# EXTRACTS from Vapor Retarders in Colorado
(What, Why, and Where?)


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# **What** are Vapor Retarders?

- **The effectiveness of a vapor retarder is limited unless air movement is also limited**
- ASTM defines an air retarder as a material or construction that is *designed and installed* to reduce air leakage
- Air permeance is measured by ASTM E 2178
- For the purposes of our discussion, this air retarder is different that the air barrier that is installed on the exterior side of the wall (also sometimes called a weather-resistive barrier; i.e. “housewrap”)

# **What** are Vapor Retarders?

- The vapor retarder and air retarder can be (but don't necessarily need to be) the same material in an assembly
- The vapor retarder does not need to be a plastic sheet membrane in the wall; it can take many different forms based on the construction
- Both the vapor retarder and the air retarder rely on <u>continuity</u> to be effective, but it is *more* important for the air retarder
- **The air retarder is <u>almost always</u> more important than the vapor retarder**

# **What** are Vapor Retarders?

- Examples:
  - Vapor Barrier: Robust polyethylene sheet (i.e. 15-mil reinforced polyethylene, 0.006 perm); self-adhering rubberized asphalt sheets (i.e. Bituthene, 0.05 perm)
  - Vapor Retarder: Vapor retarding paints (0.45 perms, depending); closed-cell polyurethane foam insulation (1" = 2.38 perms, 2 " = 1.19 perms, 3 " = 0.79 perms, 4 " = 0.60 perms)
  - Semi-Permeable Vapor Retarders: Asphalt-impregnated building paper (approx. 1-3 perm in dry conditions; 4-15 perms in very moist conditions); Certainteed MemBrain (1 perm in dry conditions; ≥ 10 perms in moist conditions)
  - Air Retarders: gypsum drywall, plywood, plastic sheeting, closed-cell polyurethane foam insulation, cast-in-place concrete
- All of these must be continuous to be effective
- Other materials in a wall assembly may have a lower permeance than the vapor retarder

# First Limit Air Movement

- **The effectiveness of a vapor retarder is limited unless air movement is also limited**
- **The air retarder is <u>almost always</u> more important than the vapor retarder**

# First Limit Air Movement

- Air flow can carry much greater amount of water vapor into a cavity than diffusion through a material

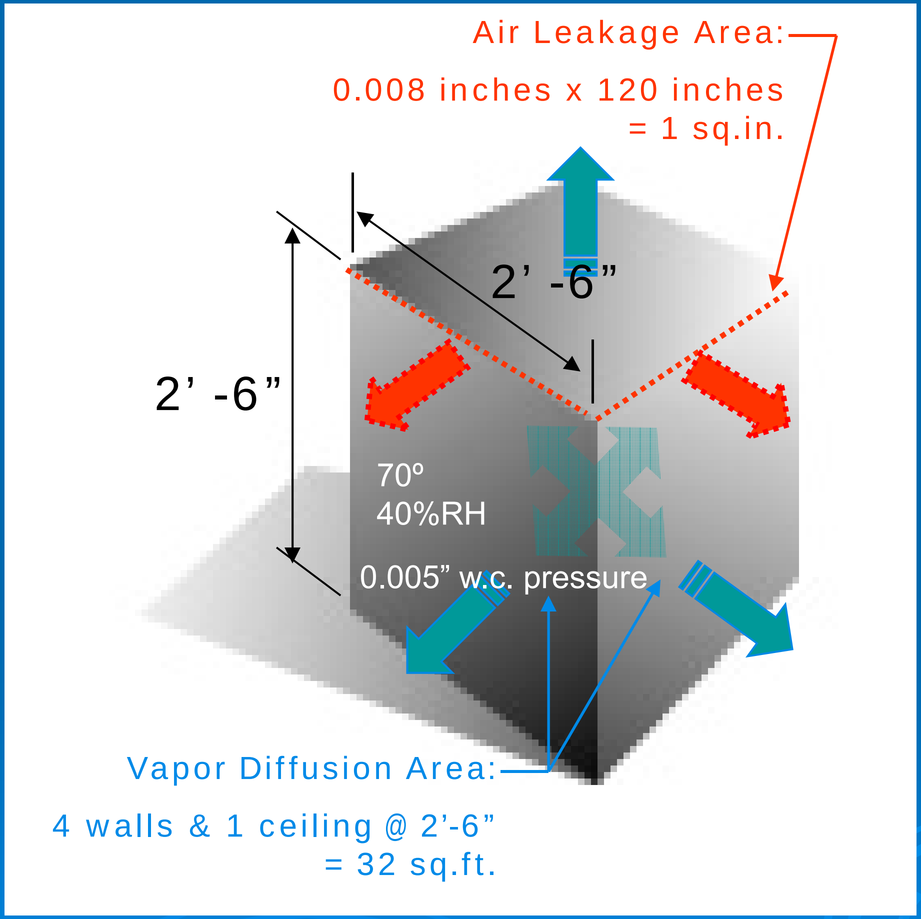
Thermal and Water Vapor Transmission Data 25.15

Table 7A Typical Water Vapor Permeance and Permeability Values for Common Building Materials[a]

| Material | Thickness, in. | Permeance, Perm | Resistance[h], Rep | Permeability, Perm-in. | Resistance/in.[h], Rep/in. |
|---|---|---|---|---|---|
| **Construction Materials** | | | | | |
| Concrete (1:2:4 mix) | | | | 3.2 | 0.31 |
| Brick masonry | 4 | 0.8[f] | 1.3 | | |
| Concrete block (cored, limestone aggregate) | 8 | 2.4[f] | 0.4 | | |
| Tile masonry, glazed | 4 | 0.12[f] | 8.3 | | |
| Asbestos cement board | 0.12 | 4-8[d] | 0.1-0.2 | | |
| With oil-base finishes | | 0.3-0.5[d] | 2-3 | | |
| Plaster on metal lath | 0.75 | 15[f] | 0.067 | | |
| Plaster on wood lath | | 11[e] | 0.091 | | |
| Plaster on plain gypsum lath (with studs) | | 20[f] | 0.050 | | |
| Gypsum wall board (plain) | 0.375 | 50[f] | 0.020 | | |
| Gypsum sheathing (asphalt impregnated) | 0.5 | | | 20[d] | 0.050 |
| Structural insulating board (sheathing quality) | | | | 20-50[f] | 0.050-0.020 |
| Structural insulating board (interior, uncoated) | 0.5 | 50-90[f] | 0.020-0.011 | | |
| Hardboard (standard) | 0.125 | 11[f] | 0.091 | | |
| Hardboard (tempered) | 0.125 | 5[f] | 0.2 | | |
| Built-up roofing (hot mopped) | | 0 | | | |
| Wood, sugar pine | | | | 0.4-5.4[b] | 2.5-0.19 |
| Plywood (douglas fir, exterior glue) | 0.25 | 0.7[f] | 1.4 | | |
| Plywood (douglas fir, interior glue) | 0.25 | 1.9[f] | 0.53 | | |
| Acrylic, glass fiber reinforced sheet | 0.056 | 0.12[d,e] | 8.3 | | |
| Polyester, glass fiber reinforced sheet | 0.048 | 0.05[d] | 20 | | |
| **Thermal Insulations** | | | | | |
| Air (still) | | | | 120[f] | 0.0083 |
| Cellular glass | | | | 0[d,e] | ∞ |
| Corkboard | | | | 2.1-2.6[d] | 0.48-0.38 |
| | | | | 9.5[e] | 0.11 |
| Mineral wool (unprotected) | | | | 116[e] | 0.0086 |
| Expanded polyurethane (R-11 blown) board stock | | | | 0.4-1.6[d] | 2.5-0.62 |
| Expanded polystyrene—extruded | | | | 1.2[d] | 0.83 |
| Expanded polystyrene—bead | | | | 2.0-5.8[d,e] | 0.50-0.17 |
| Phenolic foam (covering removed) | | | | 26 | 0.038 |
| Unicellular synthetic flexible rubber foam | | | | 0.02-0.15[d] | 50-6.7 |
| **Plastic and Metal Foils and Films[c]** | | | | | |
| Aluminum foil | 0.001 | 0.0[d] | ∞ | | |
| Aluminum foil | 0.00035 | 0.05[d] | 20 | | |
| Polyethylene | 0.002 | 0.16[d] | 6.3 | | 3100 |
| Polyethylene | 0.004 | 0.08[d] | 12.5 | | 3100 |
| Polyethylene | 0.006 | 0.06[d,e] | 17 | | 3100 |
| Polyethylene | 0.008 | 0.04[d,e] | 25 | | 3100 |
| Polyethylene | 0.010 | 0.03[d] | 33 | | 3100 |
| Polyvinylchloride, unplasticized | 0.002 | 0.68[d,e] | 1.5 | | |
| Polyvinylchloride, plasticized | 0.004 | 0.8-1.4[d] | 1.3-0.72 | | |
| Polyester | 0.001 | 0.73[d] | 1.4 | | |
| Polyester | 0.0032 | 0.23[d] | 4.3 | | |
| Polyester | 0.0076 | 0.08[d] | 12.5 | | |
| Cellulose acetate | 0.01 | 4.6[d] | 0.2 | | |
| Cellulose acetate | 0.125 | 0.32[d] | 3.1 | | |

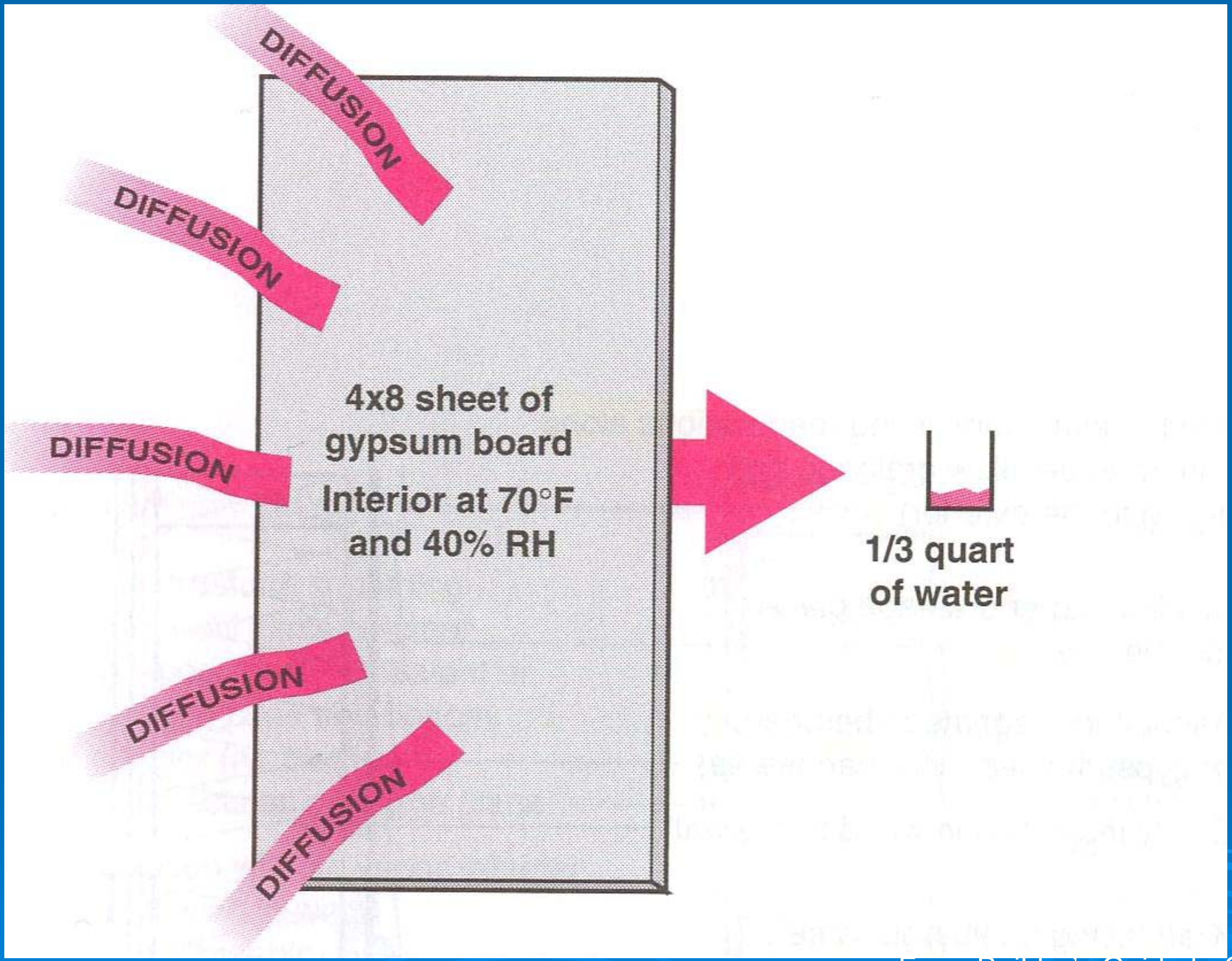
[a]*Source*: Lotz (1964).

# First Limit Air Movement




**PAINT?** **OR … SEAL THE GAPS?**

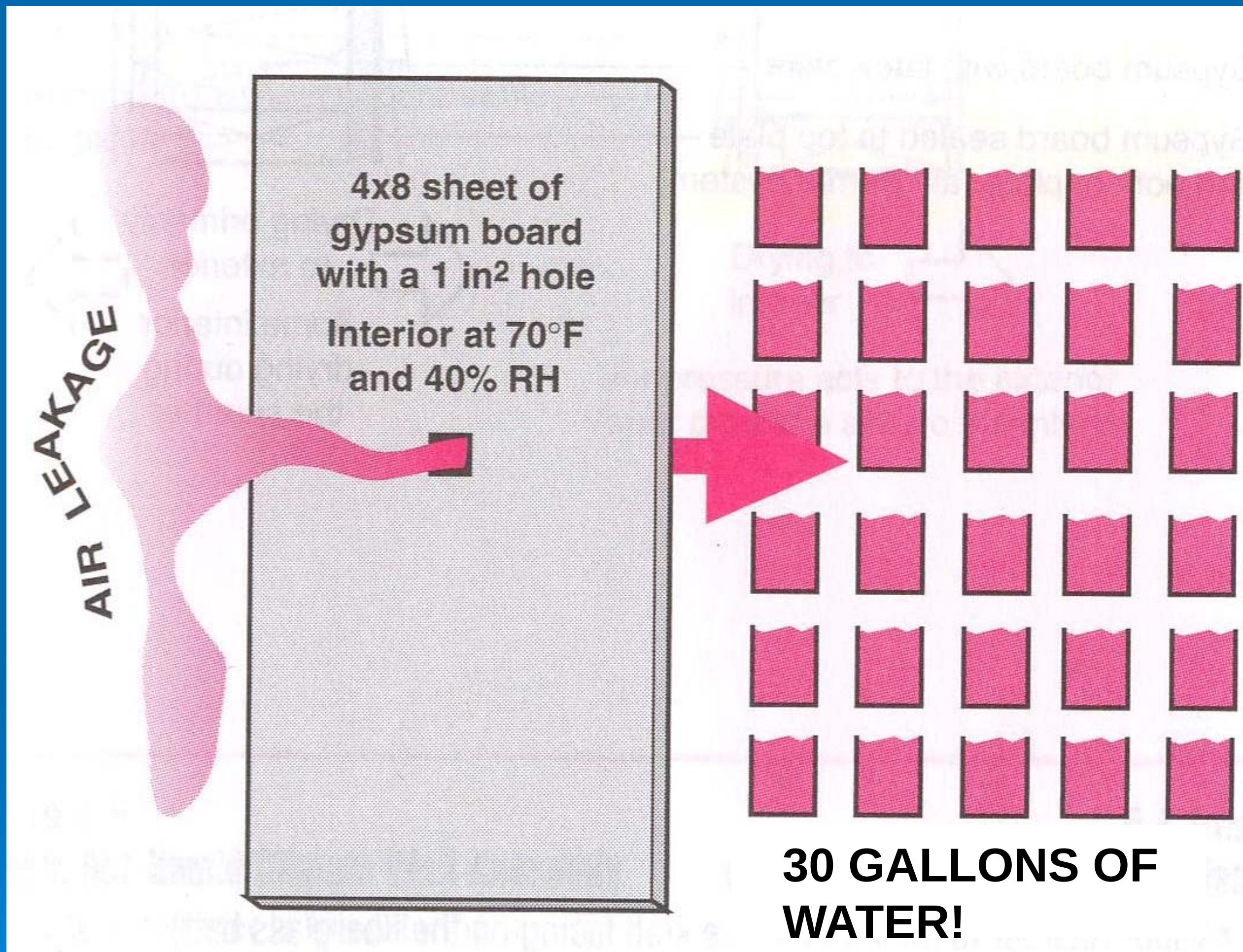
# First Limit Air Movement




From Builder's Guide to Cold Climates
by Joseph Lstiburek, 2004

# First Limit Air Movement

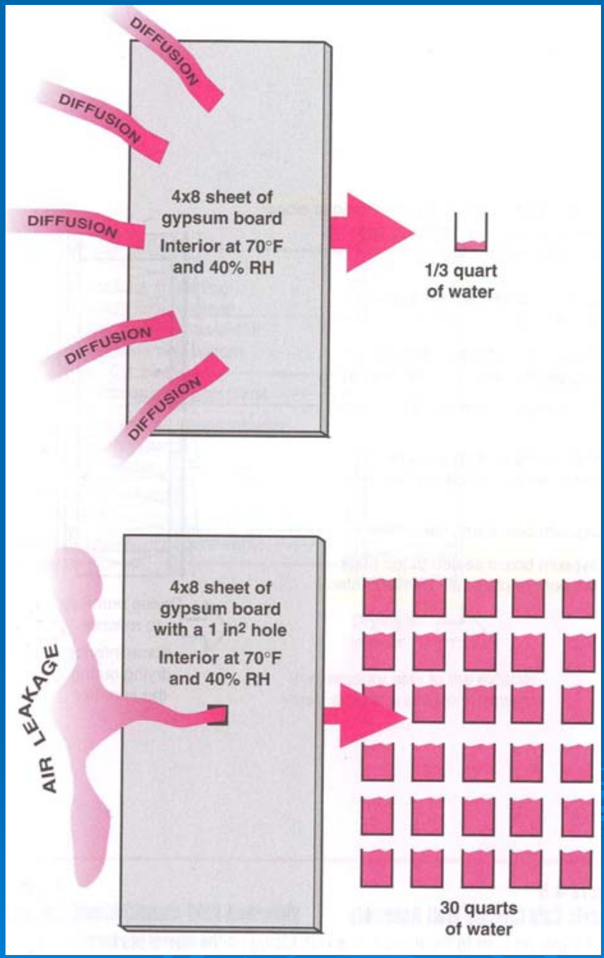
AT 6 MONTHS OF 0.065" w.c. PRESSURIZATION….




From Builder's Guide to Cold Climates
by Joseph Lstiburek, 2004

# First Limit Air Movement

- Air flow can carry much greater amount of water vapor into a cavity than diffusion through a material
- Therefore, continuity of the air retarder is of extreme importance
- Continuity of vapor retarder is less important




From Builder's Guide to Cold Climates by Joseph Lstiburek, 2004

# **Why:** Vapor Diffusion

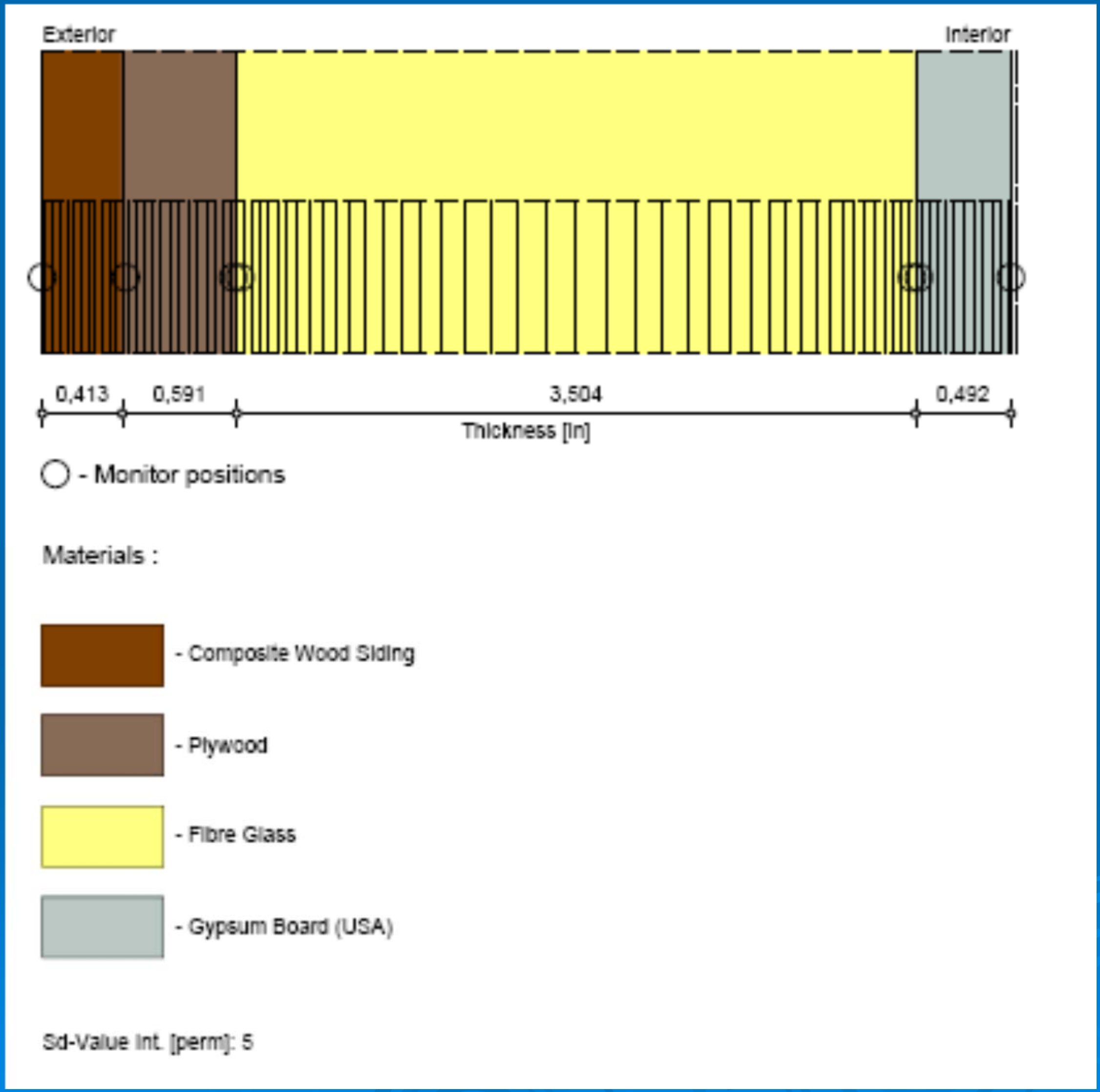
- Vapor diffusion moves moisture from areas with higher vapor pressure to lower vapor pressure (more humid to less humid)
- Interior humidity is generated by bathing, cooking, interior plants, non-vented dryers, indoor pools or hot tubs, and mechanical humidification
- In Colorado, the controlling factor is almost always higher interior humidity and lower exterior humidity in conjunction with higher interior temperatures and lower exterior temperatures

# **Why:** Vapor Diffusion

- What is Vapor Pressure?
  - It is the partial pressure exerted by water in air.

- It is a function of:
  - TEMPERATURE, and
  - RELATIVE HUMIDITY

# Why: "Dewpoint Method"



# Why: "Dewpoint or Glaser Method"

Thermal and Moisture Control in Insulated Assemblies—Fundamentals 23.11

**Table 3 Data for Example 1**

| Heat Conduction and Vapor Diffusion Properties of Wall | | | | Calculated Temperature Drops, Surface Temperatures, and Saturation Water Vapor Pressures | | | Initial and Final Calculation of Water Vapor Pressure Drops and Surface Water Vapor Pressures | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Vapor Pressure, in. Hg | |
| Air Film or Material | Thermal Resistance, °F·ft²·h/Btu | Vapor Permeance, perm | Vapor Diffusion Resistance, rep | Temperature Drop, °F | Interface Temperature, °F | Interface Saturation Vapor Pressure, in. Hg | Initial Calculation | Final Calculation |
| | | | | | 70 | 0.740 | 0.296 | 0.296 |
| Surface film coefficient | 0.68 | 160 | 0.0063 | 2.4 | | | 0.001 | 0.004 |
| | | | | | 67.6 | 0.680 | 0.295 | 0.292 |
| Gypsum board, painted, cracked joints | 0.45 | 5 | 0.2 | 1.7 | | | 0.022 | 0.131 |
| | | | | | 65.9 | 0.643 | 0.274 | 0.161 |
| Insulation, mineral fiber | 11 | 30 | 0.033 | 39.5 | | | 0.004 | 0.022 |
| | | | | | 26.4 | 0.139 | 0.270 | 0.139 |
| Plywood sheathing | 0.62 | 0.5 | 2 | 2.2 | | | 0.215 | 0.087 |
| | | | | | 24.2 | 0.126 | 0.055 | 0.053 |
| Wood siding | 1 | 35 | 0.029 | 3.6 | | | 0.003 | 0.001 |
| | | | | | 20.6 | 0.106 | 0.051 | 0.051 |
| Surface film coefficient | 0.17 | 1000 | 0.001 | 0.6 | | | 0.000 | 0.000 |
| | | | | | 20 | 0.103 | 0.051 | 0.051 |
| Total | 13.92 | | 2.27 | | | | | |

# Why: "Glaser Method"

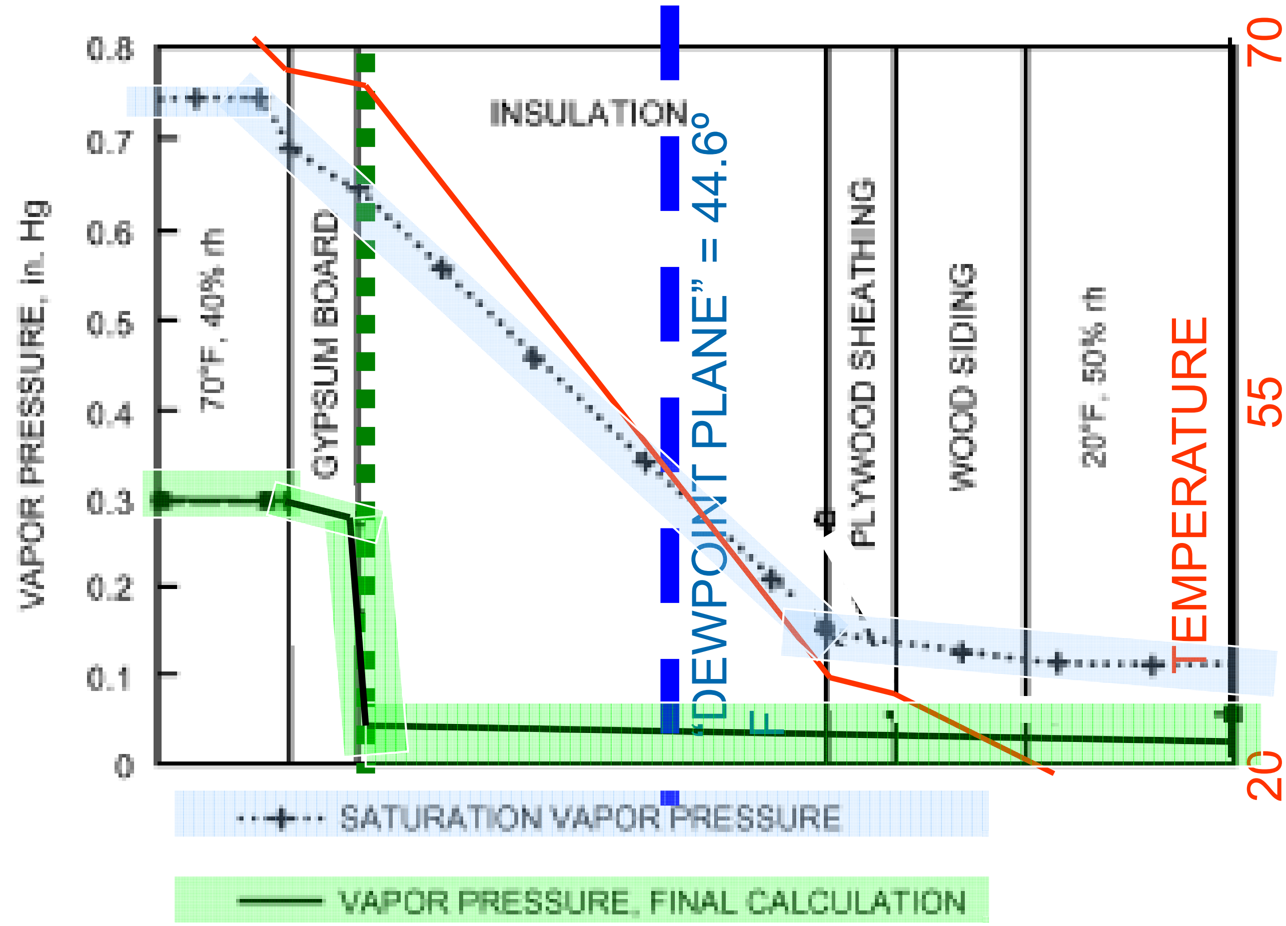
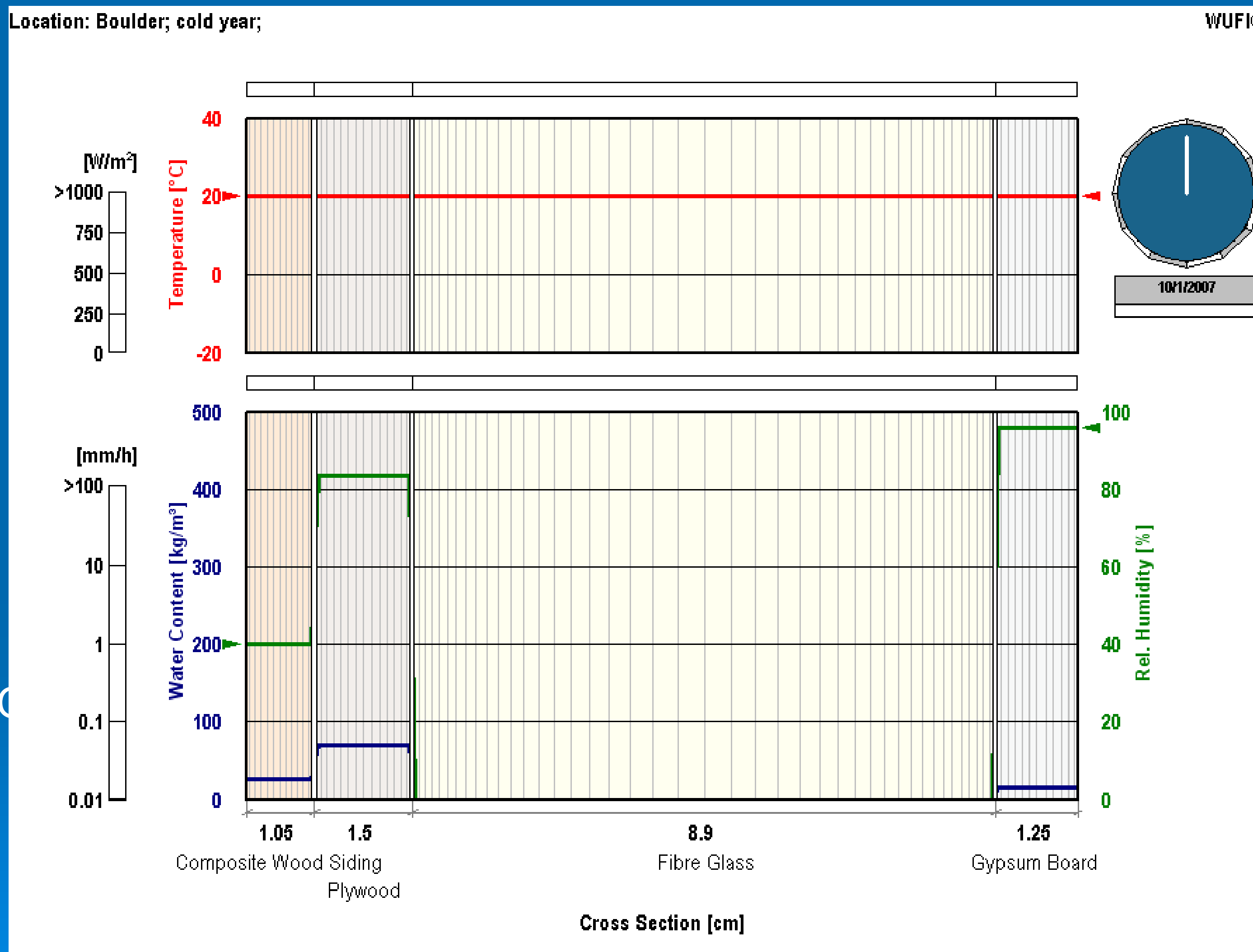



**Fig. 2 Dew-Point Calculation in Wood-Framed Wall (Example 1)**

# Why: "WUFI Method"

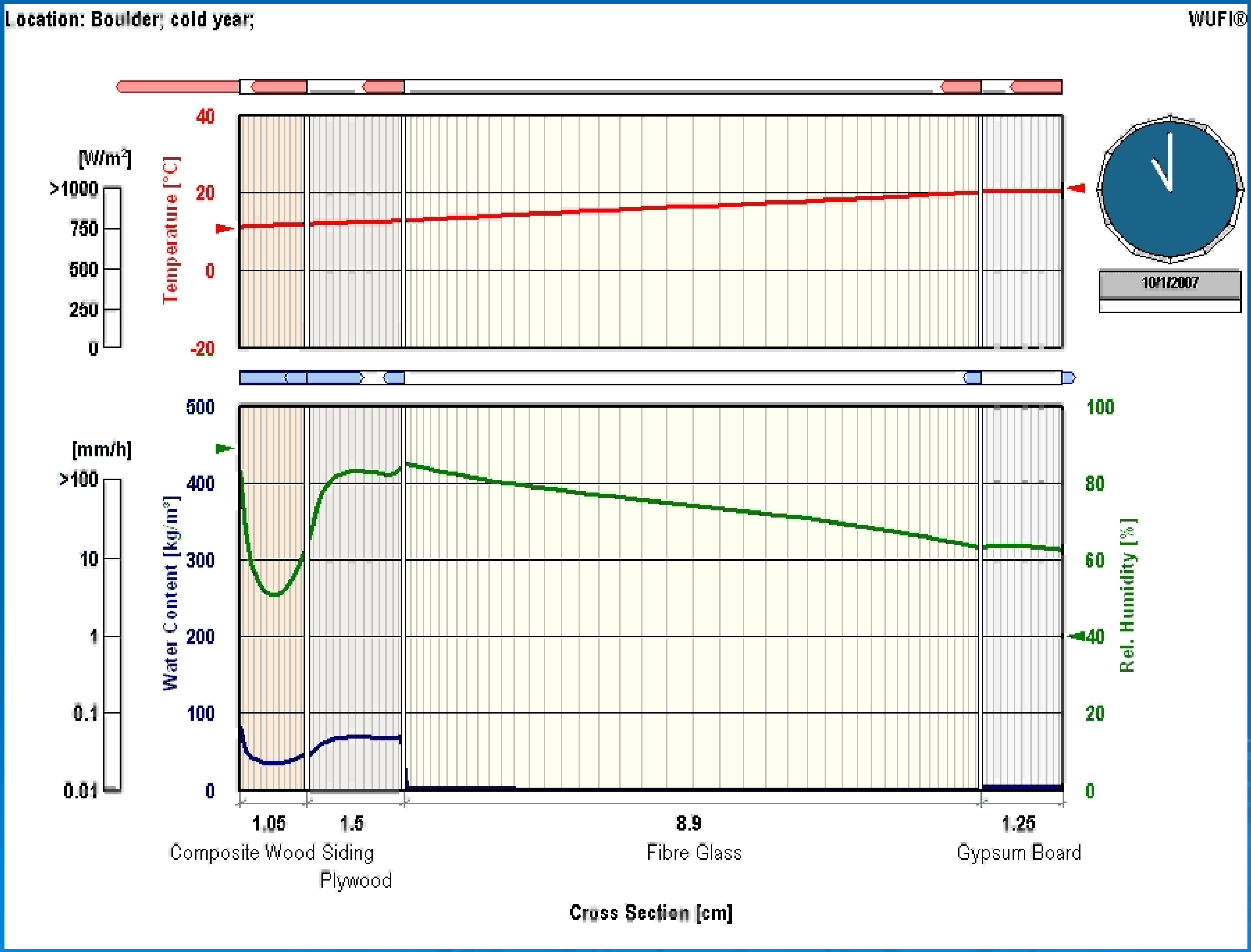
- WUFI looks at:
  - TRANSIENT EFFECTS




- LIKE …
  - ABSORPTION
  - CAPILLARITY
  - SOLAR HEATING

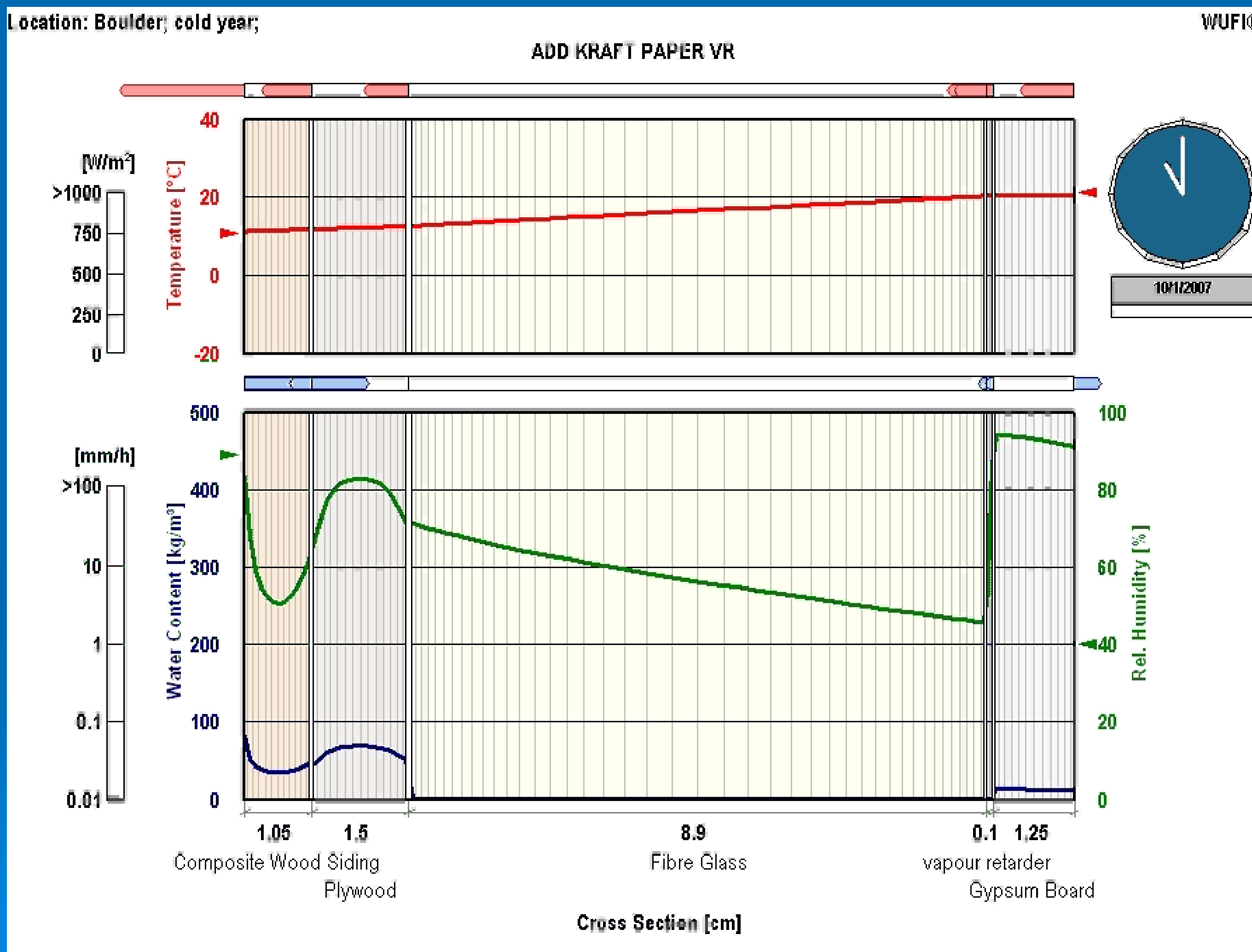
# Why: "WUFI Method"

## WITHOUT VAPOR RETARDER ...



# Why: "WUFI Method"

WITH **VAPOR RETARDER …**



# **Where** to install Vapor Retarders?

- **IT DEPENDS…**
- Do you need one? (although air retarders are usually needed) IBC 1403.3
- Do interior and exterior conditions warrant it? (temperature and humidity)
- What is the expected performance of the vapor retarder?
- What is the assembly, and the type and location of insulation?

# **Where** to install Vapor Retarders?

- Generally, in Colorado, the vapor retarder is installed on the warm-in-winter side of the insulation
- Other Considerations:
  - Vapor retarder should have lowest permeability of all materials in the assembly.
  - Can the assembly dry out if water/condensation gets in?
  - Unusual conditions like indoor pools or high moisture conditions may affect selection and location
  - Potential for construction damage
  - Cost

# **Where:** Exterior Walls

- Construction issues
  - Lack of continuity of air/vapor retarder
    - Damage
    - Discontinuity due to type of air/vapor retarder
    - Framing
    - Plumbing
    - HVAC / Electrical / Ventilation

# **Where:** Exterior Walls

- Damage from installation – numerous gaps makes it a poor air retarder.

# **Where:** Exterior Walls

# **Where:** Exterior Walls

Bathroom wall missing vapor retarder?

According to Georgia Pacific, Dens Shield Tile Backer should not be installed over a vapor retarder.

# **Where:** Exterior Walls

- Lack of continuity at ceiling plane and at framing.

# **Where:** Exterior Walls

- Missing air barrier on electrical box facing inward.

# References and Resources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- Lstiburek, Joseph, and Carmody, John. Moisture Control Handbook. New York: Wiley, 1994.
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- Stein, Benjamin, et al. Mechanical and Electrical Equipment for Buildings. New York: Wiley, 1986.
- Suprenant, Bruce A., and Malisch, Ward R. "Where to place the vapor retarder." Concrete Construction May 1998.
- ASTM: C77, E96, E154, E241, E631, E1745, E1643, E1677, E1745, E1993, E2178
- 2003 IBC: 1203.2 (attics); 1203.3.2 (crawl spaces); 1403.3 (exterior walls); 1911.1 (slabs-on-grade)
- 2003 IRC: R308 (attics); R318.1 (exterior walls); R408 (crawl spaces); R506 (slabs-on-grade)

# Vapor Retarders in Colorado
(What, Why, and Where?)

Thank You and Questions