Building Science for Architects

Moisture Control

Betsy Pettit, AIA

www.buildingscience.com

Moisture Flow

- Most difficult to understand
  - Can be easy to understand
  - Drainage of liquid water
- "Moisture goes from warm to cold"
- "Moisture goes from more to less
- Vapor barriers vs. vapor retarders
- Venting vs. non –venting of roofs, crawl spaces and walls
- Positive or negative pressures

Environmental Loads

- Hygro-thermal regions
- Rain exposure zones
- Interior climate classes
- Used to design building envelopes and mechanical systems

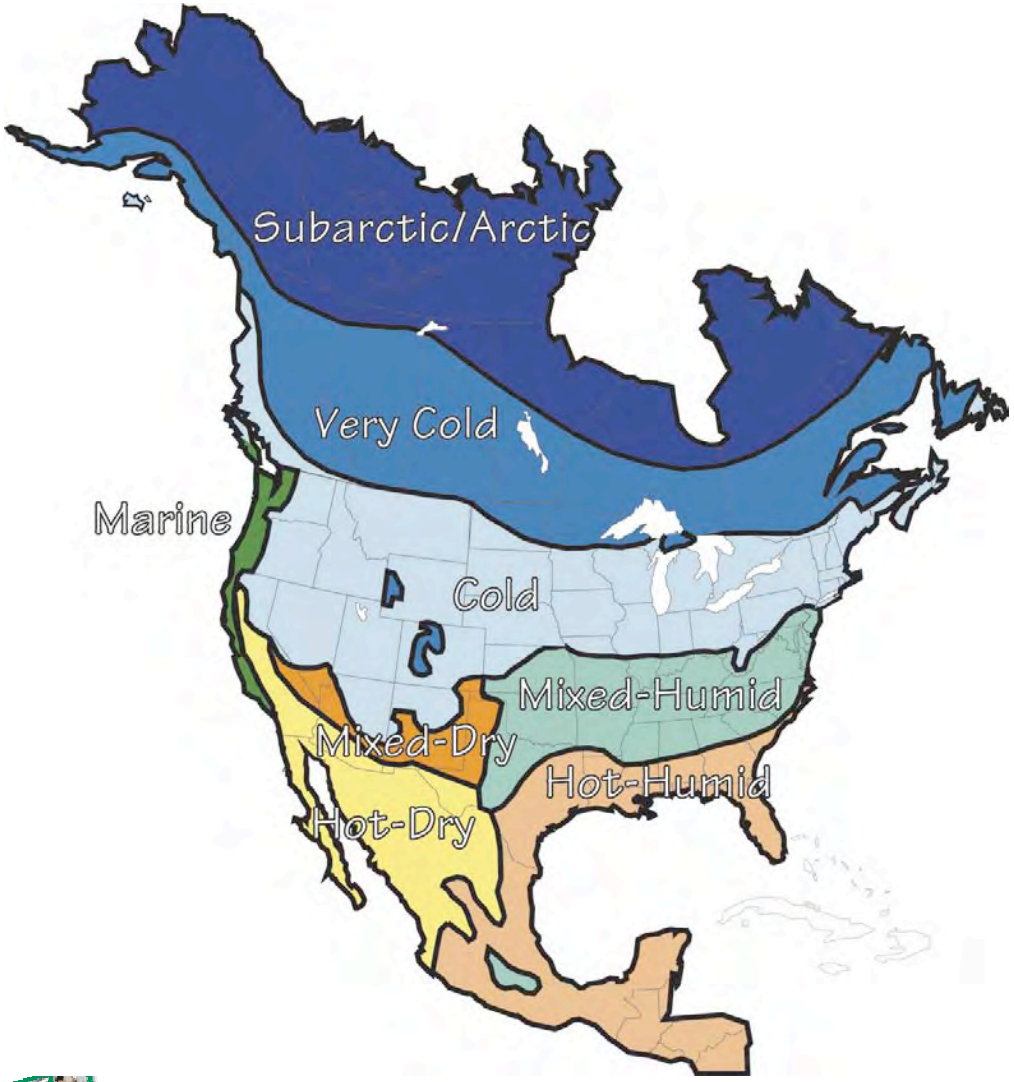
Hygro-Thermal Regions

- Severe Cold
- Cold
- Mixed-Humid
- Marine
- Hot-Dry/Mixed Dry
- Hot-Humid

Rain Exposure Zones

- Extreme (above 60 inches annual precipitation)
- High (40 to 60 inches annual precipitation)
- Moderate (20 to 40 inches annual precipitation)
- Low (less than 20 inches annual precipitation)

Hygro-Thermal Regions



Subarctic/Arctic
A subarctic and arctic climate is defined as a region with approximately 12,600 heating degree days (65°F basis) or greater.

Very Cold
A very cold climate is defined as a region with approximately 9,000 heating degree days (65°F basis) or greater and less than approximately 12,60 heating degree days (65°F basis).

Cold
A cold climate is defined as a region with approximately 5,400 heating degree days (65°F basis) or greater and less than approximately 9,000 heating degree days (65°F basis) .

Mixed-Humid
A mixed-humid climate is defined as a region that receives more than 20 inches (50 cm) of annual precipitation, has approximately 5,400 heating degree days (65°F basis) or less, and where the average monthly outdoor temperature drops below 45°F (7°C) during the winter months.

Hot-Humid
A hot-humid climate is defined as a region that receives more than 20 inches (50 cm) of annual precipitation and where one or both of the following occur:

- a 67°F (19.5°C) or higher wet bulb temperature for 3,000 or more hours during the warmest six consecutive months of the year; or
- a 73°F (23°C) or higher wet bulb temperature for 1,500 or more hours during the warmest six consecutive months of the year. †

† These last two criteria are identical to those used in the ASHRAE definition of warm-humid climates and are very closely aligned with a region where the monthly average outdoor temperature remains above 45°F (7°C) throughout the year.

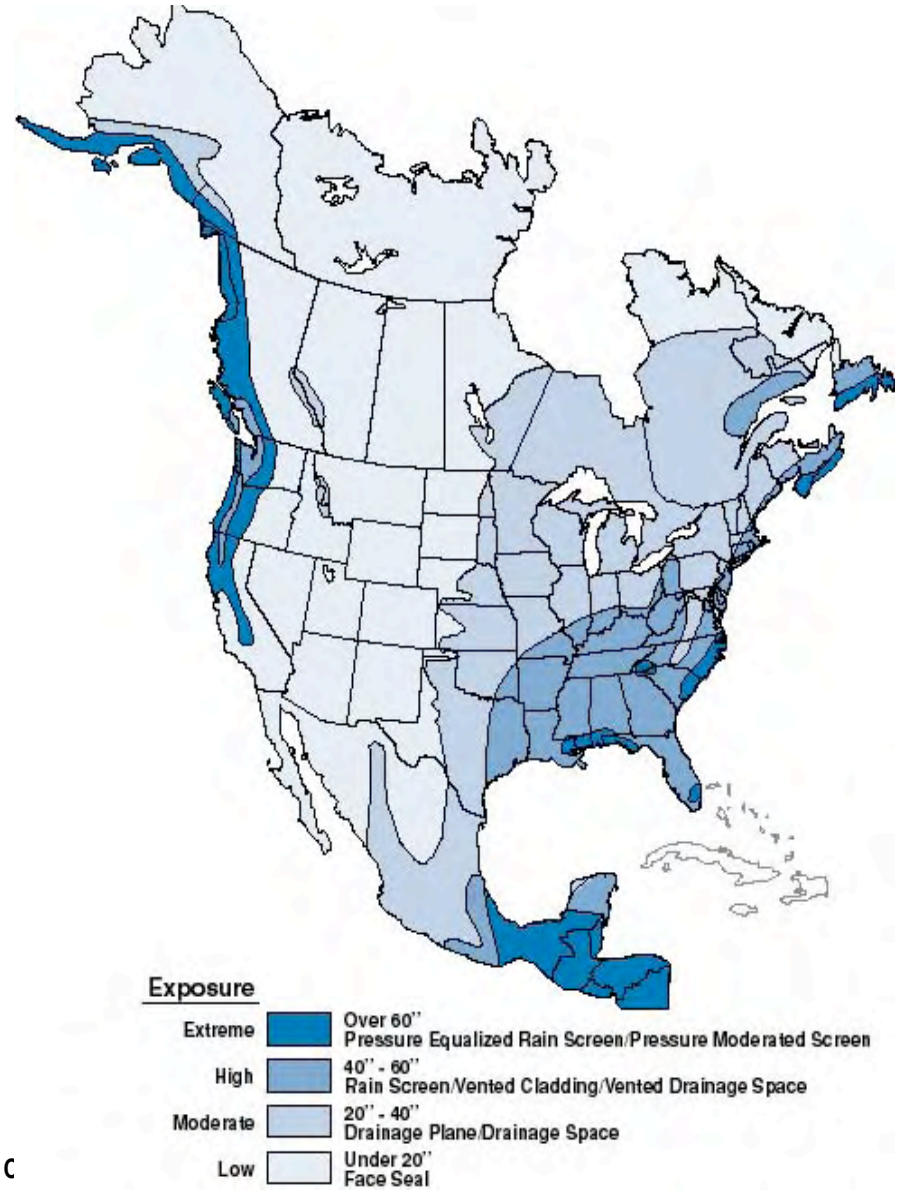
Hot-Dry
A hot-dry climate is defined as a region that receives less than 20 inches (50 cm) of annual precipitation and where the monthly average outdoor temperature remains above 45°F (7°C) throughout the year.

Mixed-Dry
A mixed-dry climate is defined as a region that receives less than 20 inches (50 cm) of annual precipitation, has approximately 5,400 heating degree days (50° F basis) or less, and where the average monthly outdoor temperature drops below 45°F (7°C) during the winter months.

Marine
A marine climate meets all of the following criteria:

- A mean temperature of coldest month between 27°F (–3°C) and 65°F (18°C)
- A warmest month mean of less than 72°F (22°C)
- At least four months with mean temperatures over 50°F (10°C)
- A dry season in summer. The month with the heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least precipitation in the rest of the year. The cold season is October through March in the Northern Hemisphere and April through September in the Southern Hemisphere.

Rain Exposure Zones



Interior Climate Classes

I – Temperature moderated

Vapor pressure uncontrolled

Air pressure uncontrolled (warehouses, garages, storage rooms)

II – Temperature controlled

Vapor pressure moderated

Air pressure moderated (houses, apartments, offices, schools, commercial and retail spaces)

III –Temperature controlled

Vapor pressure controlled

Air Pressure controlled (hospitals, museums, swimming pool enclosures and computer facilities)

Moisture Balance

- Building assemblies get wet from the outside, get wet from the inside and start out wet.

- We must control wetting from the outside, control wetting from the inside, and let assemblies dry to the inside, or to the outside, or to both sides.

Moisture Control

- Various strategies can be implemented to minimize the risk of moisture damage

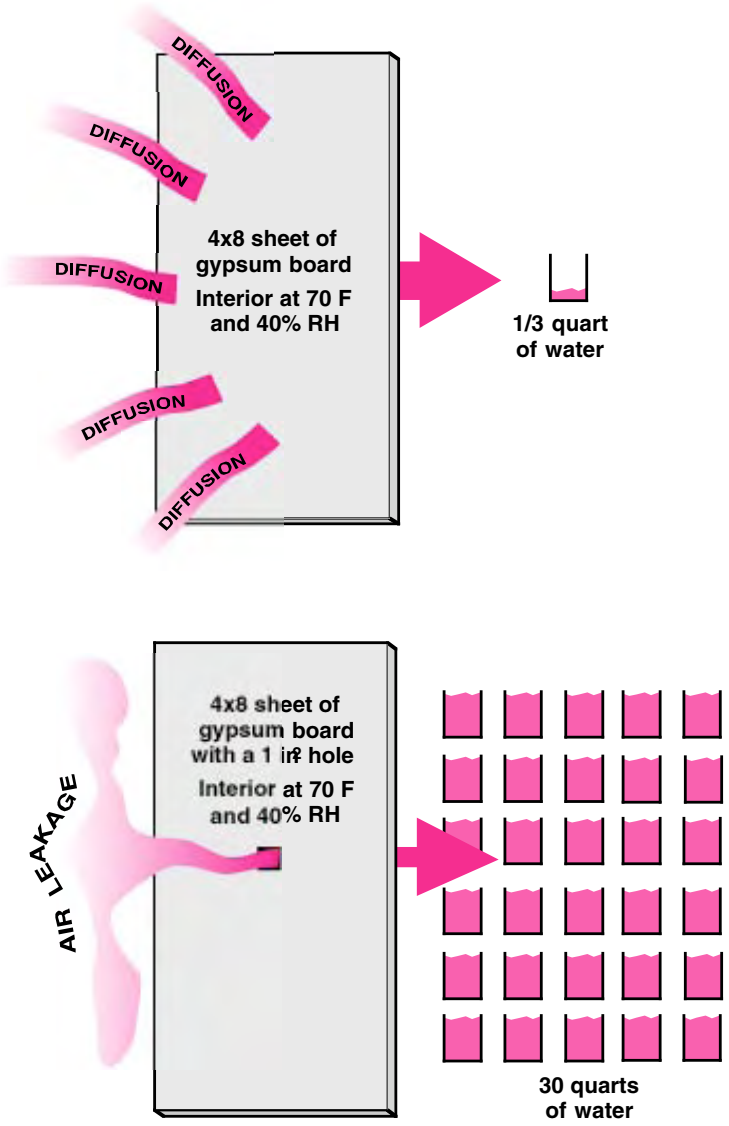
- The strategies fall into following three groups:
  - Control of moisture entry
  - Control of moisture accumulation
  - Removal of moisture

The Big Four of Moisture Control

- Controlling rain entry
- Controlling ground water
- Controlling water vapor via air transport
- Controlling water vapor via vapor diffusion

Moisture Movement through Air Leakage vs. Diffusion

In most cold climates over an entire heating season, 1/3 quart of water can be collected by diffusion, 30 quarts of water can be collected by air leakage



Vapor Diffusion Control

- Diffusion
  - Migration of moisture by means of vapor pressure differential
  - Occurs in either direction based on climate conditions and interior levels of humidity

Vapor Diffusion Control

- Vapor retarder? Barrier? Location?
- Is this a flow-through assembly, does it have uni-directional, bi-directional or no drying potential?
- What's a "perm?"
- First condensing surface?
- Reservoir cladding?
- Interior humidity control?

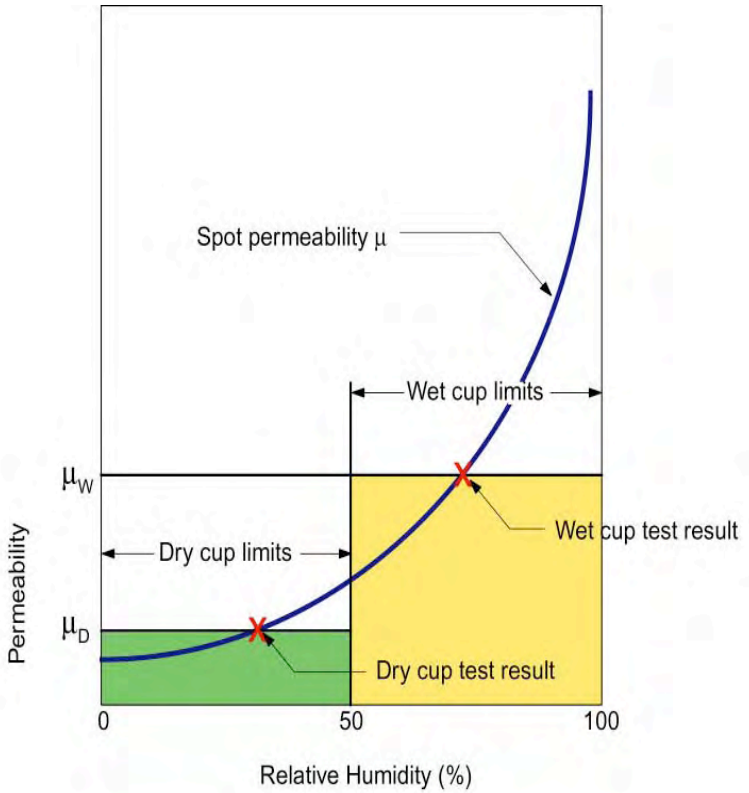
PERM Definition

1 perm = one grain (avoir dupois) of water vapor per hour

flowing through 1 square foot of material or construction

induced by a vapor pressure difference of 1 inch Hg across two surfaces.

(1 pound = 7,000 grains or 1 ounce = 437.5 grains)



μ_D = Dry cup permeability

μ_W = Wet cup permeability

Permeability vs. Relative Humidity

- Typical relationship between dry- and wet-cup methods and spot permeability for many hygroscopic building materials such as asphalt impregnated felt building papers, plywood, OSB and kraft facings on insulation batts
- μ_W = 2 to 3 times greater than μ_D
- Wet cup testing occurs with 50% RH on one side of test specimen and 100% RH on other side
- Dry cup testing occurs with 0% RH on one side of test specimen and 50% RH on other side

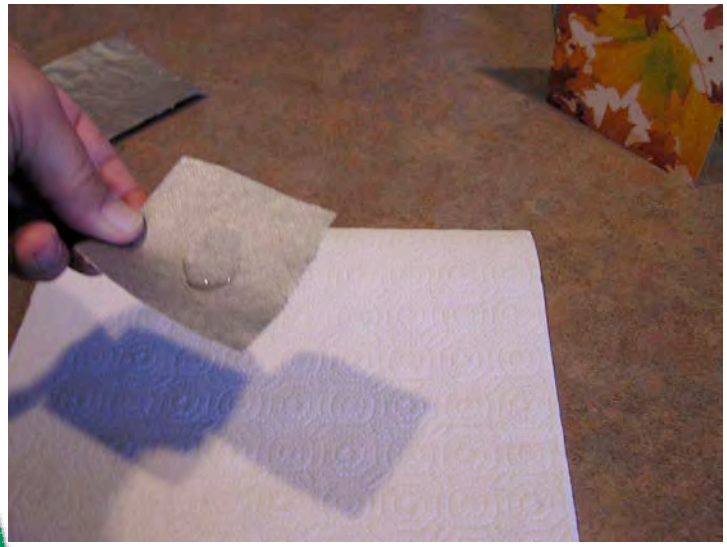
What can go wrong with a well built house?

- 1/2 GWB over poly
- R-13 unfaced batts
- Housewrap
- Cedar Clapboards

What went wrong?

What went wrong?

House-wrap from under porch



House-wrap from North Gable End

What can go wrong with a well built house?

- 1/2 GWB over poly
- R-13 unfaced batts
- 1/2” Insulating Sheathing as drainage plane
- Brick veneer

Exterior Conditions

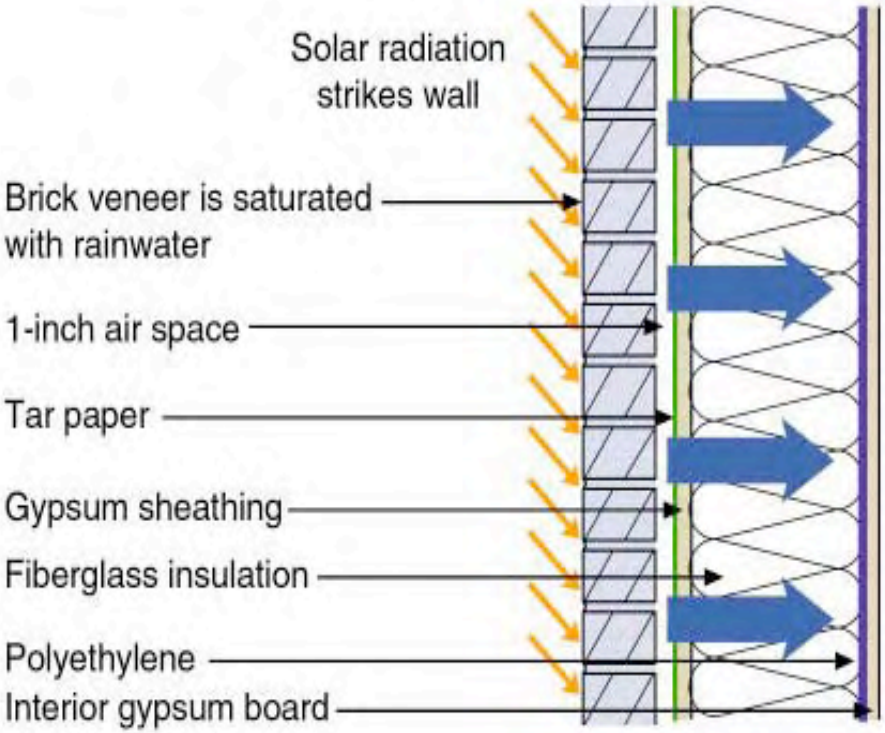
Temperature: 80°F
Relative humidity: 75%
Vapor pressure: 2.49 kPa

Conditions within Cavity:

Temperature: 120°F
Relative humidity: 100%
Vapor pressure: 11.74 kPa

Interior Conditions

Temperature: 75°F
Relative humidity: 60%
Vapor pressure: 1.82 kPa



Vapor is driven inward by a high vapor pressure differential between the cavity and the interior

Figure 1
Inward moisture movement due to solar radiation in the summer

Strategies

- Walls Will Always Get Wet
- Walls Usually Start Out Wet
- Wet Happens
- Let Them Dry