Maximizing Building Envelope Energy Performance and Resilience

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Mason&Hanger®
A Day & Zimmermann Company


SCAD Museum of Art, Savannah, Georgia

March 23, 2026

Learning Objectives

Identify

- Specific components of robust and effective building envelopes.

Understand

- How building envelope components work in concert, and how to ensure that through testing.

Take Away

- General knowledge of the important facets of envelope design and what to look out for in your projects.

Arena and Canal District, Savannah, Georgia

Climate Zone Designations

Climate Zones Defined by

ASHRAE Standard 169 (Climatic Data for Building Design Standards)

International Energy Conservation Code (IECC)

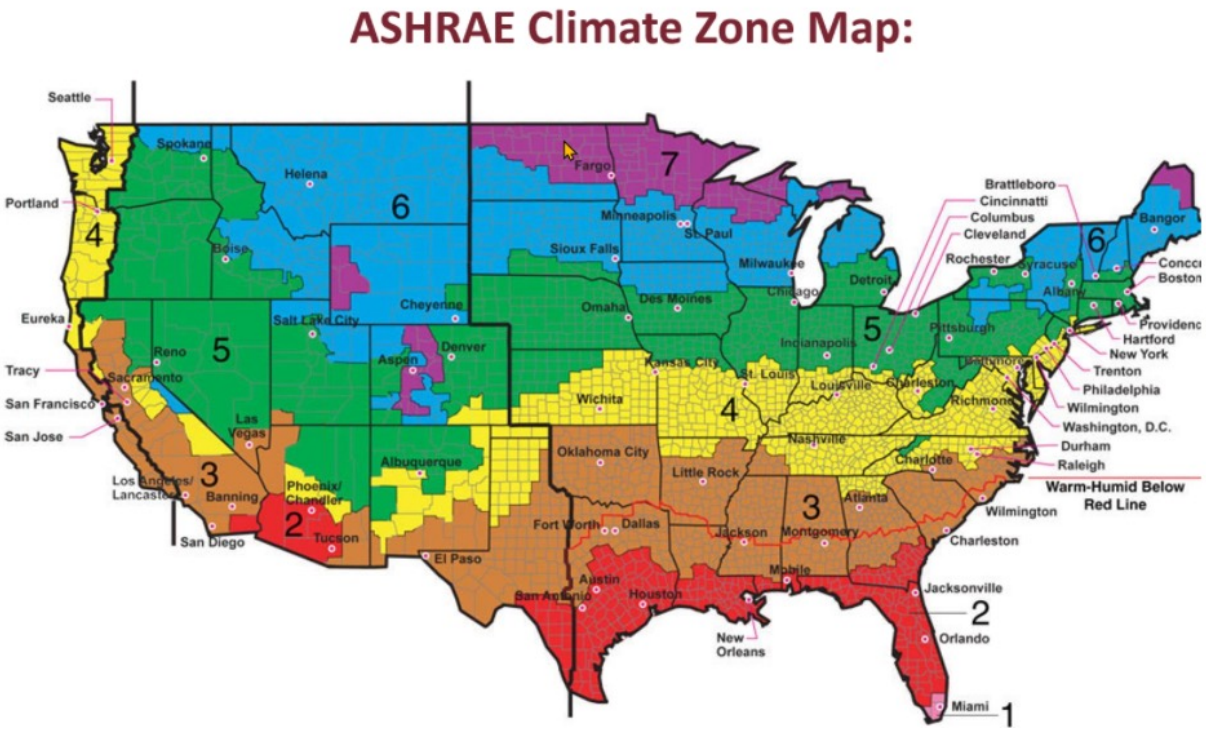
Purpose

Design, Planning and Sizing of Building Energy Systems and Equipment

Where are we now?

Chatham County, Georgia

Climate Zone 2A: Hot, Humid Conditions

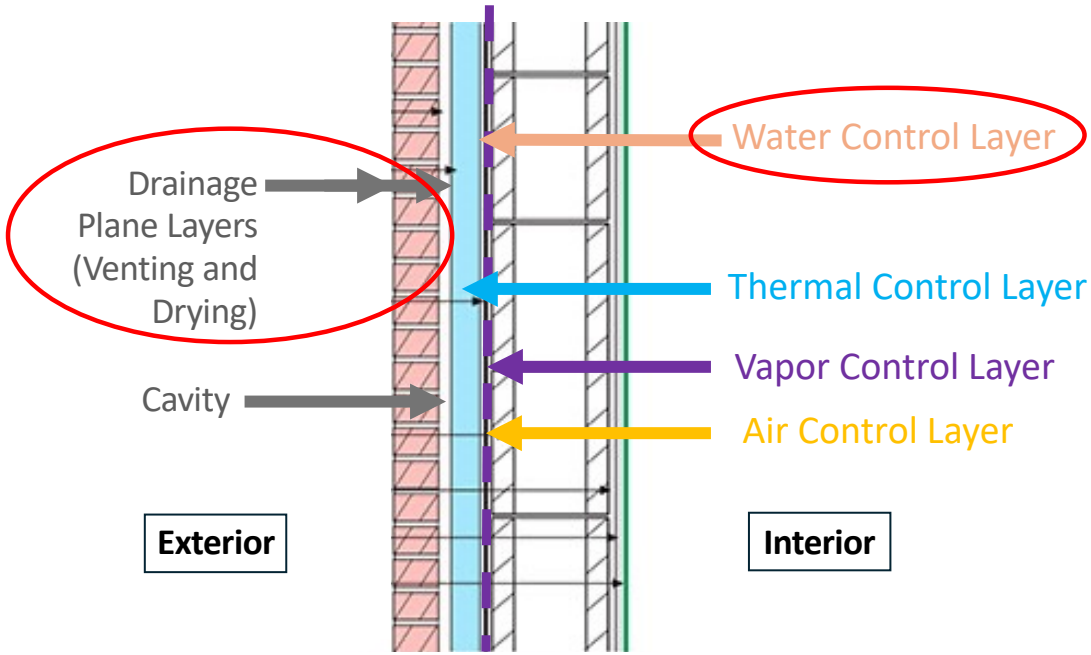


Bulk Water Control

The "Perfect Wall"

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."



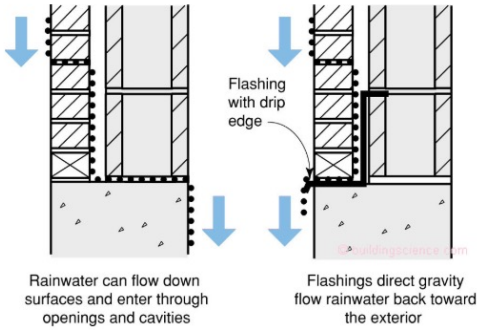
*Reference Source - BS1-001: The Perfect Wall - Building Science.com Corporation

Moisture in a modern wall is not pretty

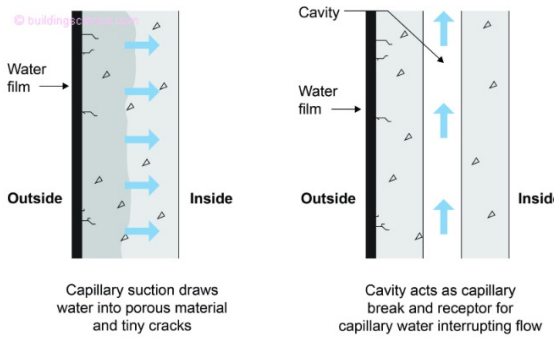
https://corksoluk.com/

https://sfwconstruction.com/

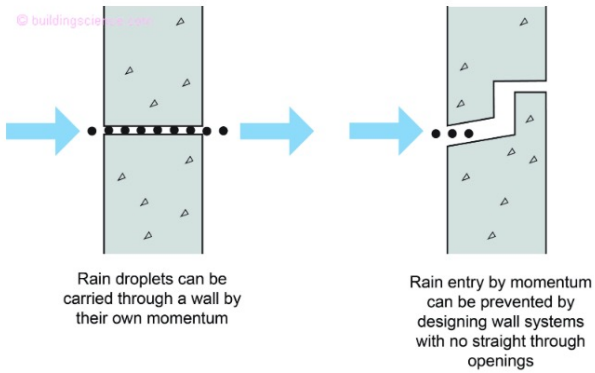
Driving Force for Rain Entry
Exterior Cladding



Gravity



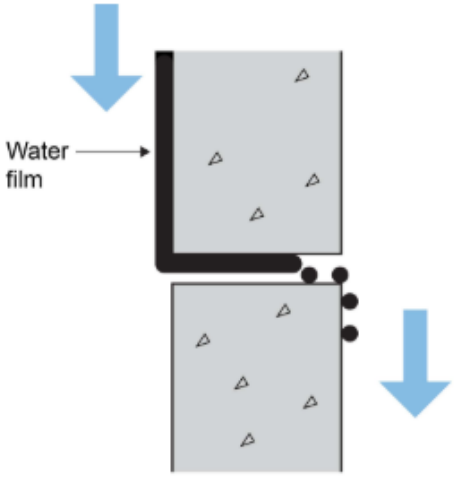
Capillarity



Momentum

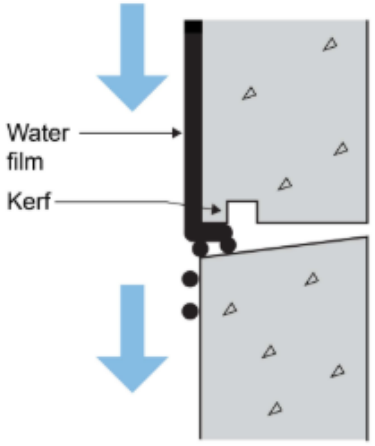
*Reference Source - BS1-117: Rain Control: Drained, Barrier and Mass– Buildingscience.com

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

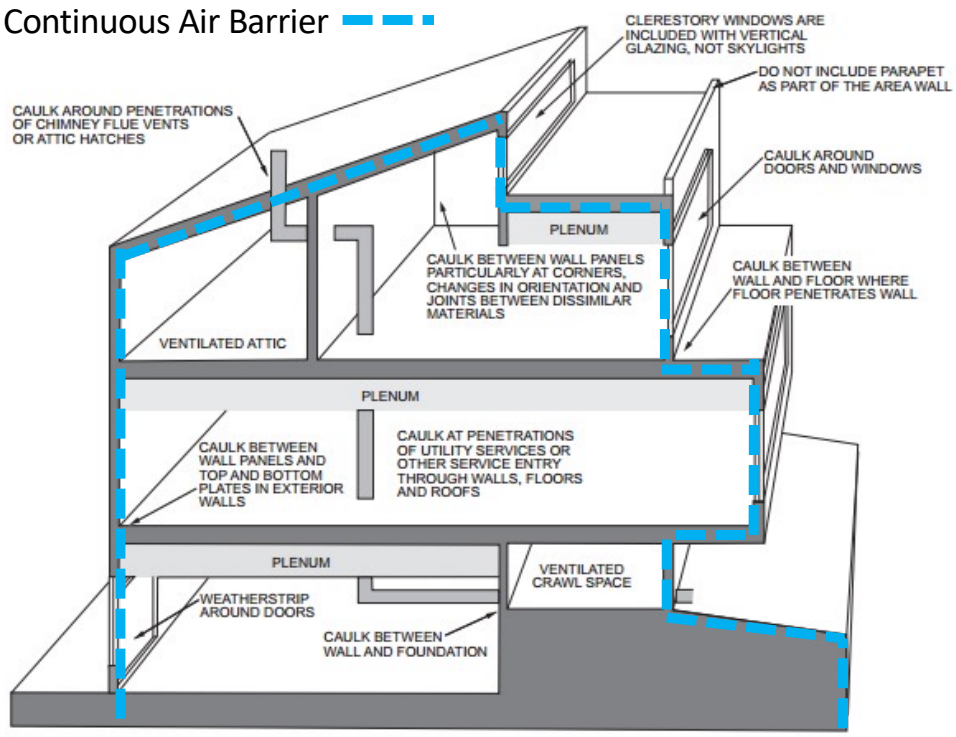
Air Barriers

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.

ASTM E2178:

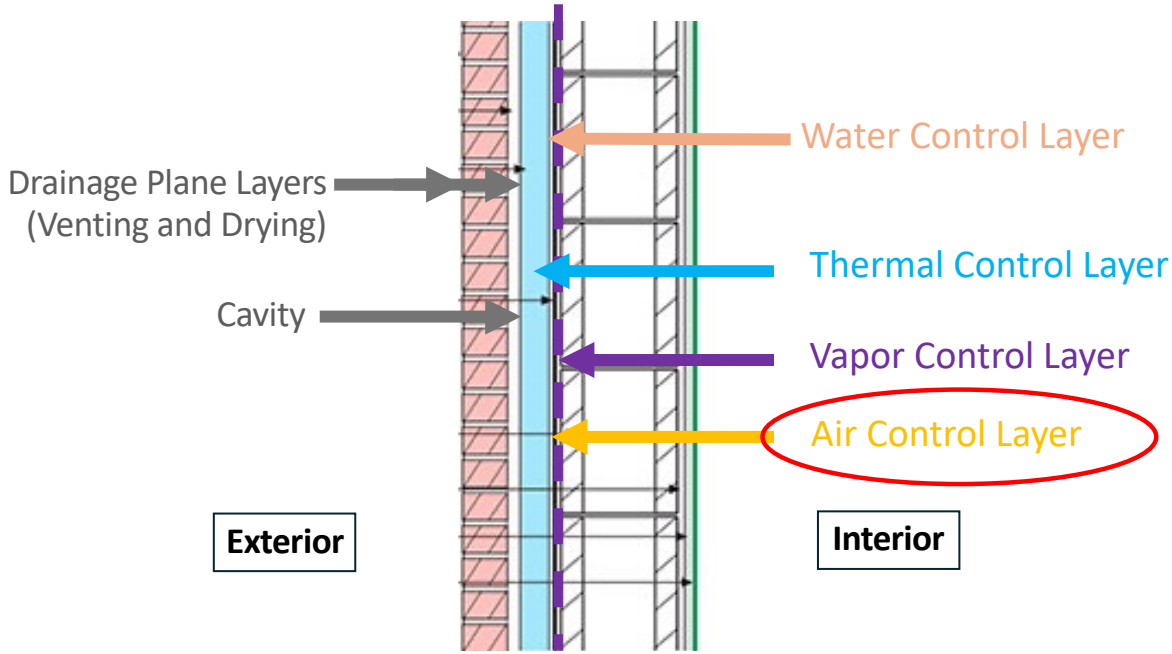
- Air barrier material test method. Air permeance of **0.004 cfm/sf or less** at 0.3" w.g.



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

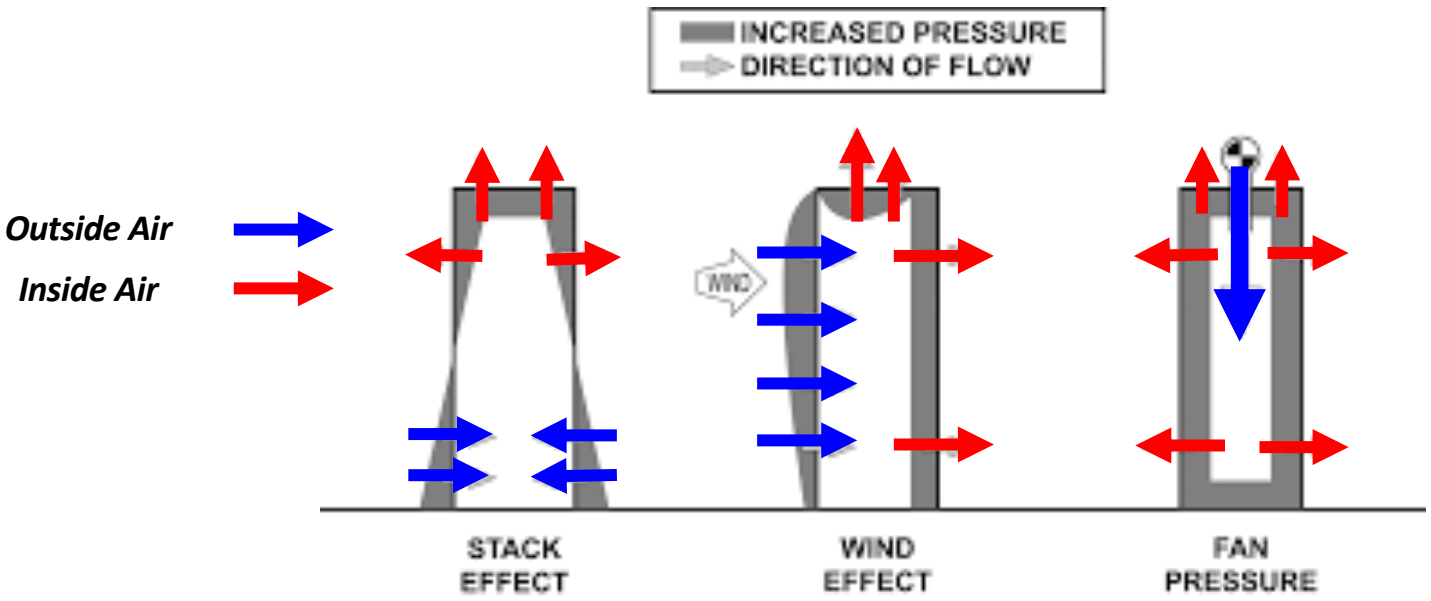
The "Perfect Wall"



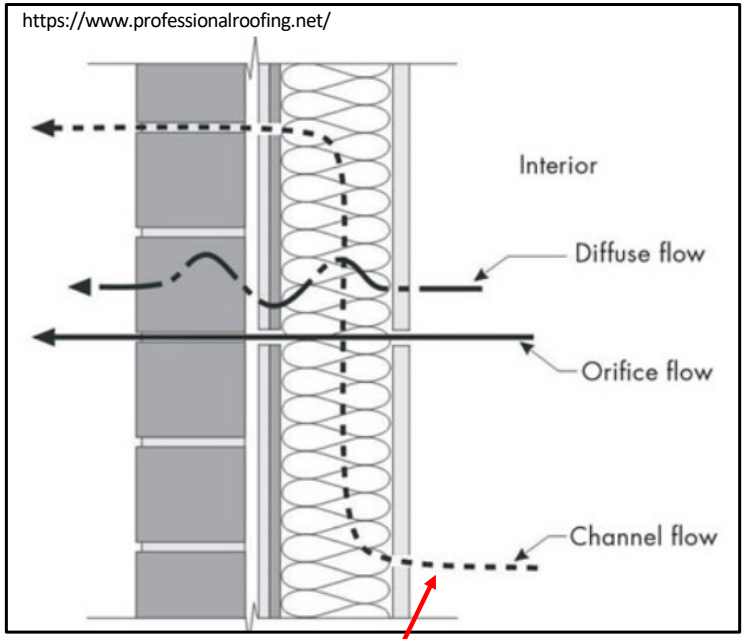
*Reference Source - BS1-001: The Perfect Wall - Building Science.com Corporation

Pressure Sources

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



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

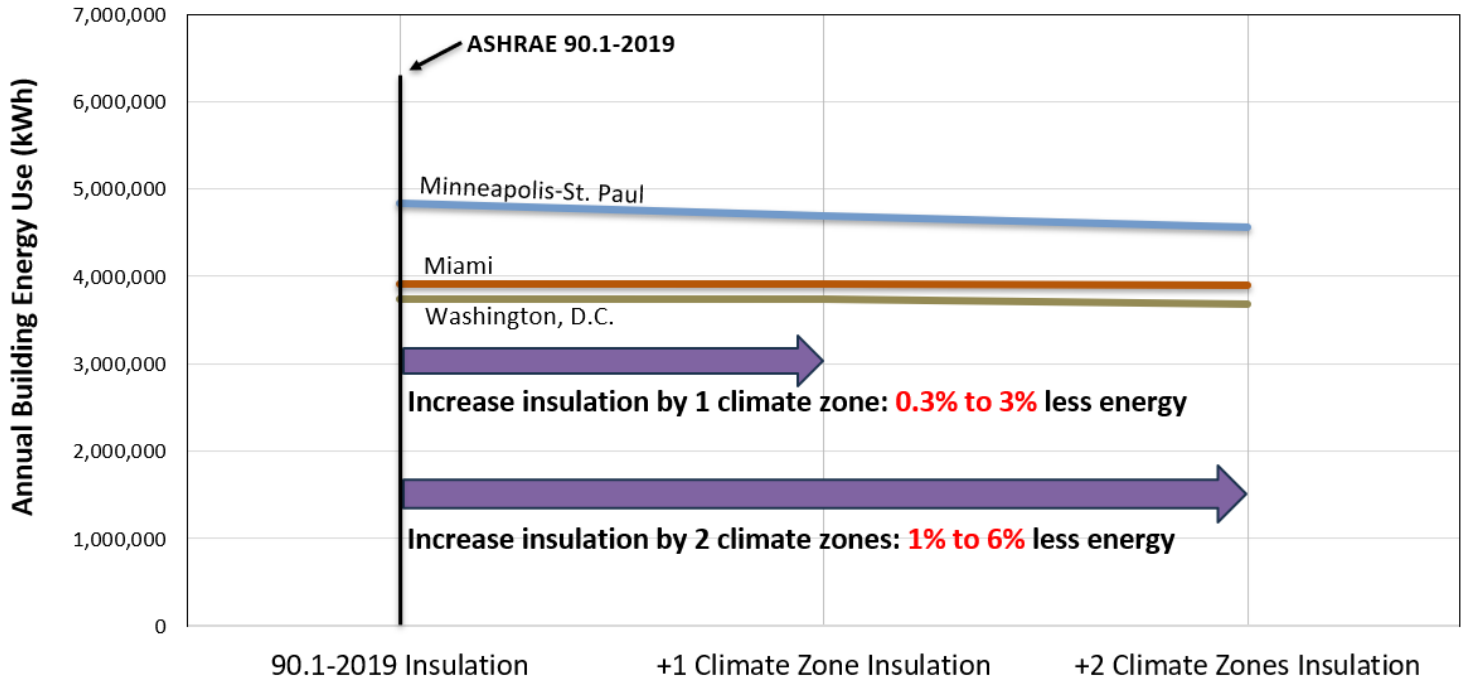
IGCC and UFC 3-101-01 modify that to **0.25 cfm/ft^2**

*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.

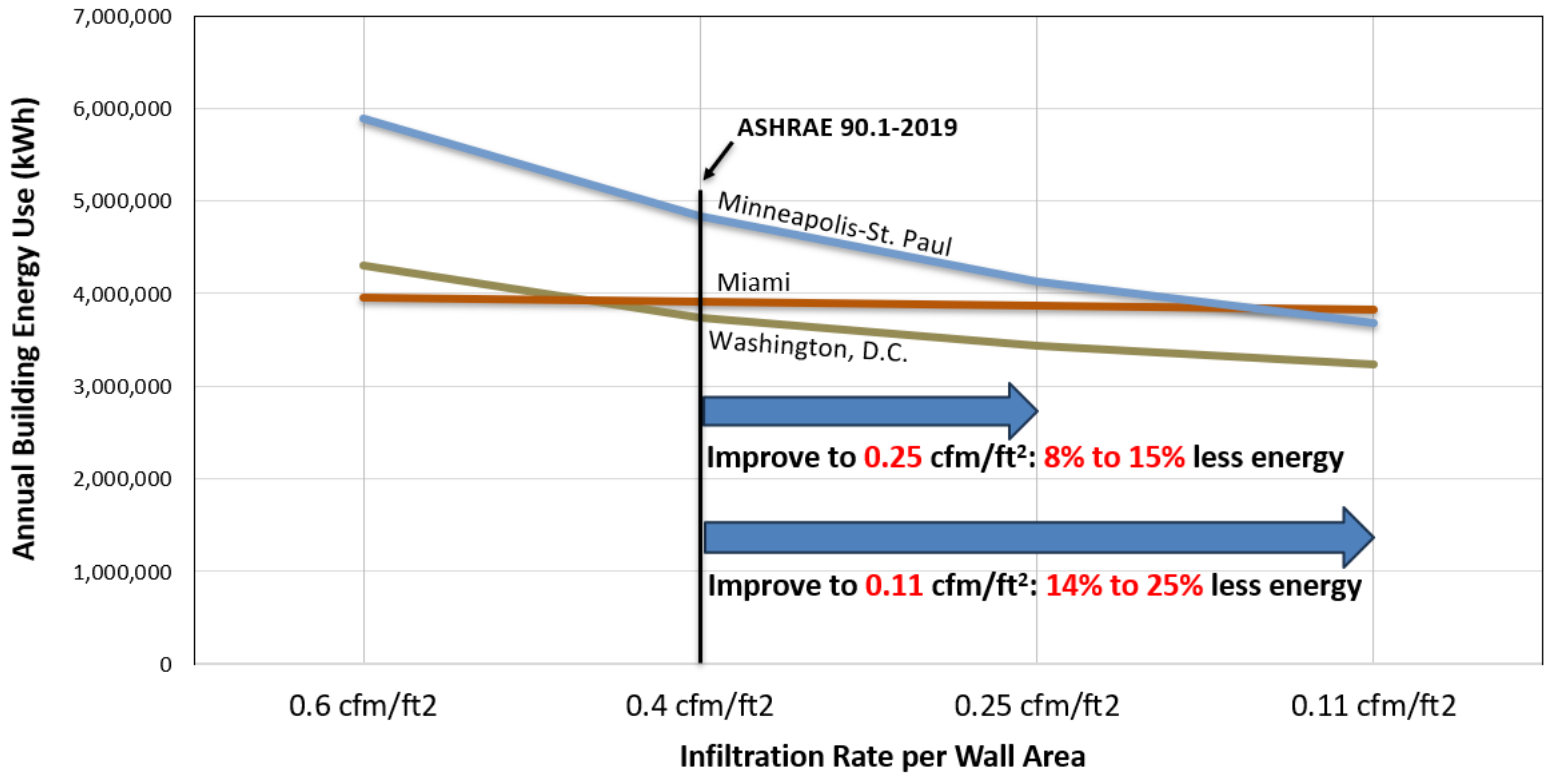
Energy Effects - Insulation

240,000 ft^2 office building



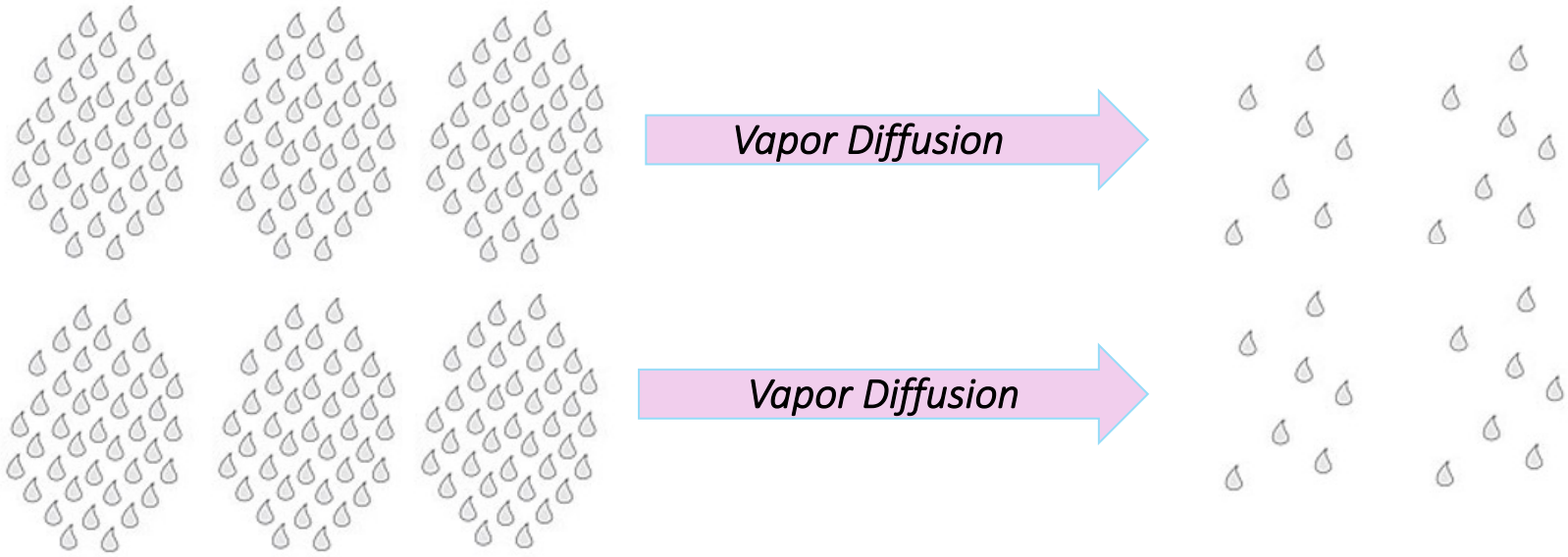
Energy Effects - **Infiltration**

240,000 ft^2 office building



Vapor Control

Vapor Control



Higher Dewpoint Temperature → *Lower Dewpoint Temperature*

Higher Water Vapor Density → *Lower Water Vapor Density*

Higher Vapor Pressure on Warm Side of Assembly → *Lower Vapor Pressure on Cold Side of Assembly*

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

Vapor Control

Goal is to **control the passage of moisture** as it diffuses through the assembly of materials in a wall

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

*Reference Source – R.L. Quirouette – The Difference Between A Vapour Barrier and an Air Barrier
*Reference Source – Waterproof! Magazine, Air Barriers/Vapor Barriers, March 25, 2025

Vapor Control – Vapor Retarder Classes

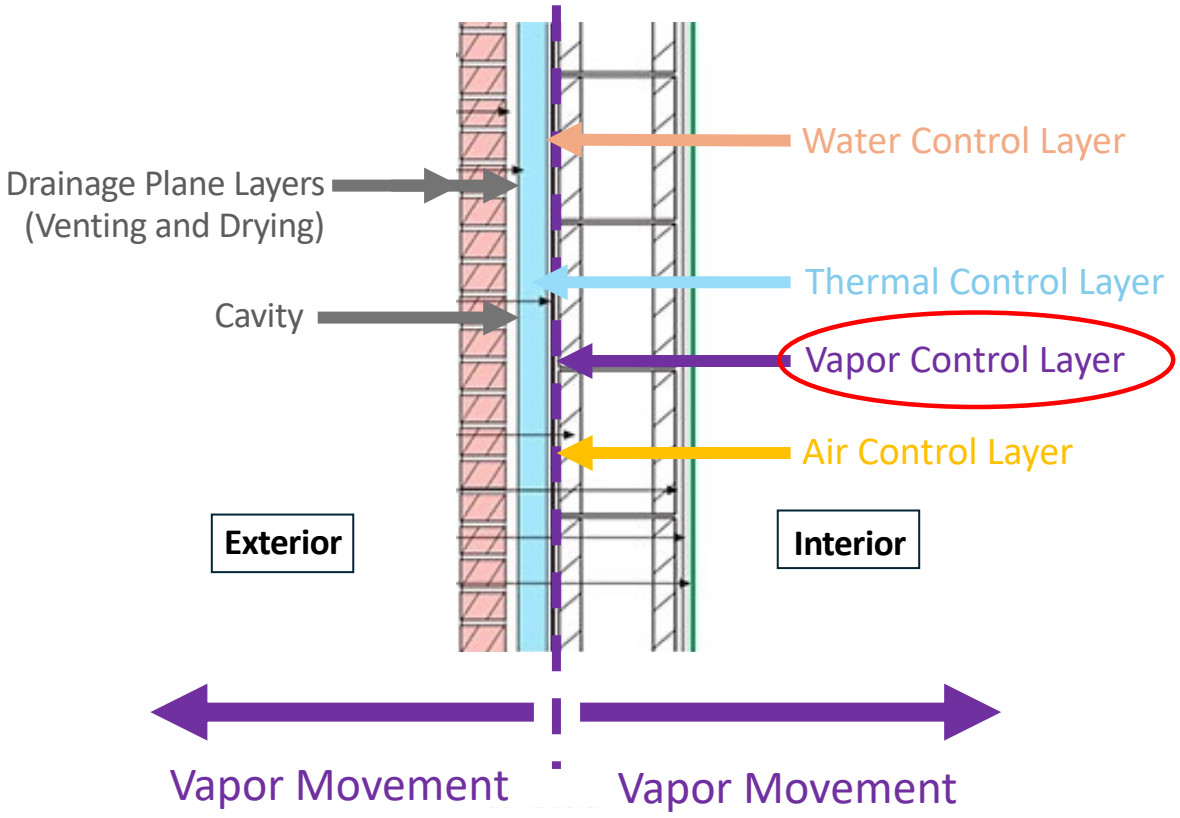
Class I	Class II	Class III
Vapor Impermeable	Semi-Vapor Permeable	Vapor Permeable
0.1 Perm or Less	**>0.1 Perm and < 1 Perm**	**1 Perm or More**
Vapor "Barrier"		
Polyethylene sheets	Kraft-faced fiberglass batts	Gypsum Board and Plaster
Glass, sheet metal	Low-perm paint	Latex Paint
Epoxy coatings	Unfaced expanded polystyrene (EPS)	Cellulose Insulation
Foil-faced insulation sheathing	Fiber-faced Polyisocyanurate	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 vapor barriers such as polyethylene vapor barriers, foil faced batt insulation on the interior of air-conditioned assemblies.
- Installation of vinyl wall coverings on the inside of air-conditioned assemblies.

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

Design To Control Vapor

Requirements

Mason&Hanger
A Day & Zimmermann Company

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

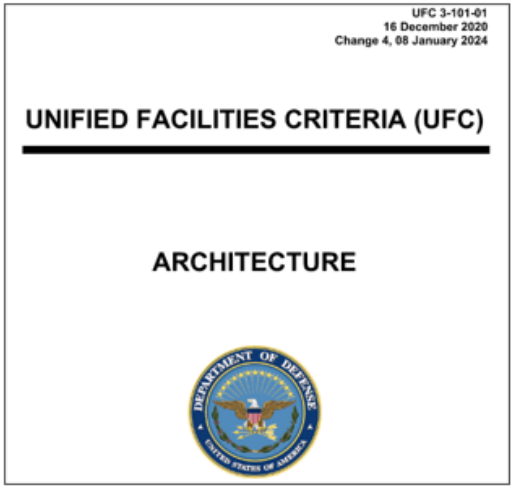
Vapor retarder design:

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.

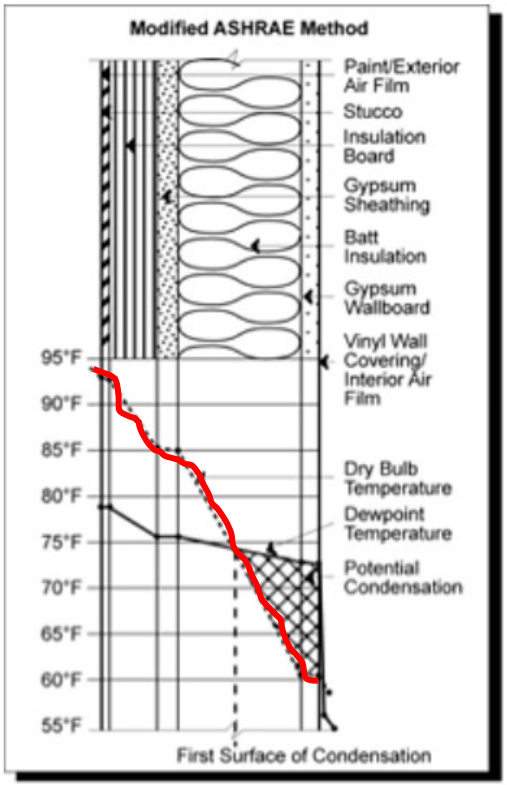
Transient analysis requires software such as WUFI.

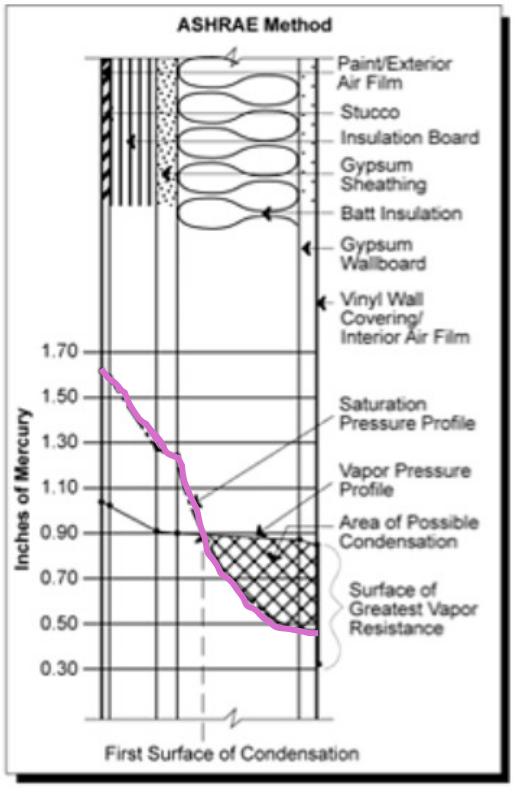

UFC 3-101-01
16 December 2020
Change 4, 08 January 2024

UNIFIED FACILITIES CRITERIA (UFC)

ARCHITECTURE

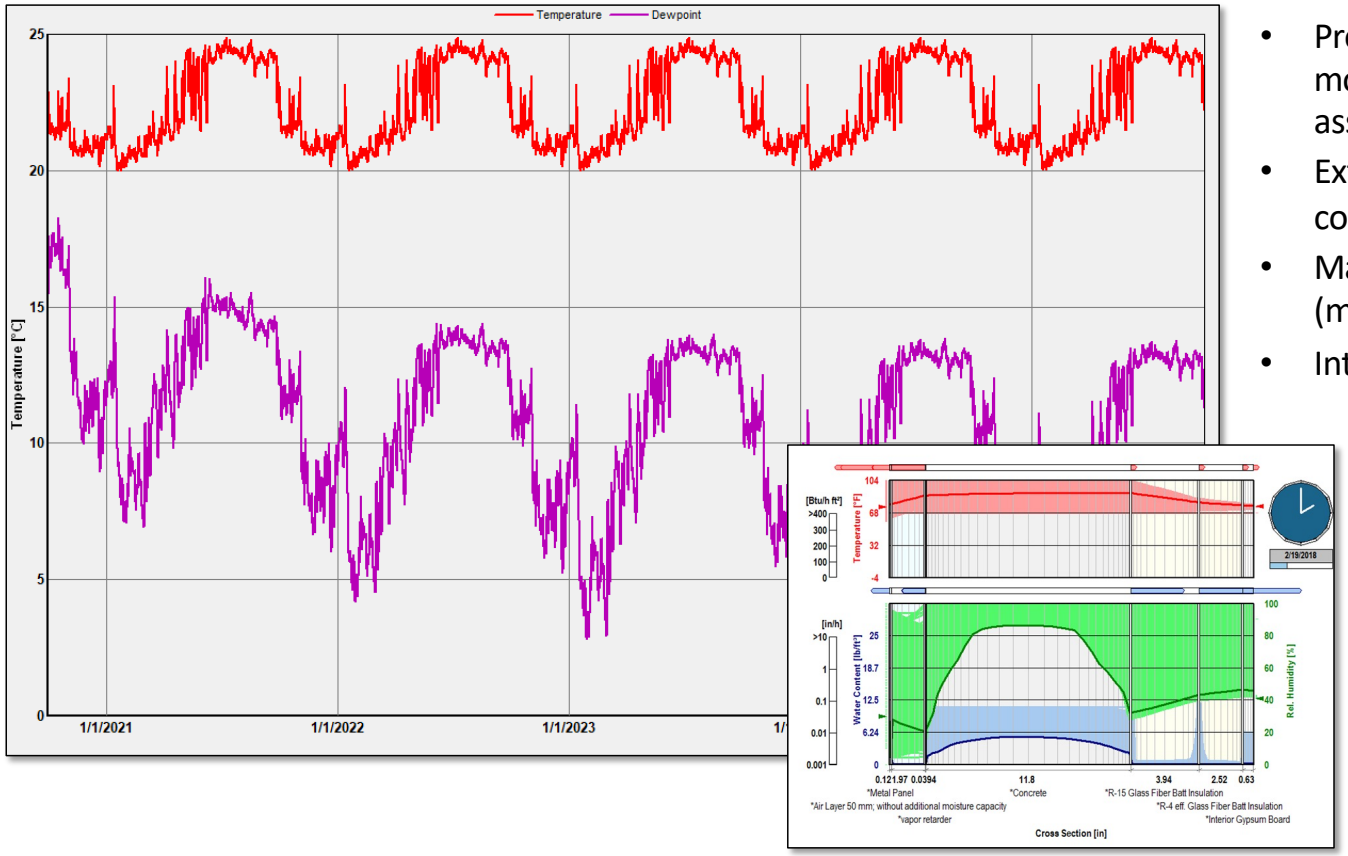
Temperature and Vapor Pressure Gradients





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

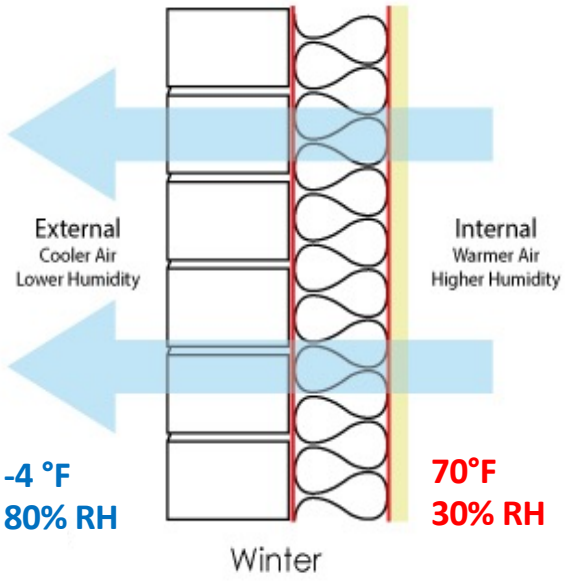
Air Leakage Again, But Worse

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.



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

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

Same Condition, But With Air Leak

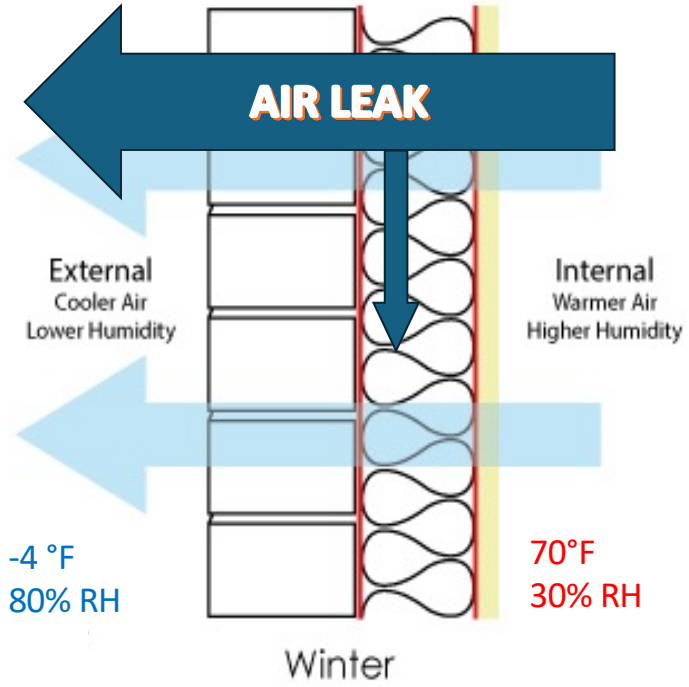
Consider:

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 6 grams of moisture in wall over a month, we get **1,400 grams** (50 oz).



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

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

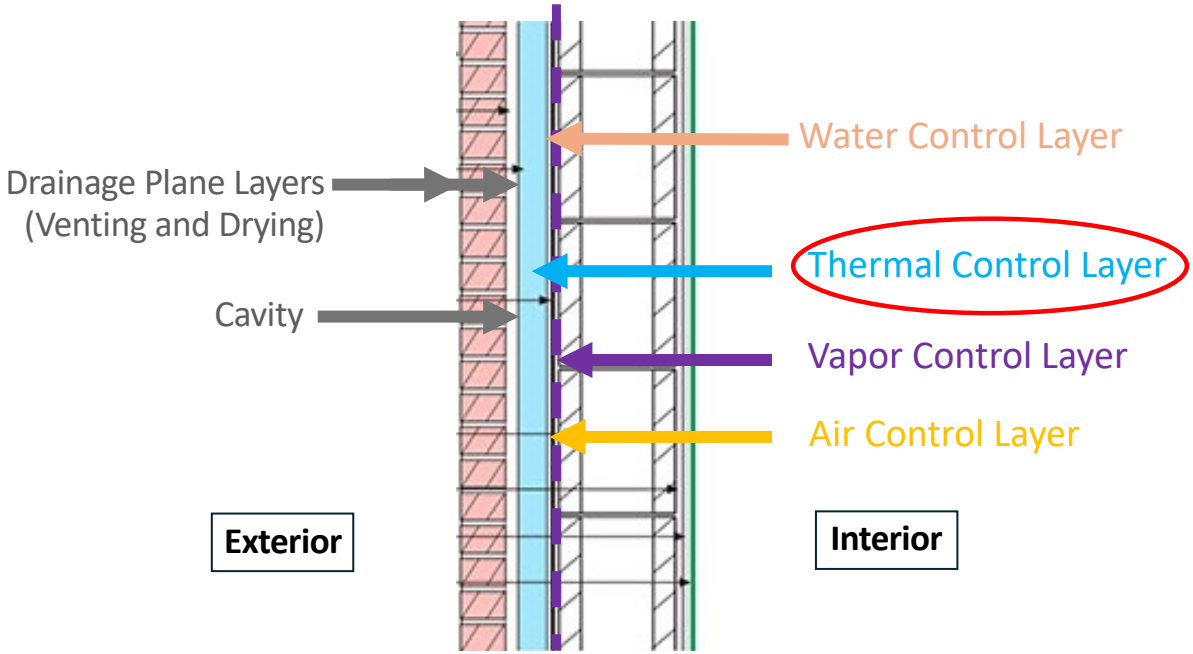
Last and Least: Thermal Control

Why is thermal control mentioned last? Again:

"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."

Insulation is only effective if these other things are under control.

The "Perfect Wall"

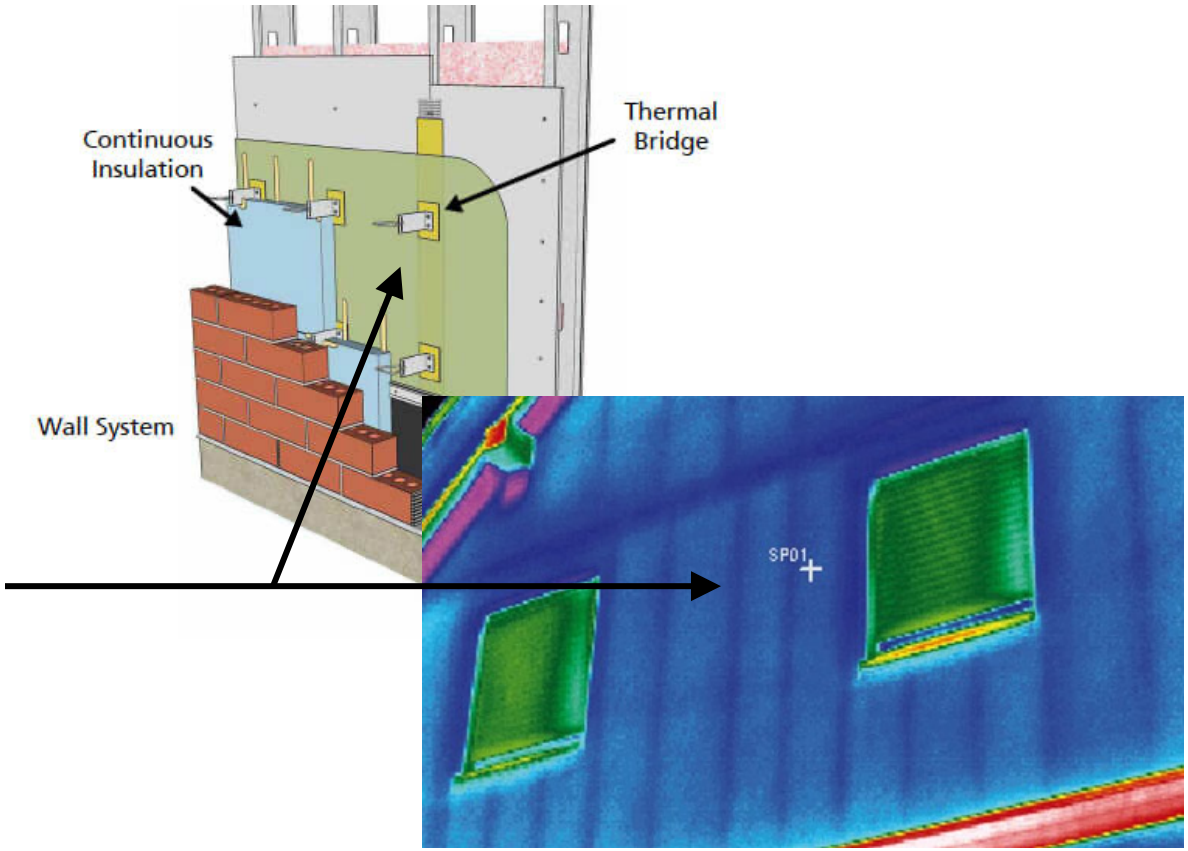


*Reference Source - BS1-001: The Perfect Wall - Building Science.com Corporation

Thermal Control

Control of heat flow in buildings requires:

- Insulation layers with limited thermal bridges (best = continuous insulation).
- Effective air barrier (including joints at windows, doors, and changes in materials and planes).
- Minimize thermal bridges.



Testing & Commissioning

Requirements – Testing/Commissioning

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

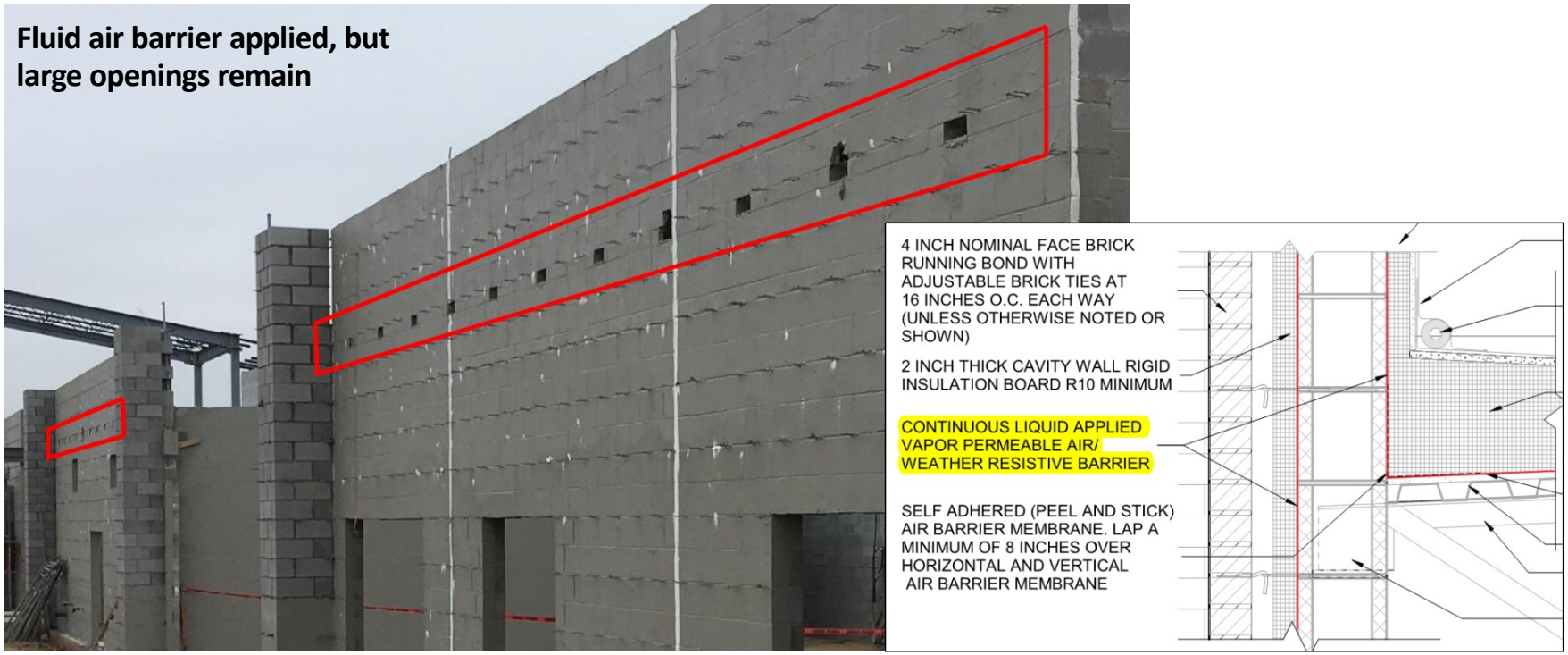
Refers to **01 91 19** for **building enclosure commissioning.** But that is **optional**.

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

If <u>not</u> doing enclosure commissioning, 07 27 10 "Building Air Barrier System" <u>also</u> refers to **01 91 19** for air barrier pressure testing.

Why is commissioning important?

Periodic Field Inspections



Why is commissioning important?

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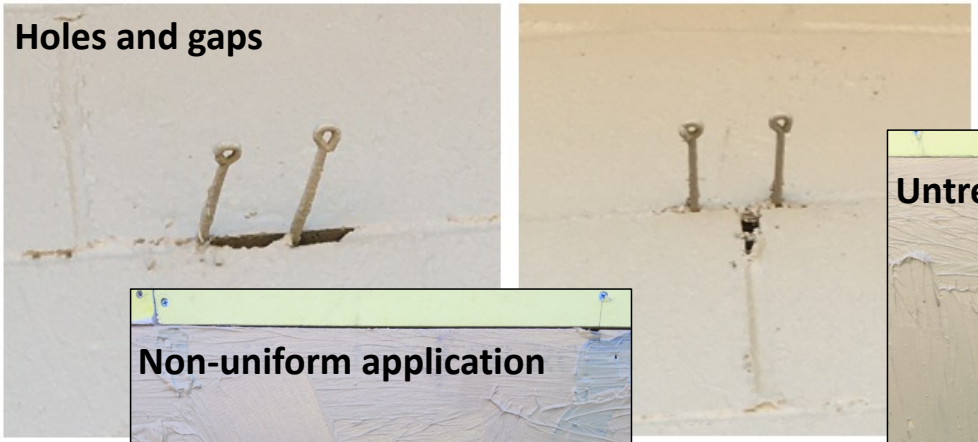
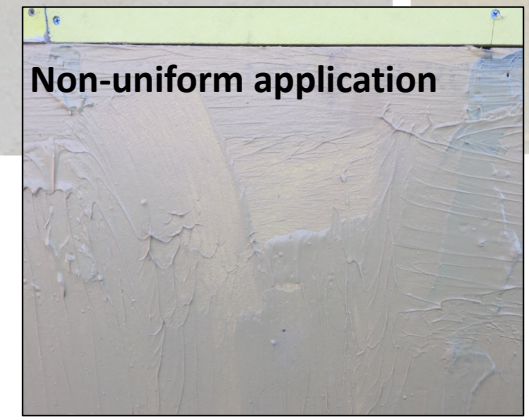
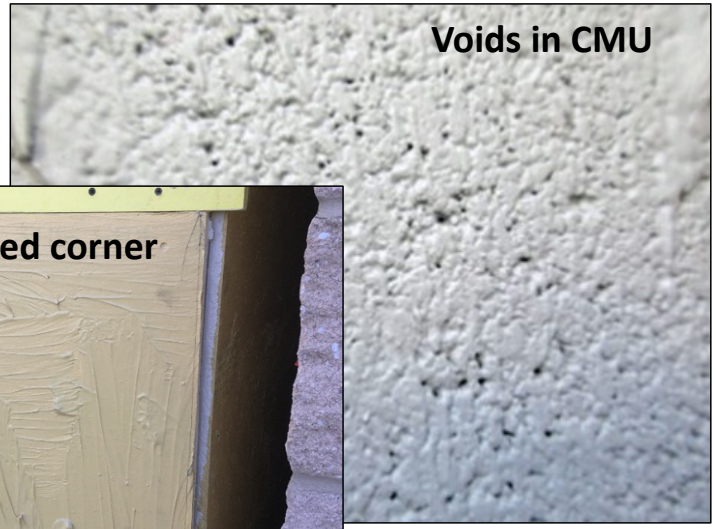






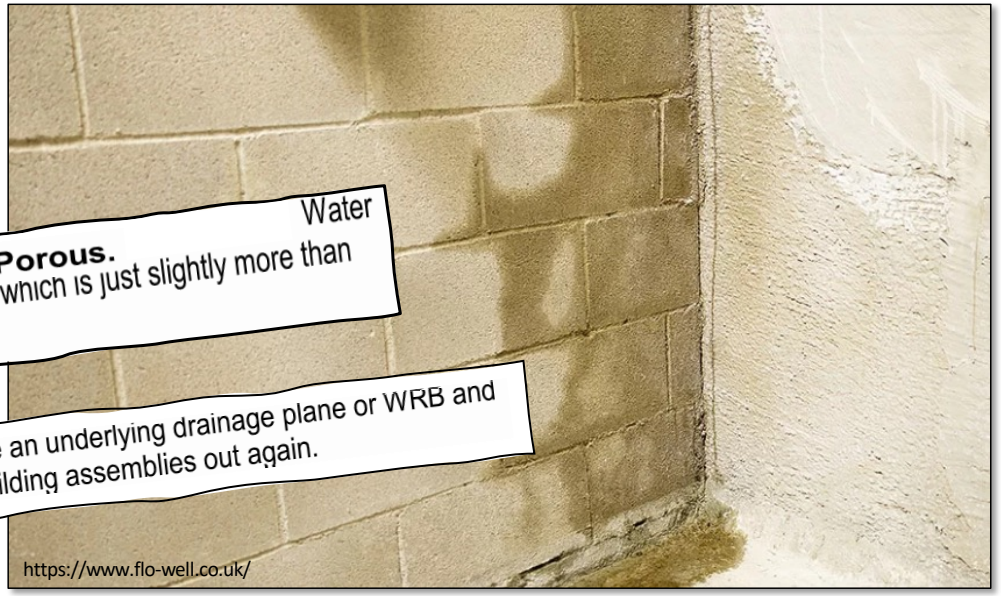
https://iibec.org/issues-encountered-with-barriers/

Water Leakage in Walls

- **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.



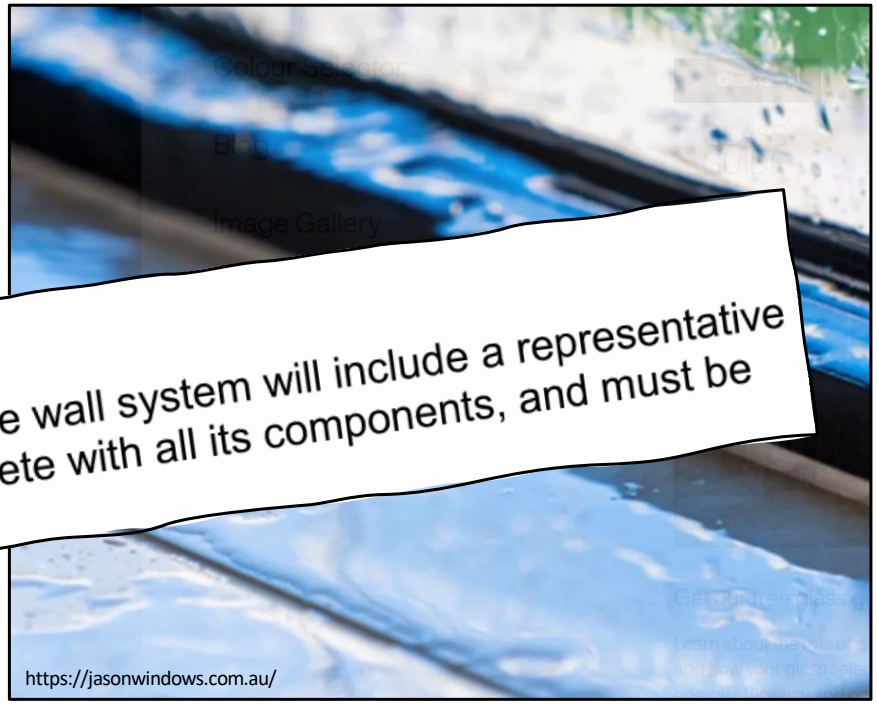
https://www.flo-well.co.uk/

Water Leakage from Windows

Again, **no requirement** in UFC 3-101-01, just a “best practice” suggestion:

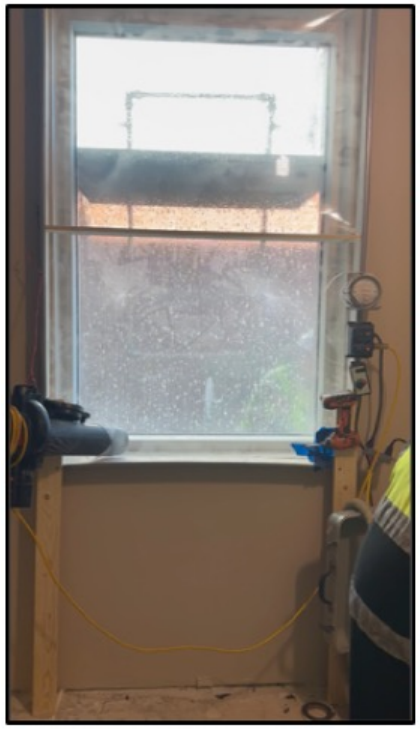
A-6.2 On Site Mock-Ups.

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.



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?