475 High Performance Building Supply

40107374

Foam Free High Performance Building Enclosures

AIACES475002

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March 26 2014

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Course Description

High performance building standards are evolving. Foam the dominant approach to high performance however falls short in many key attributes. This course demonstrates how the new paradigm in high performance can be met without the use of foam.

Learning Objectives

At the end of the this course, participants will be able to:

1. Understand what differentiates the goals of high performance enclosures and how those goals are evolving.
2. Understand how foam has come to dominate the high-performance construction market.
3. Understand how foam falls short meeting many high performance goals.
4. Understand how to practically construct high performance enclosures that are foam free.

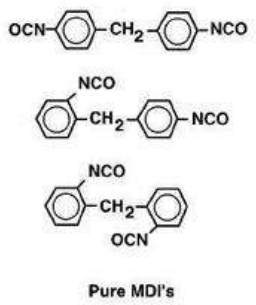
Foam-Free High Performance Building Enclosures

HIGH
PERFORMANCE
BUILDING SUPPLY

131 Union St Brooklyn, NY 11231
718.622.1600 Info@FourSevenFive.com

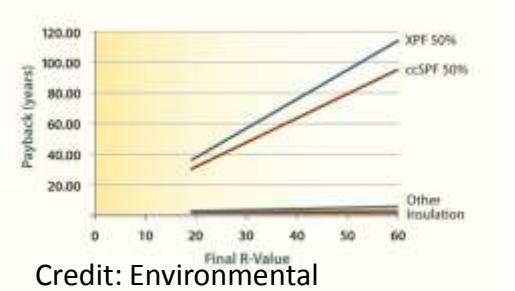
Why foam free?

Credit: The Graduate, 1967, MGM



Pure MDI's

Woods Hole, MA 2011



Credit: Environmental Building News

Dangerous **Toxic** ingredients
Unacceptable **fire accelerant**
Global warming potential
Installation **problems**
Unreliable performance

(See ***Foam Fails*** series on our **blog**.)

We have **choices**:

Insulations:
cellulose, mineral wool,
cellular glass, fiberglass, cotton,
wood fiberboard, hemp, etc, etc

Air & vapor control layers:
sheathings, membranes

Connections:
tapes, adhesives, gaskets

Let's optimize these options and **do better**.

More **robust**.

More **resilient**.

More **sustainable**.

Higher **performance**.

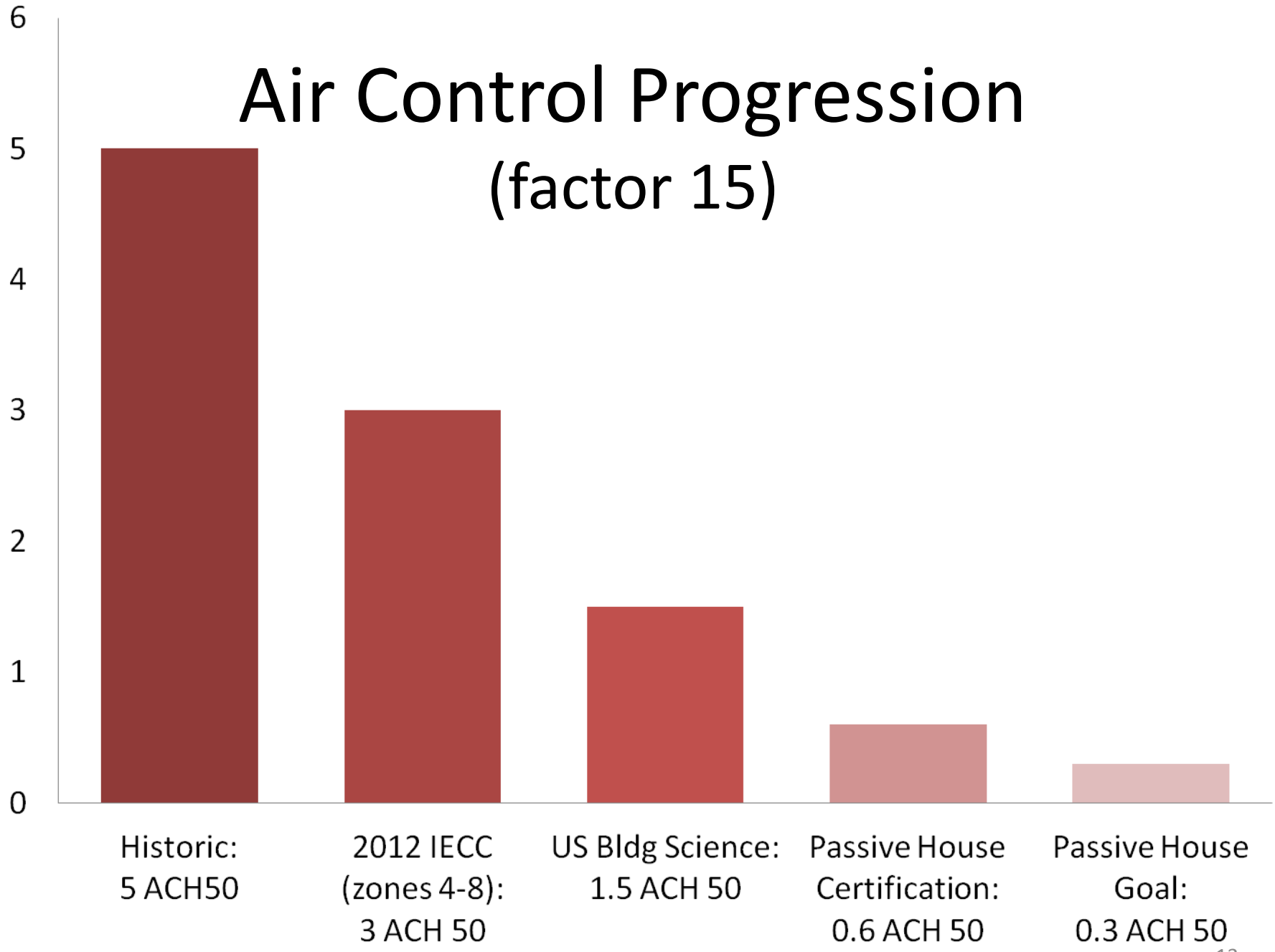
An **evolution** in **high performance**

1. **Water control**
2. Ever greater **air control**
3. More resilient **vapor control**
4. More robust **thermal control** toward thermal bridge free

---

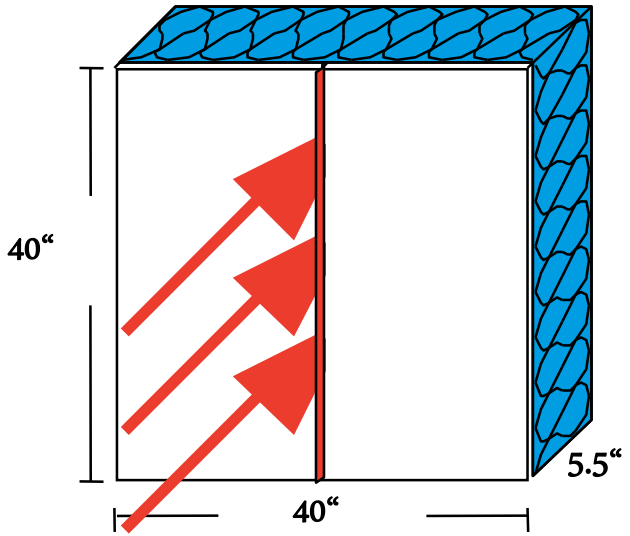
5. More **tolerant** of cold and wet job site conditions
6. More **predictable** and durable
7. Greater **cost** control.
8. More **sustainable** and “green”.

Air Control Progression
(factor 15)



Air Control

- Second only to water control.
- **Disproportionately effects**:
  - **Indoor air quality**: control the air to control the quality
  - **Comfort**: drafts are uncomfortable
  - **Air transported wetting**: a bigger liability than diffusion wetting
  - **Heat loss/thermal bypass**



With a 1/32“ gap: No vapor diffusion
Only vapor convection:28.2 oz water/10sf x 24h

Without a gap: Diffusion 35 perms
e.g. plasterboard: 5.3 oz water/ 10 sqft x24h

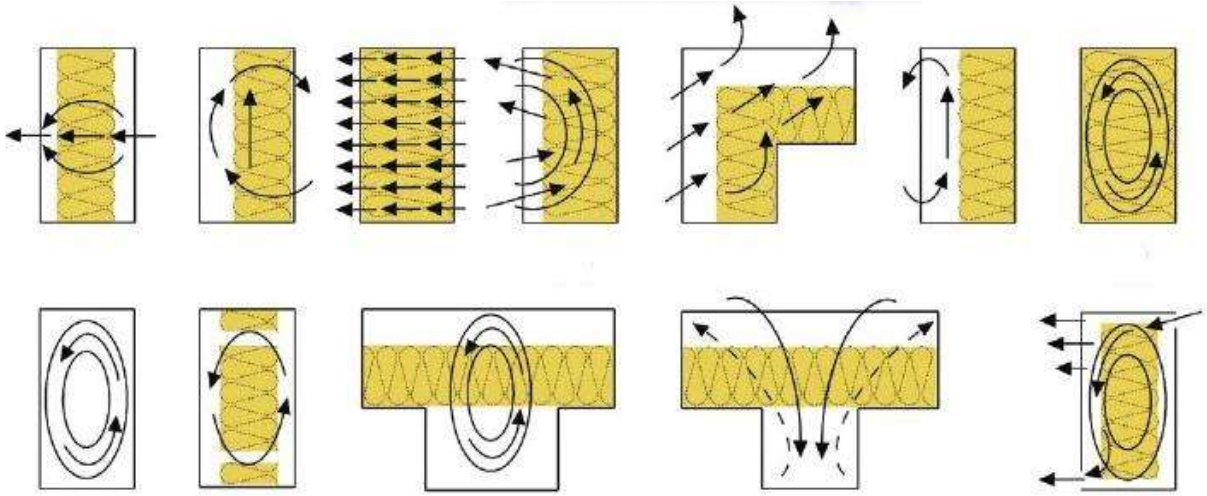
Without gap: Diffusion 0.3 perms:
e.g. INTELLO: 0.017oz water/10 sqft x24h

Reduction factor: 1600

Proclima/ IBP Fraunhofer/ Source: DBZ 12/89, page 1639ff

Thermal Bypass Diagrams

Thermal bypass describes heat loss that gets around intended thermal insulation, including:
windwashing, **air infiltration**, and **convective loops**.



Credit: Mark Siddall, Building Green Magazine

Thermal Performance of **Leaky** vs. **Air-tight** enclosures:

Factor of **4.8**

Fraunhofer Institute, Stuttgart Germany

Joe Lstiburek:

> **“Air-sealing both sides of the wall is more important than the fluffing of the insulation in the cavity.”**
>
> Building Science Camp 2012

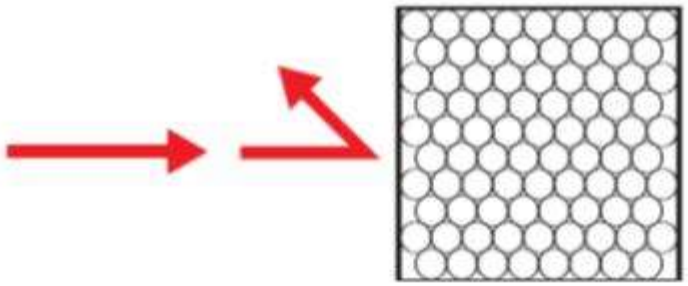
Even in foam based enclosures

Spray foam, foam boards, and SIPS: **must seal both sides**

Credit: Building Science Corporation

So make airtight
inboard & **outboard**

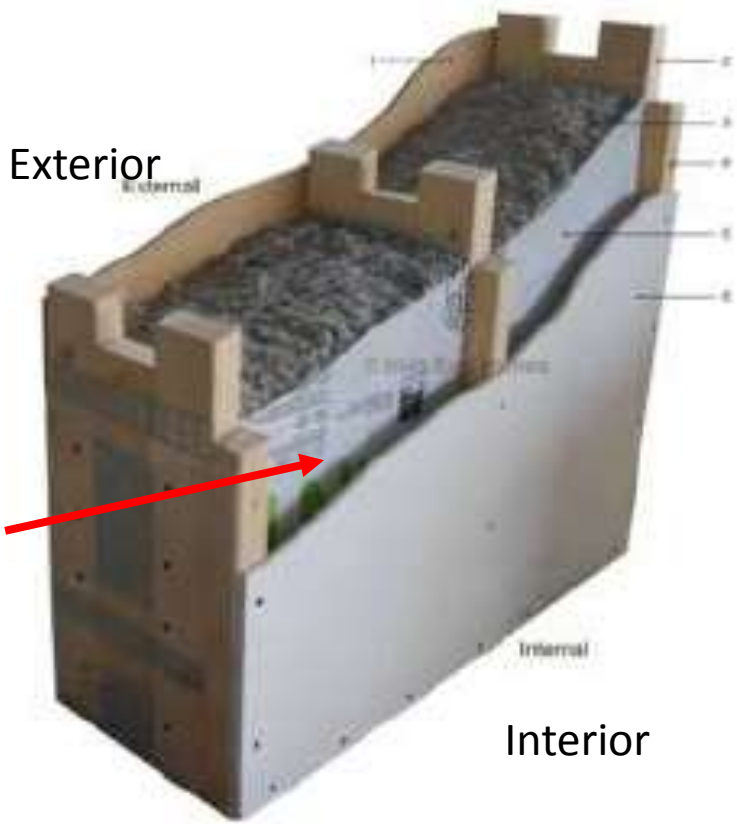
Surround your insulation in airtightness.



Now it is protected the insulation works to its optimum thermal performance

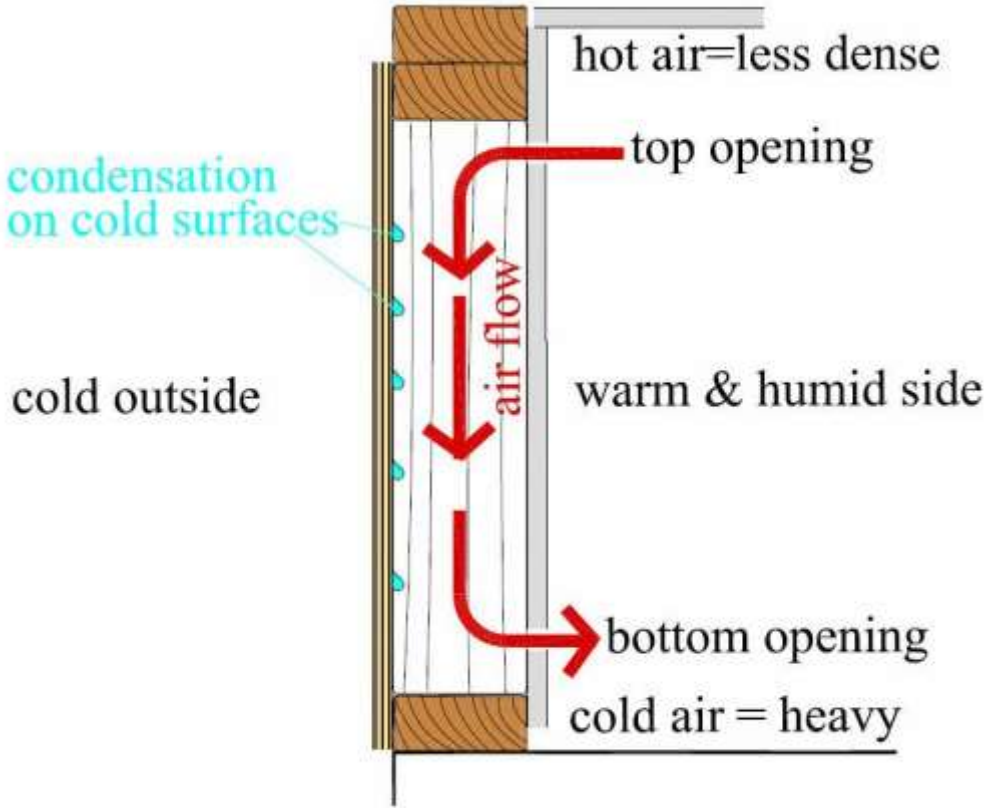
Prioritize inboard air barrier

=/>70% thermal insulation outboard of primary airbarrier



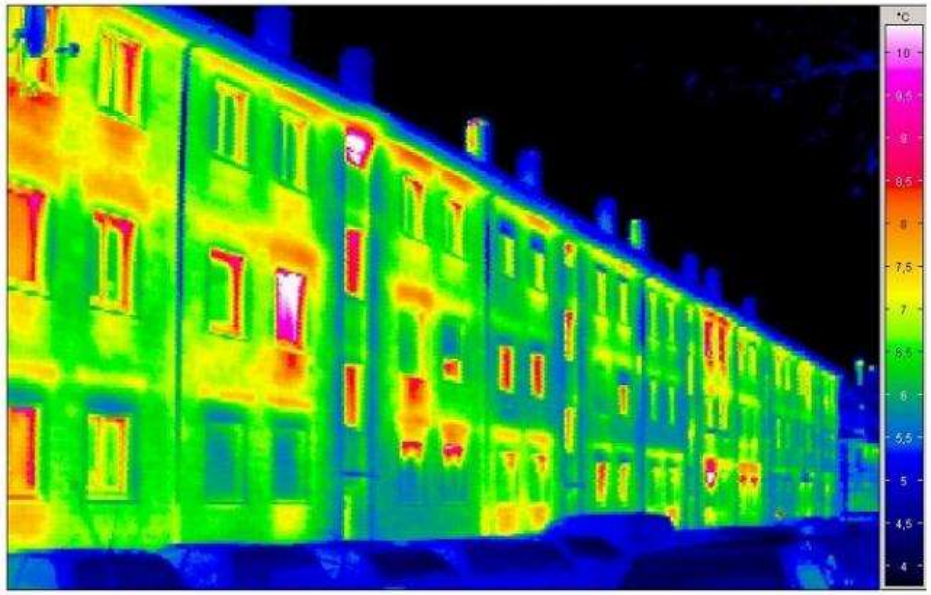
Why Inboard is Better

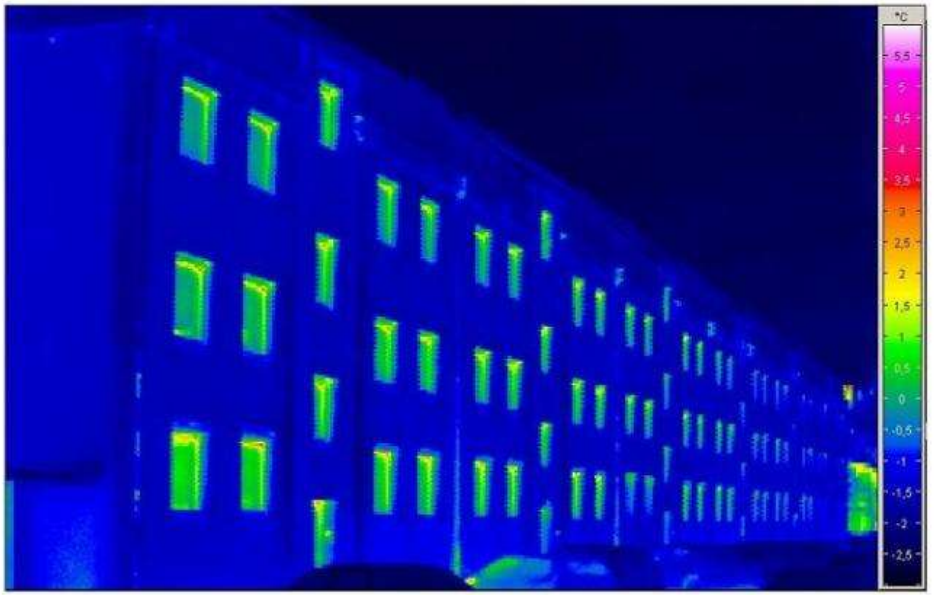
1. Keeps conditioned air within the conditioned space.
2. Better protection against condensation risk.
3. Places the components of this most important control layer in a climate controlled.
4. Leaks can often be more readily found and easier to repair.
5. **The air control layer can/should double as a vapor control layer**.



Next, the priority is **vapor control**.

- **Poorly insulated** walls are often **heated dry**.





- **Well built** assemblies **dry through vapor diffusion**. (or they don't dry)

"You need to assume that the building will get wet, somehow, at some point in time. Stuff happens. So you need a moisture-tolerant design."

Anton TenWolde, physicist at the U.S. Forest Products Laboratory **via GBA post** ***Are Dew Point Calculations Really Necessary***

Drying capacity

>

[unanticipated] Moisture stress

=

Freedom from damage

Stuff happens.
So, **help the drying**.

Work with the **dominant vapor drive**.

Mixed Climate

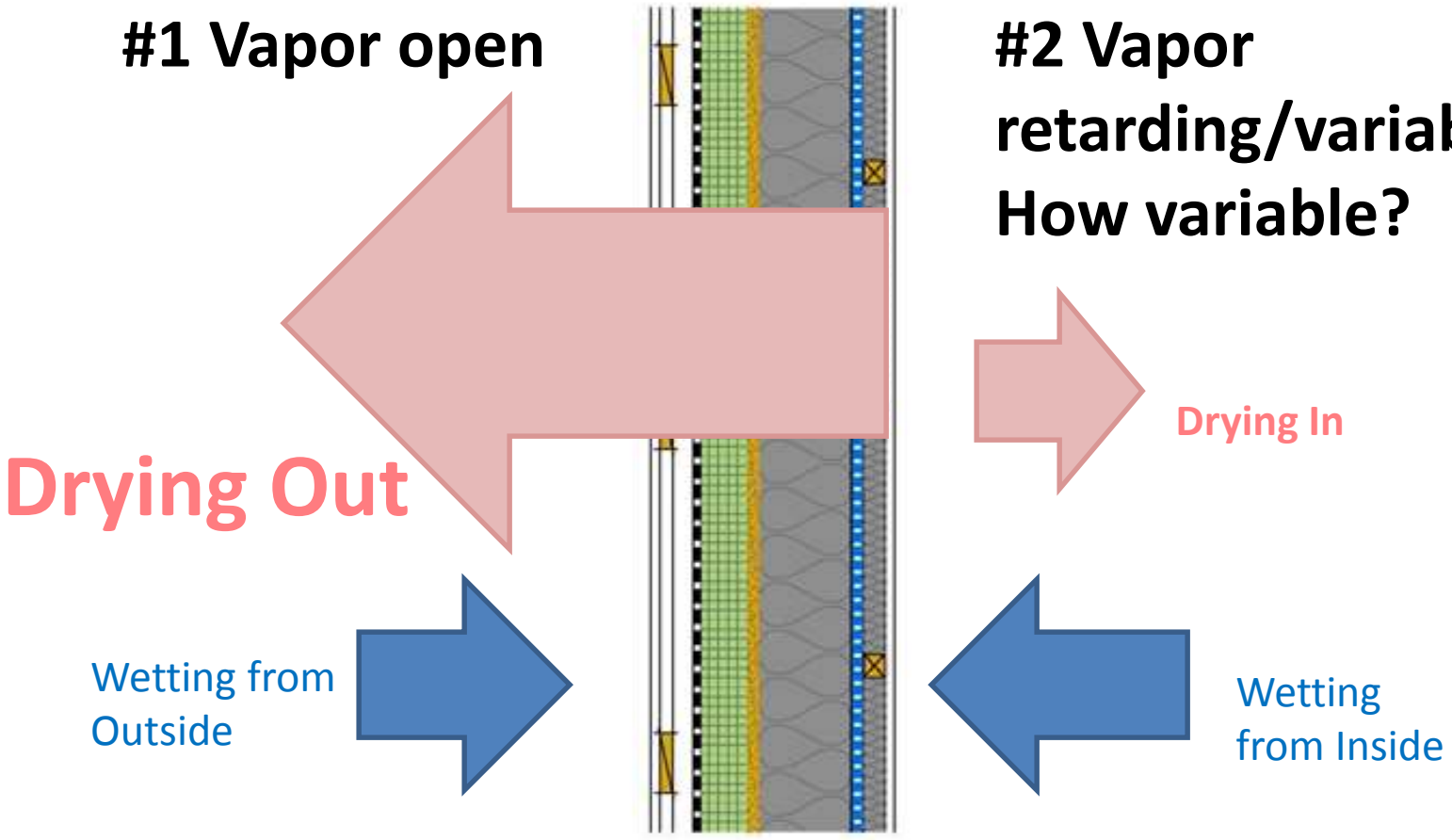
more heating than cooling

Outside

Inside

#1 Vapor open

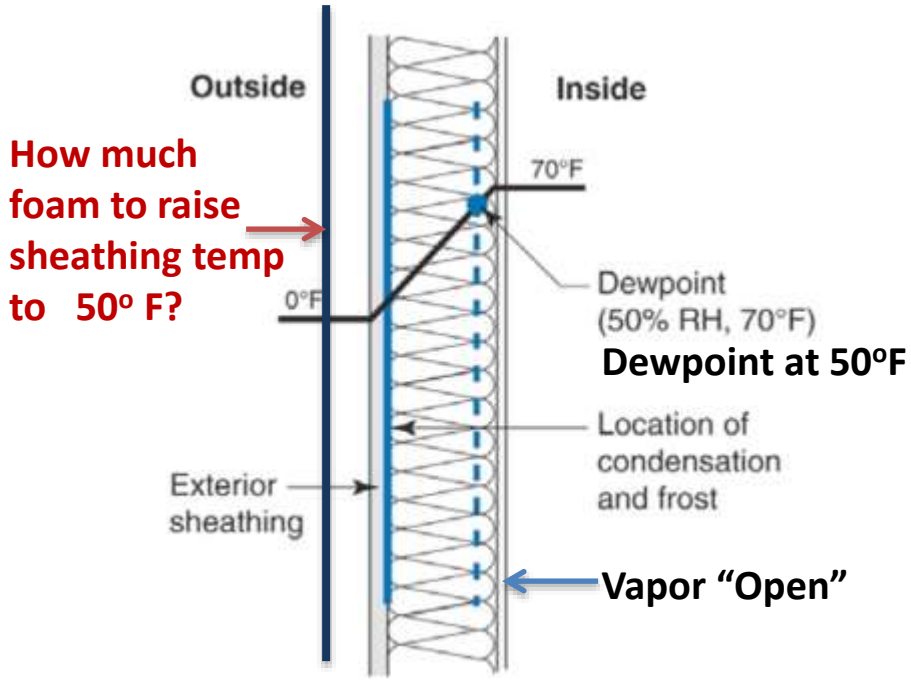
#2 Vapor retarding/variable. How variable?



Why are we installing **vapor dams**?

Credit: Synergy Companies Construction LLC

Foam is addressing **dewpoint**



Credit: Building Science Corp.
www.buildingscience.com

but can make **wetness**

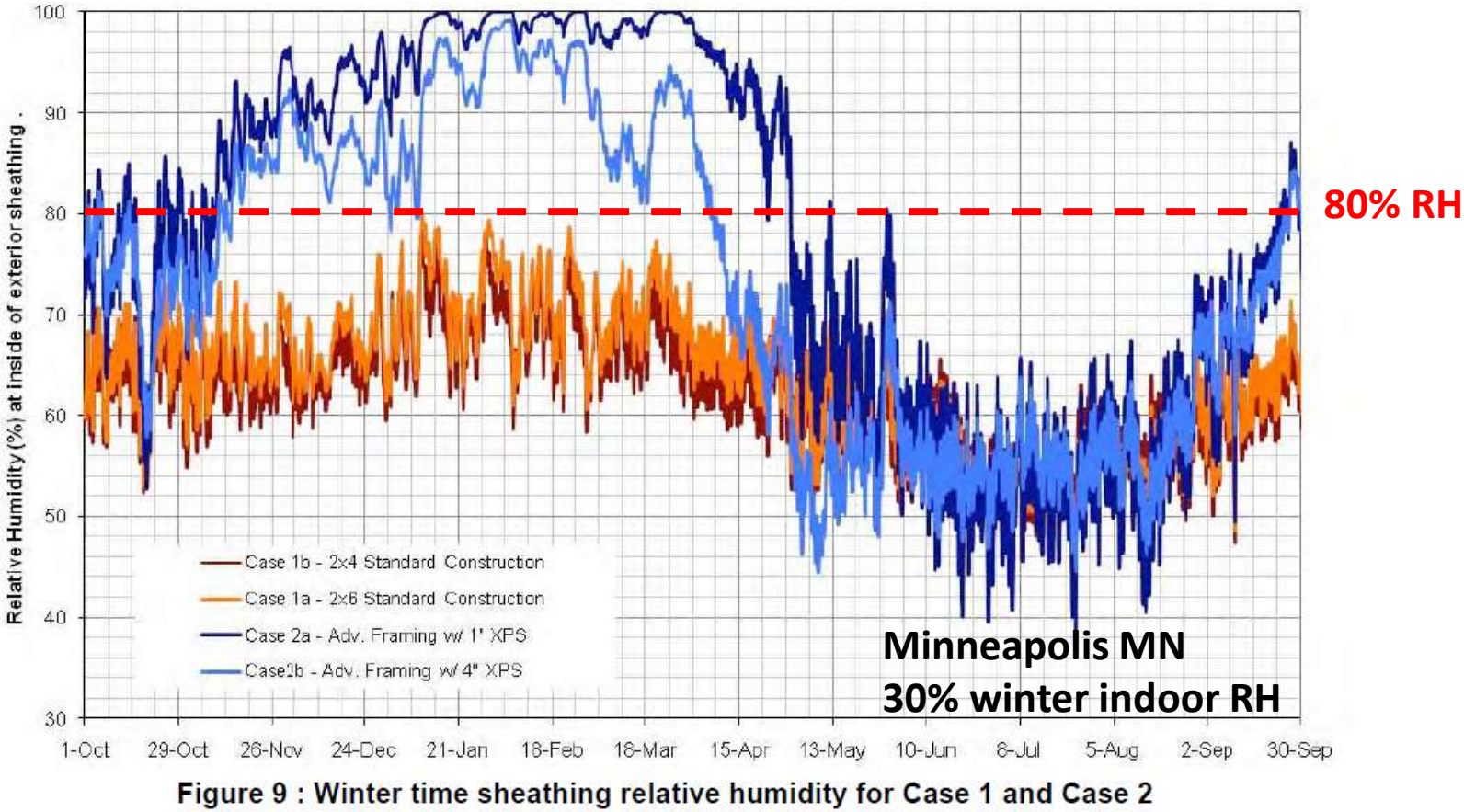


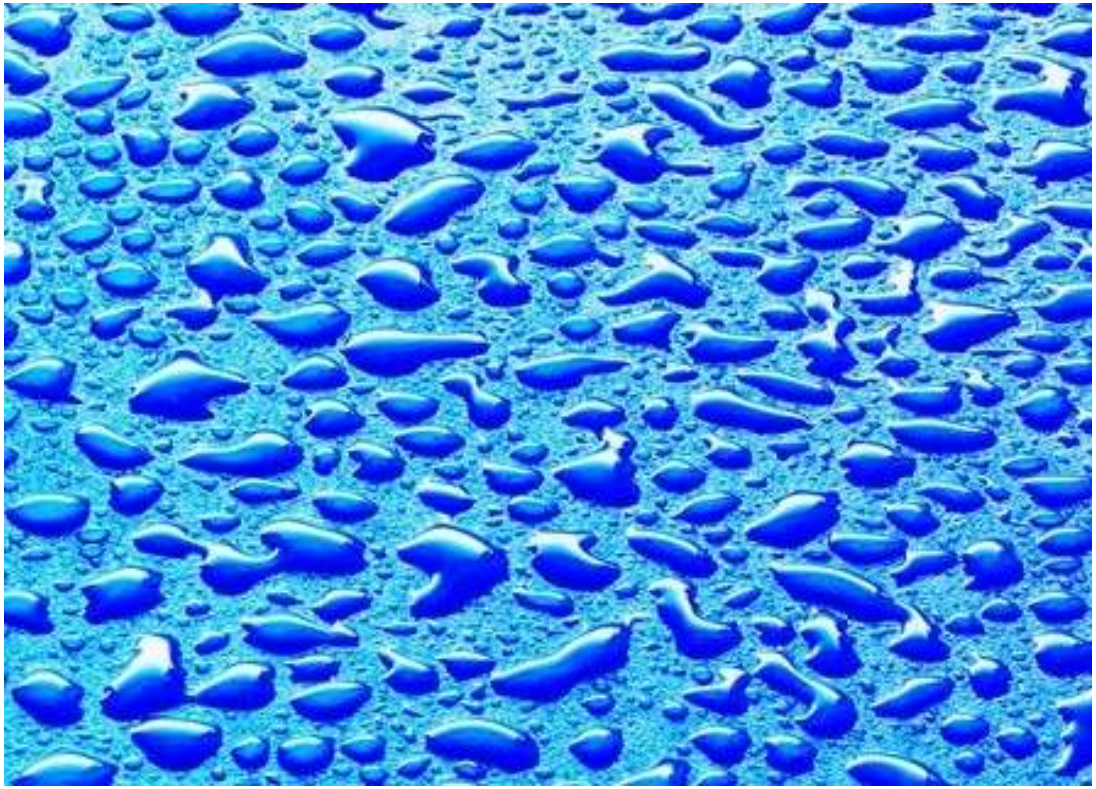
Figure 9 : Winter time sheathing relative humidity for Case 1 and Case 2

Credit: Building Science Corp, Building America Special Research Project: High R Walls Case Study Analysis

with only a 30% wintertime indoor relative humidity….

"…in a relatively airtight enclosure, the RH could increase to 40 or 50% which increases the risks significantly."

foam is **hygrophobic**



And **doesn’t help** drying.

Foam makes enclosures more **intolerant**

Credit: Fraunhofer Institute

Reduce the **intolerance**.

Increase the **resilience**.

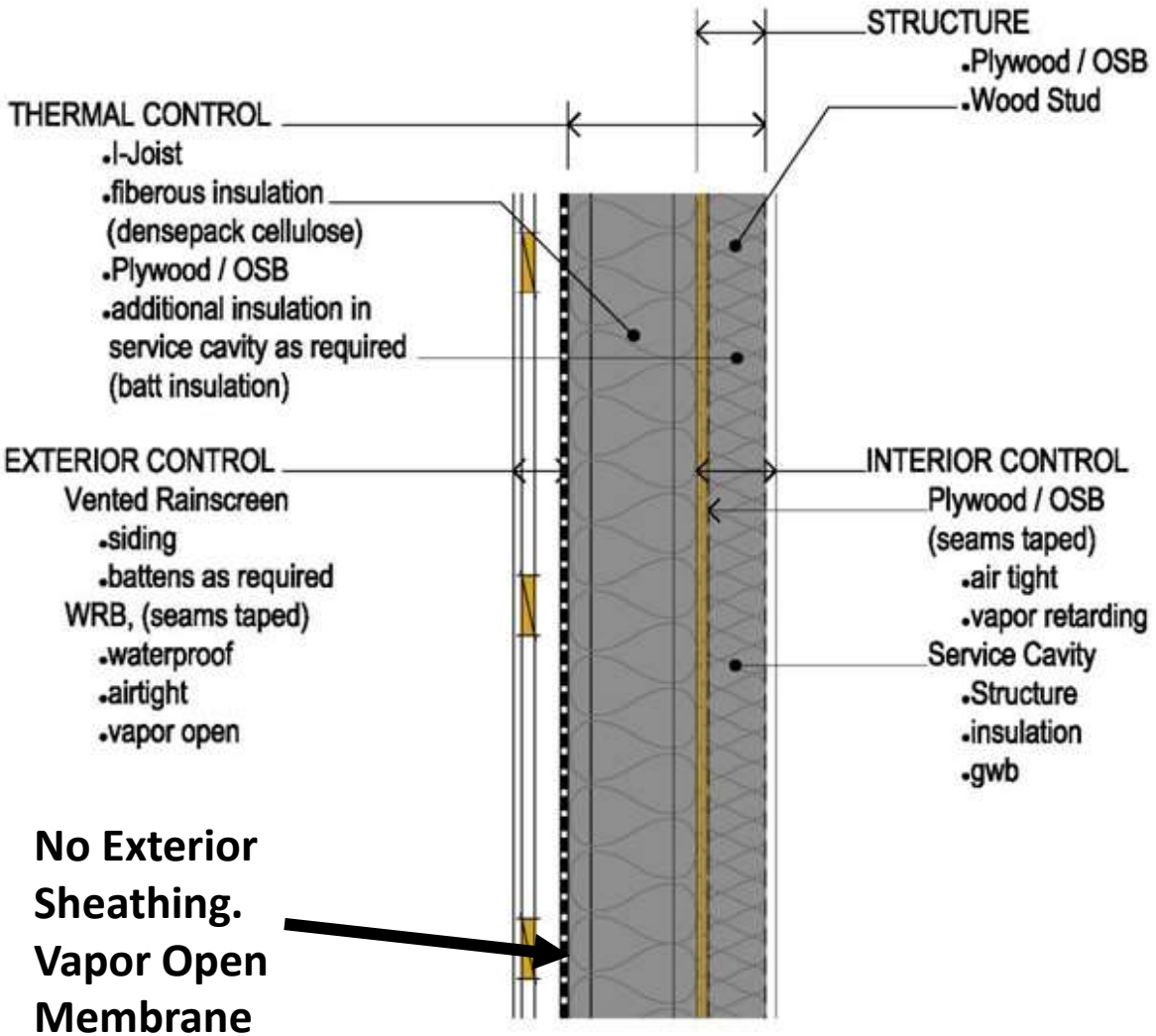
Vapor open sheathing at **Exterior**

Credit: USG

Credit: Ed May, http://bldgtypblog.blogspot.com/

or **no** (exterior) **sheathing**

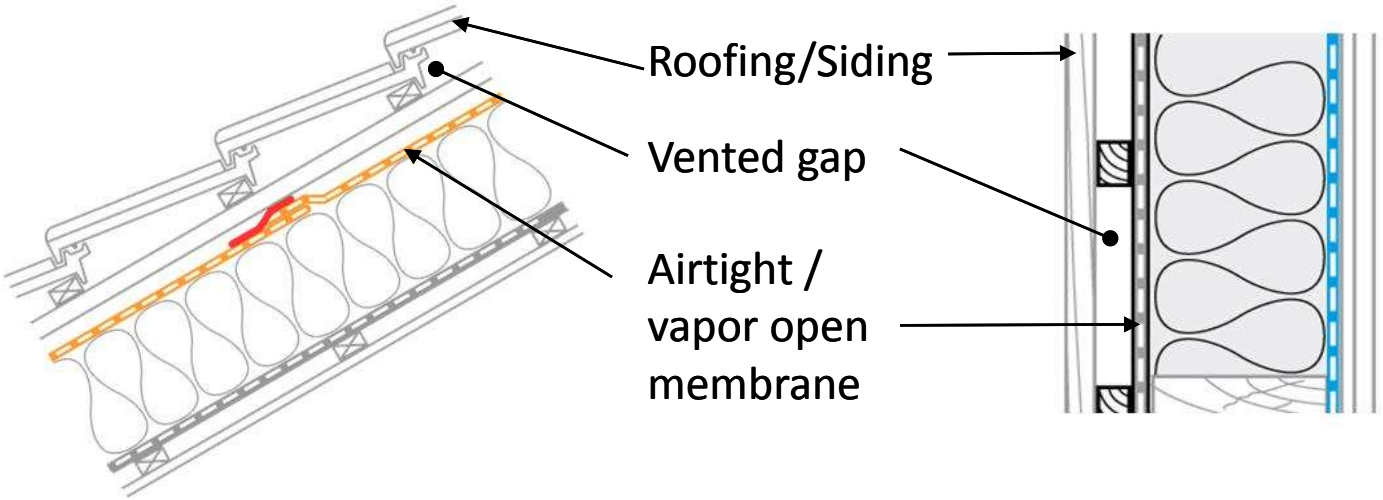
Photo Credit: Andrew Klein, Generation Green Building



No Exterior Sheathing. Vapor Open Membrane Only.

Photo Credit: Andrew Klein, Generation Green Building

Back **vented rainscreens**
(roofs and walls)



Don’t dam moisture around **openings**

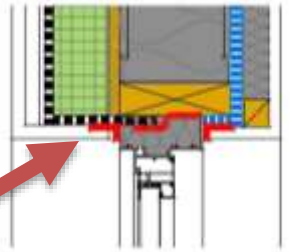
Traditional

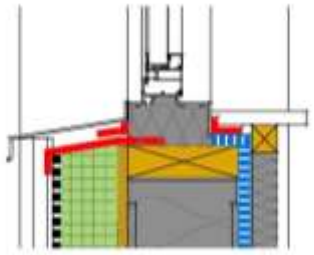
Vapor **barrier** tape

New

Vapor **permeable** tape

Vapor Open Tapes And Membranes





Vapor retarding at interior

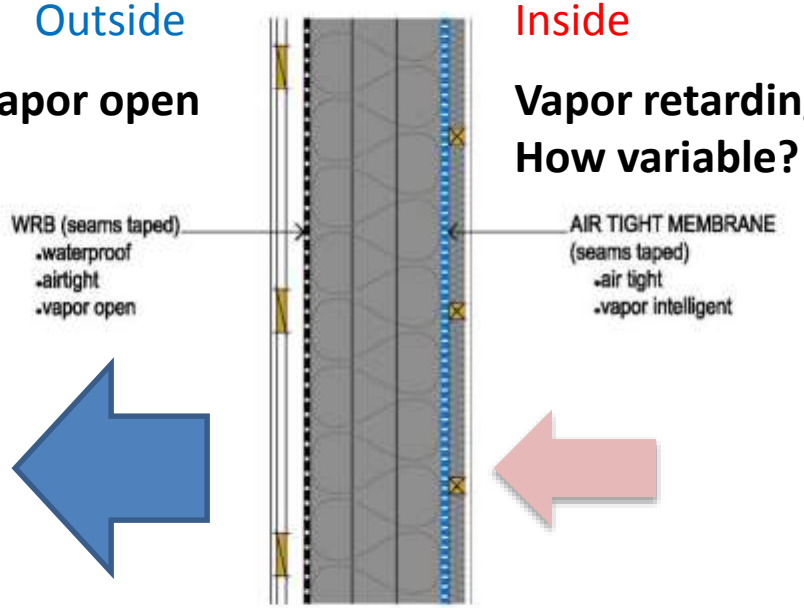
Remember: 5:1 Perm ratio rule of thumb

Outside

Vapor open

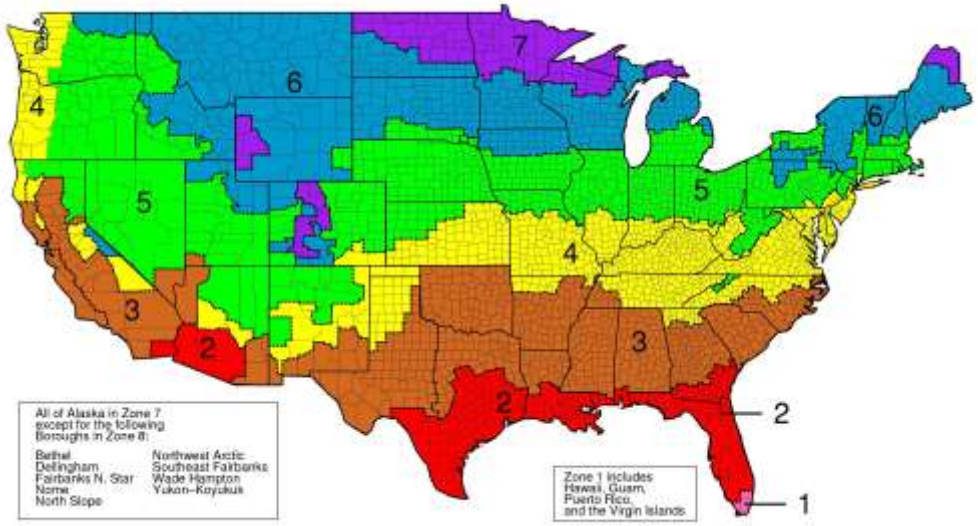
Inside

Vapor retarding/Vapor variable.
How variable?



Code requirement for interior vapor control

1405.3 Vapor retarders.
Class I or II vapor retarders shall be provided on the interior side of frame walls in Zones 5, 6, 7, 8 and Marine 4. The appropriate zone shall be selected in accordance with Chapter 3 of the *International Energy Conservation Code*.



Exceptions:
1. Basement walls.
2. Below-grade portion of any wall.
3. Construction where moisture or its freezing will not damage the materials.

R702.7.1 Class III vapor retarders.
Class III vapor retarders shall be permitted where any one of the conditions in Table R702.7.1 is met.
- Vented cladding
- Insulated outboard sheathing (per climate zone requirements)

Credit: International Code Council, 2012

Vapor Retarding Classifications

Vapor Retarders:

- **Class I**: **0.1 perm or less**: impermeable
  (Sheet polyethylene, **aluminum foil**)

- **Class II**: **0.1 perm <= 1.0 perm**: semi-impermeable
  (Kraft faced fiberglass batts, **XPS**, oil paint, **3" unfaced EPS**)

- **Class III**: **1.0 perm <= 10 perm**: semi-permeable
  (enamel paint, <3" unfaced EPS, Plywd, OSB, **Latex Paint???**)

Vapor Permeable:

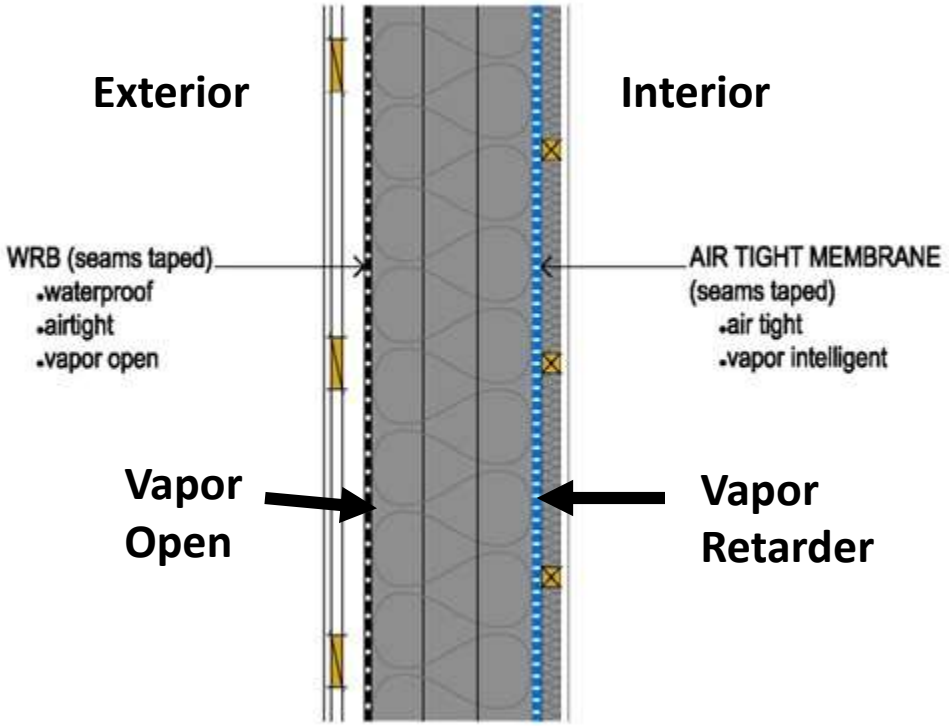
- **>10 perm**
  (gyp board, brick, cellulose, unfaced batts, **Latex Paint???**)

Interior vapor control **Materials**

Interior **Vapor** Retarder - preferably **variable & tested**
(and air barrier)

<u>Options</u>

- OSB:
  - approx **0.5 – 2** perms
- Plywood:
  - approx **0.5 – 3** perms
- Paper Based Membrane:
  - **0.8 – 5.5** perms
- Intelligent Membrane:
  - **0.17 – 13.2** perms



OSB at **interior**

0.5 – 2 perms

Paper based membrane

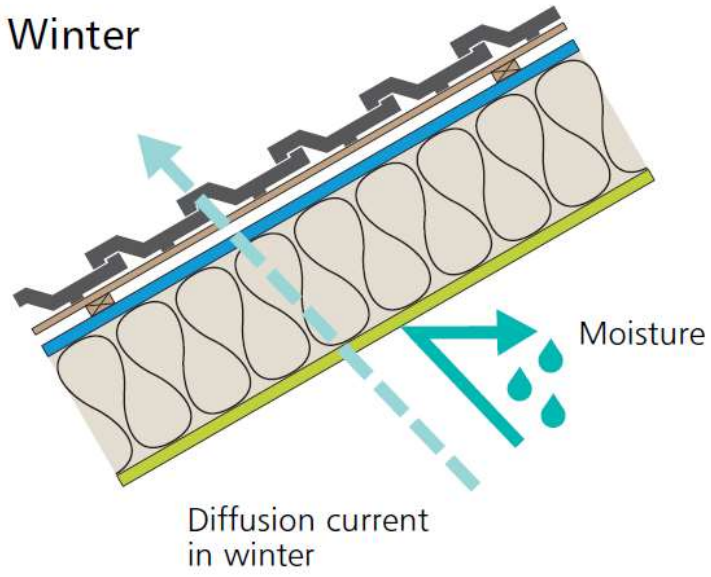
0.8 – 5.5 perms

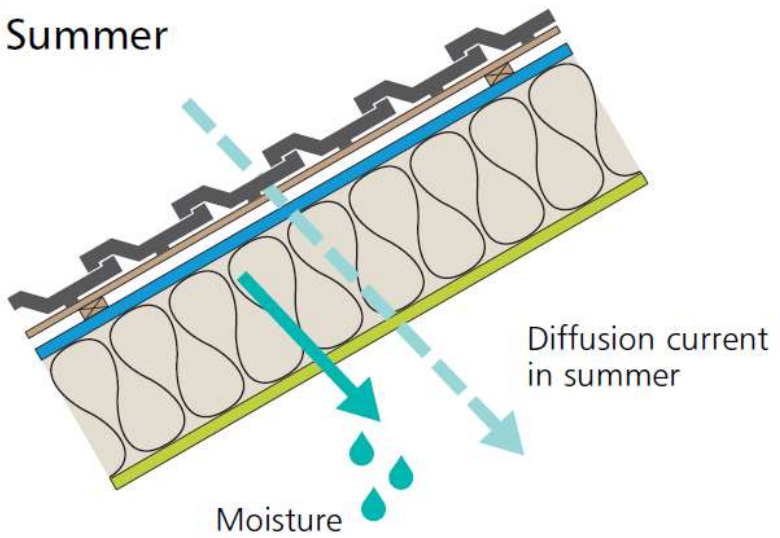
Intelligent vapor retarder

prevents wetting and **promotes drying**

for

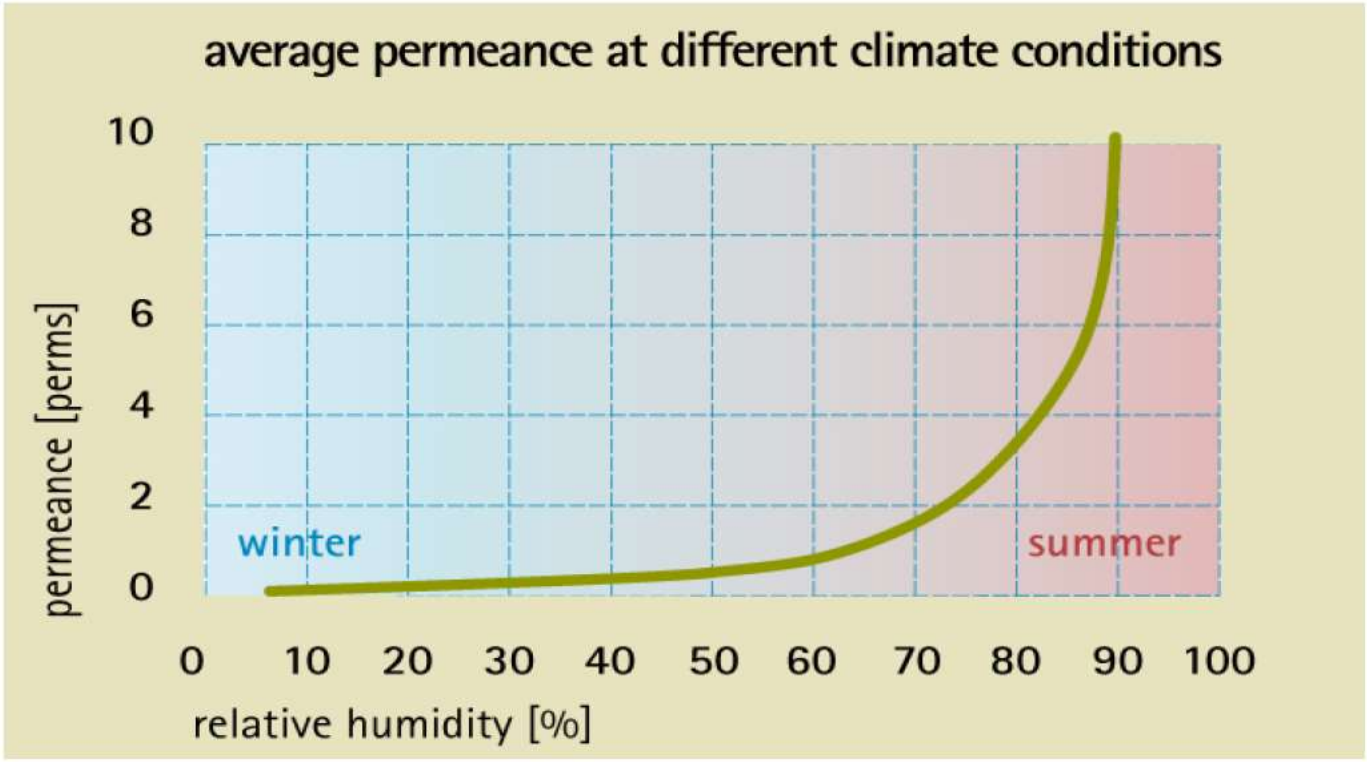
maximum protection





0.17 – 13.2 perms

Vapor **Intelligent Membrane**



From vapor closed in winter to vapor open in summer.

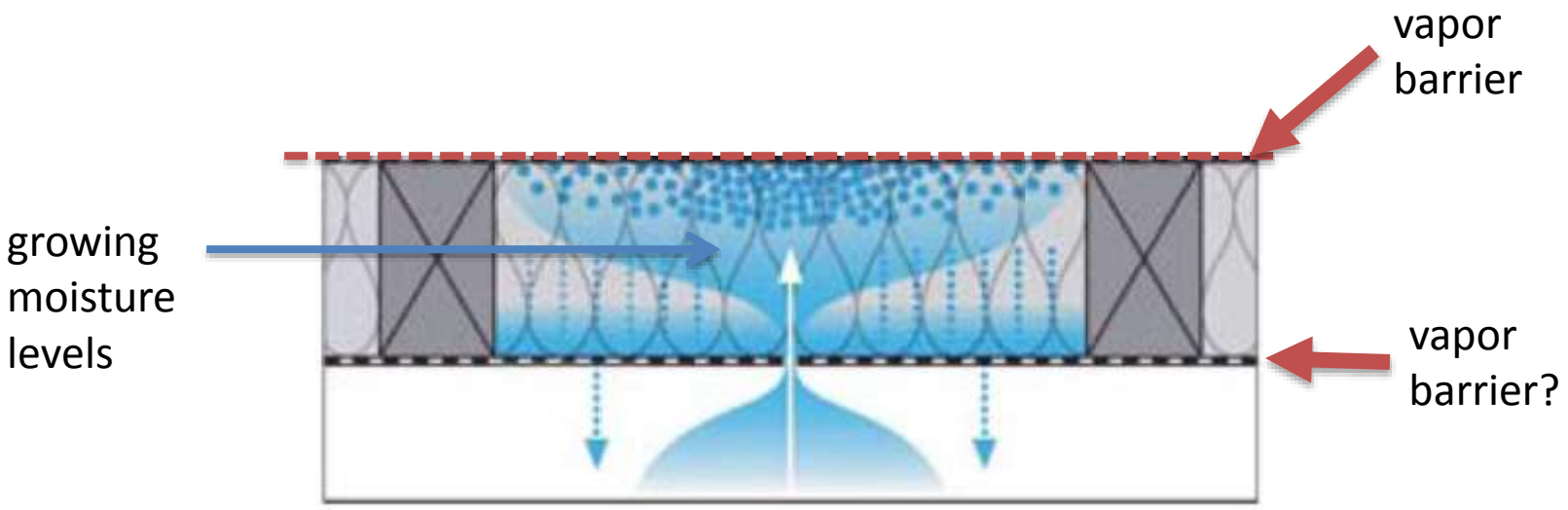
Intelligent Membrane

Ideally suited for:

1. Meeting Code for Class II vapor retarders.
2. Where assemblies have significant vapor retarding or vapor closed outboard layers.
3. Historic masonry retrofits
4. Batt insulation installations

Often roofs are vapor barriers, so **don't make it worse**

(even in California, watch out for radiant cooling)

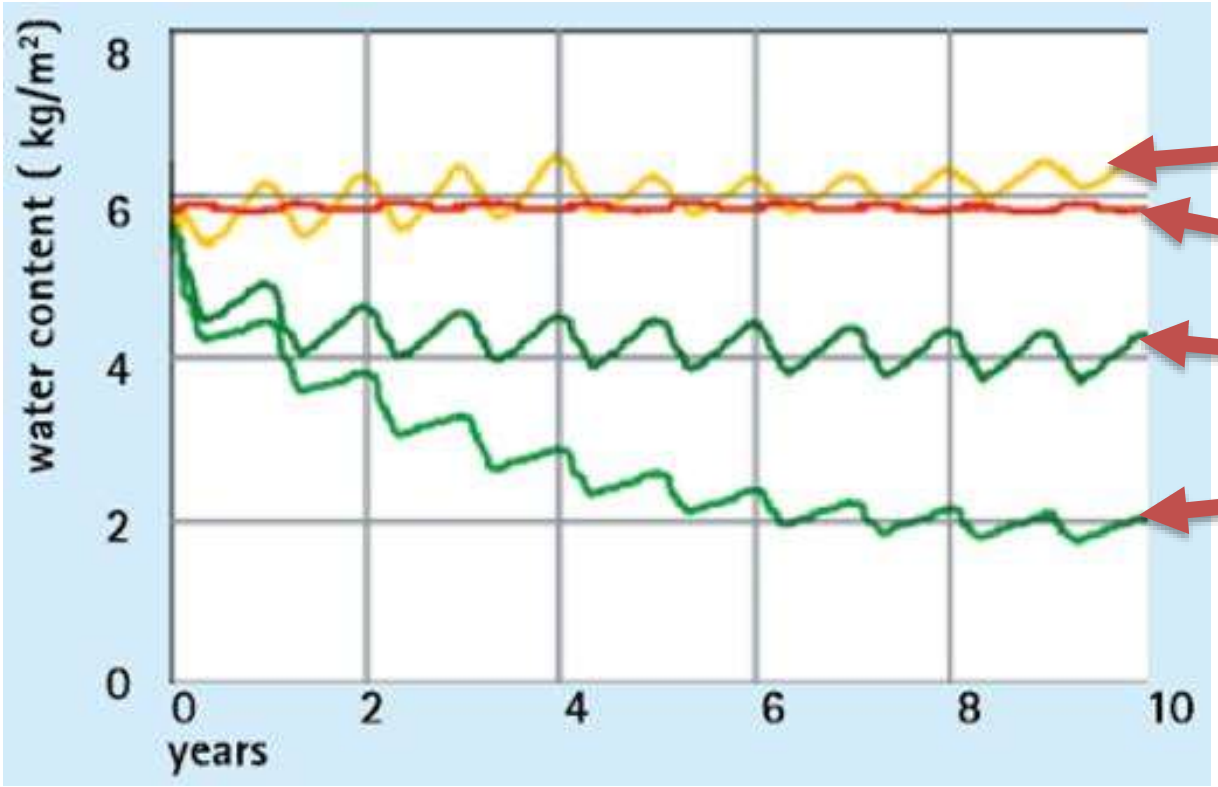


Cathedral Ceiling Roof

Worse

Credit: FineHomebuilding

Maximum drying potential

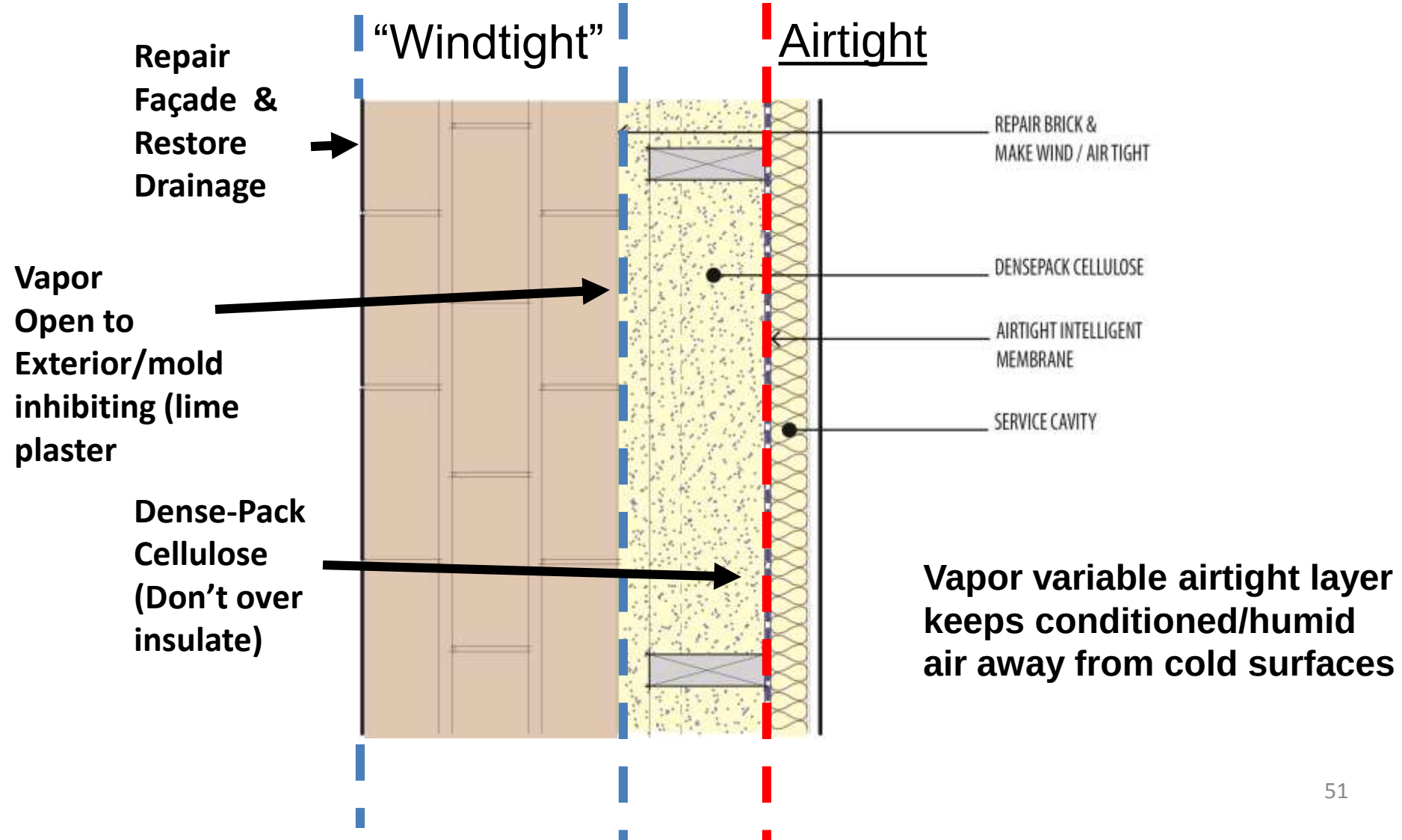


Study: Steep pitched, north facing roof at high altitude (a worst case scenario).

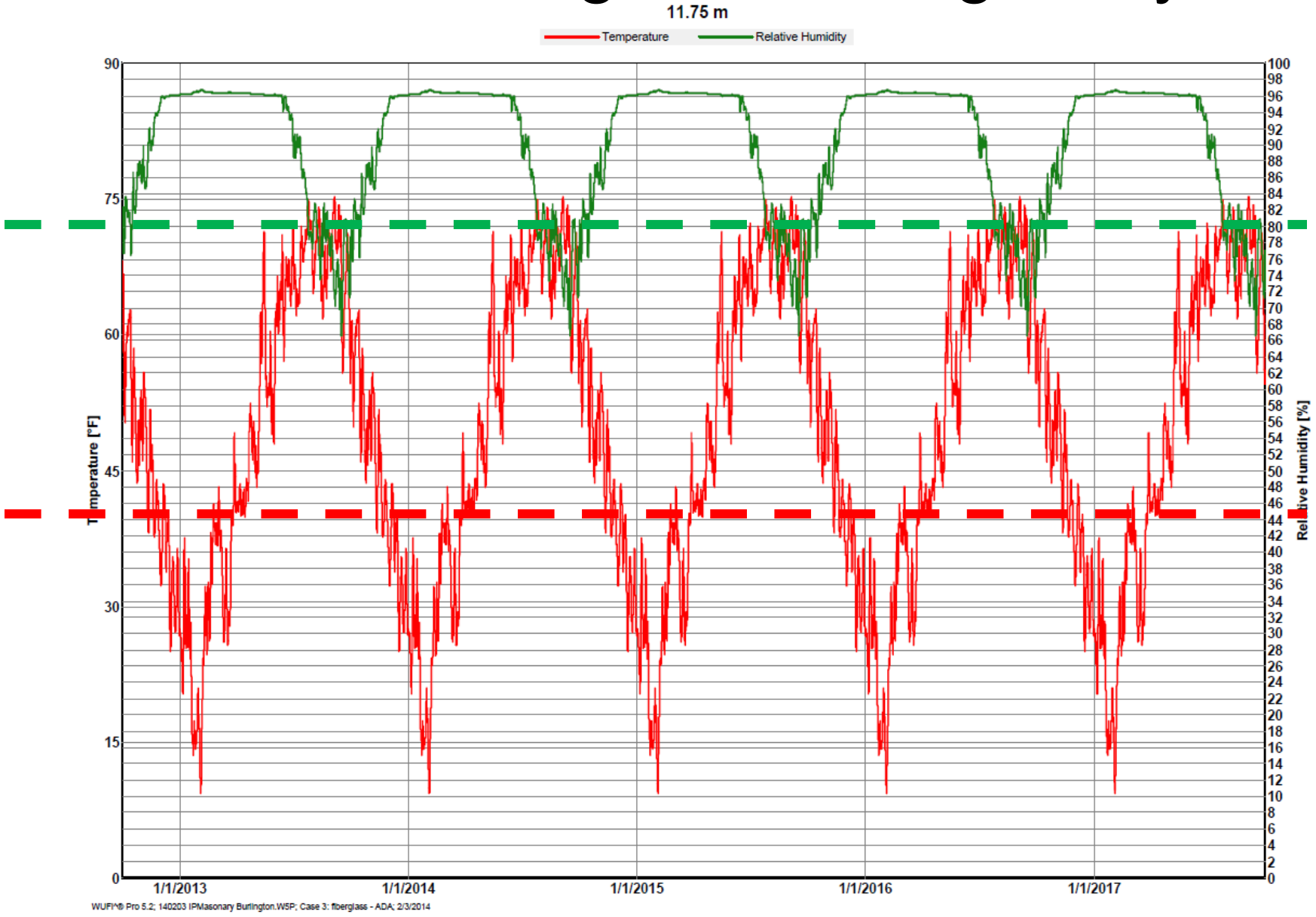
Credit: Pro Clima

Historic Masonary retrofits

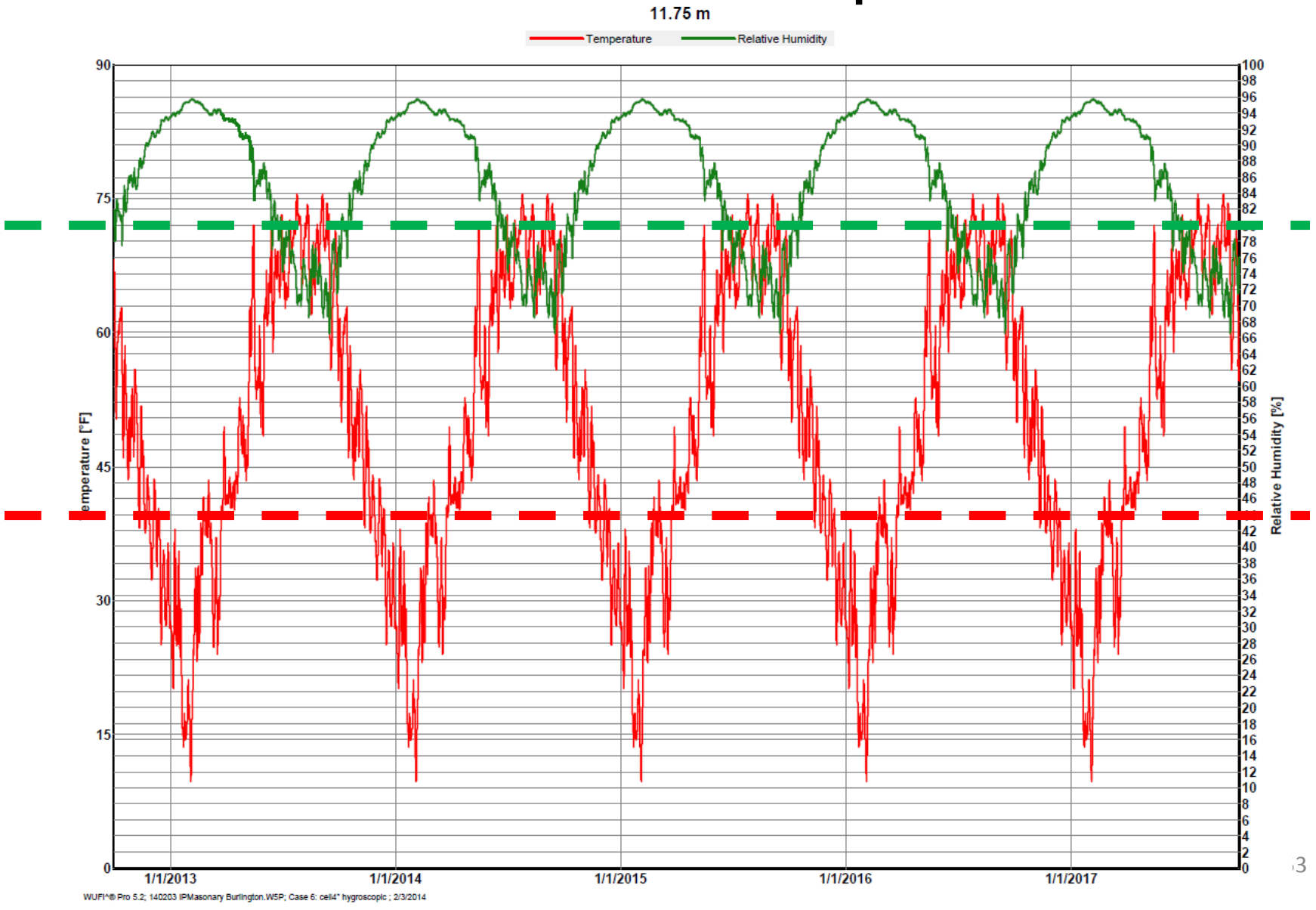
Optimal Airtightness Inboard of Insulation – prevents mold/moisture issues, Reduces chance of freeze-thaw



WUFI: 4” Fiberglass & Airtight Drywall



4” Cellulose without vapor control

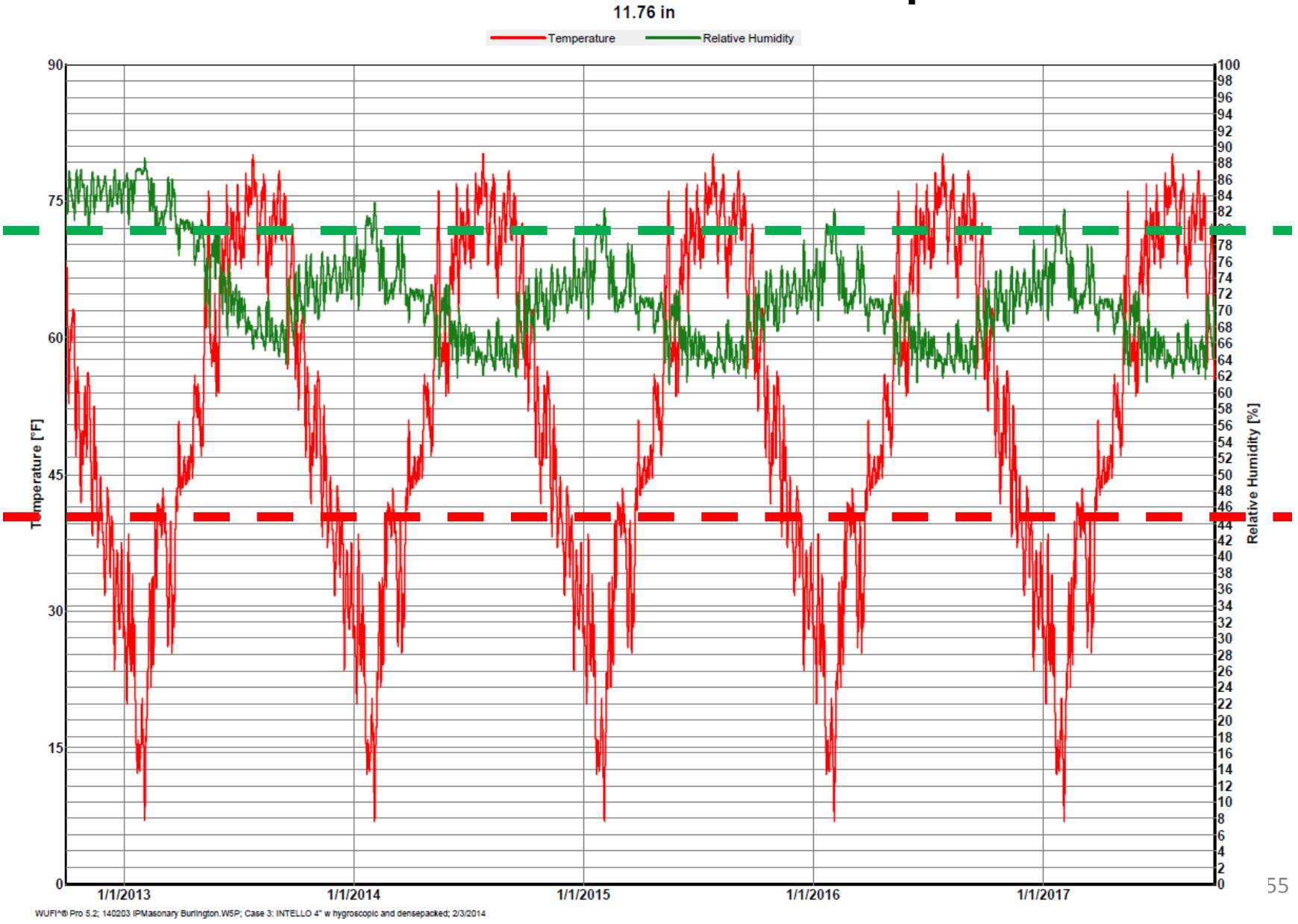


Consider an **insulation** that **helps drying**

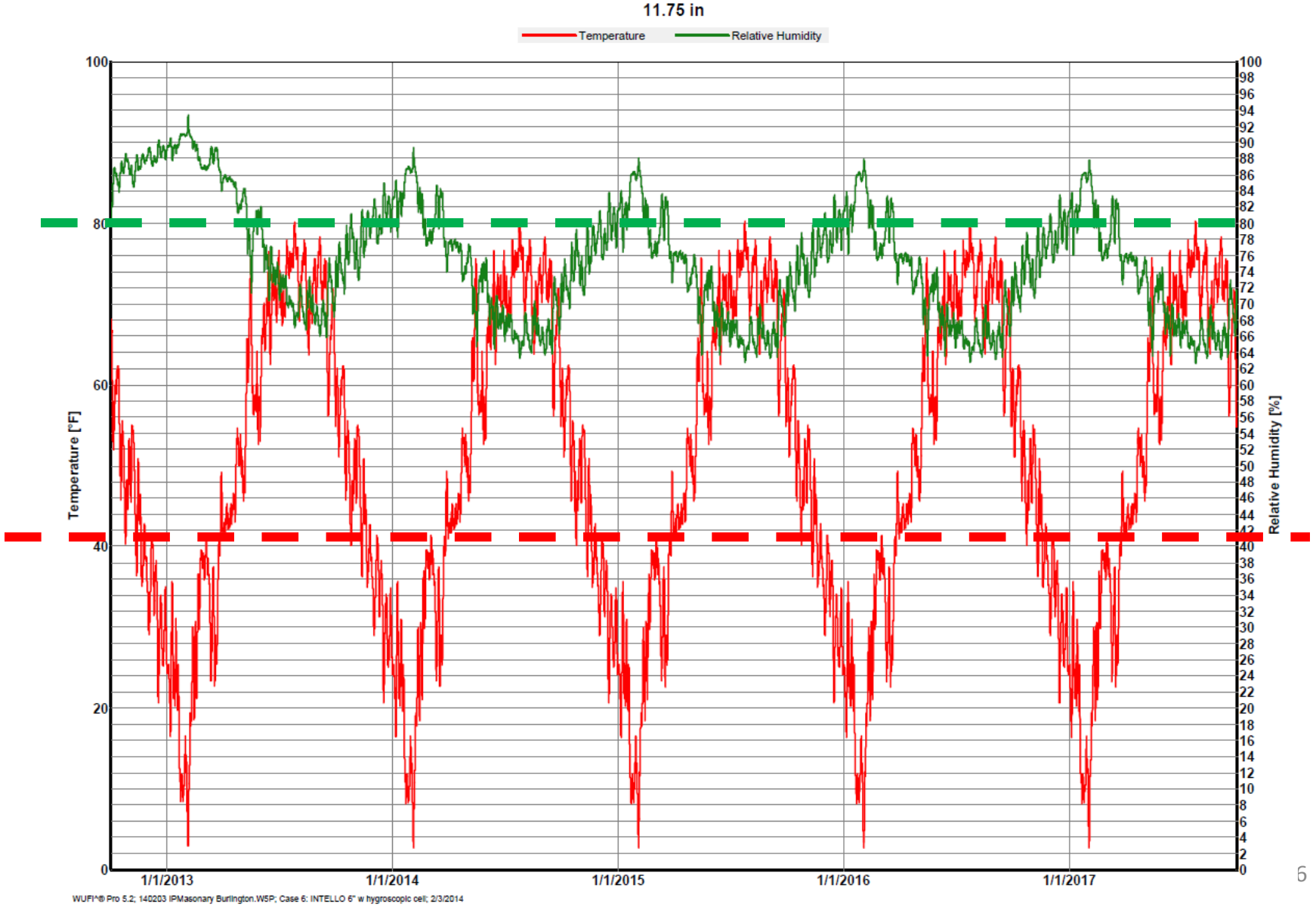
Cellulose is hygroscopic

- Cellulose is not indifferent to moisture like foam – it actively engages it.
- Dense pack cellulose will actively help manage moisture infiltration, moving moisture to dryer areas, increasing the enclosures ability to dry out.

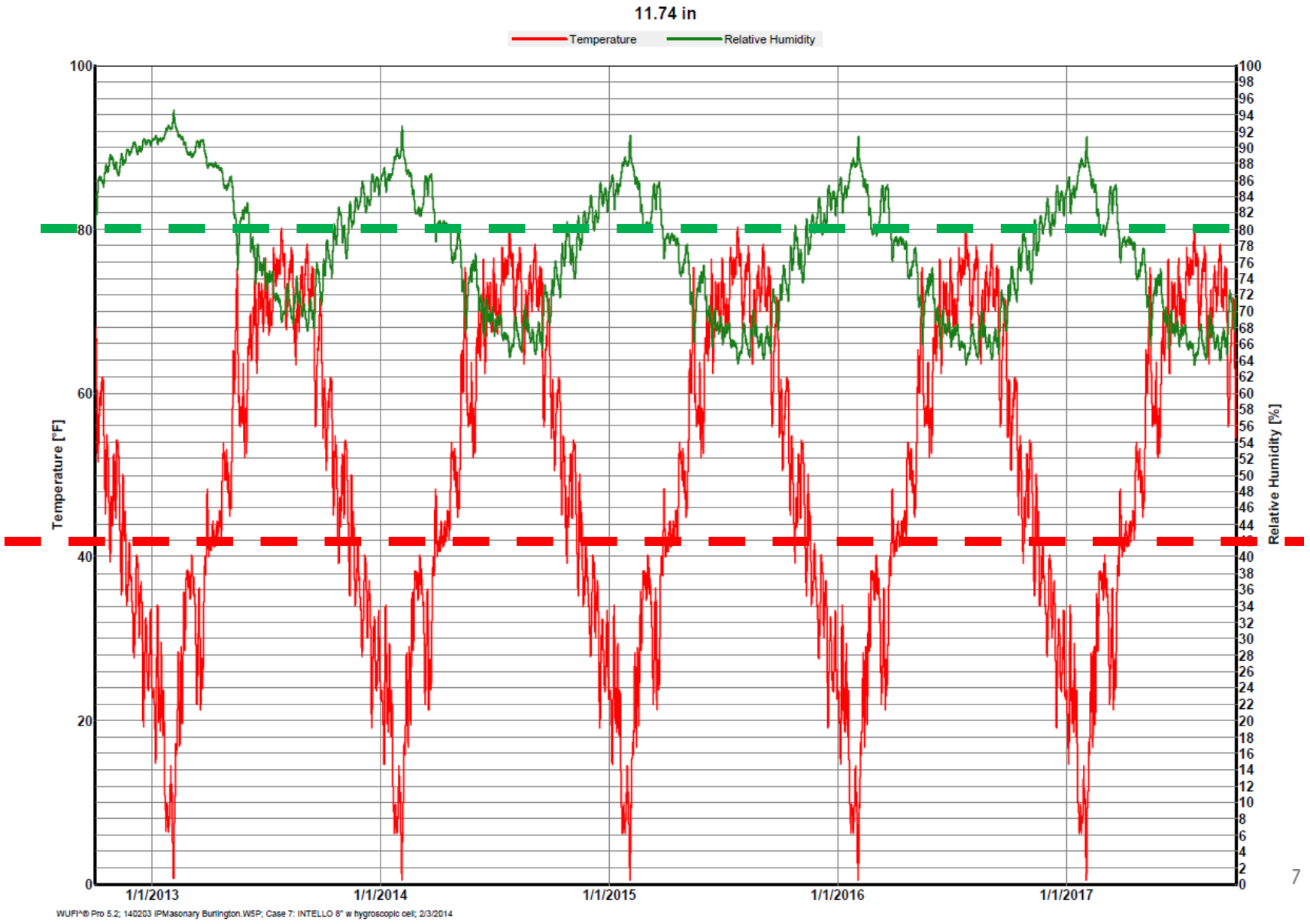
4” Cellulose with smart vapor control



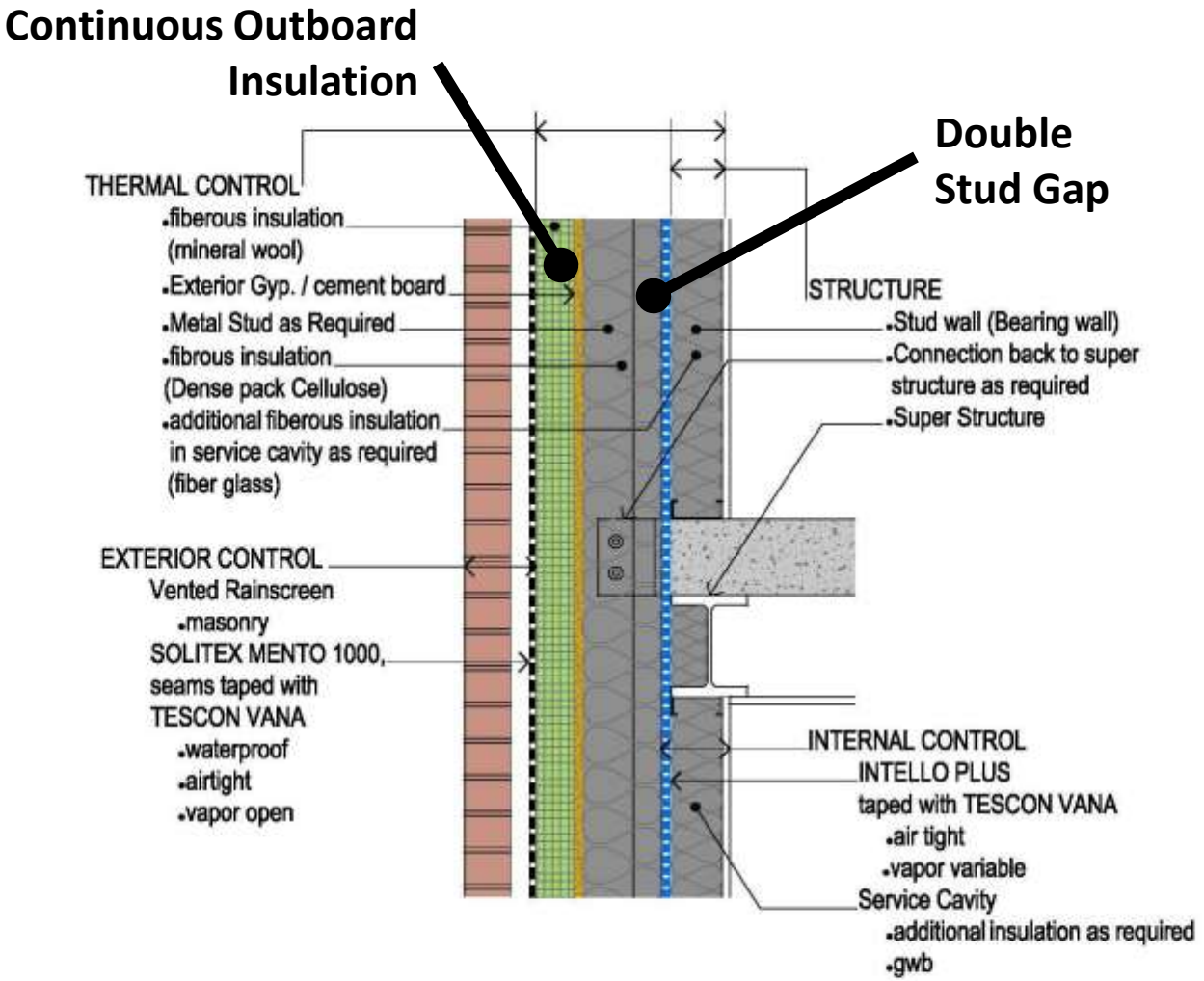
6” Cellulose with smart vapor control



8” Cellulose with smart vapor control



Thermal Bridge Free



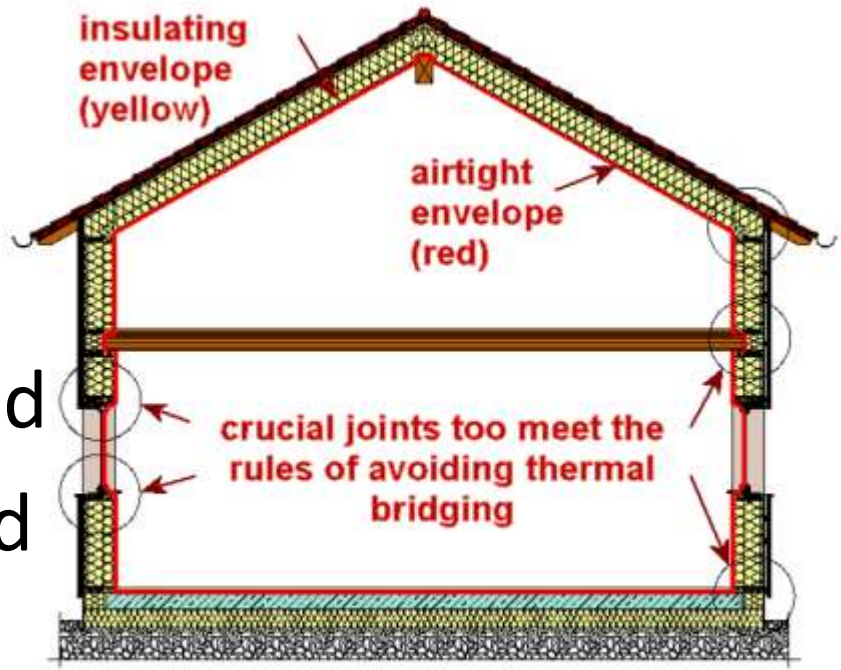
Outboard **Mineral Wool** Insulation

Renovation by Ryall Porter Sheridan,Orient Point NY

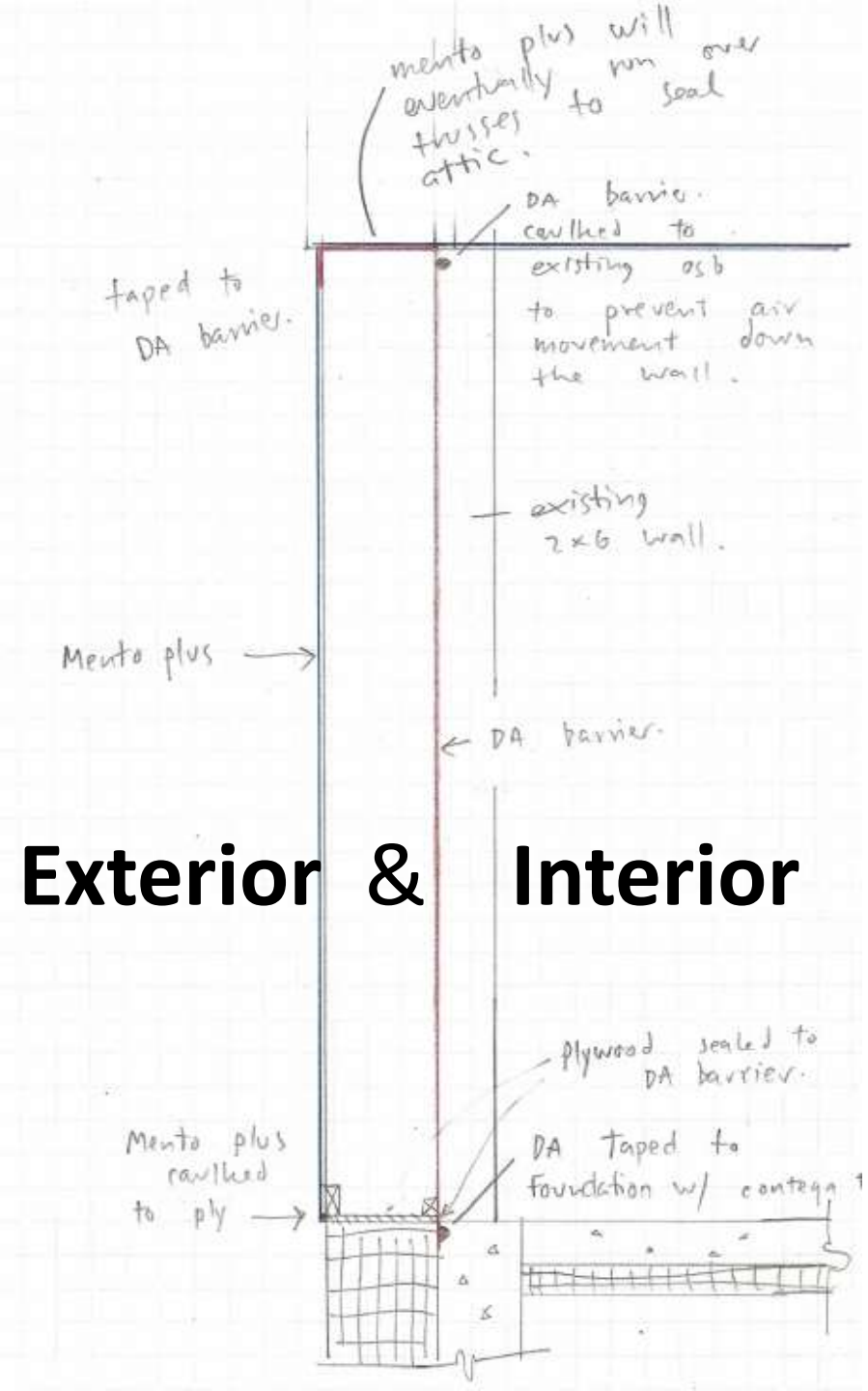
The **Predictability** and **Durability**
of
Control Layers
is dependent on
Continuity

Continuity:

- Robust materials
- Simplify
- Sequence
- Penetrations addressed
- Repairable and verified
- Protected



Ref http://passipedia.passiv.de/passipedia_en/



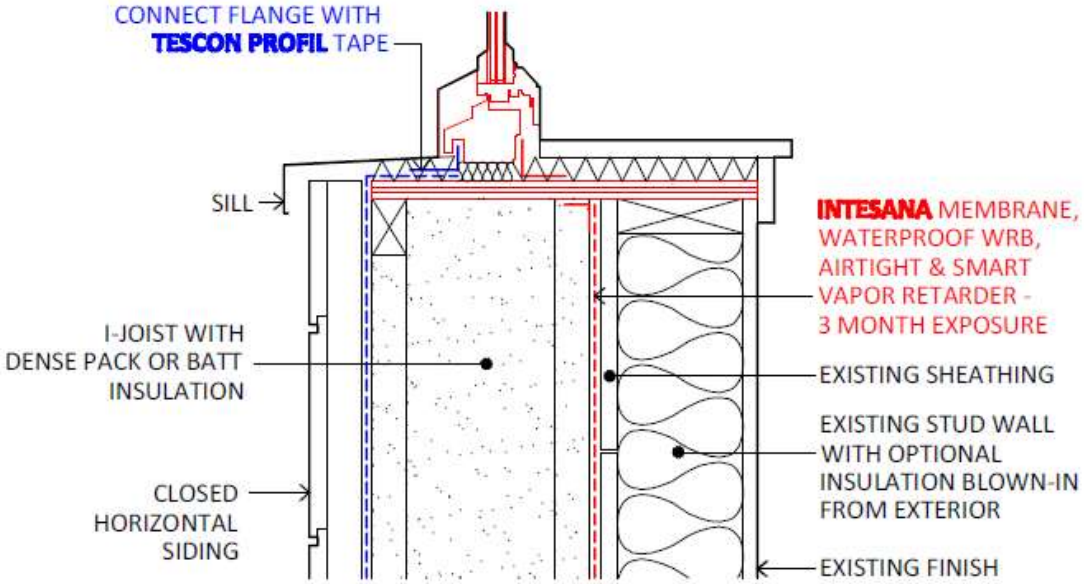
Exterior & Interior

Chainsaw retrofit

DER

Connecting the continuous airtight layer(s)

Jesper Kruse – Maine Passive House



ECOCOR – Maine – Chris Corson

Sheathing

(Typically very good)

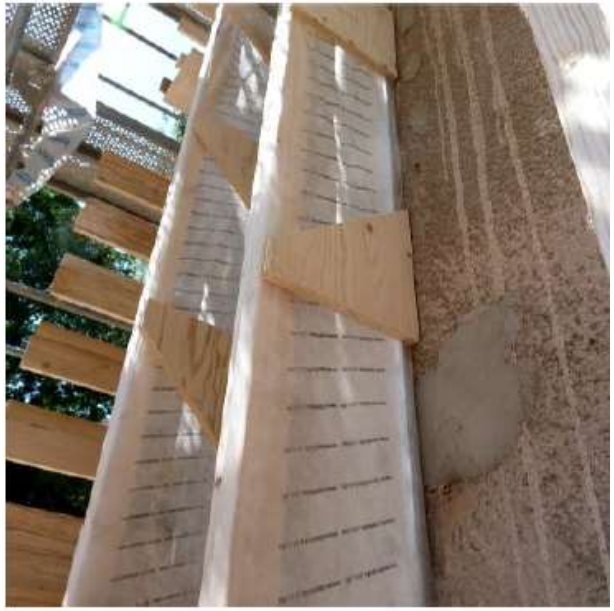
But again – prevent thermal bypass

fill cavities completely

Foam shrinks – even in SIPs

Foam Free EIFS – cellulose based

iwu.de – biomass insulation report

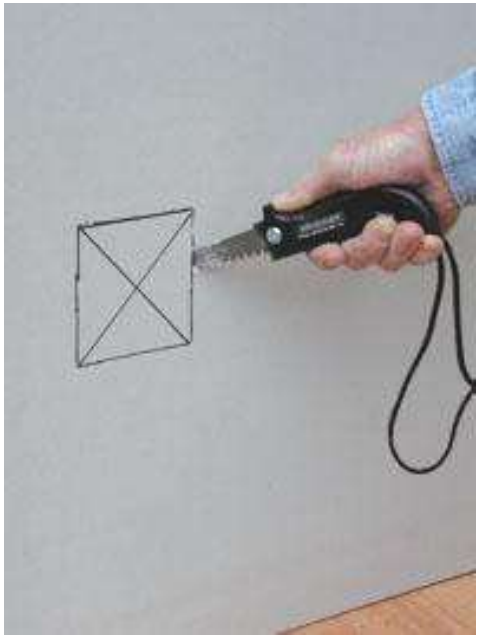


Foam Free EIFS – cellulose based

Mineral and gypsum fire ‘stops’

iwu.de – biomass insulation report

Drywall?

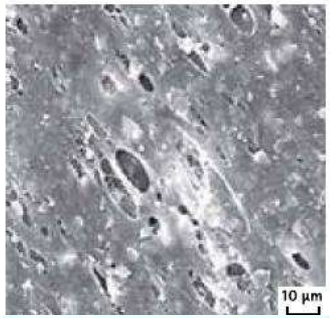


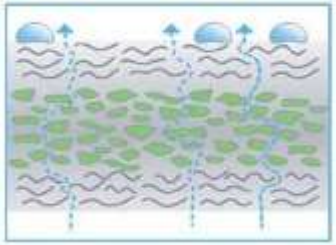
Drywall is a sacrificial layer.

Membranes

Old WRB

- ASTM E2178 = “air tight”
- 0.004 cfm/ft2
- Micropores “nonperforated”
  (Micropores for vapor movement)
- No active vapor transport – requiring vapor pressure to work.

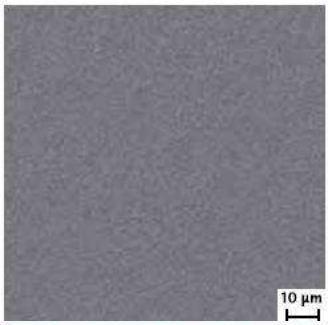


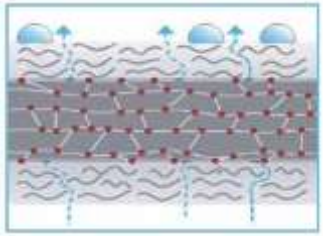


Credit: Tyvek

New WRB

- 0.00004 cfm/ft2
- Three layer, monolithic membrane: Thermoplastic Elastomer-Ether-Ester
- Active vapor transport on molecular chain

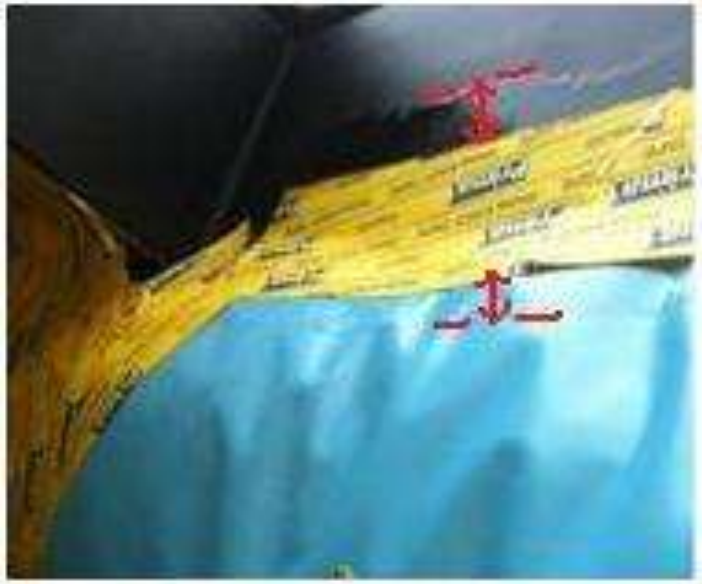




Credit: Thorsten Chlupp, Alaska

Adhesive **Tapes**, **caulking** and **gaskets**

or



(Wide range of quality)

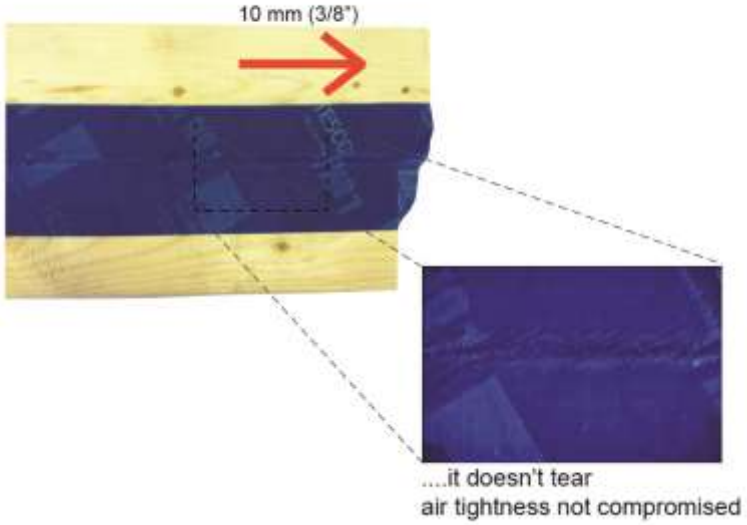
Robust connections

Old

- Many sealants dry, embrittle and fail over time

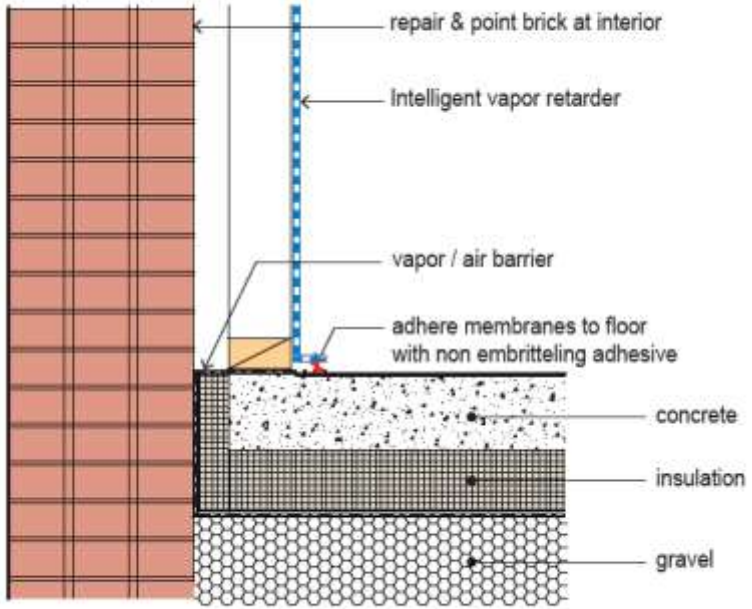
New

- PSA adhesives can move with building



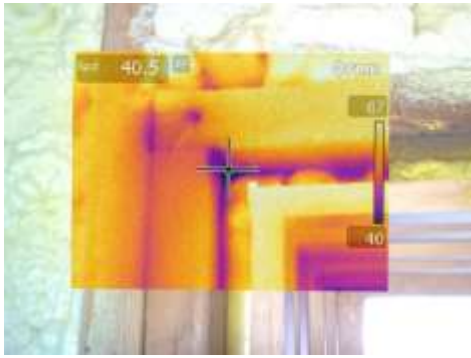
treat carefully **dissimilar** and **difficult materials**

- Acrylic adhesive for uneven and porous materials
  - Doesn't embrittle/dry out, remaining flexible



Foam is **not optimal**

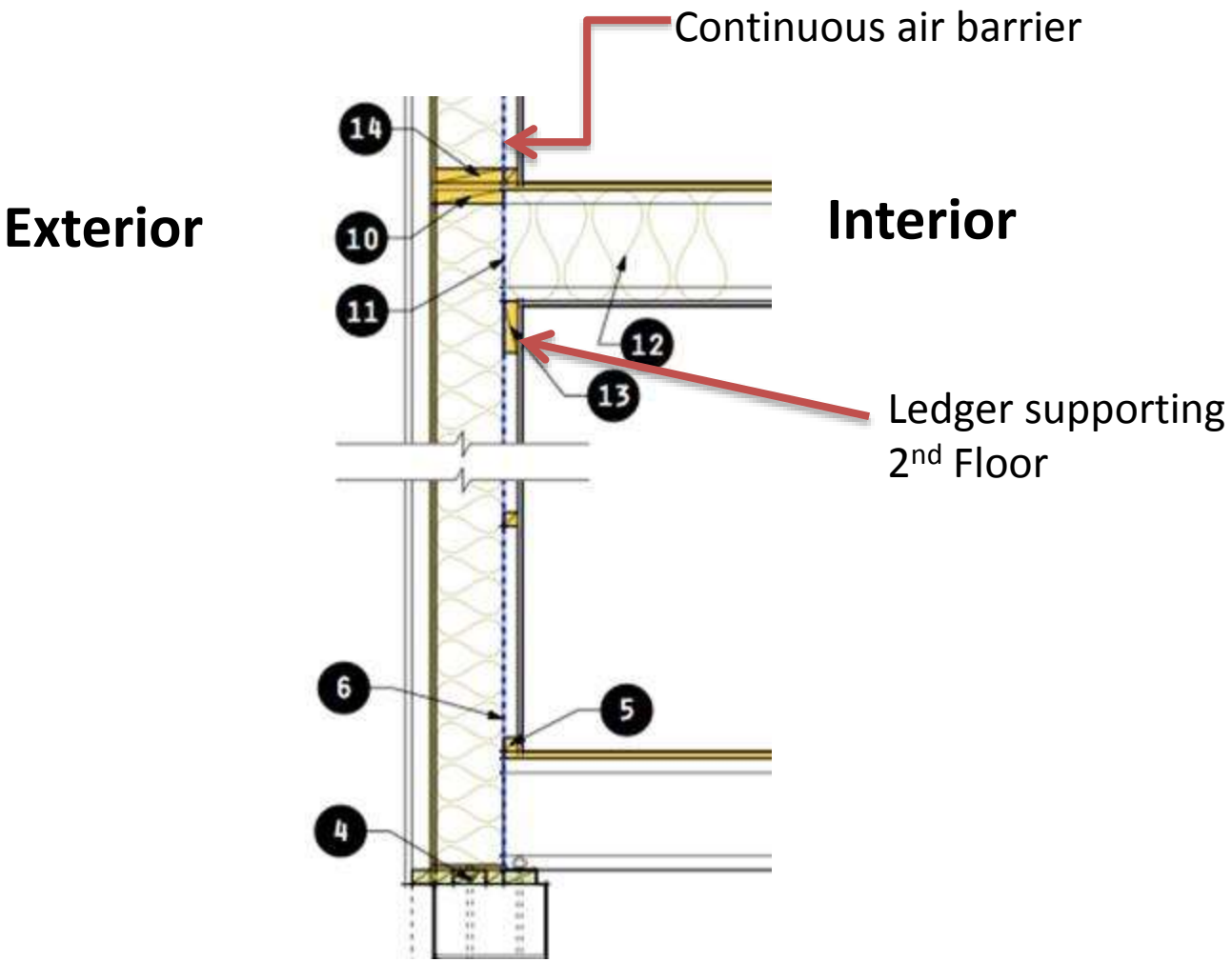
- **Quality control** is **problematic**
  - **Construction site manufacturing**: sensitive and toxic chemical components
  - **Substrate too wet**, cold and dirty: compromise adhesion, and cause delamination.
  - **Off ratio spray**: cracks, fissures, voids
  - **Too much sprayed**: exothermic heat causes cracking, fire
  - **Shrinks**
  - **Not Continuous** expand not into the holes but out of it



Credit: EnergyEfficientSolutions.com

Credit: Journal of Light Construction, *Trouble Shooting Spray-Foam Insulation* by Mason Knowles, Sept 2010

Simplify wherever possible



Credit: Gregory La Vardera, Lamidesign.com

Sequence for continuity

Step One

Step Two

Credit: Ed May, http://bldgtypblog.blogspot.com/

Wire and pipe **penetration sealing**

Allow for room to gasket properly

Credit: Ed May, BldgTYp

Credit: Roger Lin, Southern Exposure Homes

Beam penetrations

Felt tape embedded in plaster

(also for Strawbale /stucco const. etc)

Taped sheathing

Primed and taped plaster

Taped membrane

(allow space to tape)

Window penetration sealing

Window taping – on both sides - also with BJORN plaster as airseal

Nick Grant

24/7/365 means **working** in **cold** and **wet** conditions

Conventional capabilities

- Spray Foam & Butyl Based adhesives:
  - 25 to 40 degree temp limit
  - Low moisture required
  - Clean surfaces

Credit: tbd

New capabilities

Pressure Sensitive Acrylic (PSA) Adhesives

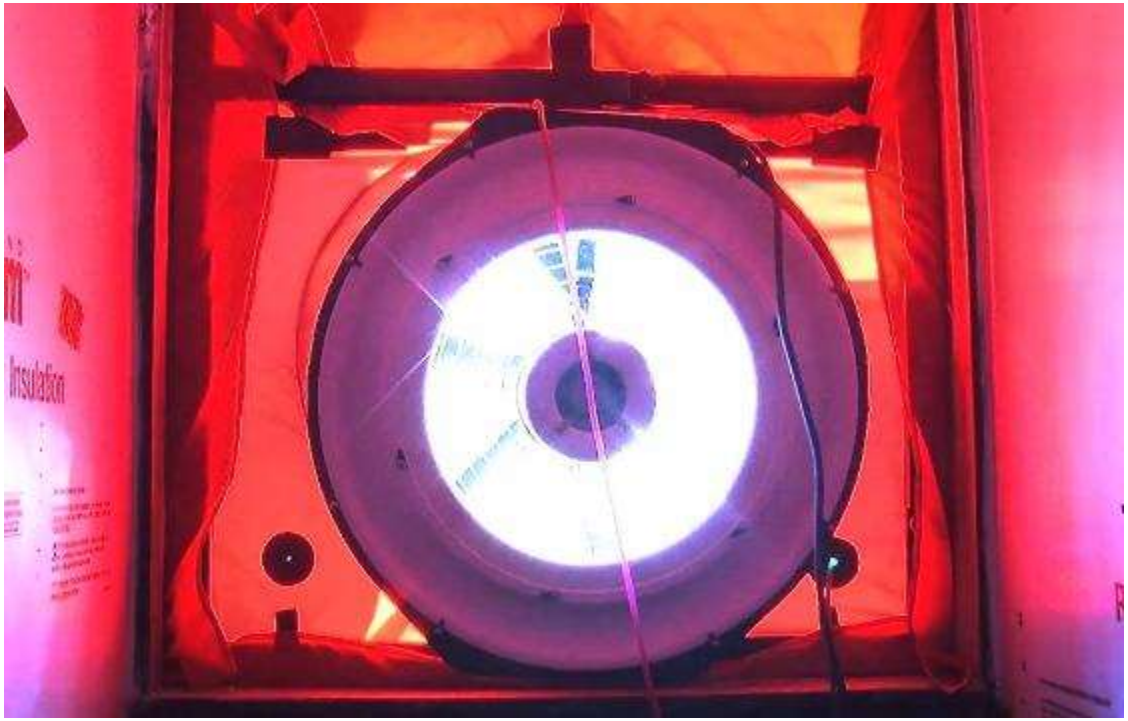
- Molecular bonding
- 1 hour setup

Caulking Adhesive

- 48 hour setup

- **15 degree temp limit**
- **Moisture tolerant**

Verify



Credit: *Passive Passion*, Charlie Hoxie

pressurize and **depressurize**

Repairable

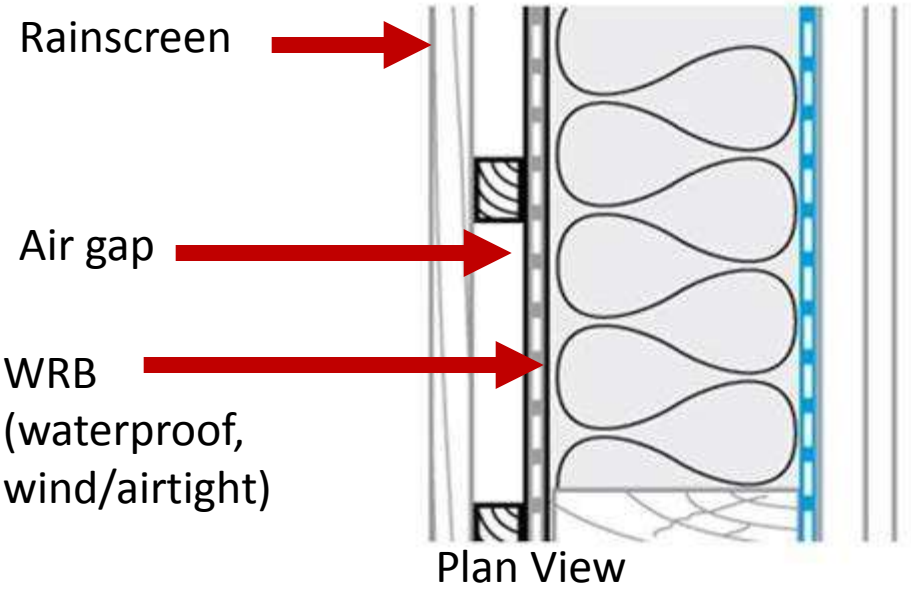
Foam is **problematic**

And not reversible

Credit: Ed May, BLDGTYP

Credit: Energy Wise Homes

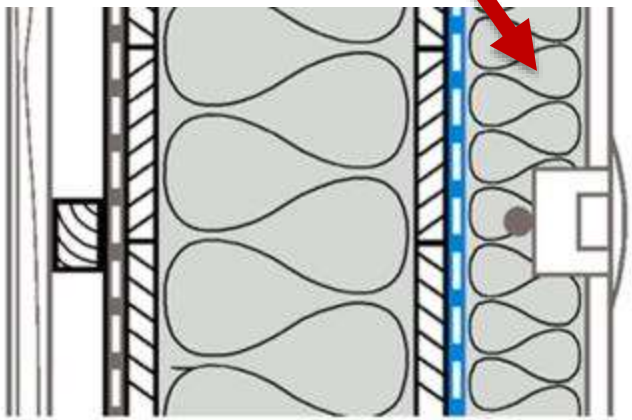
Protected by **Rain Screen**



Credit: Ryall Porter
Sheridan Architects

and **service cavity**

Service cavity protects airtight layer

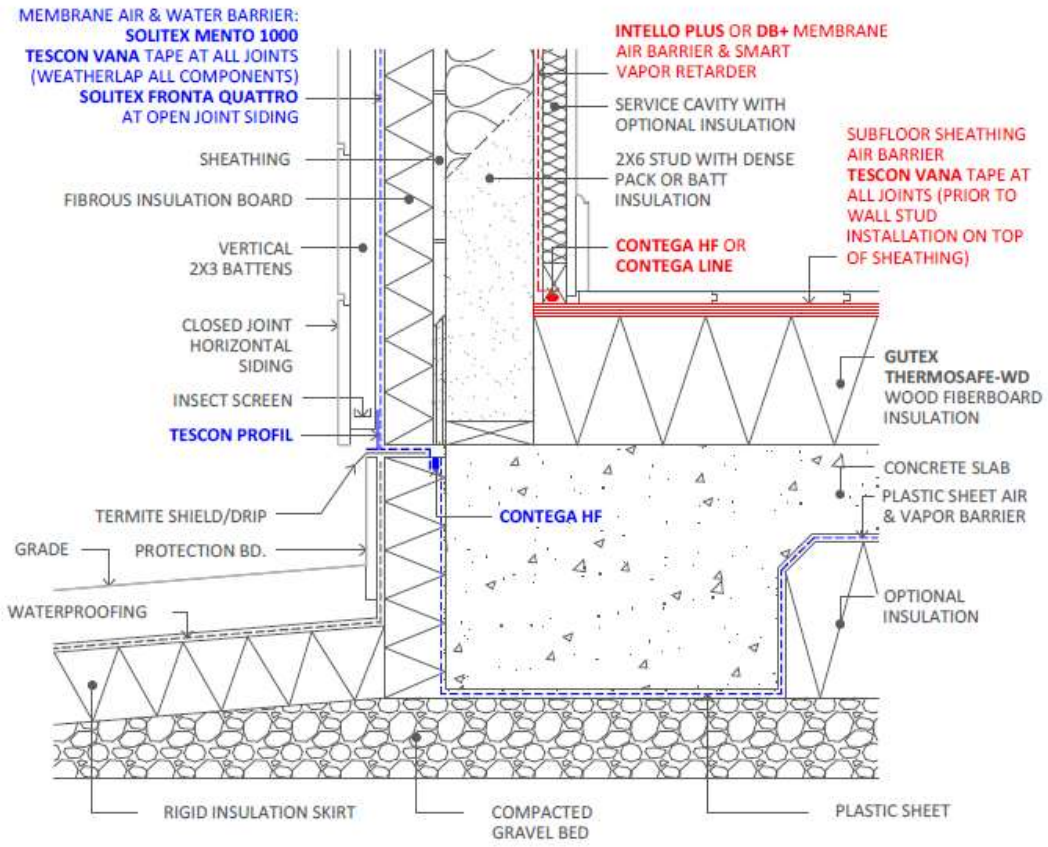


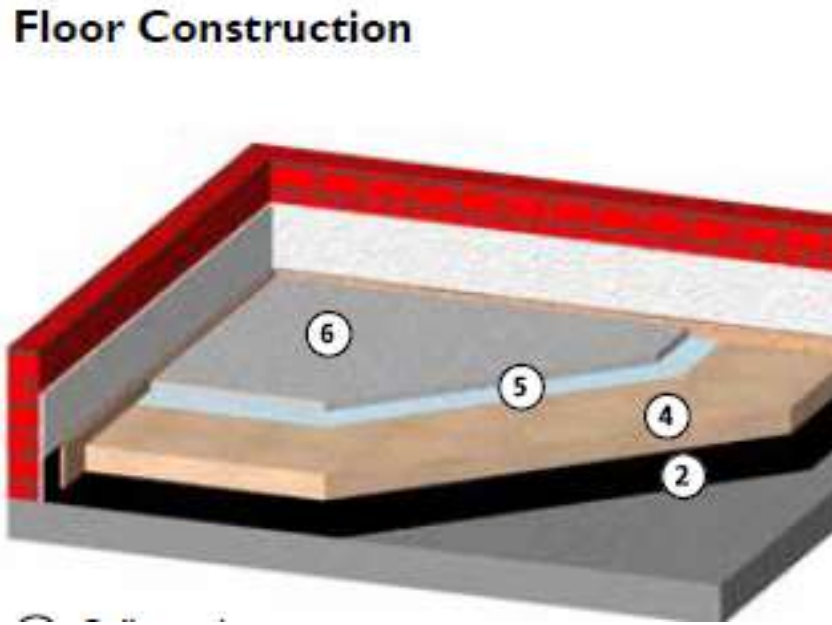
Plan View

The ‘foam-free’ insulated Slab

Foamglass gravel (working on it…)

Foam Free foundaion - The inverted Slab





insulate on top of slab with wood fiber board

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