



# Hawaii Air Barrier Requirements

Presented by:

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CEO, President

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Building Envelope

Energy

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# 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.



# 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 33 years of experience & over 12,500 projects
- ABBAE is also a leading Forensic Defect firm with hundreds of forensic projects (litigation)
- Locations – 16 offices across California, Nevada, North Carolina, Oklahoma, Oregon, Texas, Virginia, Washington, Colorado and Hawaii



# Staff & In-House Expertise

- Licensed Professional Engineers – Civil, Structural, and Mechanical
- Registered Architects
- Building Enclosure Commissioning Process Providers (BECxPs)
- Registered Building Envelope Consultant (RBEC)
- Registered Roofing Consultants (RRCs)
- Registered Waterproofing Consultants (RWCs)
- Registered Exterior Wall Consultant (REWCs)
- Registered Roof Observers (RROs)
- Certified Exterior Insulation and Finish System (EIFS) inspectors
- Curtain Wall Specialists
- ICC Certified Building Inspectors
- Quality Assurance Monitors
- Water Testing Experts
- Leak Investigation and Diagnosis Experts
- Infrared Imaging and Nuclear Moisture Scanning Experts

# ABBAE Building Expertise

- Building Envelope Systems

- Roofing Systems
  - High-Slope/Low-Slope Roofs
  - Green/Garden Roofs
  - Drainage Systems
  - Pedestrian Plazas
- Exterior Wall Systems
  - Wall Cladding/Siding/GFRC/pre-cast
  - EIFS/cement plaster/stucco
  - Sheet Metal Flashings
- Windows and Glazing Systems
  - Punched Windows
  - Curtain Wall/Window Wall Systems
  - Sliding Glass Doors
  - Skylights

- Building Envelope Systems (cont'd)

- Roofing & Waterproofing Systems
  - Deck/Balcony/Lanai Waterproofing
  - Podium Waterproofing
  - Pool/Spa Deck Waterproofing
  - Above-Grade/Below-Grade Waterproofing
  - All types of low and steep sloped roofing
- Commissioning BECx
  - OPR/BOD/Commissioning Plan
- Mechanical/HVAC Systems
  - HVAC design
  - Plumbing systems
  - Commissioning and testing

# ABBAE Core Services

- Consulting and third-party peer review services
- Engineer of record for building envelope systems
- Contract administration services
- Inspection services (usually direct with owner)
- Air and water performance testing
- Mock-up design, observation, and testing
- Building assessments and forensic investigations
- Litigation support and expert witness services
- Educational seminars with AIA credits



# Today's Objectives

- Introductions
- Air Barrier Benefits
- Hawaii's Air Barrier Code Requirements
- Air Barrier Basics
- Air Barrier Techniques and Products
- Air Barrier Design Process
- Air Barrier Testing

# Air Barrier Benefits

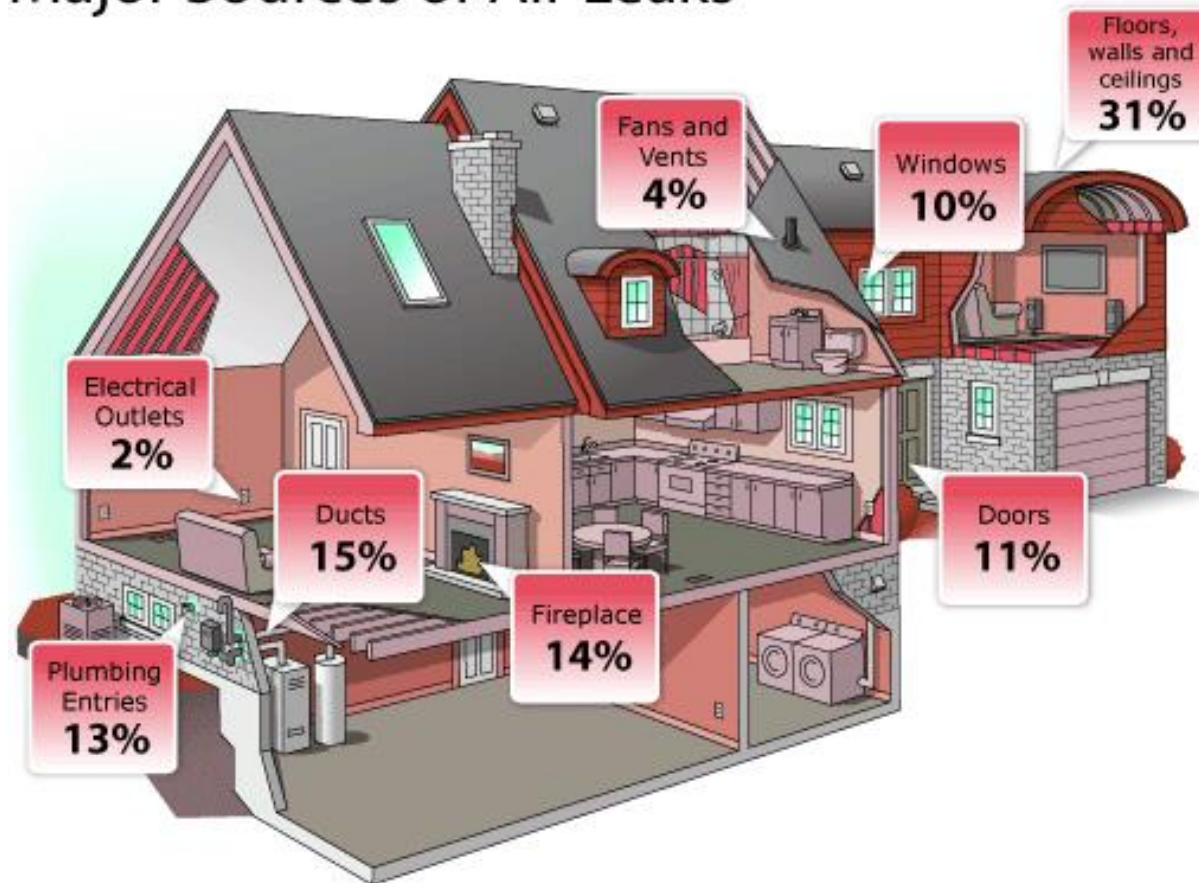


# Why Air Barriers?

- Saves Energy = Saves Money
- Smoke spread (NFPA)
- Noise Reduction
- Pest Reduction
- Moisture Reduction
- Improved Environmental Control = Better Comfort

# Air Leakage Sources

## Major Sources of Air Leaks



# Energy Savings

ACH50	Natural Air Change	Rating	% of bill	% savings potential
1.5	0.075	Super	2%	none
3.5	0.18	Excellent	6%	1 to 3%
5	0.25	Better	10%	2 to 4%
7	0.35	Good	14%	2 to 5%
10	0.50	Fair	20%	3 to 10%
20	1.0	Bad	40%	5 to 20%

# Noise and Pest Reduction

- Less Holes in the Building =
  - Less Opportunity for Pests and Rodents
- Less Noise and More Noise
- Reduction



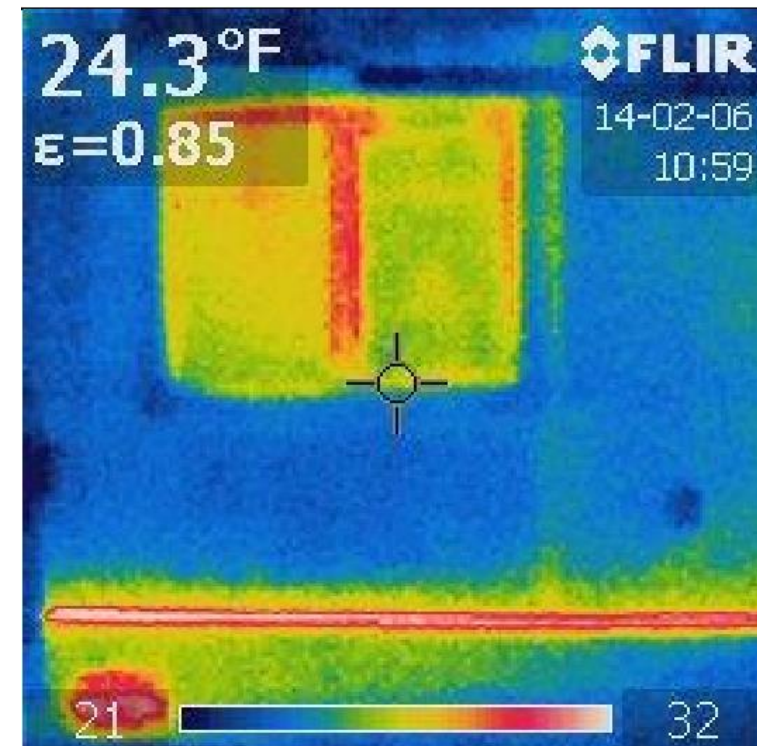
# Moisture Reduction – Improved Env. Control

- Reduced air leakage prevents condensation from occurring in unwanted parts of the building envelope.



# Moisture Reduction – Improved Env. Control

- Less uncontrolled air leakage means better air quality, tighter humidity ranges and better control of the interior environment.



# Hawaii Code Requirements

# 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*

# Chapter 4: Commercial Energy Efficiency

## Section C402 Building Envelope Requirements

### Section C402.5 Air Leakage

# C402.5 Air Leakage-Thermal Envelope

**C402.5 Air leakage—thermal envelope (Mandatory).** The thermal envelope of buildings shall comply with Sections C402.5.1 through C402.5.8, or the building thermal envelope shall be tested in accordance with ASTM E 779 at a pressure differential of 0.3 inch water gauge (75 Pa) or an equivalent method approved by the code official and deemed to comply with the provisions of this section when the tested air leakage rate of the building thermal envelope is not greater than 0.40 cfm/ft<sup>2</sup> (0.2 L/s · m<sup>2</sup>). Where compliance is based on such testing, the building shall also comply with Sections C402.5.5, C402.5.6 and C402.5.7.

- Option 1 – Comply with material and assembly requirements outlined in C402.5.1 – C402.5.8
- Option 2 – Whole Building Testing

# Option 1 – Materials

**C402.5.1.2.1 Materials.** Materials with an air permeability not greater than 0.004 cfm/ft<sup>2</sup> (0.02 L/s · m<sup>2</sup>) under a pressure differential of 0.3 inch water gauge (75 Pa) when tested in accordance with ASTM E 2178 shall comply with this section. Materials in Items 1 through 16 shall be deemed to comply with this section, provided joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions.

1. Plywood with a thickness of not less than  $\frac{3}{8}$  inch (10 mm).
2. Oriented strand board having a thickness of not less than  $\frac{3}{8}$  inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than  $\frac{1}{2}$  inch (12.7 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than  $\frac{1}{2}$  inch (12.7 mm).
5. Closed-cell spray foam a minimum density of 1.5 pcf (2.4 kg/m<sup>3</sup>) having a thickness of not less than  $1\frac{1}{2}$  inches (38 mm).
6. Open-cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m<sup>3</sup>) and having a thickness of not less than 4.5 inches (113 mm).
7. Exterior or interior gypsum board having a thickness of not less than  $\frac{1}{2}$  inch (12.7 mm).
8. Cement board having a thickness of not less than  $\frac{1}{2}$  inch (12.7 mm).
9. Built-up roofing membrane.
10. Modified bituminous roof membrane.
11. Fully adhered single-ply roof membrane.
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than  $\frac{5}{8}$  inch (15.9 mm).
13. Cast-in-place and precast concrete.
14. Fully grouted concrete block masonry.
15. Sheet steel or aluminum.
16. Solid or hollow masonry constructed of clay or shale masonry units.

# Option 1 –Assemblies

**C402.5.1.2.2 Assemblies.** Assemblies of materials and components with an average air leakage not greater than  $0.04 \text{ cfm/ft}^2$  ( $0.2 \text{ L/s} \cdot \text{m}^2$ ) under a pressure differential of 0.3 inch of water gauge (w.g.) (75 Pa) when tested in accordance with ASTM E 2357, ASTM E 1677 or ASTM E 283 shall comply with this section. Assemblies listed in Items 1 through 3 shall be deemed to comply, provided joints are sealed and the requirements of Section C402.5.1.1 are met.

1. Concrete masonry walls coated with either one application of block filler or two applications of a paint or sealer coating.
2. Masonry walls constructed of clay or shale masonry units with a nominal width of 4 inches (102 mm) or more.
3. A Portland cement/sand parge, stucco or plaster not less than  $\frac{1}{2}$  inch (12.7 mm) in thickness.

# Option 1 – Fenestration

**TABLE C402.5.2  
MAXIMUM AIR LEAKAGE RATE  
FOR FENESTRATION ASSEMBLIES**

FENESTRATION ASSEMBLY	MAXIMUM RATE (CFM/FT <sup>2</sup> )	TEST PROCEDURE
Windows	0.20 <sup>a</sup>	AAMA/WDMA/ CSA101/I.S.2/A440 or NFRC 400
Sliding doors	0.20 <sup>a</sup>	
Swinging doors	0.20 <sup>a</sup>	
Skylights – with condensation weepage openings	0.30	
Skylights – all other	0.20 <sup>a</sup>	
Curtain walls	0.06	NFRC 400 or ASTM E 283 at 1.57 psf (75 Pa)
Storefront glazing	0.06	
Commercial glazed swinging entrance doors	1.00	
Revolving doors	1.00	
Garage doors	0.40	ANSI/DASMA 105, NFRC 400, or ASTM E 283 at 1.57 psf (75 Pa)
Rolling doors	1.00	
High-speed doors	1.30	

For SI: 1 cubic foot per minute = 0.47 L/s, 1 square foot = 0.093 m<sup>2</sup>.

a. The maximum rate for windows, sliding and swinging doors, and skylights is permitted to be 0.3 cfm per square foot of fenestration or door area when tested in accordance with AAMA/WDMA/CSA101/I.S.2/A440 at 6.24 psf (300 Pa).

## Exceptions:

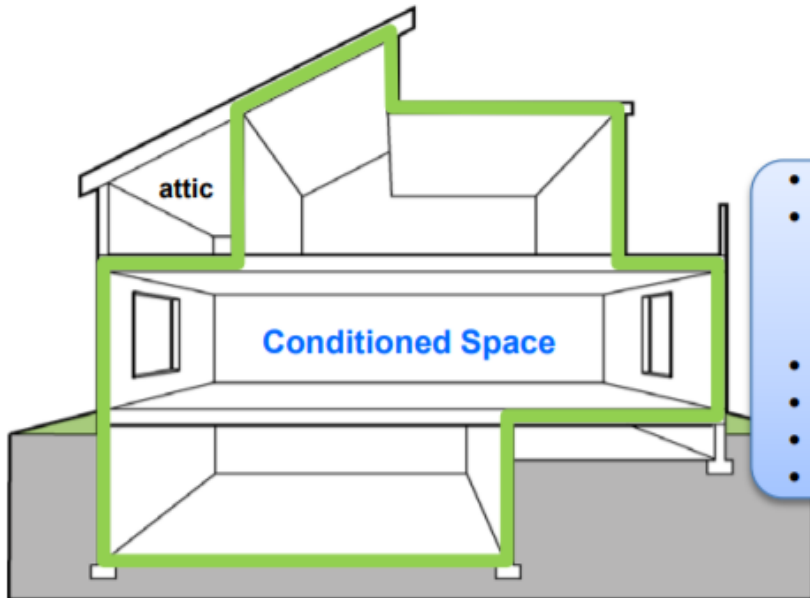
- Field fabricated fenestration assemblies that are sealed in accordance with C402.5.1.
- Fenestration in buildings that comply with testing alternatives of C402/5 are not required to meet the air leakage requirements in Table C402.5.2.

# Option 1 – Misc. Provisions

- Doors and access openings to shafts, chutes, stairways and elevator lobbies: Gasketed, weatherstripped or Sealed.
- Air intakes, exhaust openings, stairways and shafts: Dampers required.
- Loading Docks: Weatherstripped
- Vestibules: Not Required in Climate Zone 1 (Hawaii)
- Recessed Lighting: IC Rated, Air leakage rate not more than 2.0 CFM at 75Pa, sealed with gasket or sealant

# Option 2 – Whole Building Air Barrier Testing

## Building Thermal Envelope



- Ceilings
- Walls
  - Above grade
  - Below grade
  - Mass walls
- Fenestration
- Floors
- Slab
- Crawl space



# 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

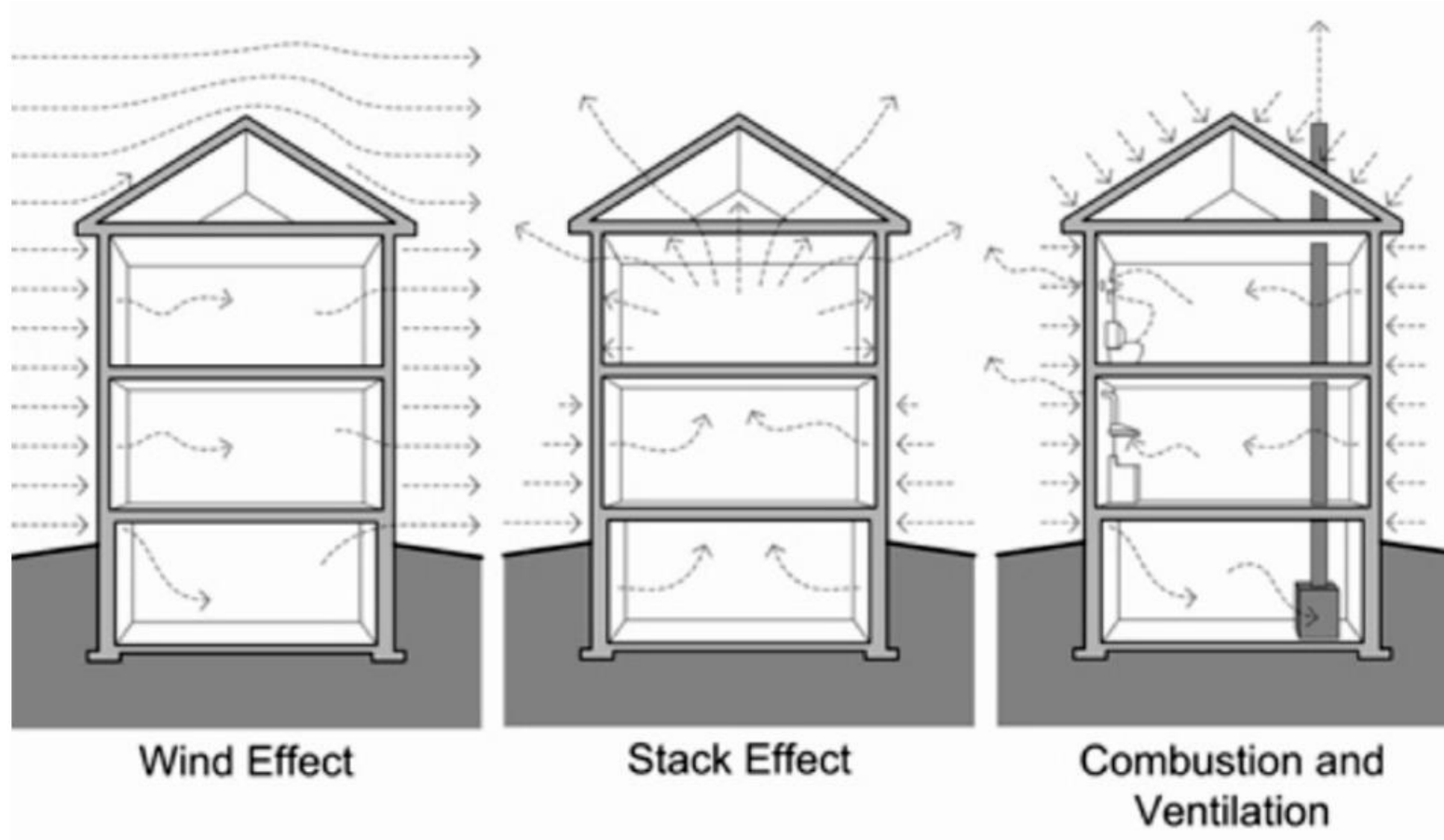


Figure 1: Examples of infiltration. Image courtesy: Building Science Corporation, [www.buildingscience.com](http://www.buildingscience.com)

# 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•m<sup>2</sup>) @ 75 Pa (0.004 cfm/ft<sup>2</sup> @ 1.57 lb/ft<sup>2</sup>)

- Air Barrier Assembly Testing Requirements

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

<0.2 L/(s•m<sup>2</sup>) @ 75 Pa (0.04 cfm/ft<sup>2</sup> @ 1.57 lb/ft<sup>2</sup>)

- *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/ft<sup>2</sup> @ 1.57 lb/ft<sup>2</sup>

US Army Corps of Engineers Requires:

< 0.25 cfm/ft<sup>2</sup> @ 1.57 lb/ft<sup>2</sup>

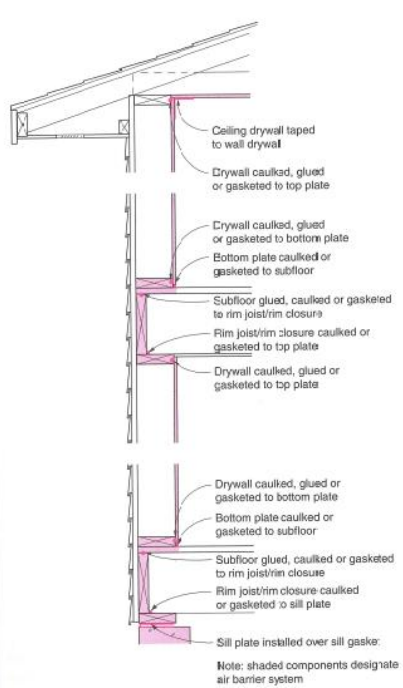
- ASTM E1827-11: Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door
- ASTM E283-04: Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
- *\*\*\*Testing 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

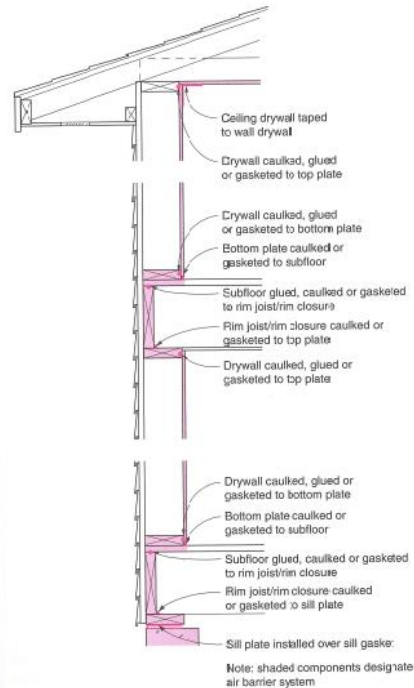
# 4 Typical Air Barrier Approaches

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

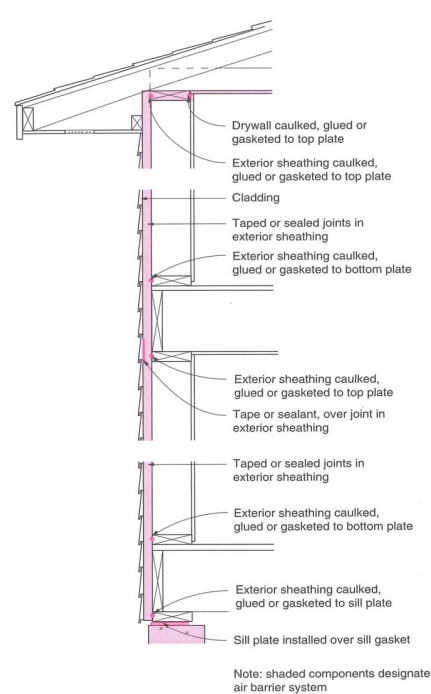
# Air Barrier Approaches



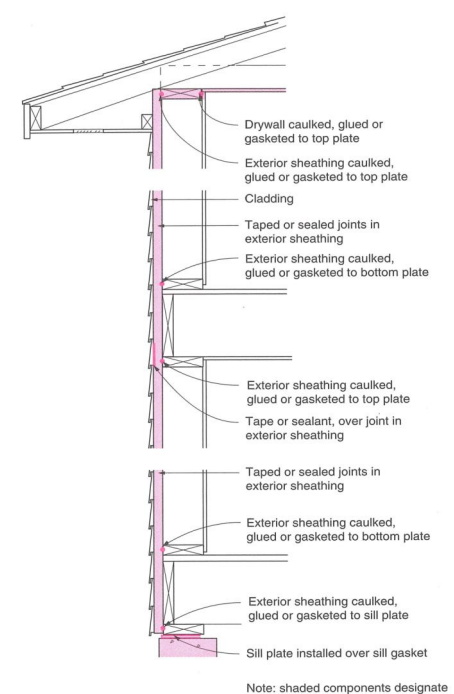
Interior Drywall Approach



Interior VB Membrane



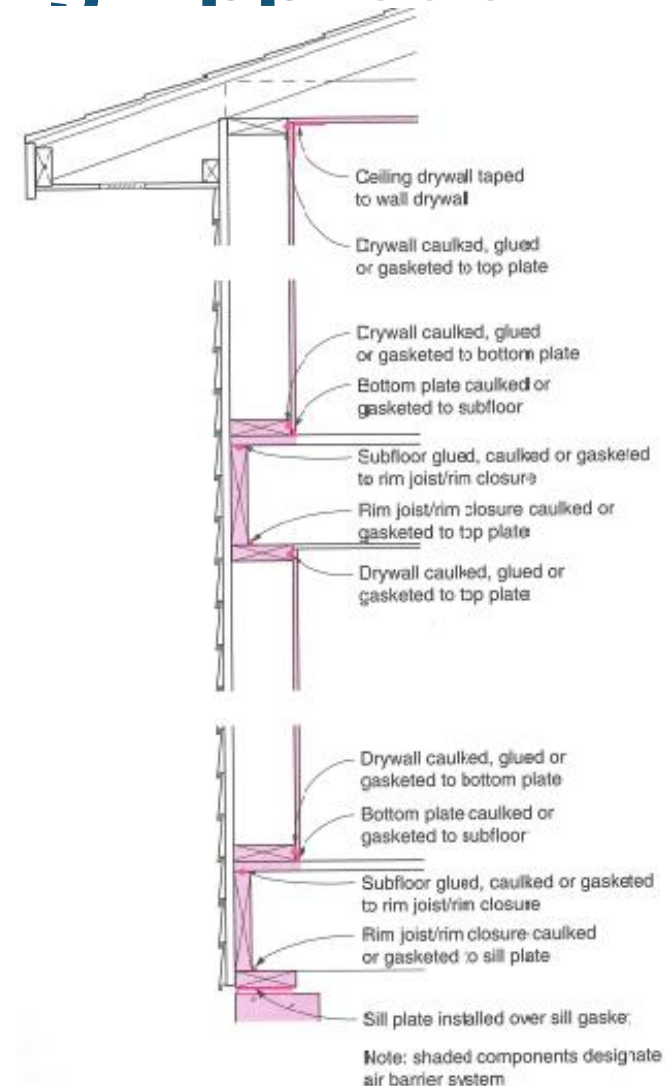
Exterior Sheathing



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

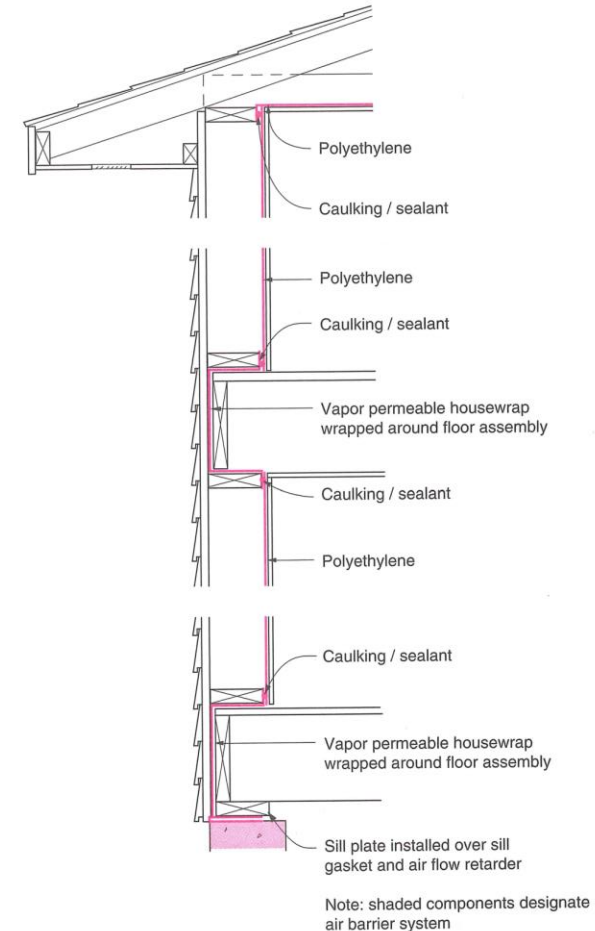
- Controls the entry of interior, moisture laden air from entering into wall cavity
- Can be enhanced with ccSPF
- Repaired easily
- Inspected visually and tested easily
- Lower cost
- Significant history of success in single family residential

## Cons

- Interior air barrier does not control wind-washing of insulation
- 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 requires a high level of coordination

# Interior Vapor Barrier Membrane Approach

- Polyethylene
- Semi-Permeable Membranes
- Interior vapor barrier not recommended for Hawaii climate!



Taken from Moisture Control Handbook

# Interior Vapor Barrier Membrane Approach

## Pros

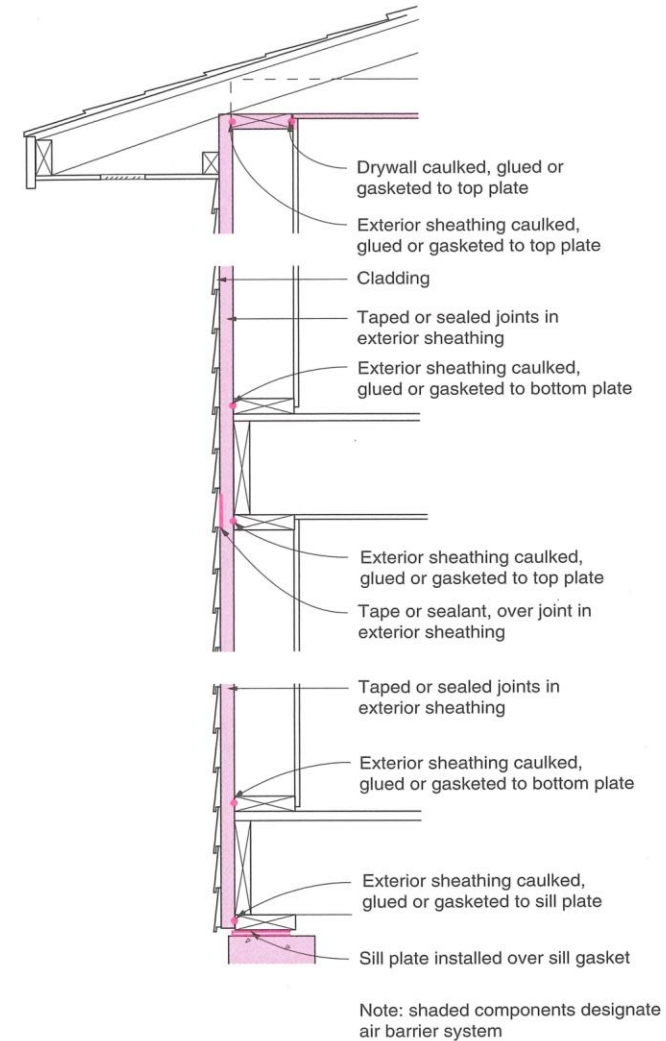
- Controls the entry of interior, moisture laden air from entering into wall cavity
- Can be enhanced with ccSPF
- Controls both air and vapor
- One – two trade installation

## Cons

- Does not allow for interior drying of wall cavity. This is necessary in a majority of climates and air conditioned spaces.
- Humid air from outside can condense on interior surfaces (Not recommended for Hawaii)
- Interior air barrier does not control wind-washing of insulation
- Not accessible for visual review and repair once drywall is installed
- Easily damaged by occupant usage

# 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



# Exterior Sheathing Approach Pros and Cons

## Pros

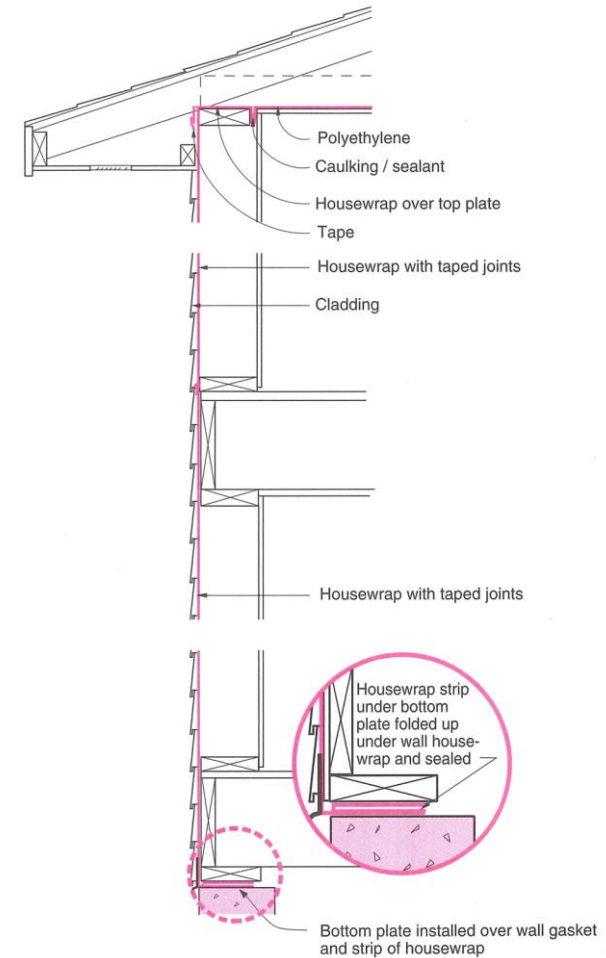
- Cost Effective
- Can be enhanced with ccSPF
- Controls both air and vapor
- One – two trade installation
- Inspected visually and tested / repaired easily
- Controls wind-washing of insulation

## 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 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 Perm-A-Barrier Liquid	0.09 / 0.03	<0.004 <0.004
Henry Co.	Air Bloc 31 Air Bloc 32	0.57 / 36.12 0.23 / 1.02	0.004 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 Air Shield LM	na / na na / na	0.0026 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 un-cladded
- Potential blow off issues if left un-cladded
- 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	25.31/32.68	0.0023
	Tyvek Commervial Wrap D	42.65/42.48	0.00225
	Tyvek HomeWrap	56 / 54	Pass
Pactiv	GreenGuard Rain Drop	12.33 / np	<0.001
	GreenGuard Max	13.52 / np	<0.001
	GreenGuard Ultra Wrap	45.45 / np	<0.0001
VaproShield	Wallshield	np / 212	Not A.B.
	Wrapshield IT	np / 50	<0.0094
Typar	MetroWrap	10 / np	Not Test'd
	HouseWrap	12 / np	Not Test'd

# Adhered Membrane



# WRB/AB – Vapor Permeable, 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
- Impermeable (Good for Hawaii)
- 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

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 Design Process

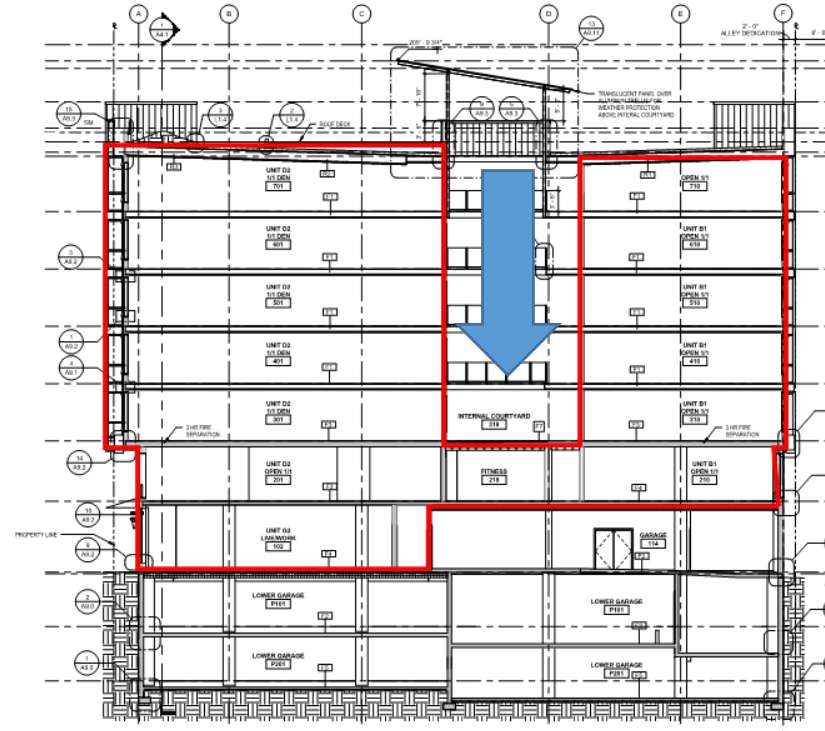
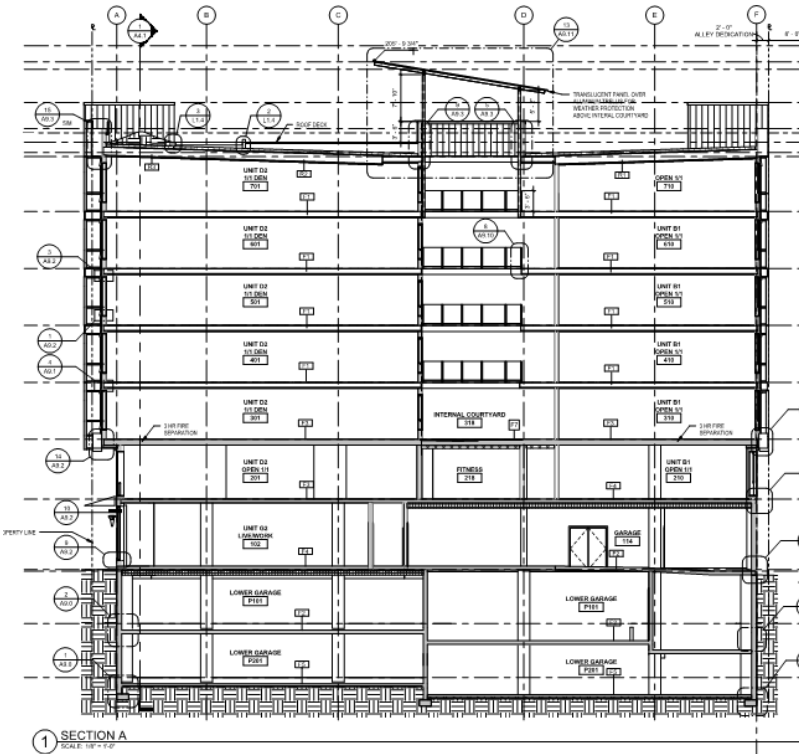
# Design QA

- Define Conditioned vs. Unconditioned Spaces
- Beware of “semi” conditioned spaces
  - If Energy Consultant/Mechanical Engineer is on team, have them define
- Staircases, Elevator Shafts?
- Lobbies, Back of House



Location of  
Pressure  
Boundary

# Outlining the Pressure Boundary



Courtyard is Covered but not Connected, Walls are on the Pressure Boundary



# Challenges

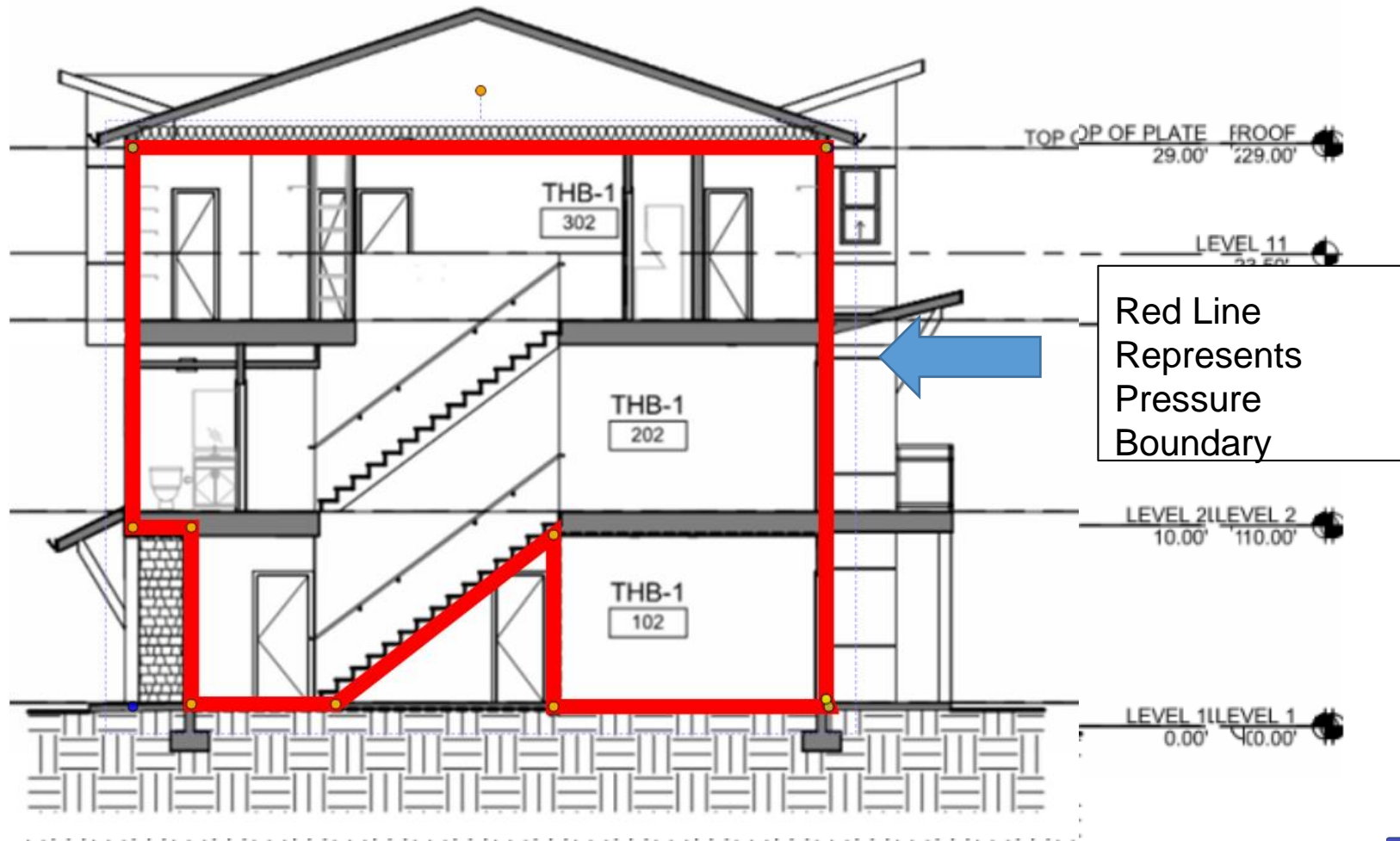
Transition between floors at breezeway difficult to air seal



Interior, pre-finished steel door, difficult to provide air seal

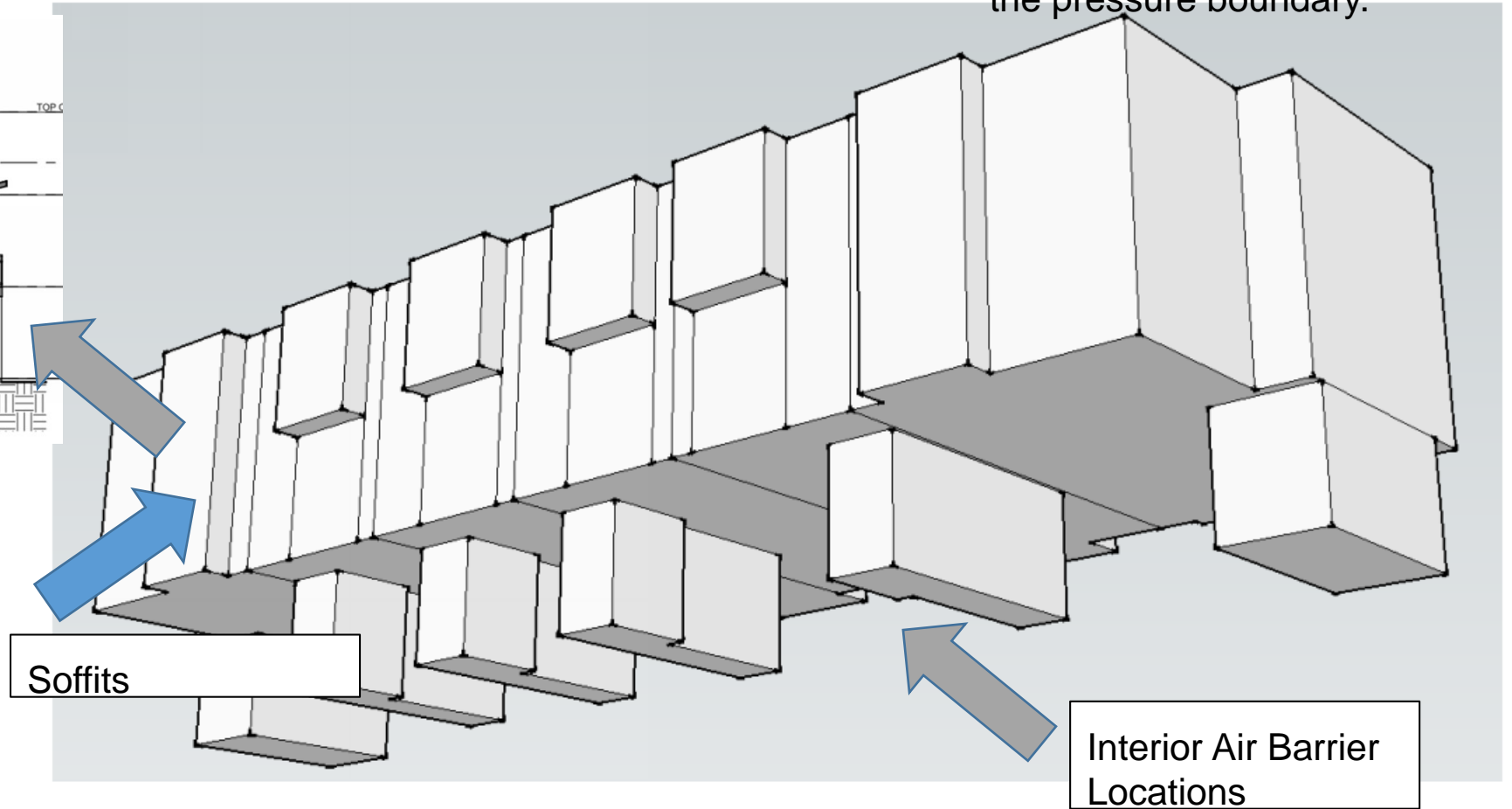
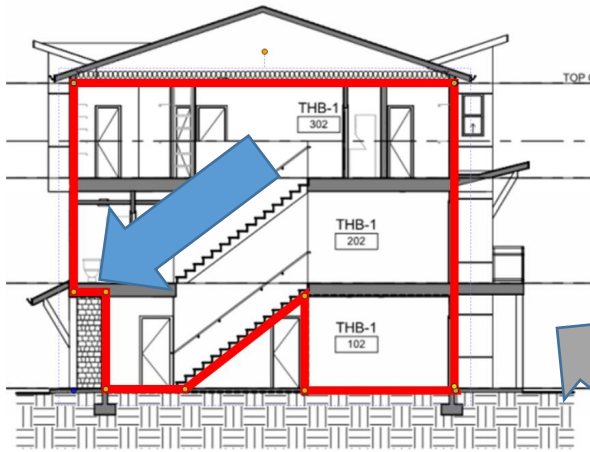


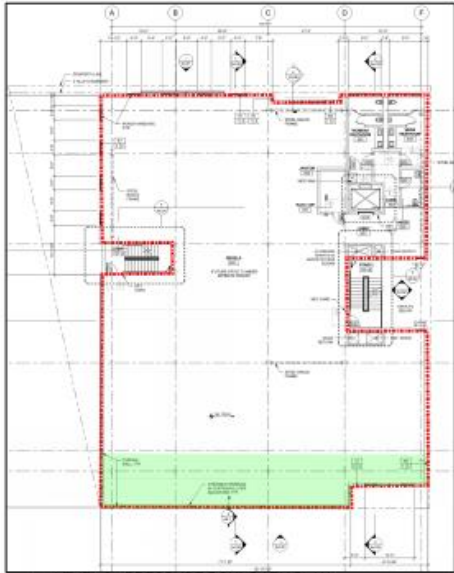
# Pressure Boundary = 6 Sided Box



# 6 Sided Box

Plan and Section Views (only) can limit our understanding of the pressure boundary.

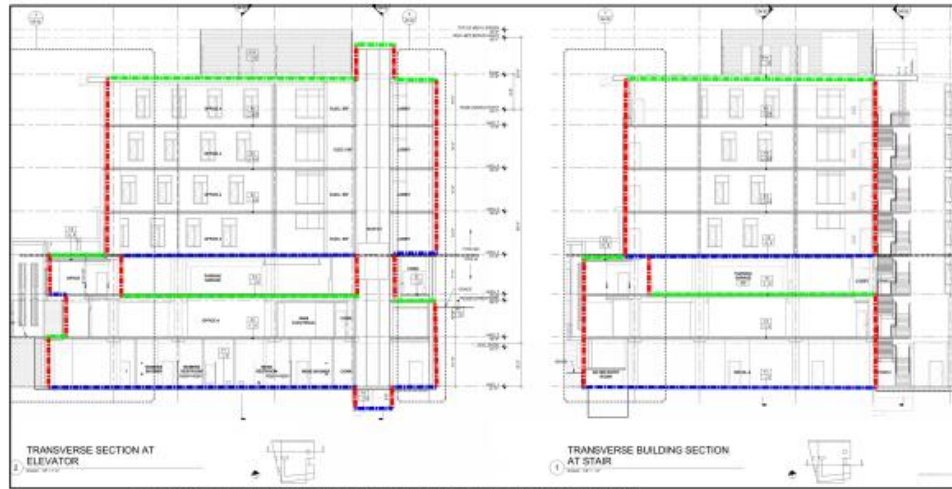




① LEVEL 6 - PRESSURE BOUNDARY PLAN



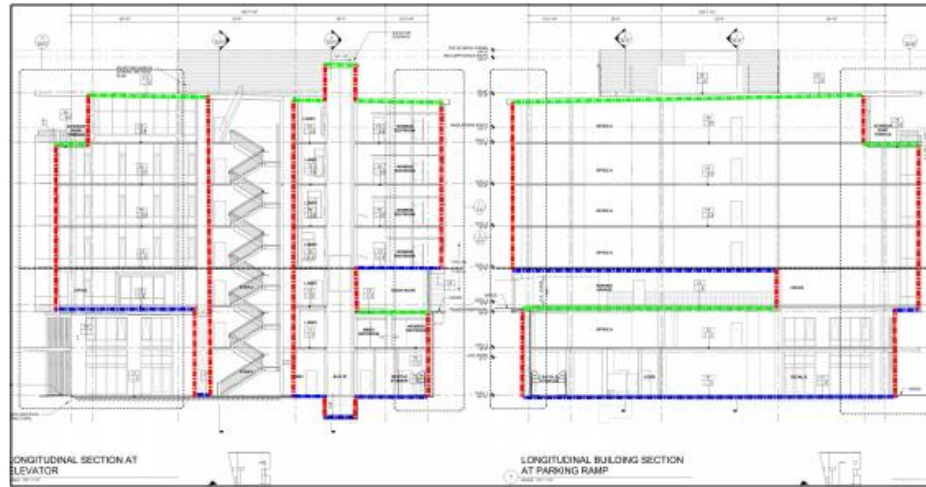
① LEVEL 7 - PRESSURE BOUNDARY PLAN



② PRESSURE BOUNDARY PLAN AT TRANSVERSE BUILDING SECTIONS

**Air Barrier/ Pressure Boundary Line Diagram Legend**

AB/PB At Wall	
AB/PB at Floor/Soft	
AB/PB At Ceiling/Roof	



③ PRESSURE BOUNDARY PLAN AT LONGITUDINAL BUILDING SECTIONS



**TITAN OFFICE BUILDING**  
901 N 54TH STREET  
SEATTLE, WA 98103

**CBQ, LLC**  
2001 5L NORTH LAKE WAY,  
SUITE 201  
SEATTLE, WA 98103

10/1/20	10/20/19
10/1/20	10/20/19
10/1/20	10/20/19
10/1/20	10/20/19
10/1/20	10/20/19
10/1/20	10/20/19
10/1/20	10/20/19
10/1/20	10/20/19



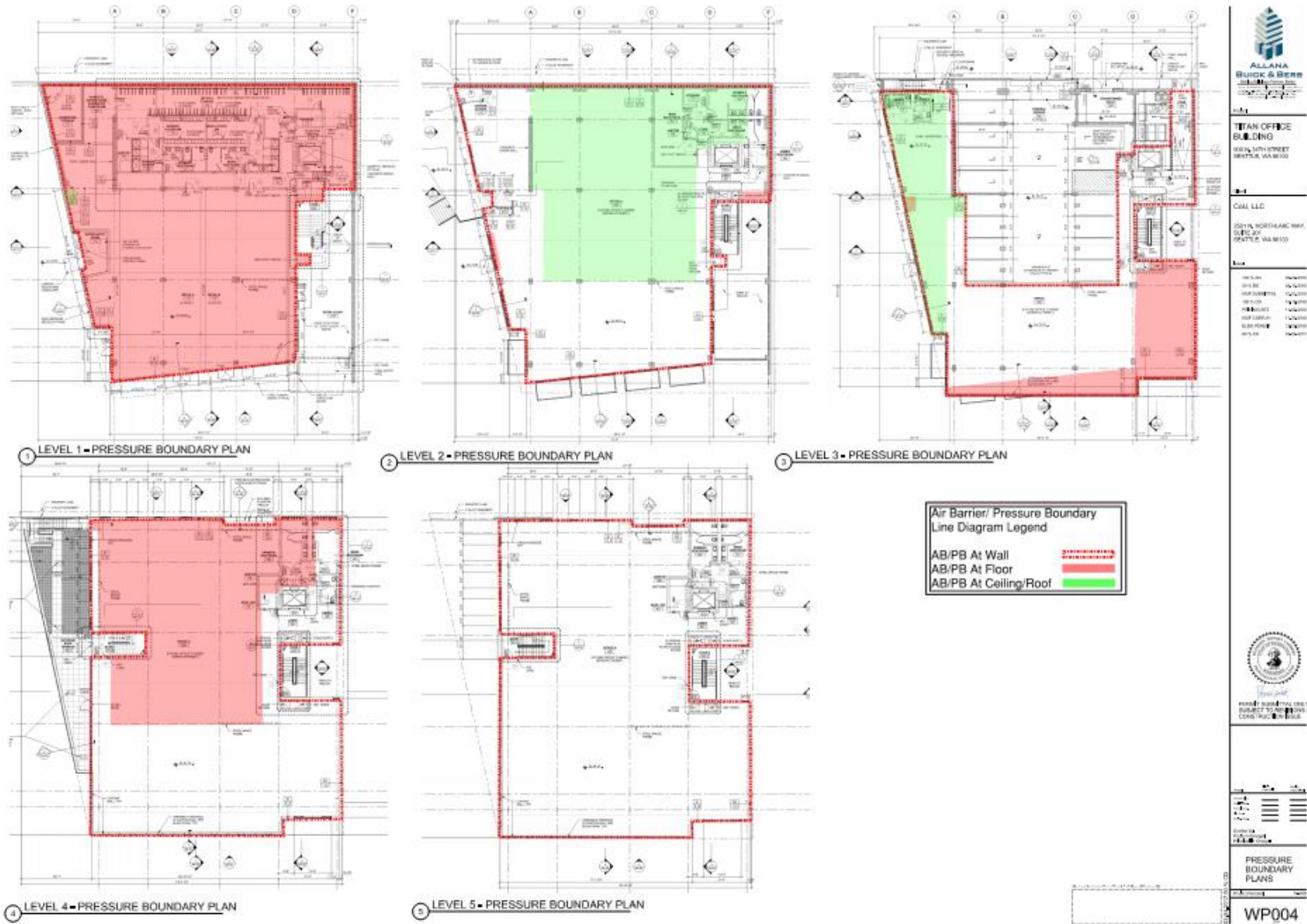
FOR SUBMITTAL ONLY  
SUBJECT TO THE BOARD'S  
CONSTRUCTION ISSUE

Scale	1/8" = 1'-0"
Scale	1/4" = 1'-0"
Scale	1/2" = 1'-0"
Scale	3/4" = 1'-0"
Scale	1" = 1'-0"

**PRESSURE BOUNDARY PLANS & SECTIONS**

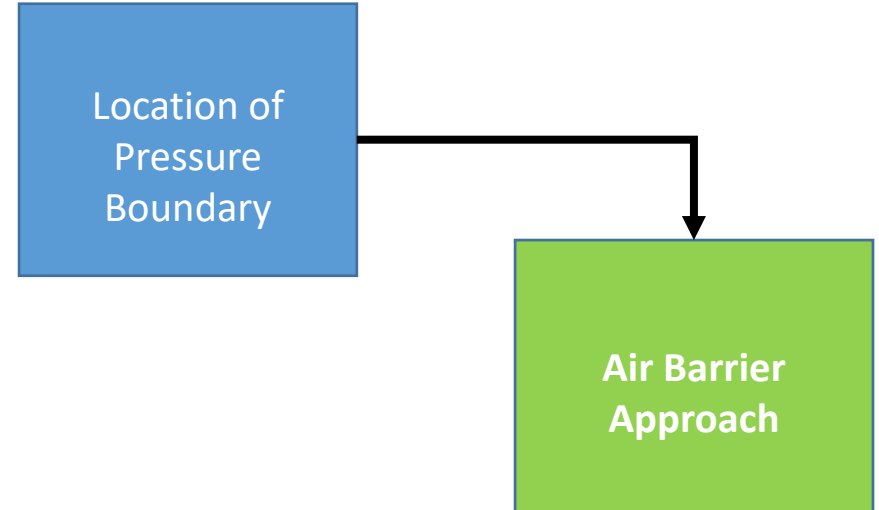
WP005





# Design QA

- Exterior WRB typically “easiest”
- Soffits, Fins, Decks over Conditioned Spaces may require approach changes
- Vented Areas Require Approach changes

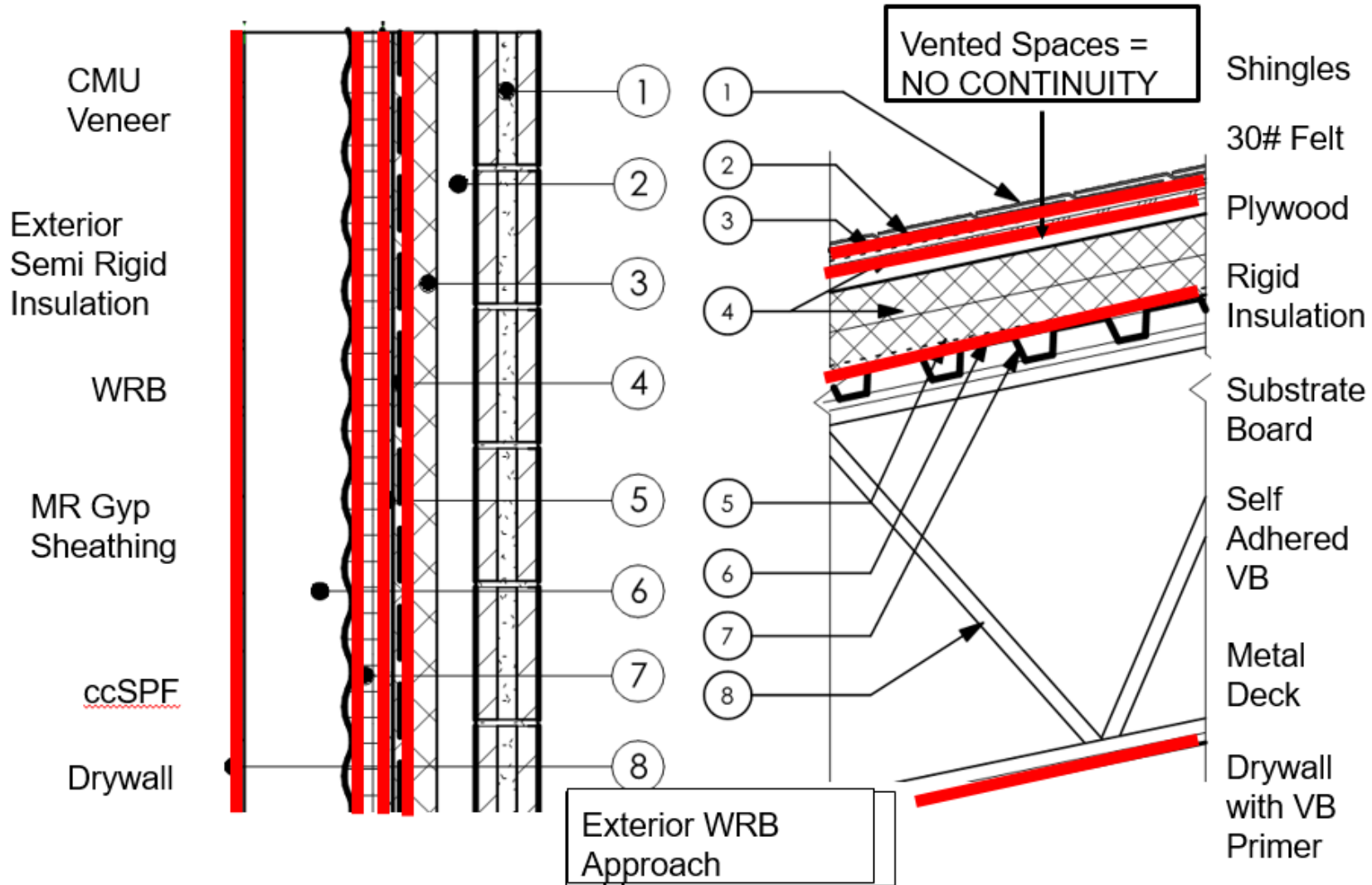


# Air Barrier Approach – Practical Challenge Example

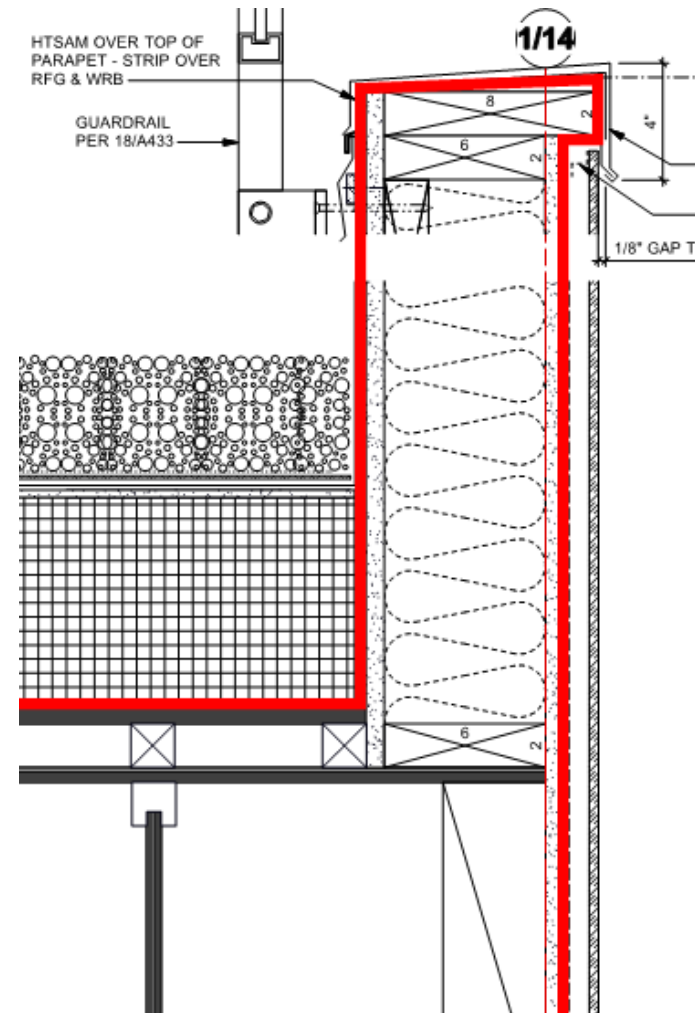
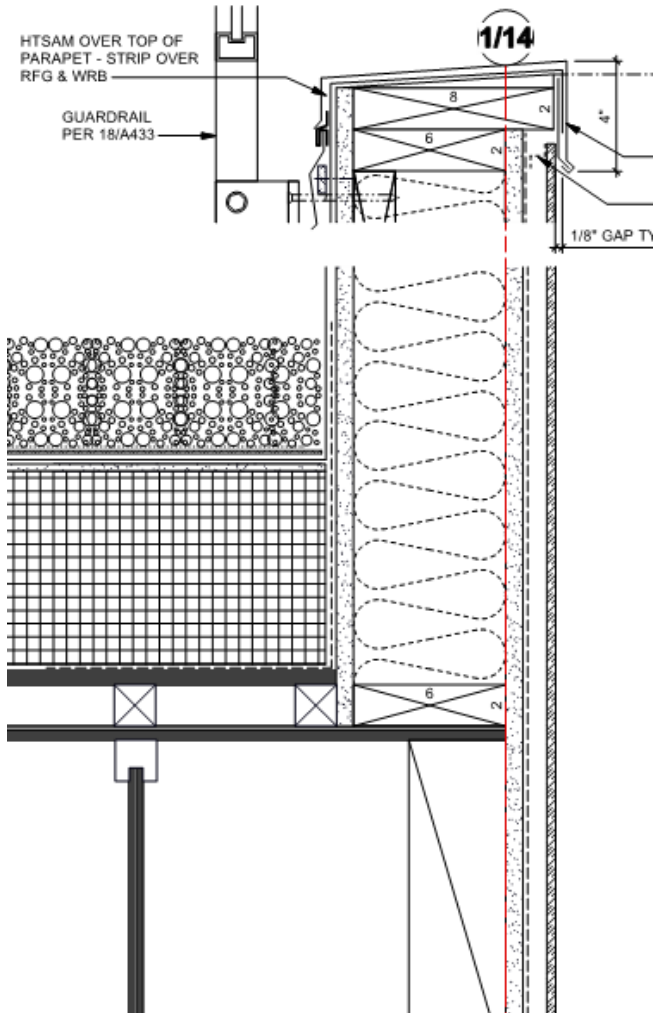
- School Project in Tumwater, WA
- District has envelope standards
- District wants High Performance Building
- CMU Veneer and Fiber Cement Façade
- Steep Slope Roof over Trusses
- On Grade



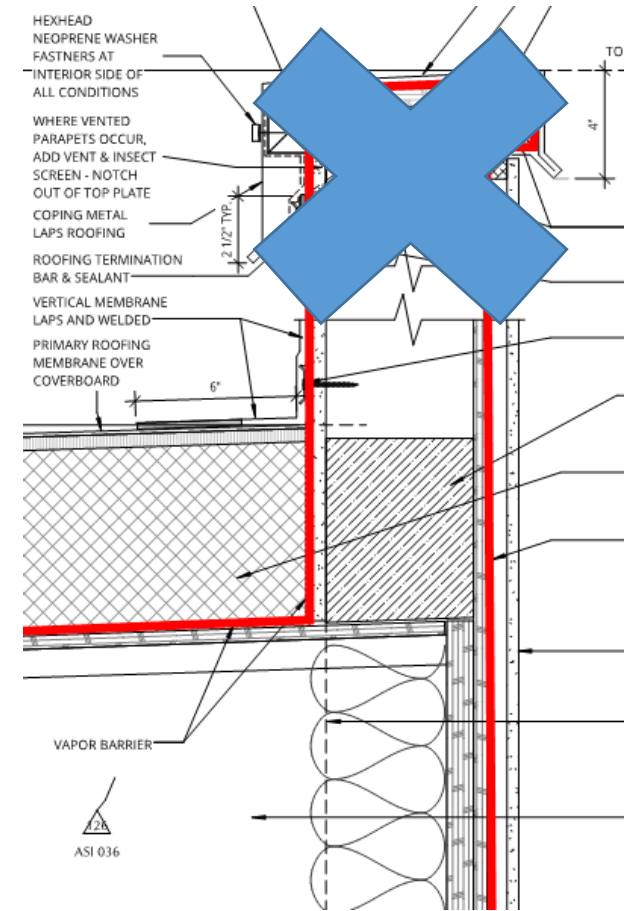
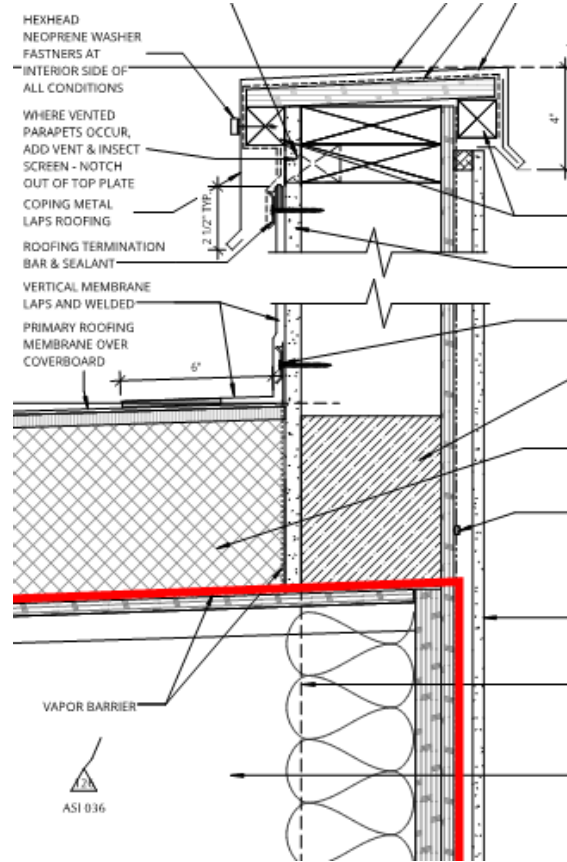
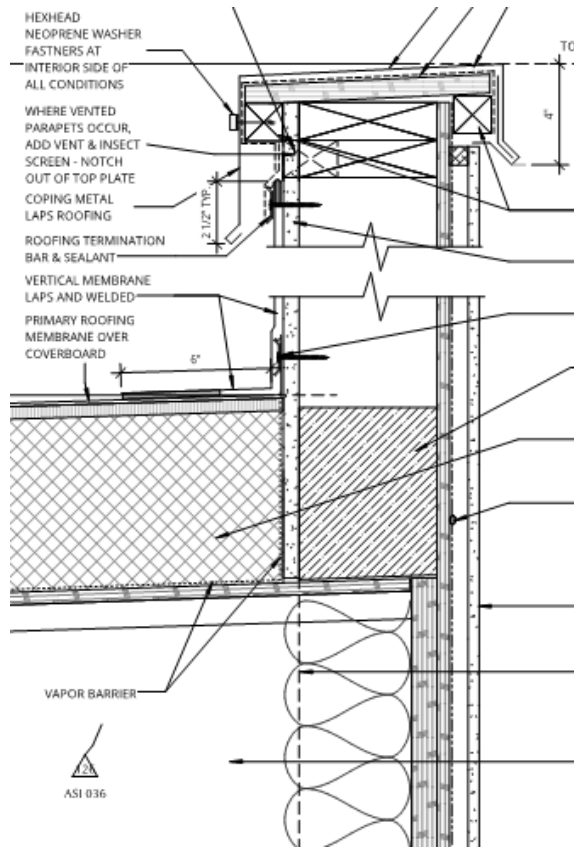
# Air Barrier Approach – Practical Challenge Example



# Vented vs. Non-vented Parapet



# Vented vs. Non-vented Parapet



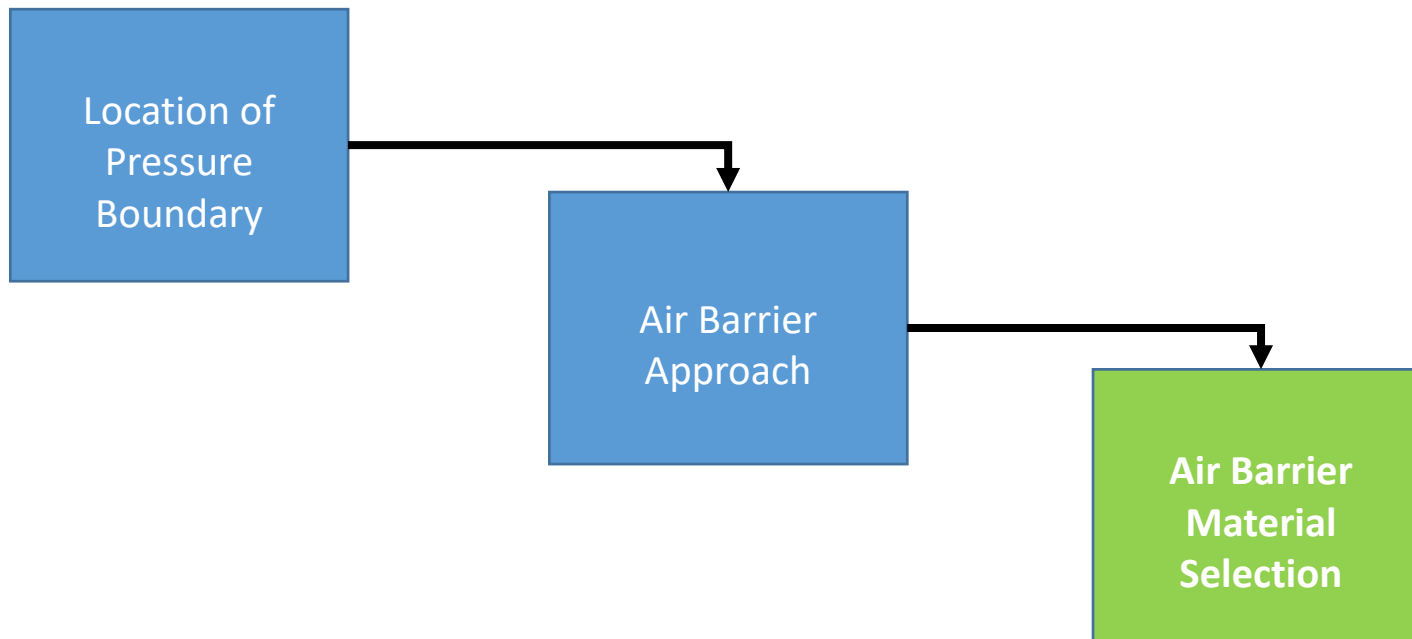
~ VAPOR BARRIER / AIR BARRIER (AB)

~ 4" HIGH SPRAY FOAM PLUG (AIR BARRIER), TYP

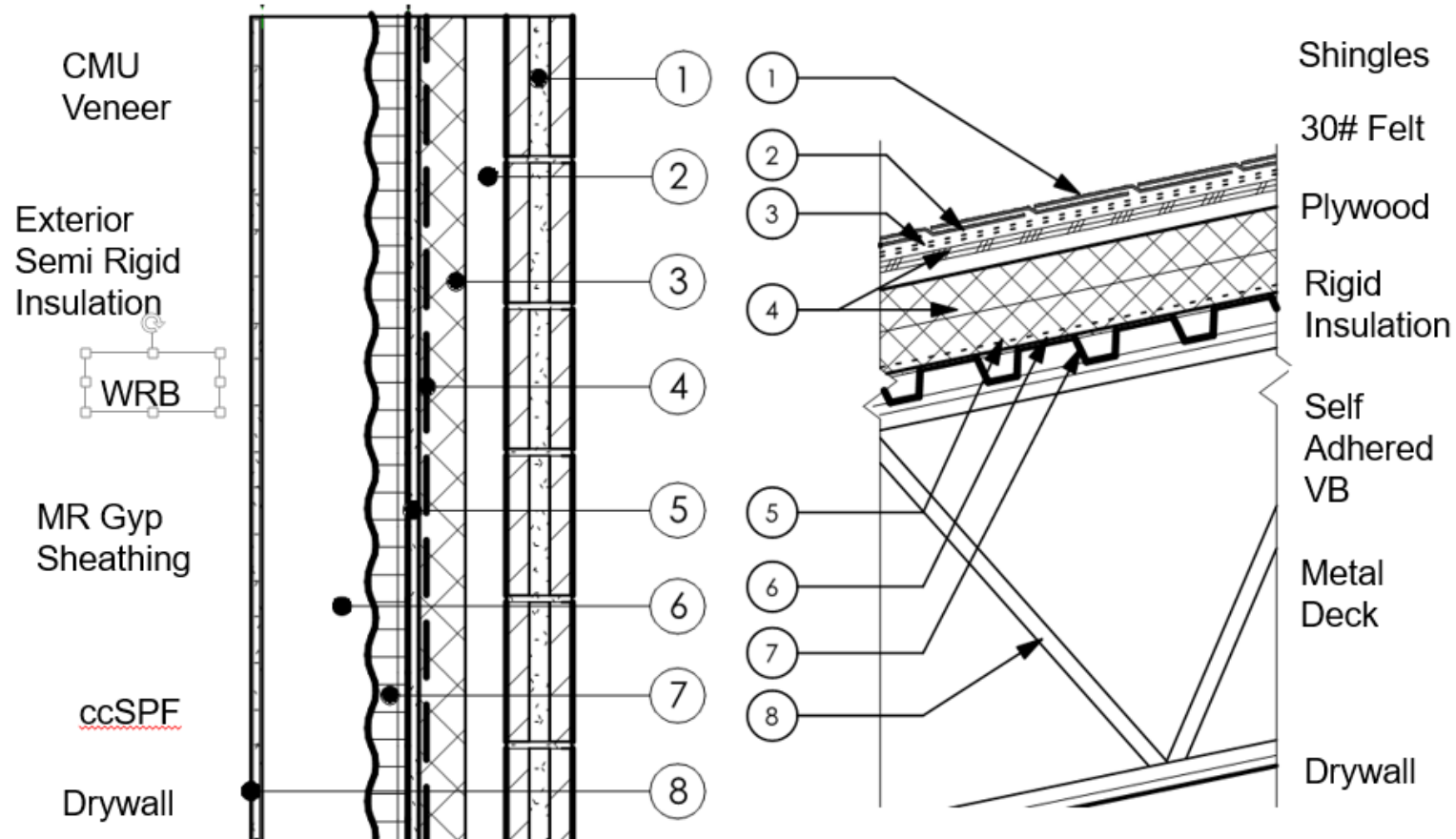
~ WRB/AB SEALED TO SHEATHING WITH SEALANT

# Design QA

- Confirm Material and System Air Permeance
- Compatibility with Adjacent Air Barrier Materials
- Vapor Permeability



# Air Barrier Material – Practical Challenge Example



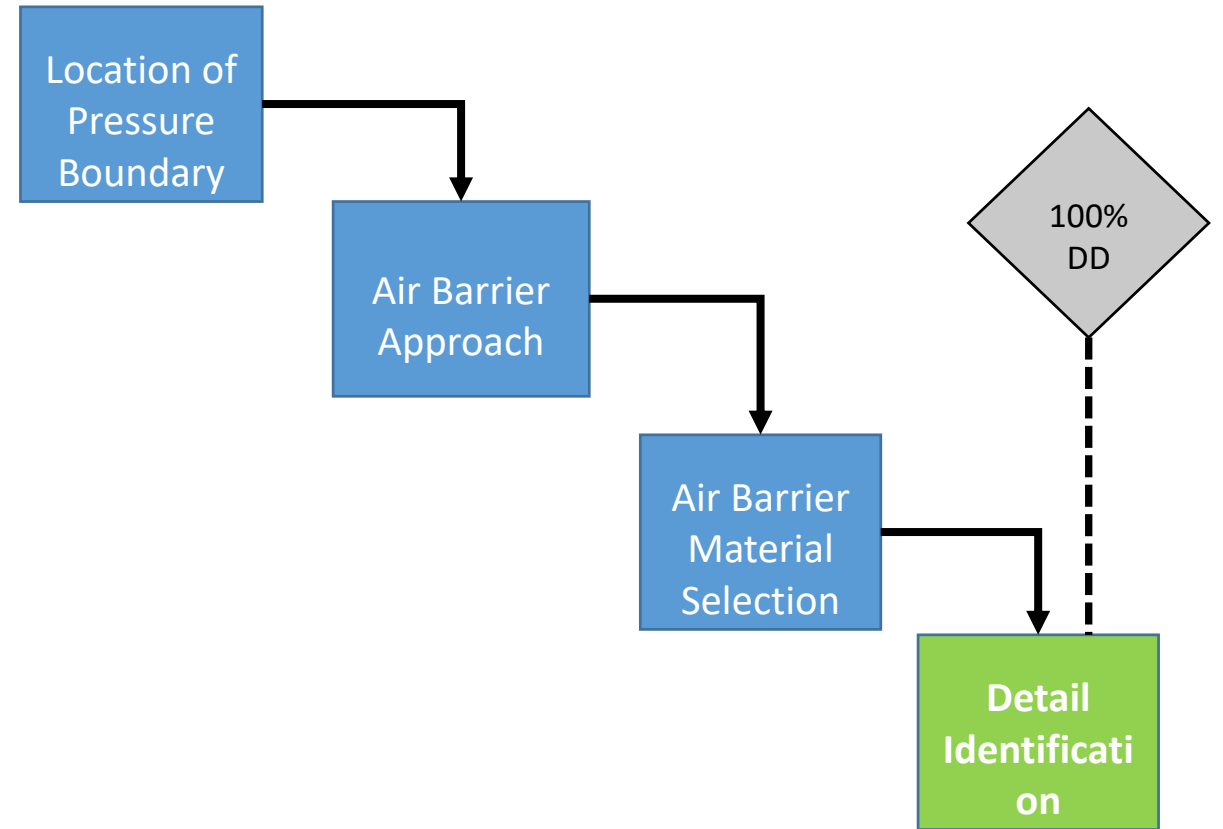
# Code Approved Air Barrier Materials

- Plywood (3/8 inch min)
- OSB (3/8 inch min)
- EPS (1/2 inch min)
- Foil Faced Polyiso (1/2 inch min)
- ccSPF (4.5 inch min)
- Gypsum Sheathing (1/2 inch min)
- Cement Board (1/2 inch min)
- BUR Roofing Membrane
- Fully Adhered Single Ply Roof
- Stucco (5/8 inch min)
- CIP or Precast Concrete
- Fully Grouted CMU
- Sheet Steel of Aluminum

-2012 IECC

# Design QA

- Identify transitions between air barrier membranes and approaches
- Trace Pressure Boundary
- Create schedule of details



# Typical Continuity Challenges

- Changes in Materials at Exterior
- Penetrations
- Changes in Air Barrier Approaches
- Window and Door Sills / Thresholds
- Roof to Wall Connections
- Wall to Foundation
- Roof Level Changes
- Interior Common Demising Walls
- Separation of Attics to Conditioned Space

# Soffits

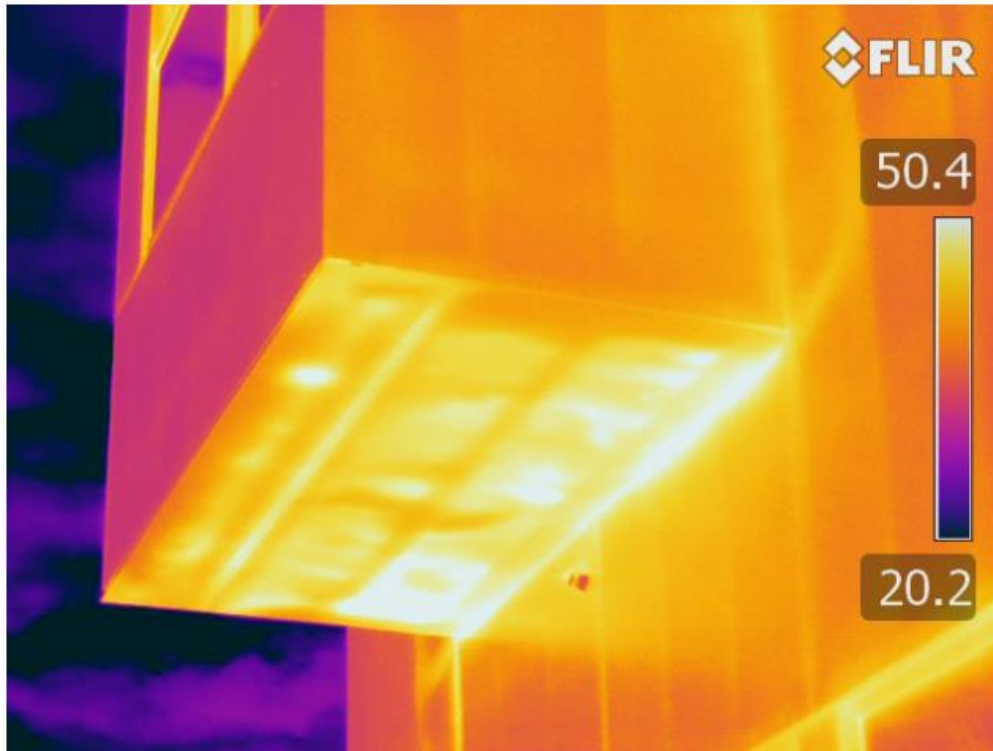


Conditioned Space Above Soffit =  
Pressure Boundary =  
Air Barrier Approach Needed

# Soffits

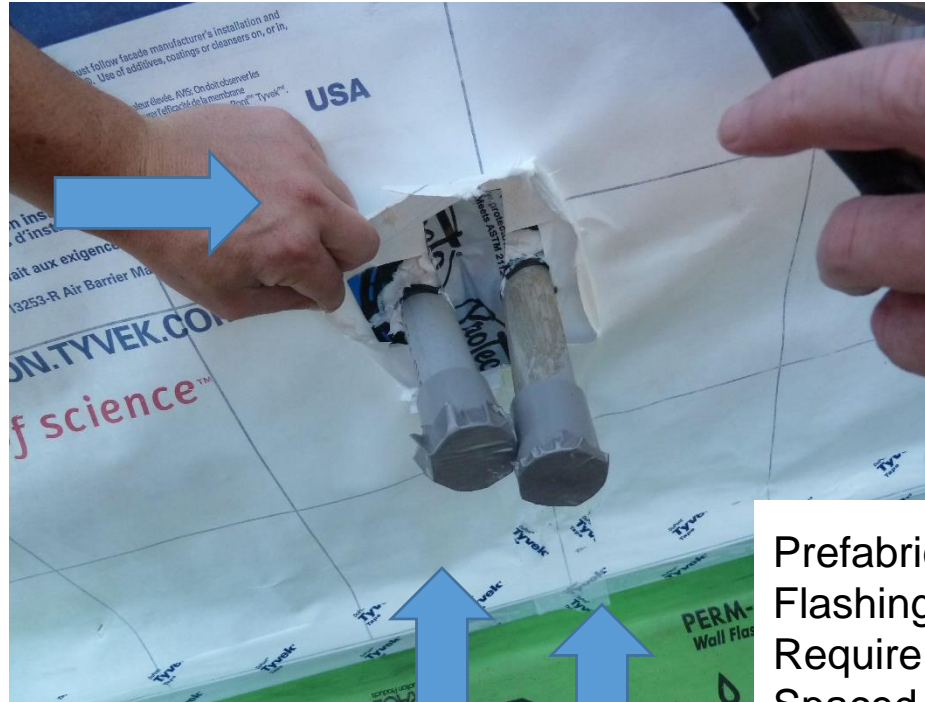


# Soffit – Air Leakage



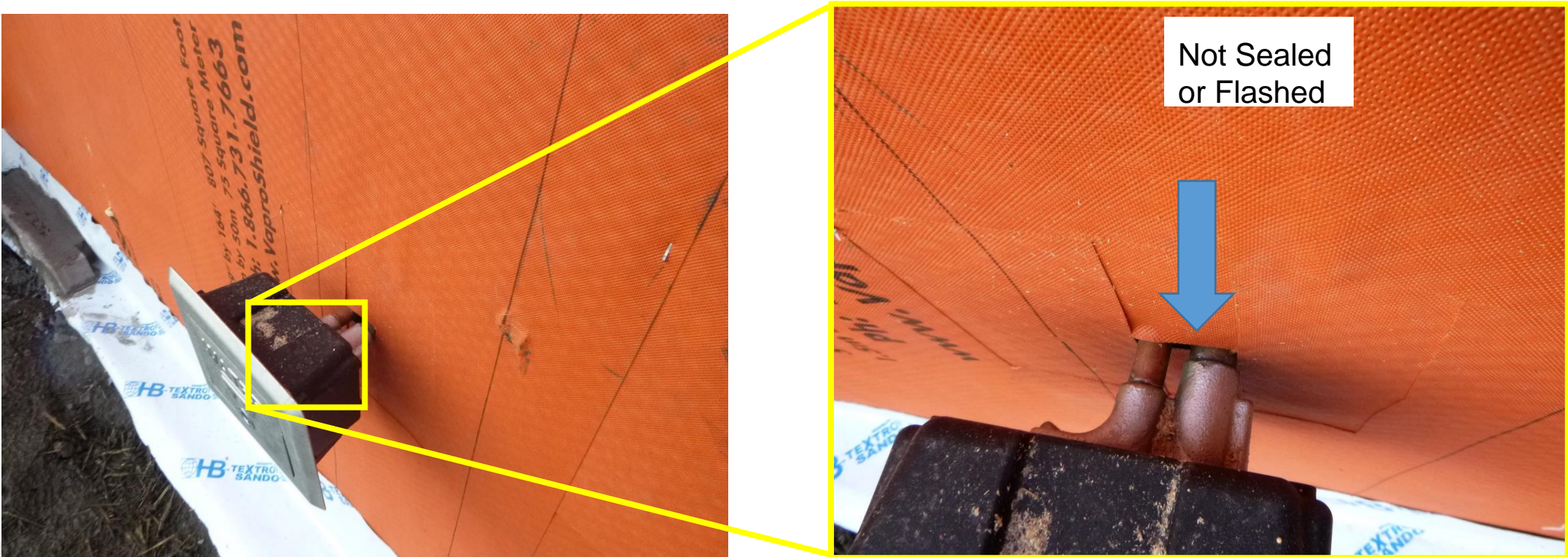
# Penetration Detailing

Prefabricated  
Penetration  
Flashing

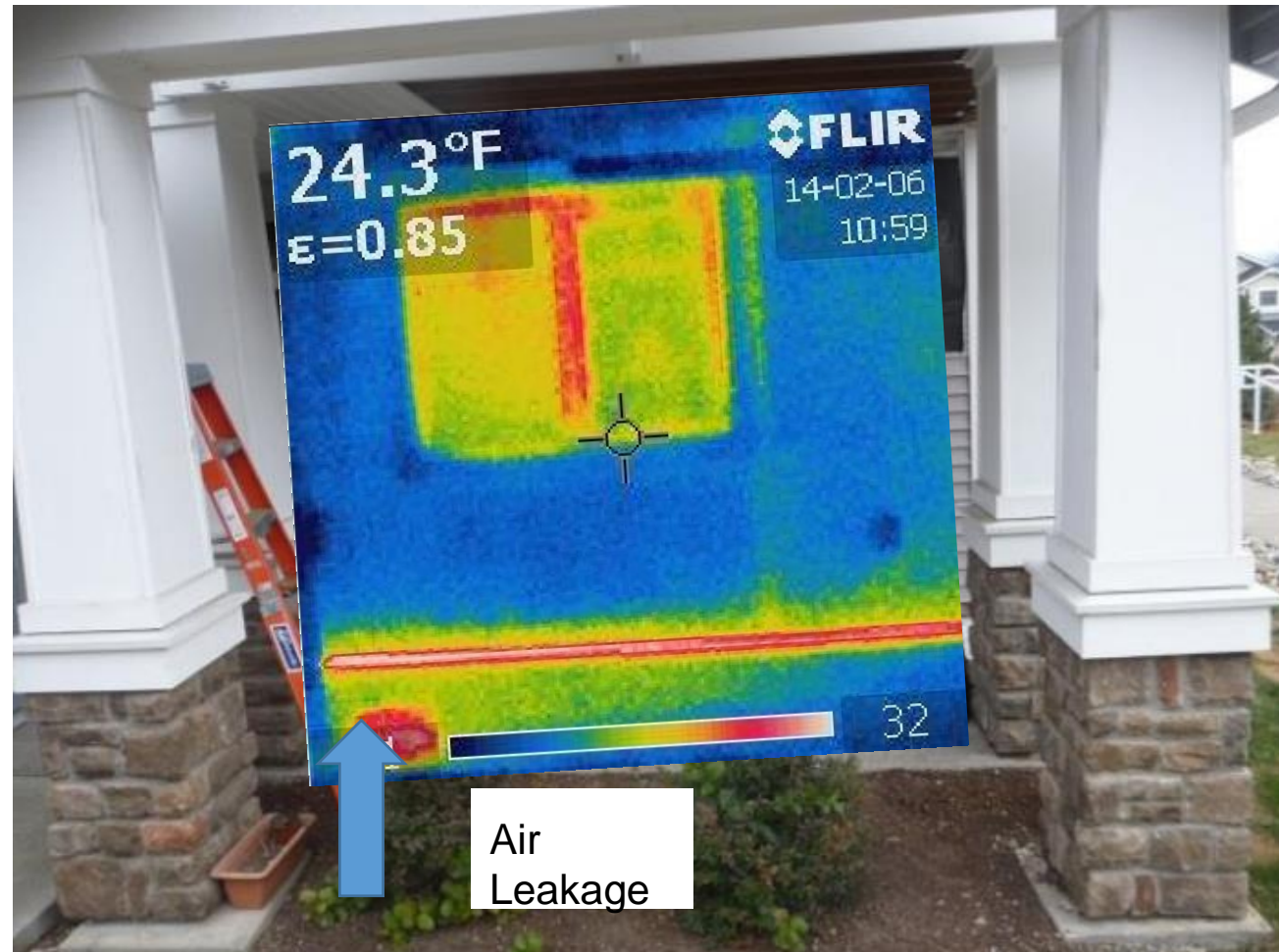


Prefabricated  
Flashings  
Require  
Spaced Out  
Penetrations

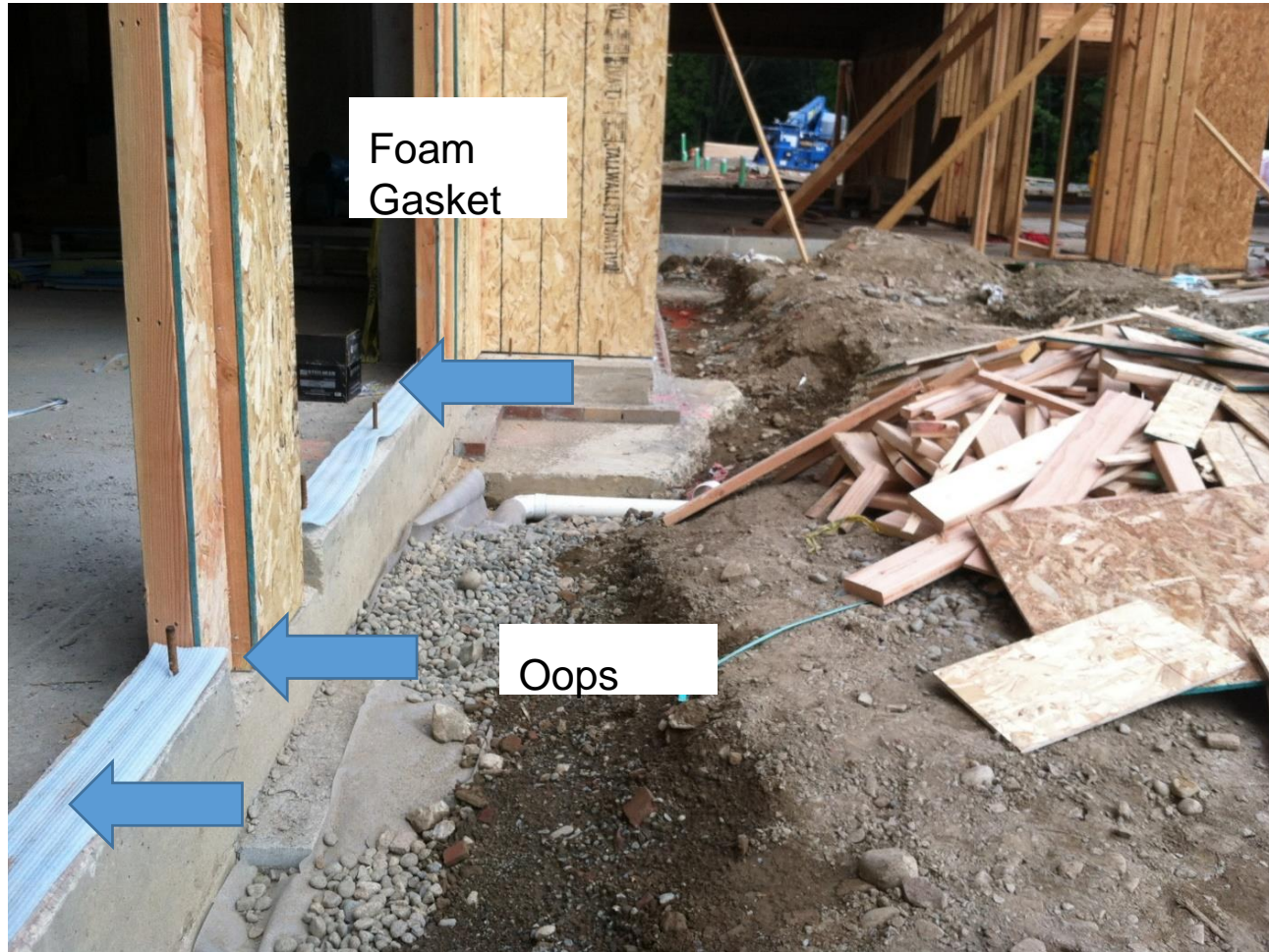
# Penetration Detailing



# Base of Wall

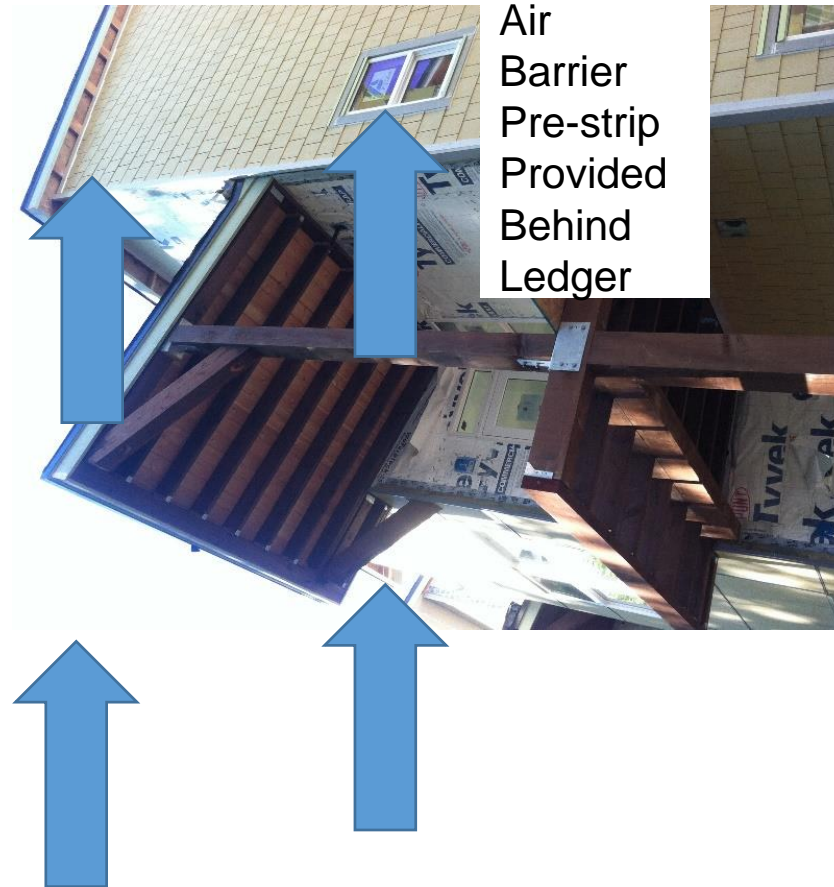


# Base of Wall





# “Plant On Features”



# Projections and Fin Walls

- Air Barrier Approach Options:
- If Vented Soffit –
  - Pre Strip
  - Through projection with multiple approaches (sheathing, ccSPF and WRB)
  - Around the projection, but can not use soffit sheathing or soffit WRB due to venting.
- If Unvented Soffit –
  - Pre Strip
  - Through projection with multiple approaches (sheathing, ccSPF and WRB)
  - Around the projection. Can use soffit sheathing or soffit WRB.



# Projections and Fin Walls

Had the QA/QC process been followed, this transition would have been discussed during a pre-construction meeting as an item that would need to be reviewed during the framing installation.



QA person will need to identify approach from documents and determine if compliant.

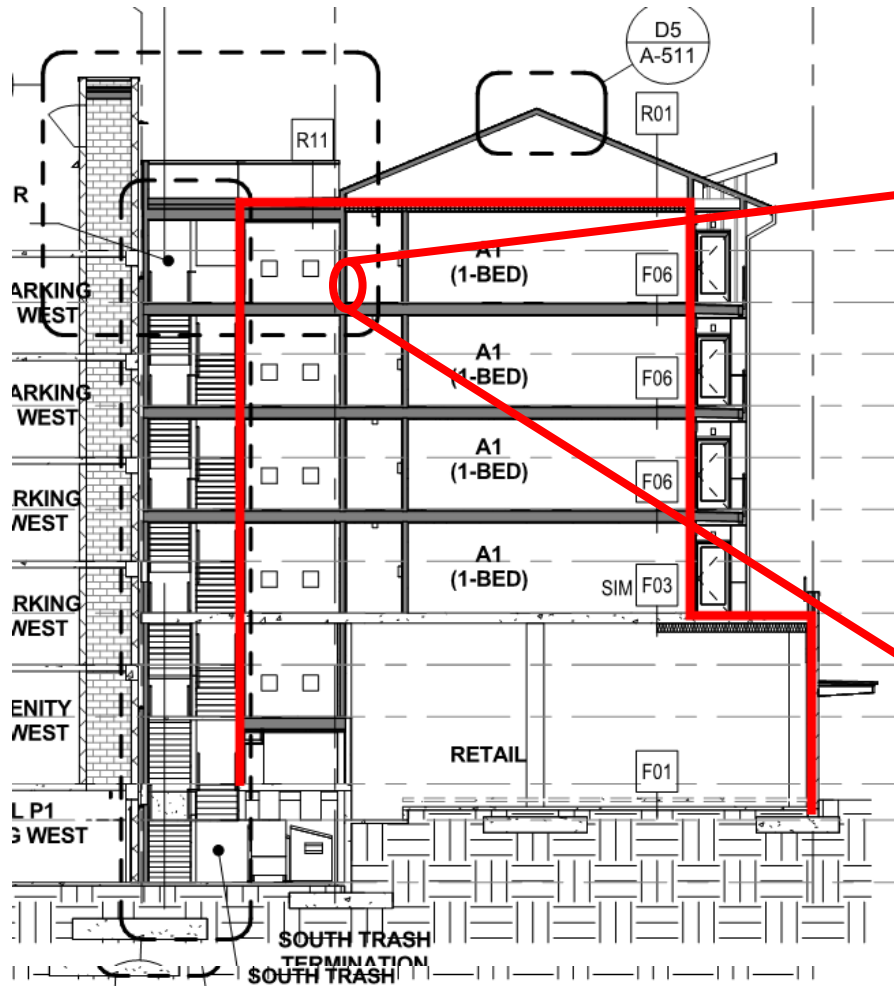
Air Barrier Can Not Pass Through via a Pre-Strip

Hopefully Seen in CD Phase and Detailed

# Projections and Fin Walls



# Attic Access Hatch (Vented Roof)



# Roof to Wall at Vented Attic



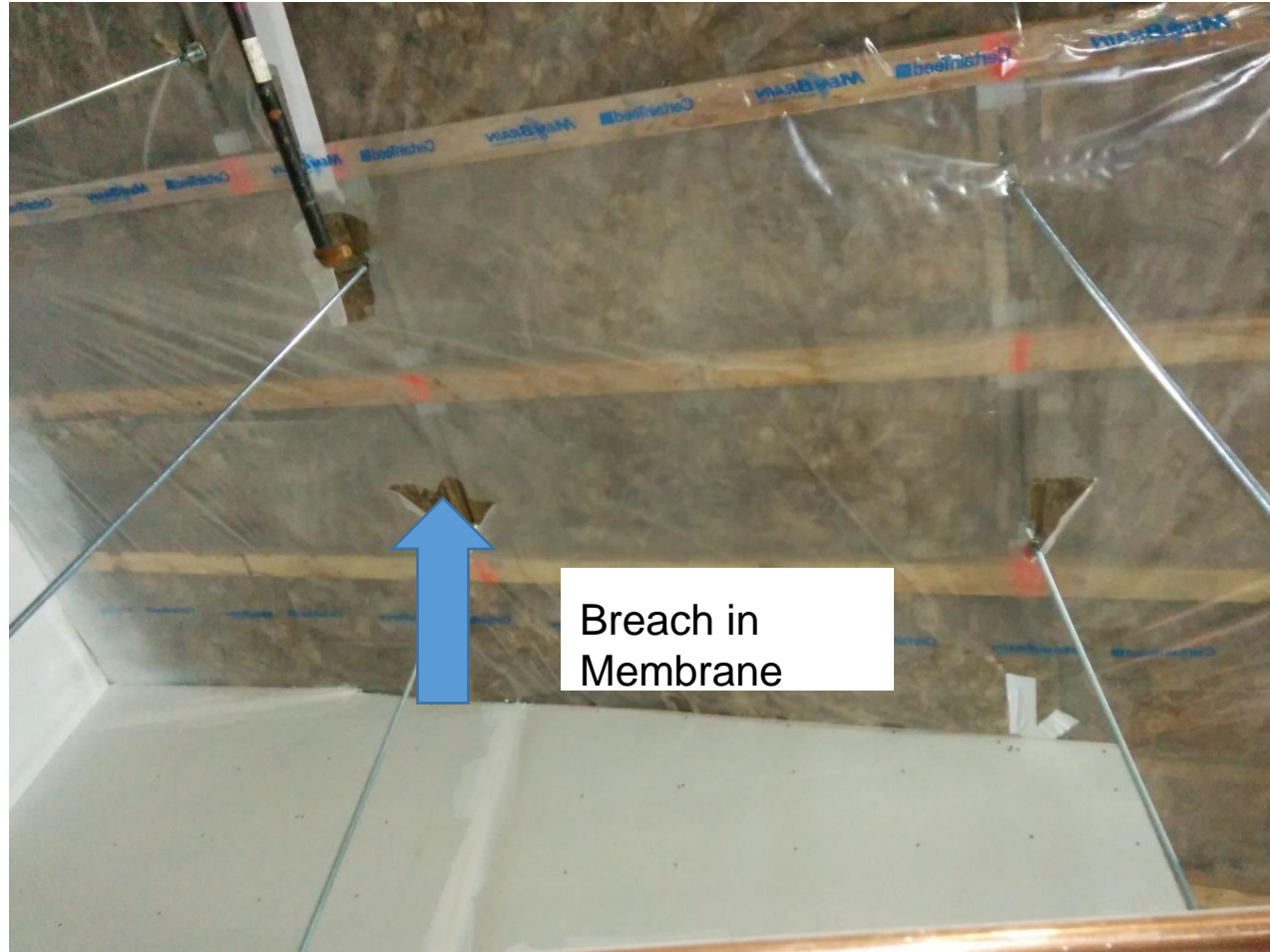
# Roof to Wall at Vented Attic



# Ceiling Air Barrier at Vented Attic



# Ceiling Air Barrier at Vented Attic



# Inform and Document

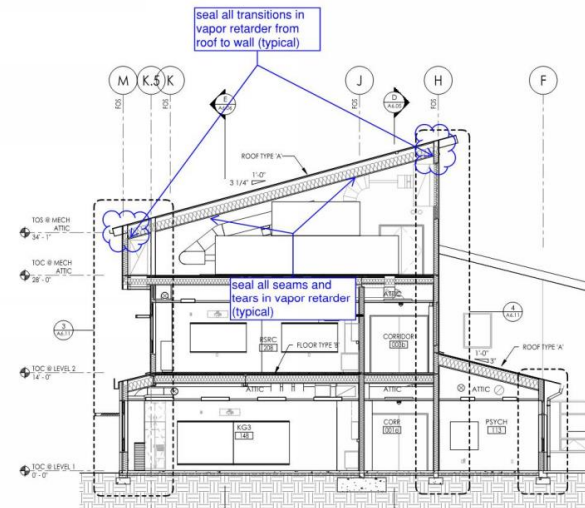
## Item 03 – Vapor Retarder Installation

Elevation; Various - ceiling at main roof - Floor; Roof/Mechanical - Detail Reference; 2/A30.01, A40.00

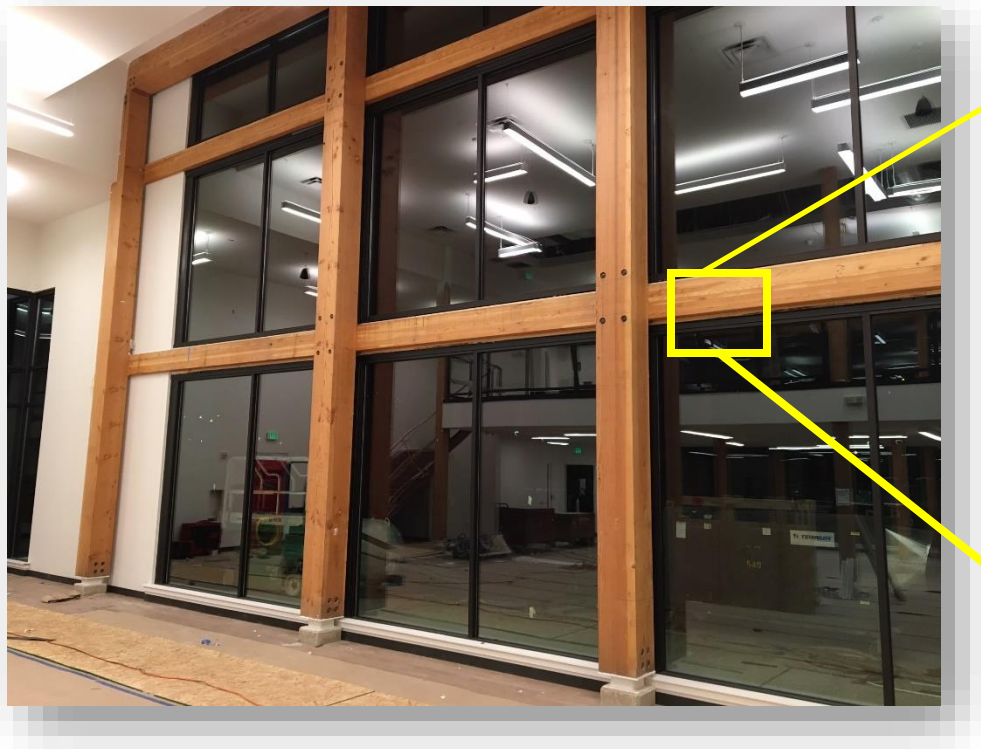
1. The writer observed most of the vapor retarder installations at the underside of the main roof assembly and noted overall general compliance with the construction documents and the manufacturer's installation instructions. There are a few areas in darkened locations of the mechanical penthouse along the south wall where small breaches were noted. Trade work (MEP) is still occurring in these areas and completed installations appear taped upon completion. Refer to photos 02.03.01 through 02.03.06

Items requiring further action indicated in item 03 are as follows:

- 1 - Ensure all roof to wall transitions are tucked, taped and terminated as indicated in the construction documents. Seal all tears and penetrations as indicated.



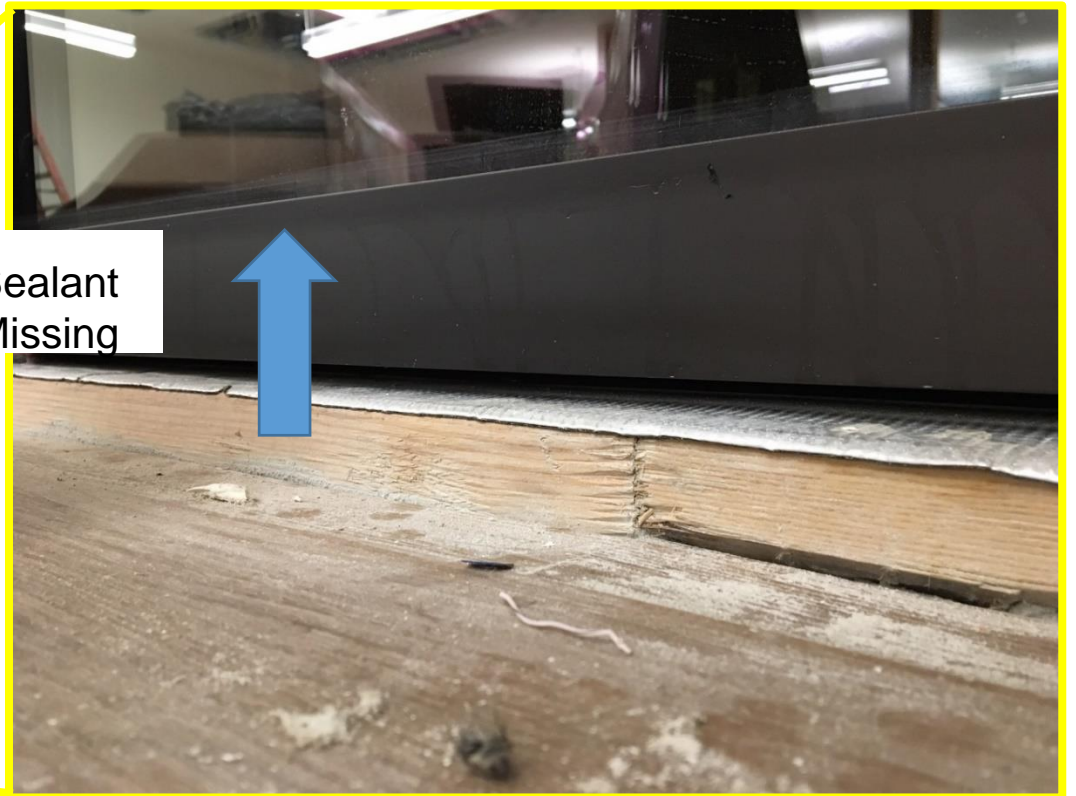
# Interior Air Seal



# Interior Air Seal



Sealant  
Missing



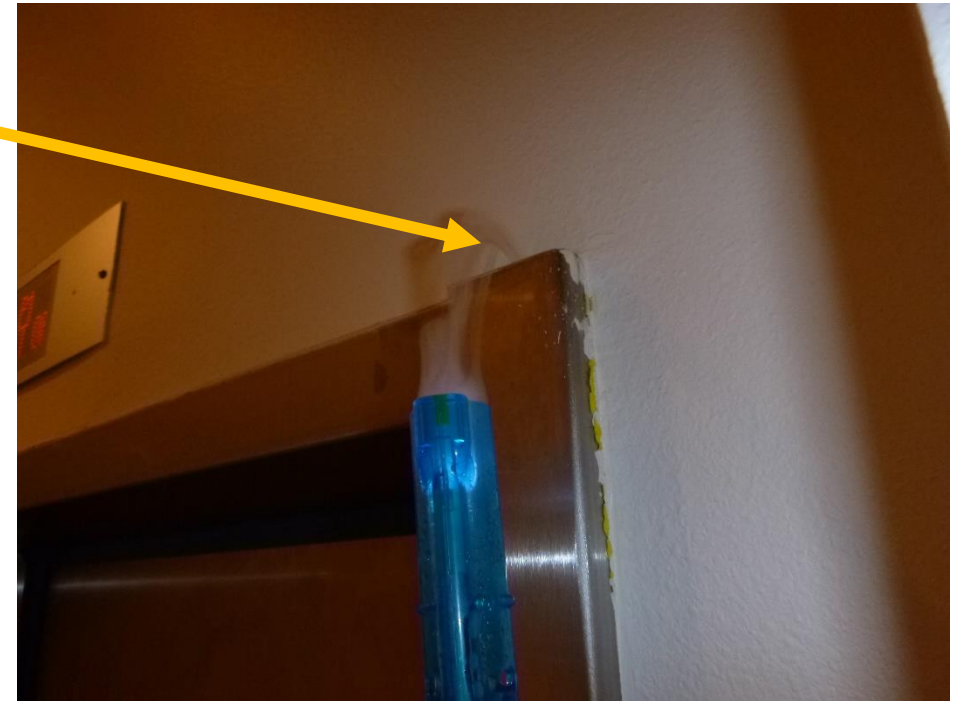
# Interior Air Seal



# Expansion Joints



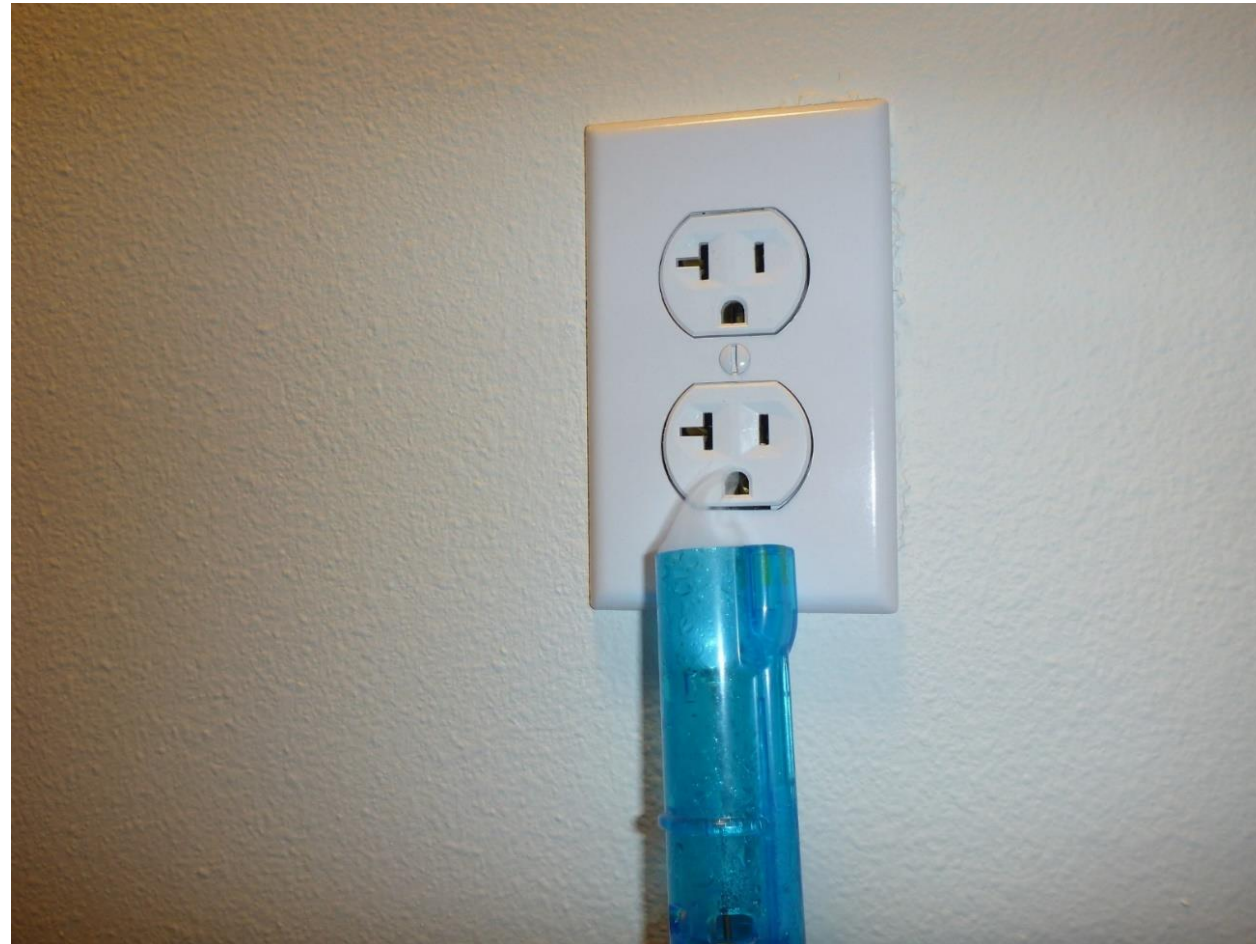
# Elevator core



# Interior Dry Wall Approach



# Interior Dry Wall Approach



# Air Barrier Testing

# Air Barrier Testing Uses

- New Construction

- Evaluate Mock-ups
- Determine whole building air leakage rates
- Air leakage of individual units

- Existing Construction

- Find sources of air leakage
- Quantify air leakage
- Monetize energy loss
- Monetize potential energy savings
- Justify capital improvements

# 2015 IECC Whole Building Testing (Commercial)

- C402.4.1.2.3 – Building Test
- ASTM E 779
- Tested air leakage that does not exceed 0.40 cfm/ft<sup>2</sup> at 75 Pa
- Report submitted to Building Official
- If exceeds limit – Visual Inspection of air barrier
- Seal leaks to extent practicable
- Additional report outlining corrective action completed

# Whole Building Test

- Based on the area of the air barrier surface = Effective Leakage Area
  - Effective Leakage Area calculated by Architect
  - Must use pressurization, but a combination of pressurization and depressurization recommended
  - Requires planning, prep and building shut down
- ASTM E779 – Standard Test Method for Determining Air Leakage Rate by Fan Pressurization



Designation: E779 – 10

## Standard Test Method for Determining Air Leakage Rate by Fan Pressurization<sup>1</sup>

This standard is issued under the first designation E779; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last approval. A superscript symbol (s) indicates an editorial change since the last revision or approval.

### 1. Scope

1.1 This test method measures air-leakage rates through a building envelope under controlled pressurization and depressurization.

1.2 This test method is applicable to small temperature differentials and low-wind pressure differential, therefore strong winds and large indoor-outdoor temperature differentials shall be avoided.

1.3 This test method is intended to quantify the air tightness of a building envelope. This test method does not measure air change rate or air leakage rate under normal weather conditions and building operation.

1.4 This test method is intended to be used for measuring the air tightness of building envelopes of single-zone buildings. For the purpose of this test method, many multi-zone buildings can be treated as single-zone buildings by opening interior doors or by inducing equal pressures in adjacent zones.

1.5 Only metric SI units of measurement are used in this standard. If a value for measurement is followed by a value in other units in parentheses, the second value may be approximate. The first stated value is the requirement.

1.6 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific hazard statements see Section 7.

1.7 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific hazard statements see Section 7.

1.8 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific hazard statements see Section 7.

1.9 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific hazard statements see Section 7.

1.10 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific hazard statements see Section 7.

1.11 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific hazard statements see Section 7.

1.12 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific hazard statements see Section 7.

E741 Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution

E1258 Test Method for Airflow Calibration of Fan Pressurization Devices

3. Terminology

3.1 For definitions of terms used in this test method, refer to Terminology E631.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 air-change rate,  $n$ —air leakage rate in volume units, divided by the building space volume with identical volume units, normally expressed as air changes, ACH.

3.2.2 air-leakage,  $n$ —the movement/flow of air through the building envelope, which is driven by either or both positive (infiltration) and negative (exfiltration) pressure differences across the envelope.

3.2.3 air-leakage graph,  $n$ —the graph that shows the relationship of measured airflow rates to the corresponding measured pressure differences, plotted on a log-log scale.

3.2.4 air-leakage rate,  $n$ —the volume of air movement/unit time across the building envelope including airflow through joints, cracks, and porous surfaces, or a combination thereof driven by mechanical pressurization and de-pressurization, natural wind pressures, or air temperature differentials between the building interior and the outdoors, or a combination thereof.

3.2.5 building envelope,  $n$ —the boundary or barrier separating different environmental conditions within a building and from the outside environment.

3.2.6 effective leakage area,  $n$ —the area of a hole, with a discharge coefficient of 1.0, which, with a 4 Pa pressure difference, leaks the same as the building, also known as the sum of the uniminished openings in the structure.

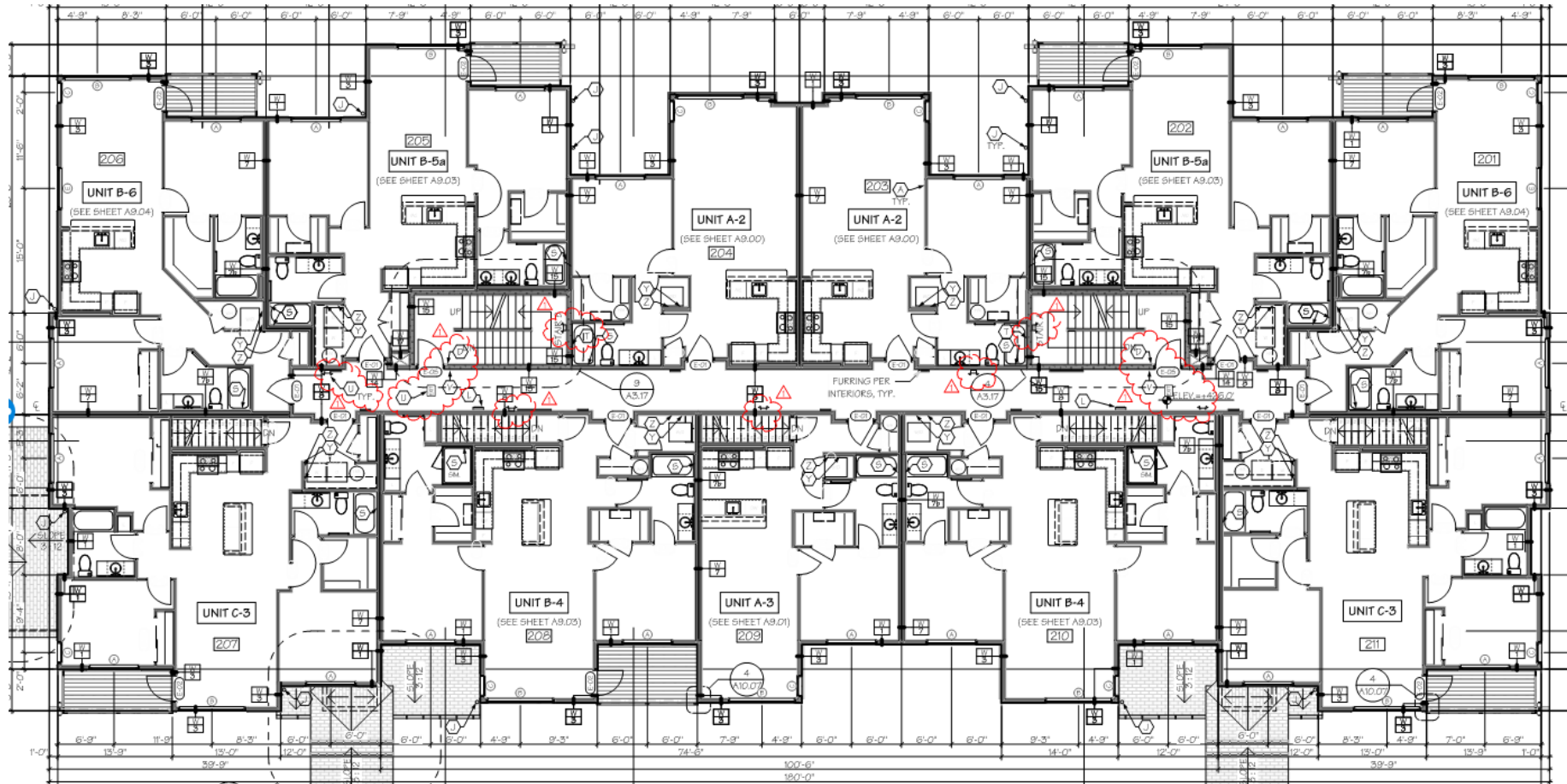
3.2.7 height, building,  $n$ —the vertical distance from grade plane to the average height of the highest ceiling surface.

3.2.8 interior volume,  $n$ —deliberately conditioned space within a building, generally not including attics and attached structures, for example, garages, unless such spaces are connected to the heating and air conditioning system, such as a crawl space plenum.

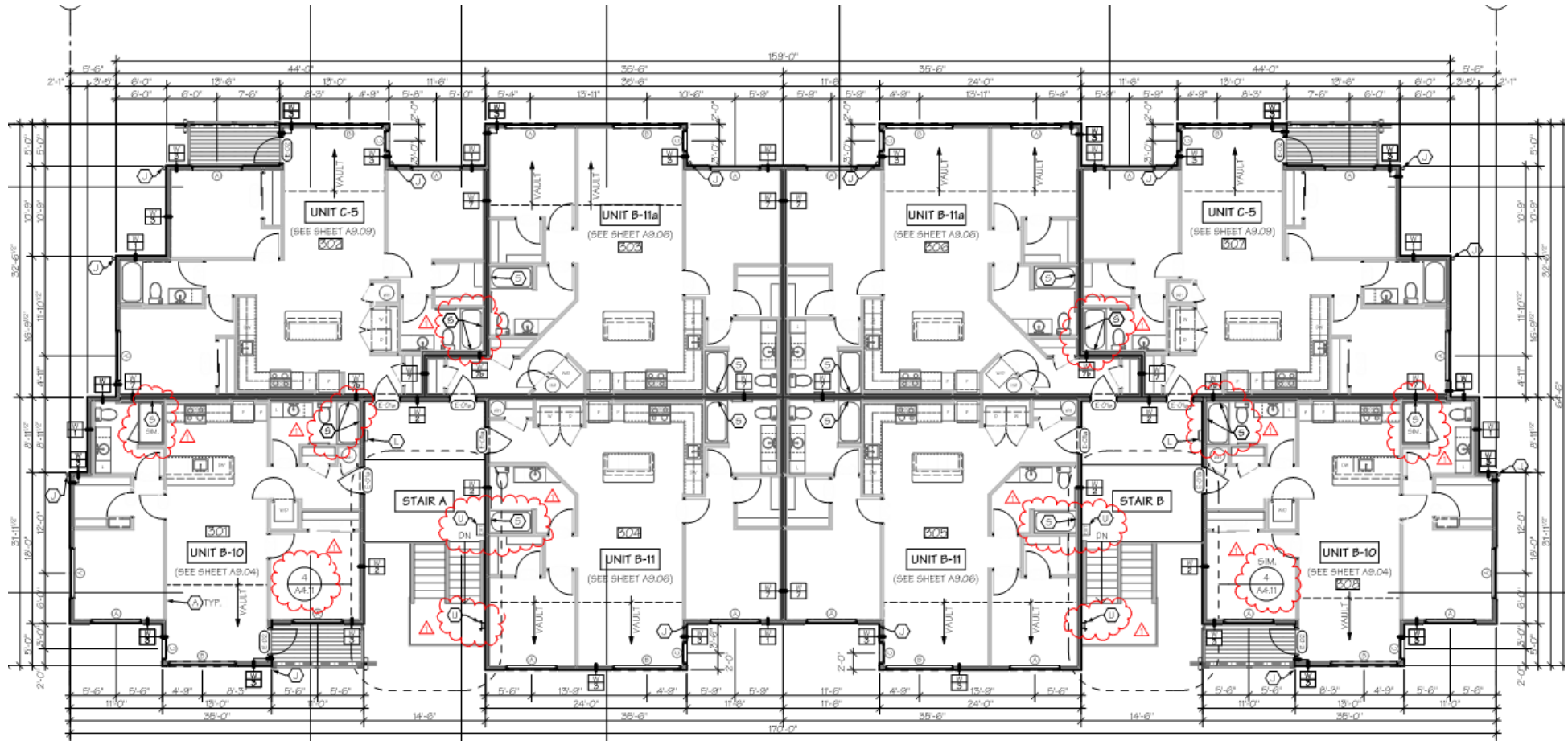
3.2.9 single zone,  $n$ —a space in which the pressure differences between any two places, differ by no more than 5 % of



# Conditioned Spaces Connected via (Interior Hallway)



# Conditioned Spaces Not Connected (Walk-ups)



# Preparation



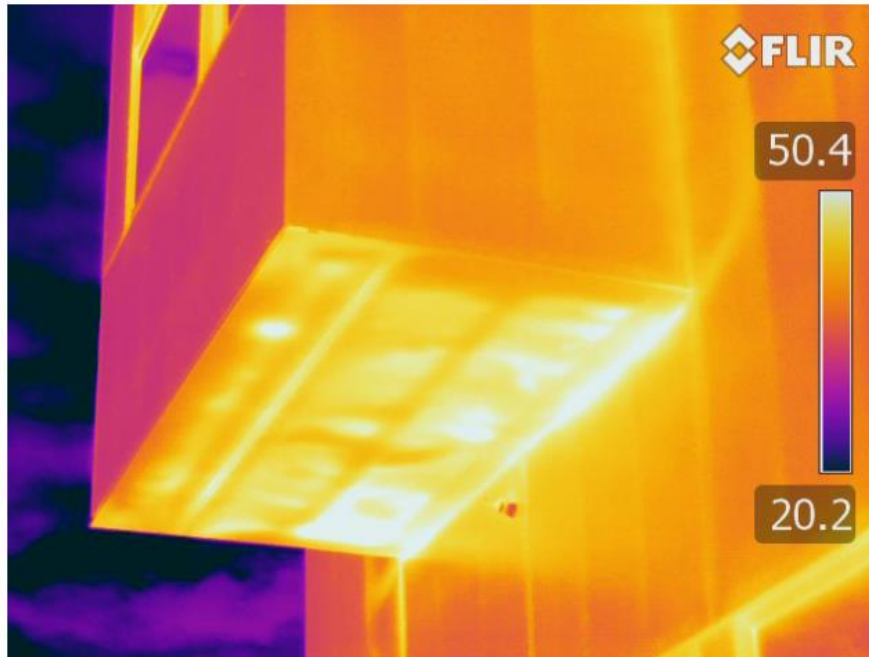
# Set Up



# Identifying Air Leakage

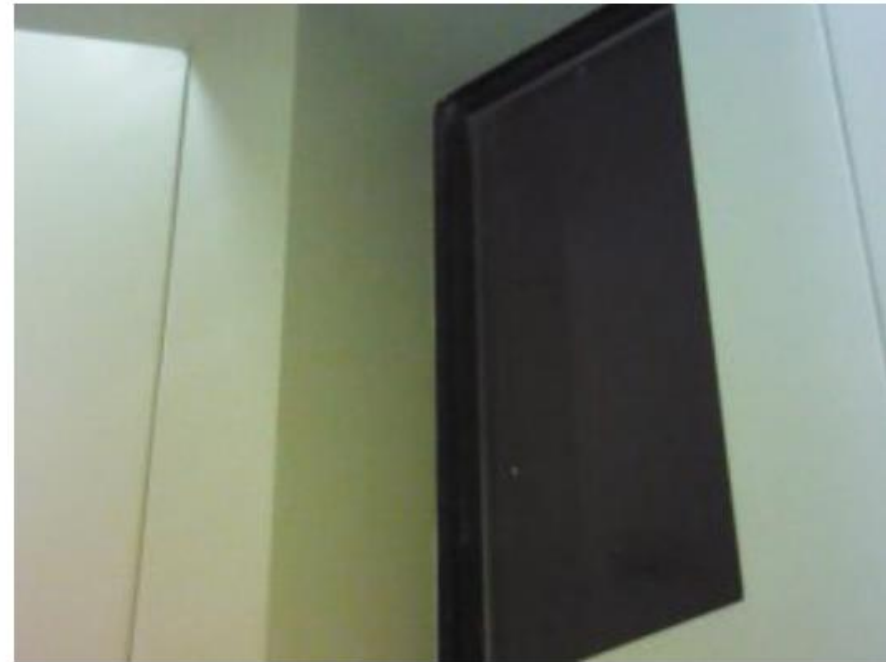
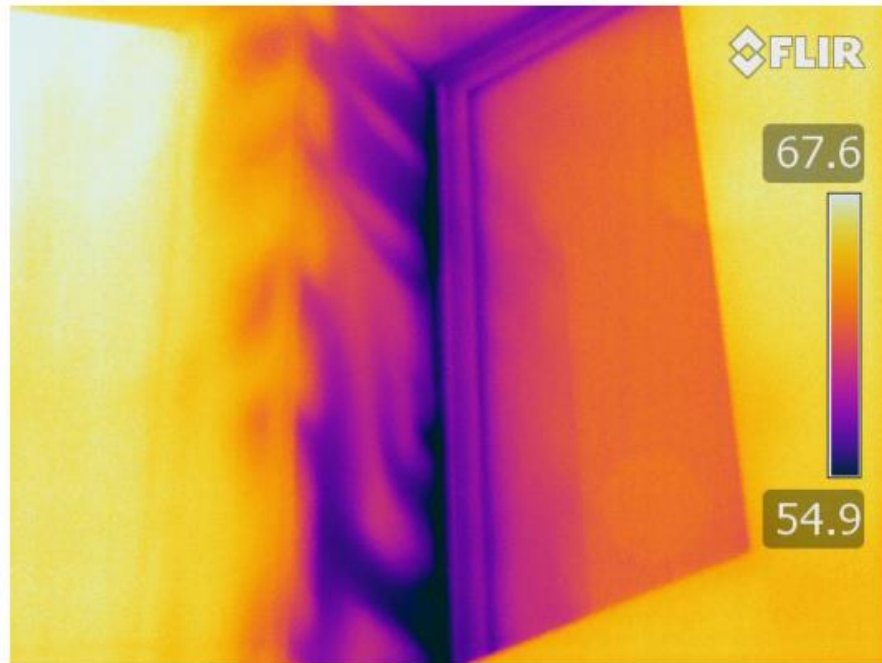
- ASTM E1186 – Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems
- 4.2.1 Air Infiltration Site Detection Using Infrared Scanning
- 4.2.2 Smoke Tracers Used in Whole Building Pressurization or Depressurization
- 4.2.6 Smoke Tracers Used in Chamber Pressurization or Depressurization
- 4.2.7 Detection Liquid Air Testing

# Thermal Camera – Positive Pressurization



Looking at infra-red image from exterior side

# Thermal Camera - Depressurization



Looking at infra-red image from interior side

# What Air Leakage Looks Like



Air leakage identified by tracer testing

# What No Air Leakage Looks Like



Tracer smoke test, no leakage

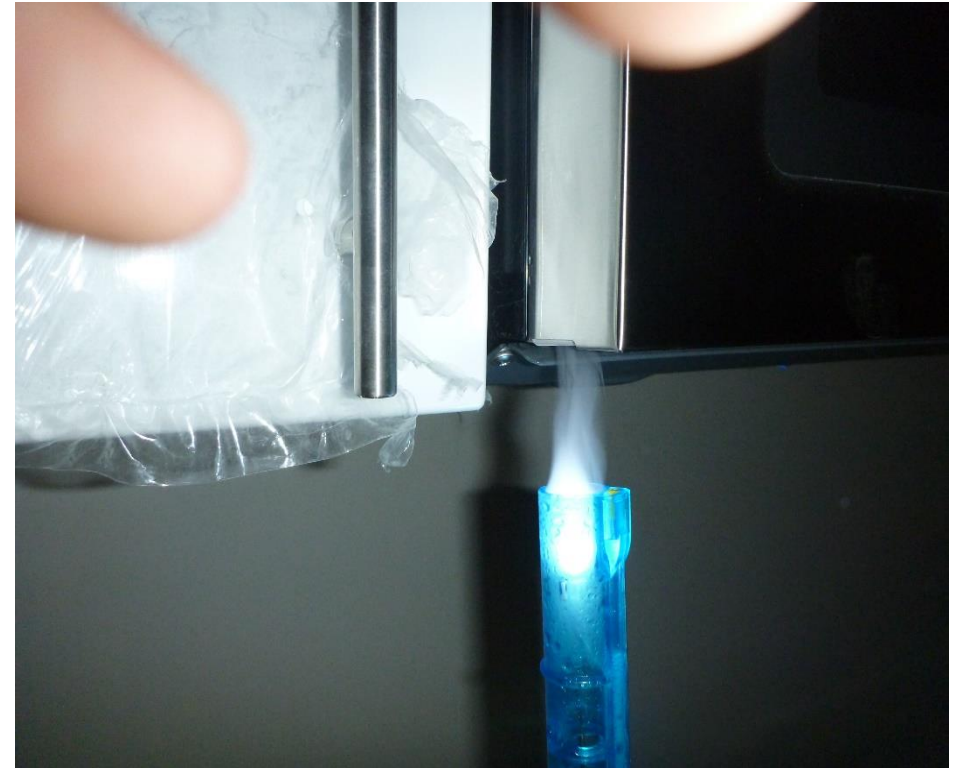
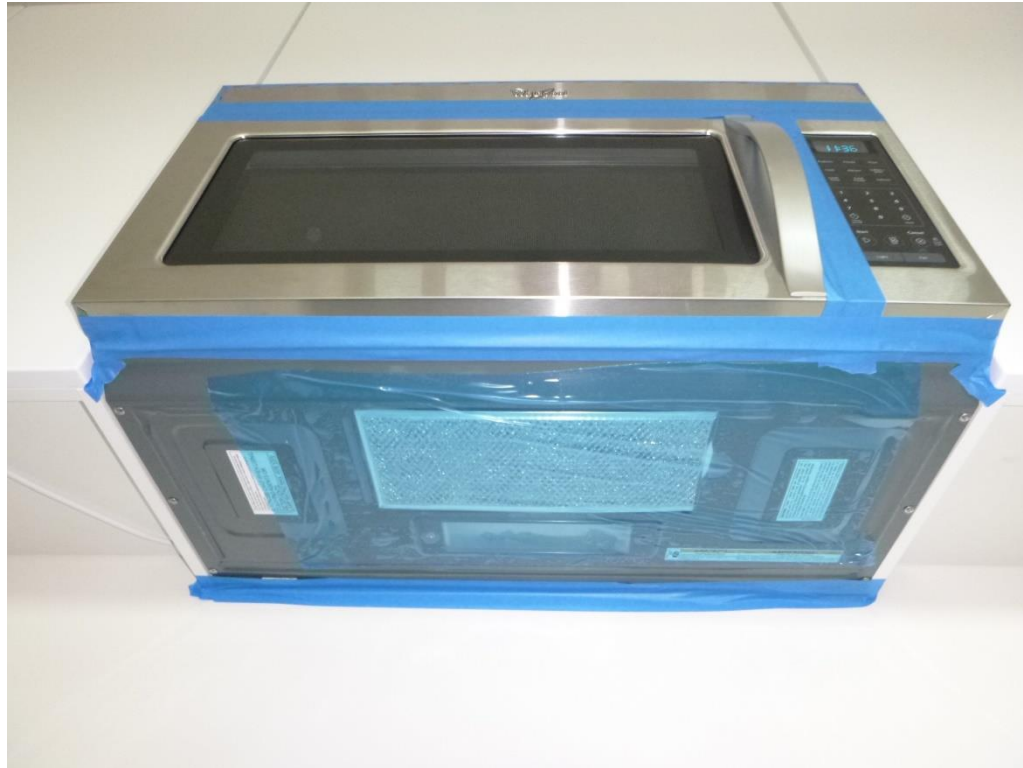
# Exterior Air Barrier Breach



# Fire Rated Assembly Breaches



# Things that make the day longer



# Things that make the day longer



# Things that make the day longer



# When all else fails....



# Questions and Answers

Thank You!

Karim Allana, PE, RRC, RWC  
karim@abbae.com