Affordable Comfort 2005

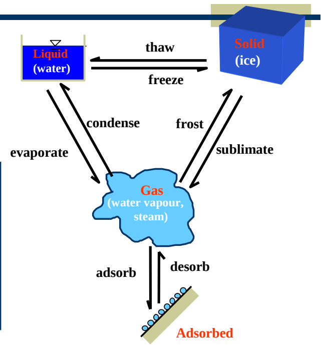
Myths and Realities of
Air & Vapour Barriers

Air Barriers & Vapour Barriers

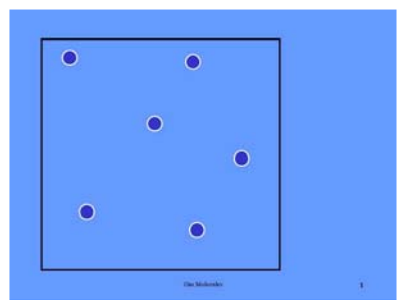
- ***Air Barriers Control Air Leakage***
  - Heat (for comfort & energy considerations)
  - Smoke & odours
  - Sound
  - Moisture
- ***Vapour Barriers Control Vapour Diffusion***
  - Moisture

The 4 phases of Water

Air Barriers & Vapour Barriers only deal with the ***Vapour Phase***



Water Vapour Pressure

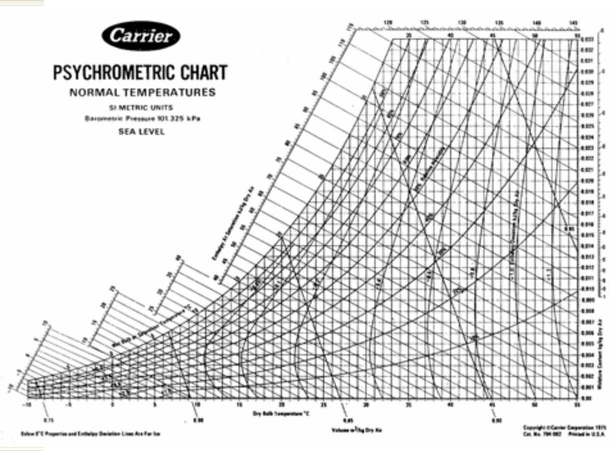


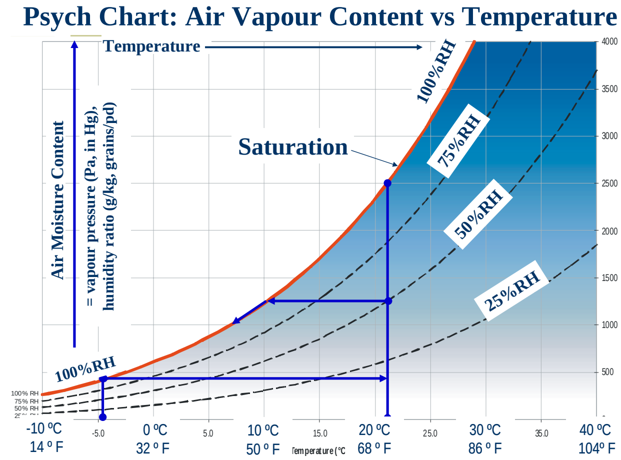
Water Vapour Pressure

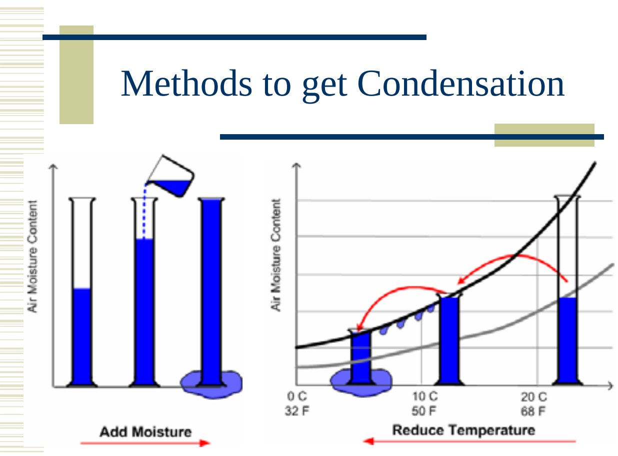
- For water vapour in a container
- Higher temperature =
  - more energy
  - higher velocity
  - harder collisions with wall (higher pressure)
- Greater number of molecules =
  - more collisions with walls (higher pressure)
  - pressure simply another measure for moisture content

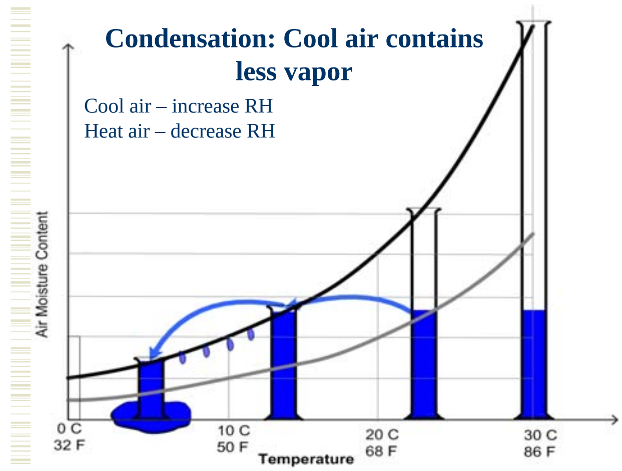
Water Vapour in Air

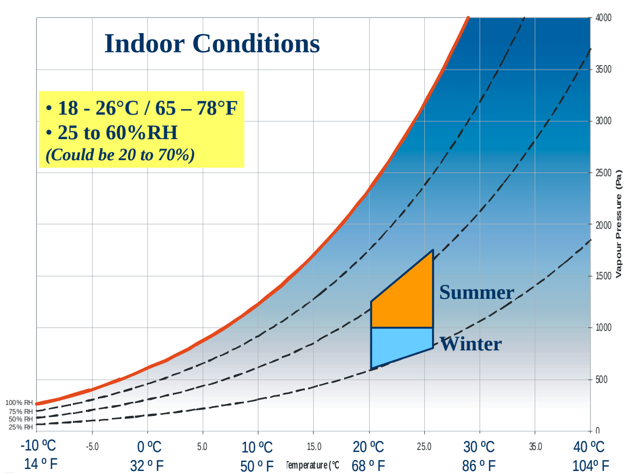
- Water vapour exists in all air
- Air has a maximum vapour holding capacity
  - This capacity changes dramatically with temperature
  - When the maximum holding capacity is exceeded, *condensation* occurs
- These facts are summarized by the ***psychrometric*** chart

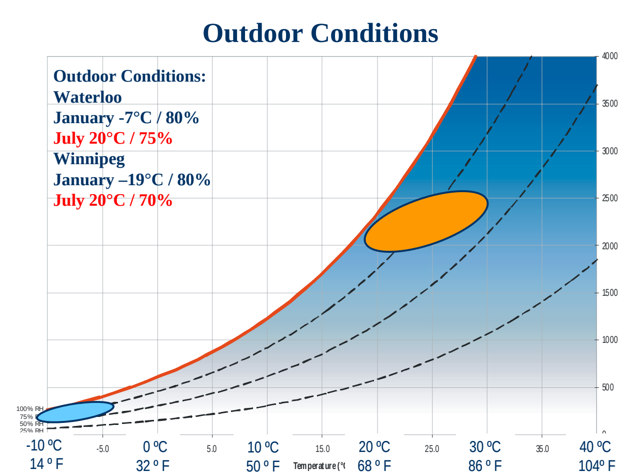

Carrier
PSYCHROMETRIC CHART
NORMAL TEMPERATURES
SI METRIC UNITS
SEA LEVEL


Psych Chart: Air Vapour Content vs Temperature
Temperature
Air Moisture Content
= vapour pressure (Pa, in Hg), humidity ratio (g/kg, grains/pd)
Saturation
100%RH
75%RH
50%RH
25%RH
100%RH
-10 ºC
14 º F
0 ºC
32 º F
10 ºC
50 º F
20 ºC
68 º F
30 ºC
86 º F
40 ºC
104º F

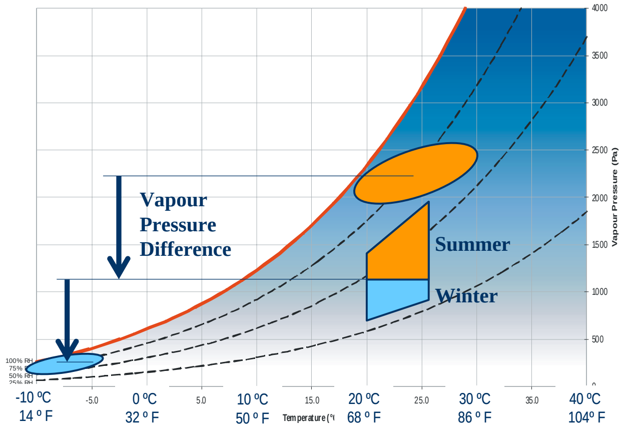

Methods to get Condensation
Air Moisture Content
Add Moisture
Air Moisture Content
0 C
32 F
10 C
50 F
20 C
68 F
Reduce Temperature


Condensation: Cool air contains less vapor
Cool air – increase RH
Heat air – decrease RH
Air Moisture Content
0 C
32 F
10 C
50 F
20 C
68 F
30 C
86 F
Temperature


Indoor Conditions
• 18 - 26°C / 65 – 78°F
• 25 to 60%RH
(Could be 20 to 70%)
Summer
Winter
-10 ºC
14 º F
0 ºC
32 º F
10 ºC
50 º F
20 ºC
68 º F
30 ºC
86 º F
40 ºC
104º F


Outdoor Conditions
Outdoor Conditions:
Waterloo
January -7°C / 80%
July 20°C / 75%
Winnipeg
January –19°C / 80%
July 20°C / 70%
-10 ºC
14 º F
0 ºC
32 º F
10 ºC
50 º F
20 ºC
68 º F
30 ºC
86 º F
40 ºC
104º F

Indoor vs Outdoor Conditions



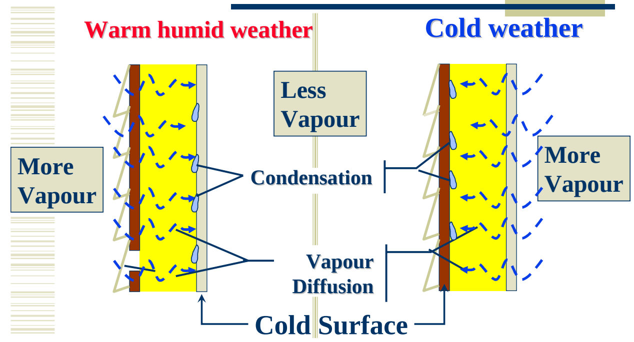
Water Vapour Transport

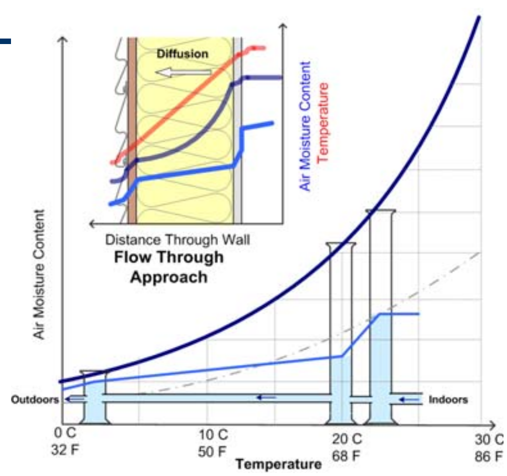
- Vapour Diffusion (like heat conduction)
  - more to less vapour
- Air Convection (like heat convection)
  - more to less air pressure
  - vapour is along for the ride

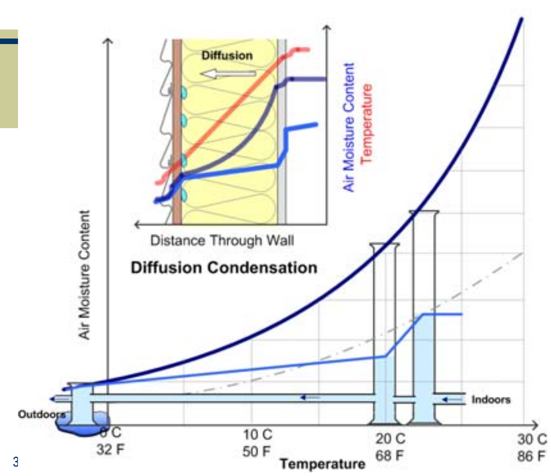
Vapour Diffusion

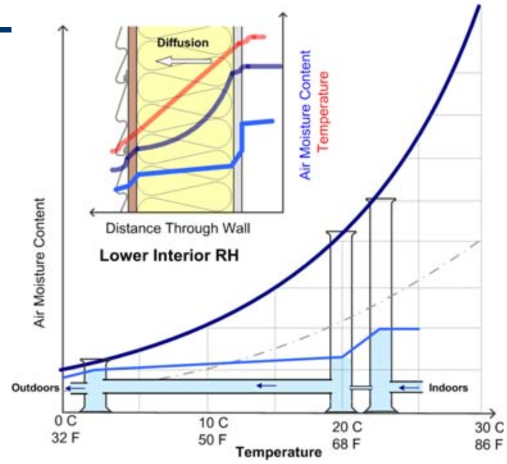
- Movement from ***more*** vapour to ***less***
- Slow process
- Many materials slow this process
  - concrete, brick, stone
- Some stop, or practically stop it
  - many plastics (poly), steel, glass
- May cause condensation (but not usually)

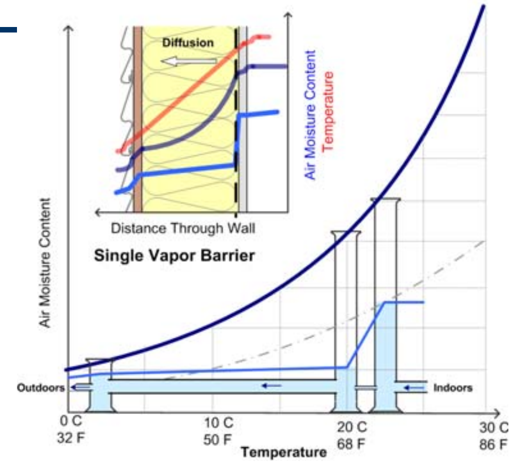
Water Vapour Diffusion

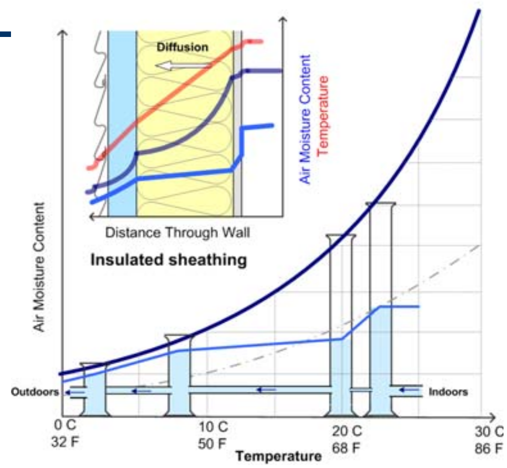


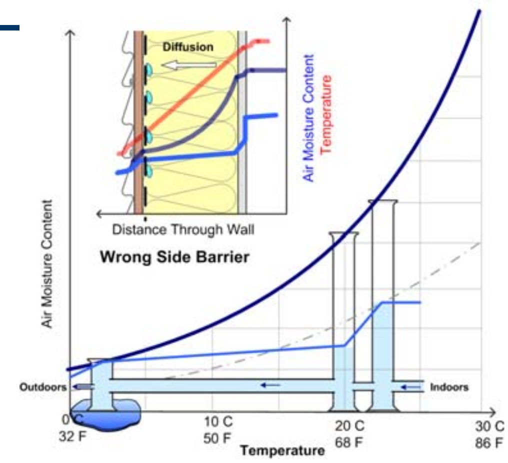


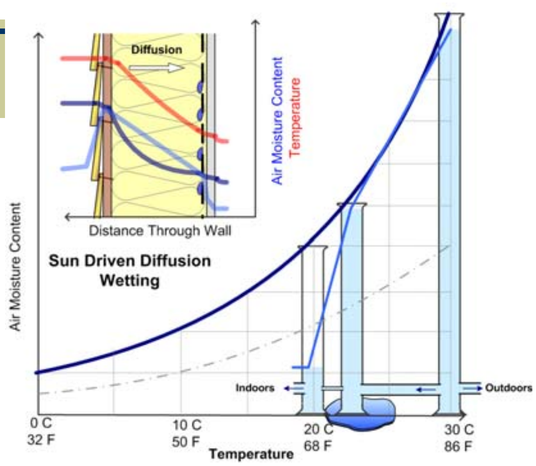












Vapour Retarders

- **Vapour retarders are needed to *control vapour diffusion***
- ***Don't*** **need be continuous – small tears and openings OK**
- **Usually placed near the warm side of the wall or roof -- near the inside in our climates**
- **Semi-permeable barriers allow more design flexibility (and more drying)**

Vapour Barriers

- Vapour barriers in Code: <1 US perm
  - based on Rowley 1937
  - no good science
- Vapour retarder approx 2-5 US perm
- Measurement Units
  - ***Metric*** perms ng /(s·m^2·Pa)
  - ***US*** perm grain/(hr·in Hg· ft^2)
  - WVT grams/(sq ft/24 hours)

Vapour Retarders

- **Inner permeance usually should be less than outer in our climate**
  - **unvented metal cladding, use polyethylene inside**
- **Walls with insulated sheathing do not need as much inner resistance**
  - **e.g., paint works well in this case**
- **Too low inner permeance resists drying, promotes summer condensation**
  - **e.g., polyethylene is often too much**

Low-perm Materials (<1/60)

- 6 mil Poly 0.1 US perm (5.7 metric)
- Vinyl wall paper 0.3 perm (17.1)
- 8" Conc. Fdn. wall 1/2 perm (28.5)
- Drywall with a VB paint 0.1 to 1 perm (5.7- 57)
- Brick veneer 1/2 - 2 perms (28.5-57)
- Extruded foam 1/2 - 1 for 1.5" (28.5-85.5)
- Plywood 0.5 to 20 (dry to wet) (28.5-1140)
- Kraft paper 0.3 to 2 (dry and wet) (17.1-114)

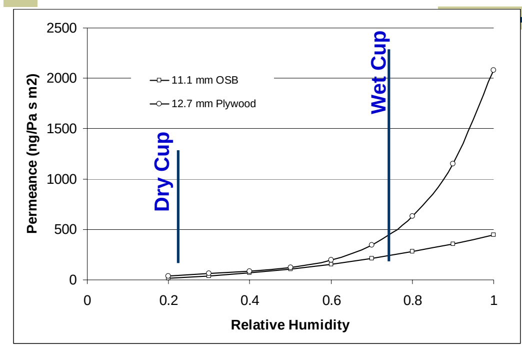
Mid-perm Materials (1-10)

- Plywood 0.5 to 20 (dry to wet) (28 -1100)
- Expanded polystyrene foam 2.5 - 5 perms for 1 inch (150-300)
- Spray PUR about 2 perms (120)
- Drywall with latex paint (2-5 perms) (120-300)

High-perm Materials (>10/600)

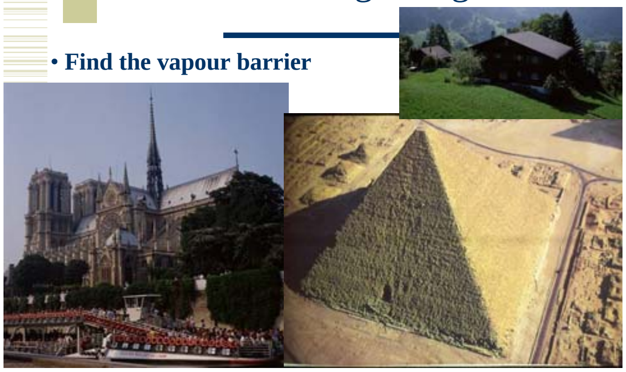
- Fibreboard over 20 (>1100)
- Plywood 0.5 to 20 (dry to wet) (30-1100)
- Icynene open cell spray foam 10-13 (500-750)
- Tyvek other housewraps 20 to 50 perms (1100-2800)
- Building paper over 5 to 20 (250-1200)

Vapour Permeance: Sheathing



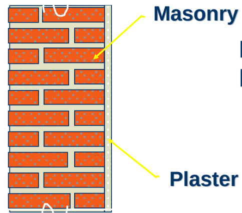
In the beginning

• **Find the vapour barrier**



Old Assemblies

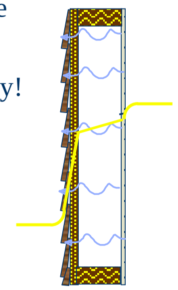
- Integral vapour resistance
- Massive moisture storage



Old Framed Assemblies

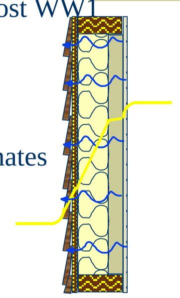
- Little to some vapour resistance
- Little moisture storage
- Little insulation / air leaky = dry!

No vapour barrier of course



Changes . . .

- Increase in wood frame, esp. post WW1
- Began to add insulation
  - comfort
  - wood scarcity, coal
- Moisture problems in cold climates noted in 1930’s
- Paint peeling of siding

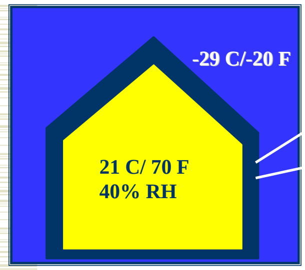


Dr Frank Rowley

- Professor of Mechanical Engineering at University of Minnesota
- ASH&VE 1932 president
- Proponent of using heat flow analogy for vapor flow in calculations
- Conducted full scale house in climate chamber studies –paid for by insulation companies

The One US Perm

This research resulted in 1 perm / 60 ng/Pa s m² or less vapor barriers



No VB:
21.5 g/m²/day
(0.07 ounce/ft²/day)

ASH&VE Transactions No 44, "Condensation Within Walls" 1938

Air barriers discovered

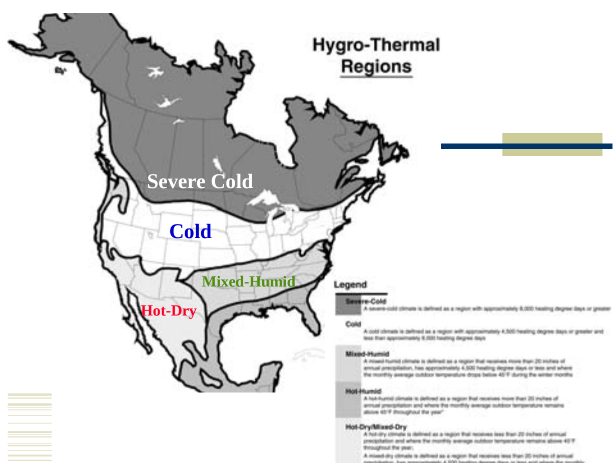
- Air leakage identified by : *"The rate of condensation is about ten times that at which vapour might be expected to diffuse through …It seems necessary to assume some other mechanism … the leakage of warm moist air outward .."* Neal Hutcheon, 1950
- Solution suggested by many:
  - Why not use the vapour barrier
- Add "sealed" or "continuous" to codes language
- Air barriers spelled out in 1985 NBCC

When and where

- Choice of vapour permeance and location of vapor barrier depends on
  - Exterior Climate
  - Interior Climate
  - Wall Assembly
- *Any "rule" that does not consider these factors cannot provide correct guidance*

When and Where

- Place on warm side of enclosure
  - summer and winter balance
- If you use a VB on cold side of wall - ventilate!
- If extreme temps/RH, use VB
- If moderate, use VR (retarder, like paint)
- Insulated sheathing changes everything
- If in doubt - figure it out
- Climate is one guide



Climate and VB

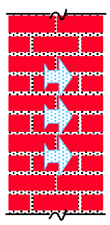
- Florida is hot and humid
  - moisture is outdoors
  - place VB near outside
  - allow vapour to flow INWARD
- Winnipeg/Bismark is cold/dry
  - bitterly cold winters
  - summers are hot and dry
  - place VB near inside
  - allow vapour to flow outward

Climate and VB

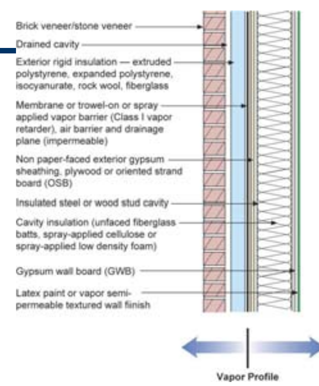
- Vancouver/Seattle
  - moisture is both indoors outdoors
  - allow vapour to flow inward and outward
  - use VR near inside (paint)
- Toronto/Detroit
  - summers are hot and humid, winters cold
  - if rain-wetted cladding, inward is important!
  - allow vapour to flow inward and outward
  - use VR near inside (paint) or exterior insulation

VB and Wall design

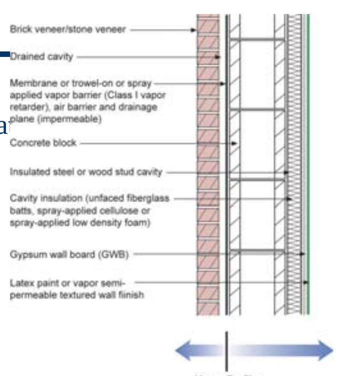
- **Likely need vapour barriers:**
  - low integral vapour resistance
    - framed walls with batt
- **Rarely need VB:**
  - Integral vapour resistance
    - SIPS
    - spray foam
  - Built in VB
    - concrete
  - Kept warm
    - insulating sheathing



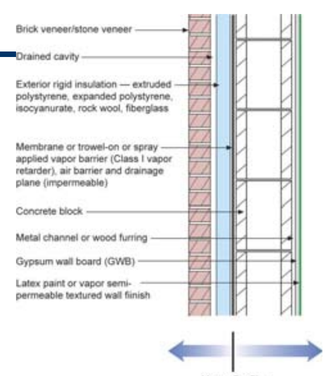
- OK for cool climates if the ratio of exterior R value to interior is high. Calculate.



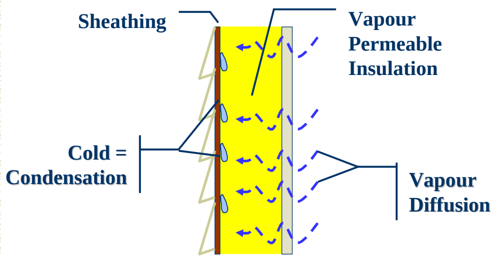
- Good for hot-humid climates that rarely get cold
- NEVER for cold climates



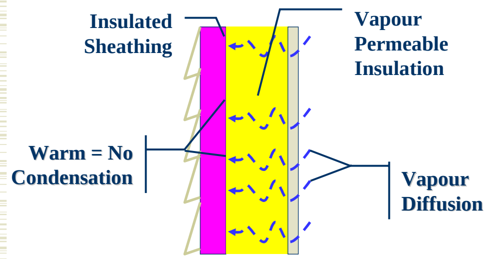
- Works everywhere without calculation



Wall w/o Insulated Sheathing



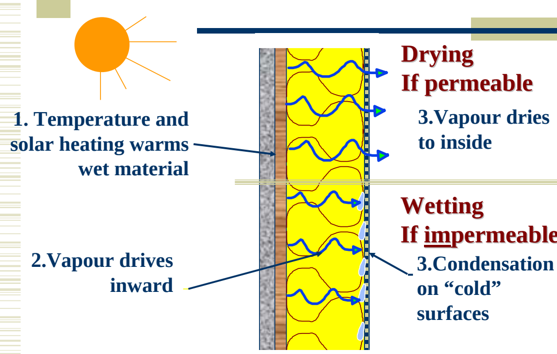
Wall with Insulated Sheathing

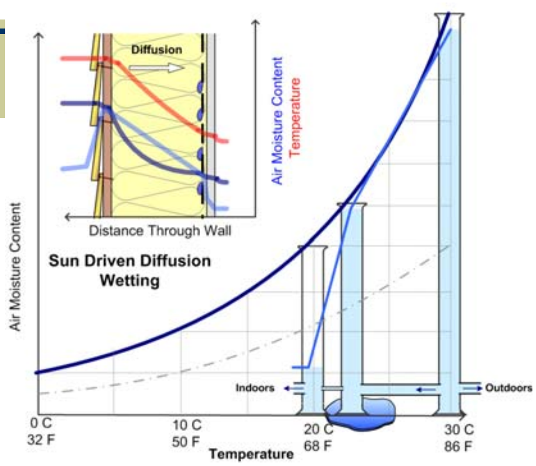


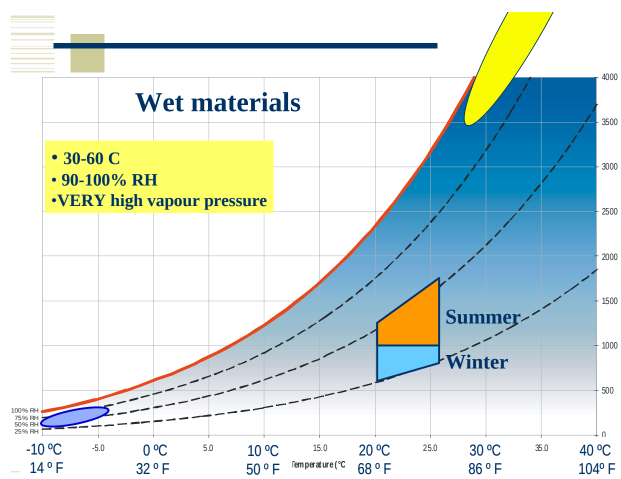
Drying

- Vapour barriers stop wetting ***and*** drying
- Overkill (e.g. poly) can cause problems!
- Inward drying is useful in many climates

Inward Diffusion







Warm climates

Cool climates

Summary for Vapour Barriers

- Vapour flows from ***more*** to ***less***
  - It goes ***both*** ways (In-Out & Out-In)
- Vapour Barriers do not need to be continuous
- Don't always need a separate vapour barrier many walls have integral resistance
- Be careful to allow drying
  - ***Vapour Barrier = Drying Retarder***

Back to Air Barriers…

There must be a continuous, durable, strong and stiff assembly of materials that is defined as the* plane of air tightness *in all buildings with conditioned space

Remember

- ***Vapour Barriers Control Vapour Diffusion***
  - Why? 1. Moisture wetting and drying
- ***Air Barriers Control Air Leakage***
  - Why? ***Six*** reasons.
  - Heat (for 1. comfort & 2. energy considerations)
  - 3. Smoke & 4. odours
  - 5. Moisture
  - 6. Sound

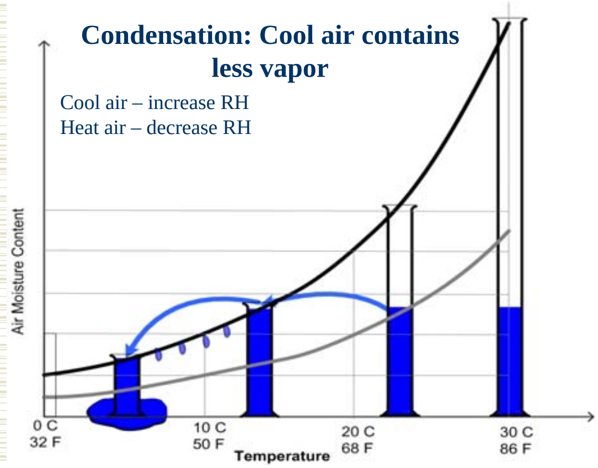
Why Air Barriers for Moisture?

- **Air leakage** moves **moist** air (**vapour**) through the assembly to locations where it can condense
- Two air leakage concerns for moisture:
  1. Through Wall
  2. Wind Washing

  } Air Barrier

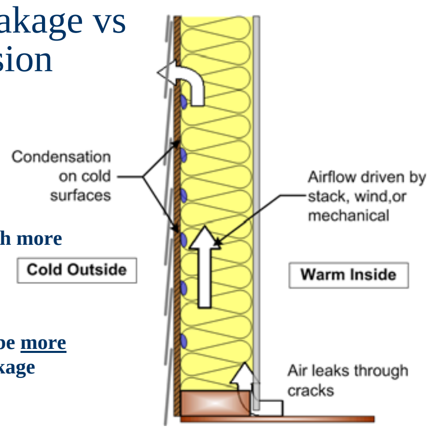
Condensation: Cool air contains less vapor

Cool air – increase RH
Heat air – decrease RH

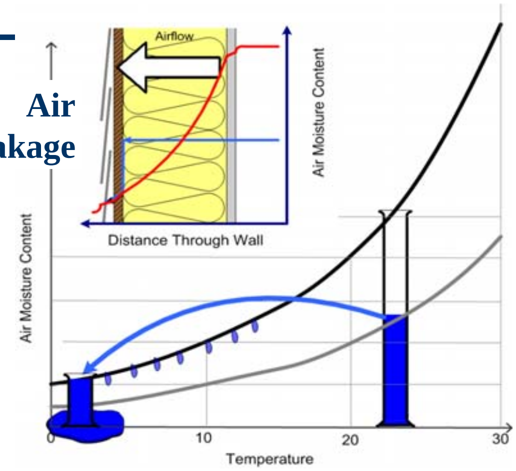


Air leakage vs Diffusion

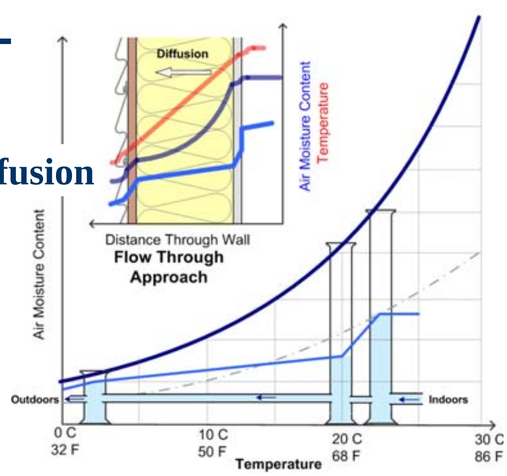
- **Air leakage is much more critical**
- **Walls sensitive to diffusion-related condensation will be <u>more</u> sensitive to air leakage**



Air leakage

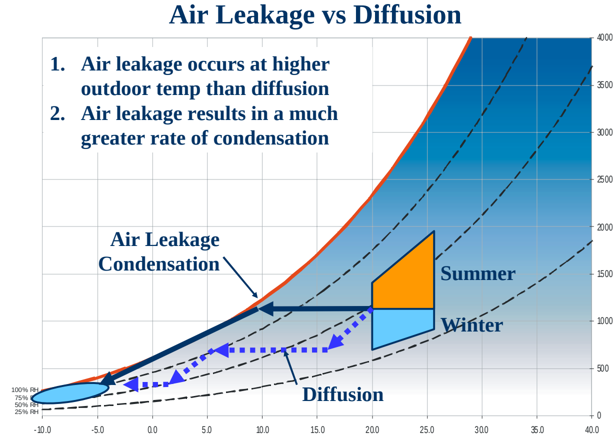


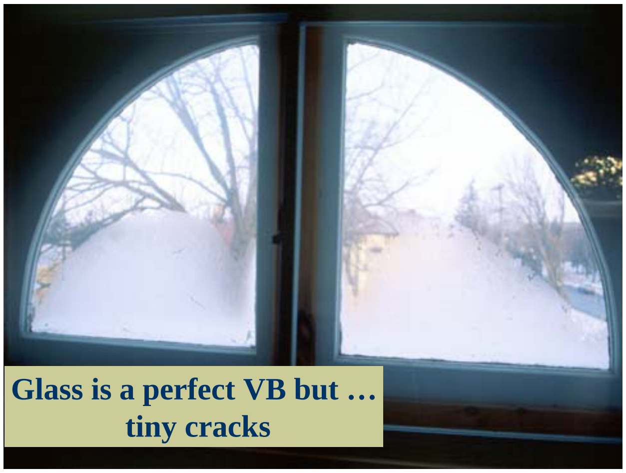
Diffusion

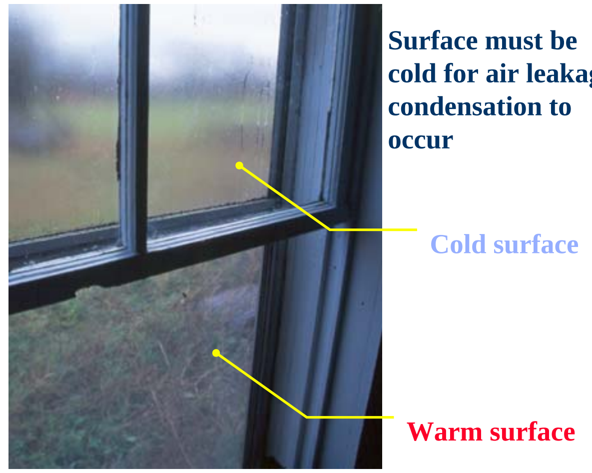


Air Leakage vs Diffusion

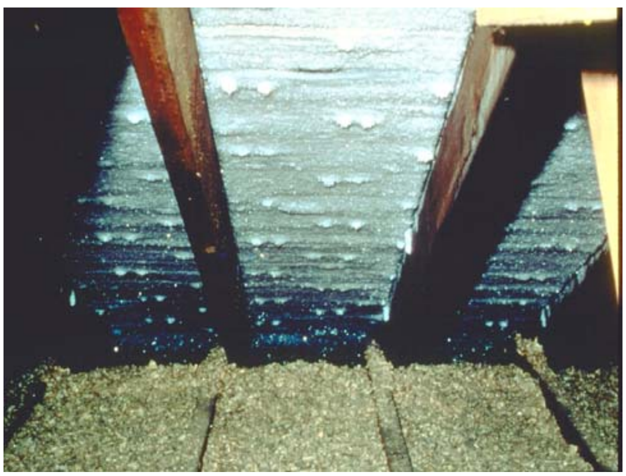
1. **Air leakage occurs at higher outdoor temp than diffusion**
2. **Air leakage results in a much greater rate of condensation**







Surface must be cold for air leakage condensation to occur



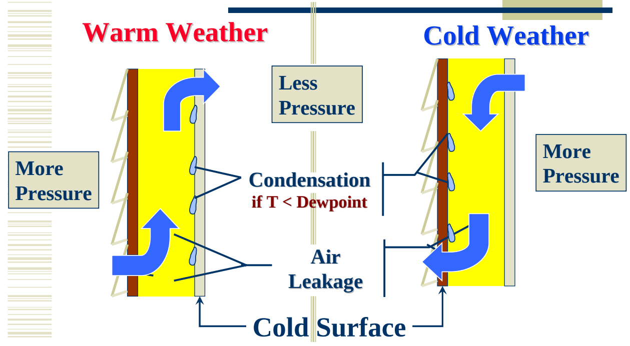
Air Leakage & Condensation

- Difficult to predict direction of air pressures and unintentional flow paths
- Damaging airflow direction is:
  - cold weather ***inside to outside***
  - warm weather ***outside to inside***
- Condensation can **ONLY** occur if *both*:
  - air contacts a cold surface, **and**
  - air flow is in the direction of more to less vapour

Controlling Air Leakage Condensation

1. **Stop all airflow**
2. **Control driving forces (HVAC/ air pressures)**
3. **Control Temperature of condensing surface**
4. **Reduce interior moisture load**

Air leakage (Convection)



Airflow Control: Where

- Stop airflow = stop many problems
  = ***Air Barrier***
- Can locate anywhere in enclosure
- Should be protected if possible
- Multiple layers are good
- Important in all climates

Air Barriers are Systems (not materials)

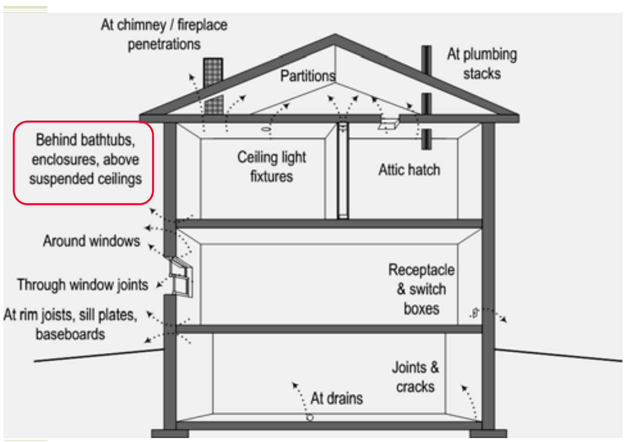
- **Air barrier systems are required to *stop airflow through enclosure***
- **ABS can be placed anywhere in the enclosure**
- **Must be strong enough to take wind gusts**
- **Air barrier systems must be *continuous***
  They leak at *joints, interfaces, penetrations*
- **multiple air barrier planes are useful for redundancy**

Air Barrier System Requirements

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

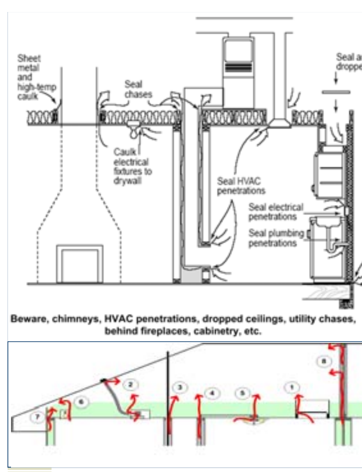
1. Stopping Leaks

"Find the holes and plug them"
This requires finicky attention to 3-D details.

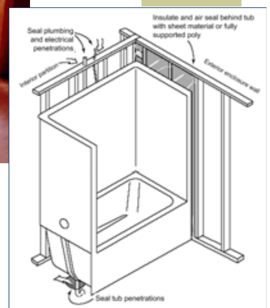


Typical Air Leakage Points

Big Air Leakage Points



Big Air Leakage Points



Seal and insulate enclosure walls before installing tub surrounds

Air Barrier Systems Summary

- Air barrier systems are required to **stop uncontrolled airflow**
- ABS can be placed anywhere in the enclosure
- Must be **strong** enough to take wind gusts
- Must be **continuous**
- Must be **durable**
- Should be **stiff** enough not flap around

Air Barrier Systems Summary

- Air barrier systems must be **continuous**
- They leak at ***joints, interfaces, penetrations***
- Hence
  - "The air permeance of the materials is less important than continuity of the system"
- Air permeance should be low
  - say less than about 0.2 lps/m^2@75 Pa, usually better

Summary

- **Air leakage** and **Diffusion** can cause
  - Wetting AND
  - Drying
  - Depends on Weather Conditions!
- Vapour barriers and air barriers reduce or slow flow in BOTH directions
- **all** vapour barriers slow inward drying
- **all** vapour resistant claddings and sheathings slow outward drying

Conclusions

- Air barriers and vapour barriers are ***different***
  - can be combined in same materials
- Vapour barriers control diffusion
  - use only when needed
  - place near WARM side only
- Air barriers control air flow
  - can be placed any where
- **Air barriers** usually ***more important***
  - continuity is key!

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