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Water, Vapor, Air: How Physics Can Help You Choose the Right Membrane

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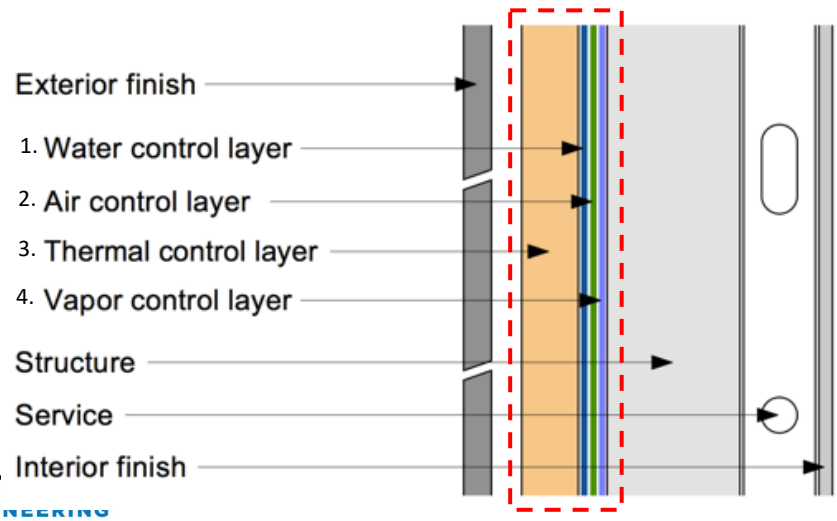
The Ideal Enclosure

- Clarity of **function**, ideal **arrangement** of materials



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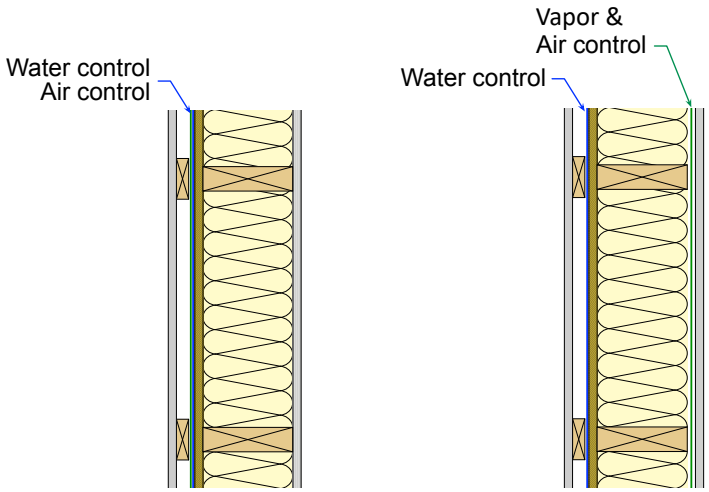
Recent Past / current



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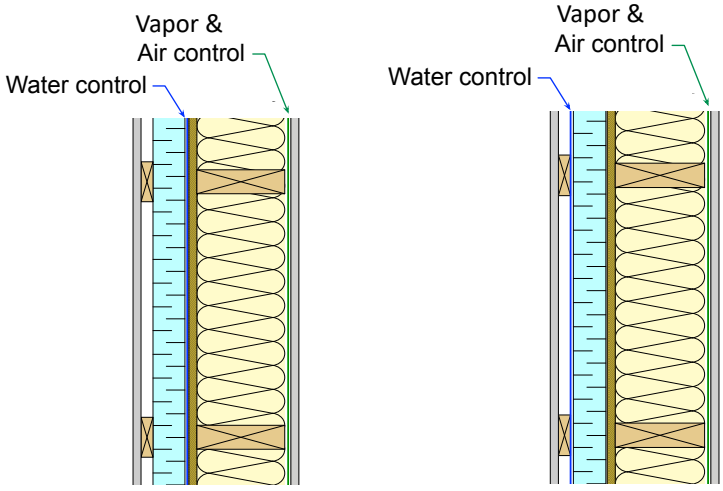
Modern , improved



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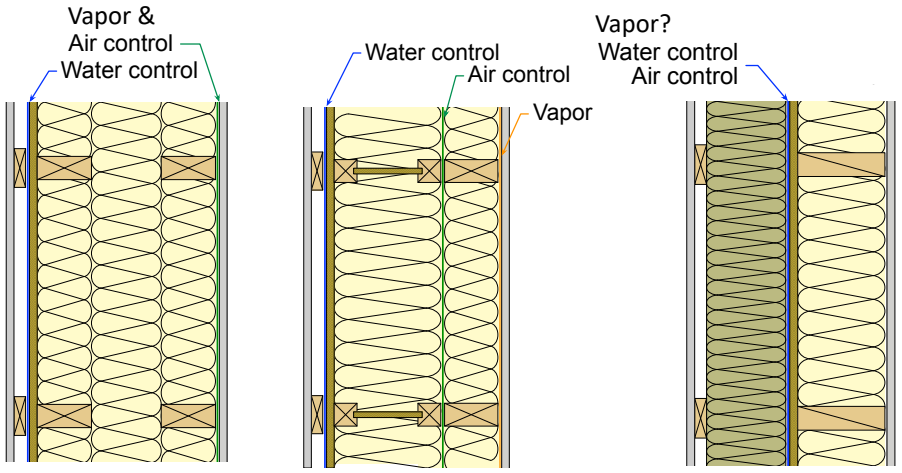
Future?



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All walls need control Layers

- 1. Rain Control
  - most important
- 2. Air Control
  - Energy, health, humidity
- 3. Thermal Control
  - Thermal bridging
- 4. Vapor control
  - Some holes can be tolerated

Confusion:
Can be *separate* layers / products
or
***combined* in same material / layer**

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Continuity

- Many **materials** have good performance
- **But**, poor continuity limits performance
- **&** Poor continuity causes most problems too:
  - E.g. air leakage condensation
  - Rain leakage
  - Surface condensation
  - Cold windows
- Thus: *continuity + proper material*

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Water Control Layer

- Continuous– lapped
  - Reverse laps: mechanical seal or good adhesive
- Water resistant
- Need not be vapor resistant or air resistant

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Lapped "Drainage Plane"

Only water control together with drain gap
Not air
Not vapor
Not even water"proof"

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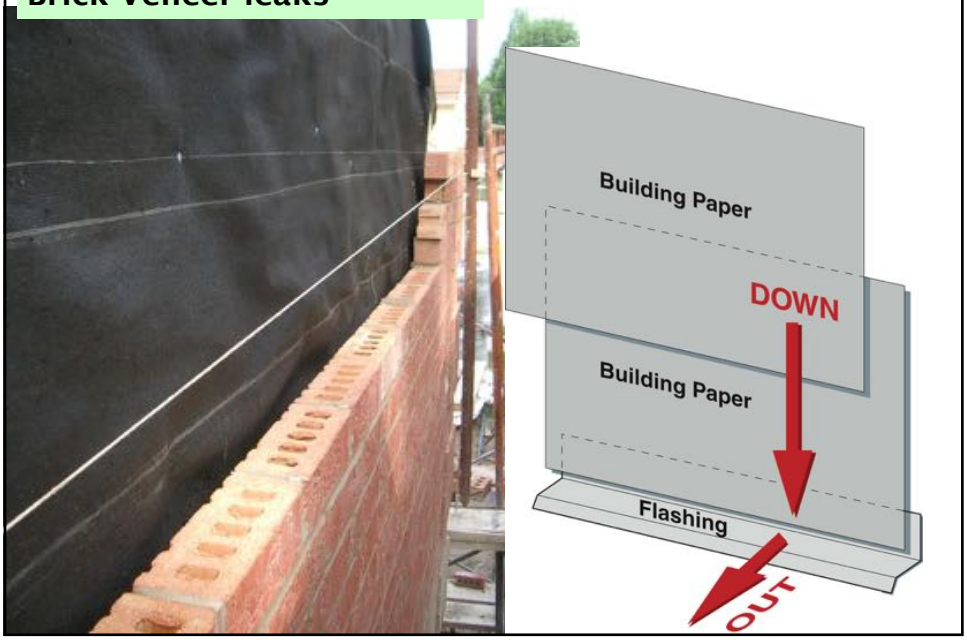
Classic Drained System: Brick Veneer leaks



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Water control Products

Control- Water (not at joints)

- Asphalt-impregnated felt
- Asphalt-coated paper
- Polymeric housewraps
- Faced (plastic,aluminum) SBS bitumen and butyl sheets
- Fluid-applied asphalts, urethanes, acrylics, silicones
- Thick layers of monolithic masonry
- 3-6" or more of high-quality reinforced concrete
- EPDM, TPO, fabric reinforced modified SBS, reinforced PVC, fabric reinf asphalt
- Glass sheets
- Metal (aluminum, steel, zinc, copper) sheets
- Closed-cell plastic foams (spray or board)

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Combo Air-Water-Vapor Layers

- Often thin layers
- *Can be*
  1. Water control (vapor permeable, not airtight), **or**
  2. Air & water control (vapor permeable), **or**
  3. Air, water & vapor (vapor impermeable).
- Examples
  - Building paper, untaped housewrap, sealed and supported housewrap, fluid applied, peel and stick

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Air-water Barrier

- Tape for airtightness, lap for water tightness

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Air Control: Air Barrier Requirements

- Continuous
  - primary need, common failure
- Strong
  - designed for full wind load
- Durable
  - critical component - repair, replacement
- Stiff
  - control billowing, pumping
- Air Impermeable
  - (may be vapour permeable)

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Example Air Control Products

Many products could be **part** of air barrier system

- Polymeric housewraps
- Wood panel boards (OSB, plywood)
- Faced (plastic, aluminum) SBS Bitumen and Butyl Sheets
- Fluid-applied asphalts, urethanes, acrylics, silicones, etc.
- Thick layers of monolithic masonry
- 3-6” or more of high-quality reinforced concrete
- EPDM, TPO, reinforced PVC, fabric reinforced SBS modified bitumen, fabric reinforced asphalt
- Glass sheet
- Metal (aluminum, steel, zinc, copper) sheets
- Closed-cell plastic foams (spray, e.g. ccSPF; or board XPS, PIC)
- Gypsum board

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Air Barriers Are Systems

Materials | Components | Accessories

Whole Building Airtightness

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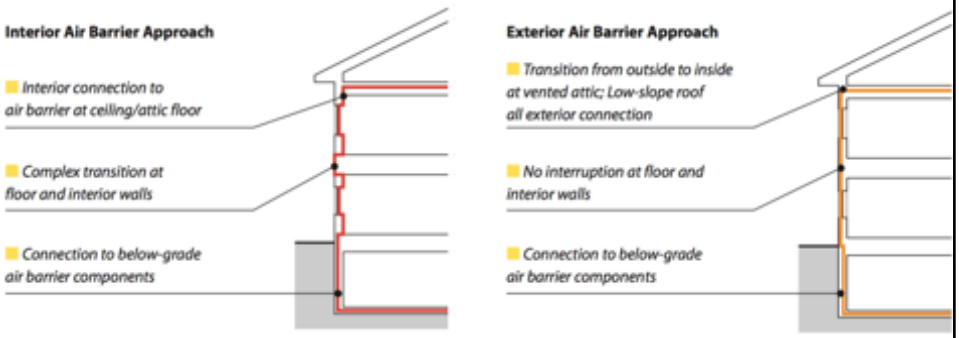
"Exterior" Air Barriers

- Many more penetrations and details with interior air barrier approach
- Exterior is preferred today



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Vapor Permeable membranes

- Vapor permeable air- and air-water barriers
  - Many products available
- Can be located anywhere in assembly
  - Tyvek was a huge innovation
  - Can locate outside moisture sensitive wood
- Fully-adhered vs loose membrane is biggest practical distinction

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Non-adhered, vapor permeable =modest performance

Supported **flexible membrane is better**

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Fully-adhered is better

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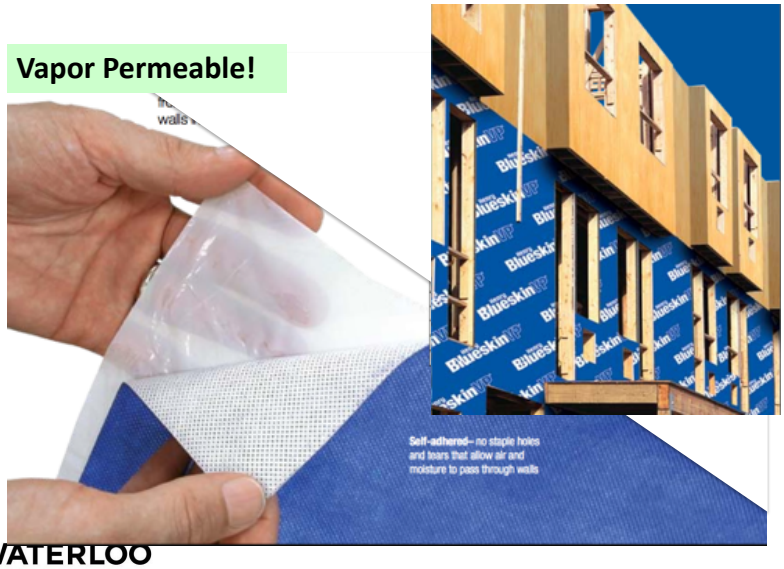
Fully-adhered air-water barrier

Vapor Permeable!



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Fluid-applied

DuPont™ Tyvek® Fluid Applied WB

A DURABLE, VAPOR PERMEABLE FLUID APPLIED ~~WEATHER~~ BARRIER

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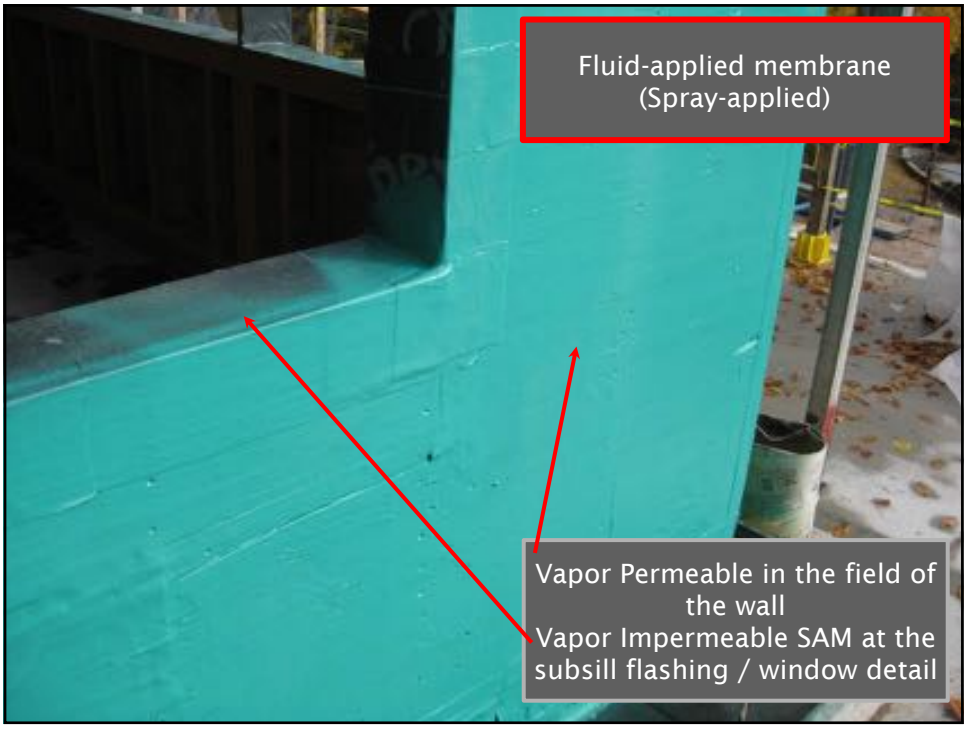

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Air+water Taped Rigid Foam Sheathing

Moderately vapor permeable
Challenge is water sealing

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But some foams are vapor barriers

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Vapor tight *and* thin = bad

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Self-adhered membrane
(preformed sheet membrane)

Vapor **Impermeable**
Excellent water-air control

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Vapor **Impermeable**
But lots of exterior insulation
to avoid condensation

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Air Barriers vs Vapor Barriers

- ***Vapour Barriers Control Vapour Diffusion***
  - Why? 1. Moisture wetting and drying
- ***Air Barriers Control Air Leakage***
  - Why? At least ***six*** reasons.
  - Health (control contaminants)
  - Moisture (avoid condensation)
  - Heat (for comfort & energy considerations)
  - Smoke & odors
  - Sound

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Requirements

- Air Barriers
  - Continuous (no holes), strong, durable and preferably stiff I
  - Need in all assemblies and joints
- Vapor Barriers
  - Covers most of assembly, resists vapor diffusion through materials
  - May not be needed because of other wall layers having low permeance, climate, or design

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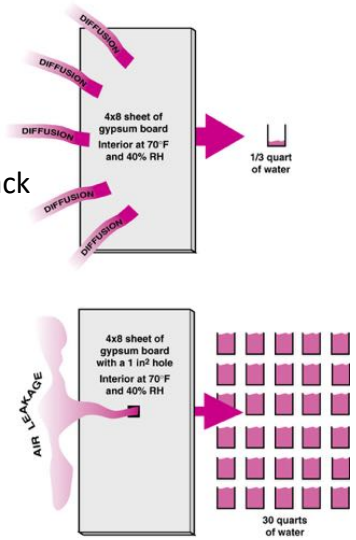
Air leakage

- Confusion between air & vapor barrier arises because both control flow of water vapor
- Much more vapor can be carried on back of air flow than diffusion
- Condensation only happens if air flows towards cold surface



Source: Lstiburek, BSC

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Water Vapor Transport

- Diffusion
  - Flow of water vapor from high concentration to low concentration
- Air leakage
  - Flow of water vapor along with the flow of air
  - Air moves from high to low pressure

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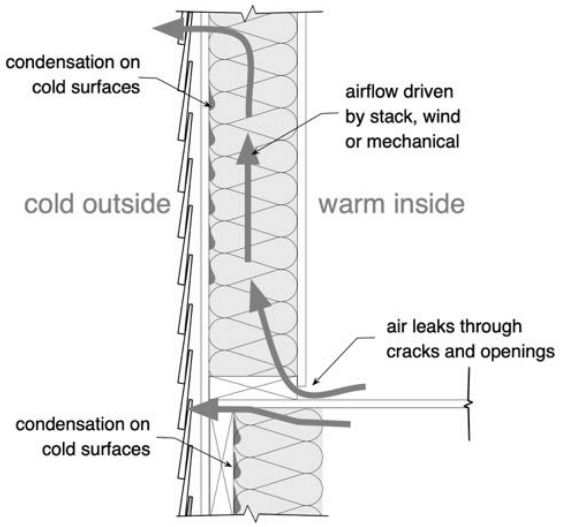
Air leakage Condensation

- **Air leakage is much more critical than diffusion**
- **We limit air flow for reasons other than condensation!**



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Air leaks concentrate

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Air Leakage or Vapor Diffusion?

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Where does condensation occur?
Diffusion *or* Air Leakage (Convection)

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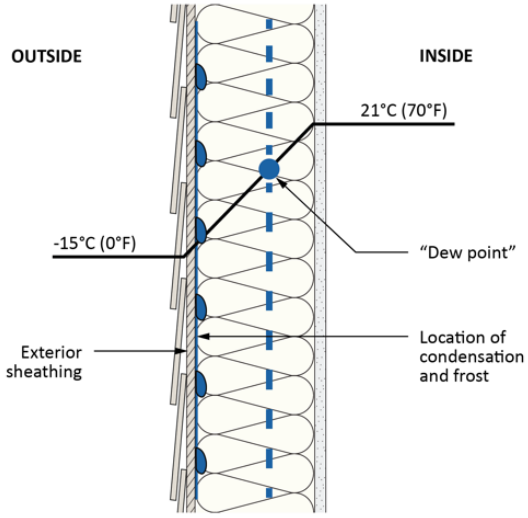

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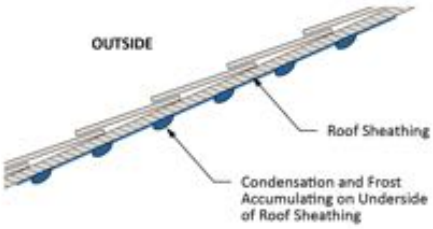
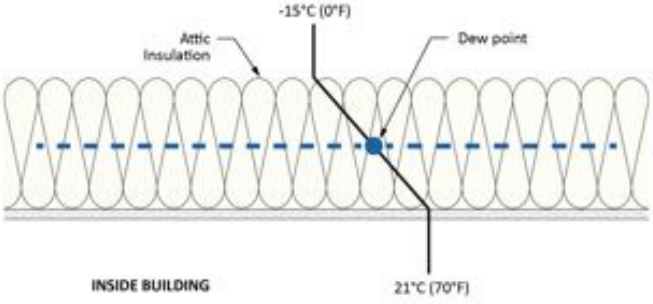


"Condensation occurs on the first solid upstream facing surface downstream of the dewpoint being exceeded"

VENTILATED ATTIC



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Inside of roof sheathing from attic hatch

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Wall w/o continuous exterior insulation

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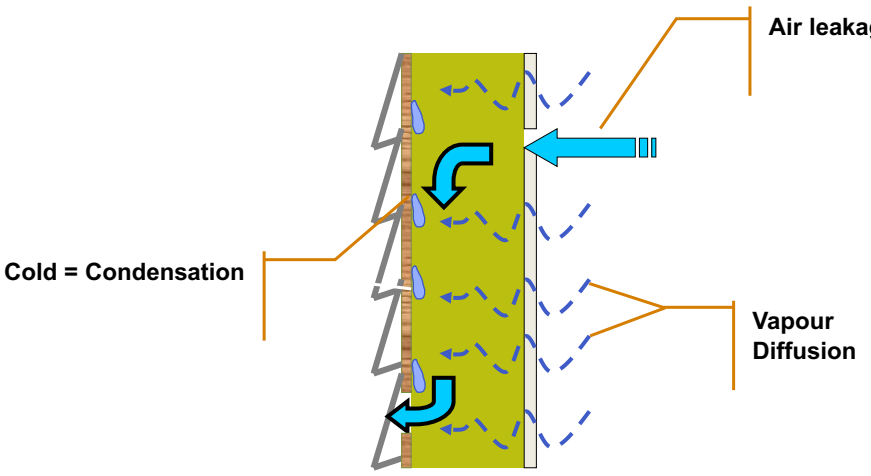

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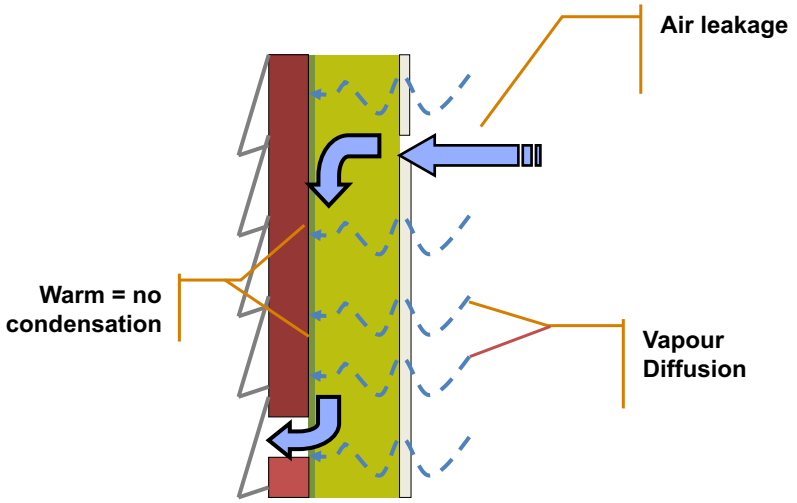
Wall with exterior continuous insulation



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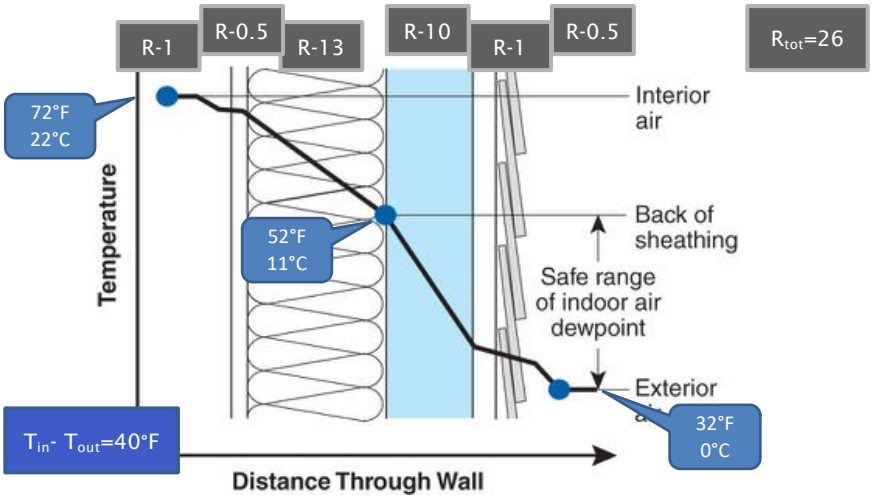
Temperature Gradients



$$T_{back\ of\ sheathing} = T_{interior} - (T_{interior} - T_{exterior})\ R_{batt}/R_{total}$$

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See: BSD-163 at buildingscience.com

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Vapor Control

- Categories of vapor control
  - Permeable: over 10 US perms
  - Semi-permeable: 1-10
  - Semi-impermeable 0.1-1
  - Impermeable <0.1
- Less than 1 perm is often defined as a "vapor barrier"
- Designating only one material a vapor barrier does not mean others in wall are not!

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Vapor Control Layer Location

- Put in location where it is warm enough to avoid condensation
  - Inside in cold weather, outside in warm
- Or, if condensation can occur, adjoining materials must be water tolerant
  - E.g. precast, exposed masonry

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Vapor Control Layers

- Layer defined by Material & Thickness

Material	Inches to reach 1 perm
polyethylene	0.6 mille
Metal (facer)	>0 (assuming no pinholes)
wood	0.5 – 5.0 (depends on MC, species)
XPS EPS	1-1.2 1.5 to 3
Polyiso	1.5-2.5 (unfaced)
ccSPF ocSPF	1.5-2+ 48
Concrete	3-10 (depends on density, porosity)
gypsum	16

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Vapor Control Materials

Specialty paints/coatings, such as epoxy
All metal sheets, extrusions, films, castings
Glass
Asphalt butyl coatings, thick enough (e.g., over 1 mm is enough)
Polyethylene, saran, polycarbonate, polypropylene as films, not woven or perforated
Closed cell polyurethane foam (over 2")
EXPS (over 1-2")
EPS (density matters, usually over 2" or so)
Concrete (good quality, over 2-3", lower quality porous, 6-10")
Dense stone (few pores, over 2-4" thickness or so)
Closely spaced perforations usually mostly eliminate vapor resistance
Wood, depending on density, species and thickness (over 4" for softwoods)

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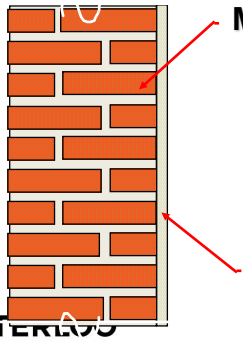
Old Assemblies

- Vapour resistance integrated with insulation
  - Like foam today?
- Massive moisture storage



No vapour barrier, of course

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Air+vapor

- 1960's, the beginning, loose membrane
- Confusion with vapor barriers
- Summer condensation

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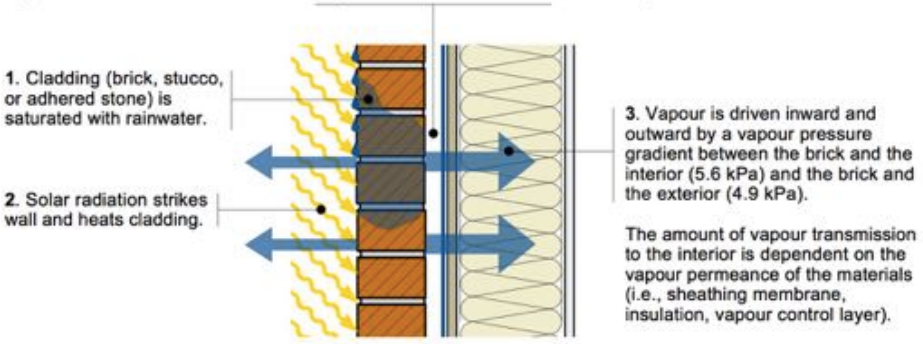
Controlling Interstitial Condensation (Sun-Driven Moisture)



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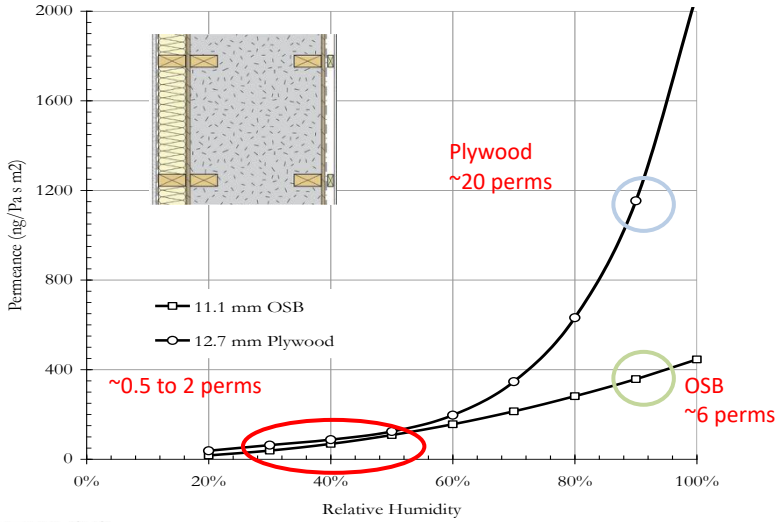
Plywood & OSB - RH vs Vapor Permeance



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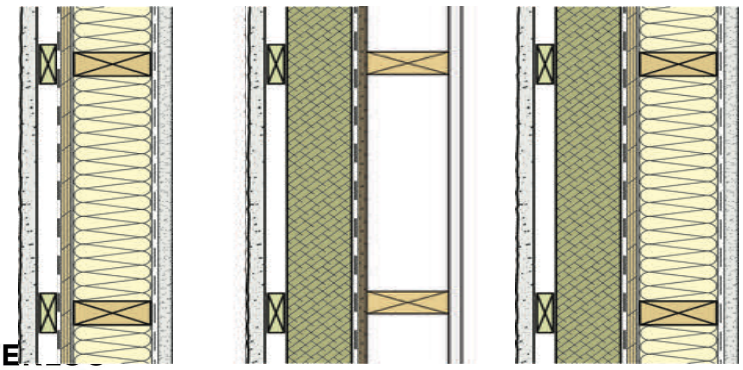
Consider Vapor Diffusion through All Layers

- Must consider the whole assembly, not only the properties of the Air (/Water /Vapor) Barriers
- Sheathing, exterior finishes can have significant resistance
- Don't be tricked by labels… low perm layers are vapor barriers



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Summary

- Identify control layers in design is critical
- Design/build continuity of air + water layers!
- Understand what you expect and what products provide for
  - Air
  - Water
  - Vapor
- Condensation can be controlled with insulation

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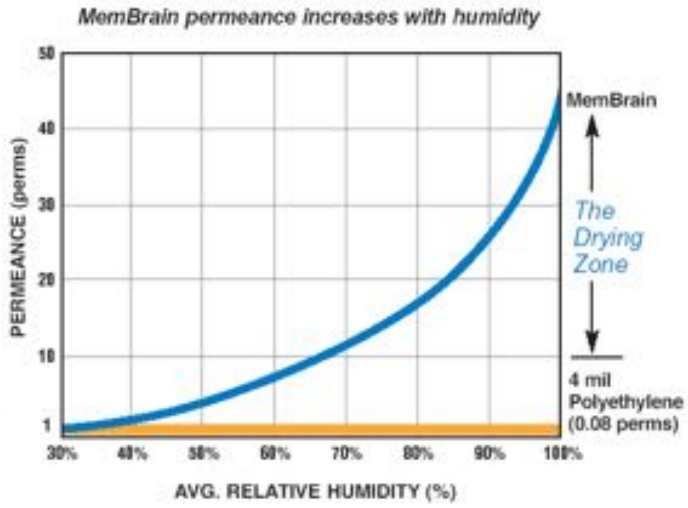
Smart Vapor Barrier Permeance



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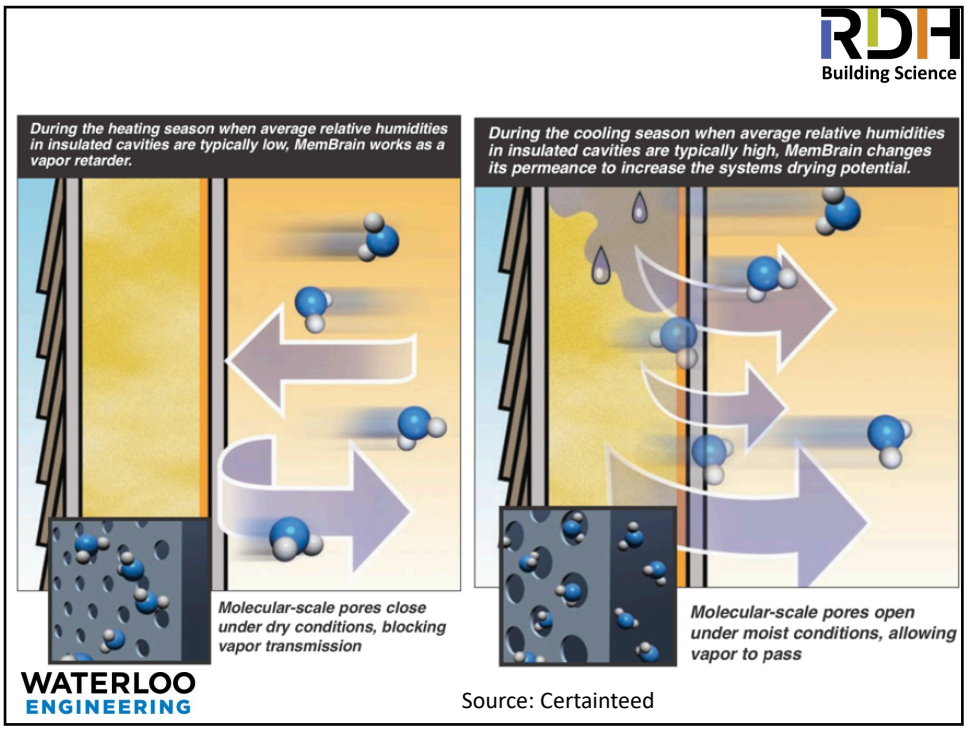

Source: Certainteed

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