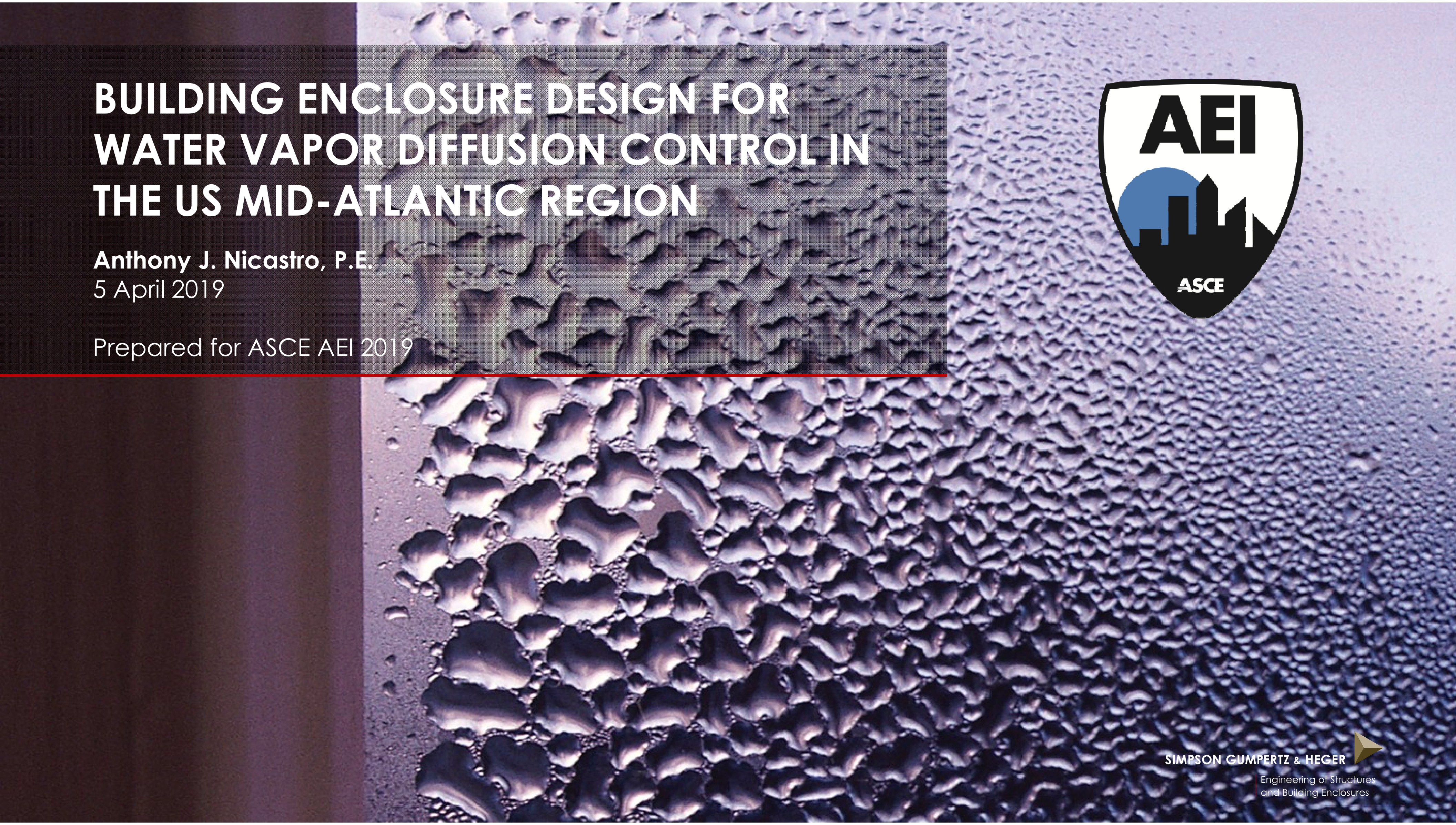

BUILDING ENCLOSURE DESIGN FOR WATER VAPOR DIFFUSION CONTROL IN THE US MID-ATLANTIC REGION

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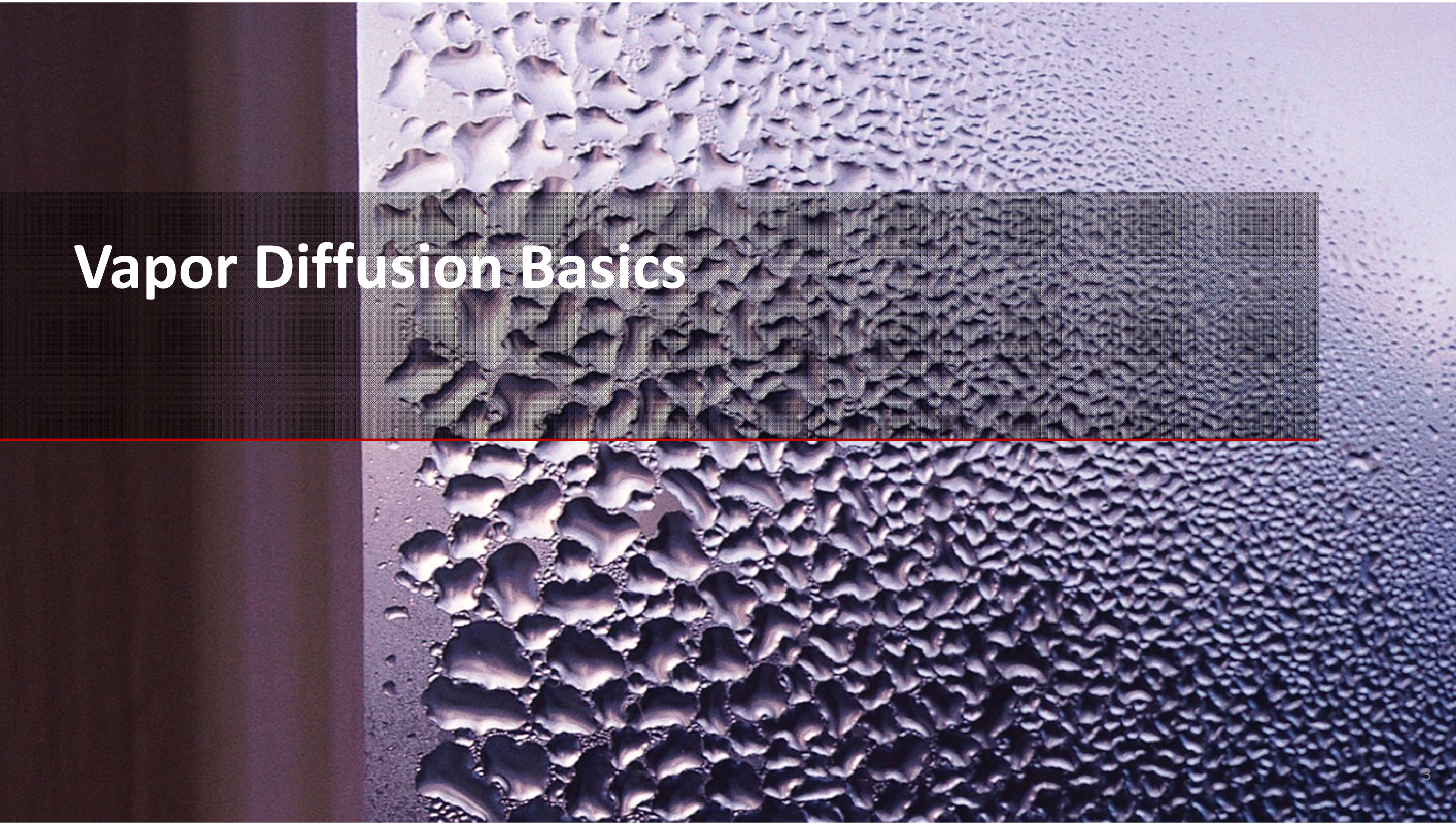
SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

Learning Objectives

1. Understand code requirements for exterior walls that include continuous insulation.
2. Learn about the placement of the air, water, and vapor barriers relative to insulation in walls.
3. Learn techniques to select, review, and analyze different insulation, air barriers, and vapor retarders.
4. Learn about construction considerations designers must negotiate to achieve acceptable performance.

Vapor Diffusion Basics

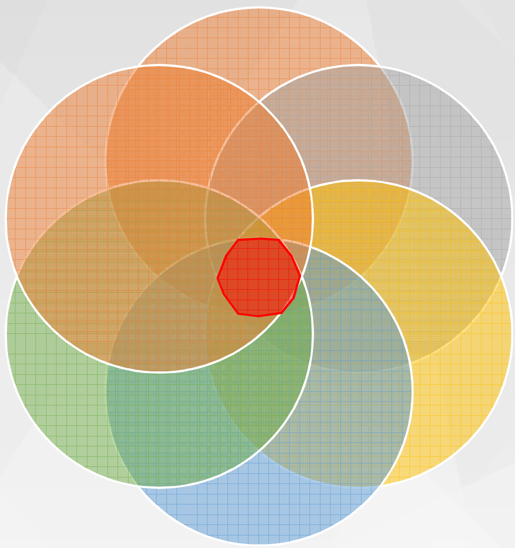


A Few Considerations for Wall Design

Insulation

Structural supports

Weather-Resistive Barrier



Flame Propagation

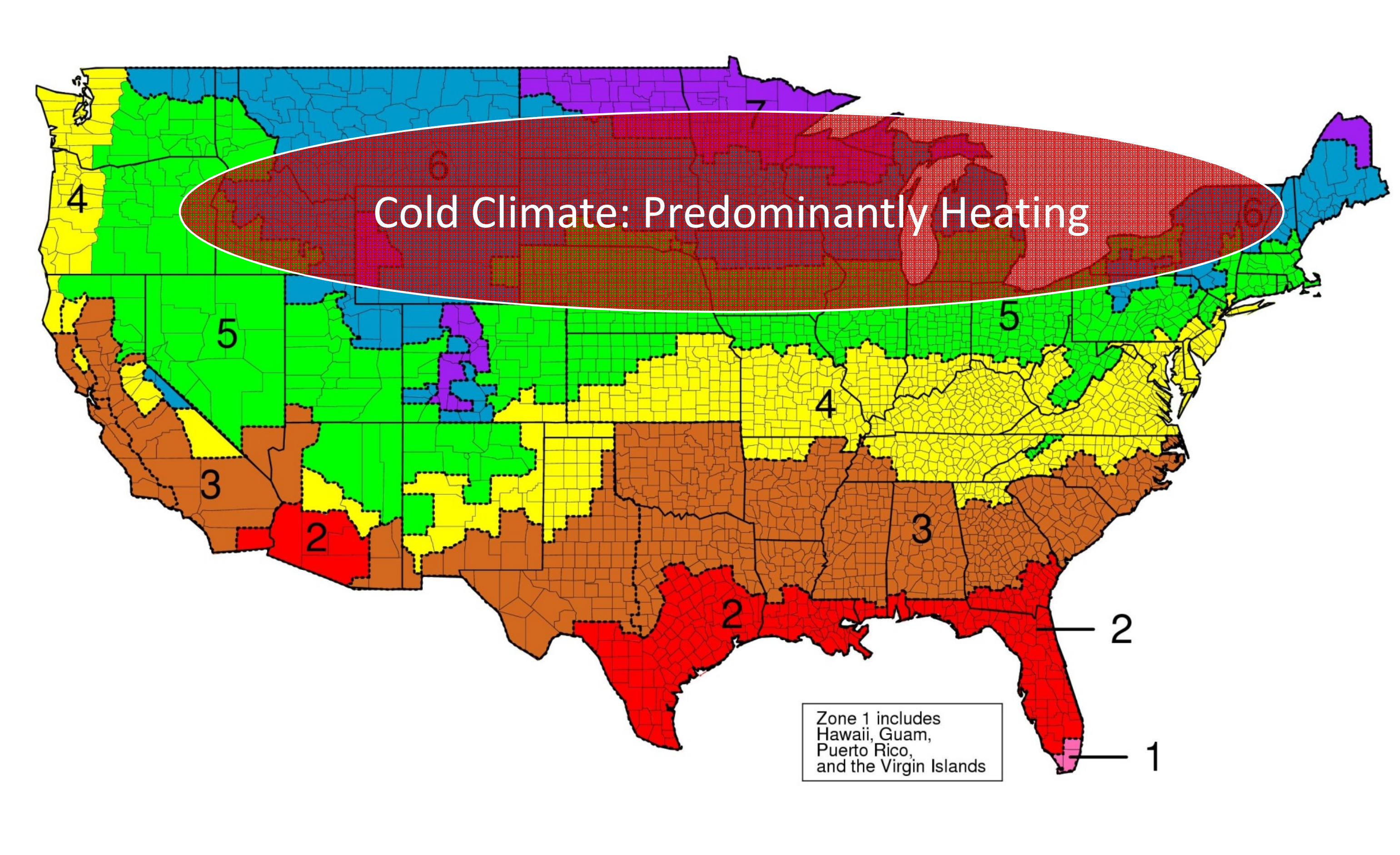
Air Barrier

Vapor Retarder

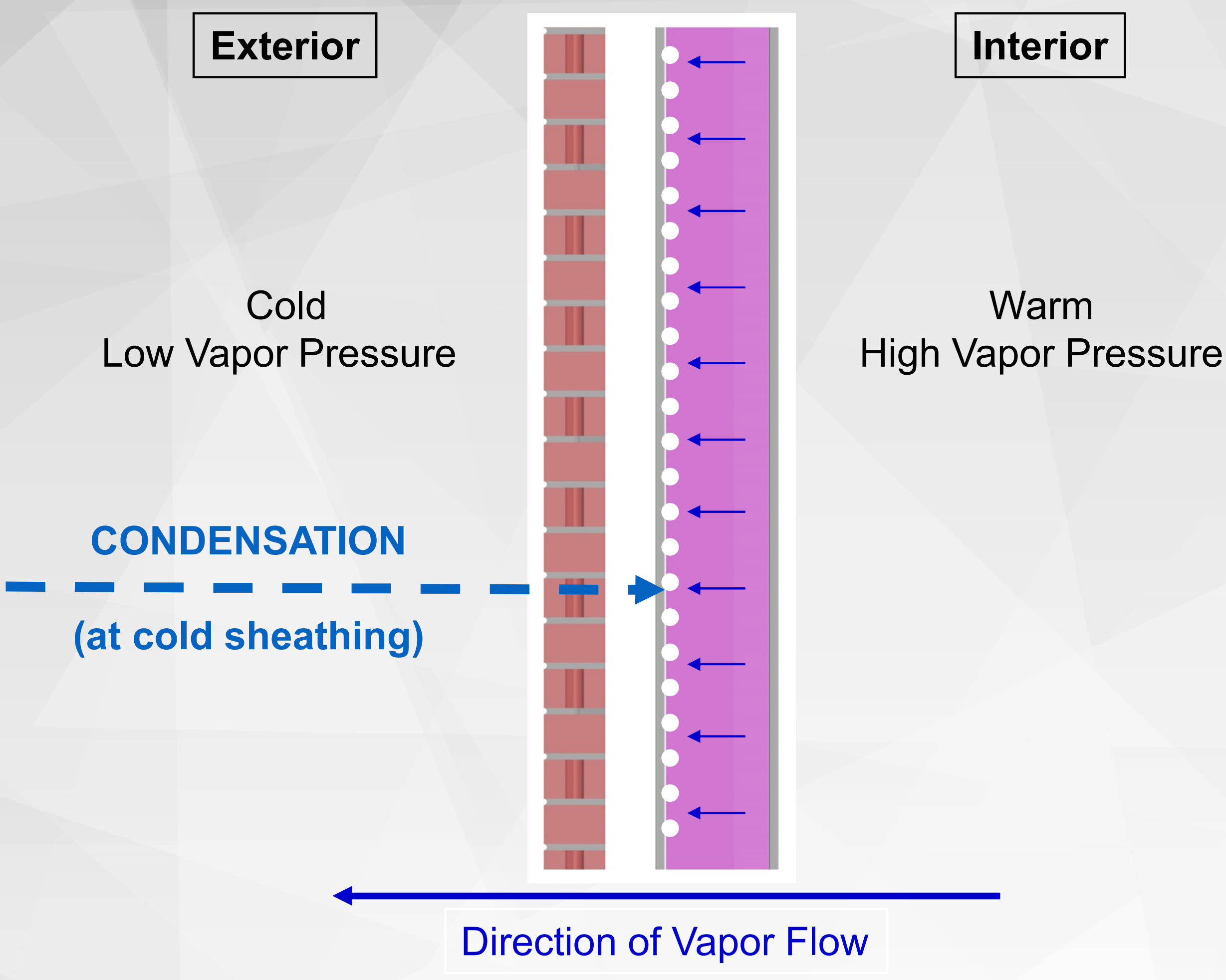
Vapor Retarder

- Controls moisture transport through materials
- Performance requirements:
  - Placement in assembly based on dominant direction of vapor drive and is relative to the insulation
  - Strength is not an issue - does not need to resist forces from difference in air pressure
  - Continuity does not need to be perfect

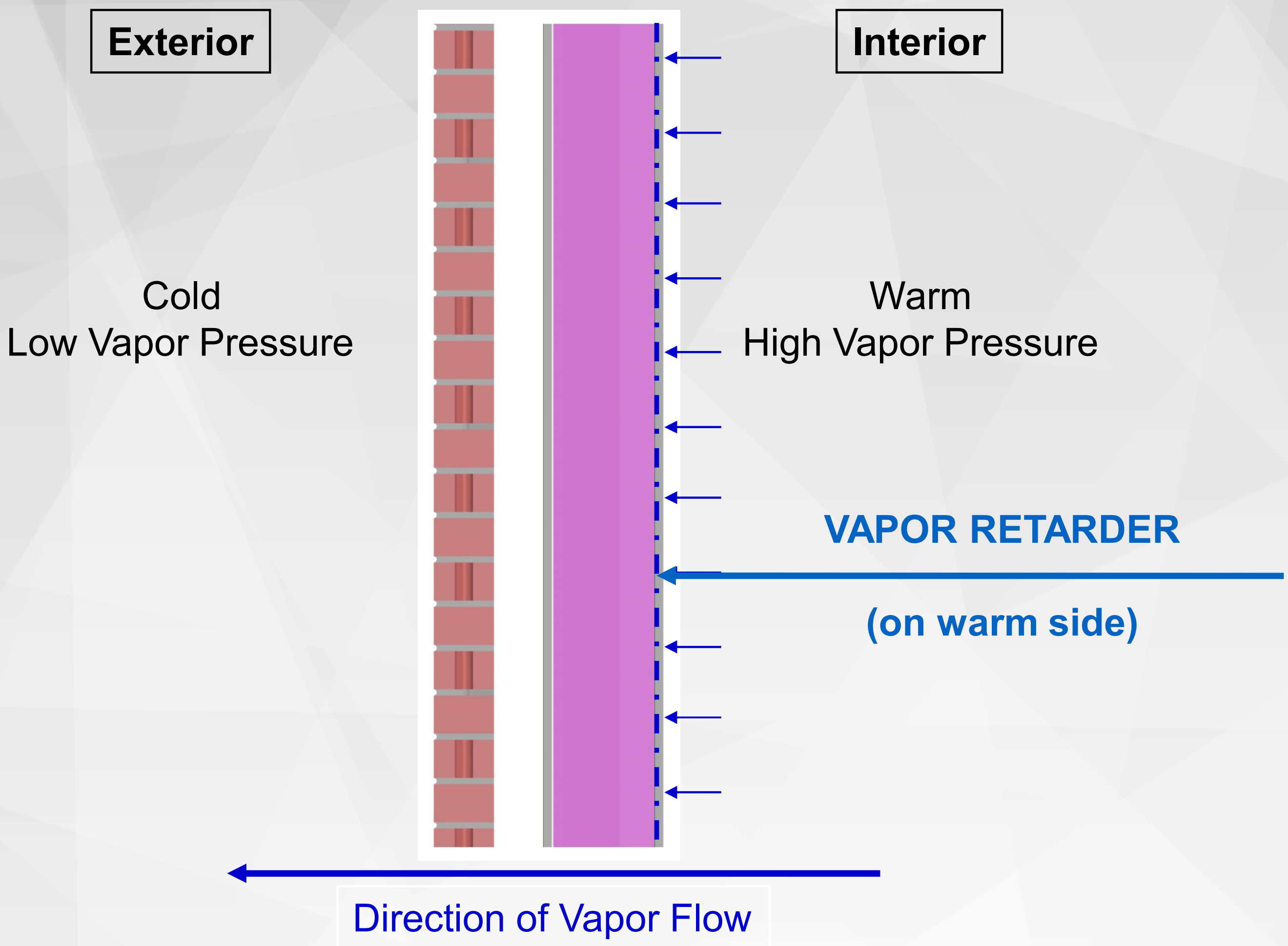
Climatic Variation



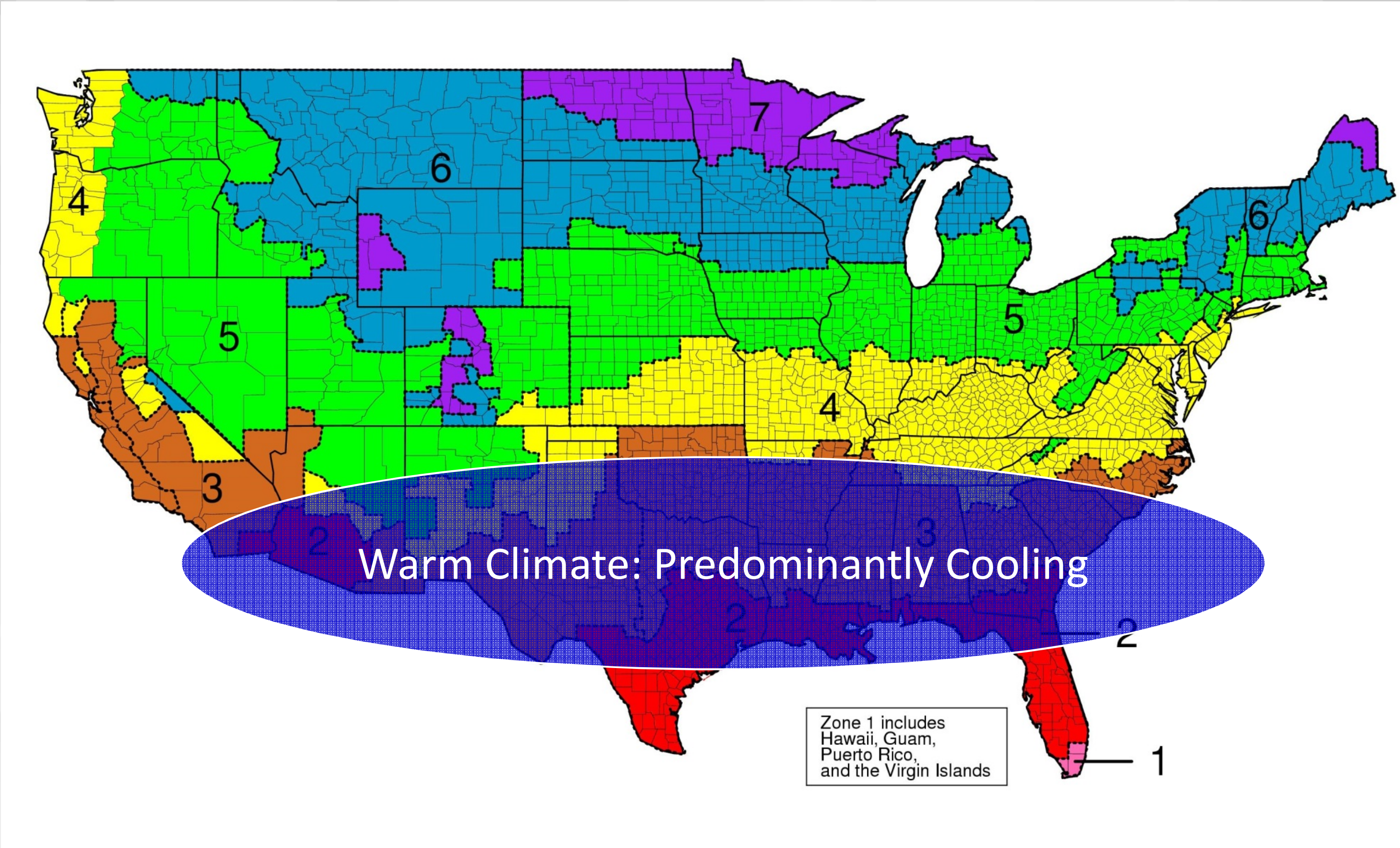
Vapor Flow- Cold Climate



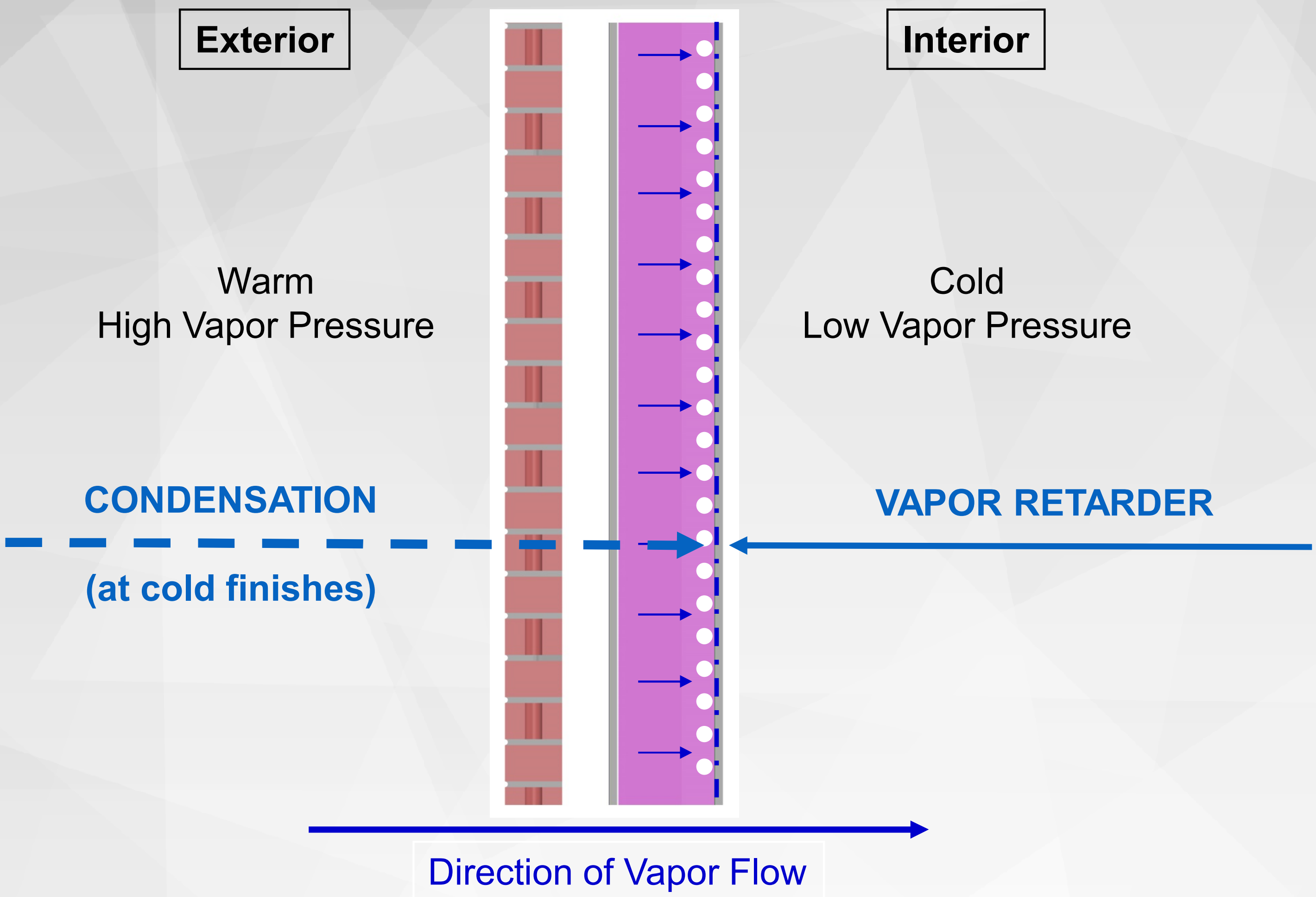
Vapor Flow- Cold Climate



Climatic Variation



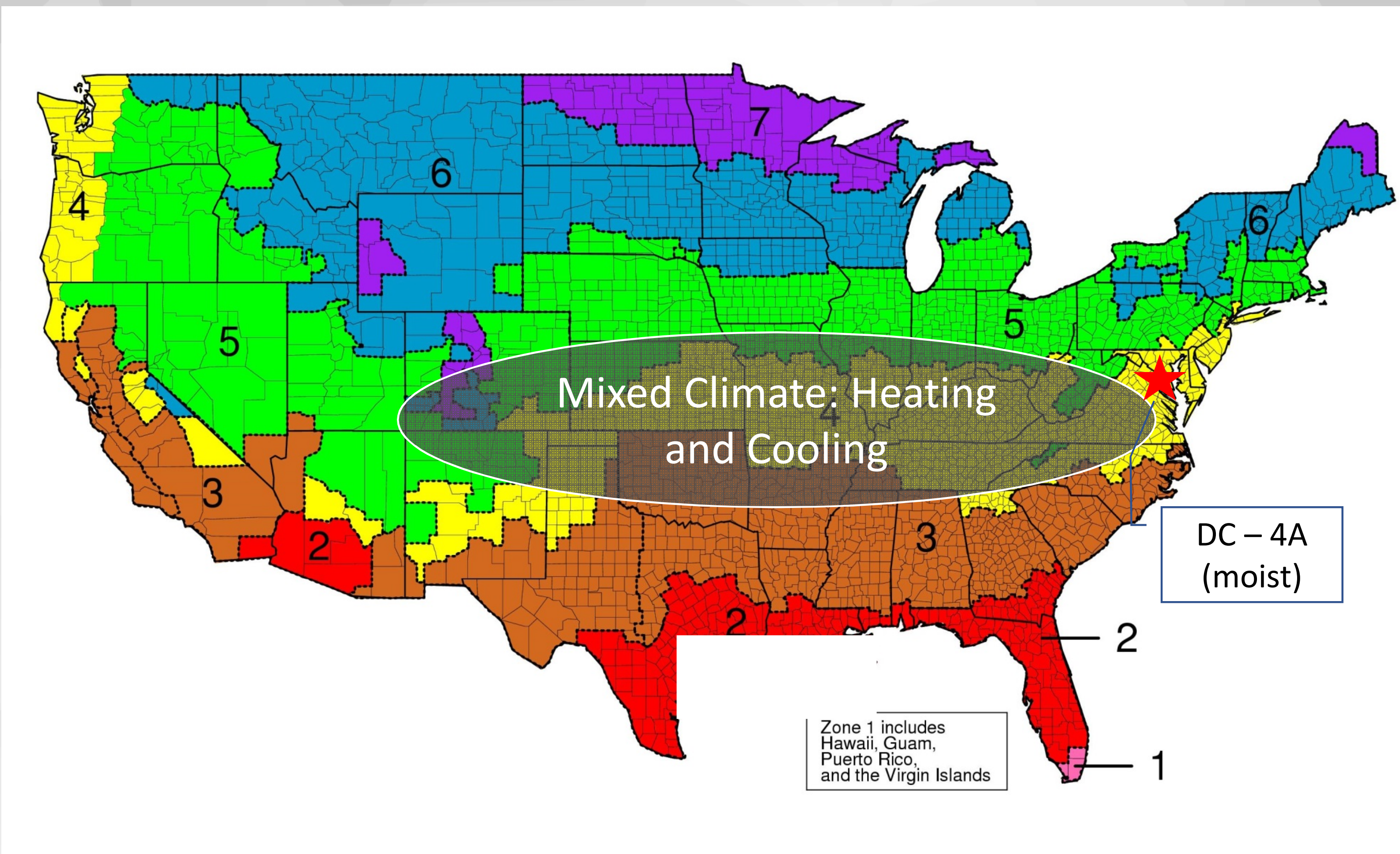
Vapor Retarders – Warm Climate



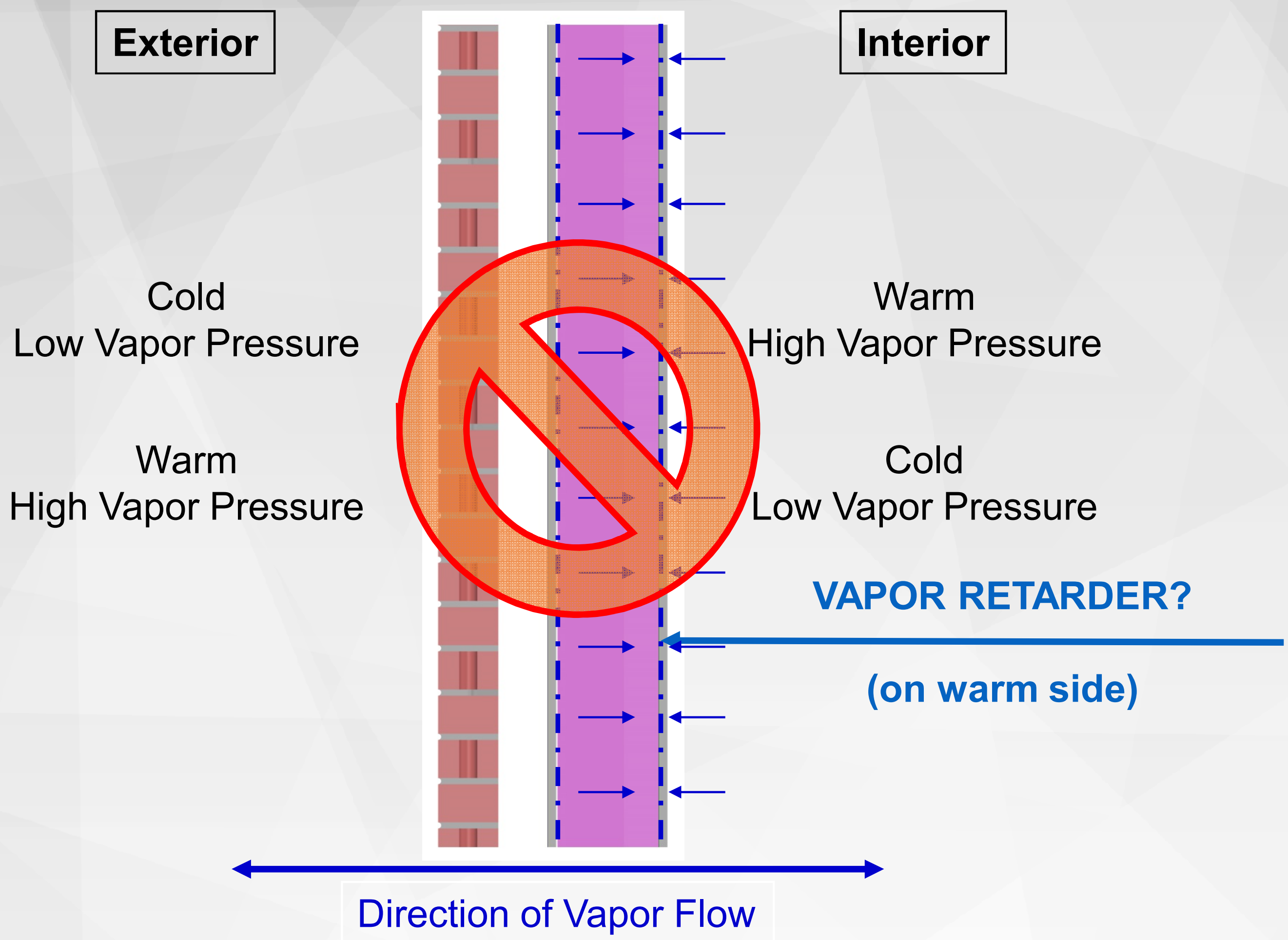
Vapor Retarders – Warm Climate

- Consequences of improper vapor retarder placement

Climatic Variation



Vapor Retarders – Mixed Climate



Current Requirements- 2015 IBC

For a vapor retarder

- Section 1405.3 Vapor retarders – Provide a vapor retarder per 1405.3.1 and 1405.3.2 or approved design using accepted engineering practice for hygrothermal analysis.
- Section 1405.3.1- Class I and II Vapor Retarders
  - requires a Class I or II vapor retarder be provided on the interior side of frame walls in Zones 5, 6, 7, and 8 or Marine 4.
  - Prohibits Class I and II vapor retarders on interior side of frame walls in Zones 1 and 2.
  - Prohibits Class I vapor retarders on interior side for frame walls in Zones 3 and 4
- Section 1405.3.2- Class III Vapor Retarders
  - Table 1405.3.2 Shows where Class III are permissible for Climate Zones Marine 4, 5, 6, 7, and 8.

Current Requirements- 2015 IBC

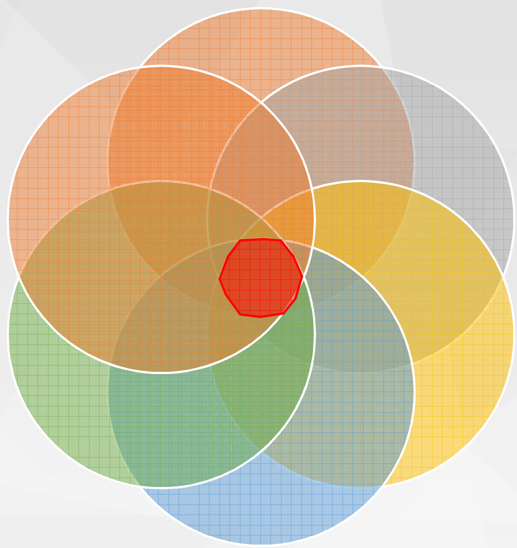
- Climate Zone 4 requirements for interior-side vapor retarders:
  - Class I vapor retarder is prohibited
  - Class II vapor retarder is permissible but not required
  - Class III vapor retarder is not permissible
- Options for Climate Zone 4:
  - Split insulation assembly, consider supporting hygrothermal analysis
  - Class II winter-warm side vapor retarder
  - No vapor retarder
- We are in the land of project-specific analysis

Multiple Considerations for Walls

Insulation

Structural supports

Weather-Resistive Barrier

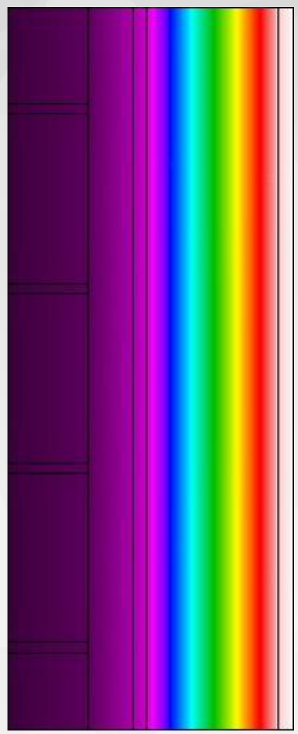


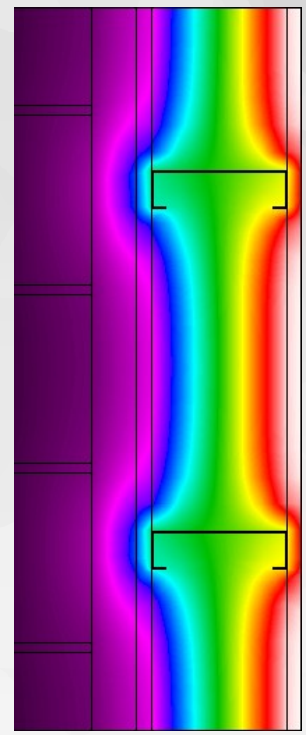
Flame Propagation

Air Barrier

Vapor Retarder

A Brief History





Insulating Value Reduced by 50%

A Brief History

- Insulation placed between framing members is thermally inefficient
- Continuous insulation is more efficient, and the AEC industry demands efficiency
- Moving insulation into the wet zone of the walls has many consequences

Split Insulation

Projects built per current code requirements include provisions for split insulation in walls

Example Analysis

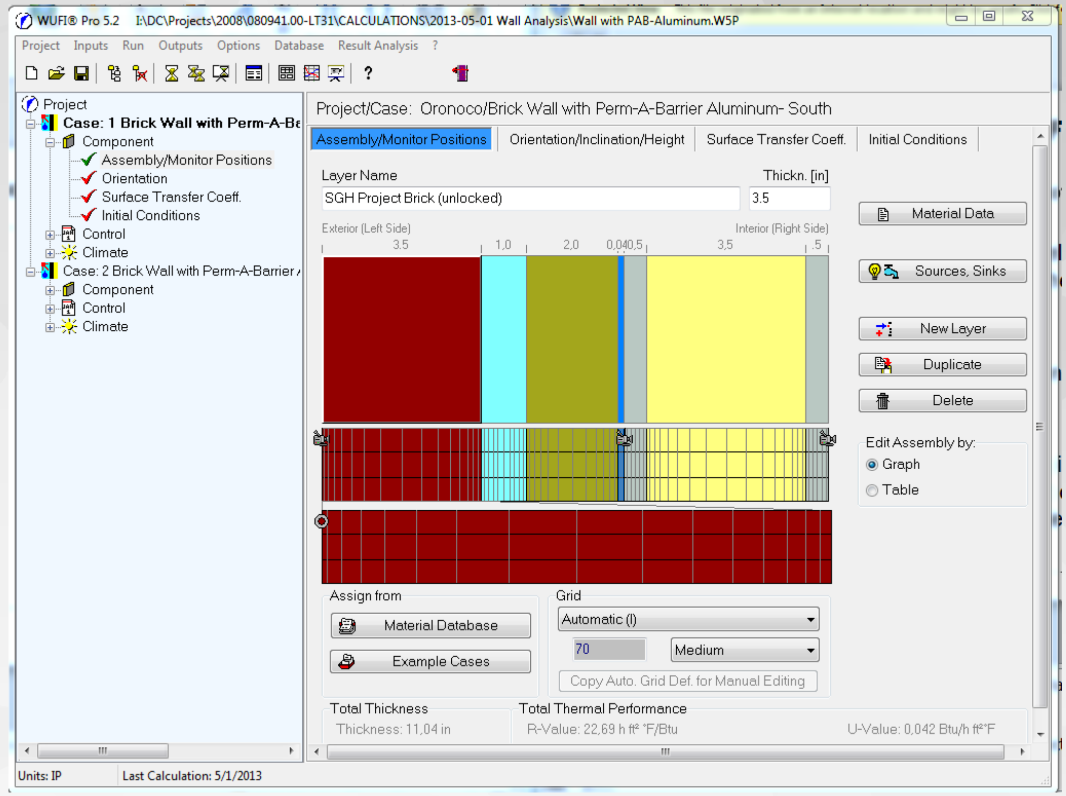
- Vary the position of the vapor retarder relative to insulation

- Boundary Conditions
  - DC Metro Area: Climate Zone 4
  - Vapor impermeable air/water barrier on exterior sheathing
  - Interior temperature varies between 68˚F and 72˚F
  - Interior relative humidity varies between 30% RH and 60% RH

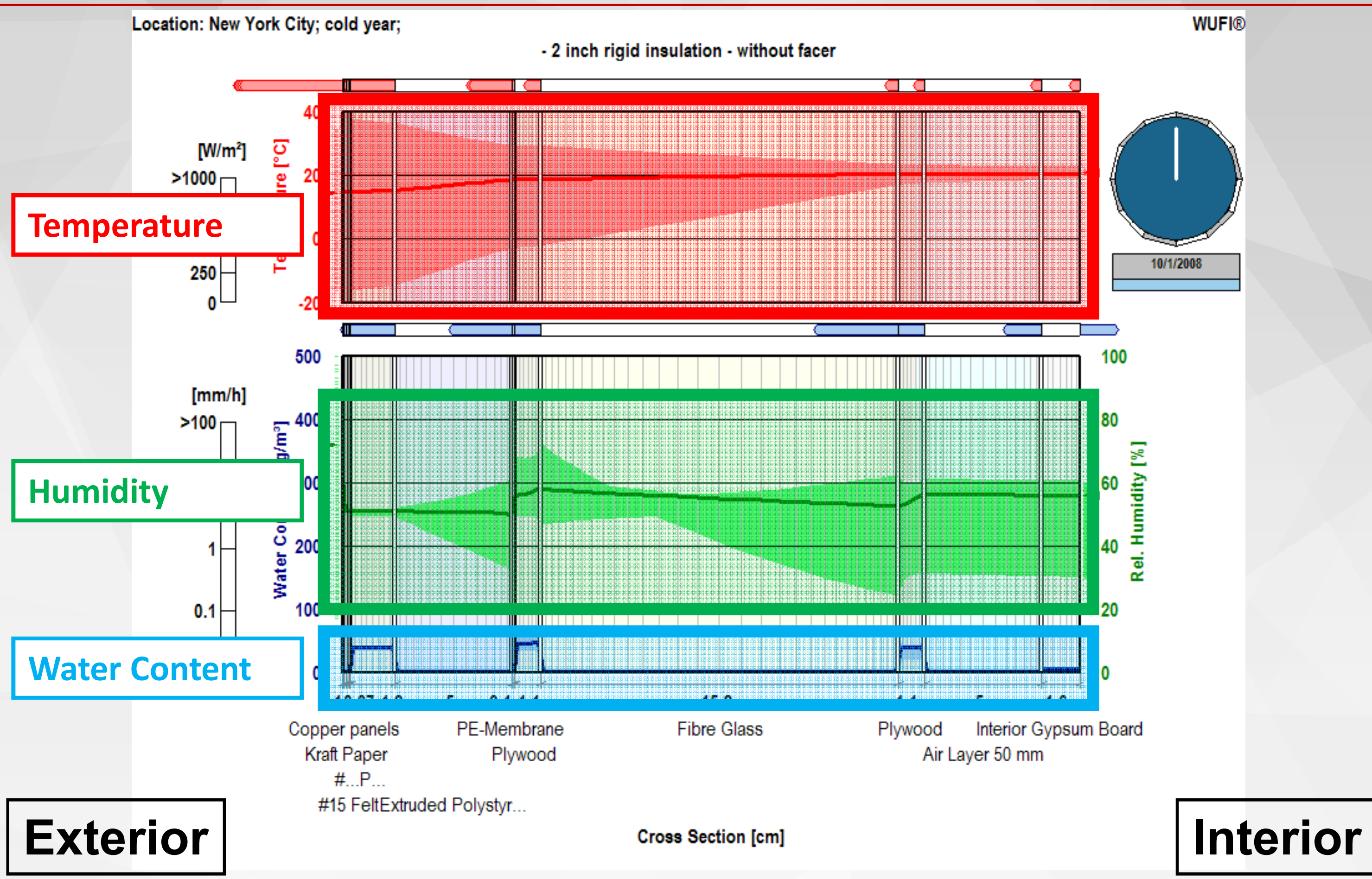
Analysis Tool- WUFI (Wärme und Feuchte Instationär)

WUFI – Calculates transient one-dimensional heat and moisture flow through building components.

We use primarily to assess potential for condensation and moisture accumulation.



WUFI Output



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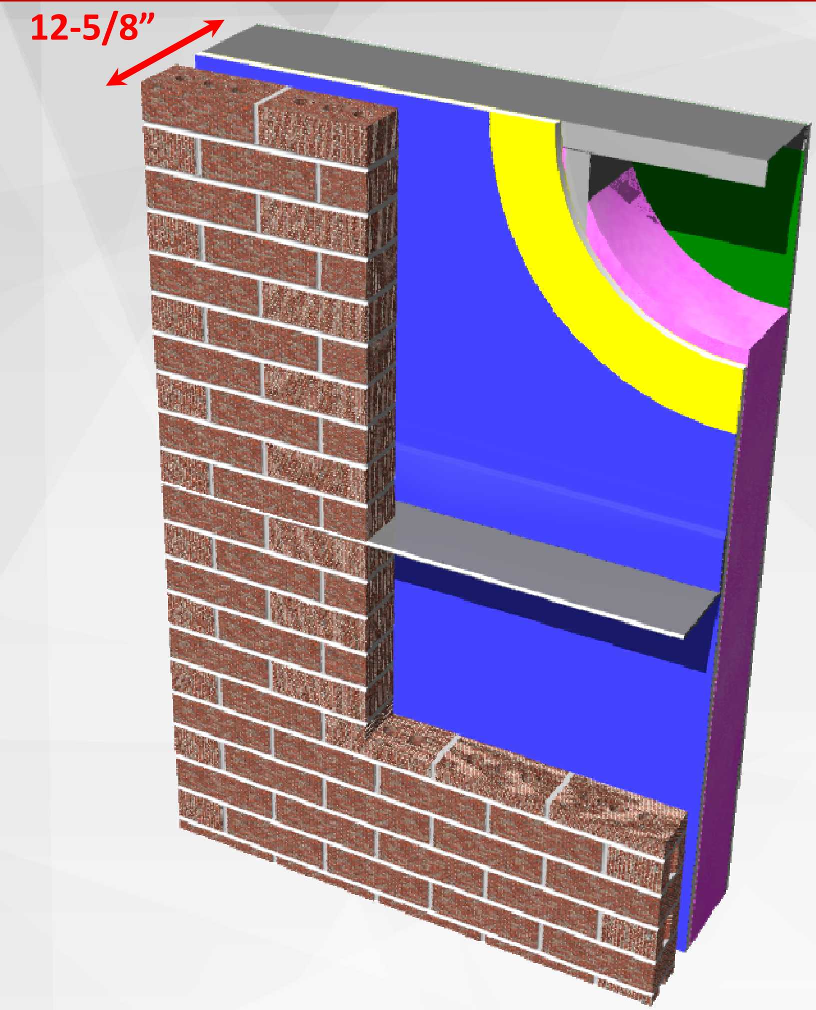
Results Analysis

- Analyze WUFI results to minimize risk of condensation and microbial growth
  - Condensation: change in state from vapor to liquid, will occur at building components with surface RH of 100%
  - Microbial growth: requires a food source (organic material) and adequate temperature and moisture

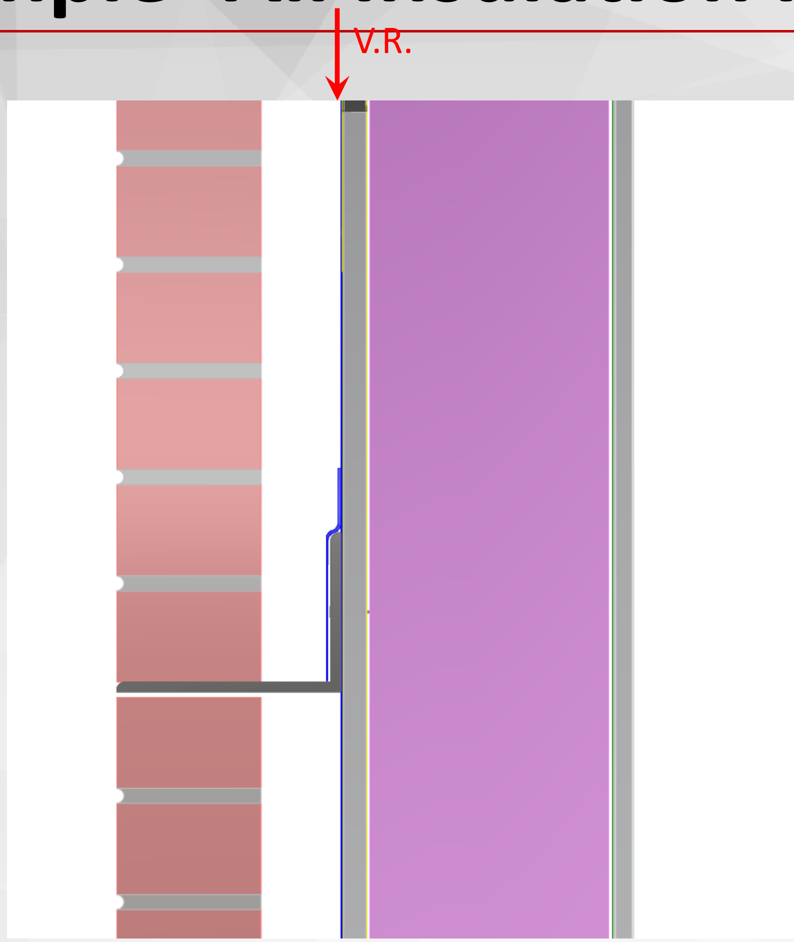
- Performance Criteria
  - Condensation: Instantaneous surface RH > 95% RH
  - Microbial Growth: Mold Index (M) < 3

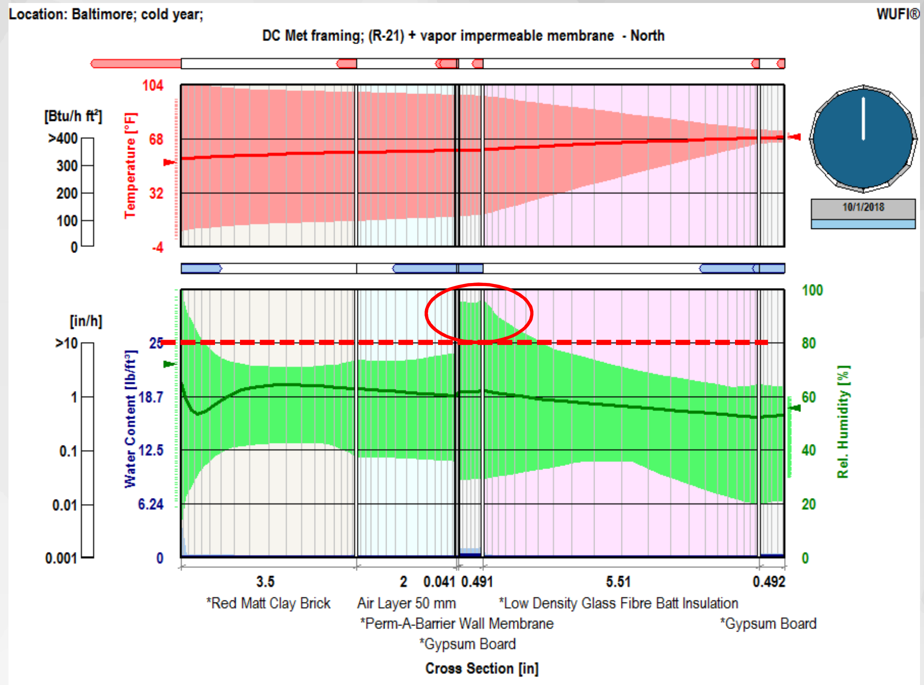
Example- All Insulation Inboard



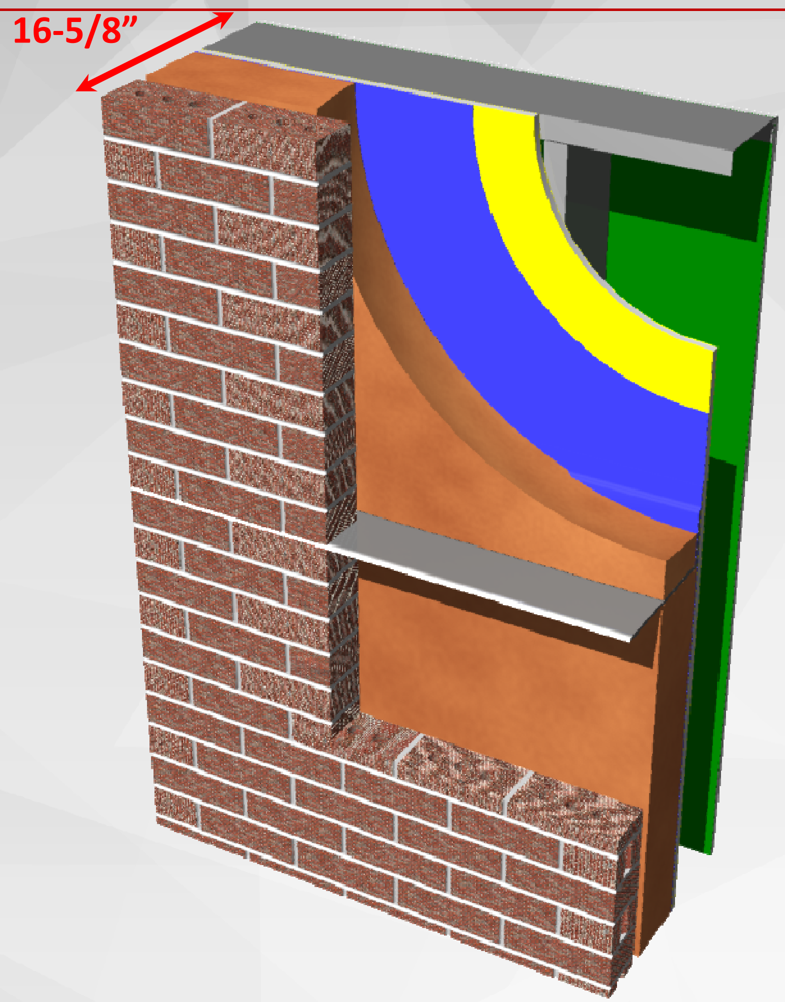
- 3.5 in. thick brick cladding
- 2 in. air gap
- Air/water/vapor barrier
- 5/8 in. thick gypsum board sheathing
- 6 in. light gauge metal framed studs with R-21 batt insulation between studs
- 1/2 in. thick interior sheathing

Example- All Insulation Inboard



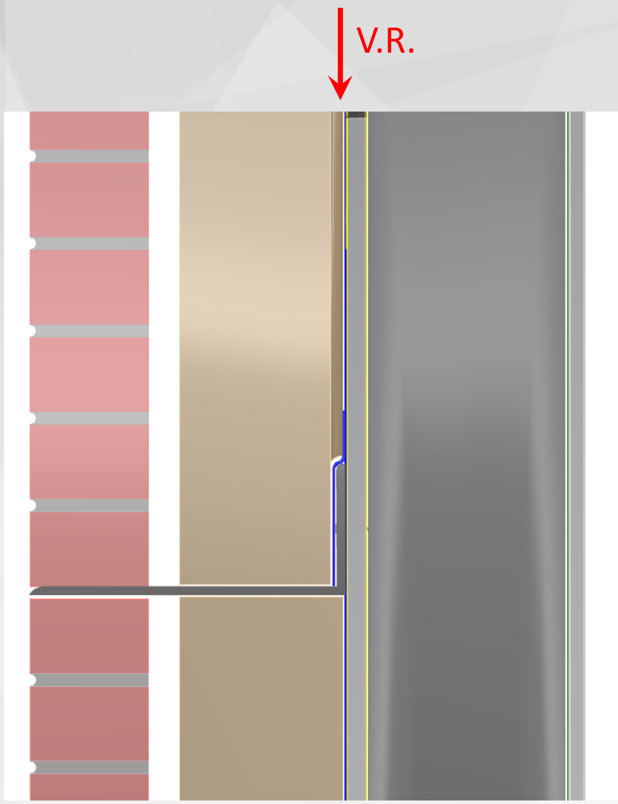


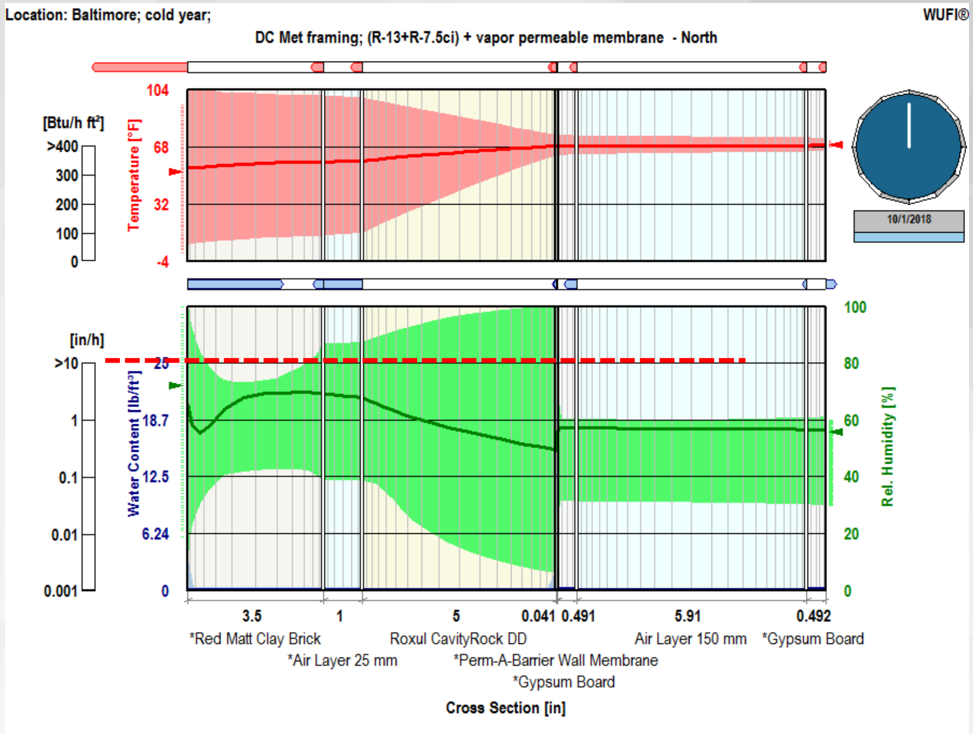
Example- All Insulation Outboard



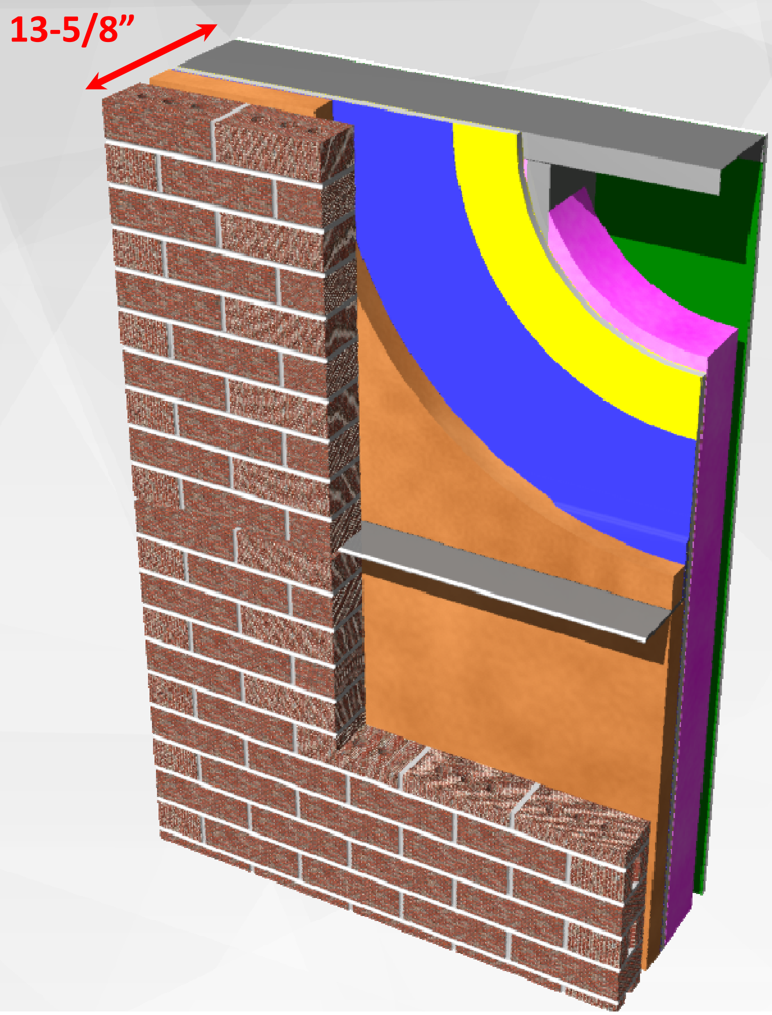
- 3.5 in. thick brick cladding
- 1 in. air gap
- 5 in. thick mineral wool
- Air/water/vapor barrier
- 5/8 in. thick gypsum board sheathing
- 6 in. light gauge metal framed studs
- 1/2 in. thick interior sheathing

Example- All Insulation Outboard



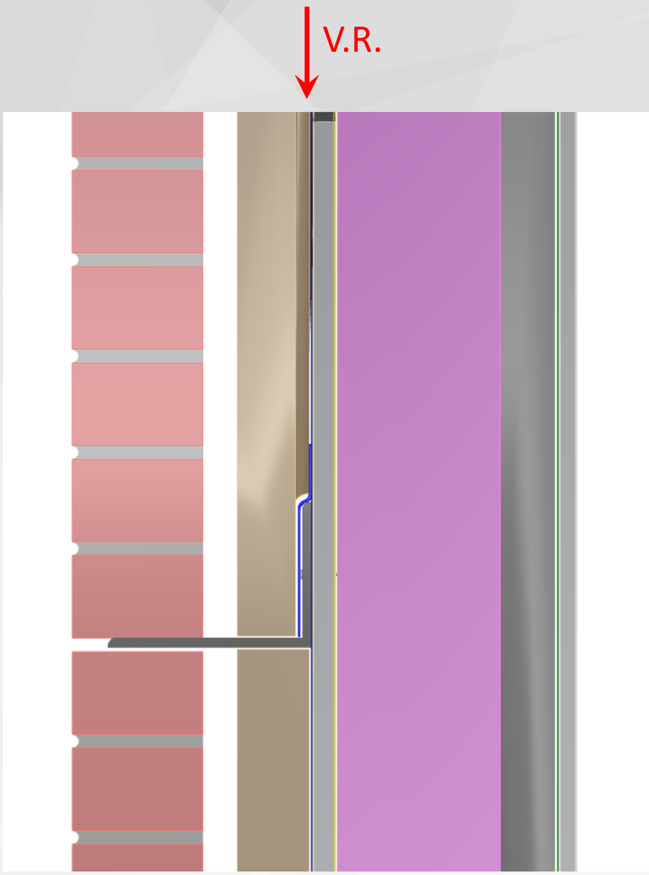


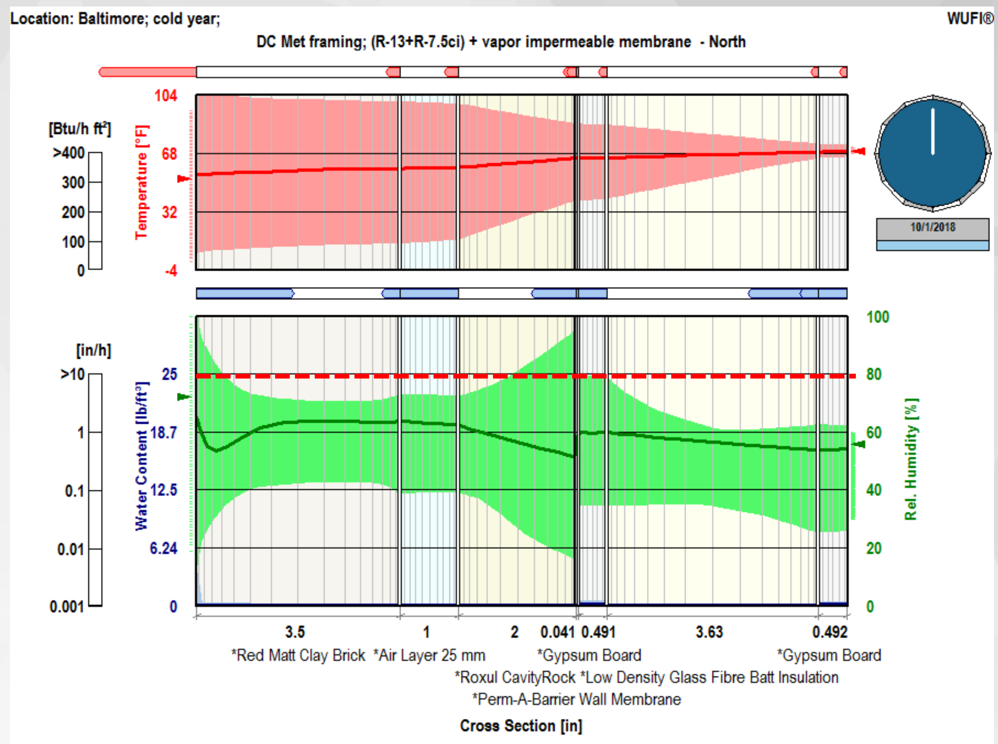
Example- Split Insulation



- 3.5 in. thick brick cladding
- 1 in. air gap
- 2 in. mineral wool insulation
- Air/water/vapor barrier
- 5/8 in. thick gypsum board sheathing
- 6 in. light gauge metal framed studs with R-13 (partial depth) batt insulation between studs
- 1/2 in. thick interior sheathing

Example- Split Insulation





Current Requirements- Insulation

- IBC
  - Chapter 13 Energy Efficiency – one page and incorporates the International Energy Conservation Code (IECC) by reference.
- IECC
  - Prescriptive
    - C402.1 – R-value Table C402.1.3 or U-Factor alternative in C402.1.4.
    - C402.4 – Fenestration: buildings that exceed allowable per Table C402.3 must comply with ASHRAE 90.1.
      - Limit is currently 30% for fenestrations (40% with daylight controls) and 3% for skylights
  - Performance – C407 →ASHRAE 90.1
    - Building Enclosure Trade-off Option – Allows lower-performance systems when higher-performance systems are included elsewhere (COMCheck or RESCheck analysis)
    - Whole Building Energy Simulation – Allows trade-offs between the building enclosure and other building systems.

Current Requirements- Insulation

- For R-value under 2015 IBC (h-ft^2-°F/Btu)
  - Wood-framed:
    - R-13 + 3.8 c.i.
    - R-20
  - Metal-framed
    - R-13 + 7.5 c.i.
- U-factor Alternative for Zones 4 and 5 (Btu/h-ft^2-°F)
  - Required to be 0.064 (same for wood and metal framed)
  - R-value equivalent is 1/0.064 = R-15.625

Contemporary Wall Design with Vapor Diffusion in Mind

Takeaways from Analyses

- "Rules of Thumb" for Climate Zone 4 (assuming typical interior conditions):
  - If 2/3 or greater of the insulation value is outboard of the vapor retarding and water management layer, no additional analysis required.
  - If 50/50 split, further analysis may be required.
  - For some applications, a vapor retarder is needed in one season but detrimental during another. Consider variable permeability vapor retarder in combination with a specially selected air/water barrier.
  - Anything outboard of the primary vapor retarder should be more permeable than the primary vapor retarder unless vented.
- Analysis required for atypical interior conditions, such as mechanical humidification, and specialized pressure controls

Developing a Balance of Insulation

1. Start with a balance of insulation based on prescriptive values for the project construction type
2. Select insulation for desired efficiency and other characteristics
3. Select air, water, and vapor barriers in wall
4. For wall assemblies that are unfamiliar or include new products, consider further hygrothermal analysis

Model limitations

- Model definitions may not adequately quantify failure risk for assemblies that:
  - Are subjected to exterior weather conditions below/above the data provided in the weather file (TMY3) in WUFI.
  - Are subject to construction activities that create temporary but demanding scenarios
  - Have 3-dimensional heat transfer through building elements that interrupt continuity of the thermal barrier.
  - Are subject to air flow behind cladding or interior finishes in excess of air leakage defined in model (e.g. interior air circulating in the stud cavity)

Mismanagement of humidity loads


TYPAR

Mismanagement of humidity loads

Conclusions

- Split insulation in walls is required due to the need for greater energy efficiency
- Designers must carefully consider placement of a vapor retarder between insulation
- Follow the “Rules of Thumb”
- Division of insulation triggers many other considerations
- Use judgment to determine when additional analysis is required

Thank you