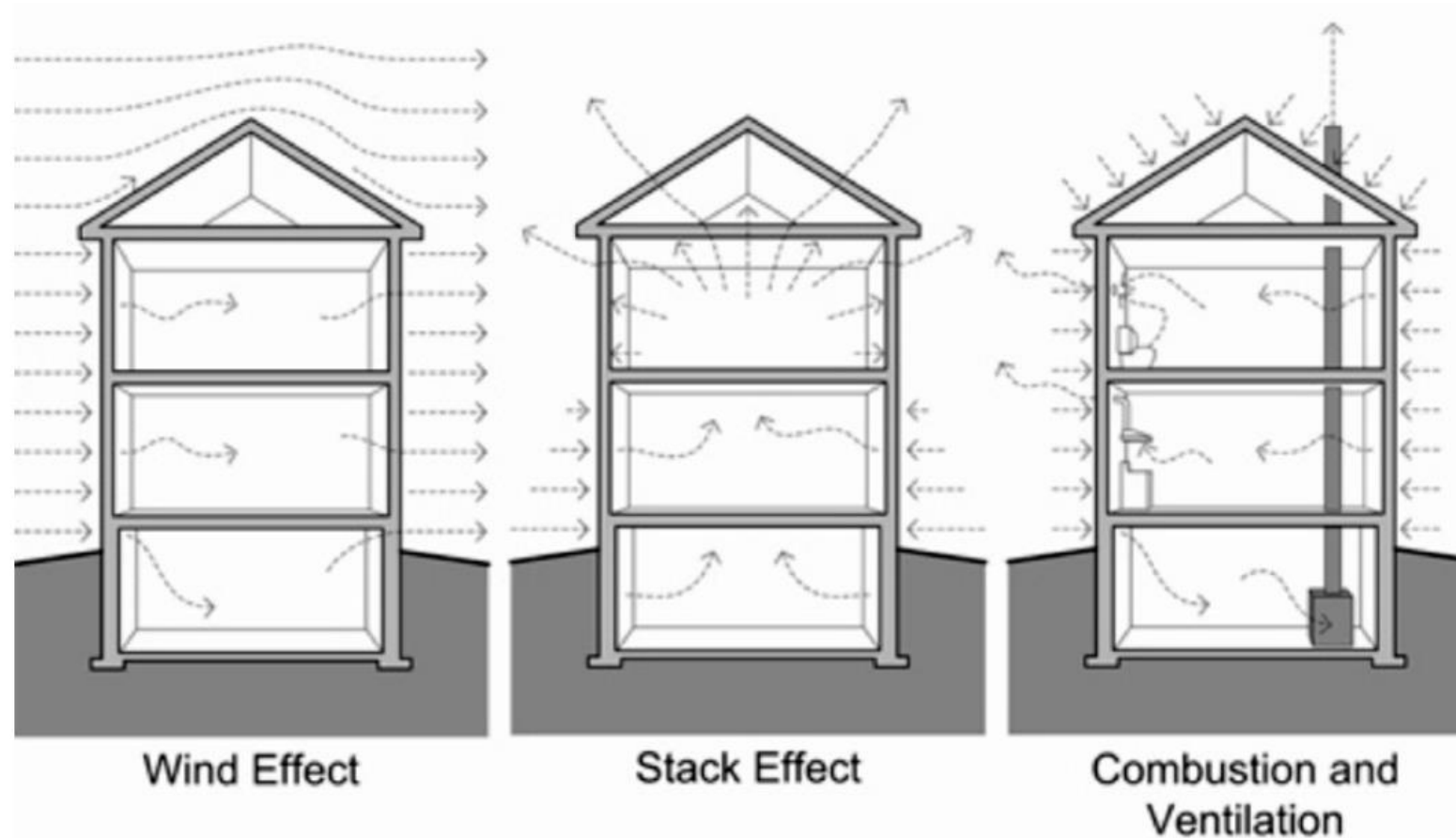


Figure 1: Examples of infiltration. Image courtesy: Building Science Corporation, www.buildingscience.com

Material vs. Assembly vs. System

Air Barriers are commonly defined and tested in three categories:

- ✓ As a Material
- ✓ As an Assembly (network of materials)
- ✓ As a System (network of assemblies)

Material vs. Assembly vs. System

- Air Barrier Material Testing Requirements

ASTM E2178-11 Standard Test Method for Air Permeance of Building Materials.

< 0.02 L/(s•m²) @ 75 Pa (0.004 cfm/ft² @ 1.57 lb/ft²)

- Air Barrier Assembly Testing Requirements

ASTM E2357-11 Standard Test Method for Determining Air Leakage of Air Barrier Assemblies

<0.2 L/(s•m²) @ 75 Pa (0.04 cfm/ft² @ 1.57 lb/ft²)

- *Air permeance is the amount of air that migrates through a material, whereas...*
- *Air leakage is the air that passes through holes or gaps*

Material vs. Assembly vs. System

- Air Barrier System (Building) Testing Requirements
- ASTM E779-10: Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
 - 2015 IECC - Energy Code Requires:
< 0.40 cfm/ft² @ 1.57 lb/ft²
 - US Army Corps of Engineers Requires:
< 0.25 cfm/ft² @ 1.57 lb/ft²
- ASTM E1827-11: Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door
- ASTM E283-04: Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
- ****Testing can be done by Unit(s), Floor(s) or Building. If air barrier testing is planned by unit, detailing and continuity needs to be by unit.*

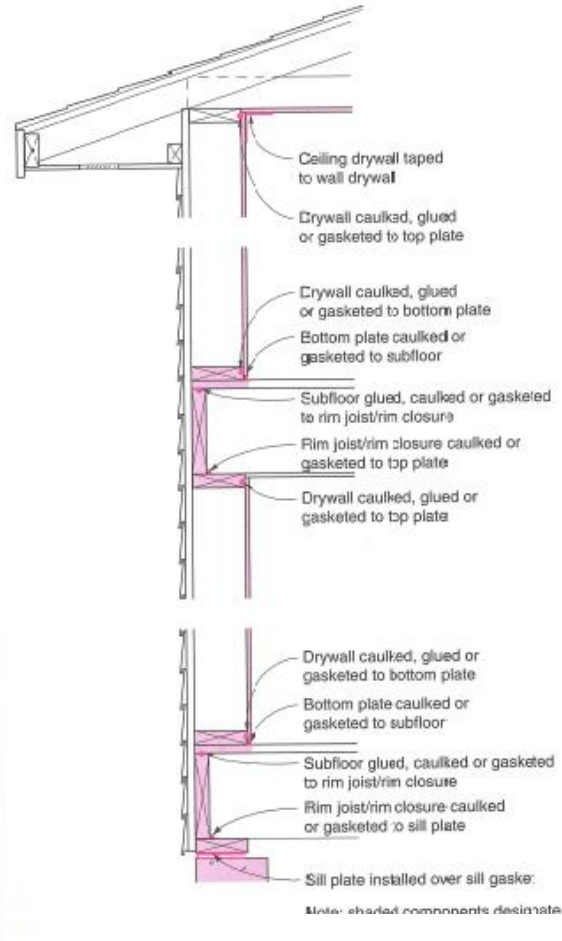


Air Barrier Techniques and Materials

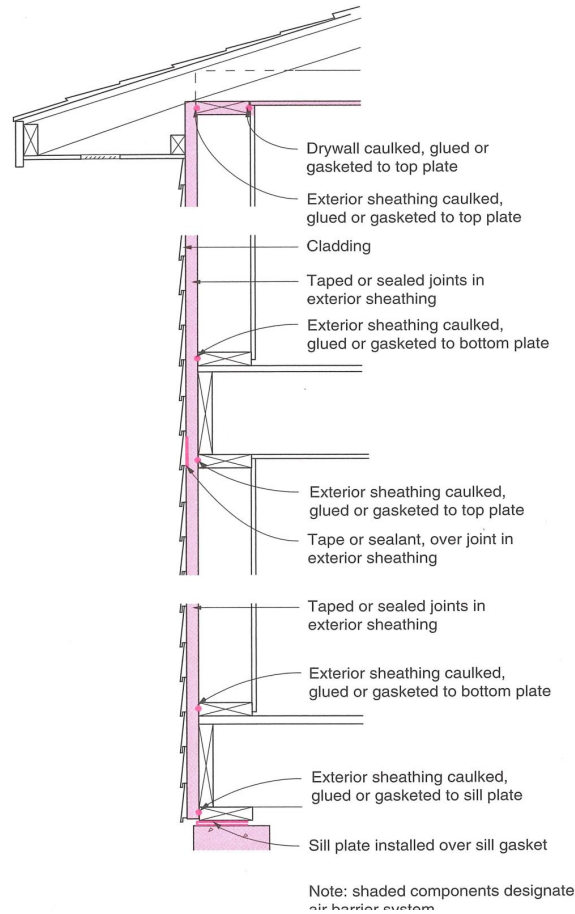
3 Typical Air Barrier Approaches

- Air Tight Drywall and Framing
- Exterior Sheathing
- Exterior Weather Resistive Barrier
- *Most successful approach is a combination of approaches*

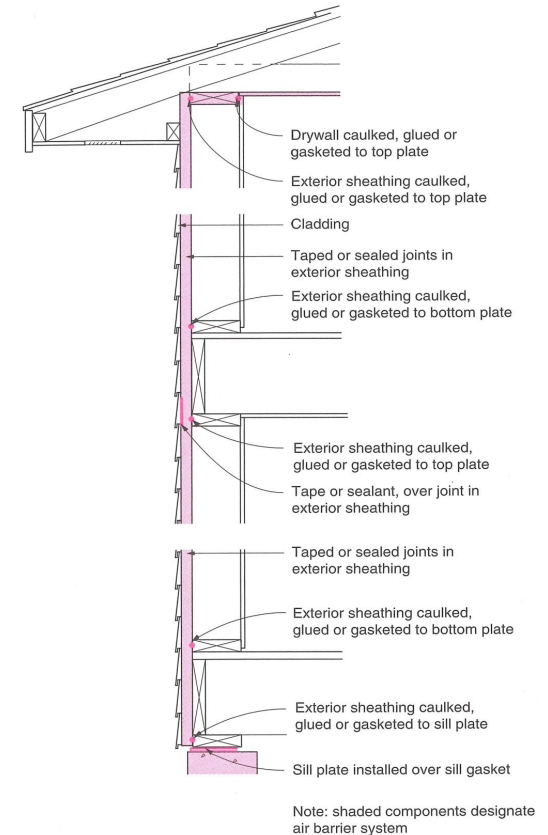
Air Barrier Approaches



Interior Drywall Approach



Exterior Sheathing

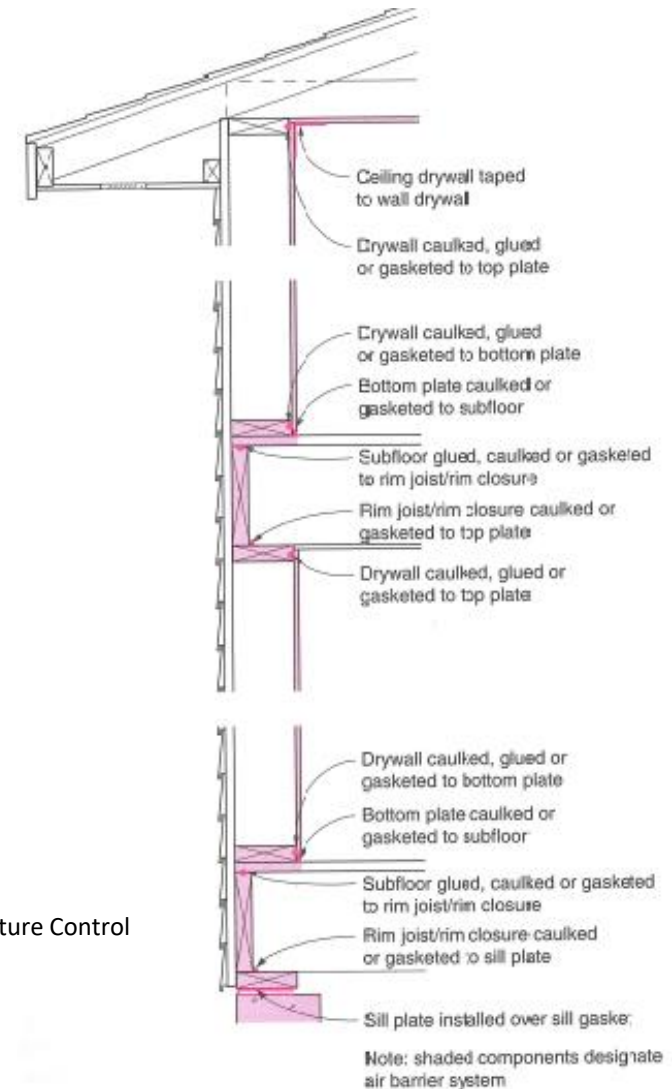


Exterior Barrier

Air Tight Drywall And Framing Approach

- Requires tapped seams, spray foam, sealants and other air barrier transition components

Taken from Moisture Control Handbook



Air Tight Drywall and Framing Approach

Pros

- Controls the entry of interior, moisture laden air from entering into wall cavity
- Can be enhanced with ccSPF
- Repaired easily
- Inspected visually and tested easily
- Lower cost

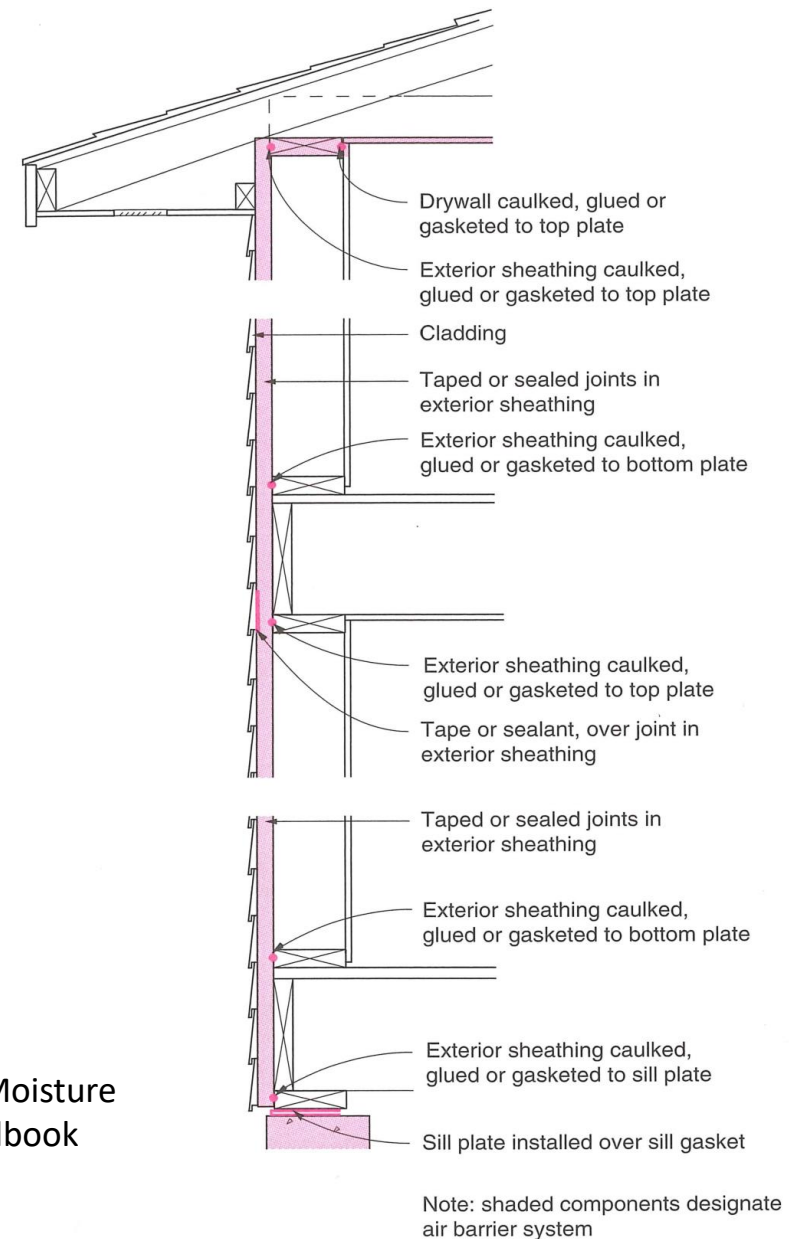
Cons

- Does not control exterior humidity from reaching interior cool surfaces
- Humid air from outside can condense on interior surfaces (Not recommended for Hawaii)
- Easily damaged by occupant usage
- Demising walls require detailing
- Several trades involved in the proper installation of the entire system

Exterior Sheathing Approach

- Plywood
- OSB
- Gypsum Board
- Requires taped seams, spray foam, sealants and other air barrier transition components

Taken from Moisture
Control Handbook



Seal Joints and Gaps



Seal Joints and Gaps in Sheathing



Thoroughly Seal Gaps in Sheathing



Sealing Sheathing Joints



Tape, mud or Seal Joints and Gaps



Seal Joints and Gaps



Rough Opening Seals

Sheathing Joint Seal

Exterior Sheathing Approach Pros and Cons

Pros

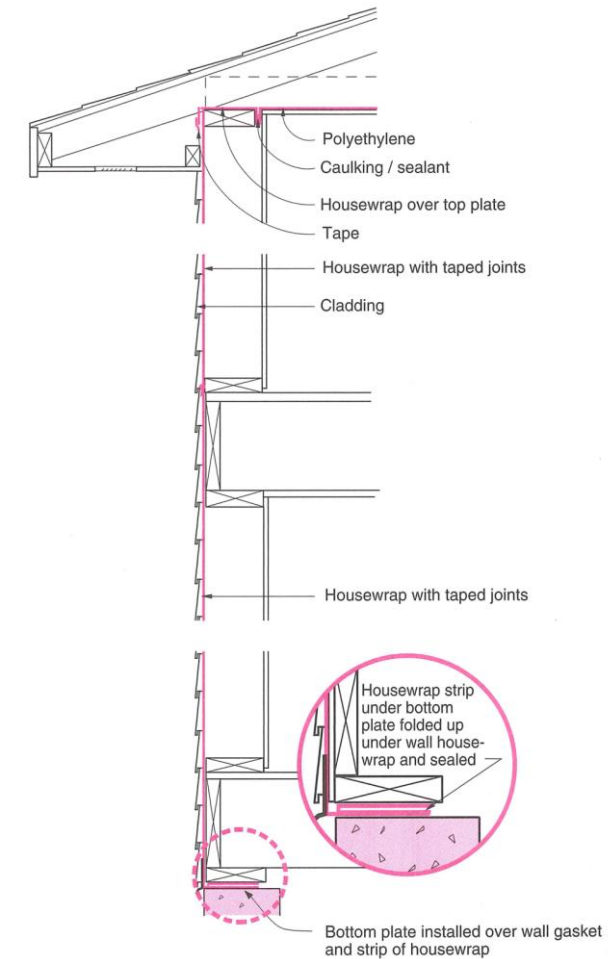
- Cost Effective
- Can be enhanced with ccSPF
- Controls both air and vapor
- One – two trade installation
- Inspected visually and tested / repaired easily
- Controls wind-washing of insulation

Cons

- Building Movement Could Create Discontinuity
- Joint Treatment may be Weather Sensitive
- Subject to construction damage / penetrations after installation
- Requires weather resistant barrier to control moisture

Exterior Weather Resistant Barrier Approach

- Liquid Applied Coatings
- Non-Adhered Membranes
- Adhered Membranes
 - Requires taped seams, spray foam, sealants and other air barrier transition components



Taken from Moisture Control Handbook

Liquid Applied WRB and Air Barrier Mock-Up



Liquid Applied With Self Adhered Flashings



Window sealed with Flexible Flashings

Liquid Applied Approach Pros and Cons

Pros

- Controls air, vapor and moisture
- One trade installation
- Inspected visually and tested / repaired easily
- Controls wind-washing of insulation
- Controls exterior humidity (Hawaii)
- Nail Seal-ability
- Seamless

Cons

- Potential Adherence Issues with Multiple Substrates
- Blistering
- Requires substrate board
- May Require Crack Bridging Characteristics
- Current total system cost higher than other approaches

Adhesion Issue



Blistering



Air and Water Barriers Manufacturers

- Permeable and Semi Permeable Fluid Applied:

Manufacturer	Product Name	Perms Dry / Wet	Air Leakage
BASF	Various Products	0.08 / 5.85	0.0066
DuPont	Tyvek Fluid Applied WB	11.48/24.23	0.0036
Grace C.P.	Perm-A-Barrier VP	0.09 / 0.03	<0.004
	Perm-A-Barrier Liquid		<0.004
Henry Co.	Air Bloc 31	0.57 / 36.12	0.004
	Air Bloc 32	0.23 / 1.02	0.0029
Momentive	SilShield AWB	4.27 / 5.49	0.0064
Parex USA	Weatherseal	0.828 / 9.2	0.0548
Prosoco Inc.	R-Guard Spray Wrap	2.52 / 10.5	0.016
Sto Corp.	Gold Coat 265	2.52 / 5.7	0.016
WR Meadows	Air Shield LMP	na / na	0.0026
	Air Shield LM	na / na	0.0035

Non-Adhered Membrane, All Seams Taped



Non-Adhered Membrane Approach

Pros

- Controls air, vapor and moisture
- One trade installation
- Inspected visually and tested / repaired easily
- Controls exterior humidity
- Potential for Nail Seal-ability
- Homogenous materials
- Not Weather or Temp dependent
- Large rolls = Fast installation

Cons

- Potential UV exposure issues if left uncladded
- Potential blow off issues if left uncladded
- Seams require taping
- May require substrate board to resistant inward and outward pressures
- Requires different fastenings than WRB installation
- Integration of flexible flashings

Air and Water Barriers Manufacturers, cont.

- Non-Adhered Sheet Assemblies

Manufacturer	Product Name	Perms Dry / Wet	Air Leakage
DuPont	Tyvek Commercial Wrap Tyvek Commervial Wrap D Tyvek HomeWrap	25.31/32.68 42.65/42.48 56 / 54	0.0023 0.00225 Pass
Pactiv	GreenGuard Rain Drop GreenGuard Max GreenGuard Ultra Wrap	12.33 / np 13.52 / np 45.45 / np	<0.001 <0.001 <0.0001
VaproShield	Wallshield Wrapshield IT	np / 212 np / 50	Not A.B. <0.0094
Typar	MetroWrap HouseWrap	10 / np 12 / np	Not Test'd Not Test'd

Adhered Membrane WRB & Air Barrier



WRB/AB –Self Adhered Sheet

Pros

- Controls air, vapor and moisture
- One trade installation
- Inspected visually and tested / repaired easily
- Controls wind-washing of insulation
- Potential for Nail Seal-ability
- Homogenous materials
- No blow off issues

Cons

- Potential UV exposure issues if left un-cladded
- Requires substrate board
- May require primer
- Higher cost
- Heavier rolls
- Compatibility issues with other air barrier components

Air and Water Barriers Manufacturers

- Self Adhered Sheet Assemblies
—
- Vapor Permeable
- Vapor Barrier are acceptable in Hawaii

Manufacturer	Product Name	Perms Dry / Wet	Air Leakage
WR Grace	Perm-A-Barrier WM	np / 0.05	0.0002
Henry	Blueskin SA	0.03 / 0.86	0.006
WR Meadows	Air Shield	np / .047	0.0013
Carlisle	CCW-705	0.05 / np	<0.0009
Vaproshield	Wrapshield SA	np / 50	<0.0001
Henry	Blueskin VP160	np / 50	<0.0001
WR Grace	Perm-A-Barrier VPS	np/ >15	<0.004

SAM, Who is this guy on my details?

- Self adhered membrane is meant to supplement the WRB by:
 - Acting as a transition between details
 - Through wall flashings at grade
 - Head flashings
 - Window sill and jambs
 - Penetrations
 - Providing “self sealing” at highly nailed regions of the WRB for air and water
 - Brick ties
 - Trim
 - “z” girts
 - Providing a higher level of water resistance at horizontal projections

Air Barrier & CI Design Considerations

- Location of the Air Barrier / WRB
- Thermal Bridging
- Edge treatments and terminations
- Sequencing and Testing – Review of WRB

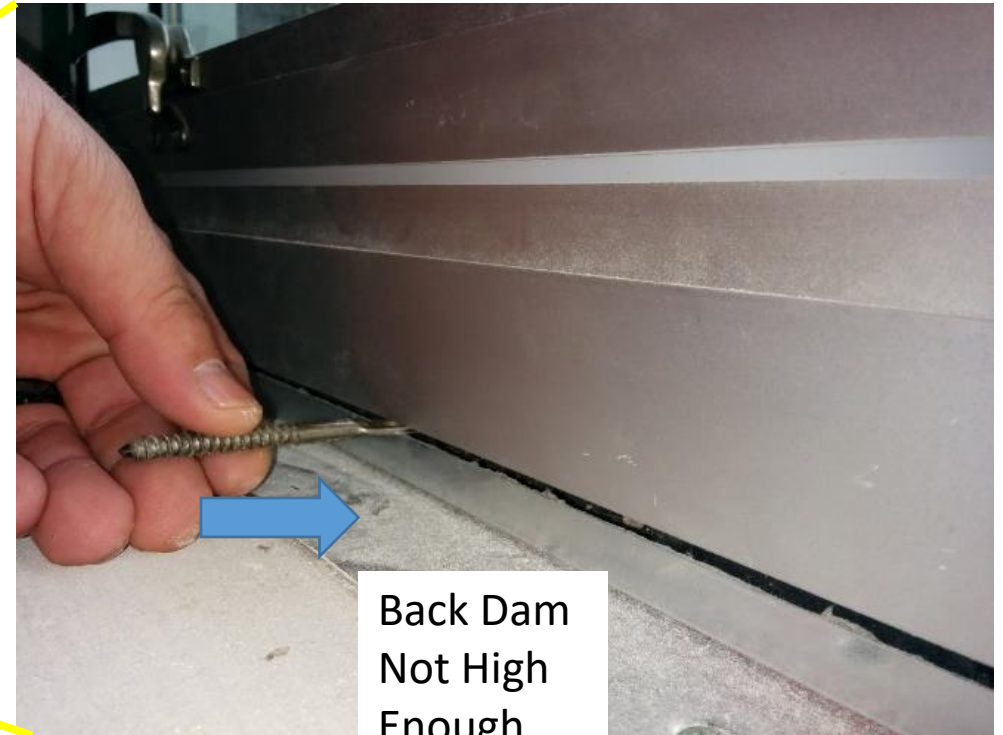
Interior Air Seal is Often Required in Fenestration



Interior Air Seal Missing



Interior Air Seal Missing



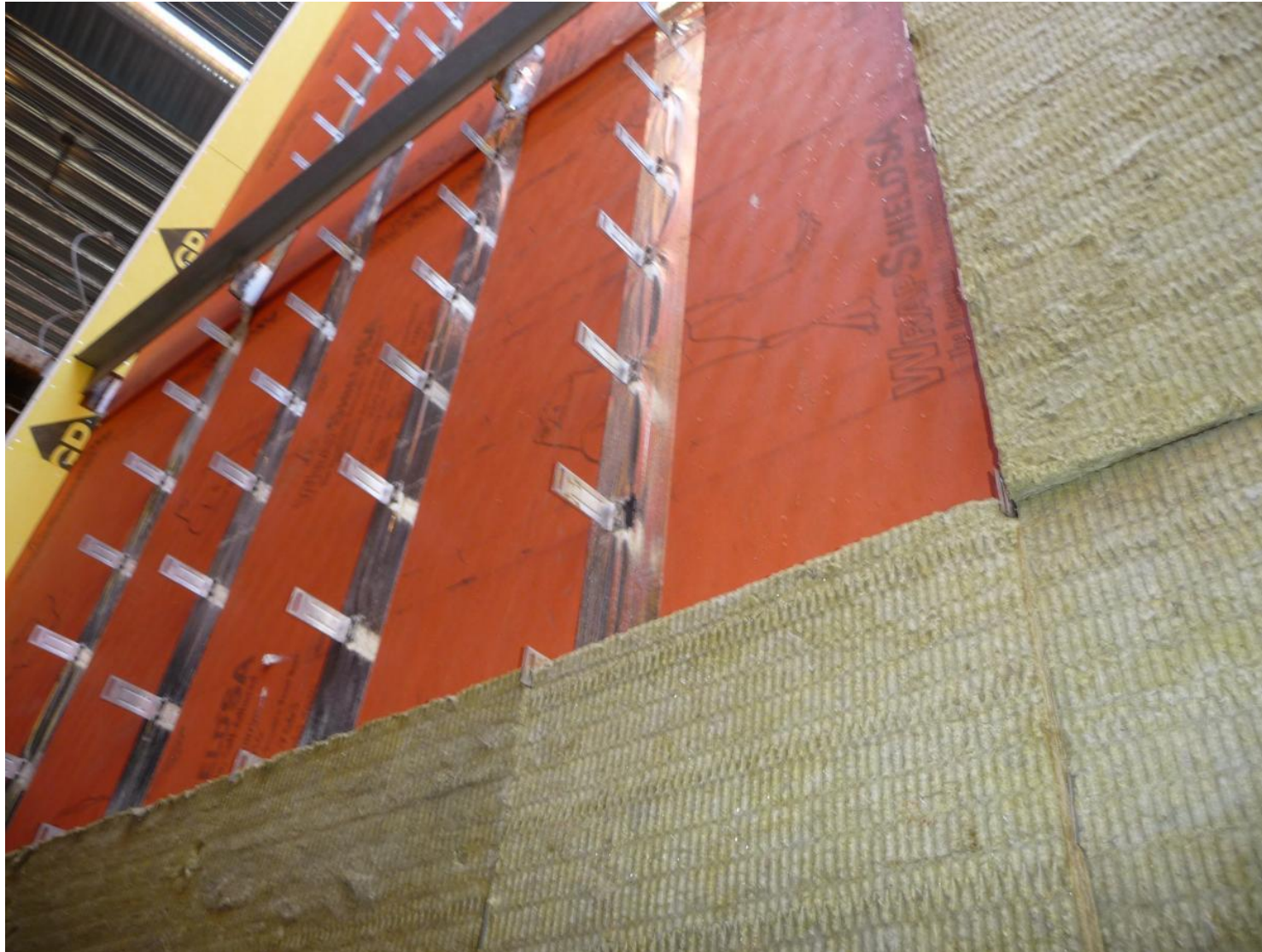
Expansion Joints. Difficult to Air & Water Tight



Mineral Wool and Self Adhered WRB



Brick Tie Back Attachment – Knife Plate



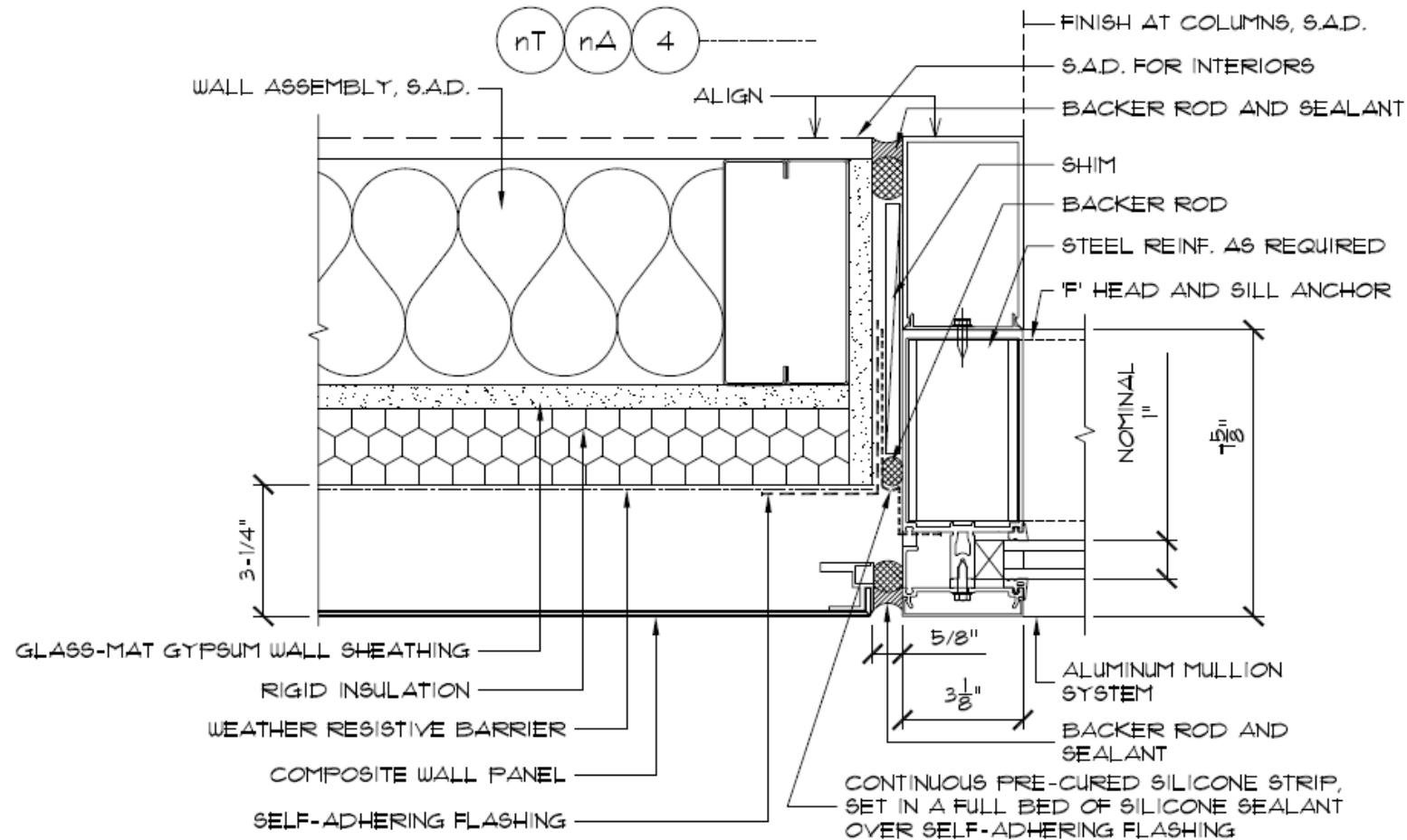
Hat Channel Over Continuous Insulation



Edge Treatments and Terminations

- Insulation requires a designed solution at it's terminations
 - ✓ Windows and Doors
 - ✓ Floor Line Flashings
 - ✓ Z-girts
 - ✓ Soffits and Parapets
- Let's review Windows and Z-Girts as they are most typical

Window Jamb

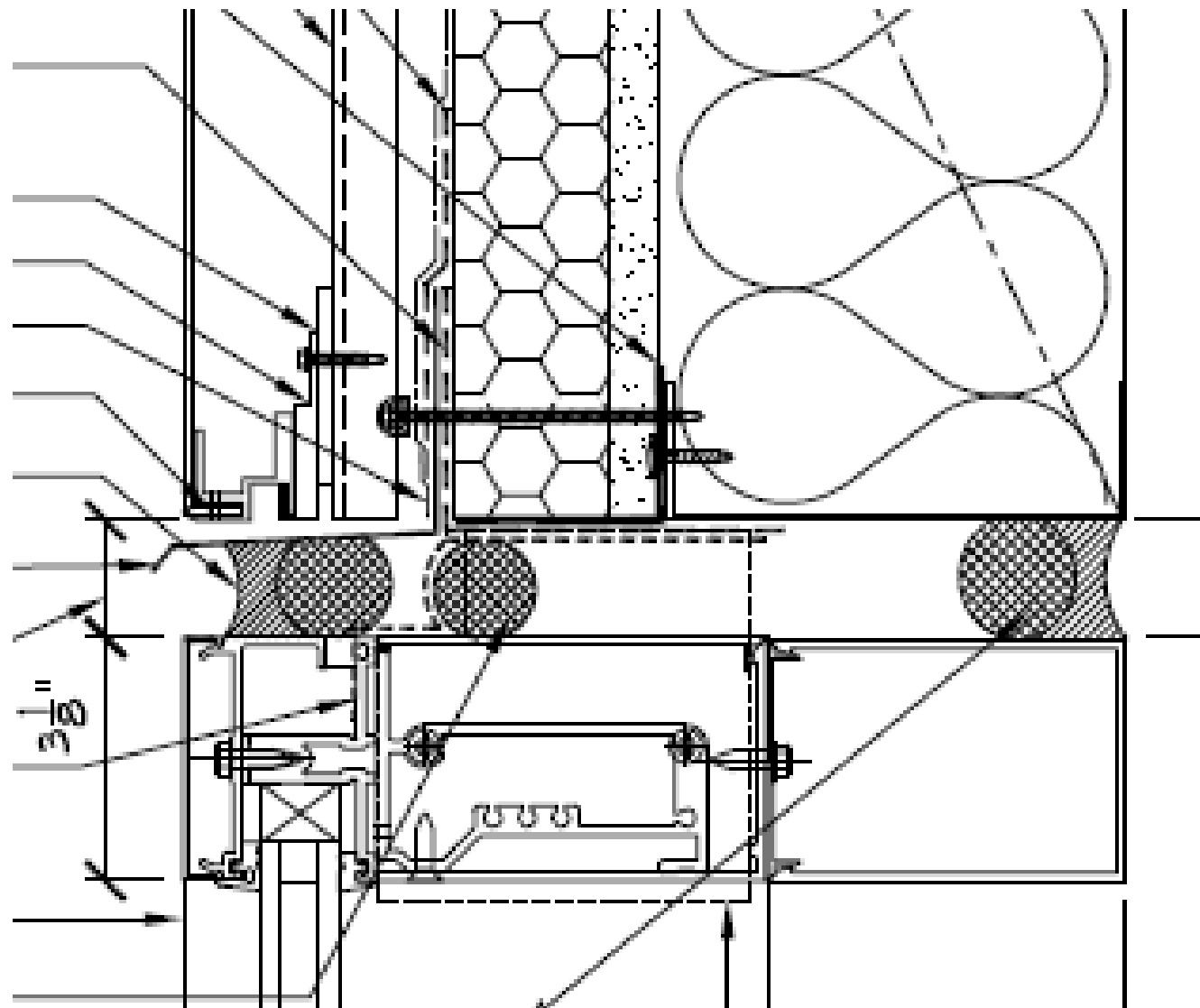


COMPOSITE WALL PANEL
TERMINATION AT TYPICAL
VERTICAL STOREFRONT JAMB

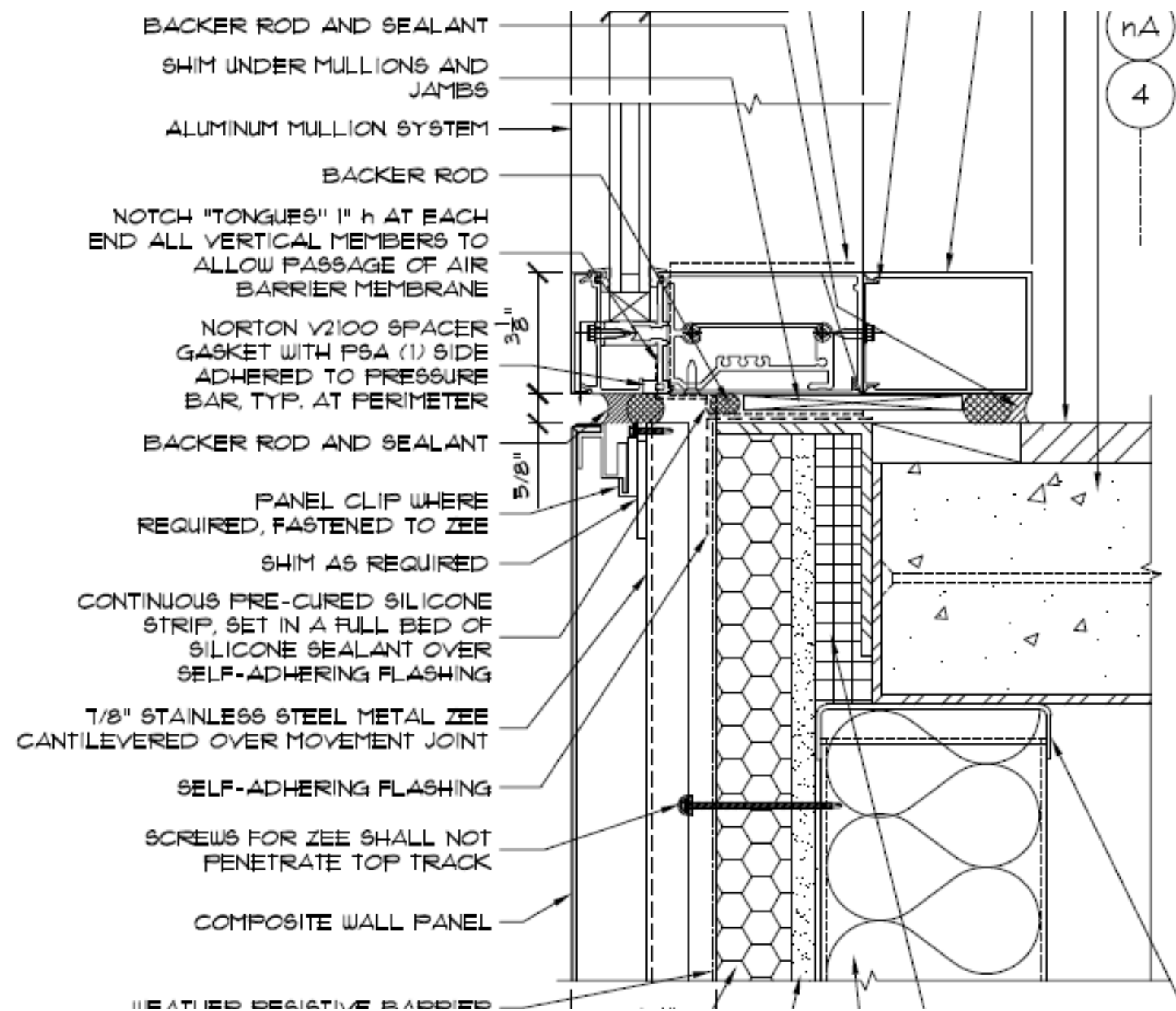
SCALE: N.T.S.

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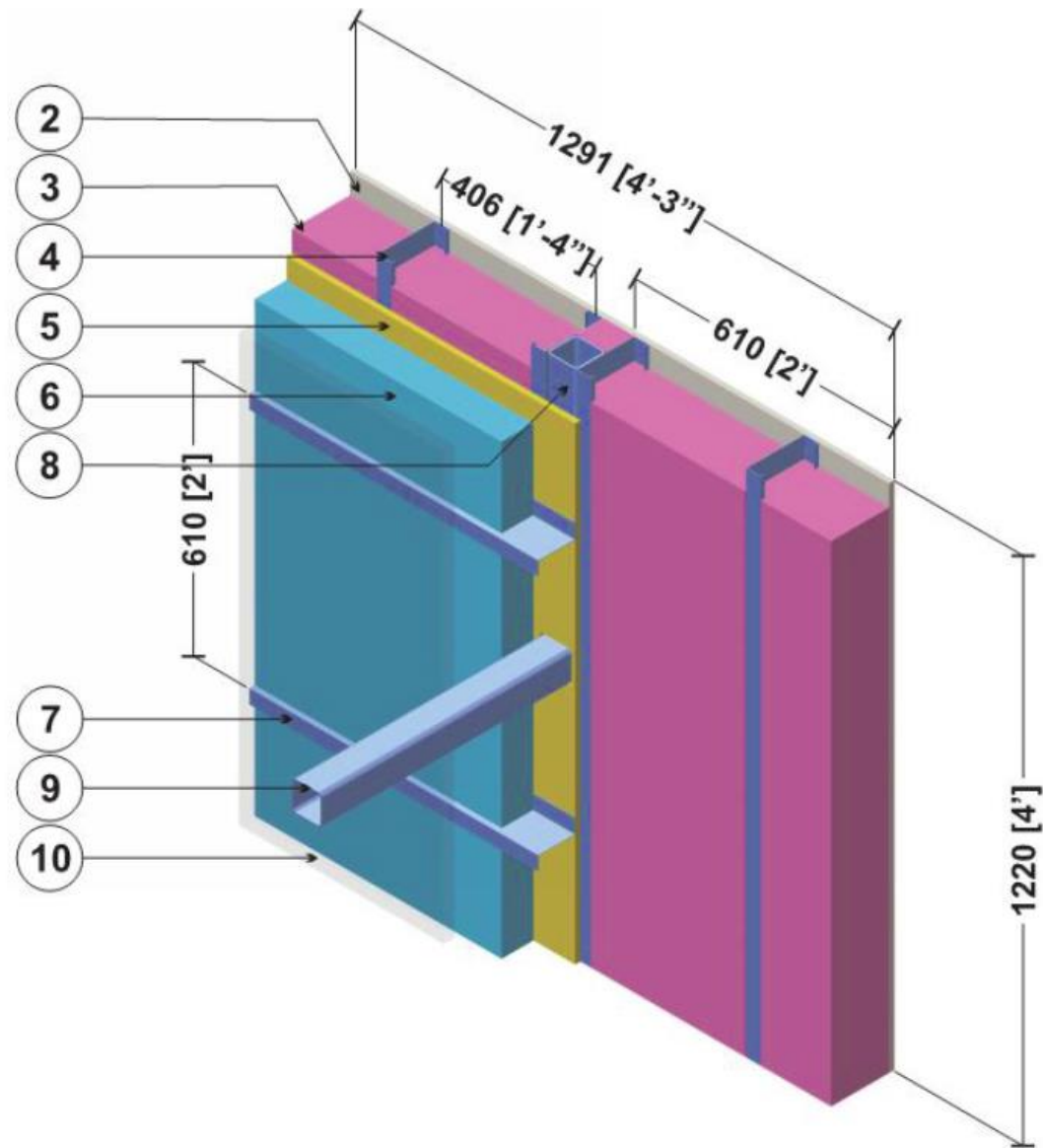
Window Head



Window Sill



Z - Girt



WRB / Air Barrier over Insulation With Hat Channels



WRB / Air Barrier Under the Insulation





Air Barrier Testing

Air Barrier System Test Standards

- **ASTM E779-10:** Standard test method for determining air leakage rate by fan pressurization
- **ASTM E1827-11:** Standard test methods for determining airtightness of buildings using an orifice blower door
- **ASTM E283-04:** Standard test method for determining rate of air leakage through exterior windows, curtain walls, and doors under specified pressure differences across the specimen
- **ASTM E1186:** Standard practices for air leakage site detection in building envelopes and air barrier systems

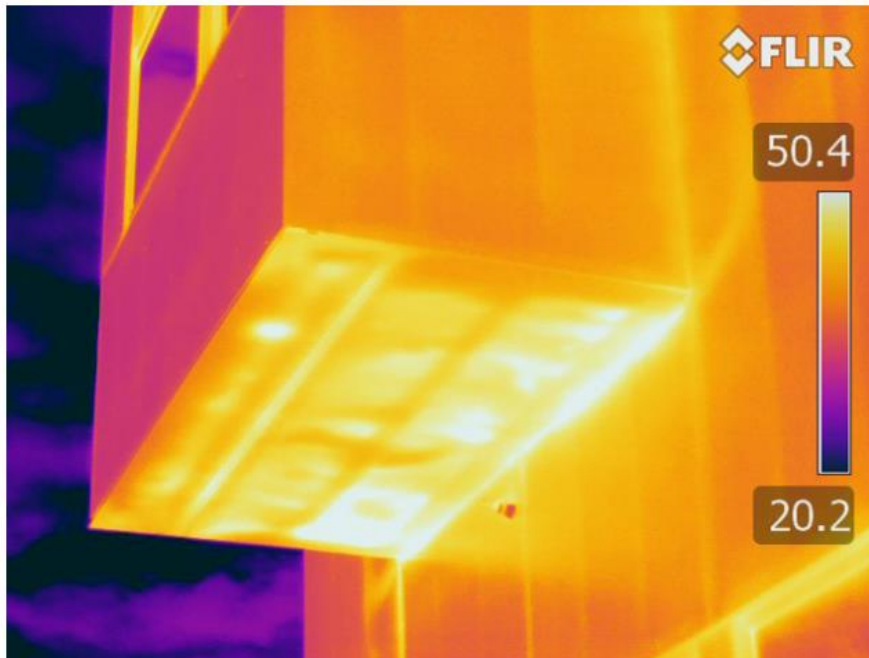
ASTM E779 Whole Building Fan Pressurization



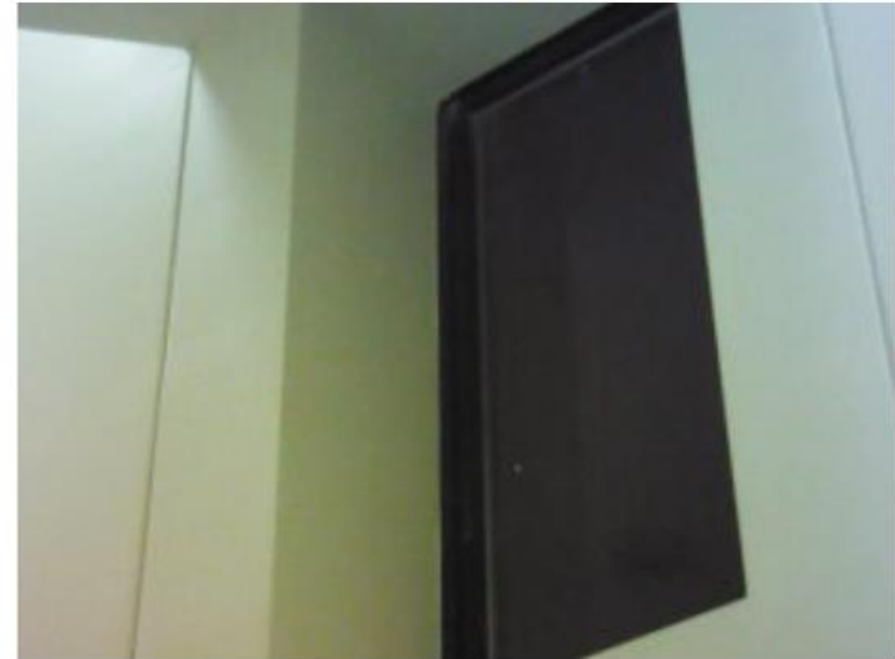
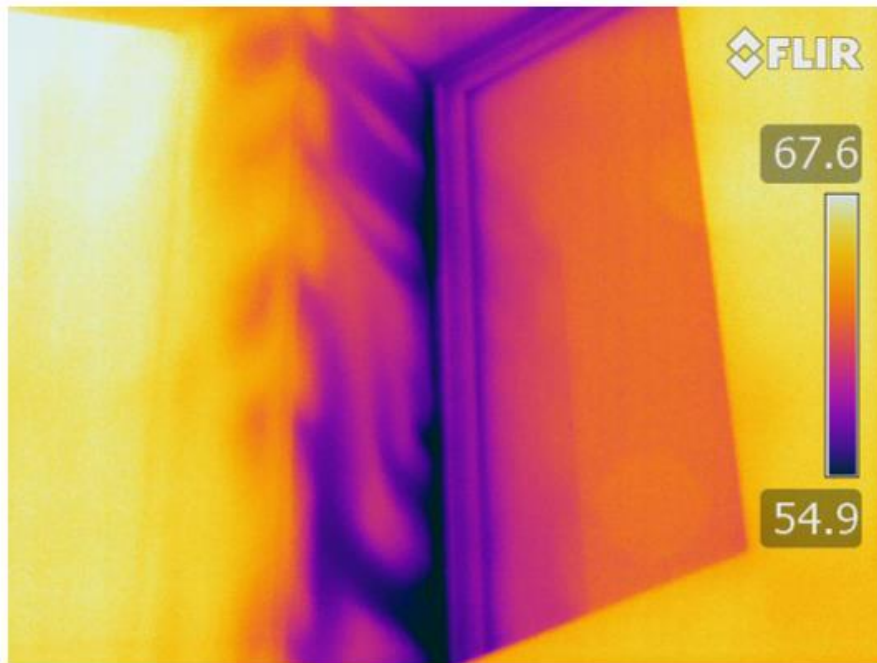
ASTM E779 Whole Building Fan Pressurization



ASTM E1186 – 4.2.1 Positive Pressurization



ASTM E1186 – 4.2.1 Depressurization



ASTM E1186 – 4.2.6 Smoke Tracers

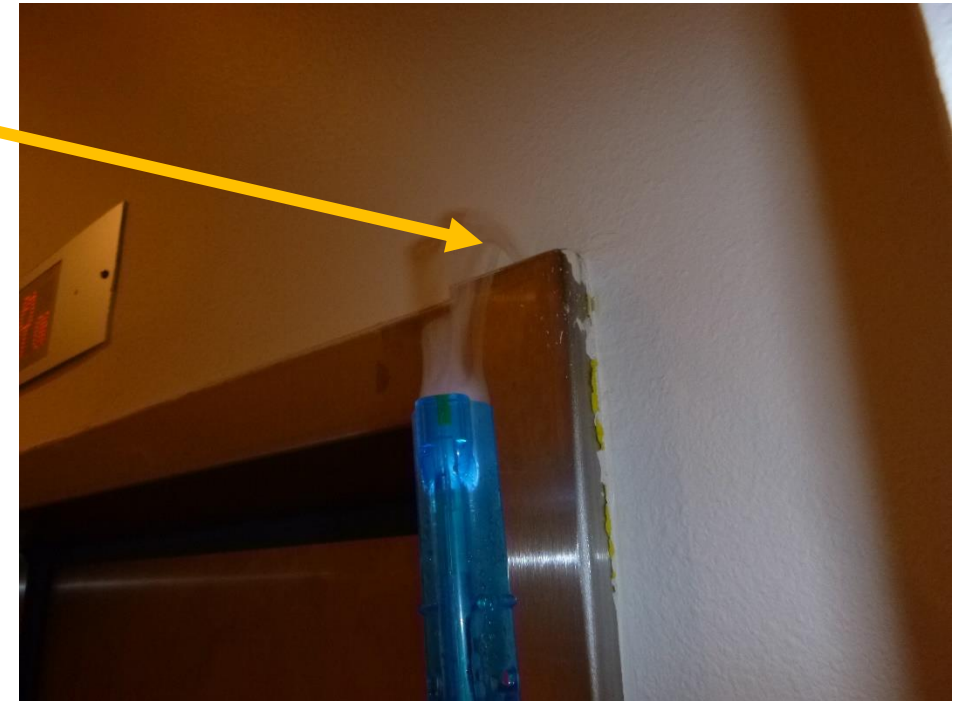
No Air Leakage



Air Leakage



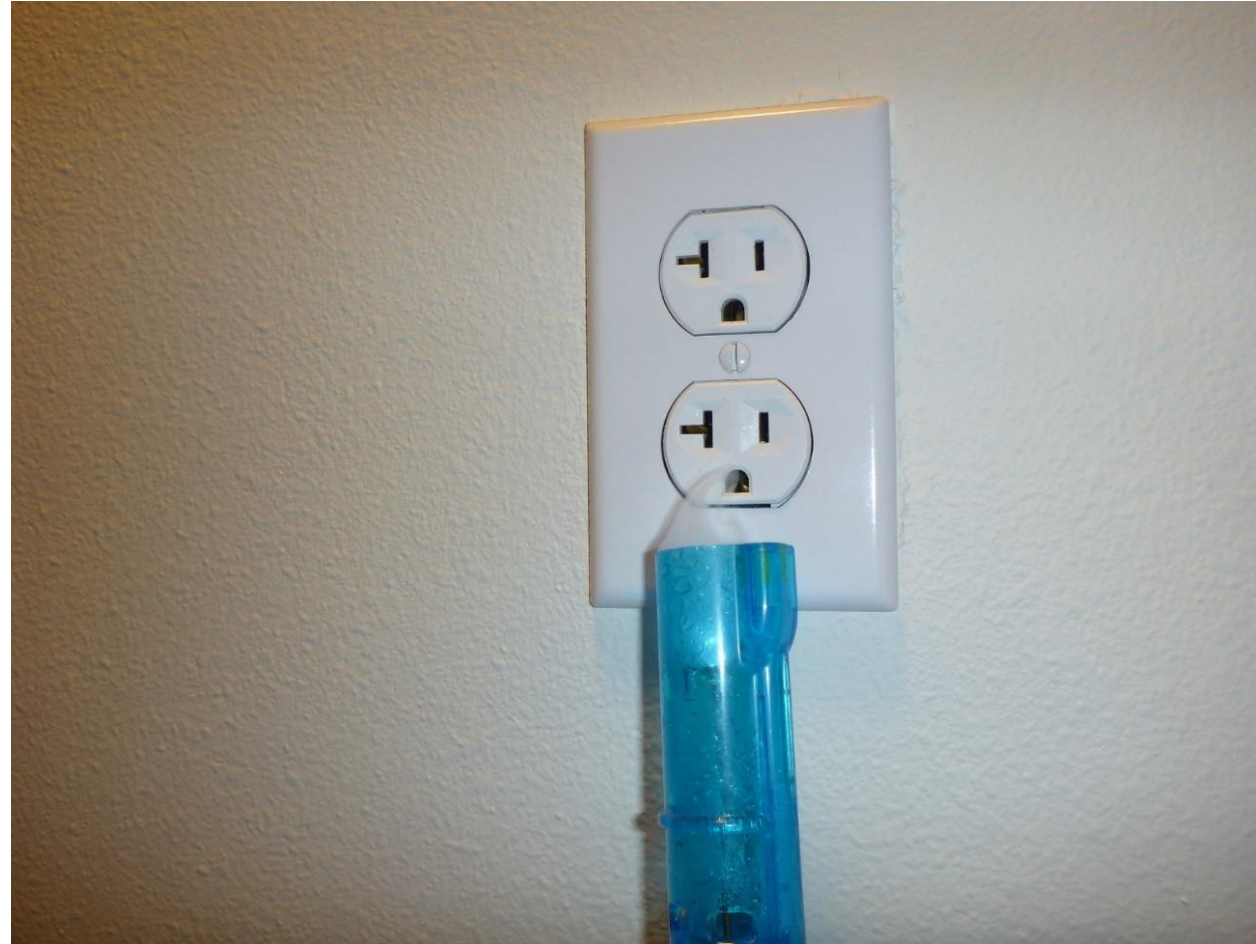
Elevator Core – Diagnosing Air Leakage



Mail Boxes – Diagnosing Air Leakage



Diagnosing Air Leakage





Mahalo!

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