Maximizing Building Envelope Energy Performance and Resilience

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Mason&Hanger®
A Day&Zimmermann Company

Army Reserve Center, Omaha, NE

May 29, 2026


https://corksoluk.com/


https://sfwconstruction.com/

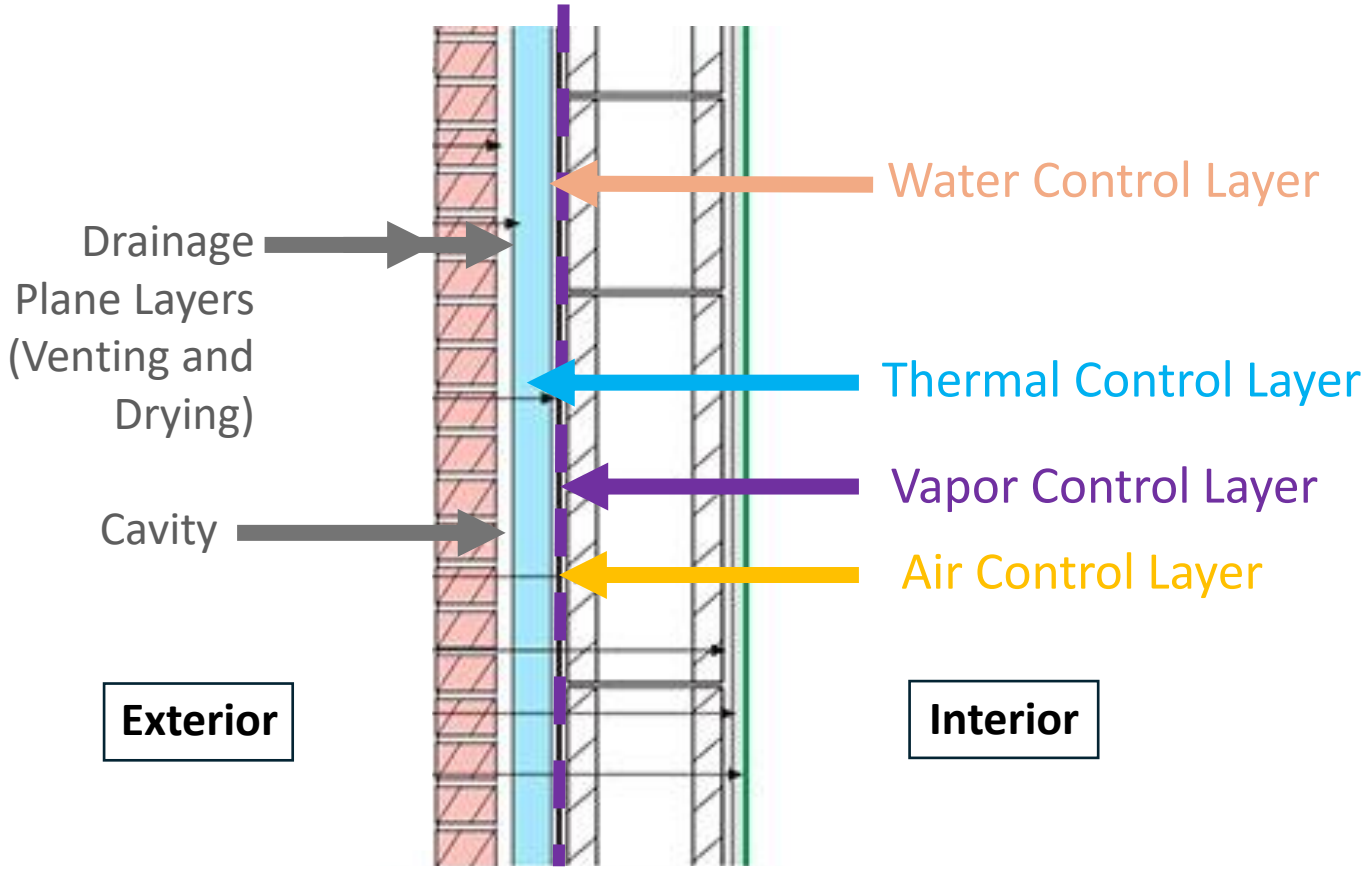

https://www.envistaforensics.com/

Lstiburek (Building Sciences Corporation) zinger:

"If you can't keep out the rain, don't waste your time on the air. If you can't keep out the air, don't waste your time on the vapor."

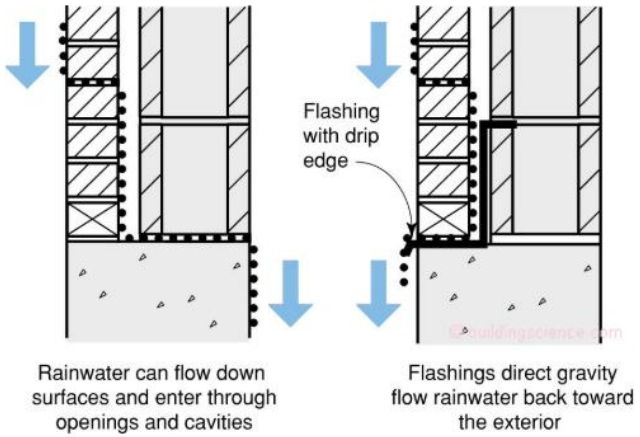
Bulk Water Control

The "Perfect Wall"

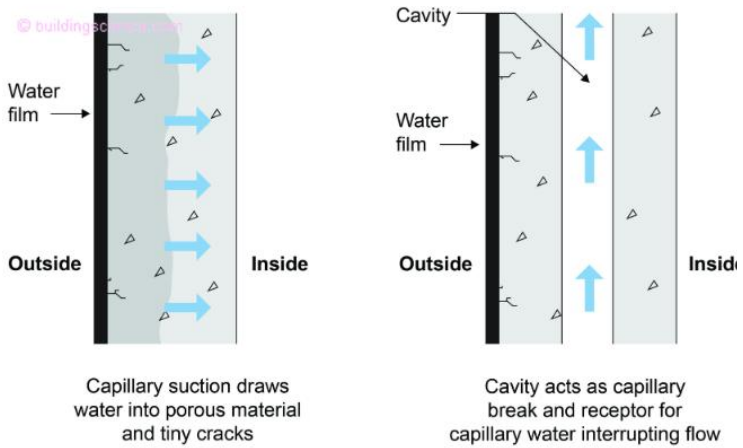


*Reference Source - BS1-001: The Perfect Wall - Building Science.com Corporation

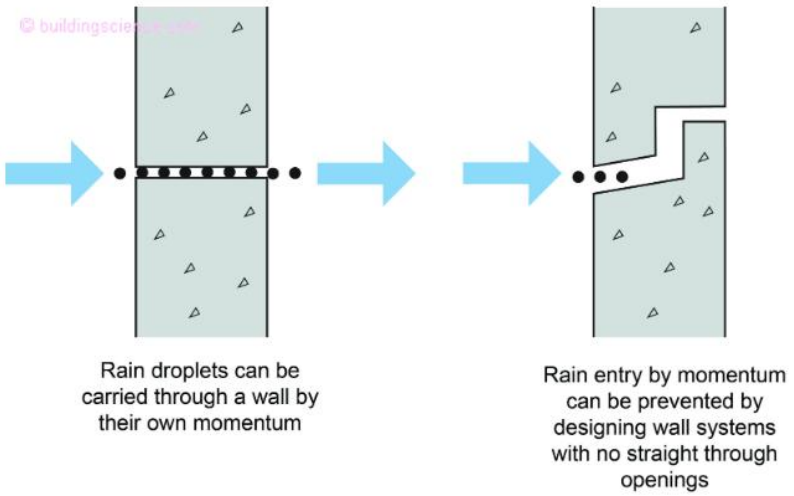
Driving Force for Rain Entry
Exterior Cladding



Gravity



Capillarity



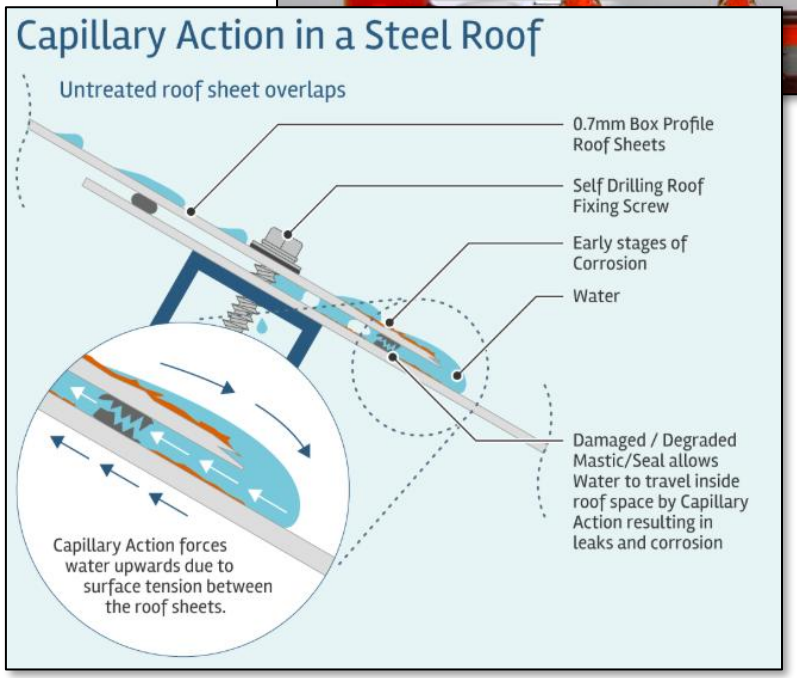
Momentum

*Reference Source - BS1-117: Rain Control: Drained, Barrier and Mass– Buildingscience.com

Capillarity

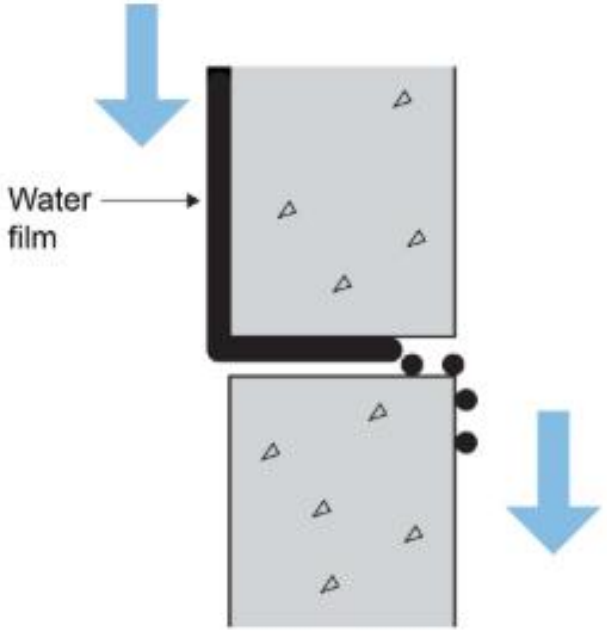
- The force that results from greater adhesion of a liquid to a solid surface than cohesion of the liquid to itself.
- Force can be enough to overcome gravity.
- Smaller the diameter, the greater the rise

https://web.mit.edu/nnf/education/wettability/gravity.html



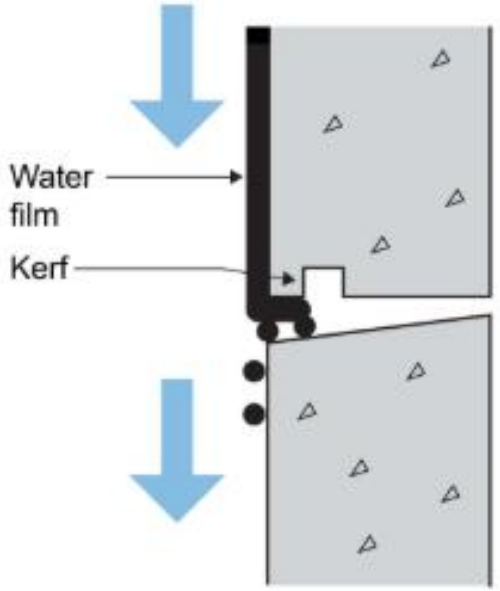
https://www.ddcoatings.co.uk/3213/capillary-action

Surface Tension
Exterior Cladding



Rainwater can flow around a surface as a result of surface tension

Figure 1



Providing a kerf or drip edge will promote the formation of a water droplet and interrupt flow

Figure 2

*Reference Source - BS1-131: Mind the Drip – Buildingscience.com

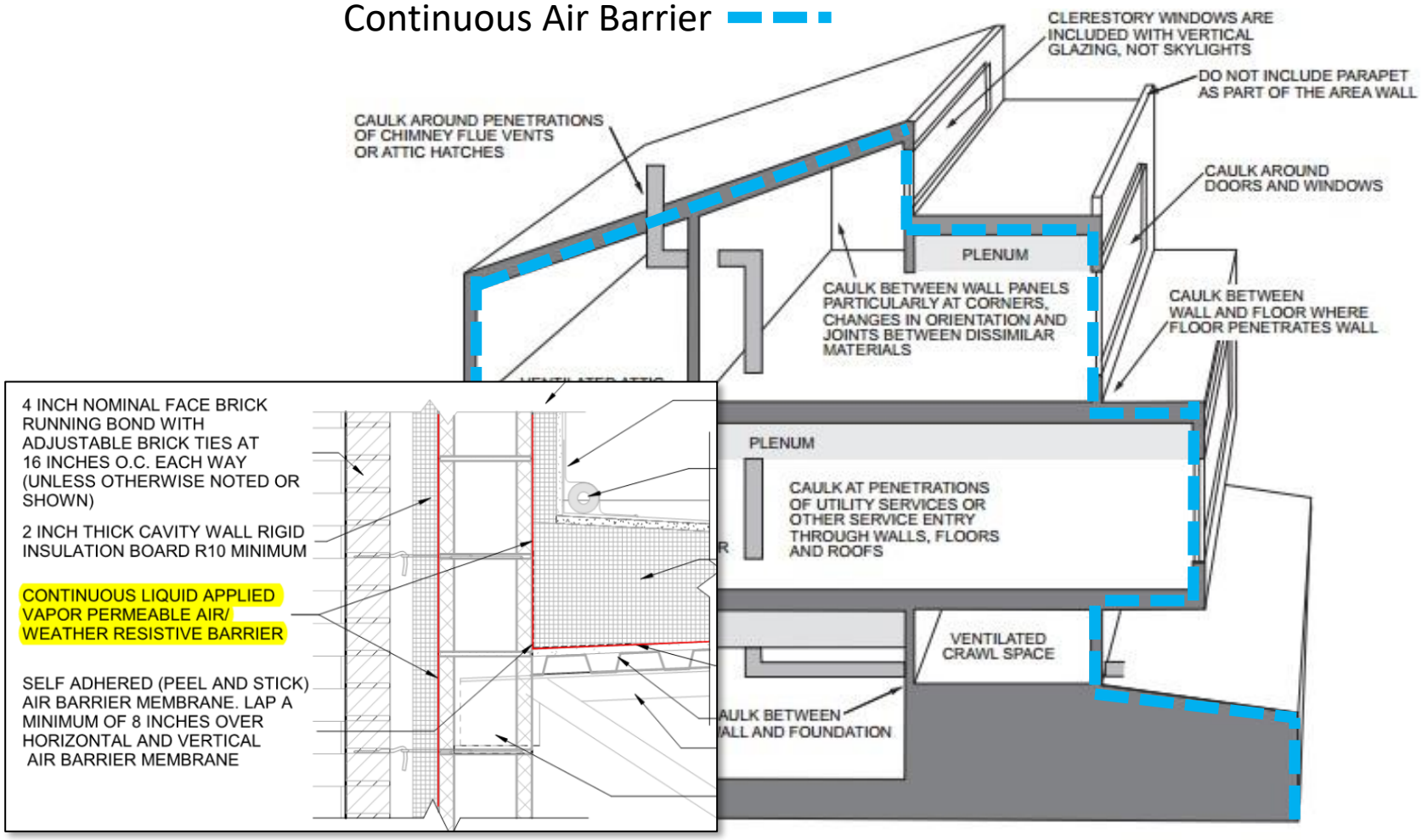
Air Control

Exterior Wall Continuity

Air Barriers

IECC 5.4.3.1.2:

- Show air barrier clearly on drawings.
- Seal all joints, penetrations, seams, opening perimeters, intersections, ductwork openings.
- Resist both positive and negative pressure.



Courtesy of U.S. Department of Energy, Office of Building Technology State and Community Programs, www.energycodes.gov

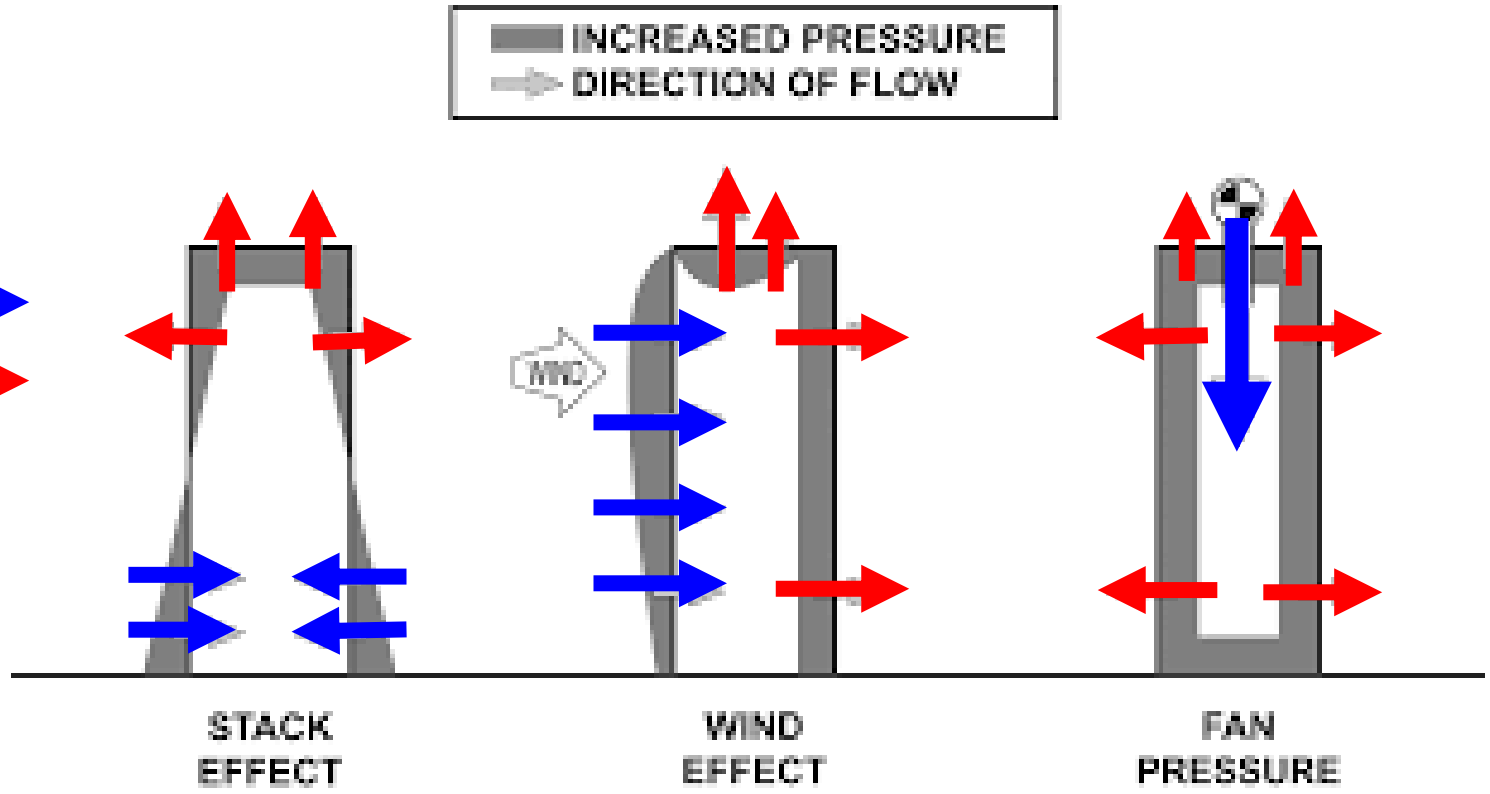
*Reference Source – 2024 IECC Commentary Chapter 5

Pressure Sources

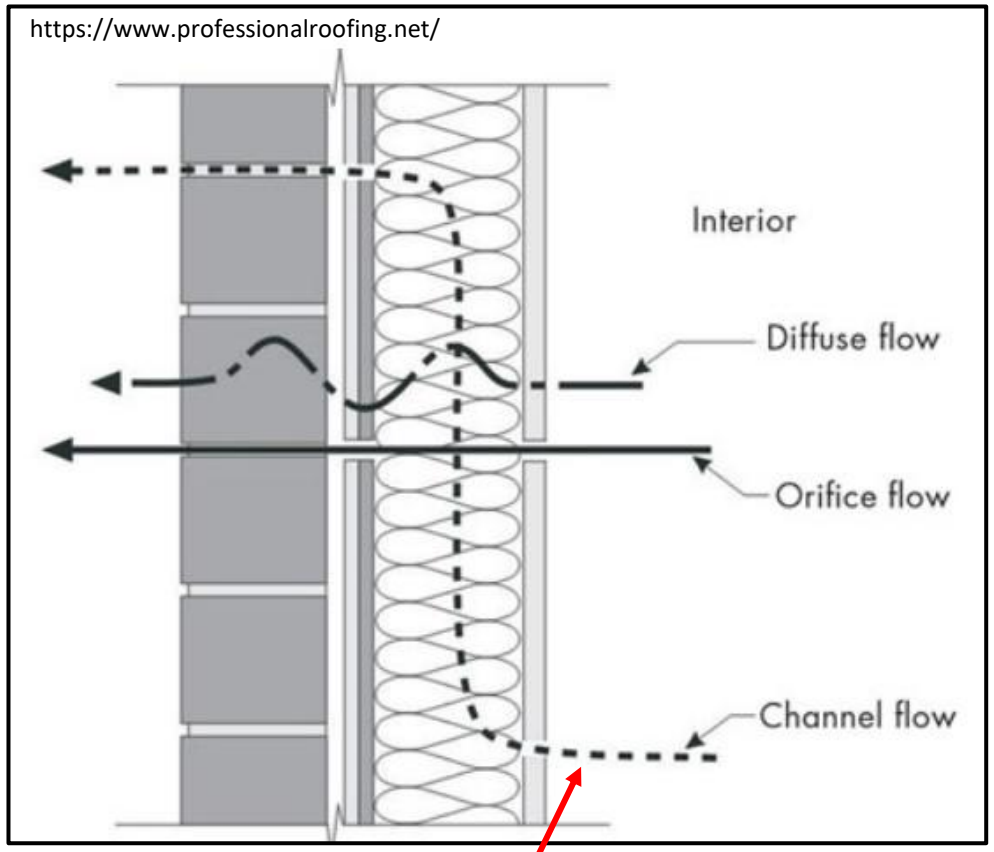
Air leakage through the openings in the building envelope are caused by air pressure differences

Outside Air

Inside Air



Envelope Leaks



Air leaks by **channel flow** – enters one part of wall, travels and exits at remote point, allowing more opportunity to cool and condense

Air leaks by **diffuse flow**: many small cracks in material, high permeance in materials like uncoated CMU, fiberboard

Air leaks through **orifices** – such as crack between window rough opening and frame. Also a direct path for **water leakage**.

Requirements

UFC 3-101-01 "Architecture" refers to IGCC & ASHRAE 90.1-2019

- Requires whole-building air leakage testing
- For buildings with over 50,000 ft^2 of conditioned floor area, less than whole-building testing is allowed.

What is leakage limit?

ASHRAE 90.1-2019: **0.4 cfm/ft^2** of wall area

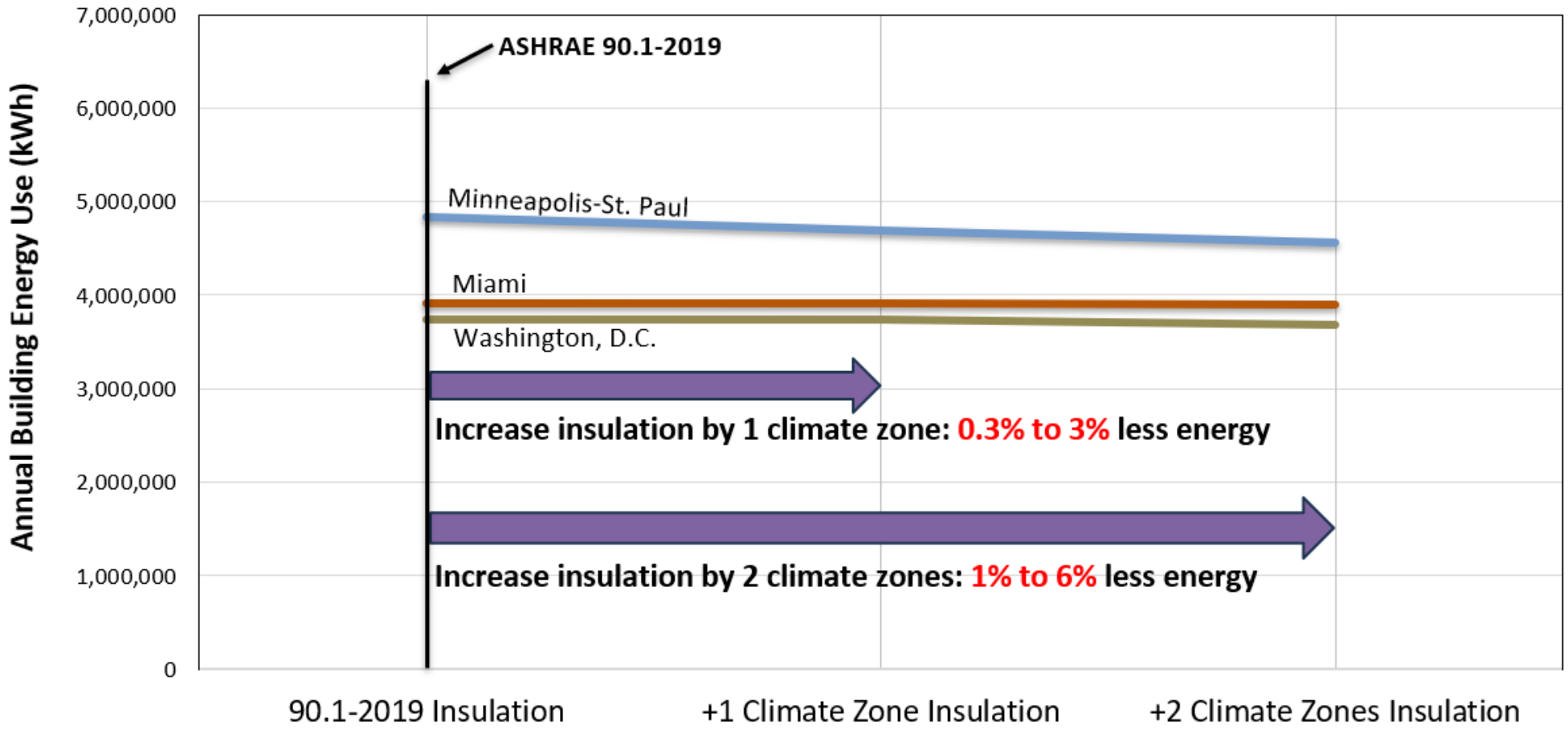
IGCC and UFC 3-101-01 modify that to **0.25 cfm/ft^2**

*at 0.3" w.g. (75 Pa)

Air leakage rate (cfm/ft^2)	Description	Standard Met
1.0	Very poor	ASHRAE 90.1-2004
0.6	Leaky building	None
0.4	Current standard practice	ASHRAE 90.1-2019
0.25	Excellent	UFC 3-101-01 & IGCC
0.11-0.08	Extraordinary	Passive House U.S.

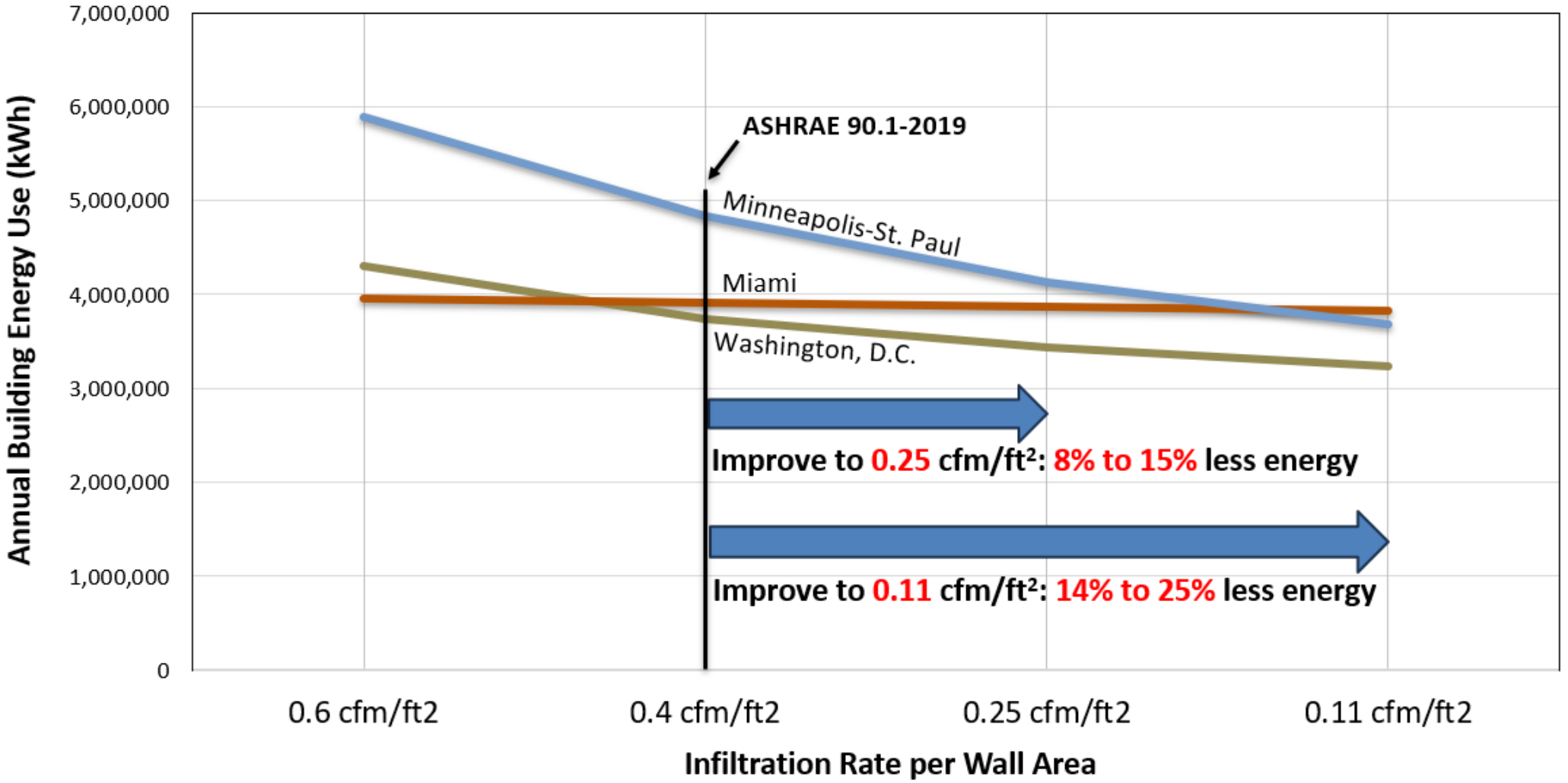
Energy Effects - Insulation

240,000 ft^2 office building



Energy Effects - **Infiltration**

240,000 ft^2 office building



Vapor Control

Vapor Permeability

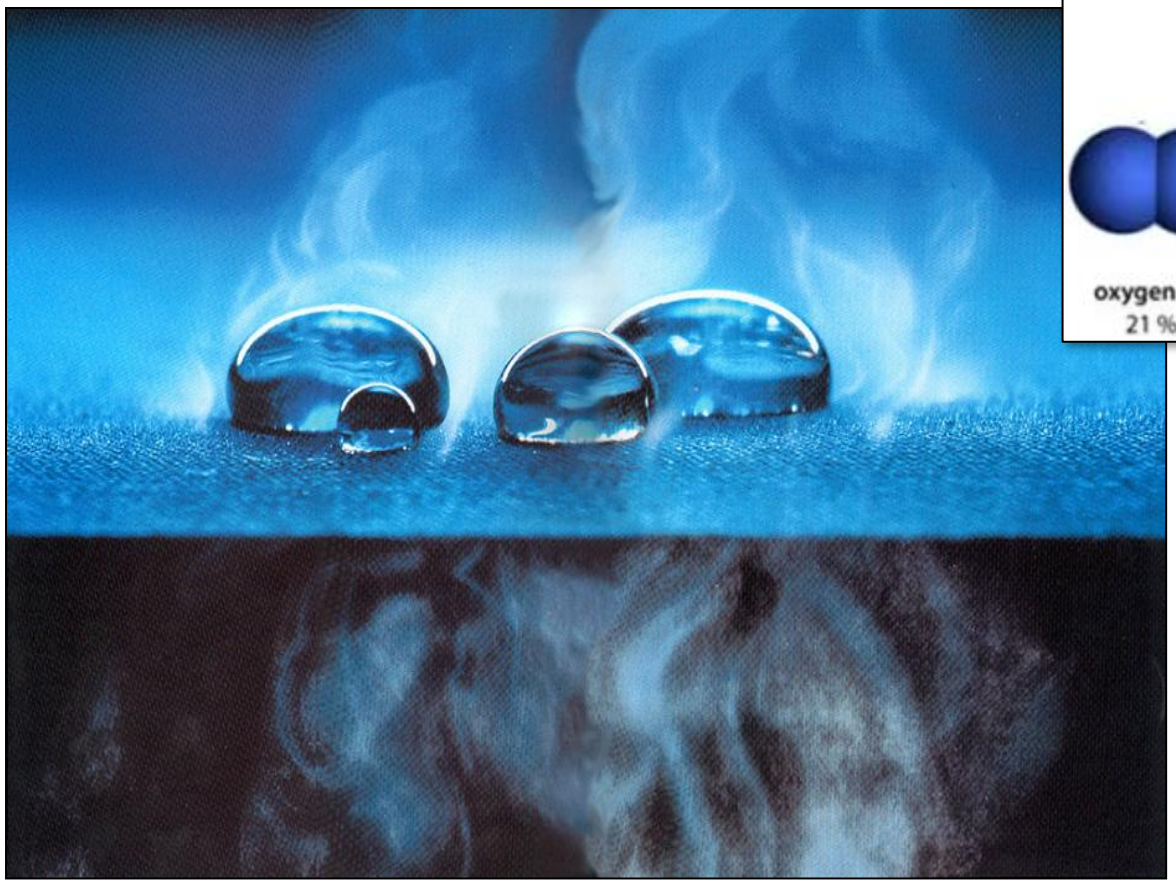
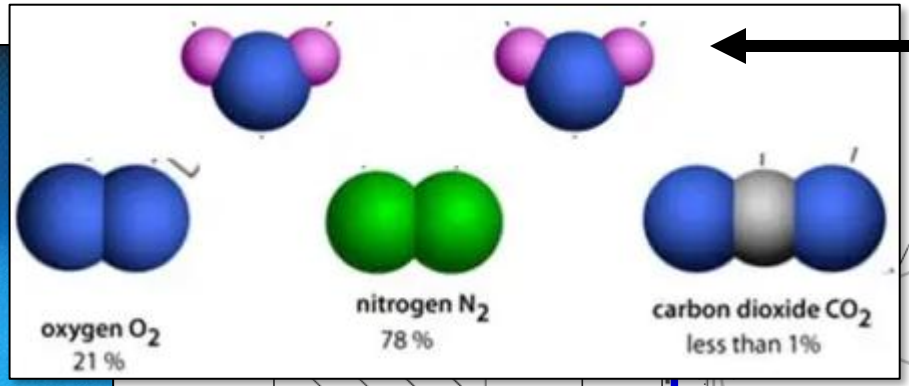
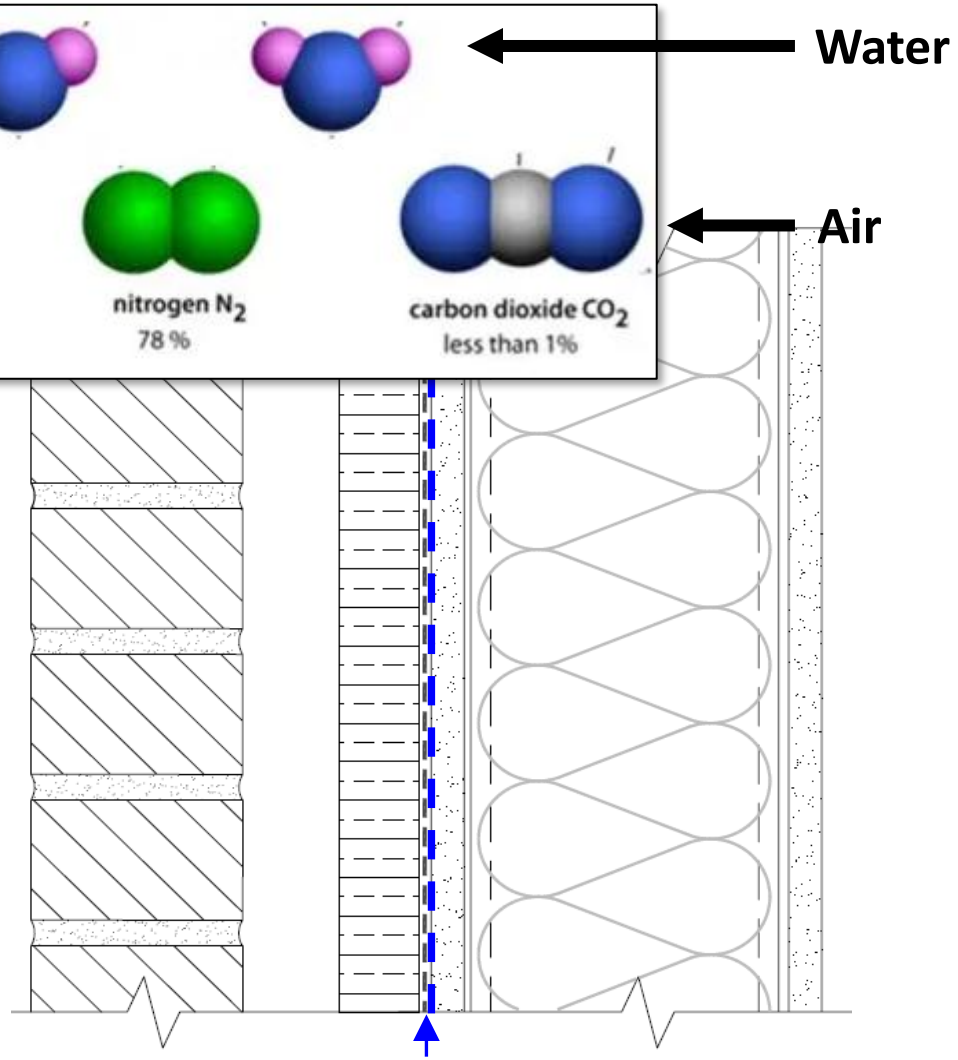


Image Source: DuPont www.dupont.com/products-and-services/construction-materials/building-envelope-systems/articles/understanding-vapor-permeability.html

https://susanabooher.wordpress.com/2016/08/19/have-you-ever-wondered-about-clouds/





Design To Control Vapor

Requirements

Mason&Hanger
A Day & Zimmermann Company

UFC **3-101-01** "Architecture"

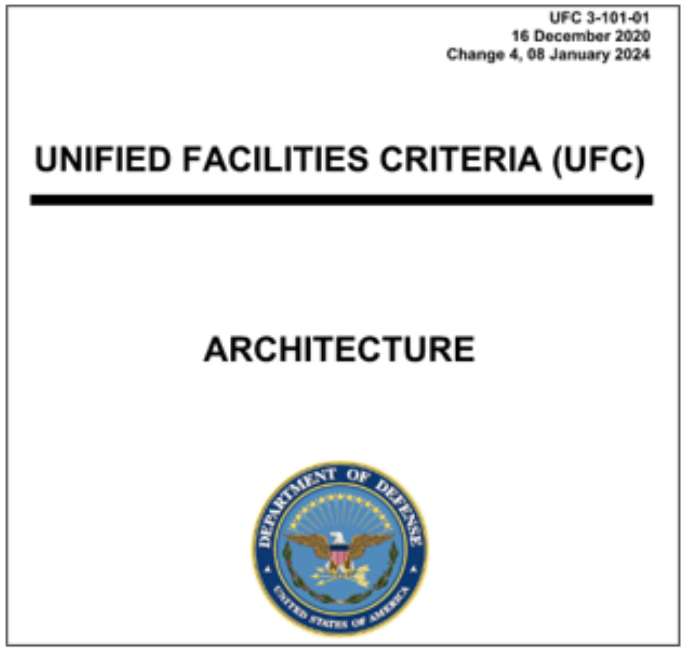
Vapor retarder design:

If worst-case vapor pressure difference (winter or summer) between outside and inside is < 0.25" Hg, place vapor retarder on the predominantly high-vapor-pressure side of the assembly.

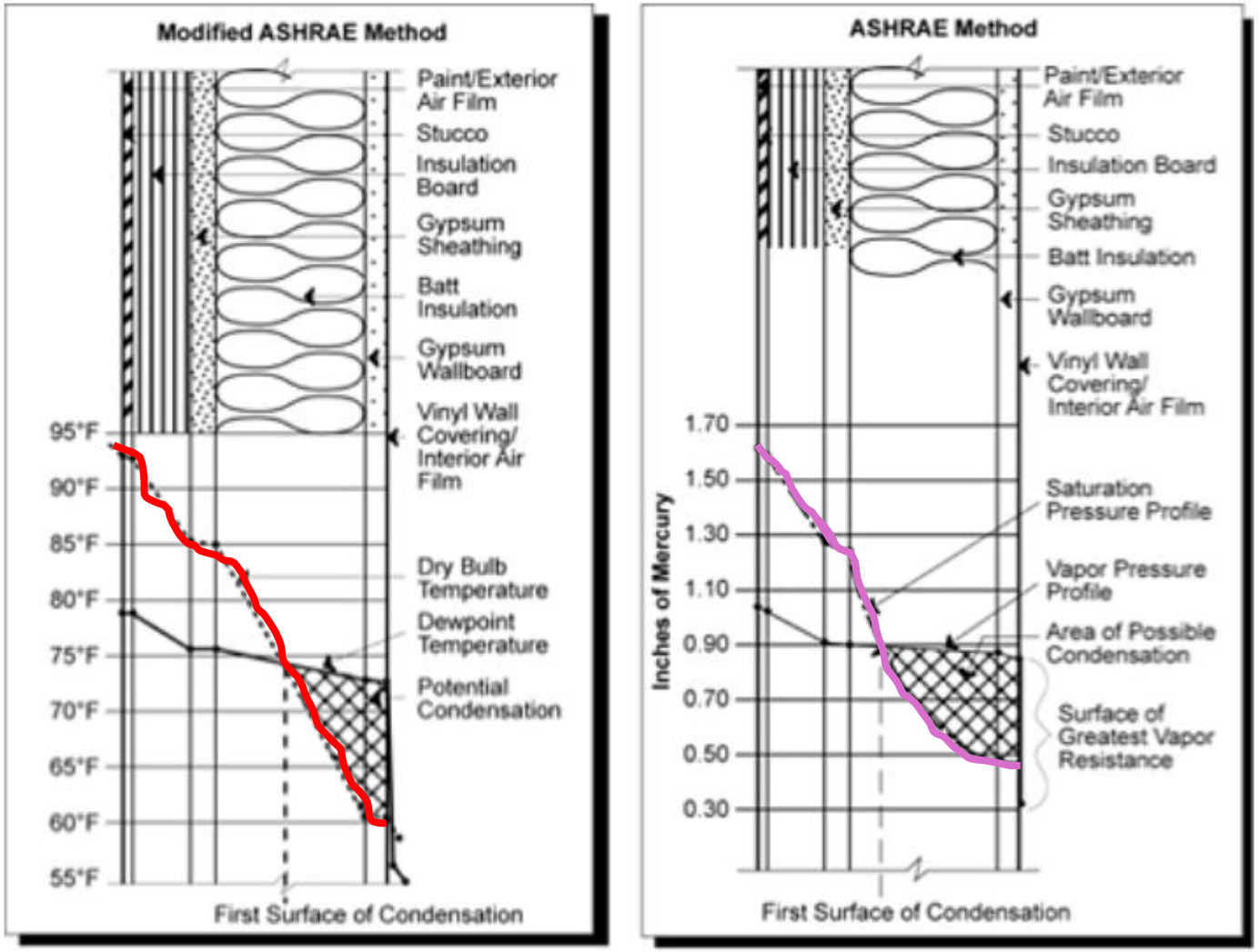
If difference > 0.25" Hg, perform a simplified OR transient vapor transmission (hygrothermal) analysis for walls, roofs, and exposed floors.

Simplified means steady-state dewpoint or Glaser method described in ASHRAE Handbook.

Transient analysis requires software such as WUFI.

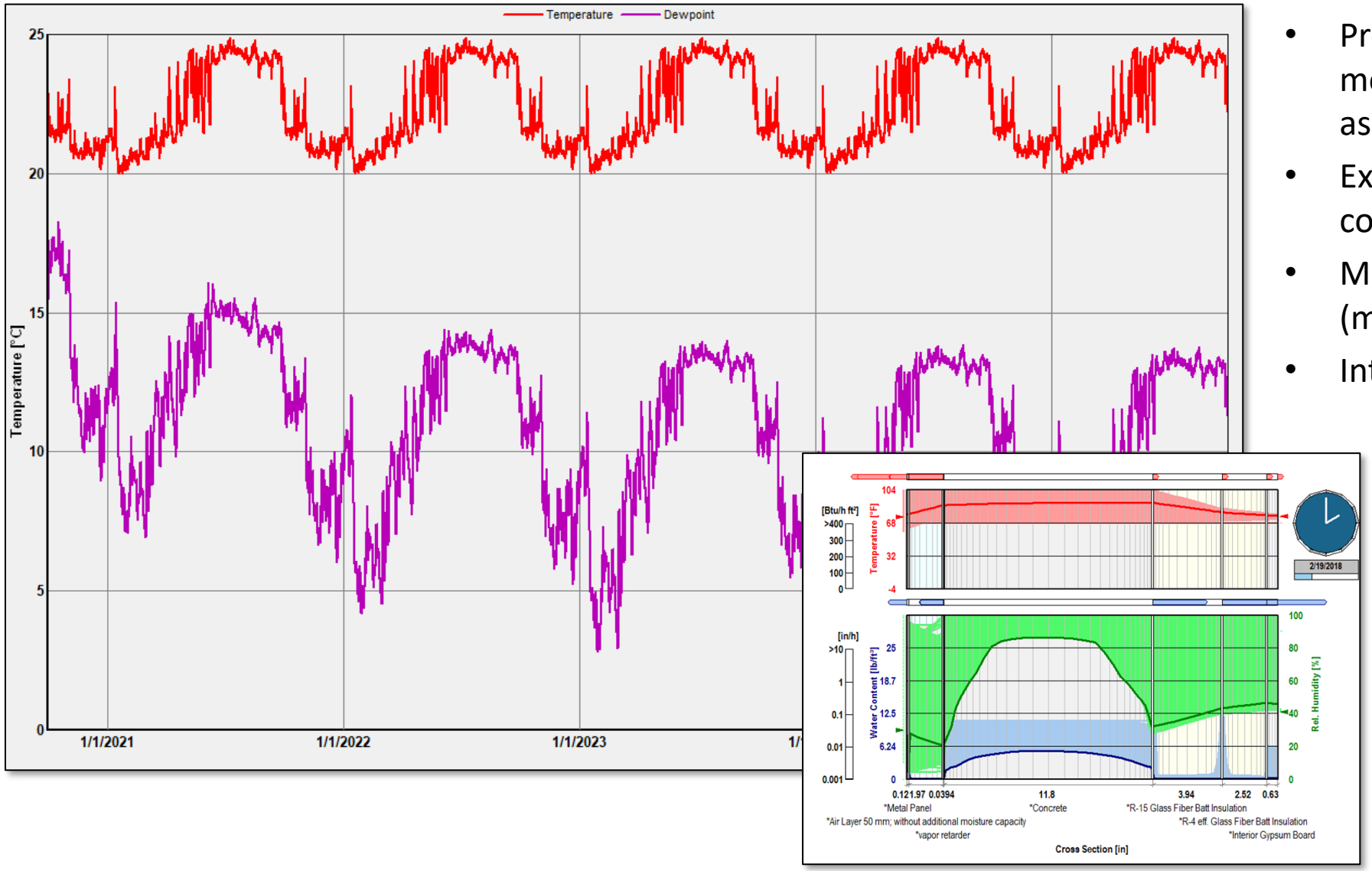


Temperature and Vapor Pressure Gradients



https://www.wbdg.org/resources/moisture-management

Transient Hygrothermal Analysis



- Predicts how moisture will move through a wall assembly over time
- Exterior weather conditions (hourly)
- Material properties (moisture and thermal)
- Interior building conditions

Vapor Drive

A “**perm**” is:

1 grain of water vapor per hour, per square foot, per inch of mercury. 59,000 grains = 1 gallon.

ASTM E96 – Test method for determining water-vapor transmission of materials

https://masonrymagazine.com/Default?pageID=4291

Vapor Control – Vapor Retarder Classes

Class I

Vapor Impermeable

0.1 Perm or Less

Vapor "Barrier"

Polyethylene sheets

Glass, sheet metal

Epoxy coatings

Foil-faced insulation sheathing

Class II

Semi-Vapor Permeable

>0.1 Perm and < 1 Perm

Kraft-faced fiberglass batts

Low-perm paint

Unfaced expanded polystyrene (EPS)

Fiber-faced Polyisocyanurate

Class III

Vapor Permeable

1 Perm or More

Gypsum Board and Plaster

Latex Paint

Cellulose Insulation

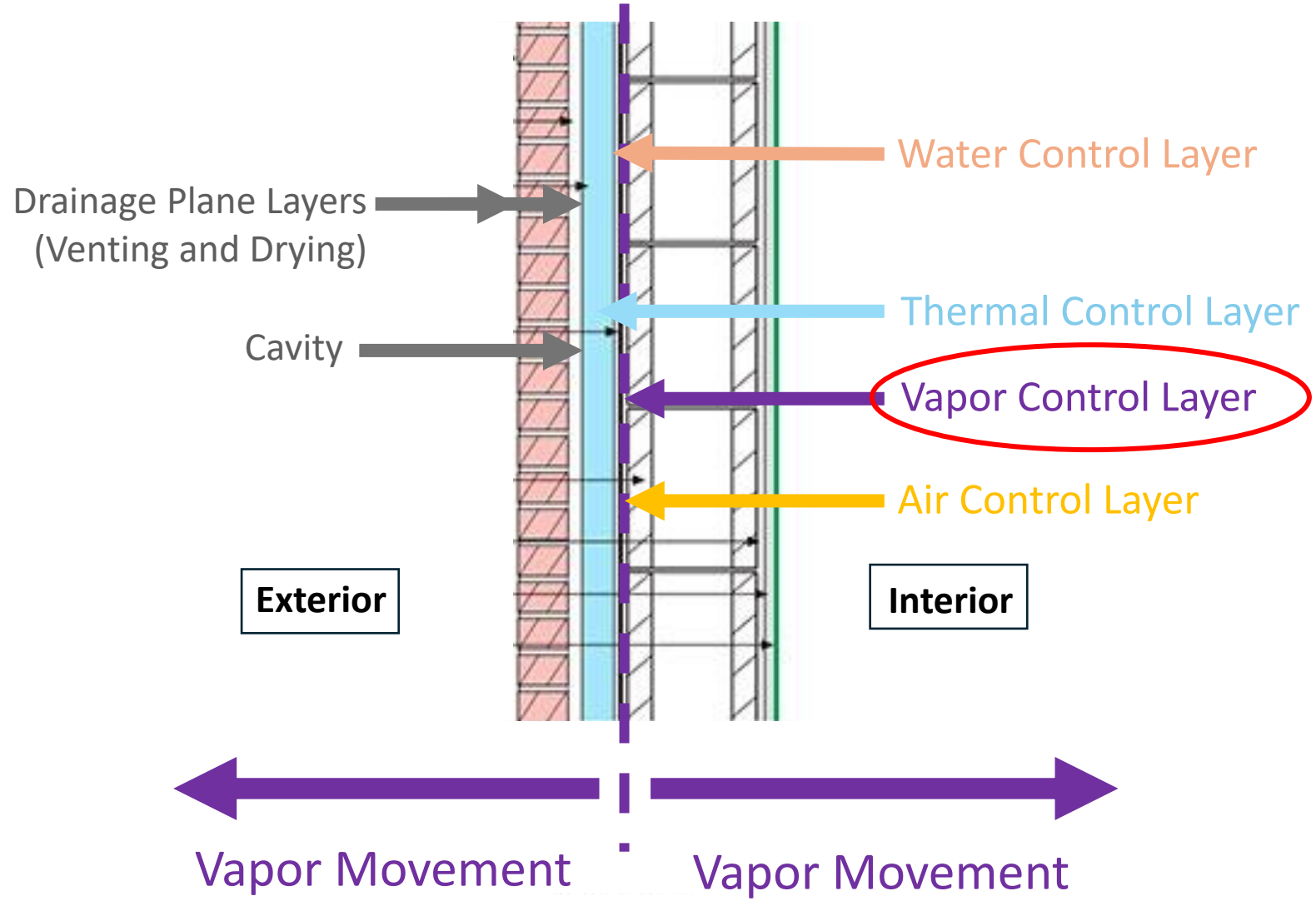
Exterior Gypsum Sheathing

IMPERMEABLE → *PERMEABLE*

*Reference Source – ASHRAE Journal February 2002 – Moisture Control for Buildings by Joseph Lstiburek

The "Perfect Wall"

Brick/CMU Exterior Wall Assembly



*Reference Source - BS1-001: The Perfect Wall - Building Science.com Corporation

Recommendations for Vapor Barriers

AVOID:

- Vapor barriers where vapor retarders will provide satisfactory performance.
- Vapor barriers on both sides of assemblies – "double vapor barriers"
- Installation of vinyl wall coverings on the inside of air-conditioned assemblies.

DO:

- Perform a condensation analysis

*Reference Source - BS1-0130: Hotel Mold. Building Science.com Corporation

Air Leakage Again, But Worse

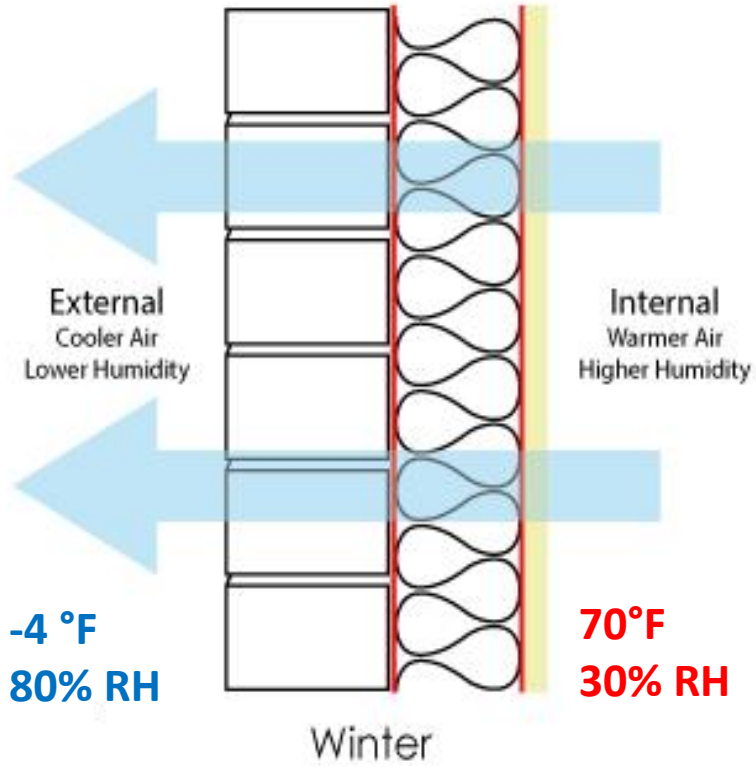
Moisture from Vapor Diffusion

Vapor diffusion into exterior walls is usually mitigated by a **vapor barrier**.

With a typical vapor barrier, conditions shown at right will transfer **6 grams (0.2 ounce)** of moisture into wall over a square meter in a month.

This is manageable and will dry with proper wall design.

Per Quirouette paper referenced in UFC 3-101-01 Architecture



https://www.celticsustainables.co.uk/

Same Condition, But With Air Leak

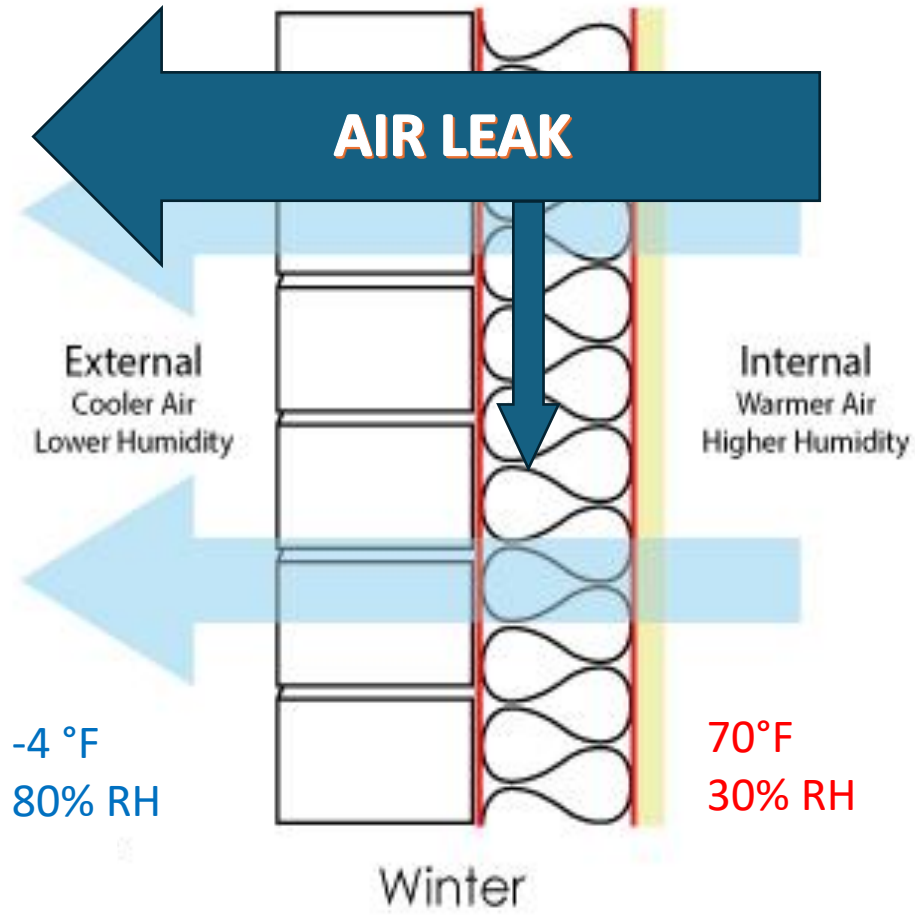
Consider:

1 in^2 leakage hole (or, a **5-foot, ½ mm crack**)

Pressure difference of 0.04” water (= **9 mph wind)**

Assume **only 10%** of leaked air ends up in wall.

Instead of 0.2 ounce of moisture in wall over a month, **50 ounces**.



https://www.celticsustainables.co.uk/

- Quirouette paper referenced in UFC 3-101-01 Architecture

Testing & Commissioning

Requirements – Testing/Commissioning

UFGS specification for total building commissioning is **01 91 00.15**

Refers to **01 91 19** for **building enclosure commissioning.** But that is **optional**.

- Design review
- Submittal review
- Inspections of envelope components
- Air barrier pressure testing.

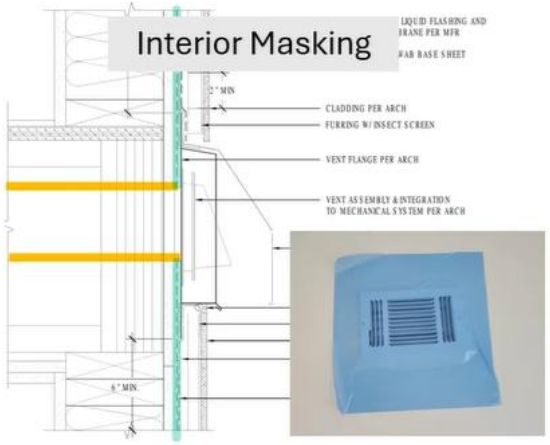
ABAA Webinar on Building Air Tightness Testing

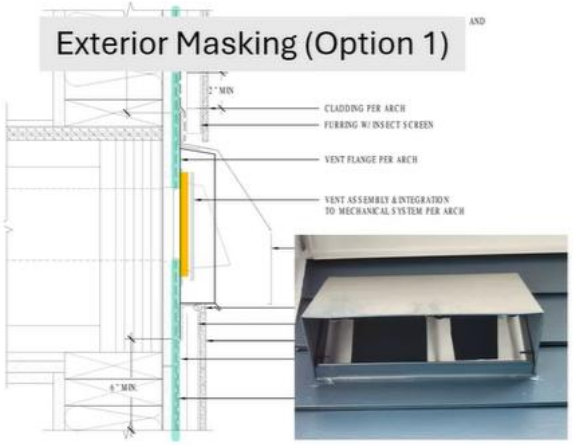
Brad Carmichael and Adam Neugebauer from 4EA

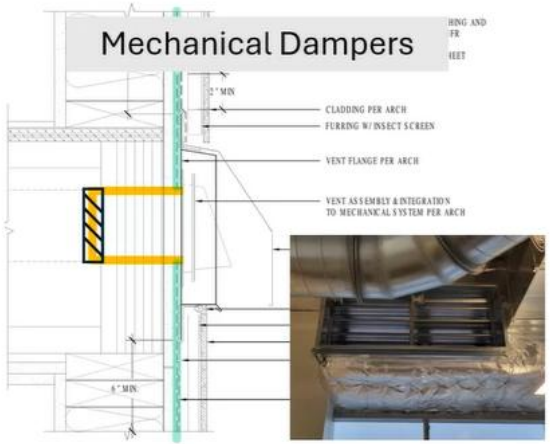
HVAC Isolation Approaches

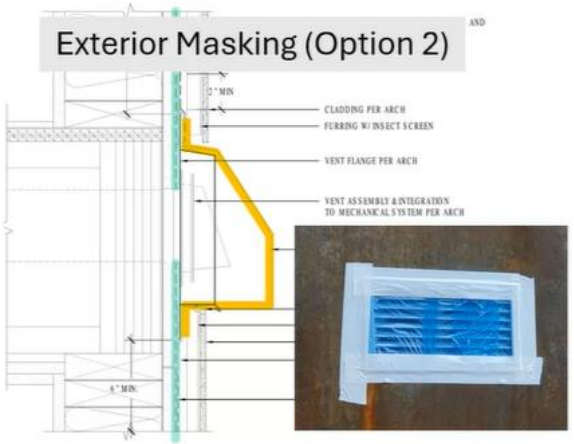
Building's Air Barrier Path

Air Tightness Boundary Added by Isolations









ABAA Webinar on Building Air Tightness Testing

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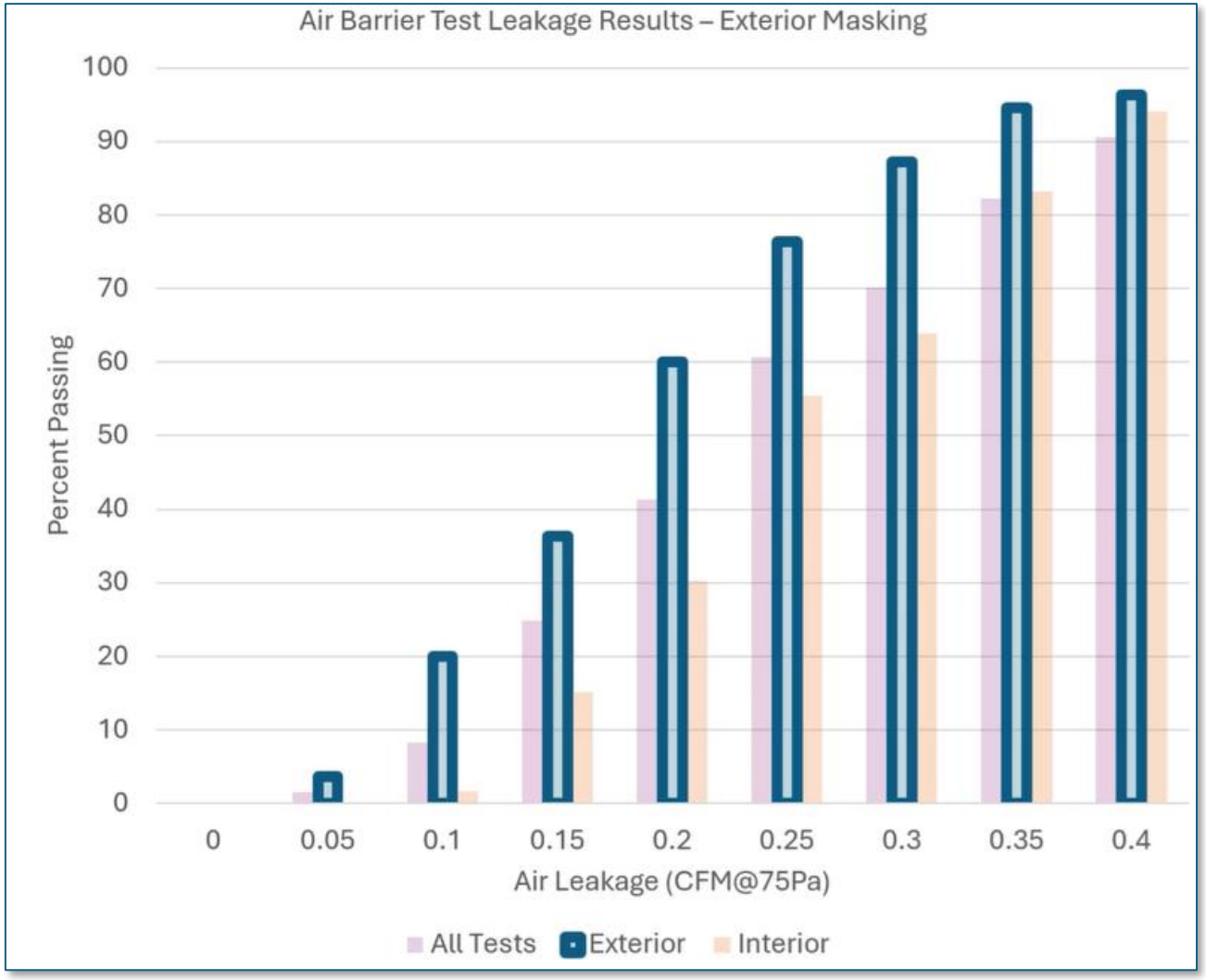
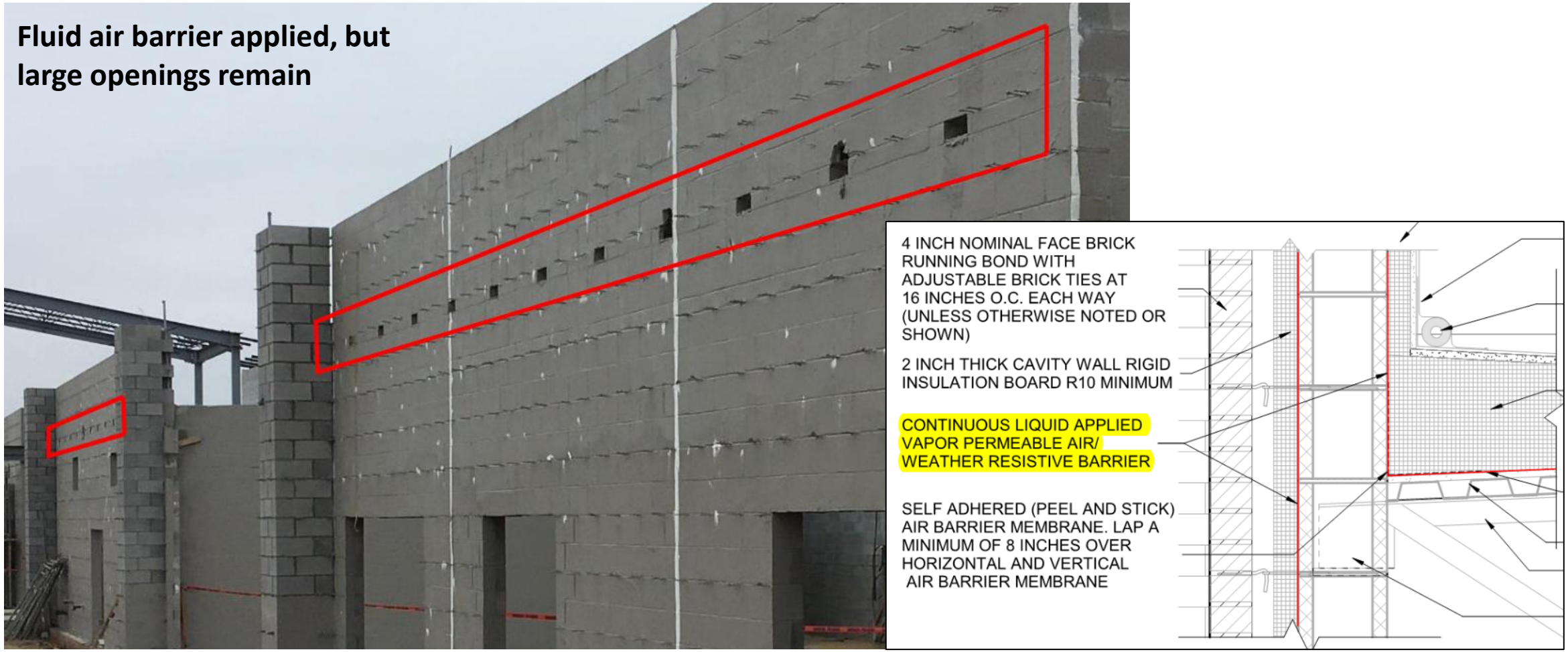


Different Masking Approaches

- They found that <u>exterior masking</u> consistently outperforms interior masking. It is more expensive.
- <u>Mechanical isolation</u> with leak proof dampers is about the same as, or slightly better than, exterior masking.

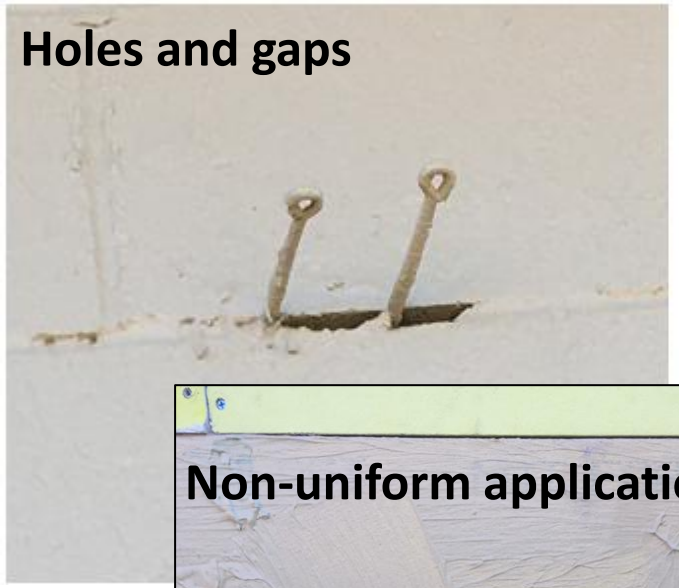
Why is commissioning important?

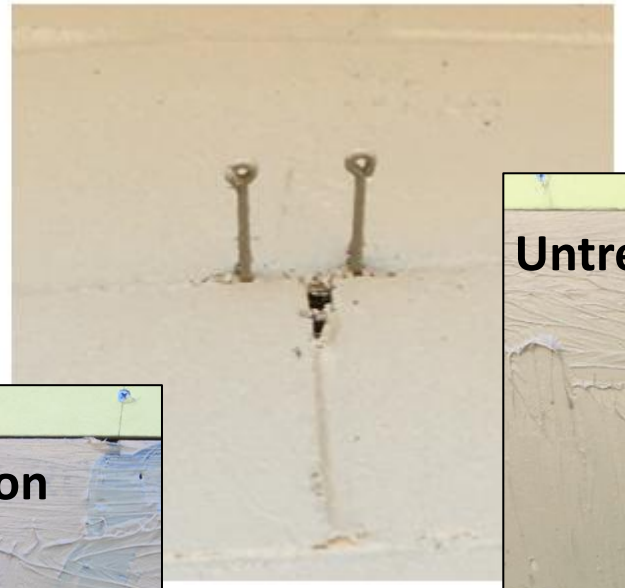
Periodic Field Inspections

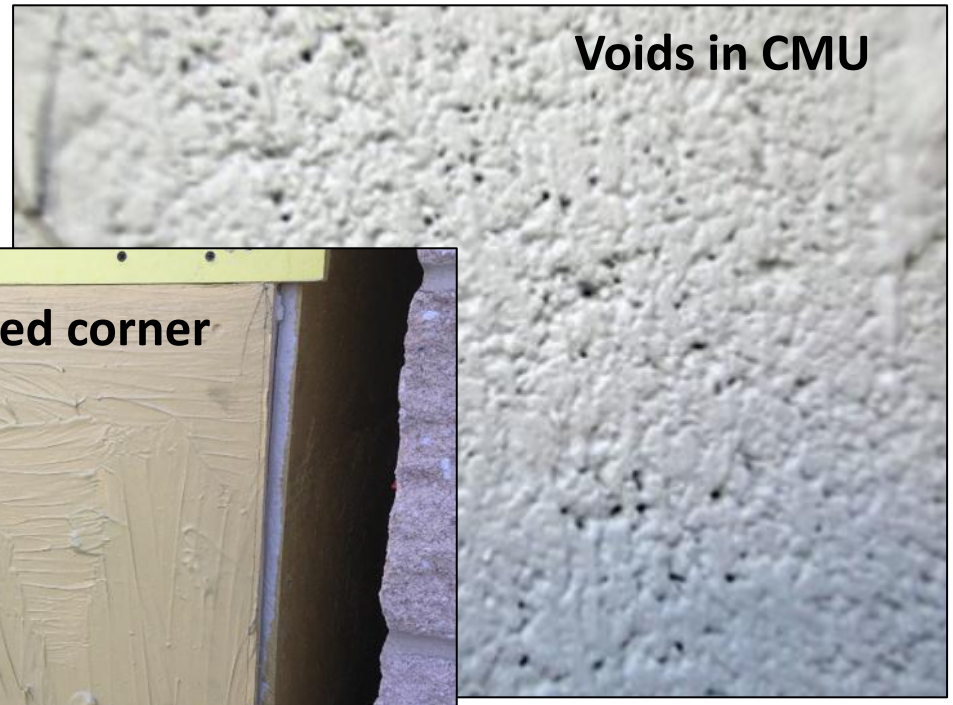


Why is commissioning important?

Periodic Field Inspections

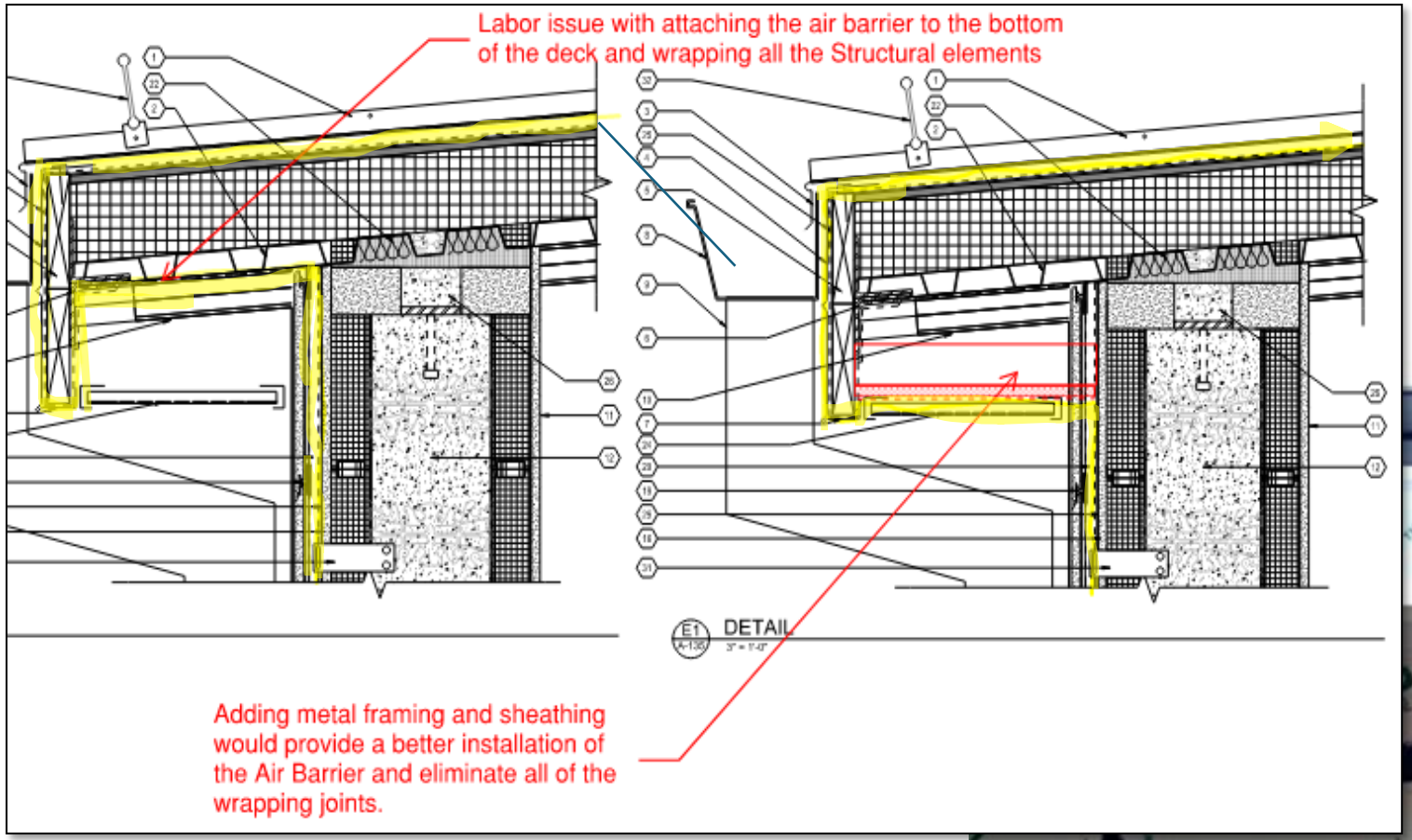


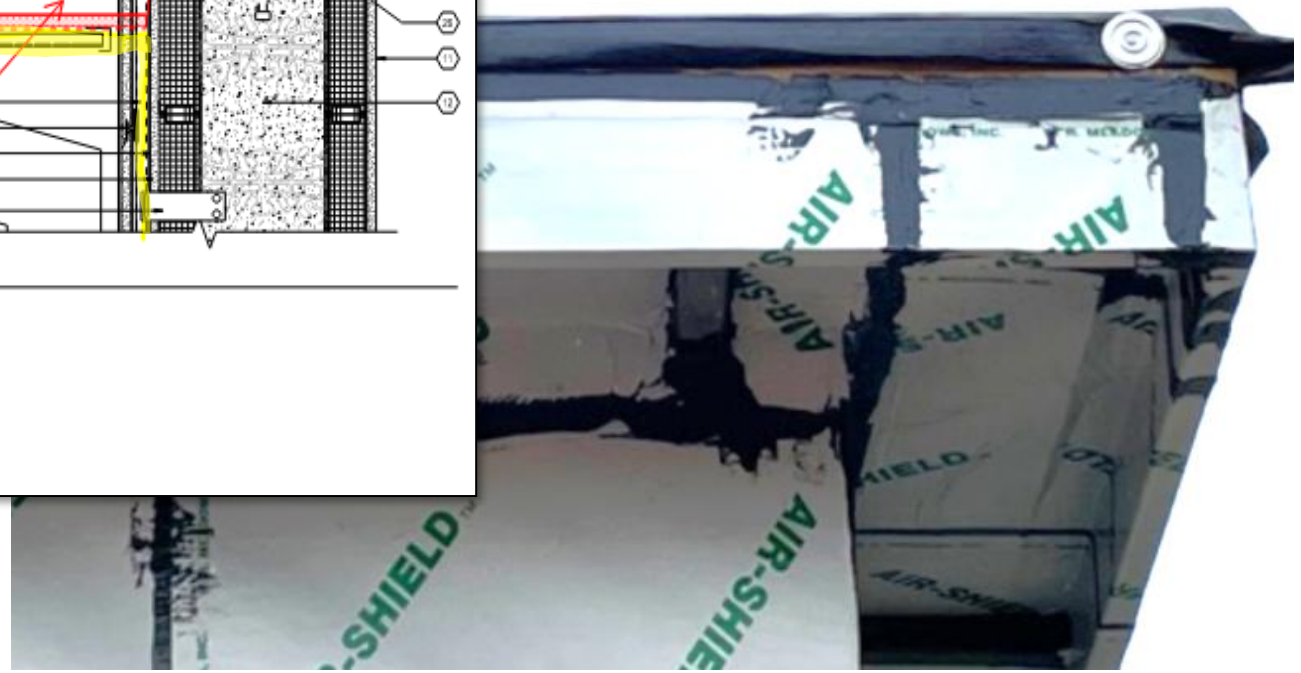




https://iibec.org/issues-encountered-with-barriers/

Envelope Commissioning – Lessons Learned

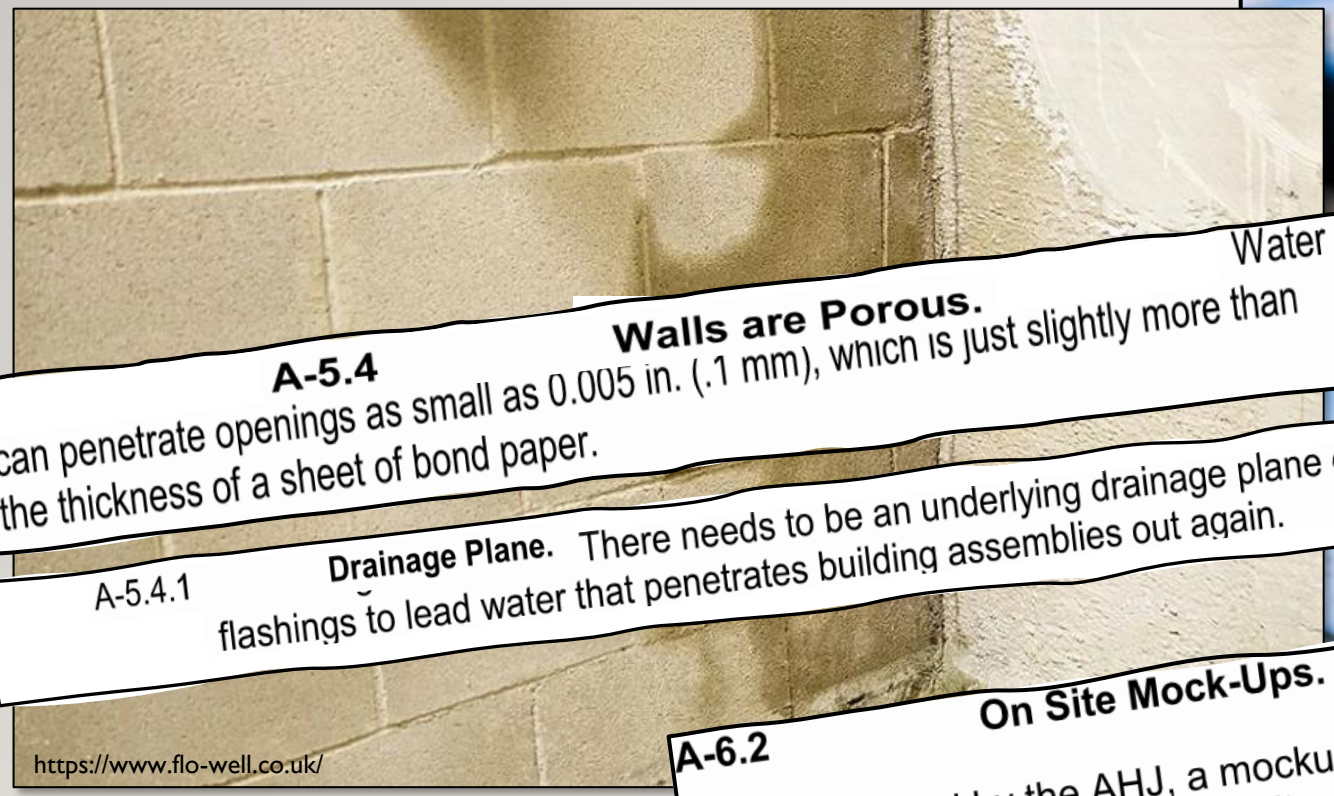




Mason & Hanger – Fort Campbell Middle School

Water Leakage

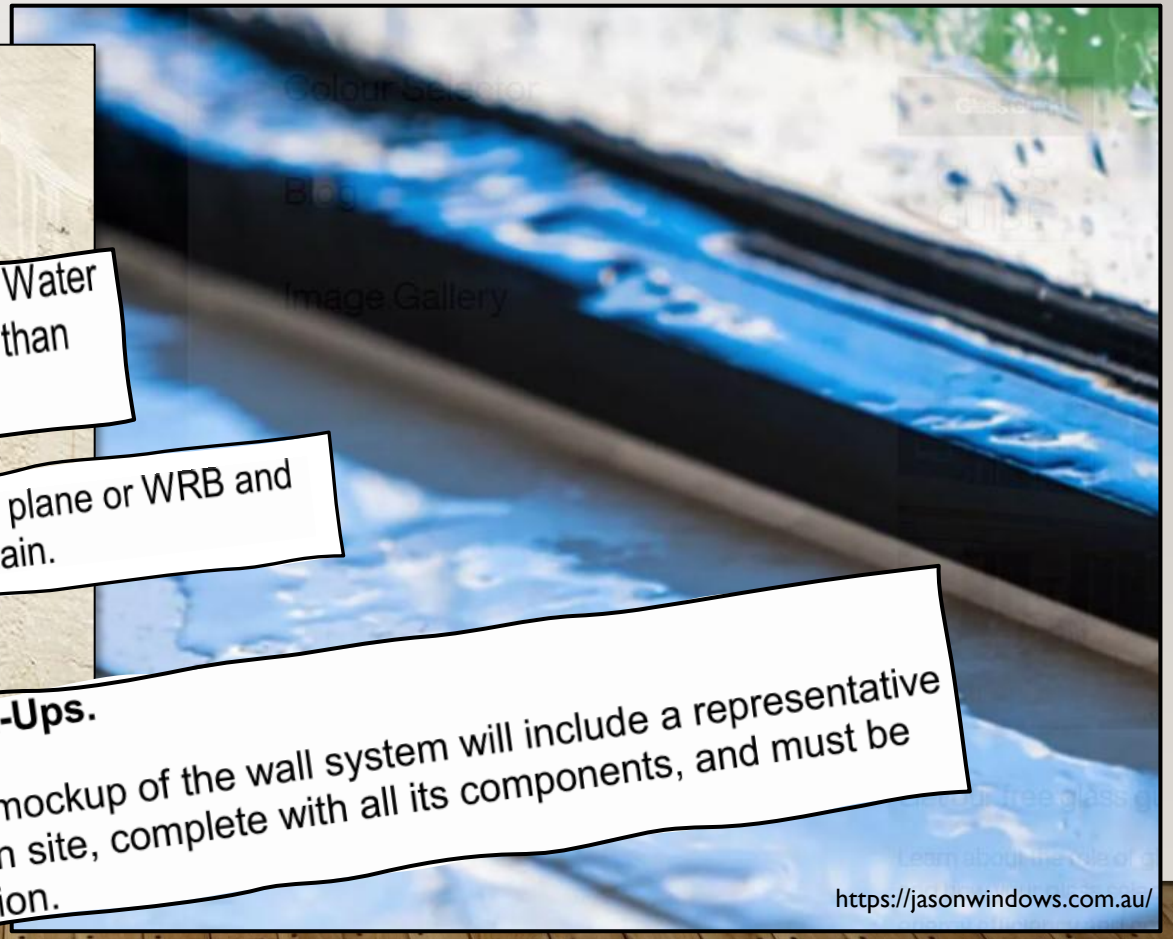
- **No requirement** in UFC 3-101-01 to test, but extensive admonishment / guidance about water intrusion.



A-5.4 Walls are Porous. Water can penetrate openings as small as 0.005 in. (.1 mm), which is just slightly more than the thickness of a sheet of bond paper.

A-5.4.1 **Drainage Plane.** There needs to be an underlying drainage plane or WRB and flashings to lead water that penetrates building assemblies out again.

https://www.flo-well.co.uk/



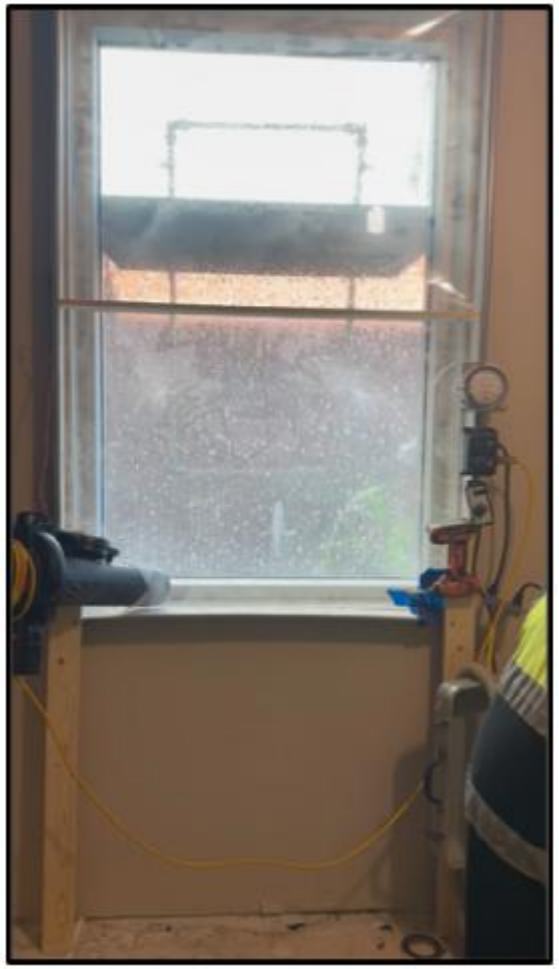
A-6.2 On Site Mock-Ups.

When approved by the AHJ, a mockup of the wall system will include a representative wall and window constructed on site, complete with all its components, and must be tested for air and water infiltration.

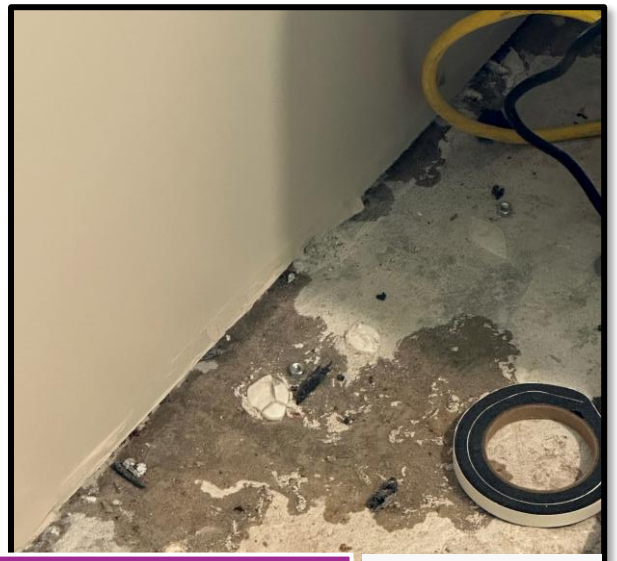
https://jasonwindows.com.au/

We test…

Direct 5 gal/ft^2-hr at window surface, create differential pressure across window.



…to ensure we avoid this



What is leakage limit?

No visible leakage

Summary

- Envelope is the single most impactful building system where resilience and energy performance are concerned.
- Thoughtful, well-informed design is critical to the integrity and resilience of envelope systems.
- Trust but verify. Commissioning is key to validating performance.

https://www.freepik.com/premium-vector/city-scene-with-rain-thunders_2094966.htm?_sm_vck=1PsZNZrJnZ5SFj23nMZTP0JFTNvRffqqPQtQMZP37PWNZJ00TjsQ&sign-up=google

Thank You

Questions?