

May 10, 2022 @ 1:00pm  
Christopher Hine (PHRC)

# Moisture Control Layers & Materials

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## Program Description

Moisture can move in two main ways, in bulk or liquid form and in vapor form. This webinar will look at how exterior wall assemblies are designed and construction to manage both forms. We will look at construction details and material properties for managing moisture.

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## Program Objectives

- Review how bulk water can enter the exterior wall assembly and cause structural concerns within the wall cavity.
- Review how water vapor moves with in a wall assembly. When dealing with water vapor, it is critical to choose the correct materials on both the inside and outside to allow the assembly to dry which will reduce the risk of mold.
- Review control layer properties and discuss which products should be used where in residential construction.
- We will look at a few assembly failures and review how the materials chosen could have played a role in the failure.

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Today's Goal

- New thermal envelope provisions are driving wall assemblies to be more energy efficient.
- Because of this, wall assemblies are less forgiving when moisture is introduced as vapor or in bulk form.
- We will look at how to reduce the risk of bulk water intrusion by discussing deflection and drainage.
- We will look at strategies and materials to allow drying through diffusion.

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Common Control Layers in a Residential Exterior Wall Assembly

- Bulk water
- Air
- Water vapor
- Thermal

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Common Control Layers in a Residential Exterior Wall Assembly

- Bulk water
- Air
- Water vapor
- Thermal

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### Items that can Inadvertently Introduce Moisture Stress to the Exterior Wall Assembly

- 3 ACH50
- Whole house mechanical ventilation
- Prescriptive provision for Class I or II Vapor Retarder
- Reservoir cladding
- Architectural designs

**"For every action there is an equal and opposite reaction"**

- Newton's Third Law



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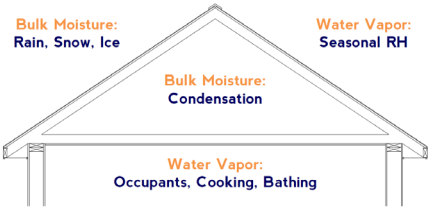
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### Where Does Moisture Come From?




**Bulk Moisture:**  
Rain, Snow, Ice

**Water Vapor:**  
Seasonal RH

**Bulk Moisture:**  
Condensation

**Water Vapor:**  
Occupants, Cooking, Bathing



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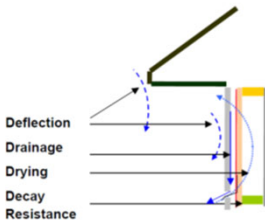
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### What are the 4 D's?

- First developed by D. Hazleden & P. Morris out of Canada




**Deflection**

**Drainage**

**Drying**

**Decay Resistance**



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## Moisture Control Layer / Strategy: Deflection

- Deflection involves the prevention of as much precipitation as possible from hitting exterior walls (including foundations)
- Properly design enclosure elements can deflect up to 90% of precipitation
  - Source: Designing for Durable Wood Construction: The 4Ds

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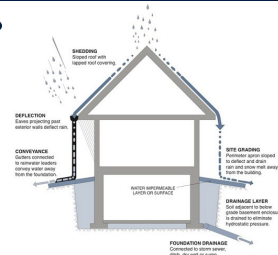
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## Deflection

- What is Deflection?



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Source: Whole Building Design Guide – Moisture Management Strategies



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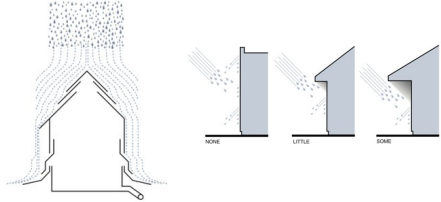
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## Roof Overhangs for Deflection

- Roof overhangs at eaves are a critical strategy for deflecting rain away from exterior walls and foundations below



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Source: Whole Building Design Guide – Moisture Management Strategies



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## Protection of Openings

- Some penetrations in the enclosure are difficult to flash
  - Exterior doors
    - Entry doors
    - Patio doors
    - Garage doors
- Long-term exposure to the elements tends to rot the base of common trim materials at these openings



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## Conclusions - Deflection

- **Keys to Deflection**
  - Roof shape
  - Roof overhangs
  - *Drip edges / caps*
  - *Kickout flashing*
  - *Gutters & downspouts*
  - *Site grading*



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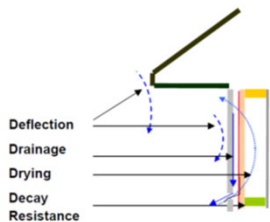
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## What are the 4 D's?



Deflection  
Drainage  
Drying  
Decay Resistance



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## Moisture Control Layer / Strategy: Drainage

- **Drainage** involves the shedding of any precipitation that may penetrate the exterior cladding
  - Water must be able to drain down and out (away) from enclosure
- Properly designed enclosure systems (flashing, WRB, etc.) can address most of the remaining 10% of precipitation present at the enclosure



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## What is a Drainage Plane?

- Control layer in an exterior wall assembly that serves as the primary surface for bulk moisture to drain down to an exit point in the enclosure
  - Water-managed systems
- Water-resistive barrier (WRB)



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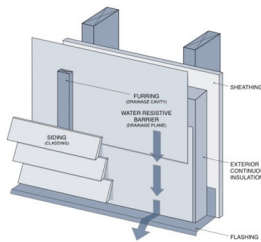
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## How Does a WRB Function?



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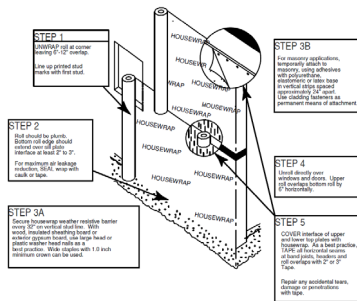
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### HOUSE WRAP - WALL APPLICATION



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### Hybrid Sheathing & WRB Systems

- Integrated structural, water resistant, and air barrier functions in a single panel
- Treated sheathing as a water resistant barrier
- Considerations are taping and flashing reverse shingle

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### WRB's with Enhanced Drainage

- Flat water-resistive barriers can have reduced ability to drain water when cladding is installed tight against the WRB
- Some WRB's have ridges or wrinkles to keep cladding off of the surface of the exterior wall to promote drainage of bulk moisture



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### What is the Purpose of Flashing?

- Integrate penetrations through the drainage plane (WRB) into the WRB using compatible and durable materials in a specific sequence

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### Critical Flashing Locations

- Windows
- Doors
- Utility Penetrations
- Changing in Cladding Material or Type
- Roof / Wall Intersection

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## Utility Penetration Flashing

- All penetrations through the exterior wall assembly must be flashed properly
- Challenges
  - Sequence
  - Responsibility
  - Coordination of trades



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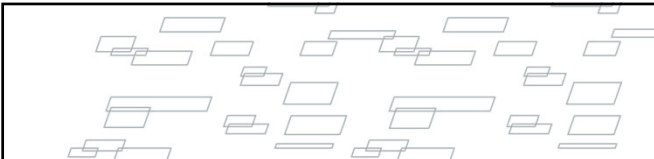
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## Control of Water Vapor in Diffusion

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## Items that can Inadvertently Introduce Moisture Stress to the Exterior Wall Assembly

- 3 ACH50
- Whole house mechanical ventilation
- Prescriptive provision for Class I or II Vapor Retarder
- Reservoir cladding
- Architectural designs

**"For every action there is an equal and opposite reaction"**

- Newton's Third Law



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## Typical Assembly Behavior

- Enclosure assemblies typically get wet through:
  - Convection
  - Bulk moisture penetration
- Enclosure assemblies typically dry though:
  - Diffusion
  - Evaporation



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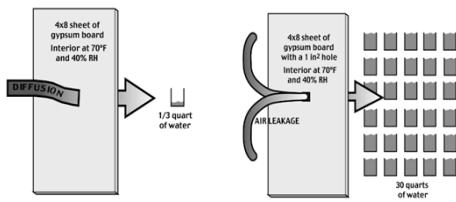
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## Diffusion vs. Convection

Source: Building Science Corporation.

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## Moisture Control Layer / Strategy: Drying

- Drying is the result of properly designing enclosure assemblies to allow for intruding moisture to **dry to the interior, exterior, or both** by diffusion and evaporation



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## Water Vapor Flow

- **Water vapor = water in gaseous state**
- **Key concepts related to water vapor:**
  - Relative humidity
  - Dew point
  - Condensation



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## What is a Throttle?

- **The material in a building enclosure assembly with the lowest vapor permeability**
  - This material will limit the overall amount of water vapor that can travel through the enclosure via diffusion
  - Example: vapor retarders are throttles by design



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## What is a Vapor Retarder?

- **The element that is designed and installed in an assembly to retard the movement of water by vapor diffusion.** (Building Science Corporation, *Understanding Vapor Barriers*)



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## Vapor Retarders

- Keep it out **and** let it out if it gets in. (Building Science Corporation, *Understanding Vapor Barriers*)
- Air Control and Vapor Control can be the same material within the assembly, but often are not.



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## Vapor Barriers & Retarders

- Material that limits the flow of vapor through diffusion
- Vapor retarders are NOT vapor barriers



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## Vapor Retarder Classifications - IRC

- **Class I Vapor Retarder:**  
< 0.1 perm
- **Class II Vapor Retarder:**  
0.1 perm – 1.0 perm
- **Class III Vapor Retarder:**  
1.0 perm – 10.0 perm



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## Vapor Permeability

- **Vapor impermeable: < 0.1 perm**
  - Foil facing
- **Vapor semi-impermeable: 0.1 perm – 1.0 perm**
  - Extruded polystyrene (XPS)
- **Vapor semi-permeable: 1.0 perm – 10.0 perm**
  - OSB
- **Vapor permeable: > 10 perms**
  - Brick veneer



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## Vapor Retarder Classification Examples



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## What do you use as your required vapor retarder?



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What Class is it?



- Kraft faced fiberglass batt insulation

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What Class is it?



- Kraft faced fiberglass batt insulation
- 1 perm = Class II

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What Class is it?



- "Tyvek" house wrap

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### What Class is it?



- “Tyvek” house wrap
- 54 perm = Vapor permeable / Vapor open

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### What Class is it?



- 1” of Johns Manville AP Foil-Faced polyisocyanurate continuous insulation

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Source: Memads.com

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### What Class is it?



- 1” of Johns Manville AP Foil-Faced polyisocyanurate continuous insulation
- 1” 0.05 perm = Class I

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Source: Memads.com

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### What Class is it?



- 1" DuPont Styrofoam XPS Foam Insulation

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### What Class is it?



- 1" DuPont Styrofoam XPS Foam Insulation
- 1" 1.5 perm = Class III

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### Product Specifications Matter

- Not all rigid foam is the same
- Specify the type of foam specifically to include or exclude facings

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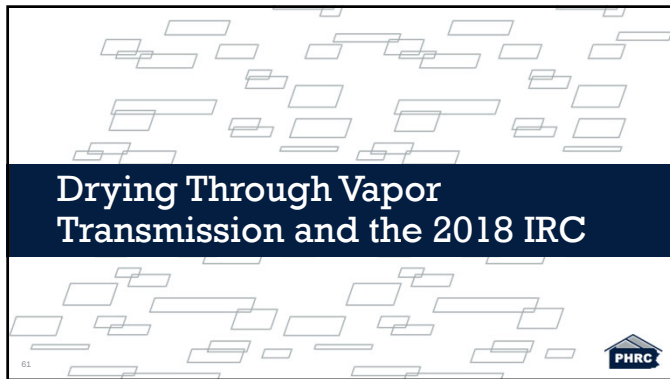
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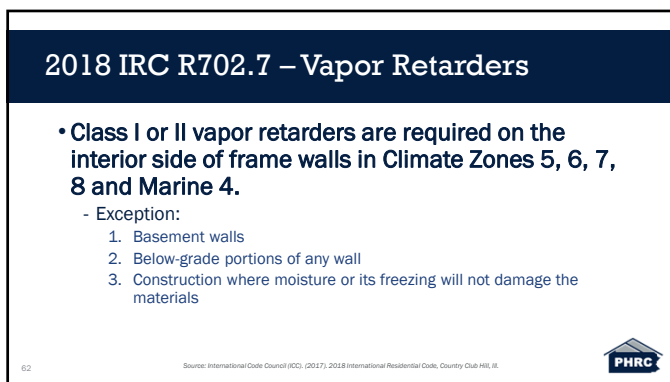
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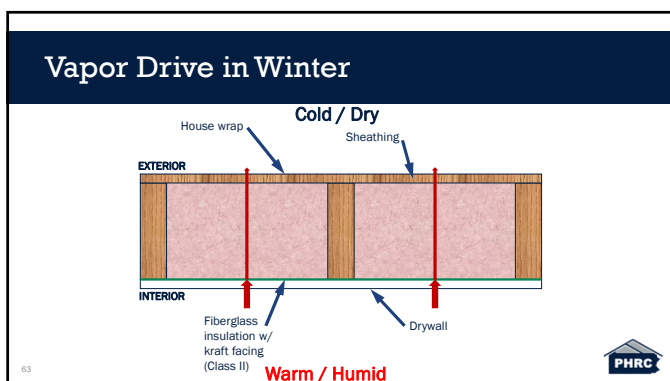
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## Use of Class III Vapor Retarders

- R702.7.1 Class III vapor retarders shall be permitted where any one of the conditions in Table R702.7.1 is met.

TABLE R702.7.1 CLASS III VAPOR RETARDERS

CLIMATE ZONE	CLASS III VAPOR RETARDERS PERMITTED FOR <sup>a</sup>
Moisture 4	Ventilated cladding over wood structural panels. Ventilated cladding over fiberboards. Ventilated cladding over gypsum. Continuous insulation with R-value $\geq 2.0$ over $2 \times 4$ wall. Continuous insulation with R-value $\geq 3.75$ over $2 \times 6$ wall.
5	Ventilated cladding over wood structural panels. Ventilated cladding over fiberboards. Ventilated cladding over gypsum. Continuous insulation with R-value $\geq 5.0$ over $2 \times 4$ wall. Continuous insulation with R-value $\geq 7.5$ over $2 \times 6$ wall.
6	Ventilated cladding over fiberboards. Ventilated cladding over gypsum. Continuous insulation with R-value $\geq 7.5$ over $2 \times 4$ wall. Continuous insulation with R-value $\geq 11.25$ over $2 \times 6$ wall.
7 and 8	Continuous insulation with R-value $\geq 10$ over $2 \times 4$ wall. Continuous insulation with R-value $\geq 15$ over $2 \times 6$ wall.

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Source: International Code Council (ICC), (2017), 2018 International Residential Code, Country Club Hill, IL.



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## 2018 IECC Table R402.1.2

2018 IRC Table N1102.1.2

TABLE N1102.1.2 (R402.1.2) INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT<sup>a</sup>

CLIMATE ZONE	FENESTRATION U-FACTOR <sup>a</sup>	SKYLIGHT <sup>b</sup> U-FACTOR	GLAZED FENESTRATION SHGC <sup>c,e</sup>	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE	FLOOR R-VALUE	BASEMENT <sup>d</sup> WALL R-VALUE	SLAB <sup>d</sup> R-VALUE & DEPTH	CRAWL SPACE <sup>d</sup> WALL R-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/5	13	0	0	0
3	0.32	0.55	0.25	38	20 or 13 + 5 <sup>b</sup>	8/13	19	5/12 <sup>f</sup>	0	5/13
4 except Marine	0.32	0.55	0.40	49	20 or 13 + 5 <sup>b</sup>	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	20 or 13 + 5 <sup>b</sup>	13/17	30 <sup>g</sup>	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20 + 5 <sup>b</sup> or 13 + 10 <sup>h</sup>	15/20	30 <sup>g</sup>	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20 + 5 <sup>b</sup> or 13 + 10 <sup>h</sup>	19/21	30 <sup>g</sup>	15/19	10, 4 ft	15/19

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Source: International Code Council (ICC), (2017), 2018 International Residential Code, Country Club Hill, IL.



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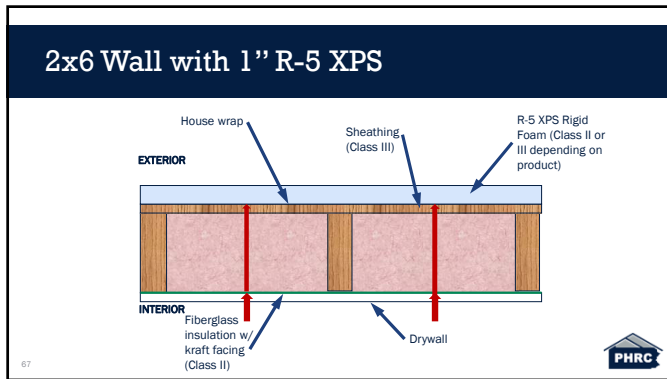
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Moisture 4	Ventilated cladding over wood structural panels. Ventilated cladding over fiberboards. Ventilated cladding over gypsum. Continuous insulation with R-value $\geq 2.0$ over $2 \times 4$ wall. Continuous insulation with R-value $\geq 3.75$ over $2 \times 6$ wall.
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6	Ventilated cladding over fiberboards. Ventilated cladding over gypsum. Continuous insulation with R-value $\geq 7.5$ over $2 \times 4$ wall. Continuous insulation with R-value $\geq 11.25$ over $2 \times 6$ wall.
7 and 8	Continuous insulation with R-value $\geq 10$ over $2 \times 4$ wall. Continuous insulation with R-value $\geq 15$ over $2 \times 6$ wall.

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Source: International Code Council (ICC), (2017), 2018 International Residential Code, Country Club Hill, IL.



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### More Restrictive Throttle

- 1" Rigid XPS = 1.5 perm max/inch; Class III
- Kraft faced batt insulation = 1 perm; Class II
- House wrap = 11-54 perm; Vapor Open

**Is this good?**  
**Remember "Throttle"**  
**Code Compliant?**

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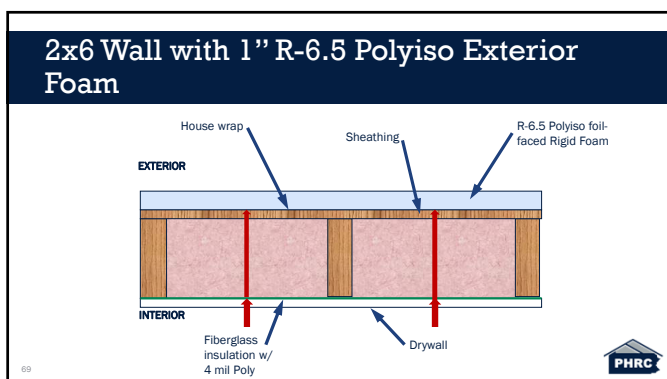
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## More Restrictive Throttle

- 1" Rigid Polyiso Foil Faced = 0.05 perm max./inch; Class I
- Batt insulation w/ Poly = 0.04 perm; Class I
- House wrap = 11-54 perm; Vapor Open

Is this good?  
Remember "Throttle"  
Is this Code Compliant?  
Is this Best Practice for a Temperate Climate?



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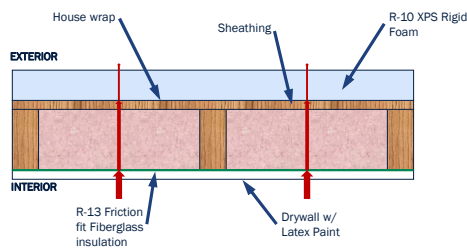
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## 2x4 Wall with 1" R-5 XPS Exterior Foam



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## Potential for Double Class II Vapor Retarder

- 2" R-10 Rigid XPS = .7 perm max./inch; Class II
- R-13 Friction Fit batt insulation = N/A
- Drywall with Latex Paint = 6 perm; Class III
- House wrap = 11-54 perm; Vapor Open

Is this good?  
Remember "Throttle"  
>1/3 (R-7.6) of the total insulation is on the exterior  
which can reduce the risk of condensation



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Summary

- Wall assemblies are now less tolerant of water in all forms
- Must manage bulk water
- Must manage water vapor through diffusion by choosing the correct materials
- Understand the moisture drive, the “throttle” and permeability to allow for drying
- Have a strategy and choose the materials that help achieve that strategy

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Resources

- Typar - [http://www.typar.com/assets/downloads/pdf/TYPAR-BuildingWrap\\_SellSheet.pdf](http://www.typar.com/assets/downloads/pdf/TYPAR-BuildingWrap_SellSheet.pdf)
- Tyvek - [https://www.dupont.com/products/tyvek-homewrap.html?src=gg-kg\\_tyvek-be-us\\_tyvek-house-wrap&solid=ChwKCAIA4WABhAJEiWATUnEF-34pIAvXGoKIGayo-6wQKVg4T-DjomZhhb3hOX6517ASF-777sRoCBnQAv0\\_BwE](https://www.dupont.com/products/tyvek-homewrap.html?src=gg-kg_tyvek-be-us_tyvek-house-wrap&solid=ChwKCAIA4WABhAJEiWATUnEF-34pIAvXGoKIGayo-6wQKVg4T-DjomZhhb3hOX6517ASF-777sRoCBnQAv0_BwE)
- HydroGap - <https://benjaminobdyke.com/product/hydrogap-drainable-housewrap/>
- Zip System - <https://www.huberwood.com/uploads/documents/technical/literature/ZIP-System-Brand-Brochure.pdf>
- Dow Styrofoam Brand - <https://www.dupont.com/content/dam/dupont/amer/us/en/performance-building-solutions/public/documents/en/SC00133-STYROFOAM%20Brand%20SM%20Insulation-PIS-Digital2.pdf>
- Owens Corning Ecotouch - <https://dcpd6wotaa0mb.cloudfront.net/ndms/dms/Residential%20Insulation/10013811/10013811-EcoTouch-PINK-FIBERGLAS-Insulation-Product-Data-Sheet.pdf?v=1592540232000>
- Johns Manville AP Foil-Faced - <https://www.jm.com/content/dam/jm/global/en/building-insulation/Files/BF%20Data%20Sheets/Res%20and%20Commercial/BID-0151-AP-Foil-Faced-DS.pdf>

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[www.phrc.psu.edu](http://www.phrc.psu.edu)

PennState College of Engineering

PENNSYLVANIA HOUSING RESEARCH CENTER

ICC

NARI CEU Approved

ICC PREFERRED EDUCATION PROVIDER

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