

# Academy of Architecture for Health On-line Professional Development

## Building Enclosure Fundamentals—Air Barriers for Health Care Facilities

### HC 101 Series

Tuesday, May 9, 2017

2:00 pm – 3:00 pm ET

1:00 pm – 2:00 pm CT

12:00 am – 1:00 pm MT

11:00 am – 12:00 pm PT

#### **Moderator**

**John Kreidich**

McCarthy Building Companies

#### **Presenter**

**Kevin Kalata, RA, SE**

Wiss, Janney, Elstner & Associates

# Health Care 101 Series

The Academy's multi-channel on-line approach provides emerging professionals, journeymen, and master professionals with convenient and economical opportunities to develop their chosen area of interest.

The HC 101 Series sessions are tailored to provide budding healthcare design professionals with conceptual and practical primer-level knowledge.

Series topics include: Master planning; Programming; Ambulatory care; Clinical support services; Emergency; ICI-acute care; Imaging; Long-term care; Maternal care; Mental health; Surgery.

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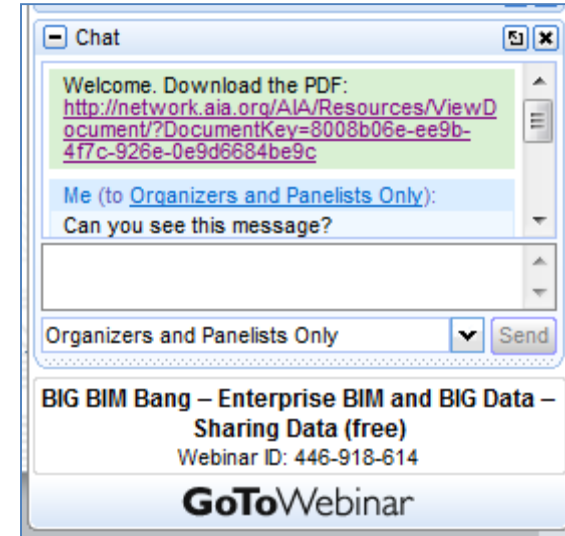
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Content-related questions will be answered during the Q&A portion at the end as time allows.

Tech support questions will be answered by AIA staff promptly.



# Building Enclosure Fundamentals—Air Barriers for Health Care Facilities

## Presenter



**Kevin Kalata, RA, SE**

Wiss, Janney, Elstner Associates, Inc.

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# Outline

- Building Science
  - General Overview
- Air Barriers
  - Performance Requirements
  - Types
  - Testing Procedures
- Additional Considerations for Enclosure Design
  - Heat Flow
  - Moisture

# Building Enclosure Fundamentals

*Air Barriers for Health Care Facilities*

## Building Science

# Building Science Basics

## *Definition*

### **Building science**

Can be defined as the study of the movement of air, moisture, and energy through the building envelope





# Building Science Basics

## *Enclosure Problems*



# Building Science Basics

## *Enclosure Problems*





# Building Science Basics

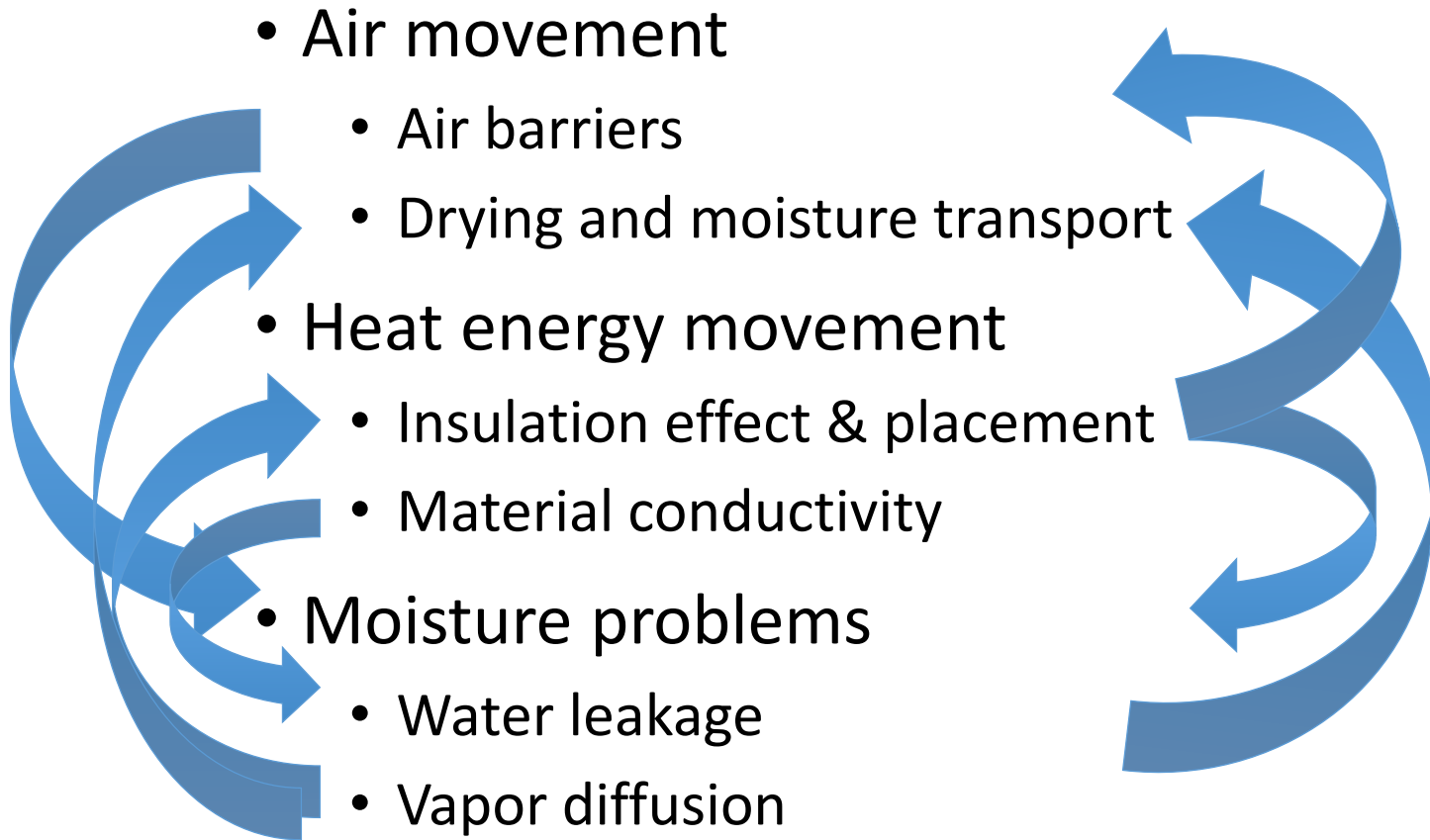
## *Overview*

- Involved in all aspects of the building enclosure design
- Principles relate to structures everywhere
- Key to understanding moisture problems
- Primary goals are to reduce energy costs & prevent moisture problems



# Building Science Basics

## Overview



# Building Enclosure Fundamentals

*Air Barriers for Health Care Facilities*

## Air Barriers

# Air Movement & Barriers

## *Air Flow Concepts*

### **Air Movement**

- High to low pressure
- Pressurization affected by:
  - Wind effects
  - Mechanical systems
  - Stack effect
- Transports: Heat & Vapor

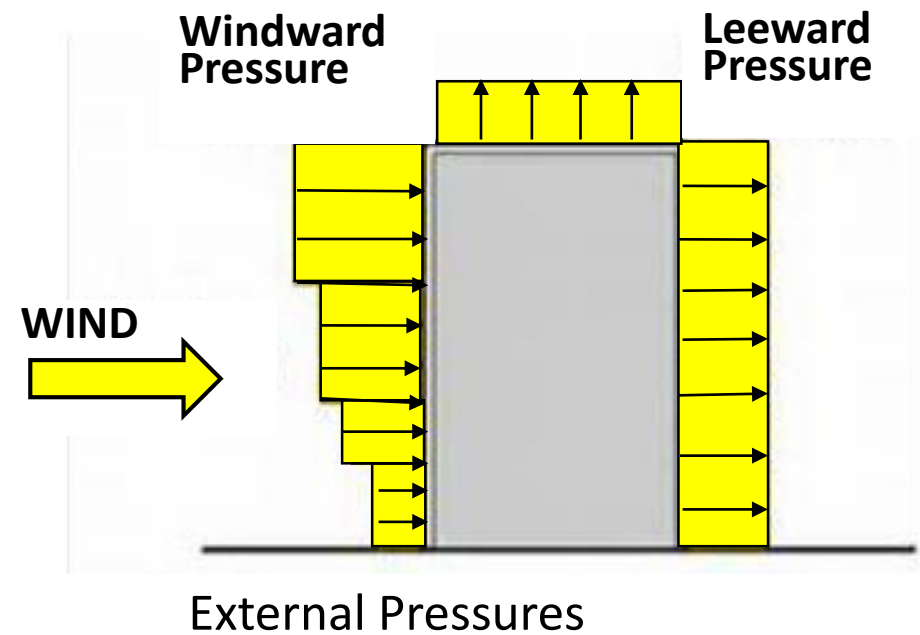




# Air Movement & Barriers

## *Wind Pressurization*

- External Pressures
  - Windward
  - Leeward
- Internal Pressures
  - Positive and negative pressure
  - Affected by: Building type (open, closed, partially enclosed)

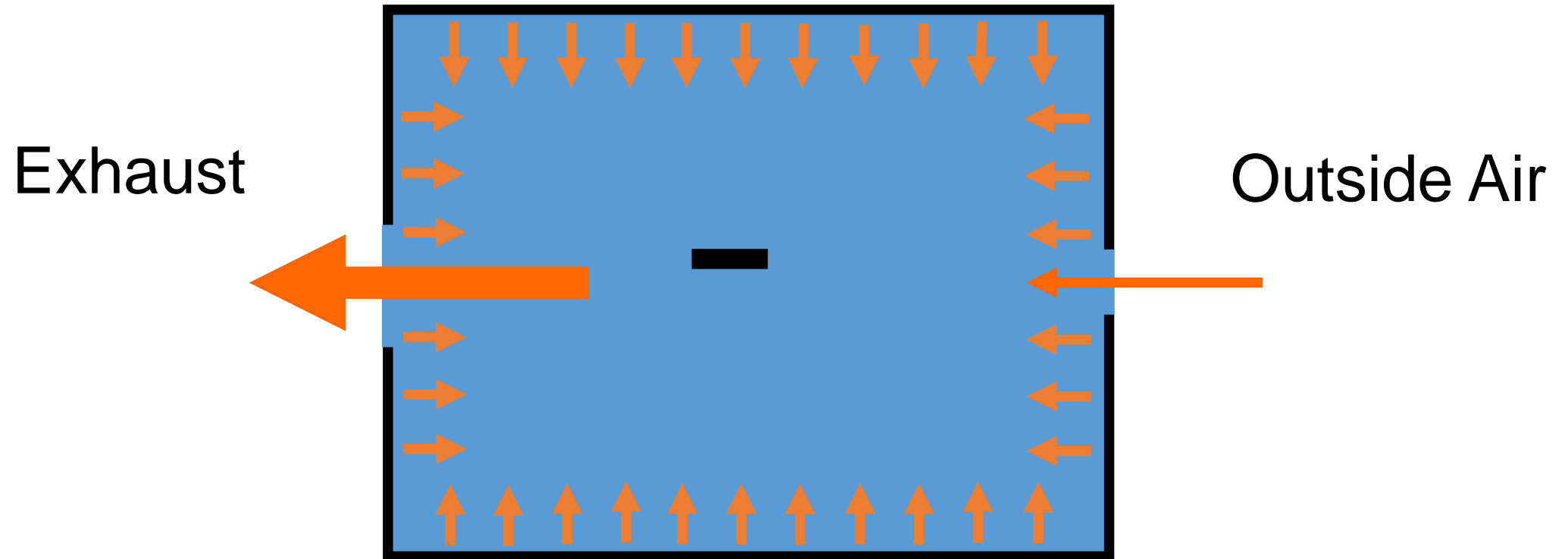


Enclosure Classification	( $G_c p_i$ )
Open Buildings	0.00
Partially Enclosed Buildings	+/- 0.55
Enclosed Buildings	+/- 0.18

Internal Pressures (per ASCE 7)

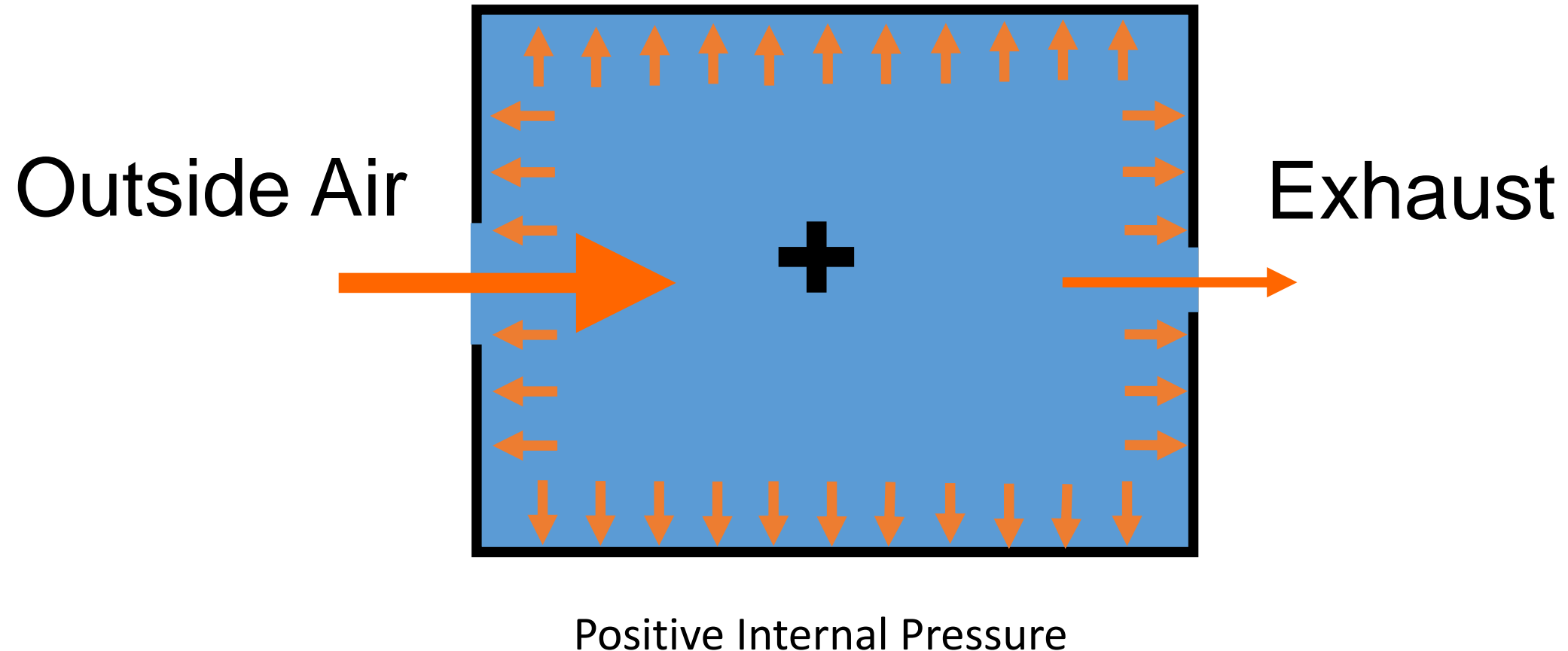
# Air Movement & Barriers

## *Mechanical Pressurization*



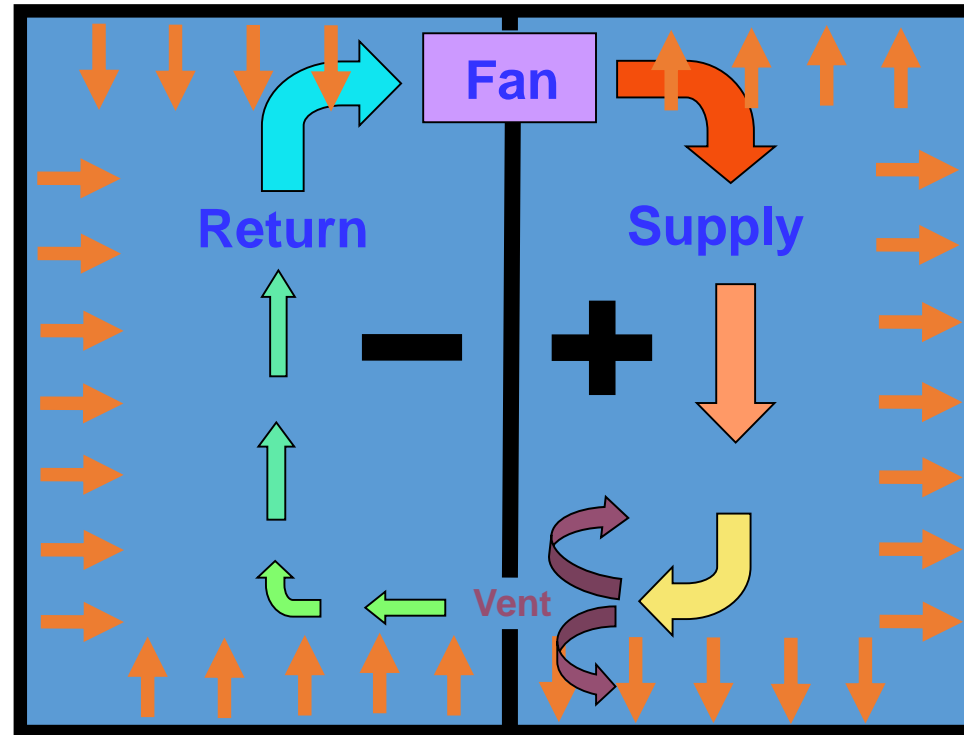
# Air Movement & Barriers

## *Mechanical Pressurization*



# Air Movement & Barriers

## *Mechanical Pressurization*



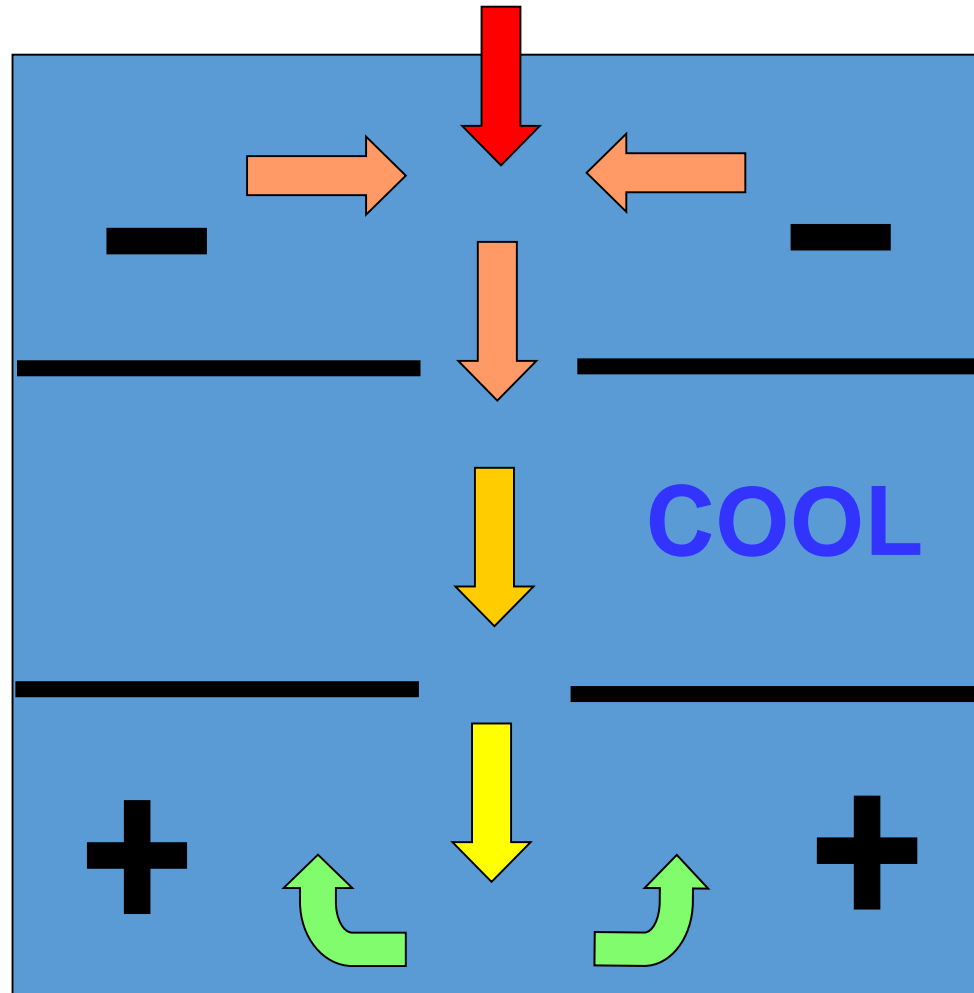
Return Air (Vent Restricts Airflow)



# Air Movement & Barriers

## *Mechanical Pressurization*

Stack Effect



Stack Effect: Hot Climate

## Mechanical Pressurization

The diagram illustrates a warm conveyor belt system. It features a blue background with horizontal black lines representing cloud layers. In the center, a vertical column of arrows shows air rising: a yellow arrow at the bottom, followed by two orange arrows, and a red arrow at the top. To the left, a black plus sign (+) is in the upper blue region, and a black minus sign (-) is in the lower blue region. To the right, a black plus sign (+) is in the upper blue region, and a black minus sign (-) is in the lower blue region. Red curved arrows point from the upper blue regions towards the central rising air column. The word "WARM" is written in large red capital letters in the middle-right section of the diagram.

# COLD

## Stack Effect: Cold Climate



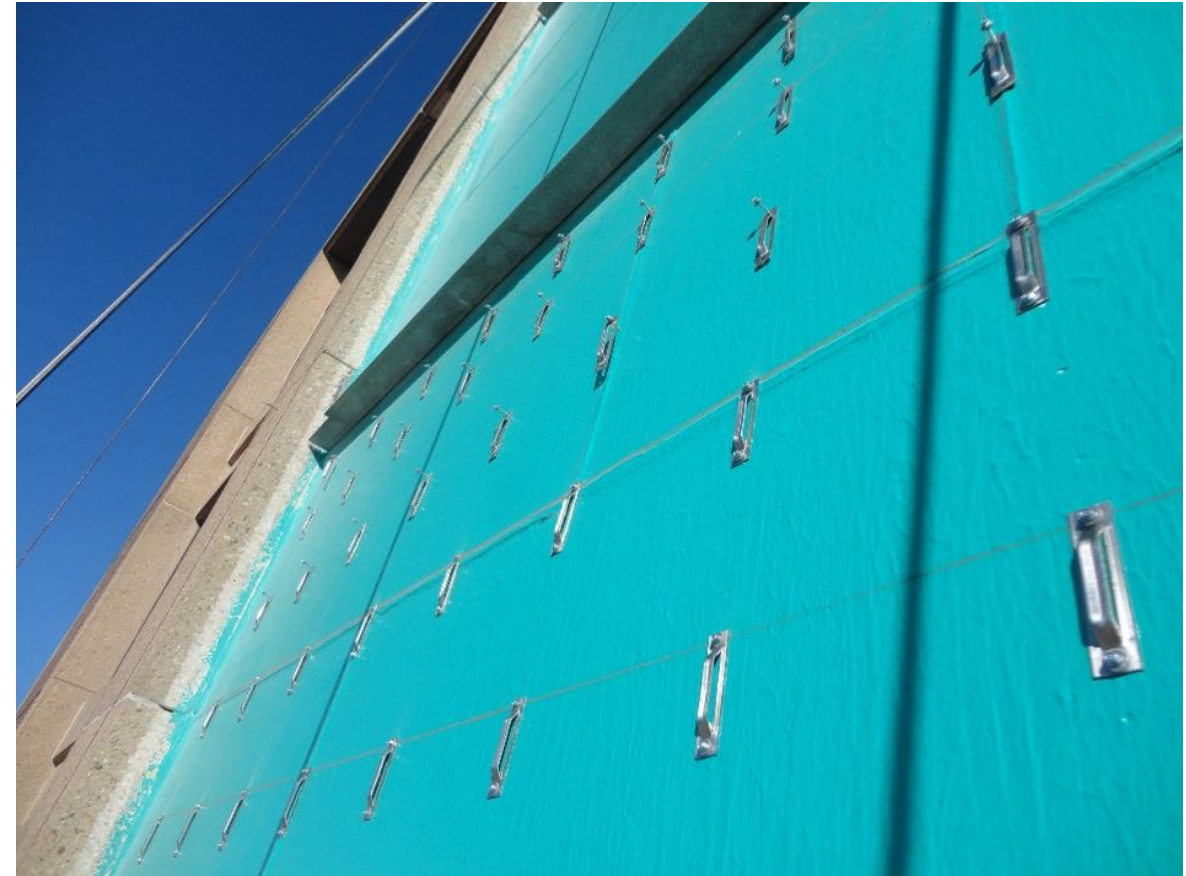
# Air Movement & Barriers

## *Barrier Definition*

### **Air Barrier**

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 IECC*



# Air Movement & Barriers

## *Air Barrier Requirements*

- Continuous across thermal envelope
- Joints & seams sealed. Penetrations caulked, gasketed, or sealed
- Seals & detailing must resist positive and negative pressures
- Penetrations must not affect integrity of air barrier (e.g., recessed light fixtures)

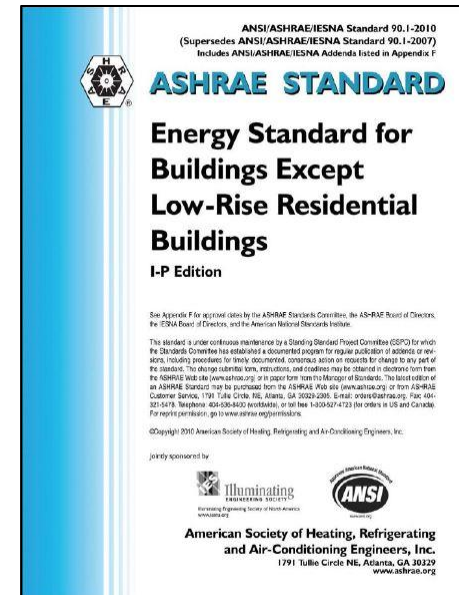
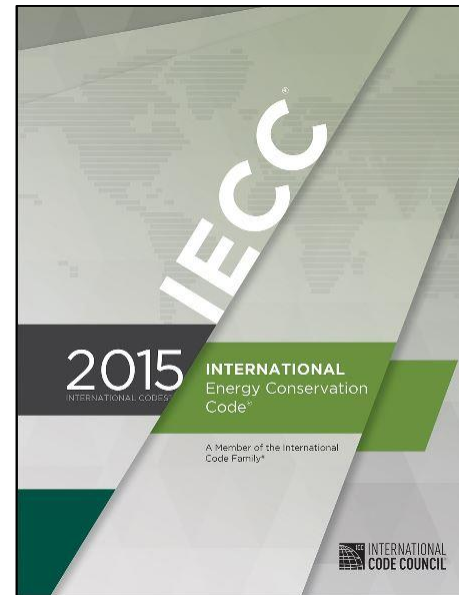
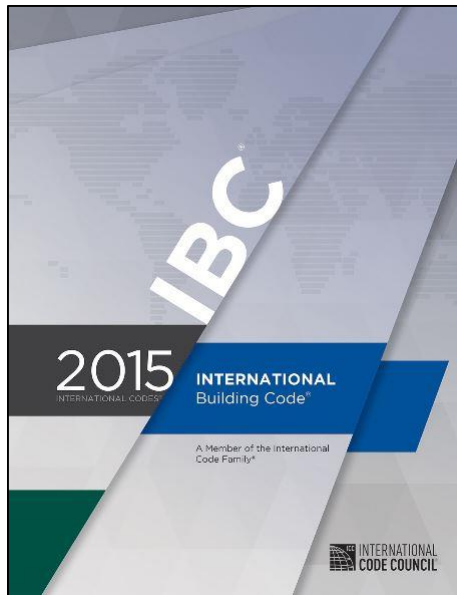




# Air Movement & Barriers

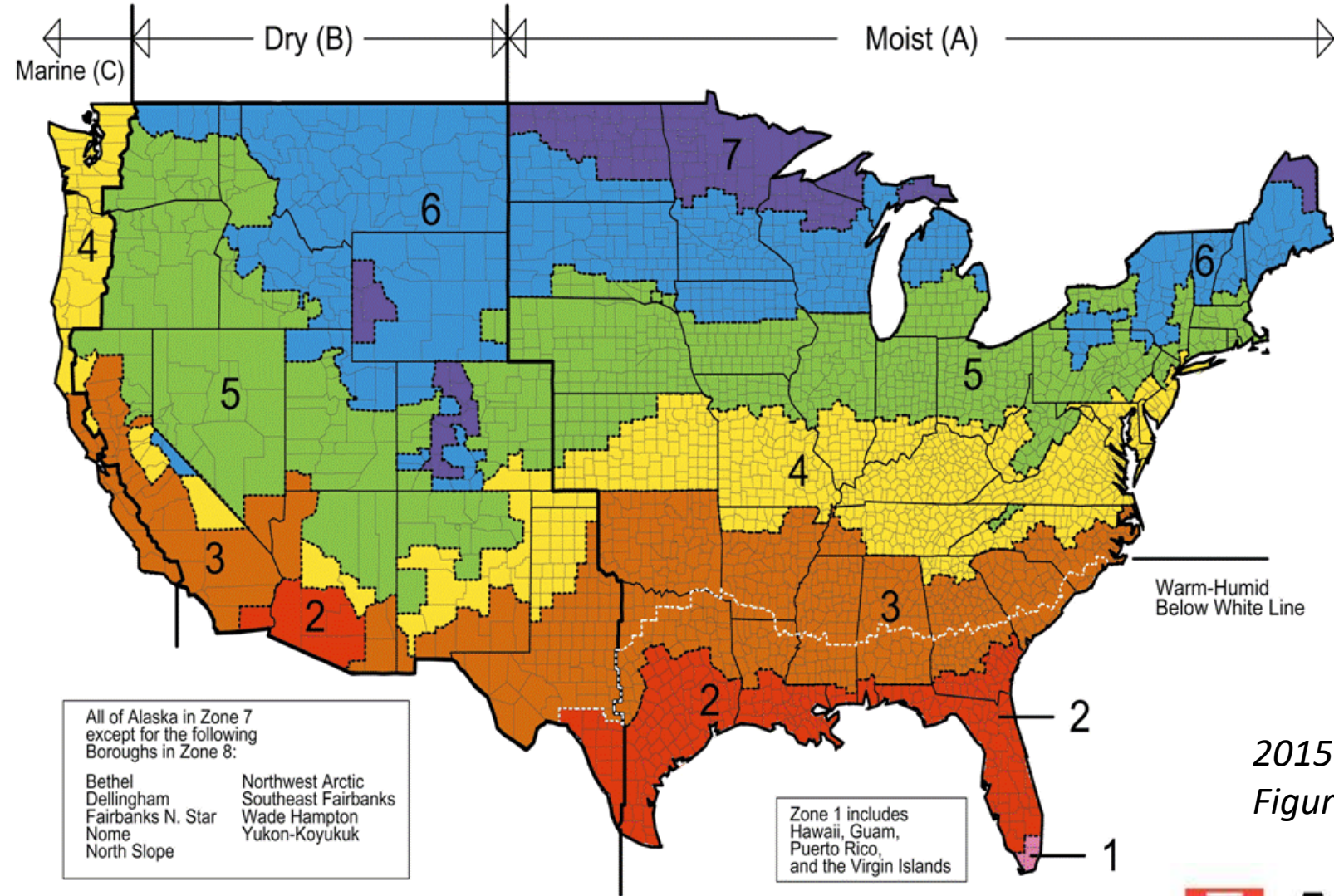
## *Air Barrier: Code Requirements*

- International Building Code
- International Energy Conservation Code
- ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings



# Air Movement & Barriers

## *Air Barrier: Code Requirements*



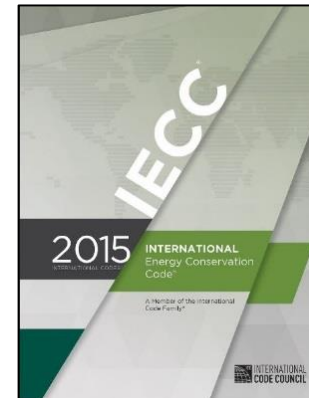
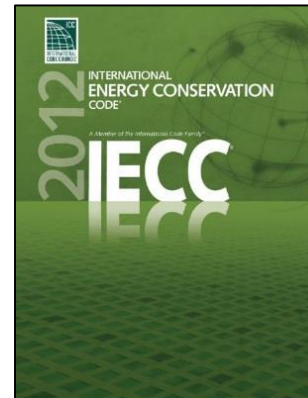
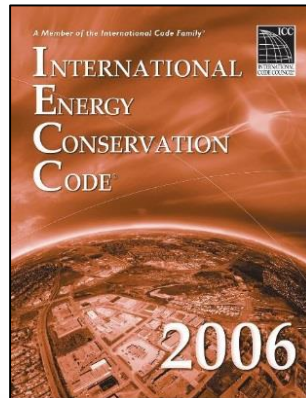
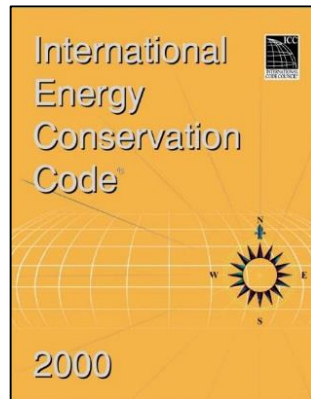
2015 IECC  
Figure C301.1

## Climate Zones

# Air Movement & Barriers

## *Code Requirements – Building Envelope*

- 2000 – Leakage rates for fenestration & openings but no opaque criteria.
- 2006 – Envelope is to be sealed to limit air infiltration.
- 2012 – Continuous air barrier required throughout the building envelope (except Climate Zones 1, 2, and 3).
- 2015 - Continuous air barrier required throughout the building envelope (except Climate Zone 2B)



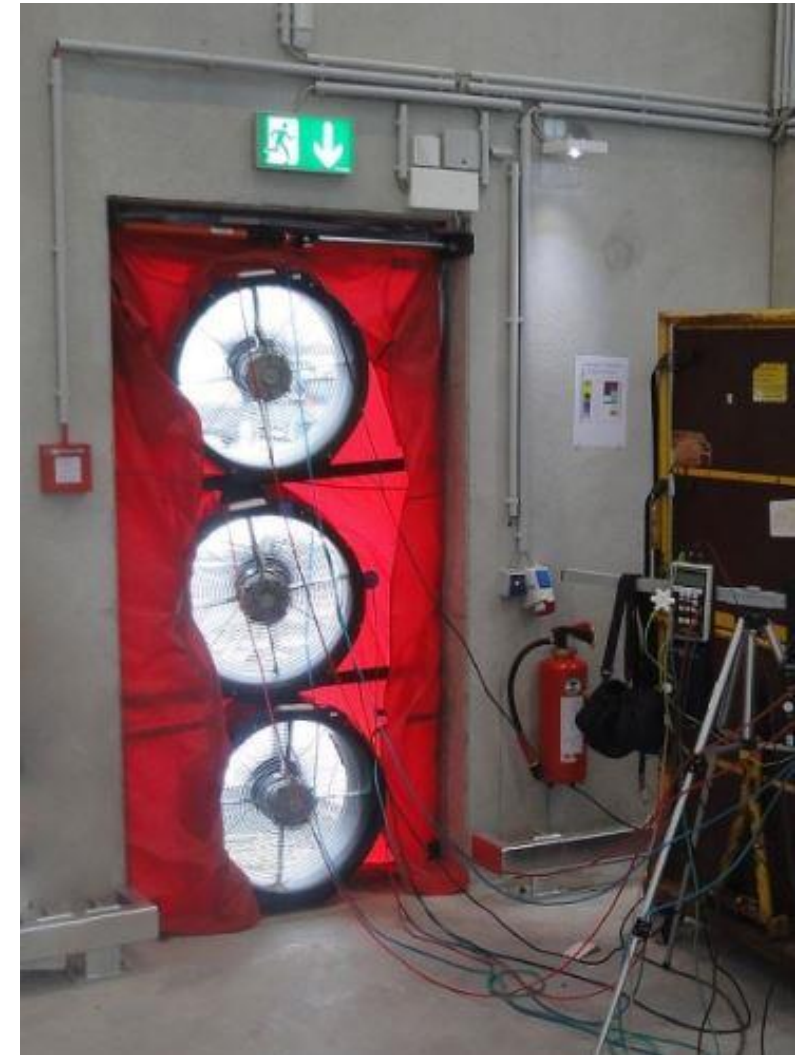


# Air Movement & Barriers

## *Code Requirements – Opaque Envelope*

Allowable air leakage at 0.3 in. w.g. (75 Pa)

- Material:  $< 0.004 \text{ cfm/ft}^2$  ( $0.02 \text{ L/s}\cdot\text{m}^2$ )
- Assembly:  $< 0.04 \text{ cfm/ft}^2$  ( $0.2 \text{ L/s}\cdot\text{m}^2$ )
- Building:  $< 0.4 \text{ cfm/ft}^2$  ( $2.0 \text{ L/s}\cdot\text{m}^2$ )



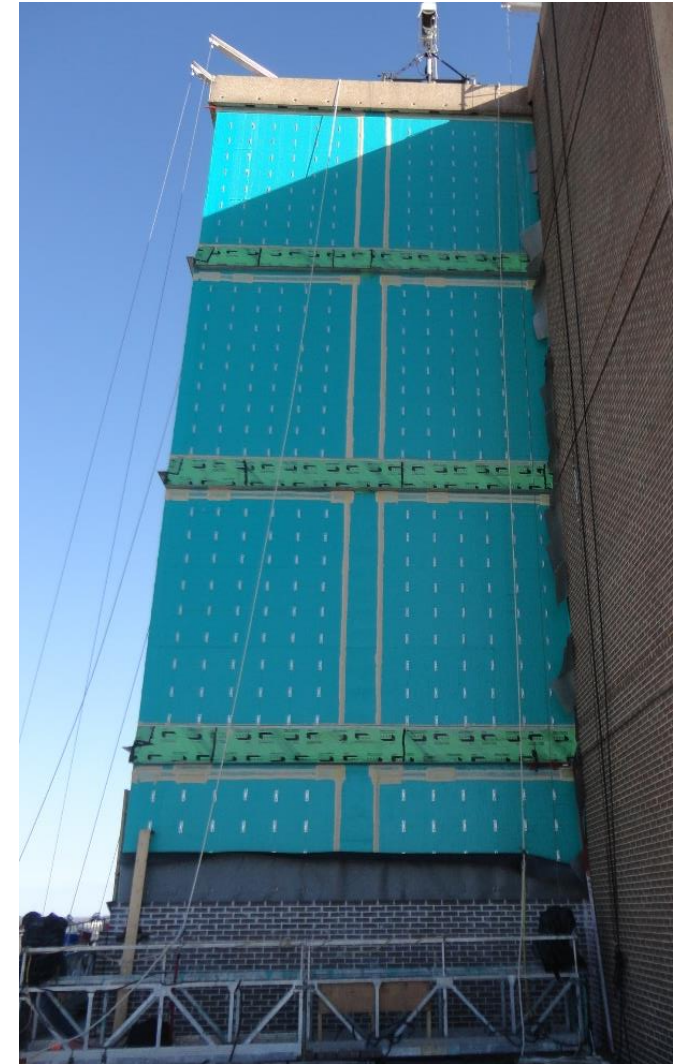
Air Leakage Tests



# Air Movement & Barriers

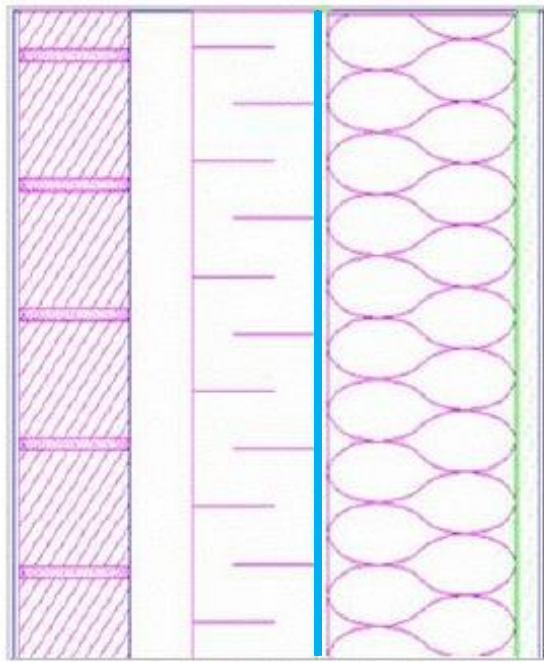
## *Types*

- Air Barrier Options:
  - Vapor permeable
  - Vapor non-permeable
  - Often serves as moisture barrier

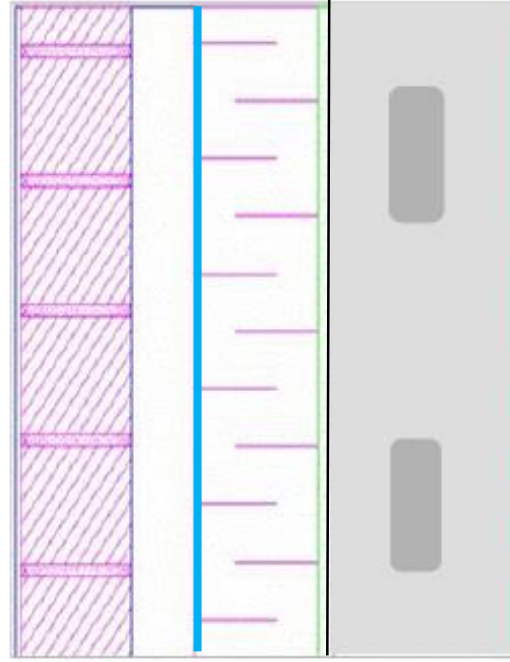


# Air Movement & Barriers

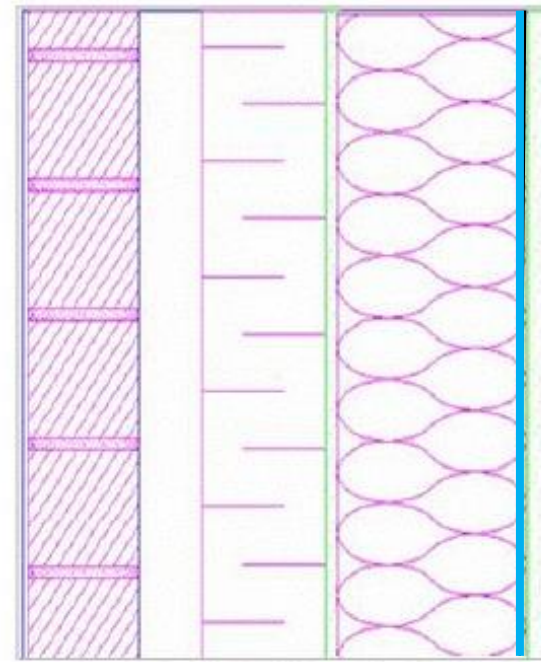
## *Air Barrier Placement*



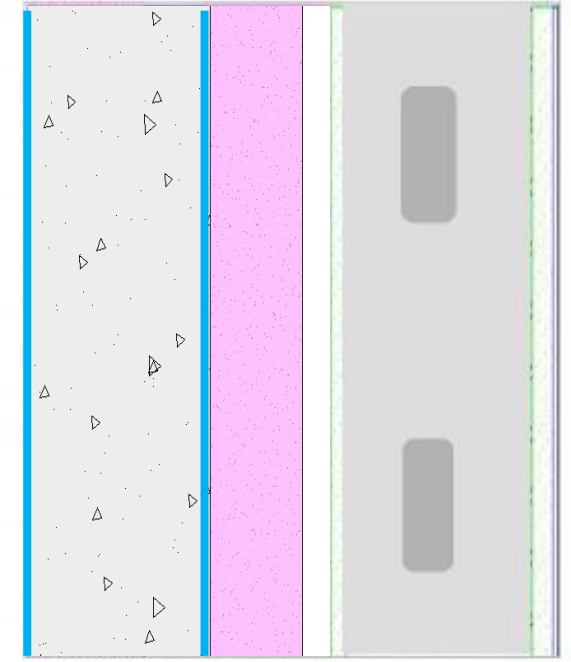
Exterior of sheathing



Insulation in cavity



Sheet on interior of studs



Precast Concrete with  
Spray Foam

# Air Movement & Barriers

## *Air Barrier Types*

- Sheet goods
- Liquid applied
- Self adhering membranes
- Spray foam insulation
- Concrete
- Others\*
  - Metal, Gypsum board, Extruded polystyrene, Foil-backed polyiso, etc.





# Air Movement & Barriers

## *Air Barrier Types*



Sheet Good



# Air Movement & Barriers

## *Air Barrier Types*



Liquid Applied



# Air Movement & Barriers

## *Air Barrier Types*



Self Adhering Membrane



# Air Movement & Barriers

## *Air Barrier Types*



Spray Foam Insulation

# Air Movement & Barriers

## *Air Barrier Types*

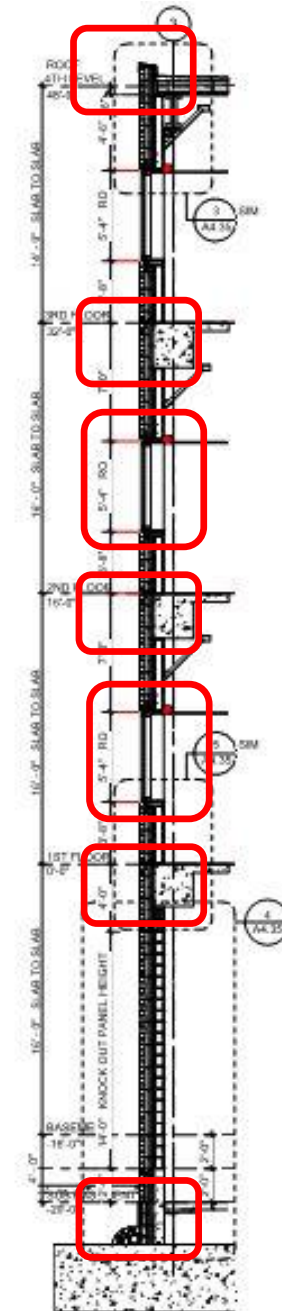


Sealed Insulated Board

# Air Movement & Barriers

## *Air Barrier Detailing Considerations*

- Continuity of system
- Interface detailing
  - Roof/Wall, Fenestration, Floor lines, Shelf Angles, Soffits, Canopies, Base of Wall, Etc.
- Movement considerations
- Material compatibility

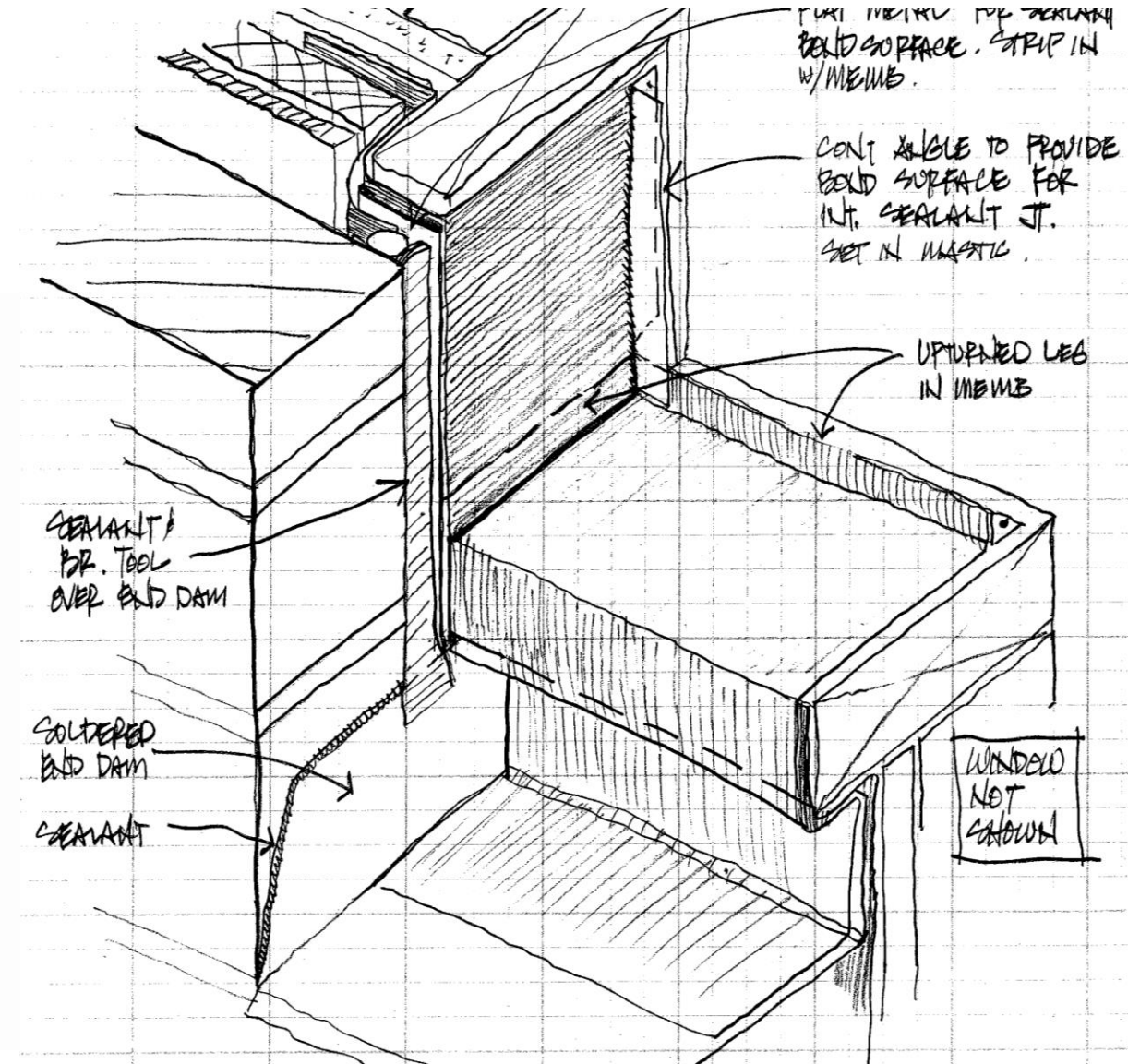
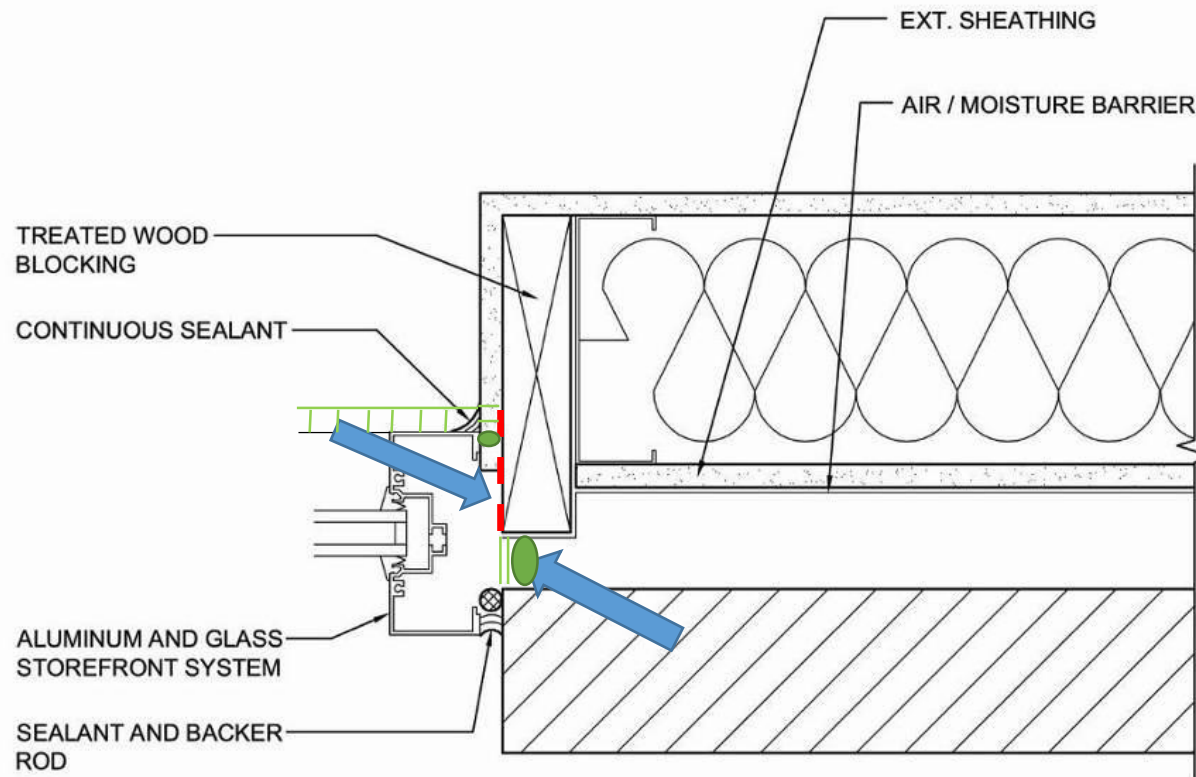




# Air Movement & Barriers

## Air Barrier Detailing Considerations

- Interface detailing
  - Storefront Window System



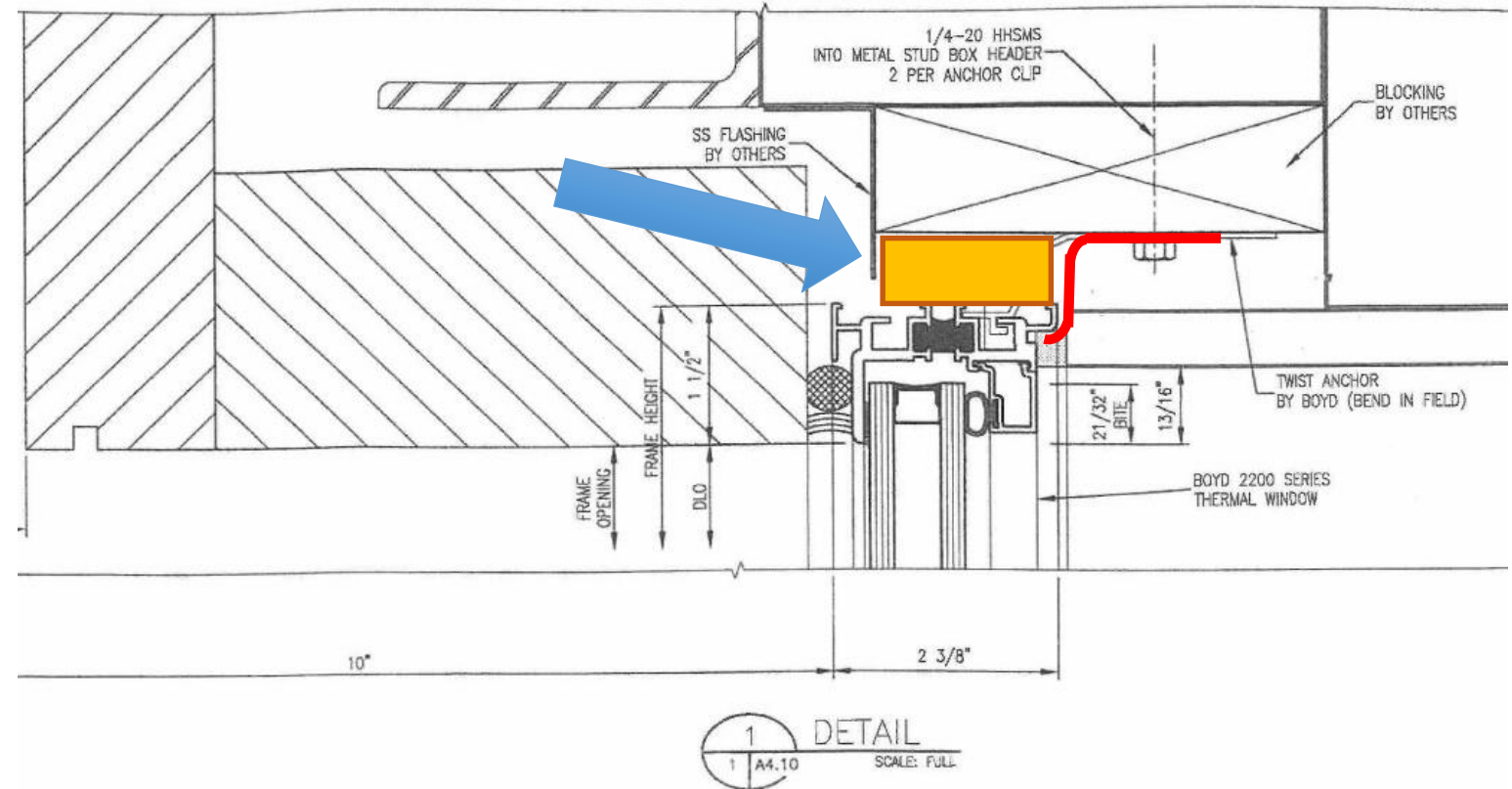




# Air Movement & Barriers

## *Air Barrier Detailing Considerations*

- Continuity / Interface detailing



Fenestration interface detailing



# Air Movement & Barriers

## *Air Barrier Detailing Considerations*

- Continuity / Interface detailing



As-built condition



Thermal barrier repair

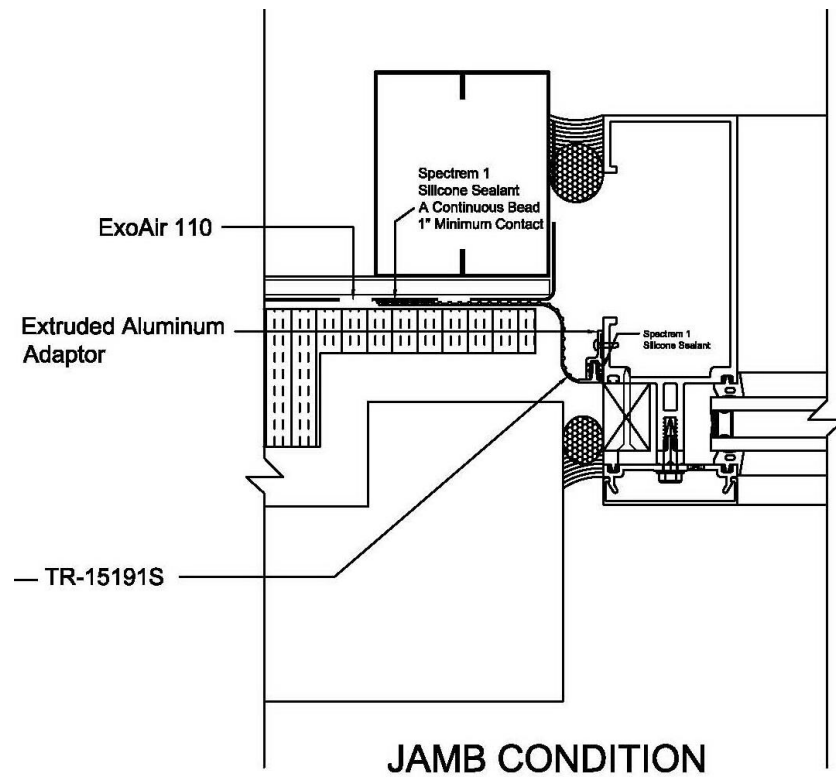


Air barrier repair

# Air Movement & Barriers

## *Air Barrier Detailing Considerations*

- Interface detailing
  - Curtain Wall

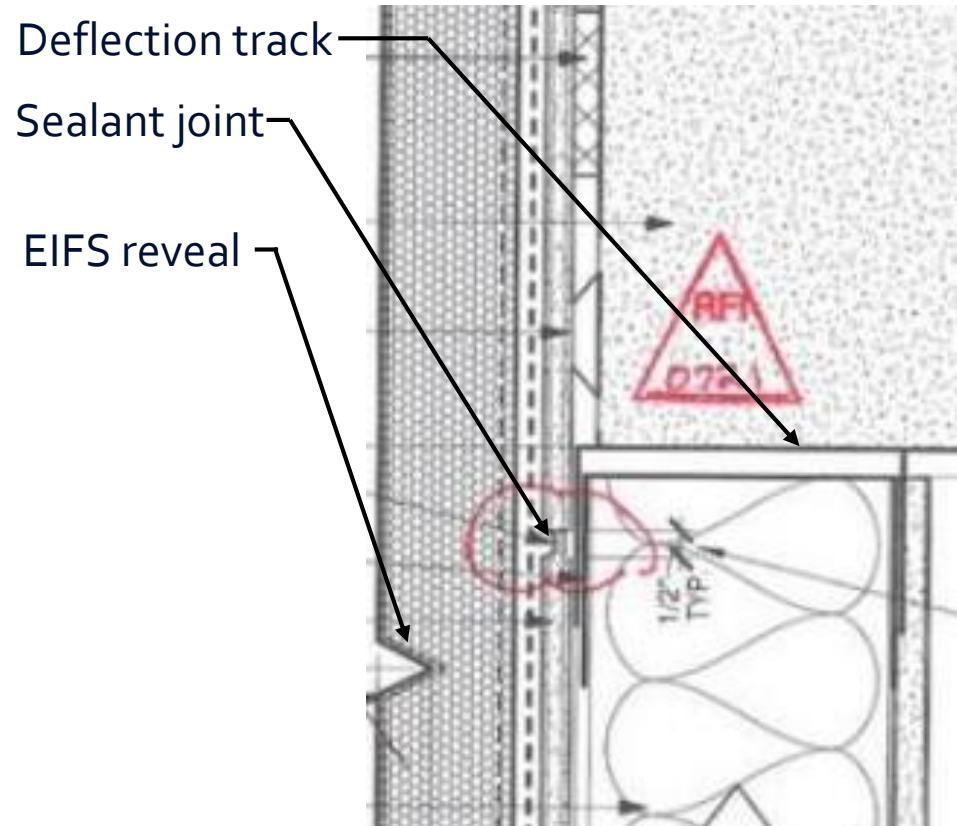




# Air Movement & Barriers

## *Air Barrier Detailing Considerations*

### ■ Movement considerations



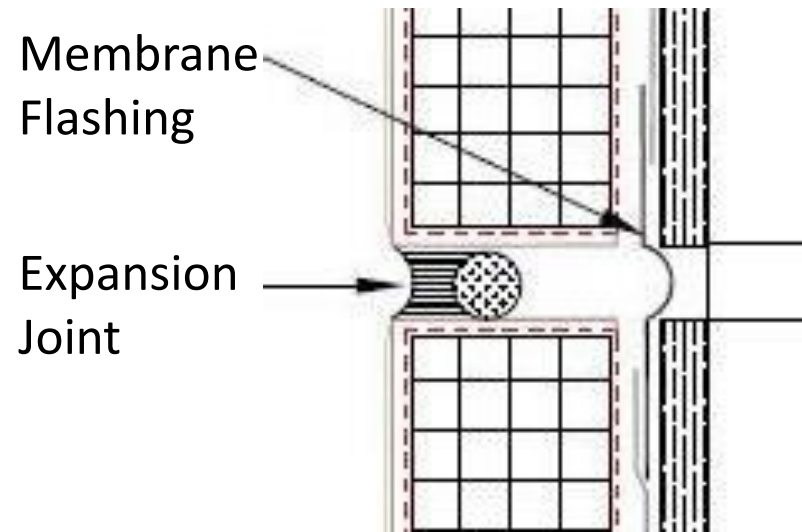
Floorline Detail



# Air Movement & Barriers

## *Air Barrier Detailing Considerations*

- Movement considerations



Membrane Transition



Preformed Silicone Transition

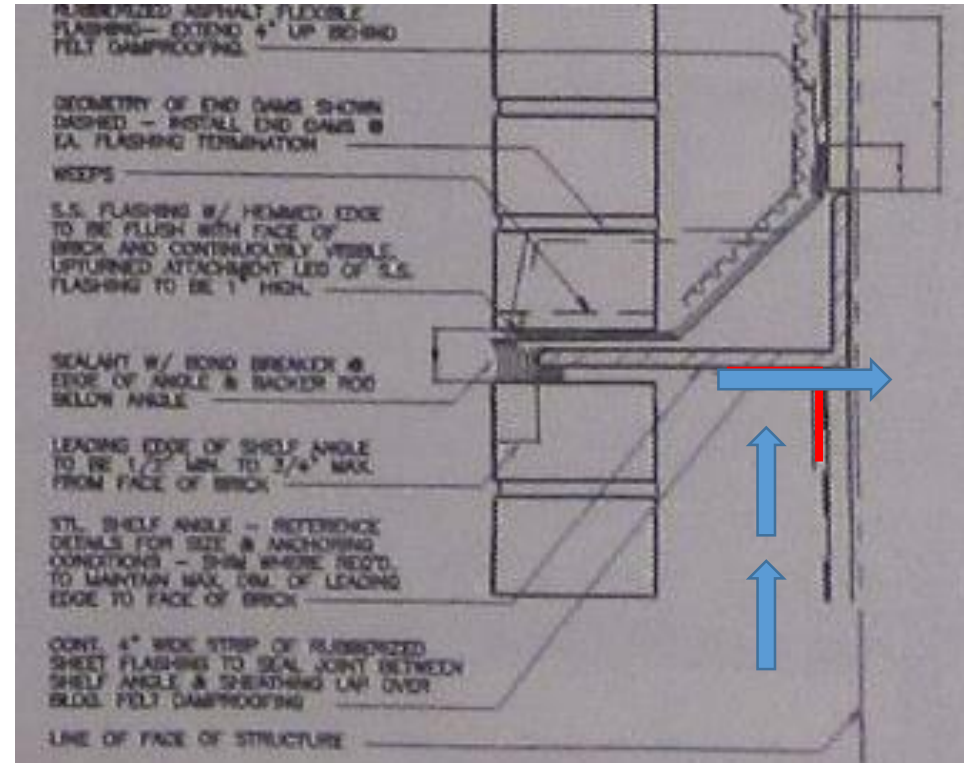
Floorline detailing options



# Air Movement & Barriers

## *Air Barrier Detailing Considerations*

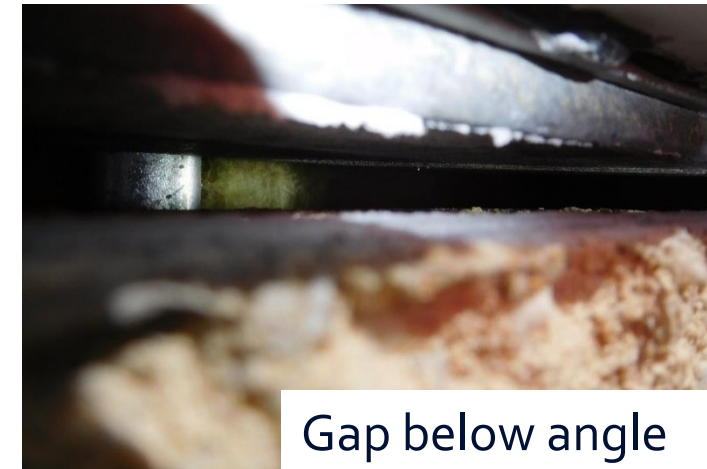
### ■ Continuity



Shelf angle detail



Exposed sheathing



Gap below angle

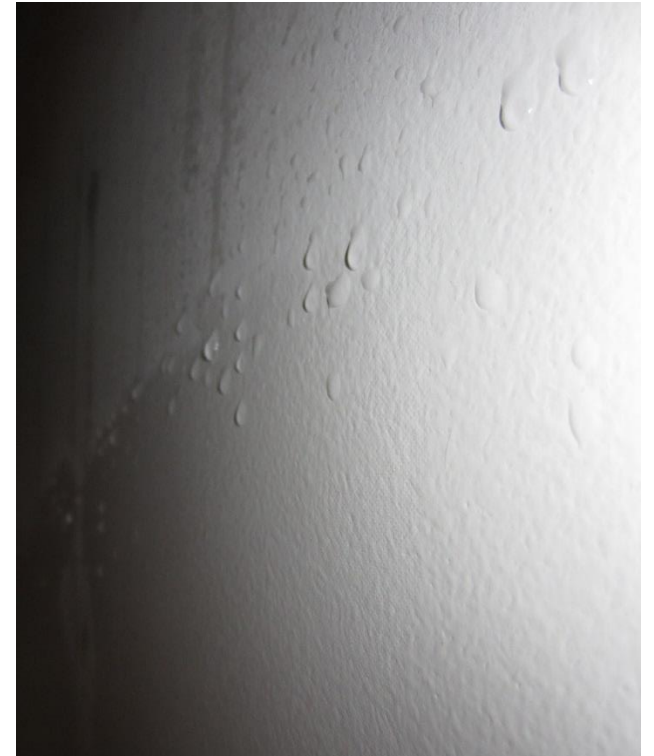




# Air Movement & Barriers

## *Air Barrier Detailing Considerations*

- Continuity at shelf angles



Air Breach in Humid Climate + Negative Pressurization = Interior Summertime Condensation

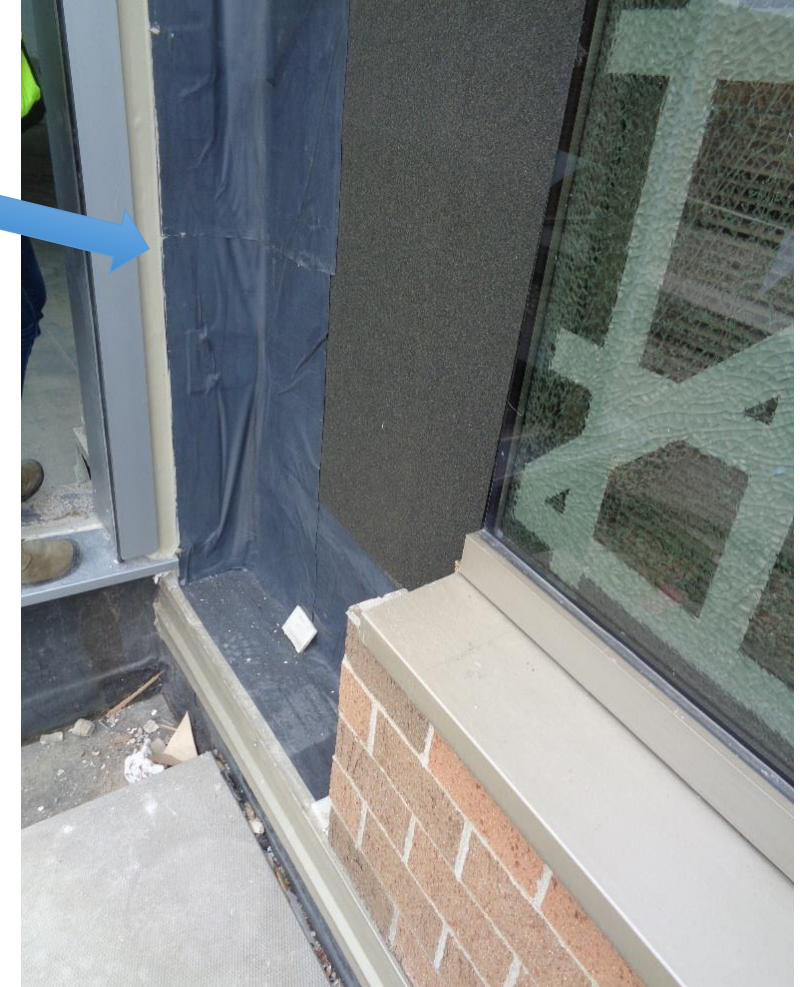
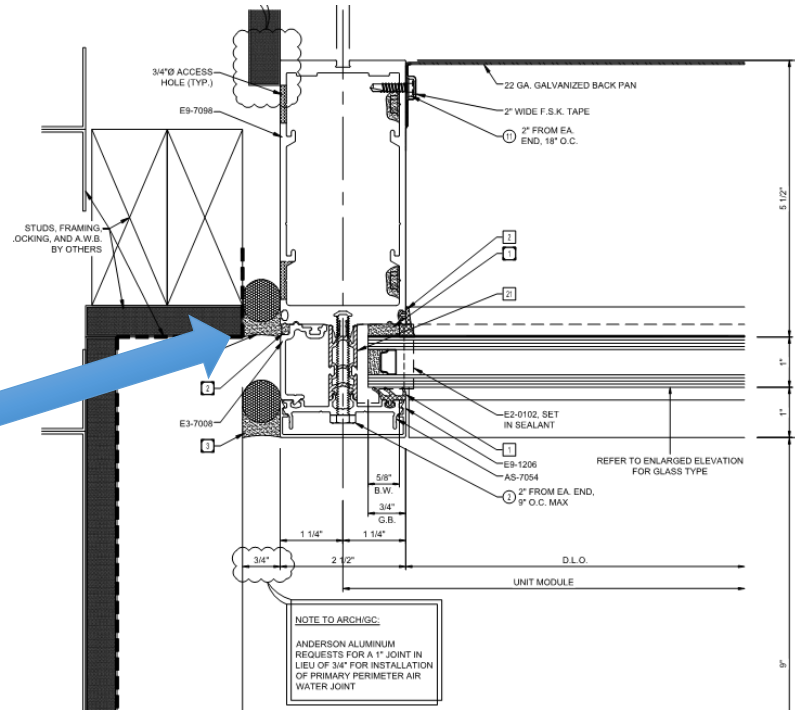
# Air Movement & Barriers

## *Air Barrier Detailing Considerations*

- Material compatibility

### Sealant & Air Barrier Flashing Interface

Most silicones will not bond to polyethylene

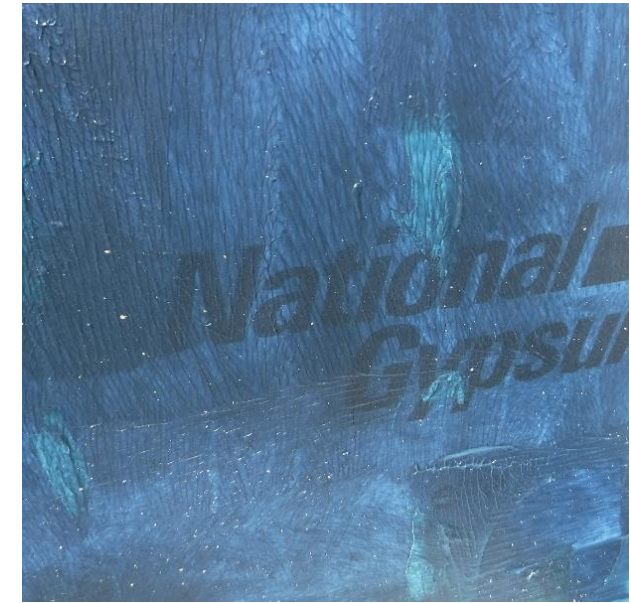
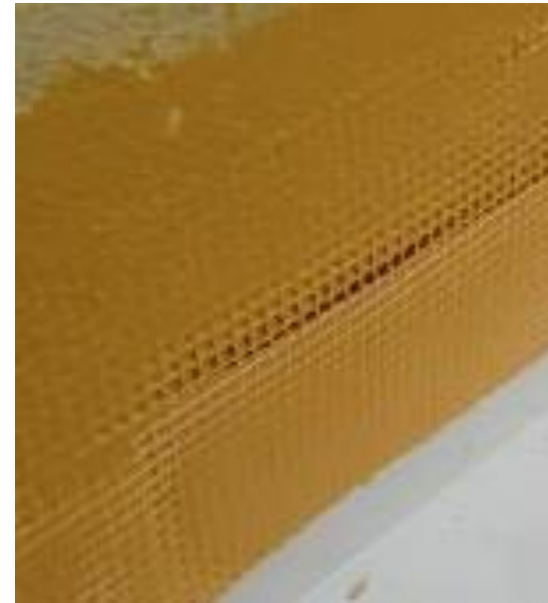




# Air Movement & Barriers

## *Air Barrier Application Issues*

- Gaps/Voids
- Unsealed penetrations
- Extended exposure to UV light
- Thin application
- Temperature restrictions
- Moisture restrictions





# Air Movement & Barriers

## *Air Barrier: QA/QC Testing*

### Air Barrier Testing

- Quantitative
  - Air flow
  - Adhesion
- Qualitative
  - Continuity
  - Interface detailing



# Air Barriers

*Quality Assurance / Quality Control*

## ASTM E783

Quantitative: Air Flow



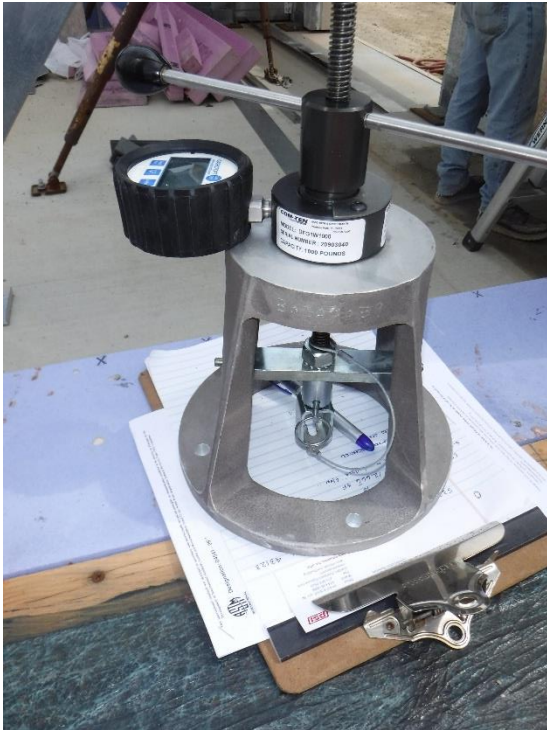


# Air Barriers

*Quality Assurance / Quality Control*

## ASTM D4541

Quantitative: Adhesion



Minimum Pull-Off Strength: 16 psi



# Air Barriers

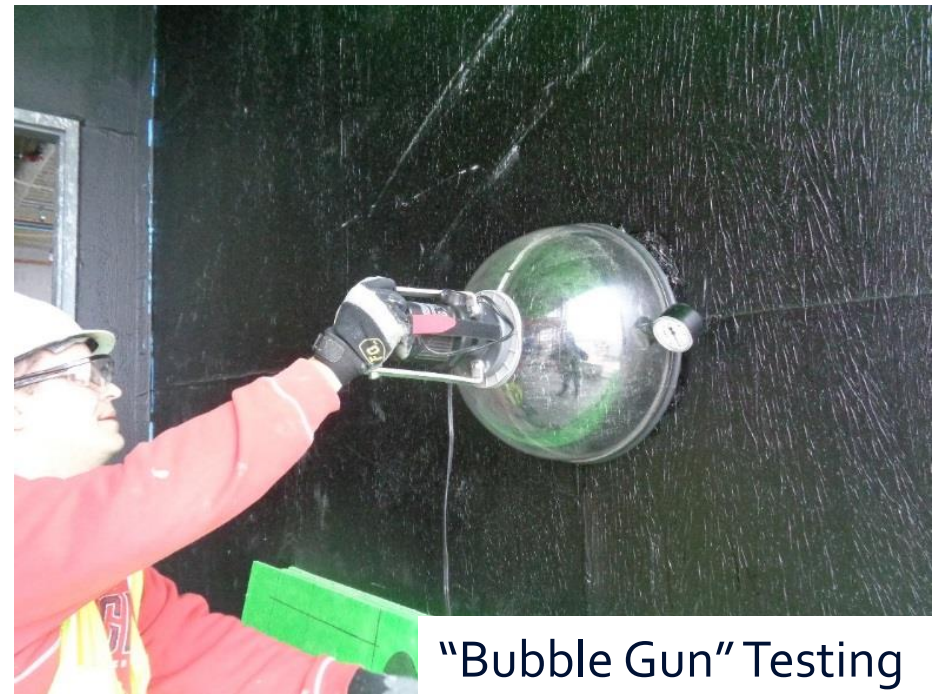
*Quality Assurance / Quality Control*

## ASTM E1186

Qualitative: Continuity

Pressurization/Depressurization  
coupled with:

- Infrared
- Tracer Gas
- Liquid Surfactant



"Bubble Gun" Testing



Tracer Gas

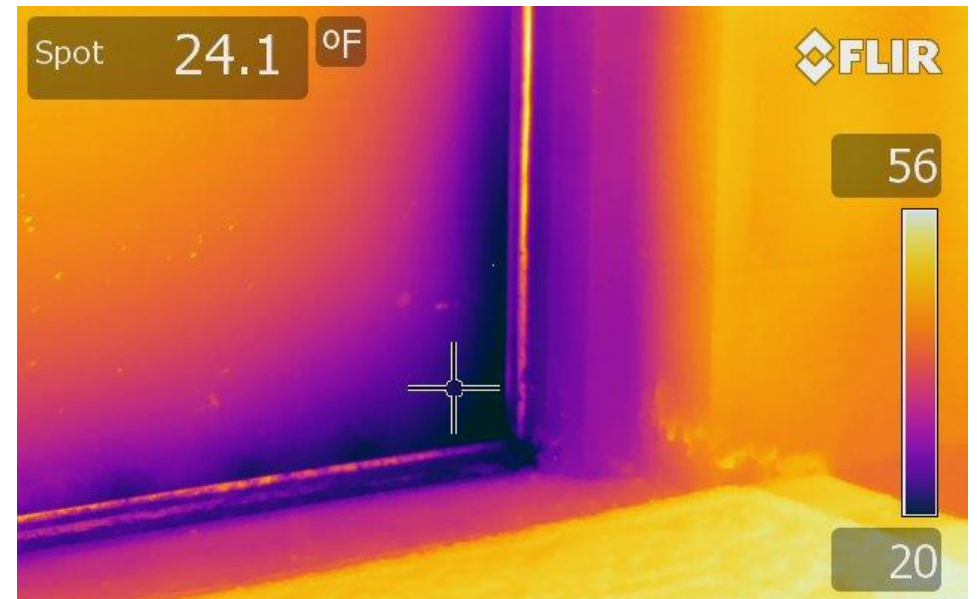
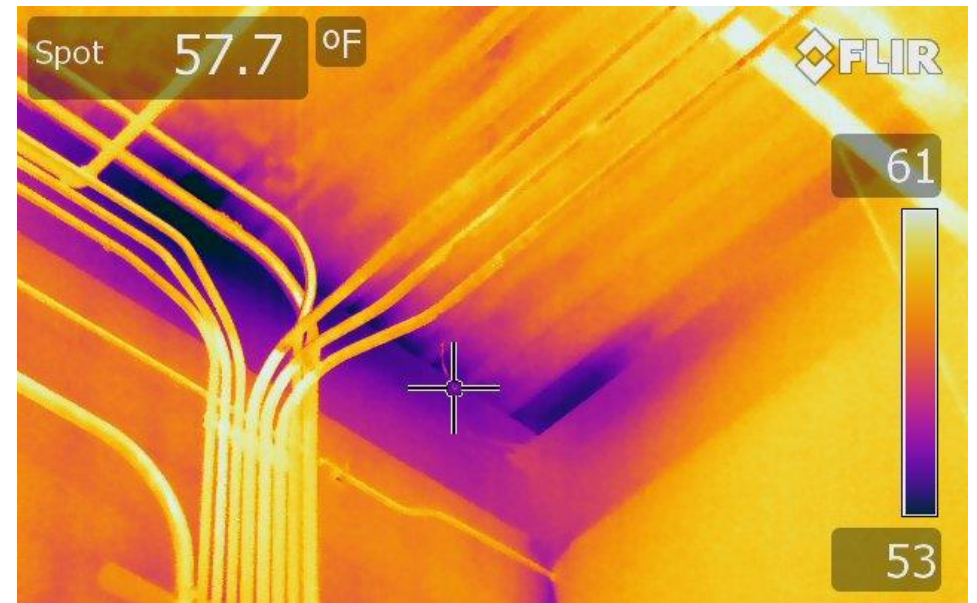


# Air Barriers

*Quality Assurance / Quality Control*

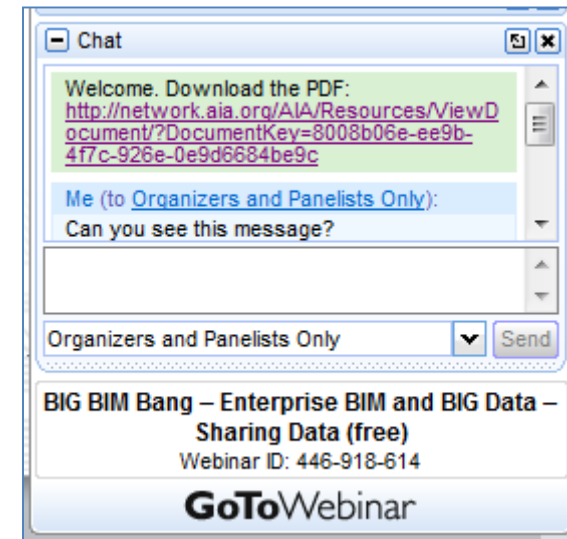
## Infrared Imaging

- Anomalies may represent air breaches or presence of moisture
- Critical factors for proper imaging
  - High temperature gradient
  - Angle of incidence
  - Solar positioning



# Upcoming Break for Questions and Comments

Submit a question to the moderator via the chat box.





# Building Enclosure Fundamentals

*Air Barriers for Health Care Facilities*

## **Additional Considerations**

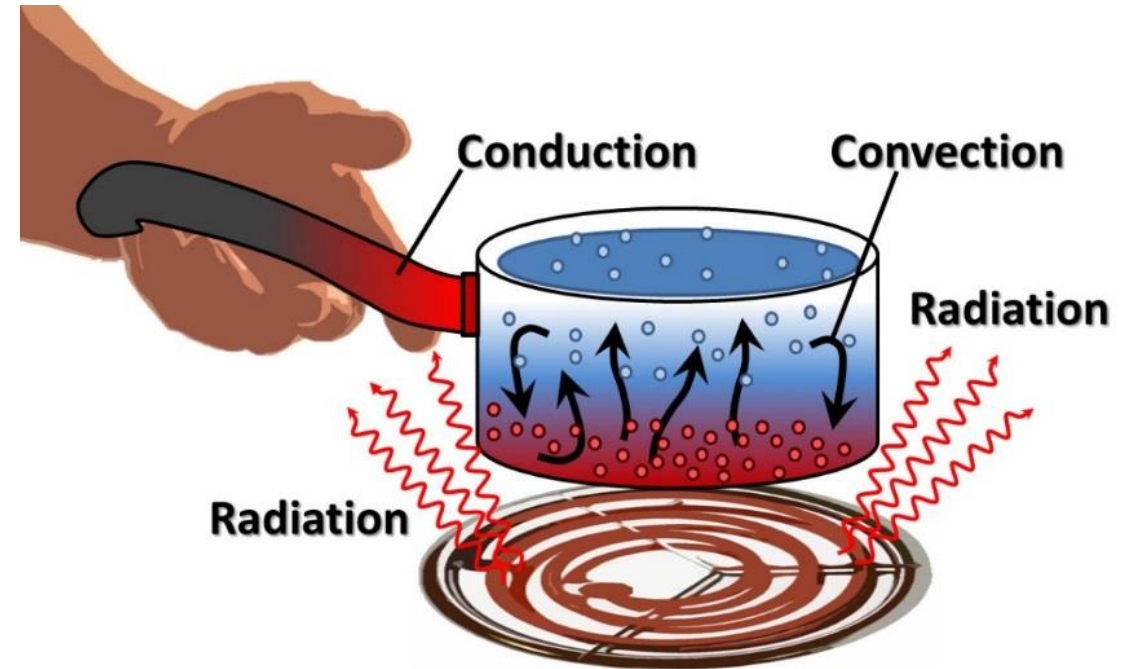
**Thermal, Moisture, & Vapor**

# Additional Considerations

*Thermal, Moisture, & Vapor*

## Heat Energy Movement

- Conduction (heat flow through materials)
- Convection (heat flow through air/fluid currents)
- Radiation (Heat flow through space)



# Additional Considerations

## *Heat Energy Movement*

- Heat energy moves from hot to cold
- Energy movement through the wall or roof system is reduced by insulation (thermal barrier)
  - The higher the R-value, the higher the reduction in heat transfer
  - Thermal bridges can greatly affect the insulation performance

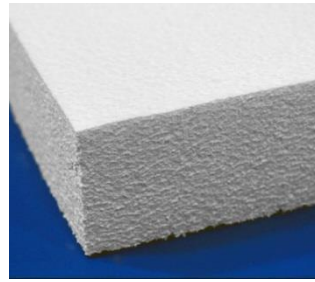




# Additional Considerations

## *Heat Energy Movement: Typical R-Values*

Insulation	R-value per inch
Fiberglass Batt	3.1 to 3.4
Mineral Wool Batt	3.1 to 3.4
Mineral Wool Board	3.1 to 4.3
Expanded Polystyrene (EPS)	3.8 to 4.6
Extruded Polystyrene (XPS)	5.0
Polyisocyanurate	5.6 to 8.0
Open Cell Spray Foam (SPF)	3.5 to 3.6
Closed Cell Spray Foam (SPF)	6 to 6.5



# Additional Considerations

## Heat Energy Movement: Code Requirements

TABLE C402.2  
OPAQUE THERMAL ENVELOPE REQUIREMENTS<sup>a</sup>

CLIMATE ZONE	1		EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Roofs												
	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci	R-35ci	R-35ci
	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Insulation entirely above deck	R-20ci	R-20ci	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-49	R-49
Walls, Above Grade												
	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci	R-25ci
	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-19.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-19.5ci
Metal buildings (with R-5 thermal blocks) <sup>a, b</sup>	R-19 + R-11 LS	R-19 + R-11 LS	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-17.5ci
	R-13 + -3.8ci or R-20	R-13 + -3.8ci or R-20	R-13 + -3.8ci or R-20	R-13 + -3.8ci or R-20	R-13 + -3.8ci or R-20	R-13 + -3.8ci or R-20	R-13 + -3.8ci or R-20	R-13 + -3.8ci or R-20	R-13 + -3.8ci or R-20	R-13 + -3.8ci or R-20	R-13 + -3.8ci or R-20	R-13 + -3.8ci or R-20
Attic and other	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-49	R-49
Walls, Below Grade												
	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-10ci	R-10ci	R-10ci	R-10ci	R-12.5ci	R-12.5ci
Floors												
	R-10ci	R-10.4ci	R-10ci	R-12.5ci	R-12.5ci	R-12.5ci	R-15ci	R-16.7ci	R-15ci	R-16.7ci	R-15ci	R-16.7ci
Mass	R-5.7ci	R-5.7ci	R-30	R-30	R-30	R-30	R-30 <sup>c</sup>	R-30 <sup>c</sup>	R-30 <sup>c</sup>	R-30 <sup>c</sup>	R-30 <sup>c</sup>	R-30 <sup>c</sup>
Slab-on-Grade Floors												
	R-10 for 1" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-10 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 24" below	R-15 for 24" below	R-20 for 24" below	R-20 for 24" below
Metal building	R-13 + R-6.5ci	R-13 + R-6.5ci	R-15 for 24" below	R-15 for 24" below	R-15 for 36" below	R-15 for 36" below	R-15 for 36" below	R-20 for 48" below	R-20 for 24" below	R-20 for 48" below	R-20 for 48" below	R-20 for 48" below
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-15 for 24" below	R-15 for 24" below	R-15 for 36" below	R-15 for 36" below	R-15 for 36" below	R-20 for 48" below	R-20 for 24" below	R-20 for 48" below	R-20 for 48" below	R-20 for 48" below
Opaque Doors												
	U-0.61	U-0.61	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37
	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75

# Additional Considerations

## *Heat Energy Movement: Code Requirements*

### Metal Framed Wall Requirements

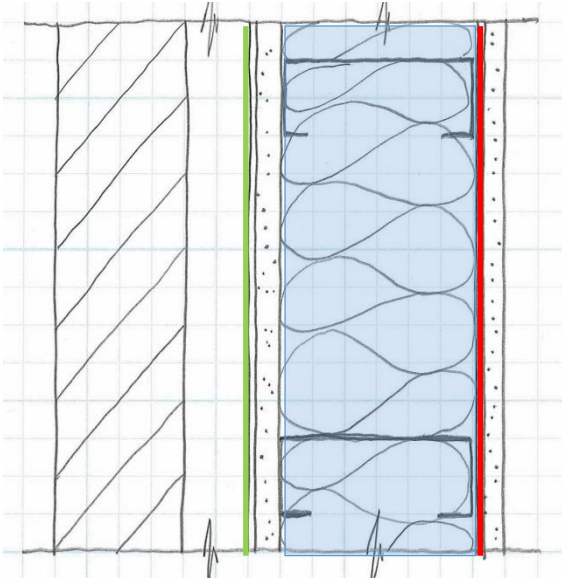
IECC Commercial Requirements:						
Minimum R-Value for Metal Framed Walls						
Climate Zone	2000	2003	2006	2009	2012	2015
1	R-0	R-0	R-13	R-13	R-13 + R-5ci	R-13 + R-5ci
2	R-11	R-11	R-13	R-13	R-13 + R-5ci	R-13 + R-5ci
3	R-11	R-11	R-13	R-13 + R-3.8ci	R-13 + R-7.5ci	R-13 + R-7.5ci
4	R-11	R-11	R-13	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci
5	R-11	R-11	R-13 + R-3.8ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci
6	R-11	R-11	R-13 + R-3.8ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci
7	R-13	R-13	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci
8	R-13	R-13	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci

ci = continuous insulation

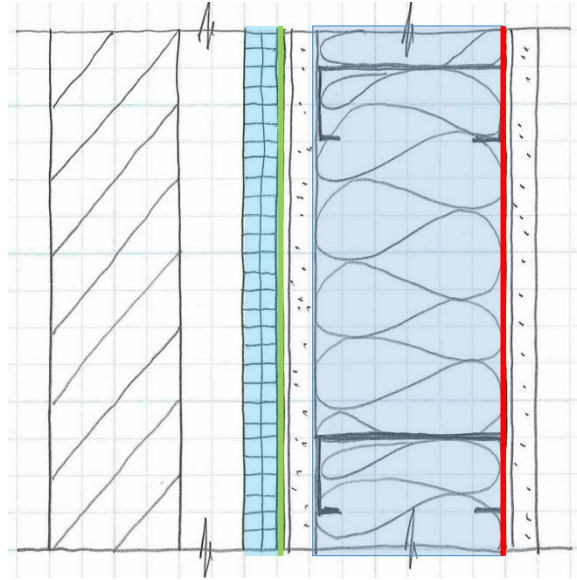


# Enclosure Design

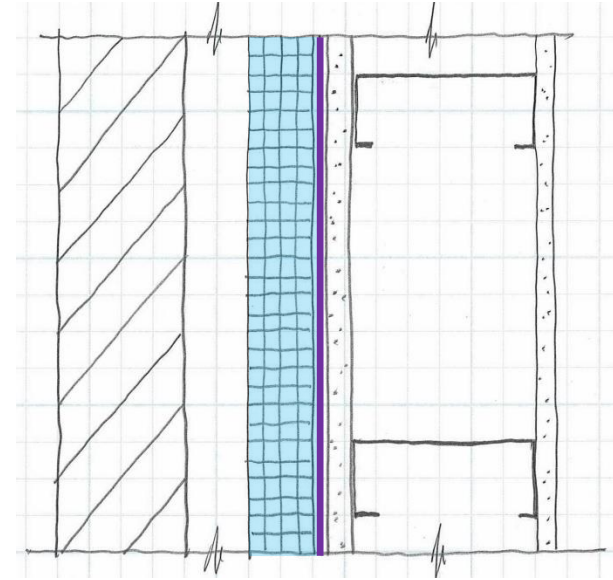
## *Heat Energy Movement: Insulation Options*



Insulation  
in Stud Space



Hybrid System



Insulation  
in Cavity

# Enclosure Design

## *Heat Energy Movement: Insulation Efficiency*

### Stud Cavity Batt Insulation

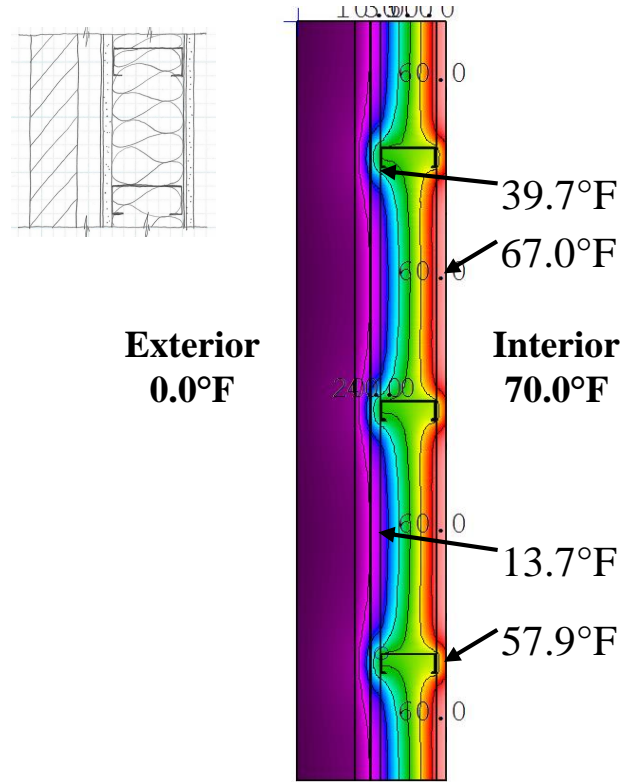
Stud Cavity Depth (in.)	Stud Spacing (in.)	Rated R-Value	Effective R-Value
3.5	16	R-11	R-5.5
3.5	16	R-13	R-6.0
3.5	16	R-15	R-6.4
6.0	16	R-19	R-7.1
6.0	16	R-21	R-7.4
3.5	24	R-11	R-6.6
3.5	24	R-13	R-7.2
3.5	24	R-15	R-7.8
6.0	24	R-19	R-8.6
6.0	24	R-21	R-9.0

ASHRAE 90.1 - Table A3.3

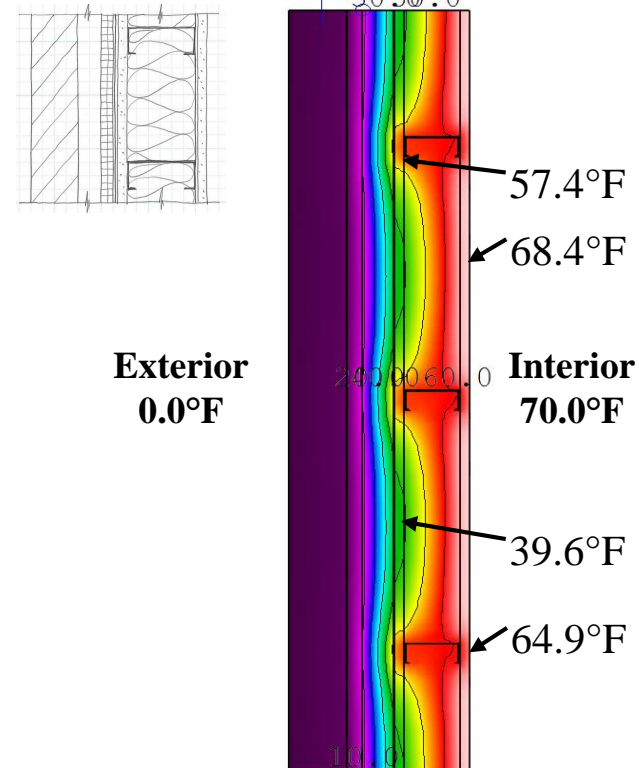
Only 35% effective

# Additional Considerations

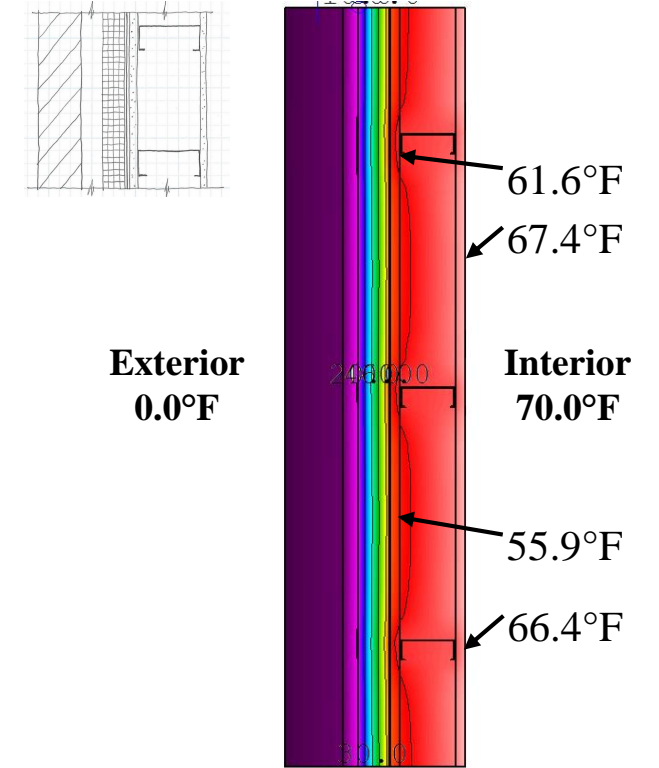
## *Heat Energy Movement: Affects of Insulation Placement*



Insulation in stud space



Hybrid



Continuous insulation



# Additional Considerations

## Condensation

### Condensation

*Change in phase from vapor to a liquid. Surface condensation occurs when water vapor contacts a non-porous surface that has a temperature lower than the dew point of the surrounding air.*

*- ASHRAE Fundamentals*

### Dew Point

*A measure of atmospheric moisture. The temperature to which the air must be cooled in order to reach saturation (assuming air pressure and moisture are constant).*

*- NOAA*



# Additional Considerations

## *Condensation*



Concrete Column with Steel Embed



Sweating on Back Side of Steel Studs



# Additional Considerations

## *Condensation*

### **Factors Affecting Condensation**

- Temperature & Relative Humidity
- Insulation Type & Placement
- Thermal Bridging
- Air Barrier Continuity
- Building Pressurization
- Vapor Retarder Placement / Type
- Interior Layout / Barriers





# Additional Considerations

*Condensation: High RH Spaces & Negative Pressurization*



- Laboratories
- Healthcare Facilities
- Natatoriums



# Additional Considerations

## *Moisture Sources*

- Moisture penetrates the envelope by:
  1. Water leakage
  2. Air infiltration
  3. Vapor diffusion



# Additional Considerations

## *Vapor Diffusion*

A measure of a material or assembly's ability to limit the amount of moisture that passes through that material or assembly

Plastic extrusion



Class I:  $\leq 0.1$  perm

Foil scrim kraft paper



Class II:  $> 0.1$  perm  
 $\leq 1.0$

Spray foam insulation\*



Class III:  $> 1.0$  perm  
 $\leq 10$  perm



# Additional Considerations

## *Vapor Diffusion*

- Very slow process (less than airflow)
- Vapor retarders control diffusion
  - Can be combined with air barrier and/or moisture barrier
  - Should be located on the “warm” side of the wall
  - Only one vapor retarder per wall assembly



# Additional Considerations

## *Vapor Diffusion*

### Common Vapor Retarders:

- Polyethylene film
- Fluid-applied vapor retarder
- Self-adhering sheet membranes
- Aluminum foil/FSK
- “Smart” vapor retarders

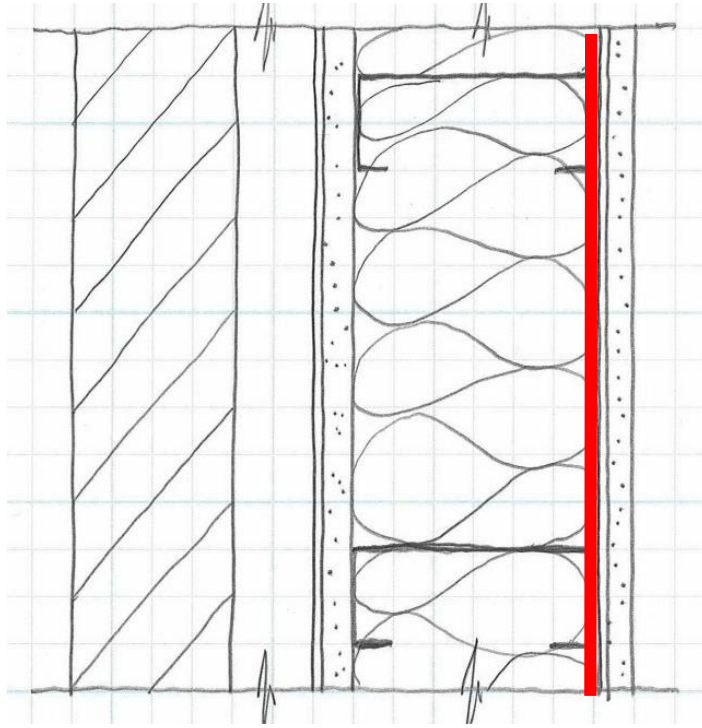
### Other Materials that Serve as Vapor Retarders

- Oil and epoxy based paints
- Polystyrene board insulation (XPS)
- Vinyl wall coverings
- Sheet metal & glass

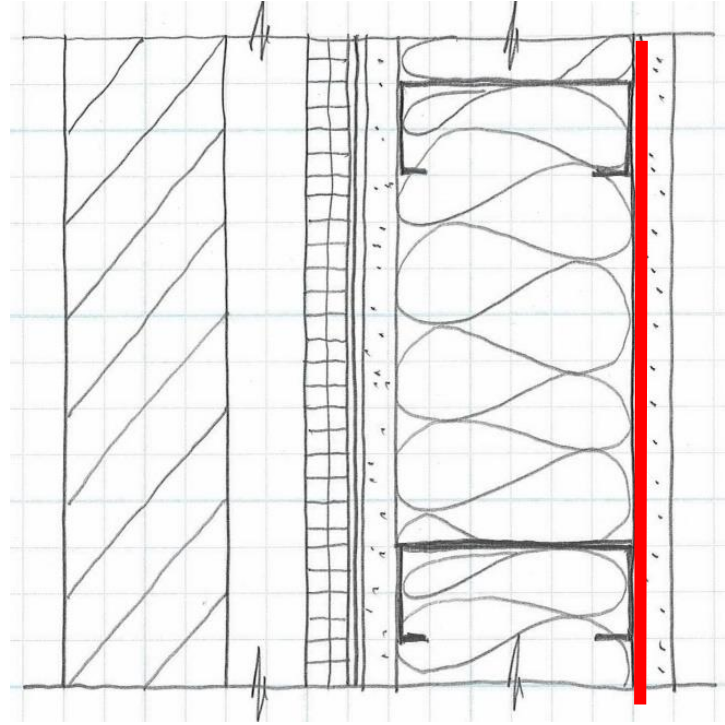


# Additional Considerations

## *Vapor Retarder Placement*

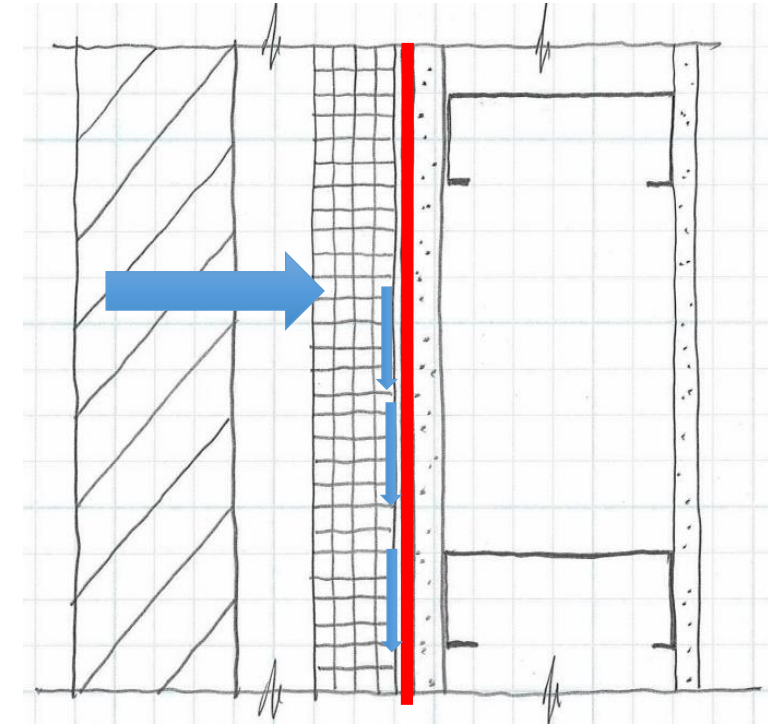


Insulation  
in Stud Space



Hybrid System

“Cold” Climate



Insulation  
in Cavity

“Hot” or “Cold” Climate



# Additional Considerations

## *Vapor Diffusion Issues: Hot Climate*



- Warm/humid climate
- “Smart” vapor retarder
- Perforated vinyl wall covering

*“The product is not suited for cooling climates with high outdoor humidities... Do not use with vinyl wall coverings or vapor retarding paints”*

*- Manufacturer’s Literature*

# Additional Considerations

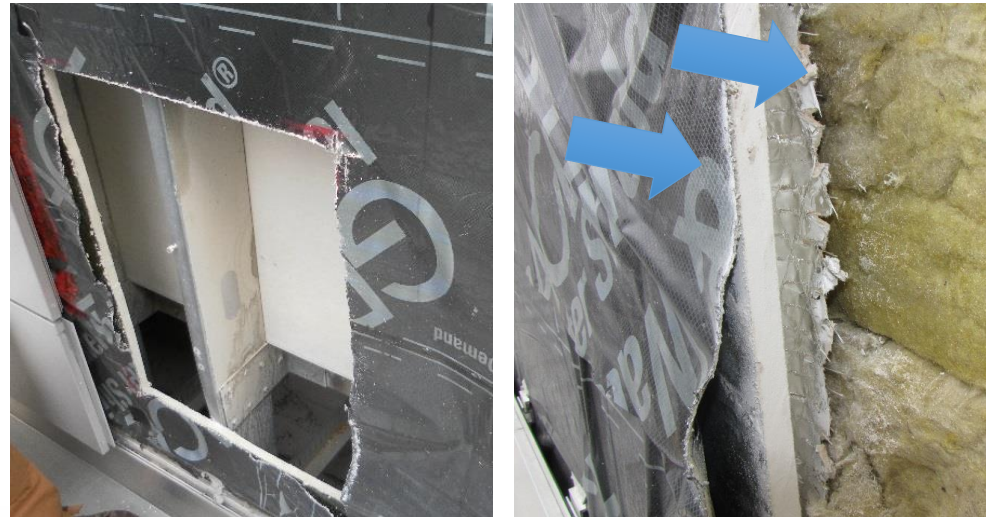
## *Vapor Diffusion Issues: Cold Climate*



Vapor retarder on cold side of insulation



Condensation on sheathing





# Building Enclosure Fundamentals

## *Summary*

- Air barriers serve to reduce energy consumption and help mitigate moisture issues with the building envelope
- Continuity, integration, and compatibility are key to air barrier design, installation, and performance
- Performance of healthcare building enclosures are dependent on the performance of not only the air barrier, but also moisture barrier, thermal barrier, and vapor retarder
- Thermal barrier code changes as well as interior design conditions make healthcare facilities especially susceptible to increased risk of condensation



# Time for Questions and Comments



**Moderator**  
**John Kreidich**  
McCarthy Building Cos.

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