Joseph Lstiburek, Ph.D., P.Eng, ASHRAE Fellow

Building Science

Adventures In Building Science

"It isn't what we don't know that gives us trouble, it's what we know that ain't so"

Will Rogers

"There are known knowns. These are things we know. There are known unknowns. There are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.

Donald Rumsfeld

Heat

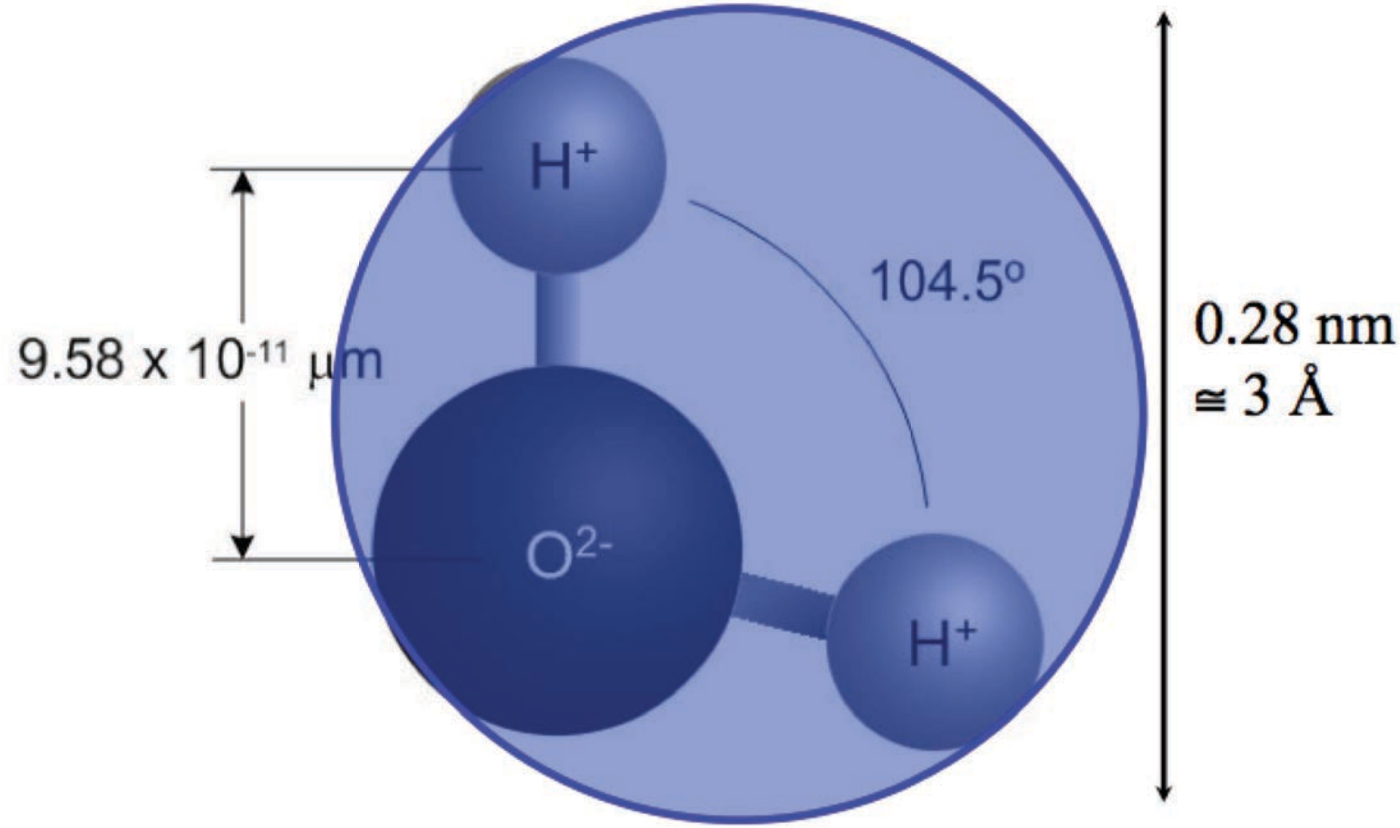
Air

Moisture

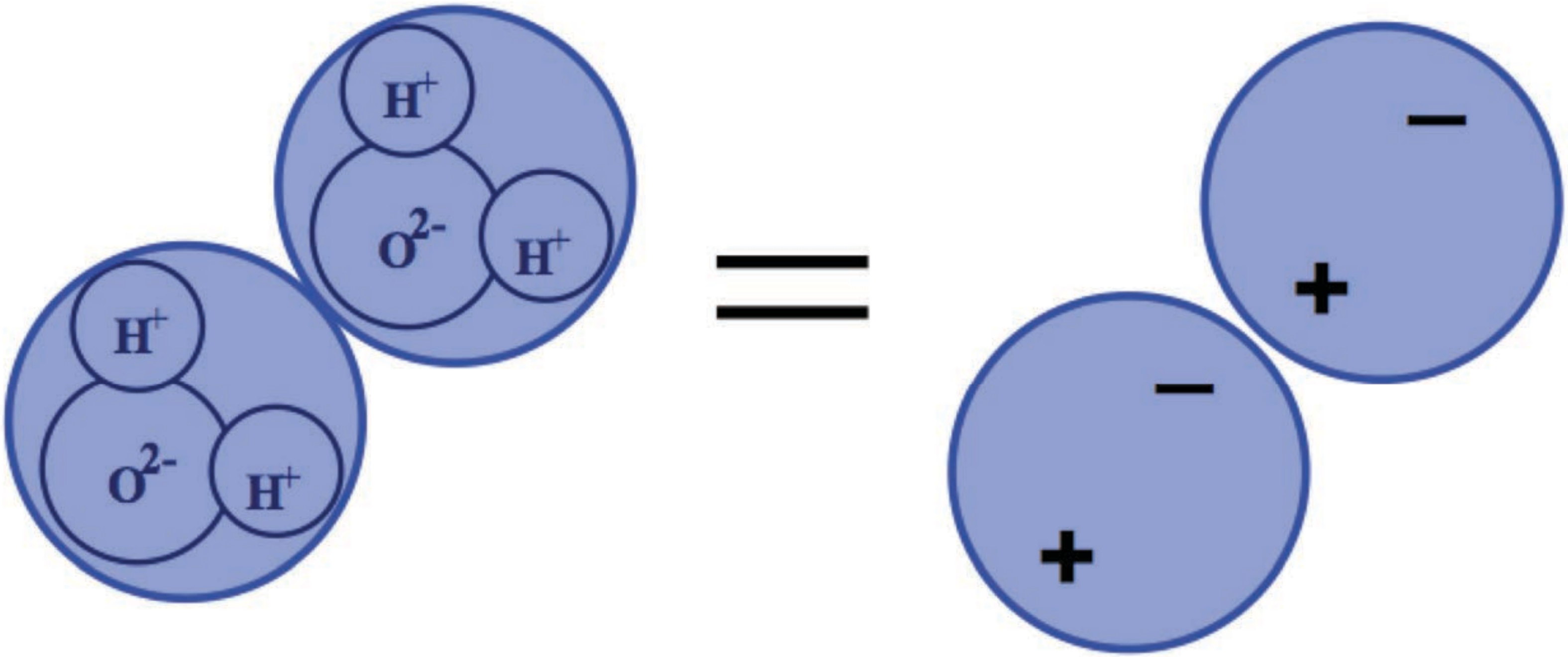
HAM

Hygrothermal Analysis

Water Molecules

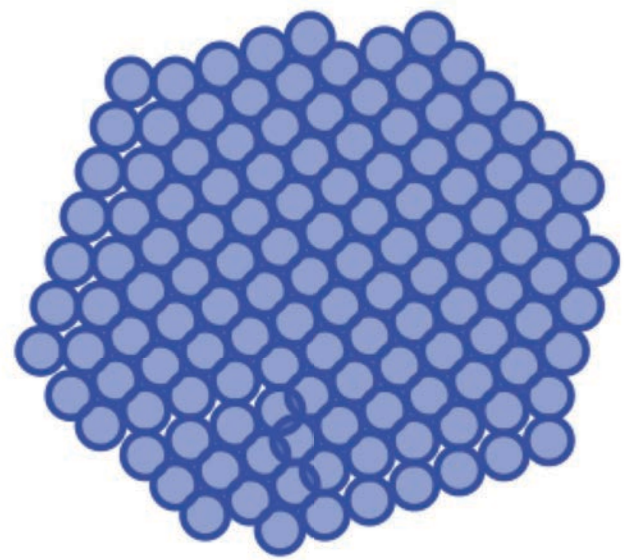

H+
104.5o
9.58 x 10-11 µm
O2-
H+
0.28 nm
≅ 3 Å

Polar Molecule


H+
O2-
H+
H+
O2-
H+
=
–
+
–
+

Size Matters

Vapor



Liquid

Periodic Table

Period ↓ / Group →	1	2	3		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																		2 He
2	3 Li	4 Be												5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg												13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc		22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y		40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	**	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
				*	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
				**	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

Nitrogen	14
Oxygen	16

Nitrogen	14	N_2	28
Oxygen	16	O_2	32
		H_2O	18

Nitrogen	14	N2	28
Oxygen	16	O2	32
		H2O	18
		Air	21% O2
			79% N2

Molecular Weight of Dry Air 29

Nitrogen	14	N_2	28
Oxygen	16	O_2	32
		H_2O	18
		Air	21% O_2
			79% N_2

Molecular Weight of Dry Air 29

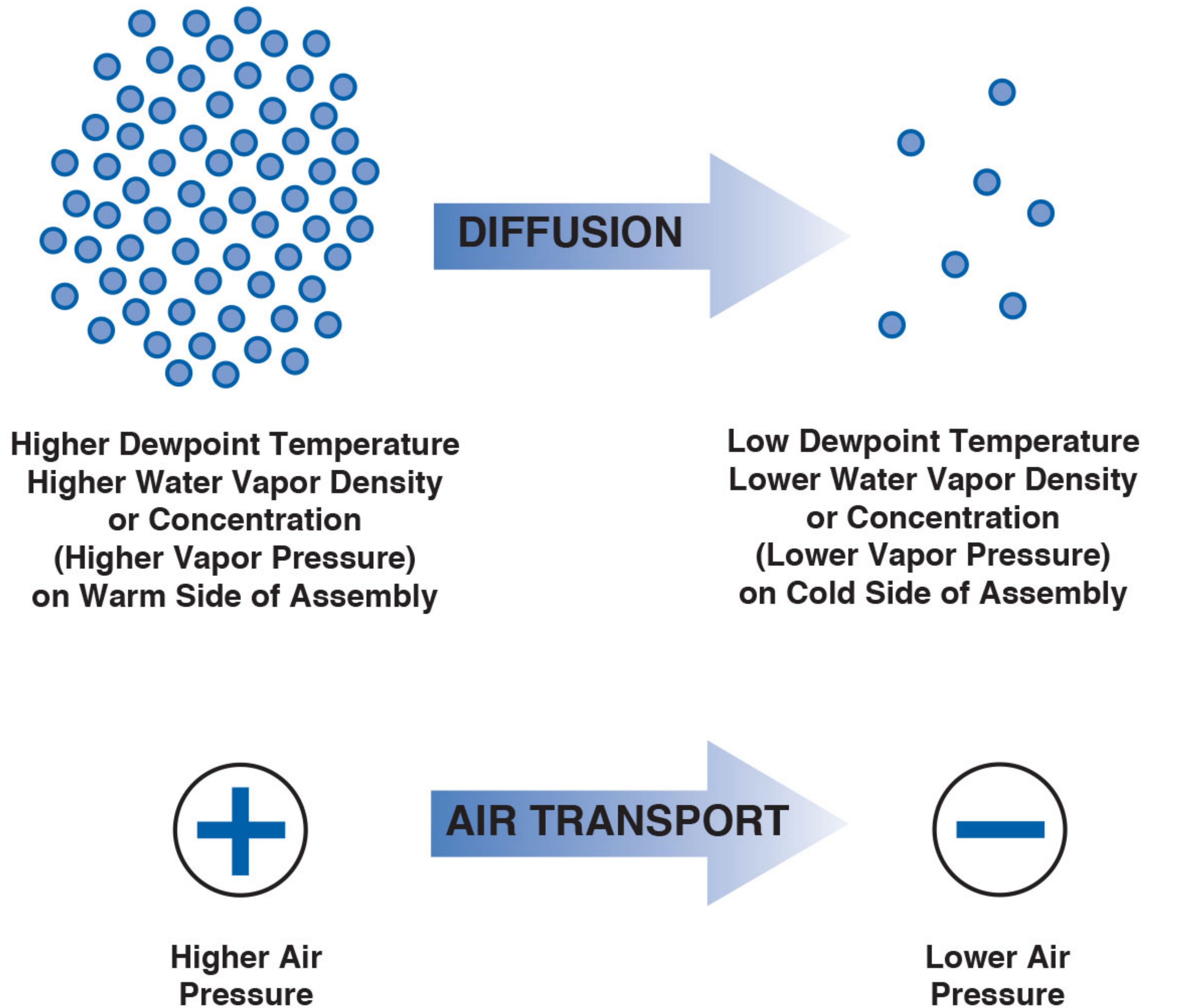
Adding Water Vapor Lowers It….

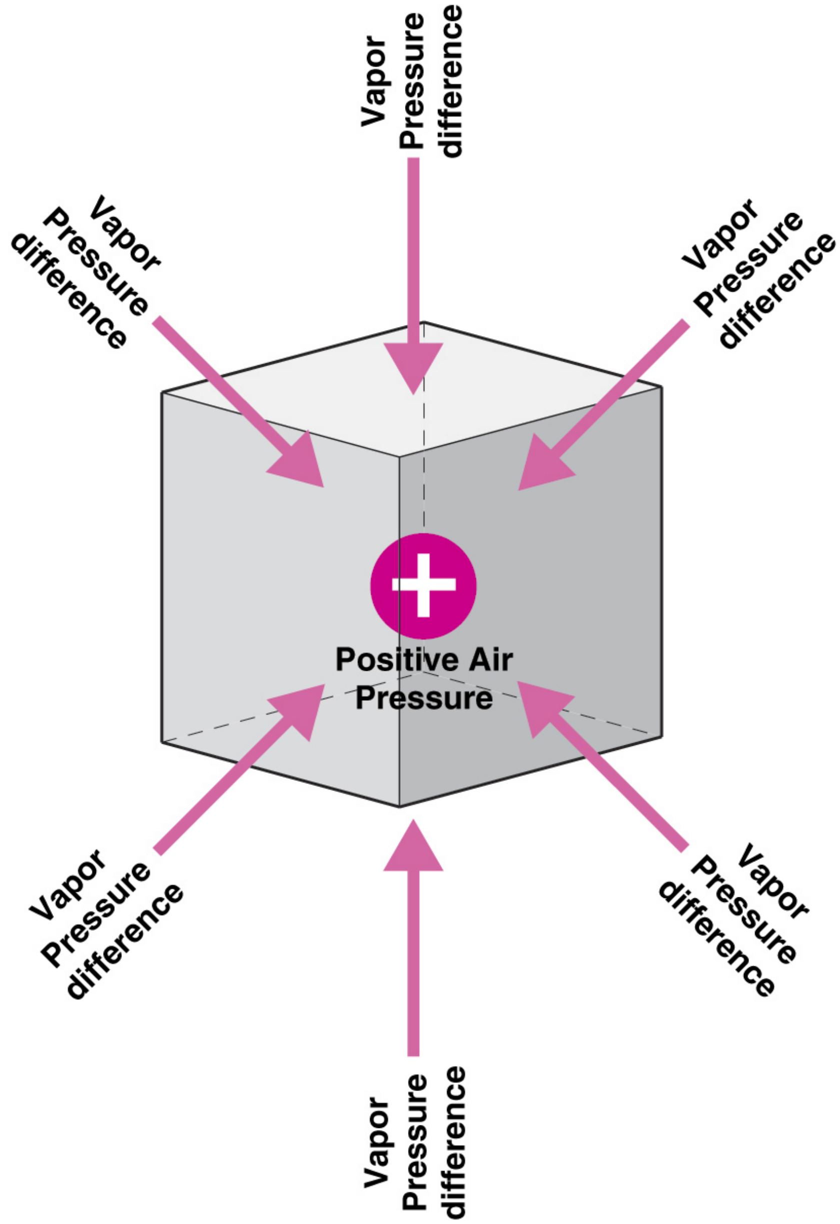
Vapor Diffusion

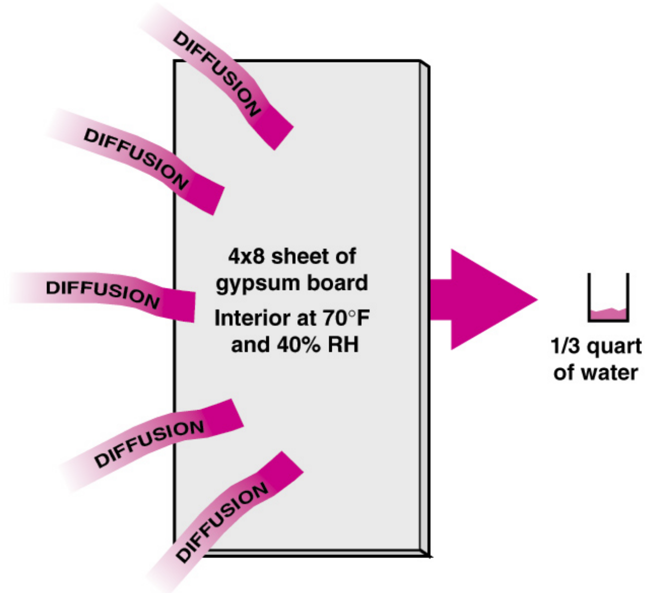
Air Transported Moisture

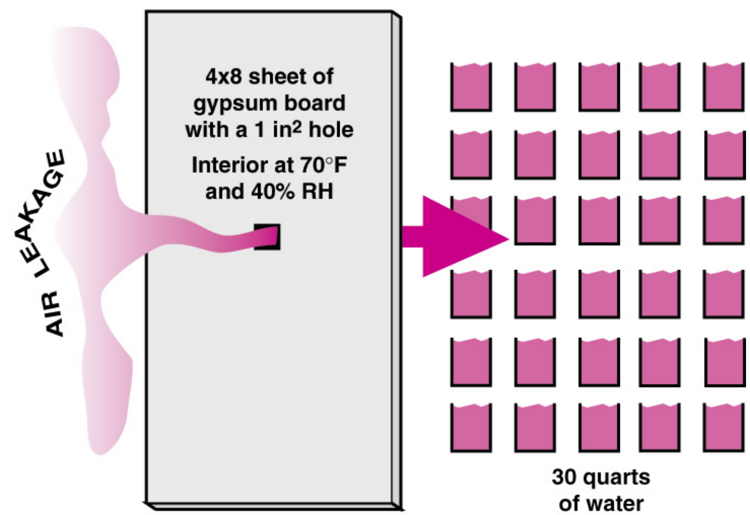
Vapor Barriers

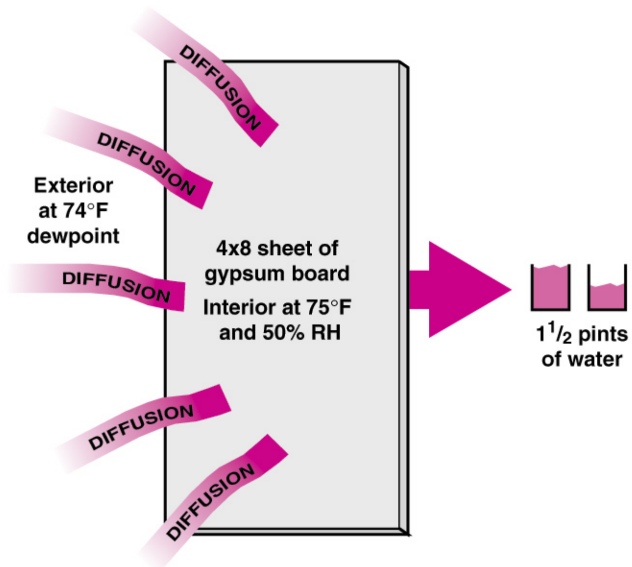
Air Barriers

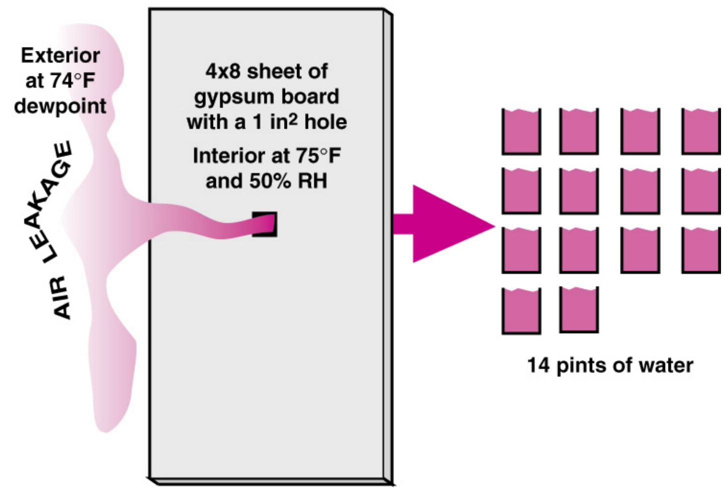

DIFFUSION
Higher Dewpoint Temperature
Higher Water Vapor Density
or Concentration
(Higher Vapor Pressure)
on Warm Side of Assembly
Low Dewpoint Temperature
Lower Water Vapor Density
or Concentration
(Lower Vapor Pressure)
on Cold Side of Assembly
AIR TRANSPORT
Higher Air
Pressure
Lower Air
Pressure


Vapor
Pressure
difference
Vapor
Pressure
difference
Vapor
Pressure
difference
Positive Air
Pressure
Vapor
Pressure
difference
Vapor
Pressure
difference
Vapor
Pressure
difference


DIFFUSION
DIFFUSION
DIFFUSION
DIFFUSION
DIFFUSION
4x8 sheet of gypsum board
Interior at 70°F and 40% RH
1/3 quart of water

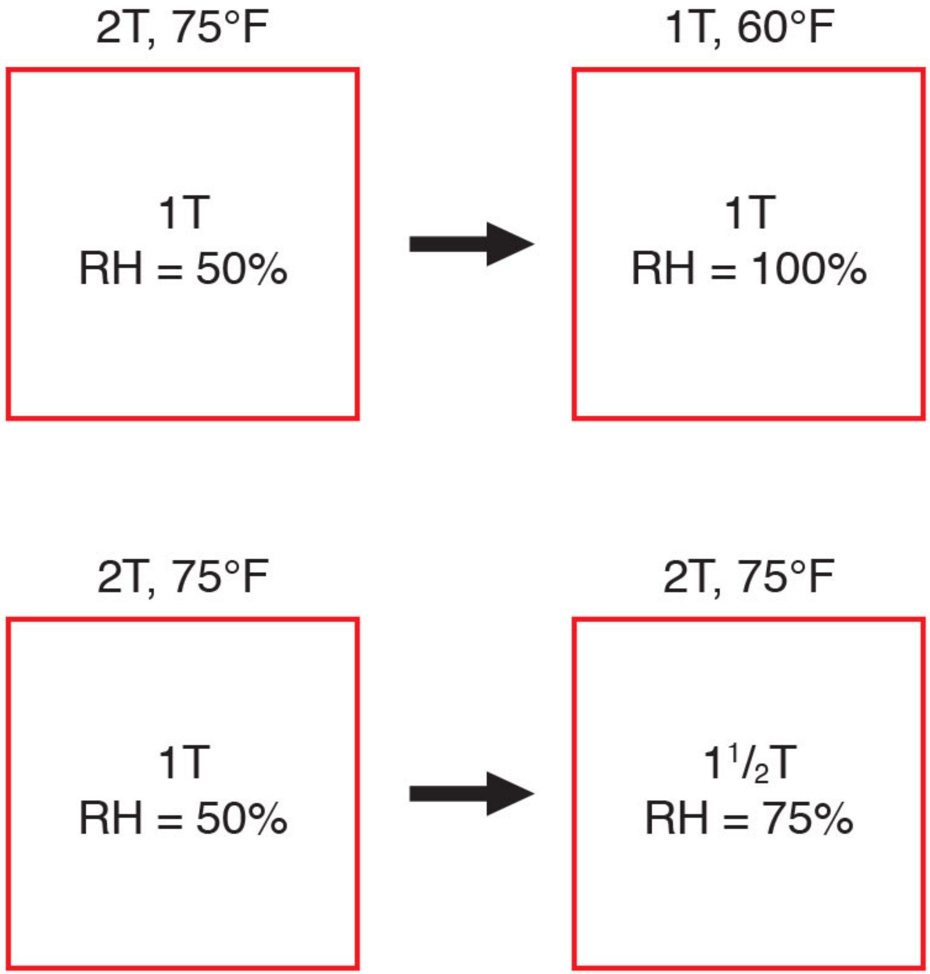

AIR LEAKAGE
4x8 sheet of gypsum board with a 1 in2 hole
Interior at 70°F and 40% RH
30 quarts of water

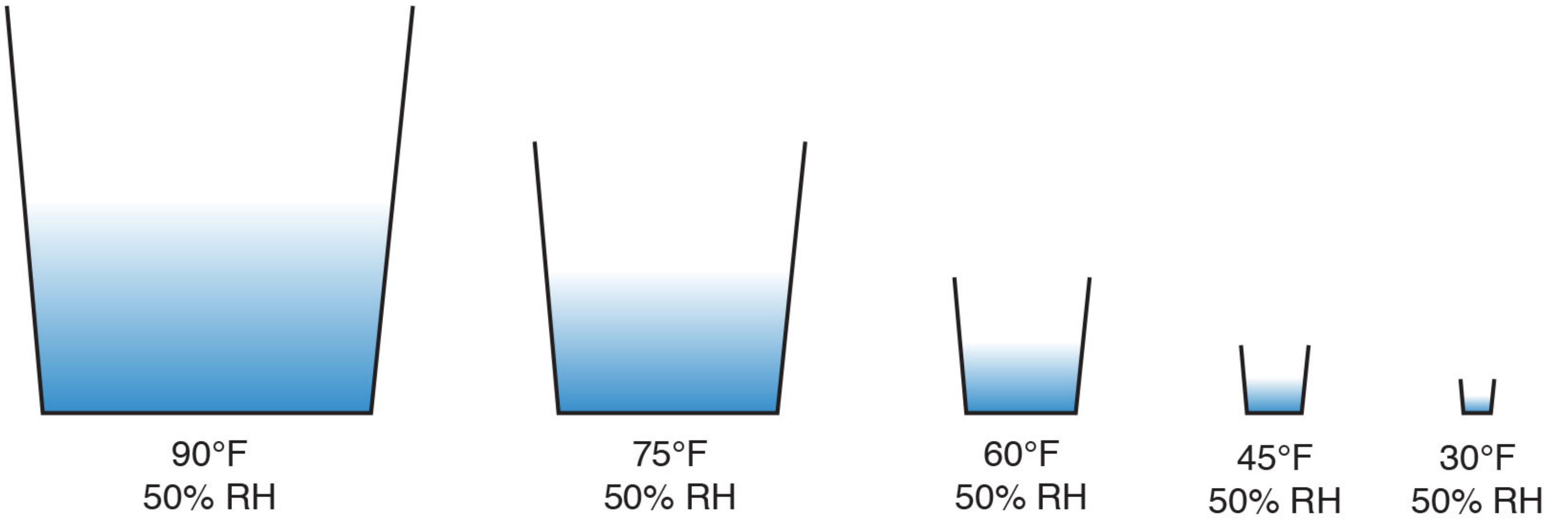

DIFFUSION
DIFFUSION
Exterior
at 74°F
dewpoint
DIFFUSION
4x8 sheet of
gypsum board
Interior at 75°F
and 50% RH
DIFFUSION
DIFFUSION
1 1/2 pints
of water

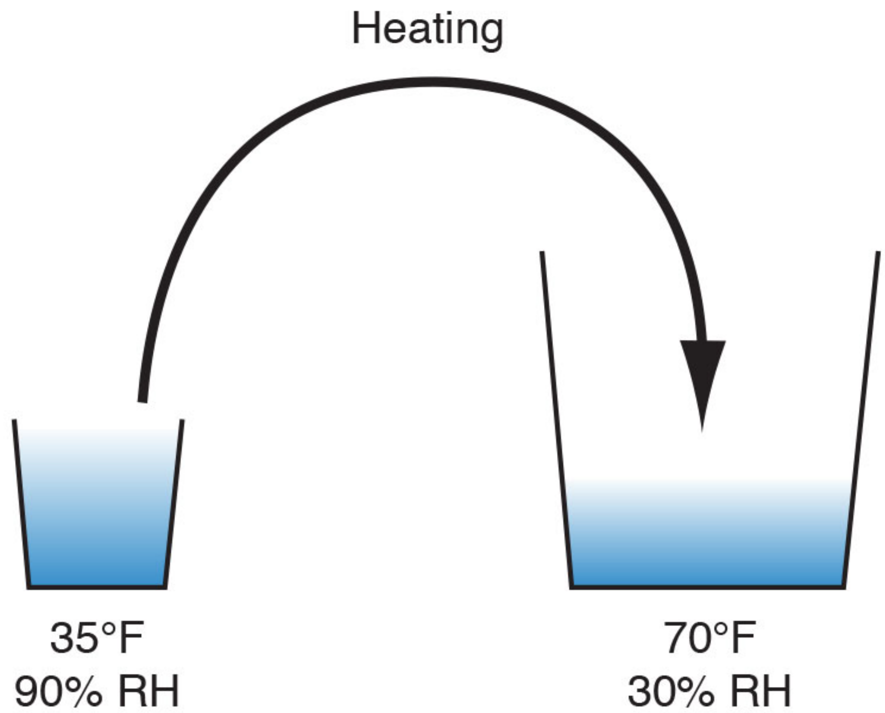

Exterior
at 74°F
dewpoint
AIR LEAKAGE
4x8 sheet of
gypsum board
with a 1 in2 hole
Interior at 75°F
and 50% RH
14 pints of water

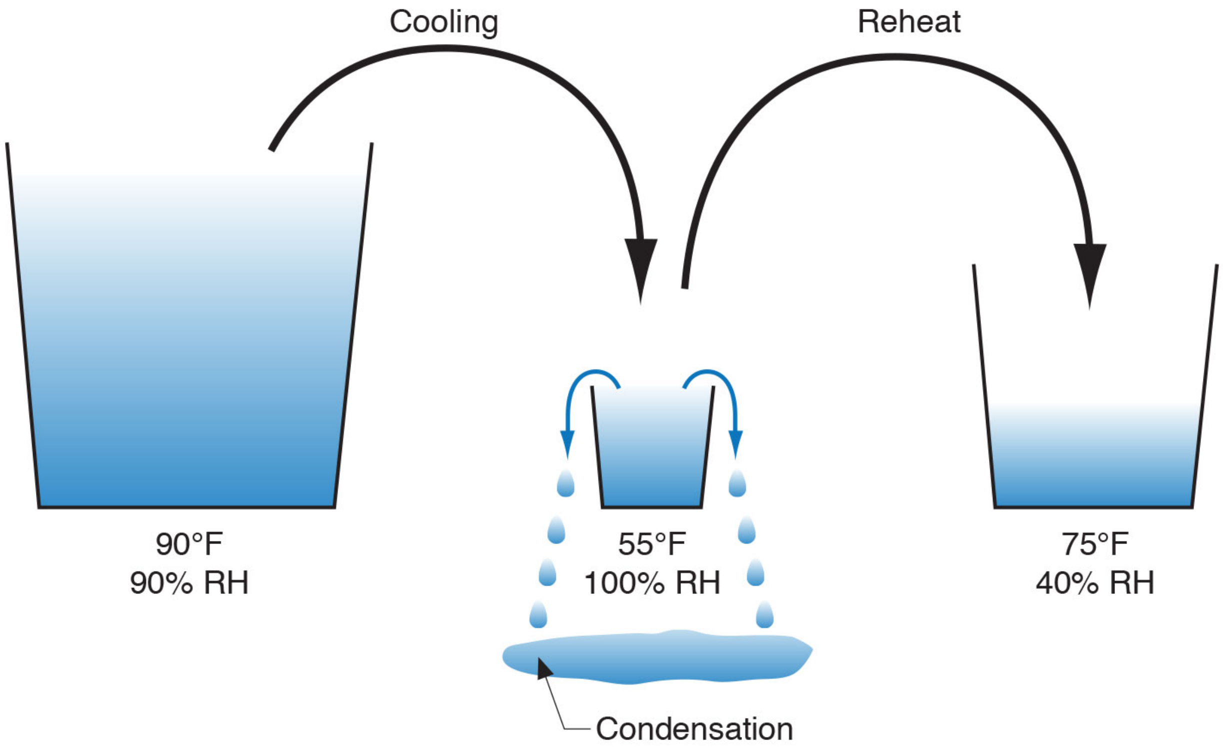
Relative Humidity

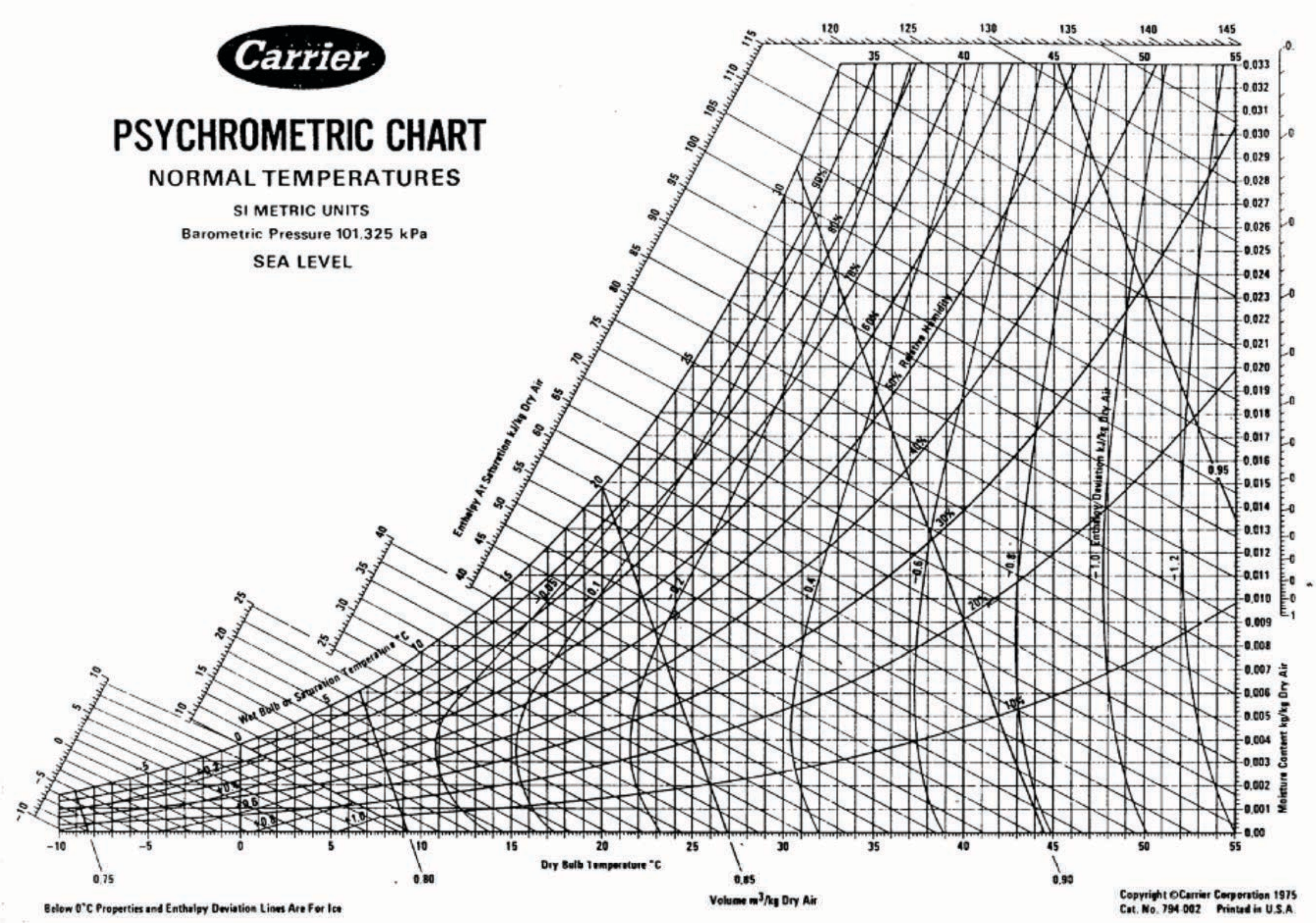
Vapor Pressure


2T, 75°F
1T
RH = 50%
1T, 60°F
1T
RH = 100%
2T, 75°F
1T
RH = 50%
2T, 75°F
1 1/2 T
RH = 75%

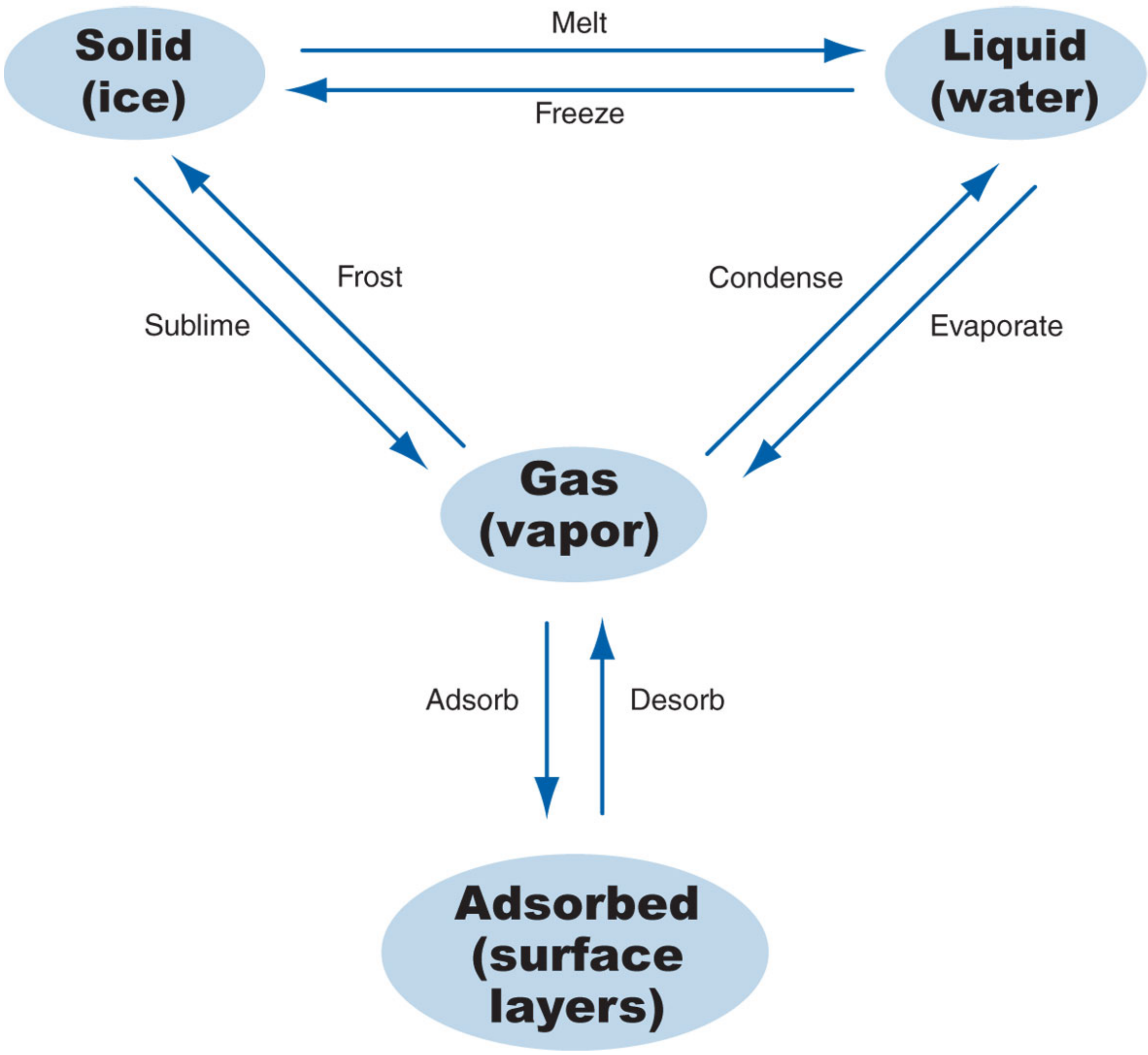

90°F
50% RH
75°F
50% RH
60°F
50% RH
45°F
50% RH
30°F
50% RH

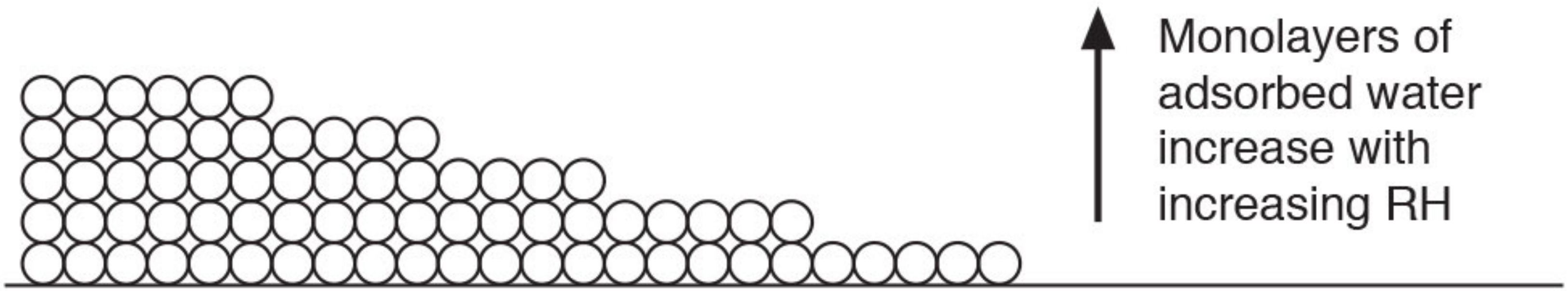

Heating
35°F
90% RH
70°F
30% RH

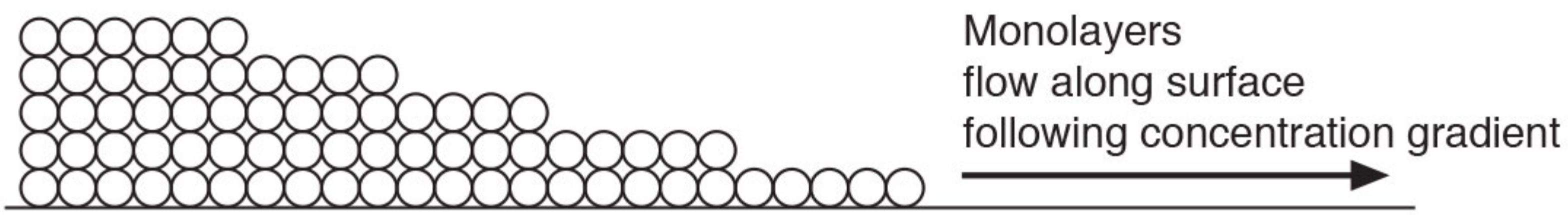

Cooling
Reheat
90°F
90% RH
55°F
100% RH
75°F
40% RH
Condensation

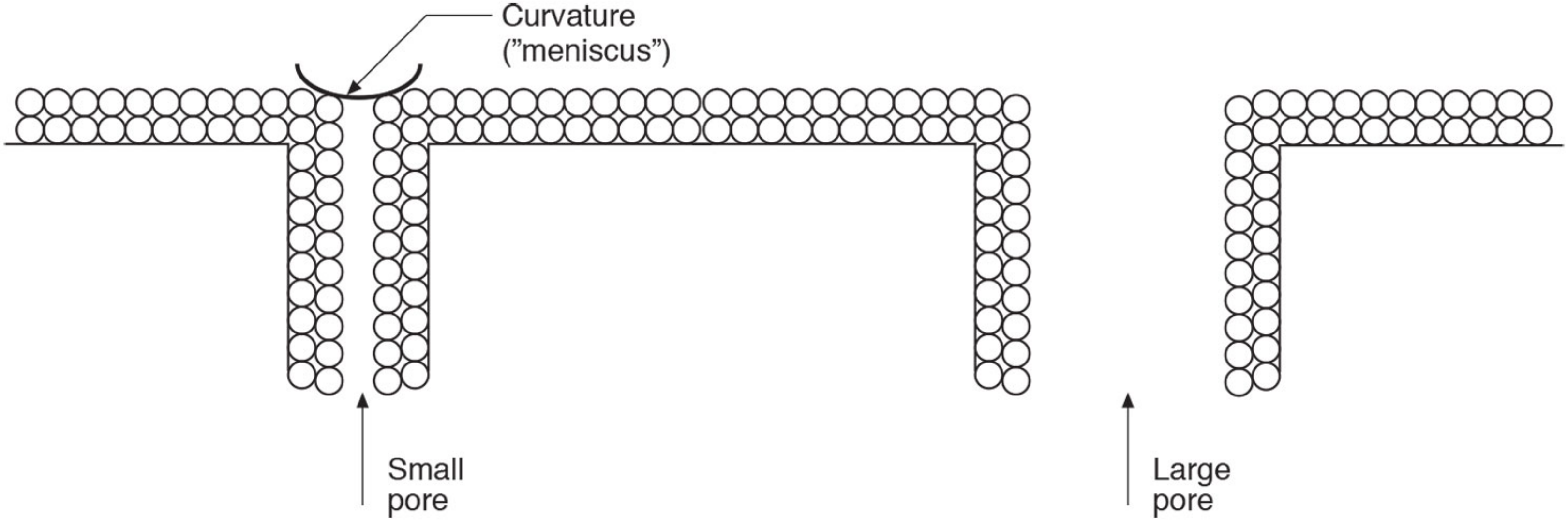

Carrier
PSYCHROMETRIC CHART
NORMAL TEMPERATURES
SI METRIC UNITS
Barometric Pressure 101.325 kPa
SEA LEVEL
Enthalpy At Saturation kJ/kg Dry Air
Wet Bulb or Saturation Temperature °C
Relative Humidity
Enthalpy Deviation kJ/kg Dry Air
Dry Bulb Temperature °C
Volume m³/kg Dry Air
Moisture Content kg/kg Dry Air
Below 0°C Properties and Enthalpy Deviation Lines Are For Ice
Copyright ©Carrier Corporation 1975
Cat. No. 794-002 Printed in U.S.A.

States of Matter


Solid
(ice)
Melt
Freeze
Liquid
(water)
Frost
Sublime
Condense
Evaporate
Gas
(vapor)
Adsorb
Desorb
Adsorbed
(surface
layers)

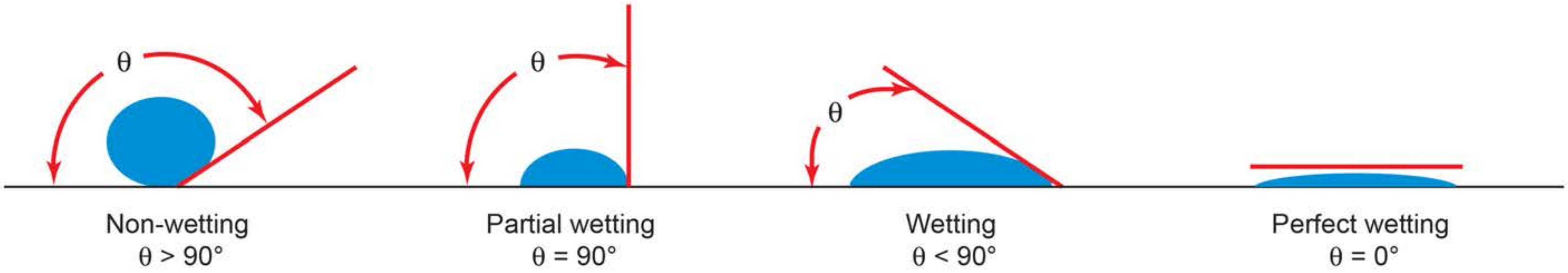

Monolayers of
adsorbed water
increase with
increasing RH

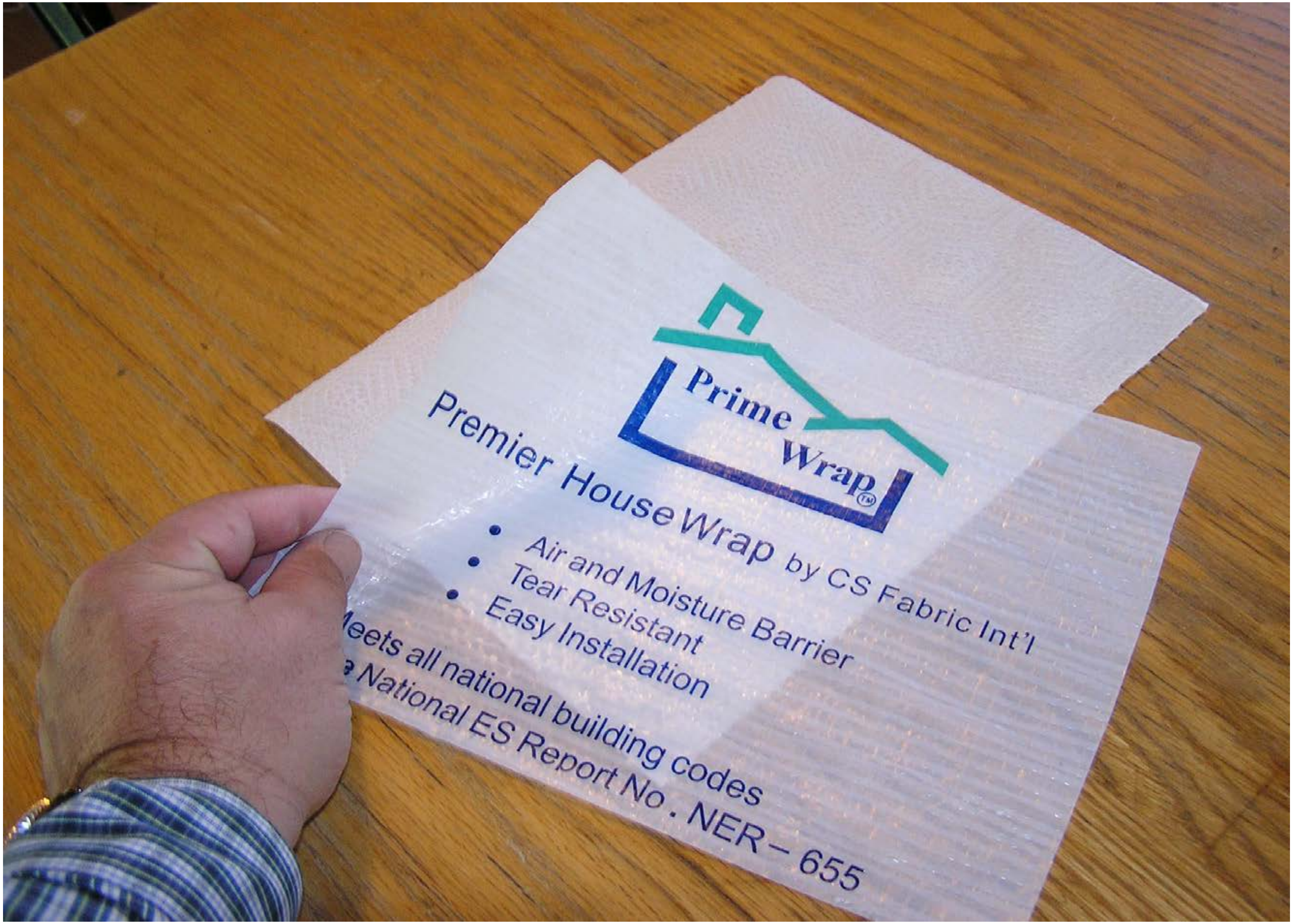

Monolayers
flow along surface
following concentration gradient


Curvature
("meniscus")
Small
pore
Large
pore

- "non-wetable" surface
- water repellant surface
- hygrophobic surface
- water more attracted to itself than to surface
- surface energy of water greater than surface energy of surface
- water "beads up"
- "greasy" surface
- high contact angle "θ"

- "wetable" surface
- non-water repellant surface
- hygroscobic surface
- water more attracted to surface than itself
- surface energy of surface greater than surface energy of water
- water "spreads out"
- "non-greasy" surface
- low contact angle "θ"


θ
θ
θ
Non-wetting
θ > 90°
Partial wetting
θ = 90°
Wetting
θ < 90°
Perfect wetting
θ = 0°


Prime Wrap
Premier House Wrap by CS Fabric Int'l
• Air and Moisture Barrier
• Tear Resistant
• Easy Installation
all national building codes
National ES Report No. NER – 655

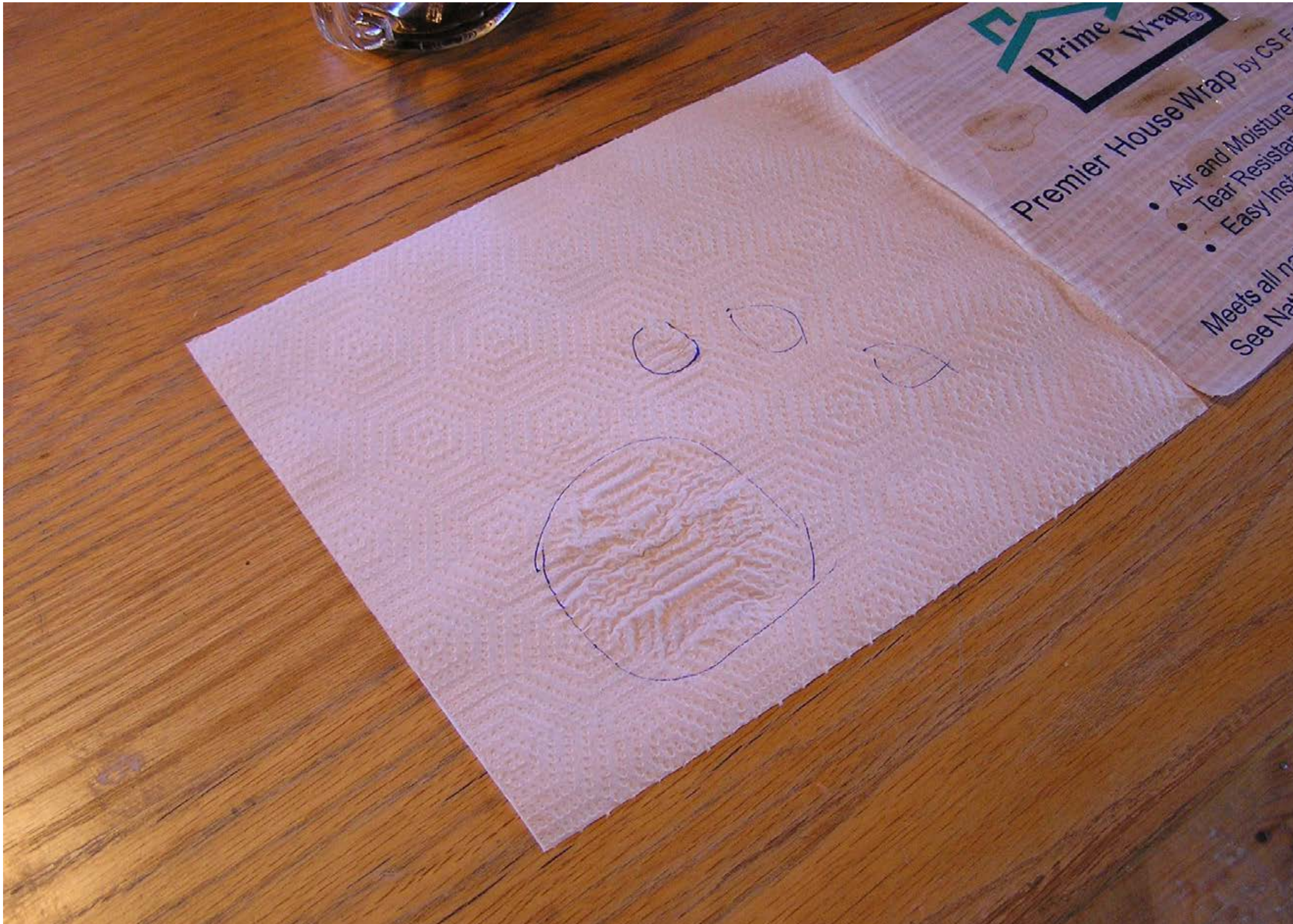

Prime
Wrap
Premier House Wrap by CS Fabric Int'l
• Air and Moisture Barrier
• Tear Resistant
• Easy Installation
Meets all national building codes
See National ES Report No . NER – 655


Prime
Wrap
TM
emier House Wrap by CS Fabric
• Air and Moisture Barrier
• Tear Resistant
• Easy Installation


abric Int'l
d Moisture Barrier
esistant
codes
eport No. NER – 655


2 CUPS
START


Prime
Wrap
Premier House Wrap by CS Fabric Int'l
• Air and Moisture Barrier
• Tear Resistant
• Easy Installation
Meets all national building codes
See National ES Report No . NER – 655
PYREX

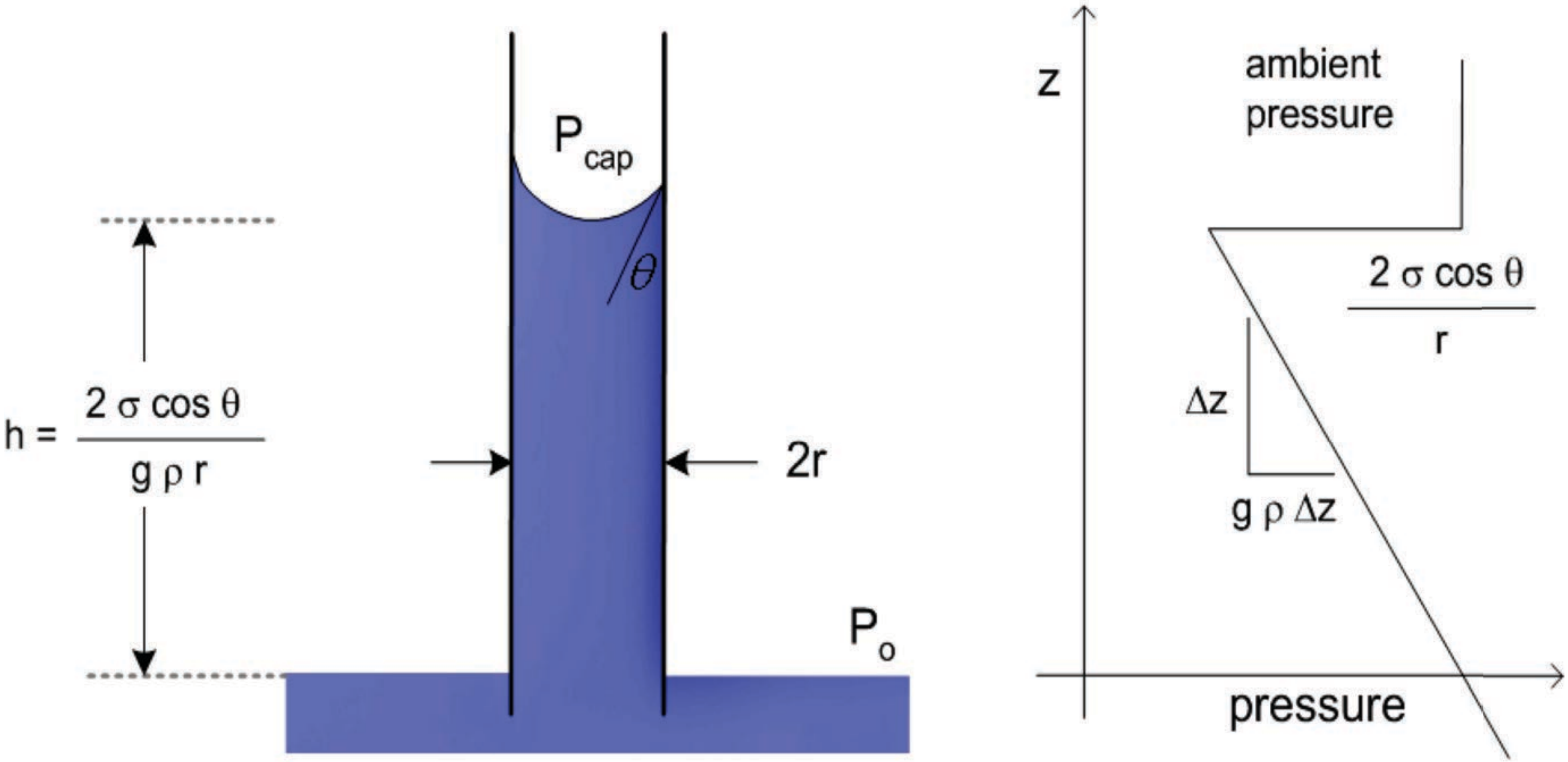

Prime Wrap
Premier HouseWrap by CS
Air and Moisture
Tear Resistant
Meets all


Cambridge
PINKWRAP

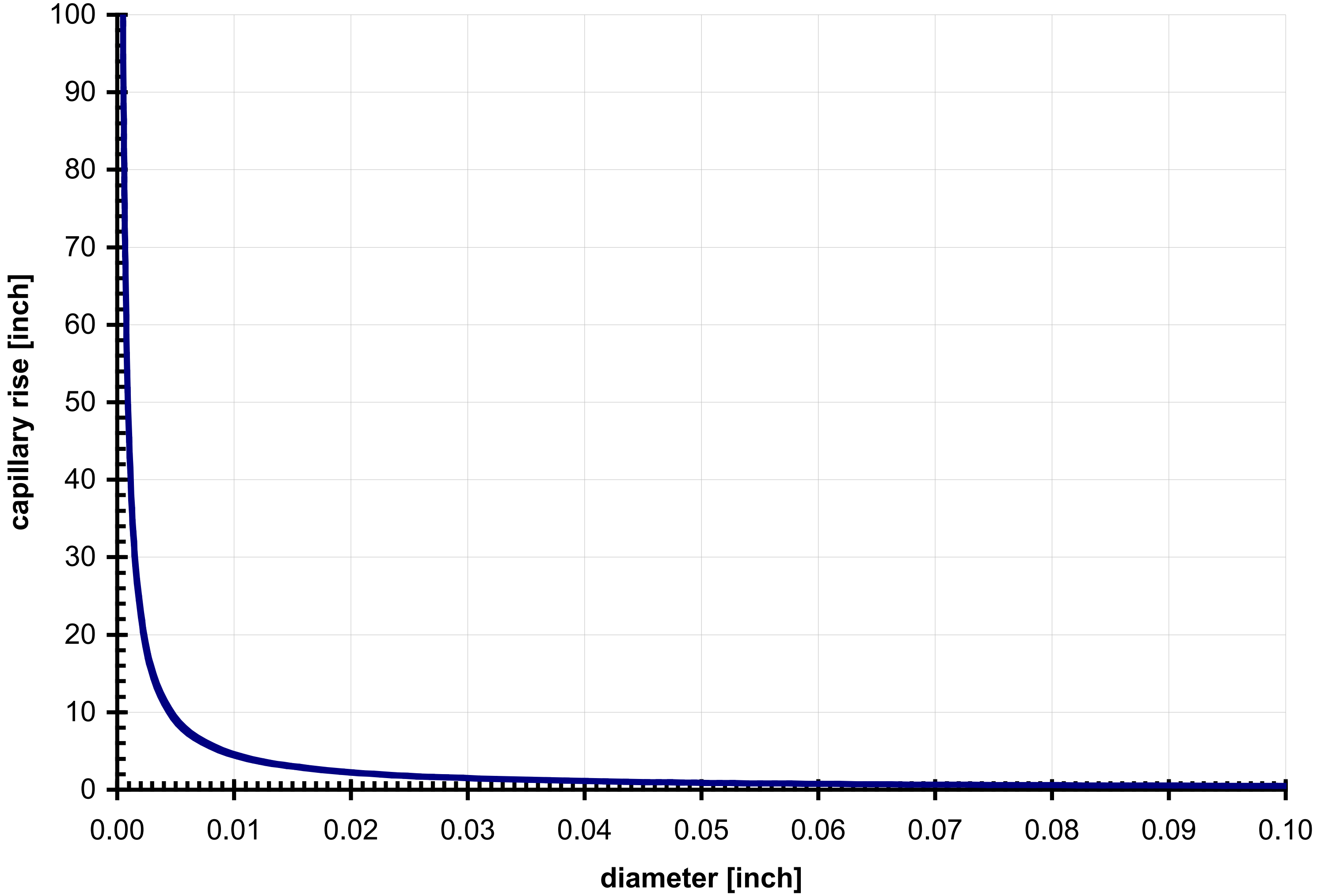

TYPAR
HouseWrap
TYPAR
HouseWrap

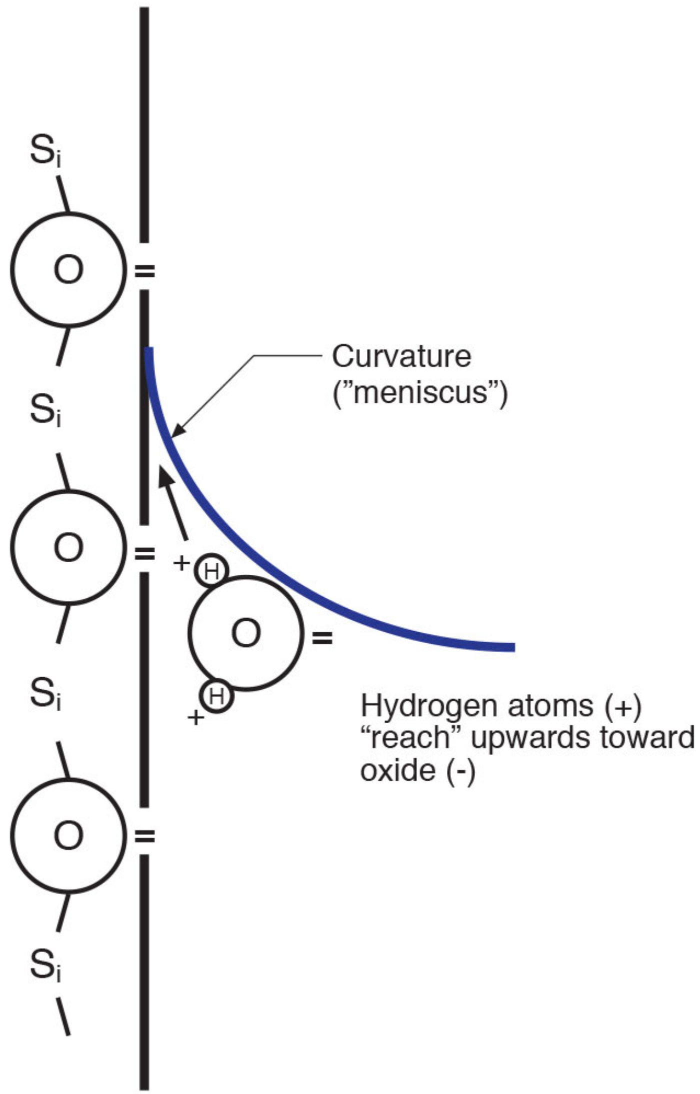
	Surface Energy
Water (20 C)	73 dynes/cm
Water (100 C)	59 dynes/cm
Epoxy	46 dynes/cm
Polyethylene	31 dynes/cm
Soapy water	30 dynes/cm
Paraffin wax	25 dynes/cm
Silicone	24 dynes/cm
Teflon	18 dynes/cm

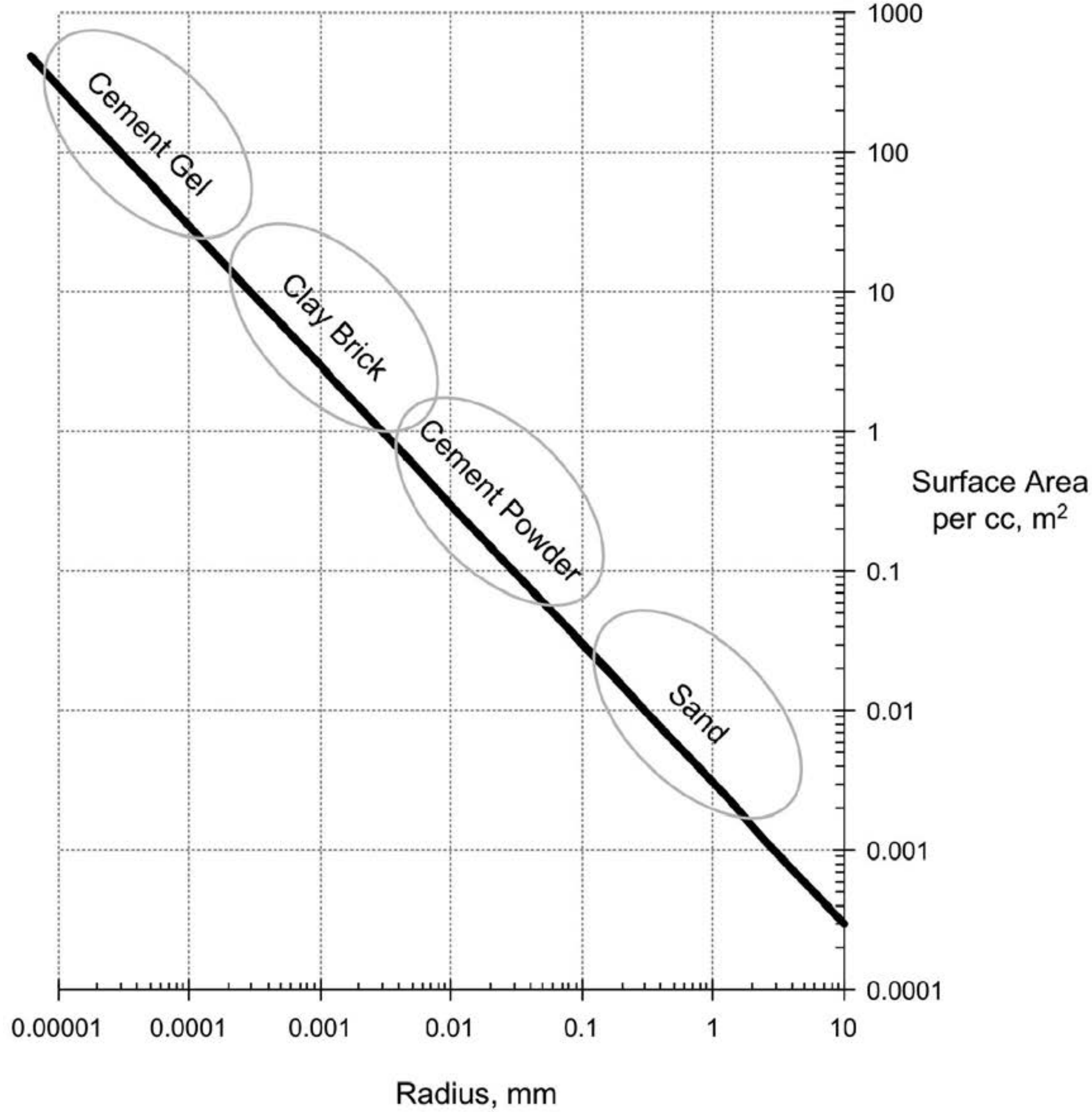
Calculating capillary rise



Capillary rise versus diameter




Si
O
Si
O
Si
O
Si
Curvature
("meniscus")
+ H
O
H +
Hydrogen atoms (+)
"reach" upwards toward
oxide (-)



Surface area vs. particle size
From Straube & Burnett, 2005

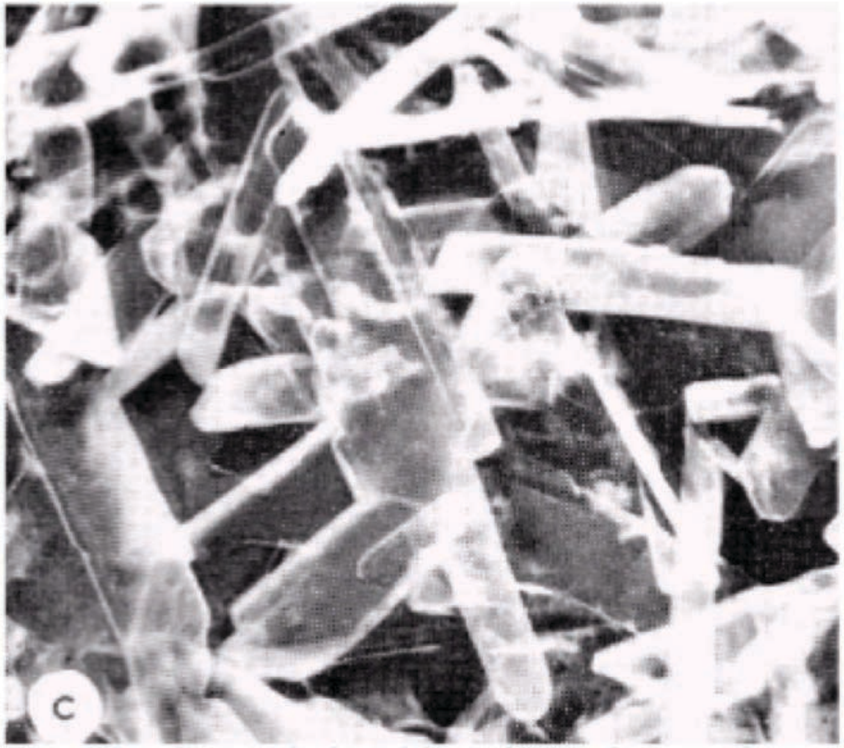


Figure 1c. Gypsum, hydrated from plaster of paris and water, porosity 30 per cent.

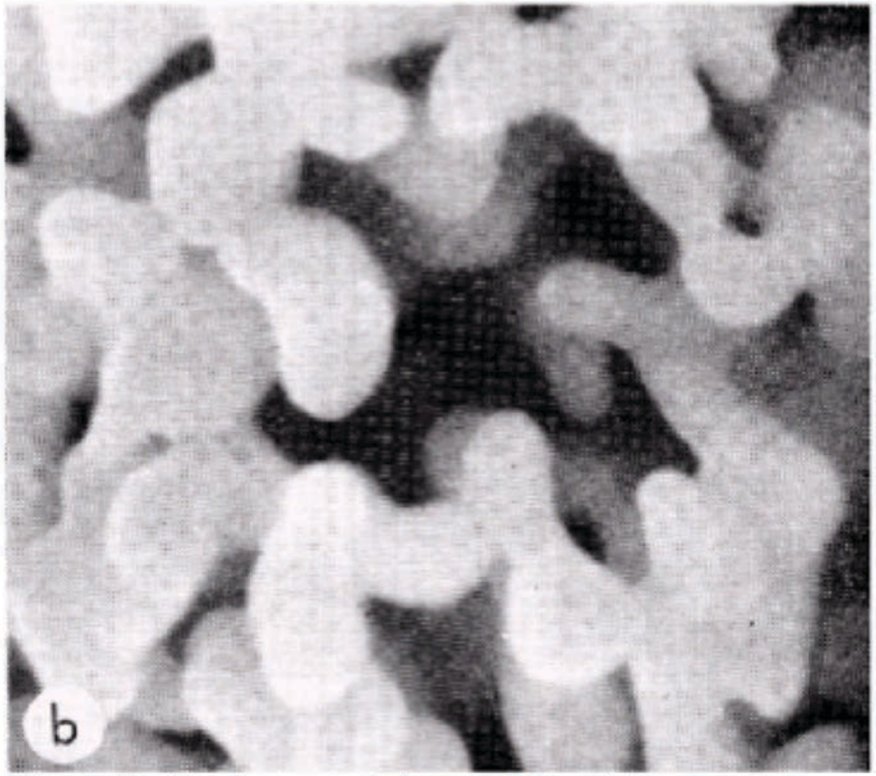
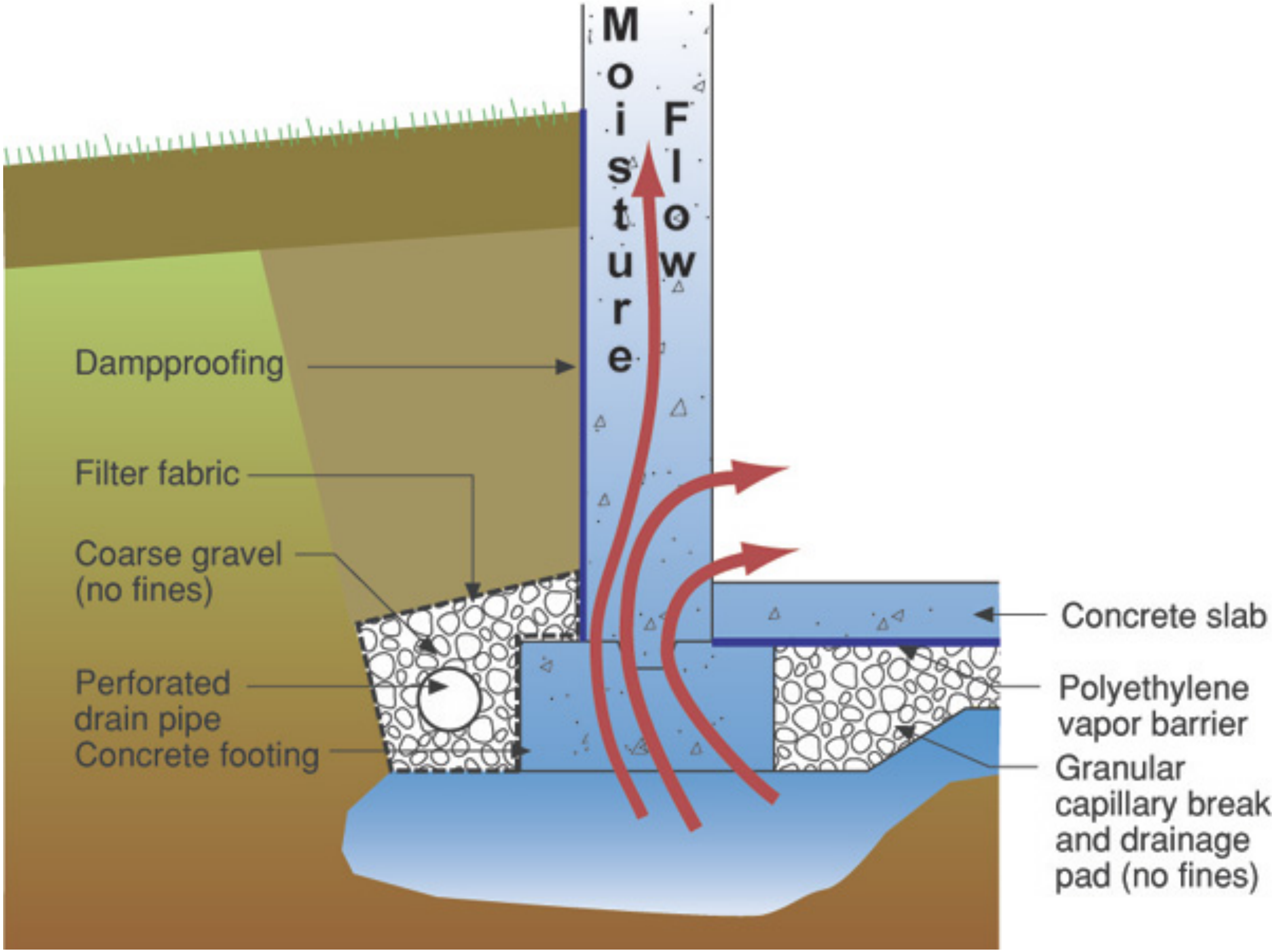
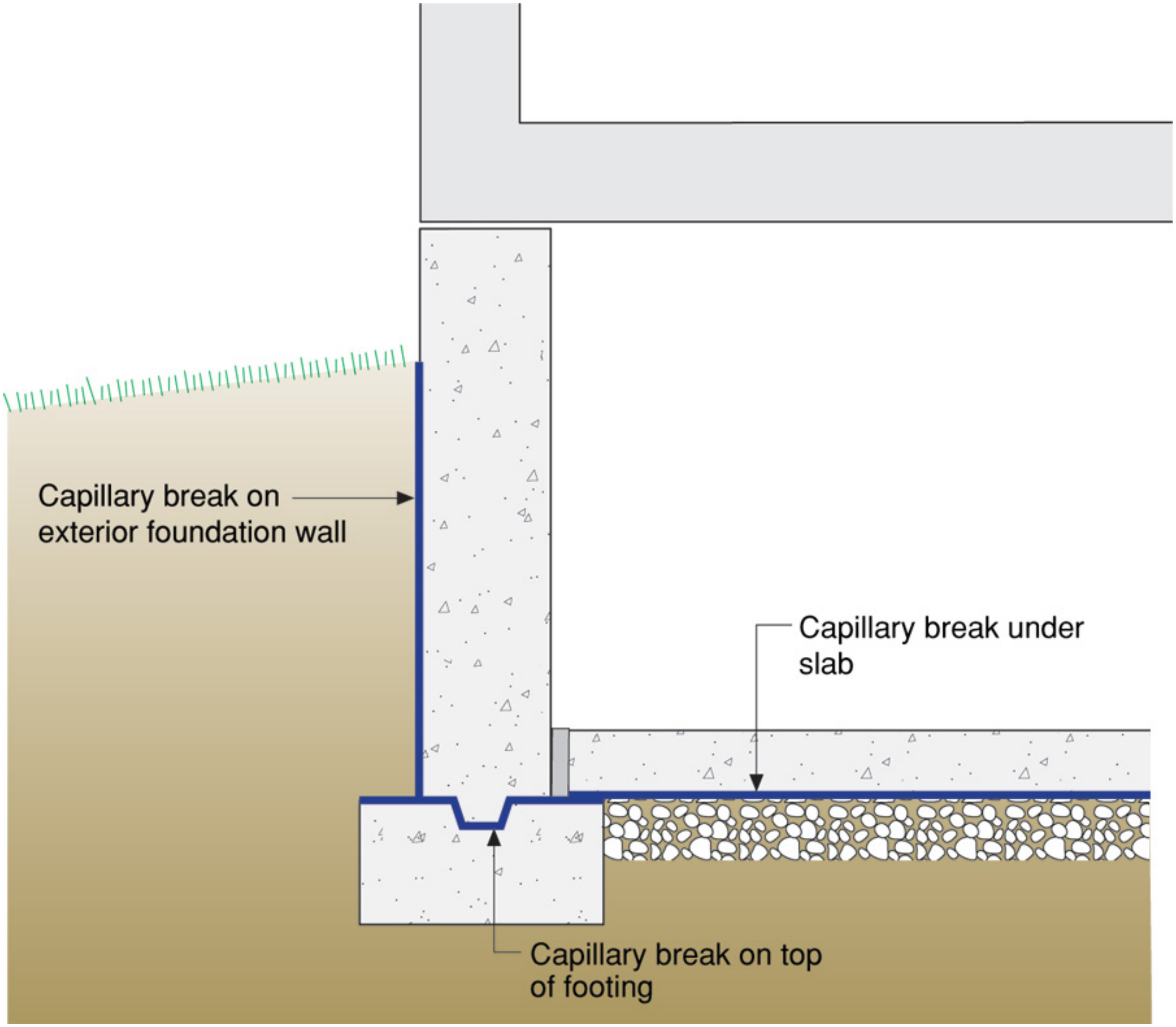


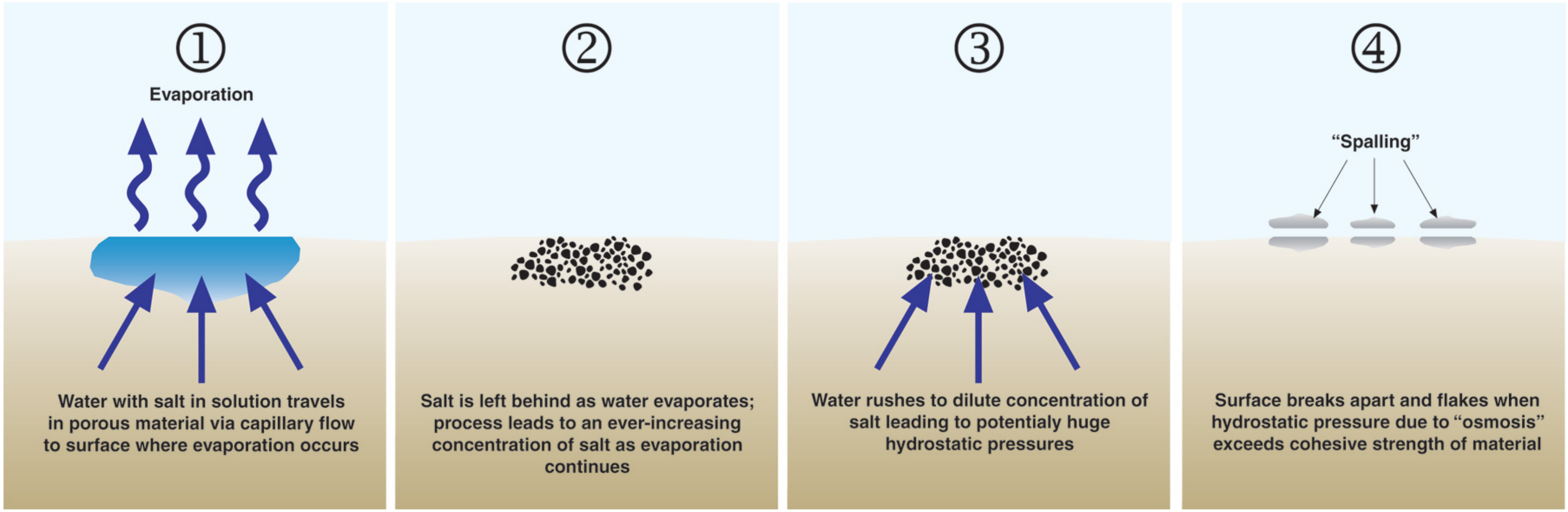
Figure 1b. Brick, sintered clay, porosity 40 per cent.


Moisture Flow
Dampproofing
Filter fabric
Coarse gravel (no fines)
Perforated drain pipe
Concrete footing
Concrete slab
Polyethylene vapor barrier
Granular capillary break and drainage pad (no fines)


Capillary break on
exterior foundation wall
Capillary break under
slab
Capillary break on top
of footing

Capillarity + Salt = Osmosis

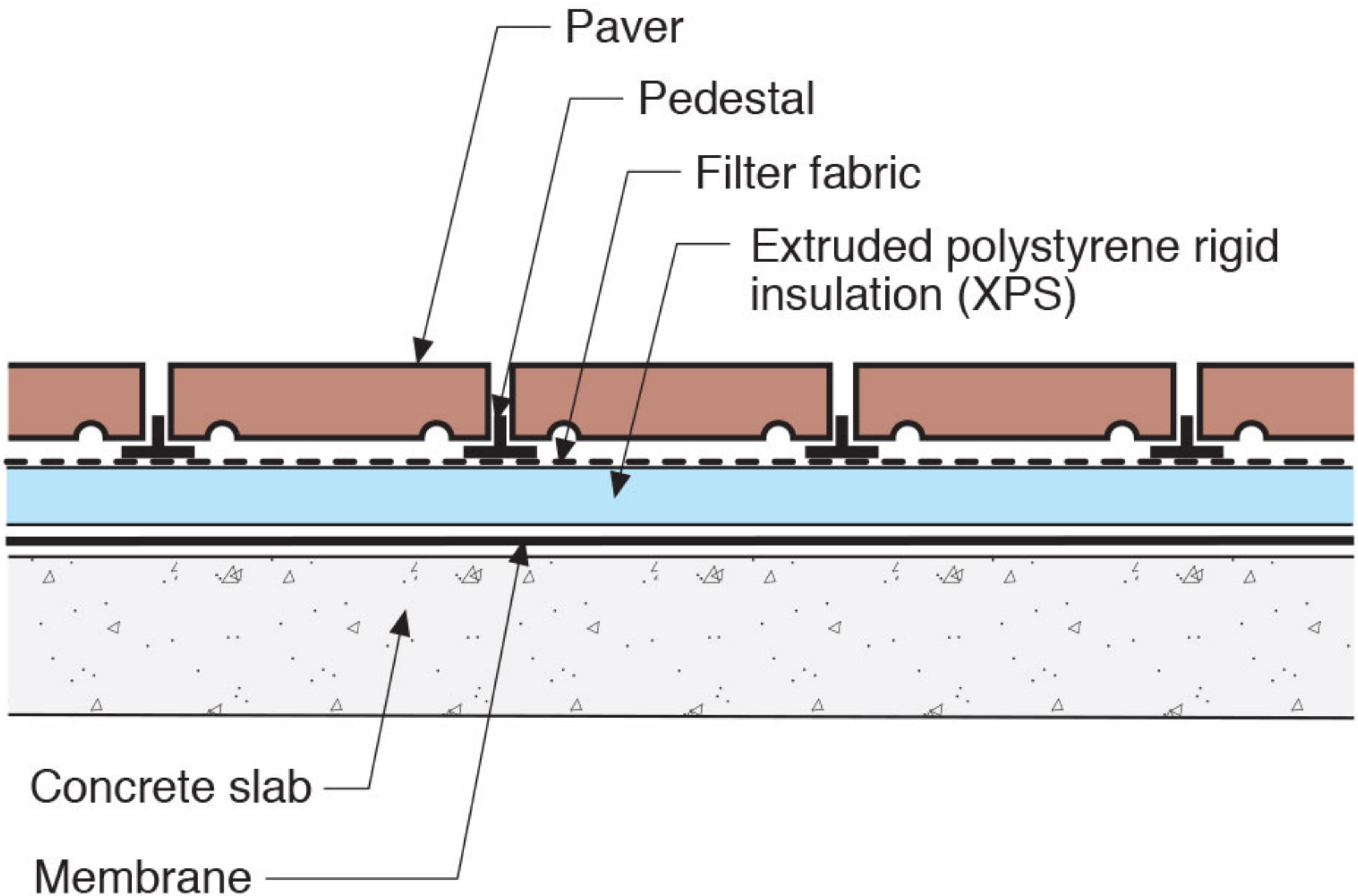
- Mineral salts carried in solution by capillary water
- When water evaporates from a surface the salts left behind form crystals in process called efflorescence
- When water evaporated beneath a surface the salts crystallize within the pore structure of the material in called sub-efflorescence
- The salt crystallization causes expansive forces that can exceed the cohesive strength of the material leading to spalling

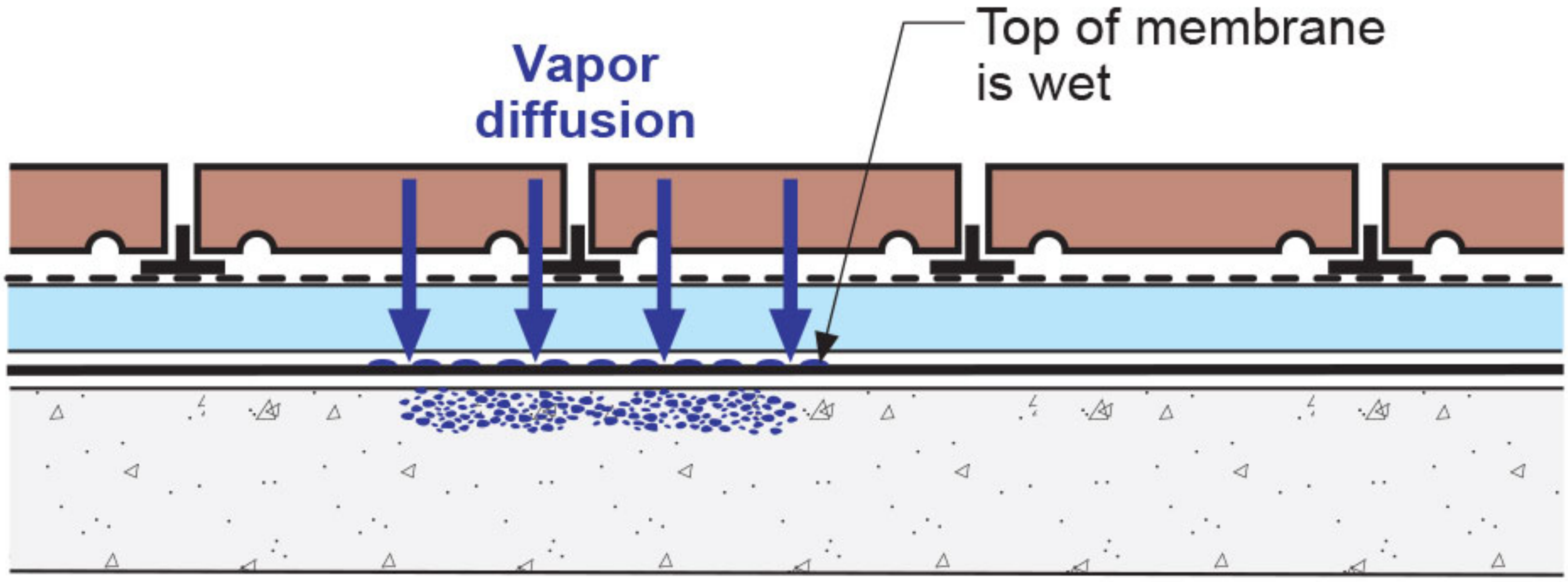

①
Evaporation
Water with salt in solution travels
in porous material via capillary flow
to surface where evaporation occurs
②
Salt is left behind as water evaporates;
process leads to an ever-increasing
concentration of salt as evaporation
continues
③
Water rushes to dilute concentration of
salt leading to potentialy huge
hydrostatic pressures
④
"Spalling"
Surface breaks apart and flakes when
hydrostatic pressure due to "osmosis"
exceeds cohesive strength of material

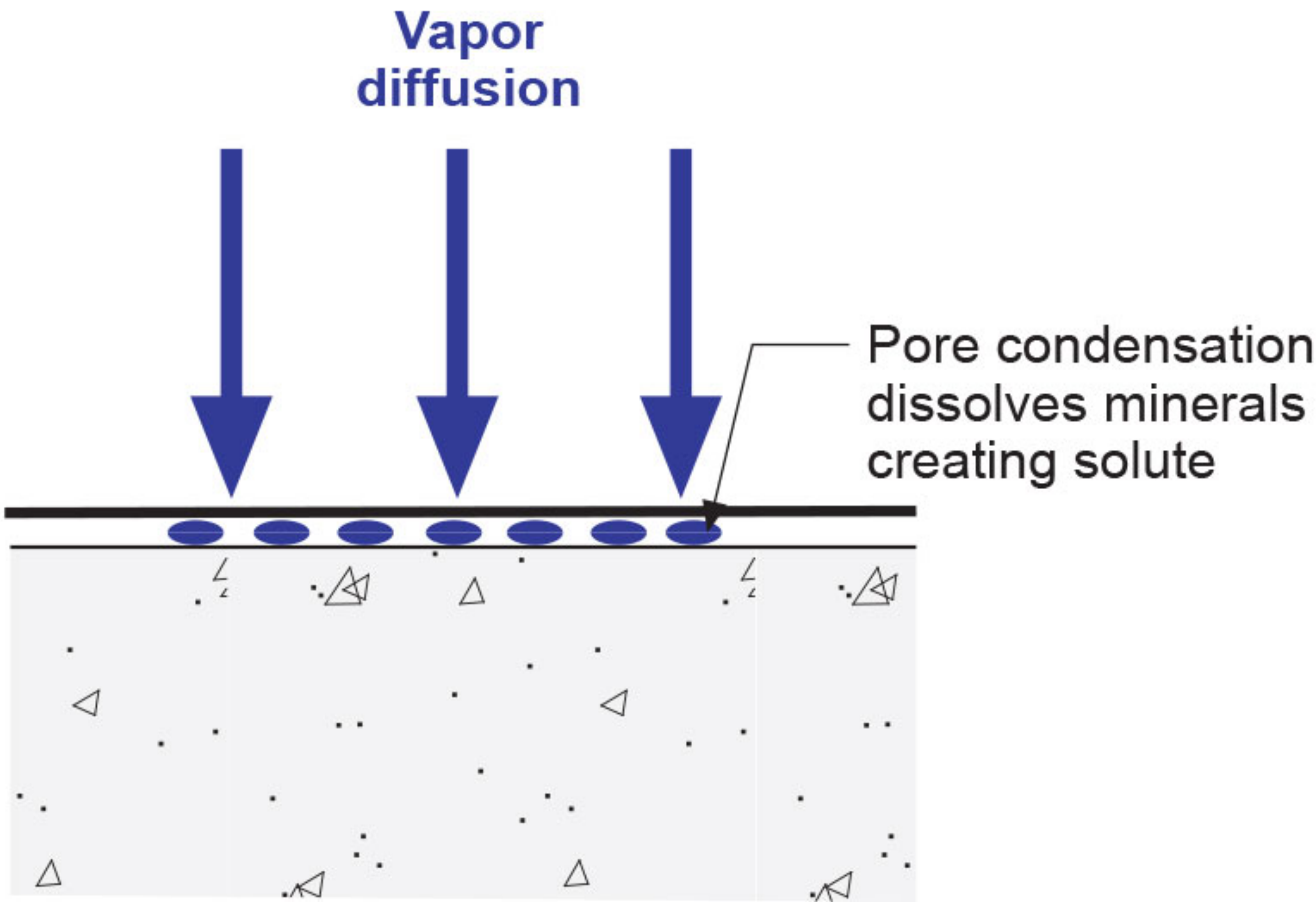
Pressures

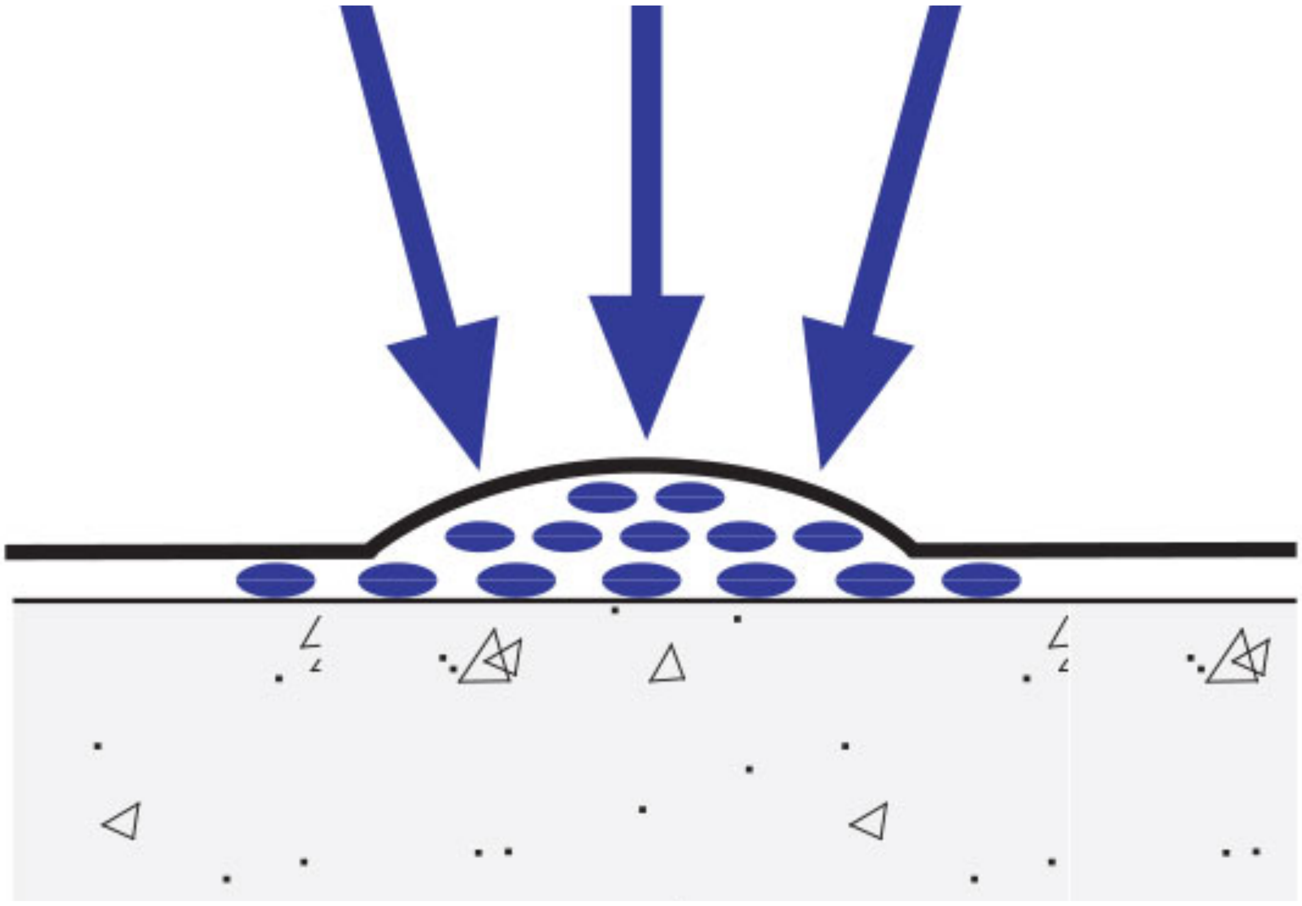
• Diffusion Vapor Pressure	3 to 5 psi
• Capillary Pressure	300 to 500 psi
• Osmosis Pressure	3,000 to 5,000 psi

More Osmosis

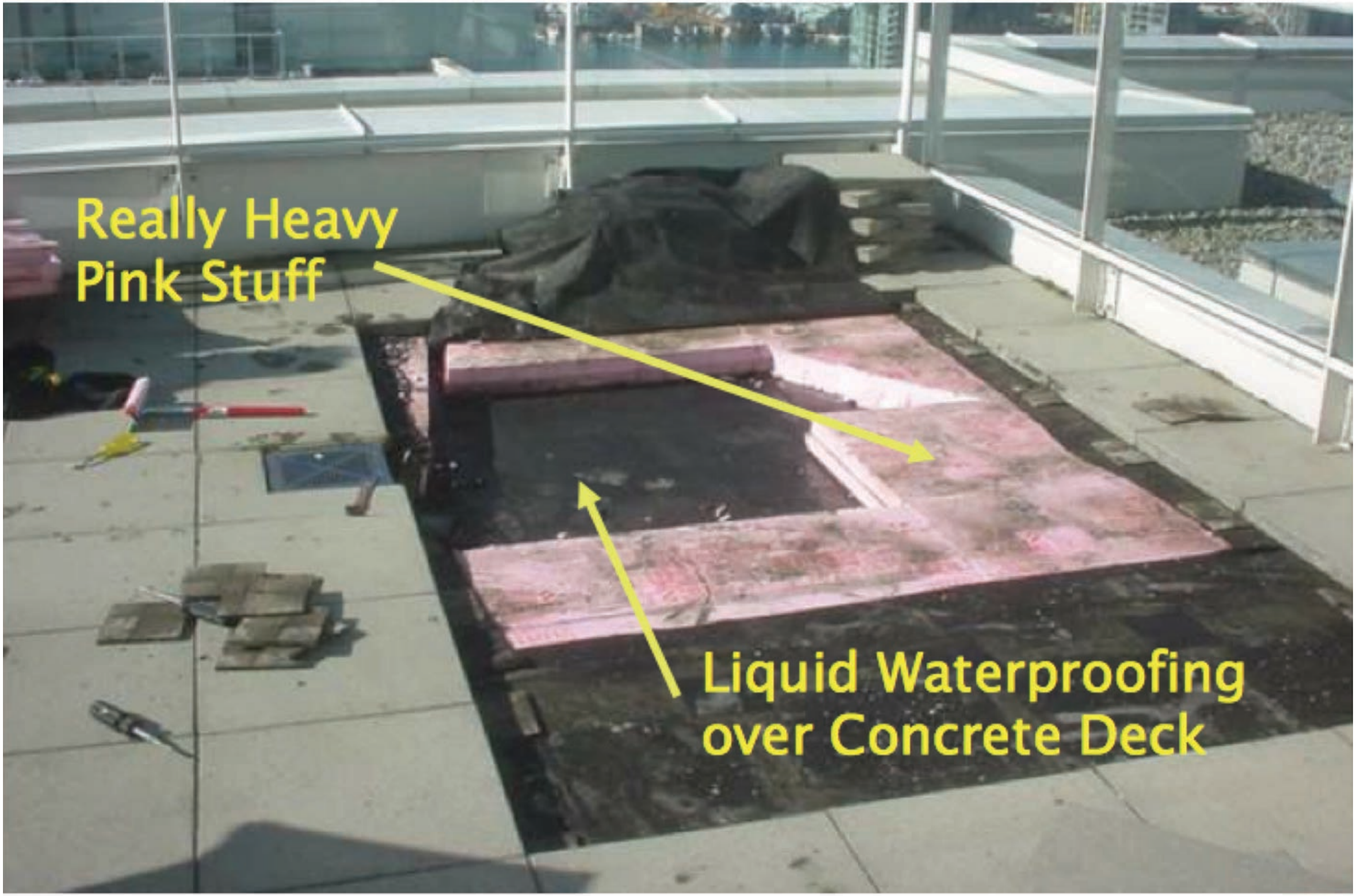

Paver
Pedestal
Filter fabric
Extruded polystyrene rigid insulation (XPS)
Concrete slab
Membrane

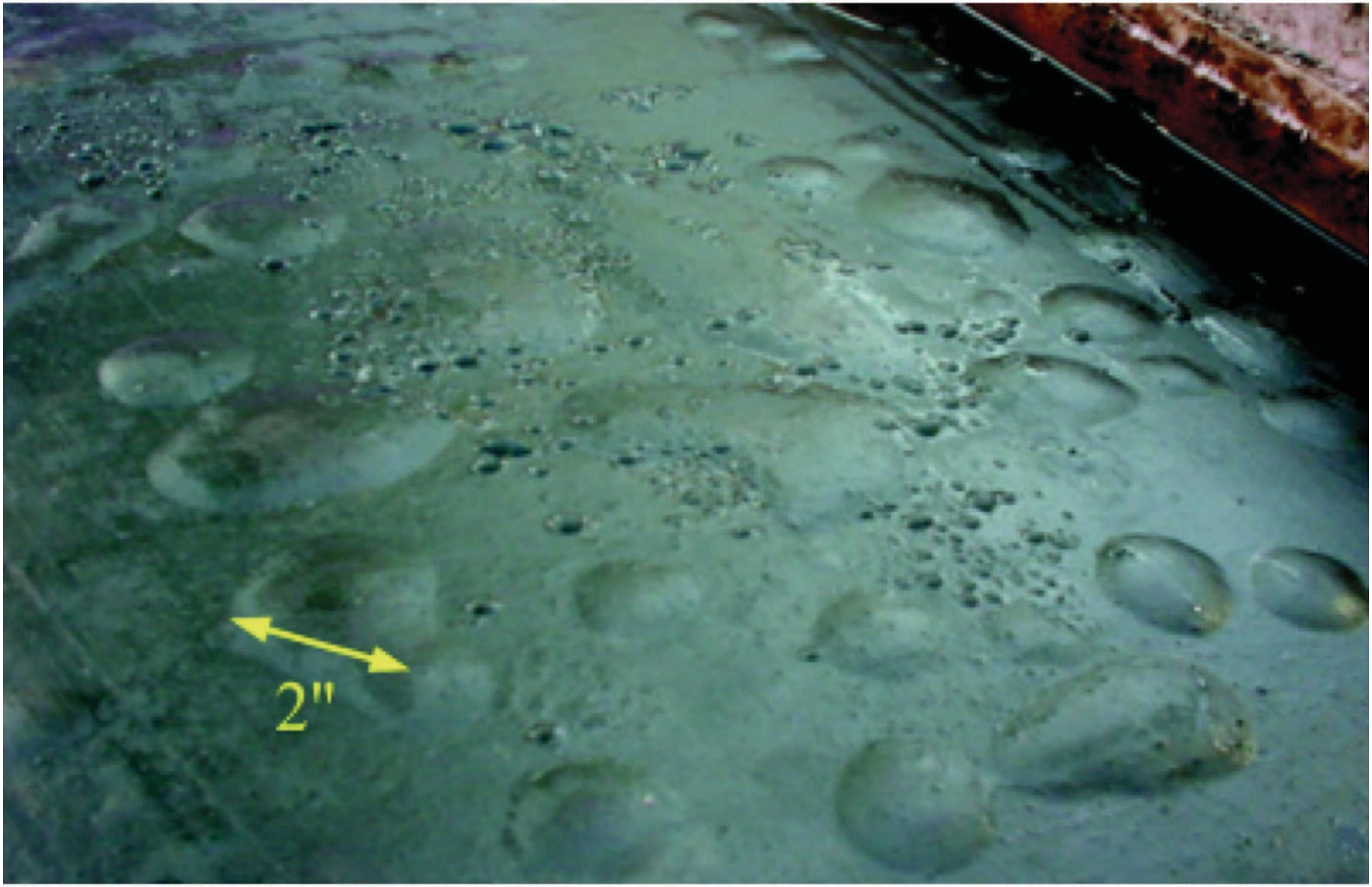

Vapor diffusion
Top of membrane is wet

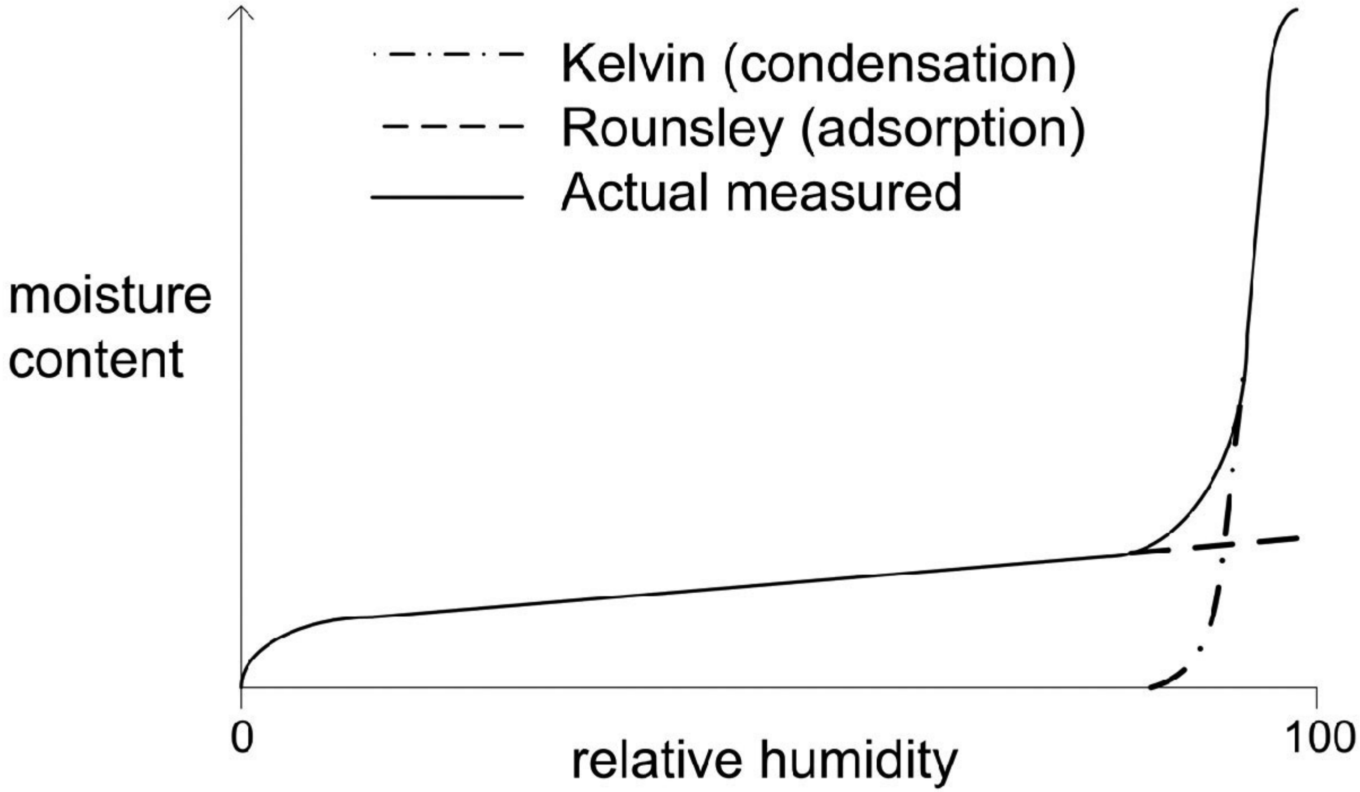

Vapor diffusion
Pore condensation dissolves minerals creating solute



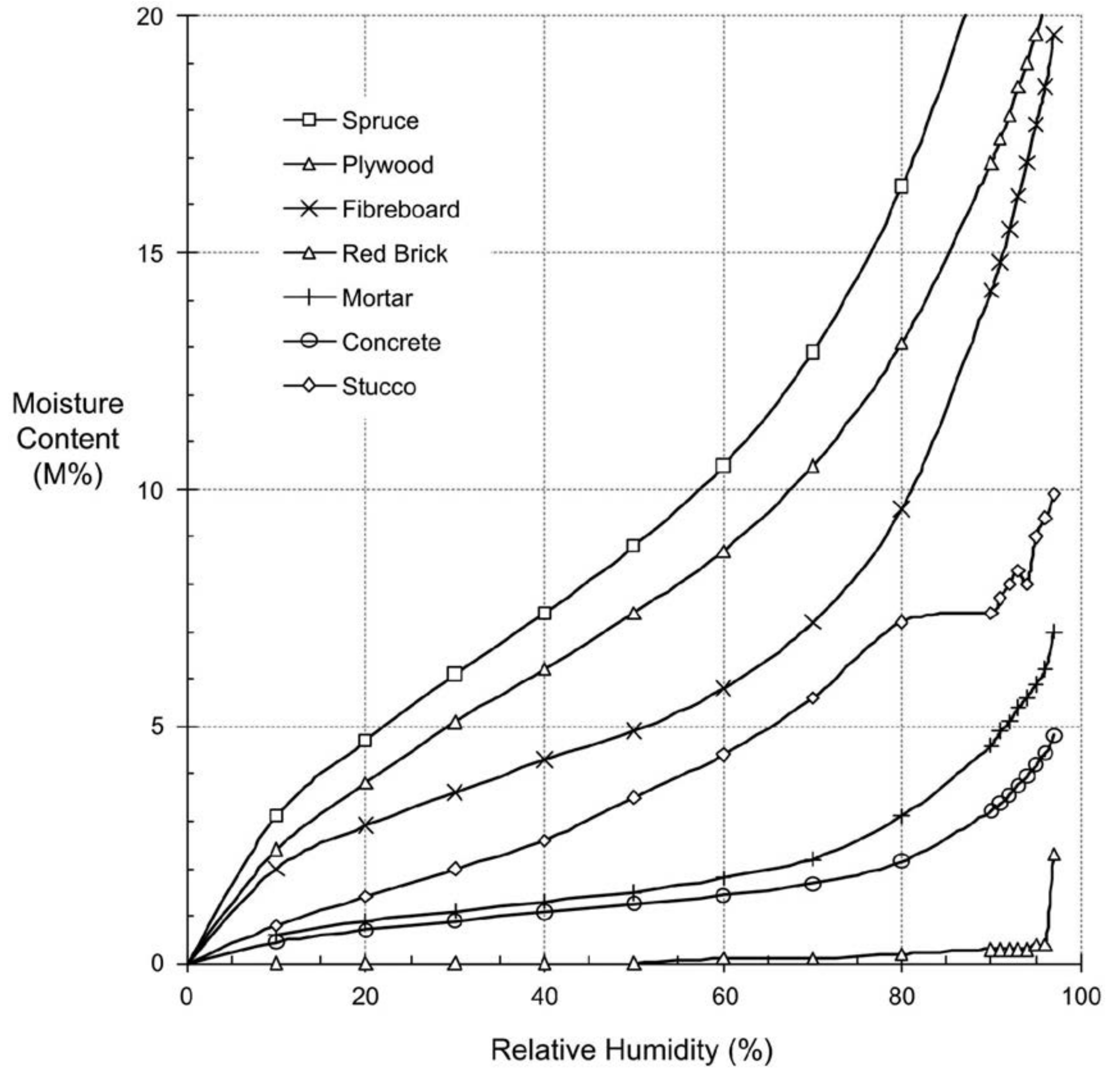

Paver Water Beds!


Really Heavy
Pink Stuff
Liquid Waterproofing
over Concrete Deck

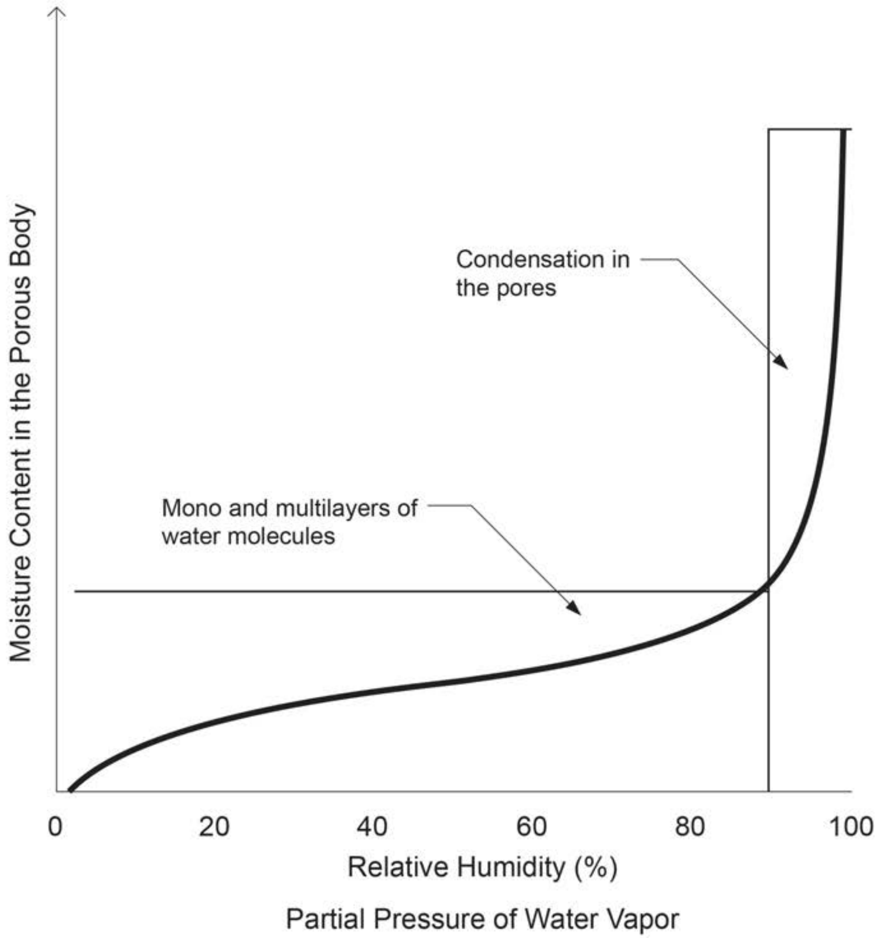

2"



Typical predicted sorption isotherm according to Kelvin equation and modified BET theory
From Straube & Burnett, 2005



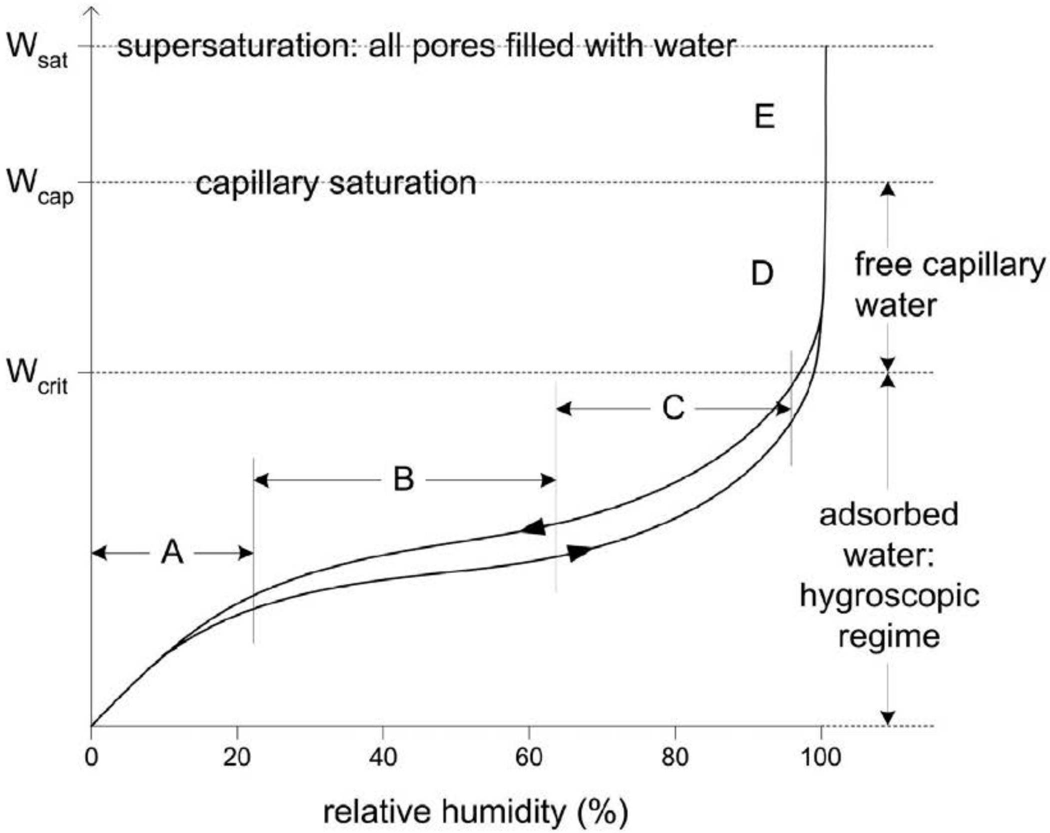
Sorption isotherm for several building materials [Kumaran 2002]
From Straube & Burnett, 2005



Change in the storage of moisture in a porous building material as the partial pressure of water vapor in the ambient air increases from zero to full saturation value at a given temperature.

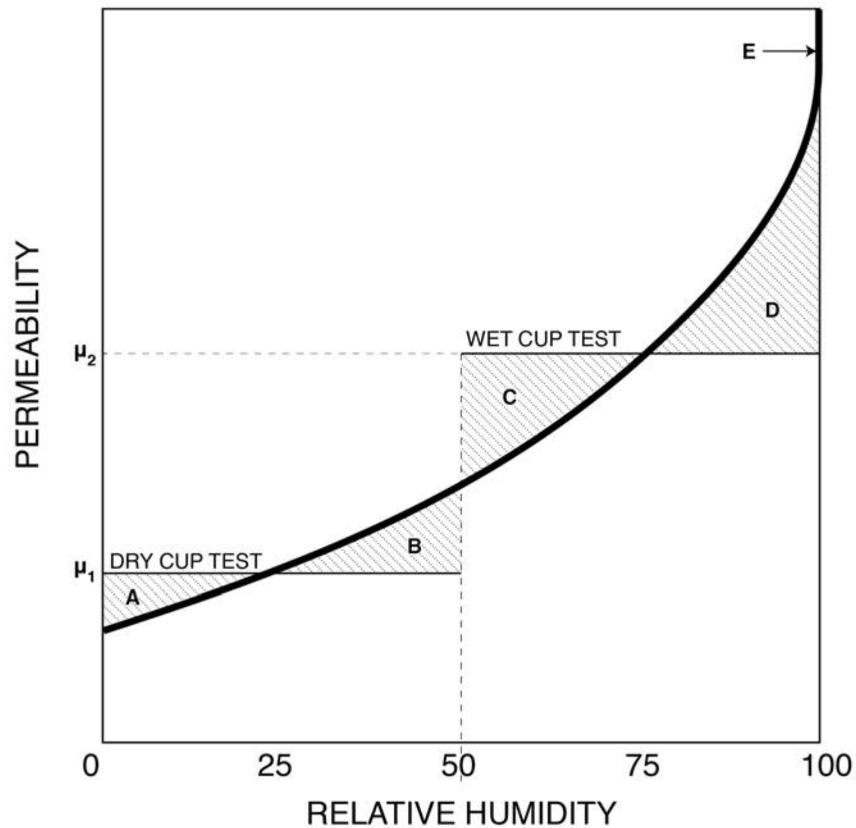
Sorption Curve

From M.K. Kumaran, ASTM MNL 18-2nd Edition, Moisture Control in Buildings, 2009



A: Single-layer of adsorbed molecules
B: Multiple layers of adsorbed molecules
C: Interconnected layers (internal capillary condensation
D: Free water in Pores, capillary suction
E: Supersaturated Regime

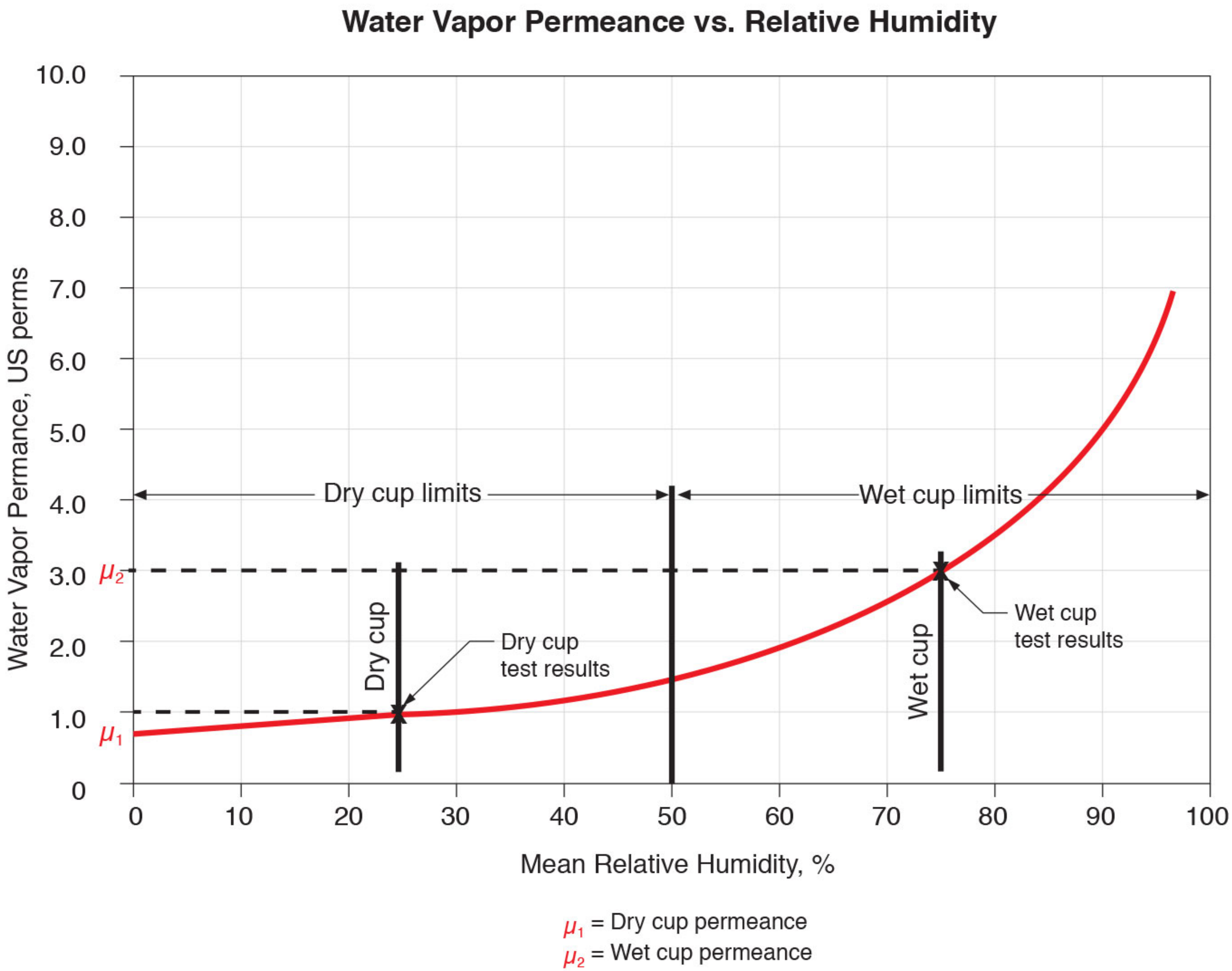
Regimes of moisture storage in a hygroscopic porous material
From Straube & Burnett, 2005

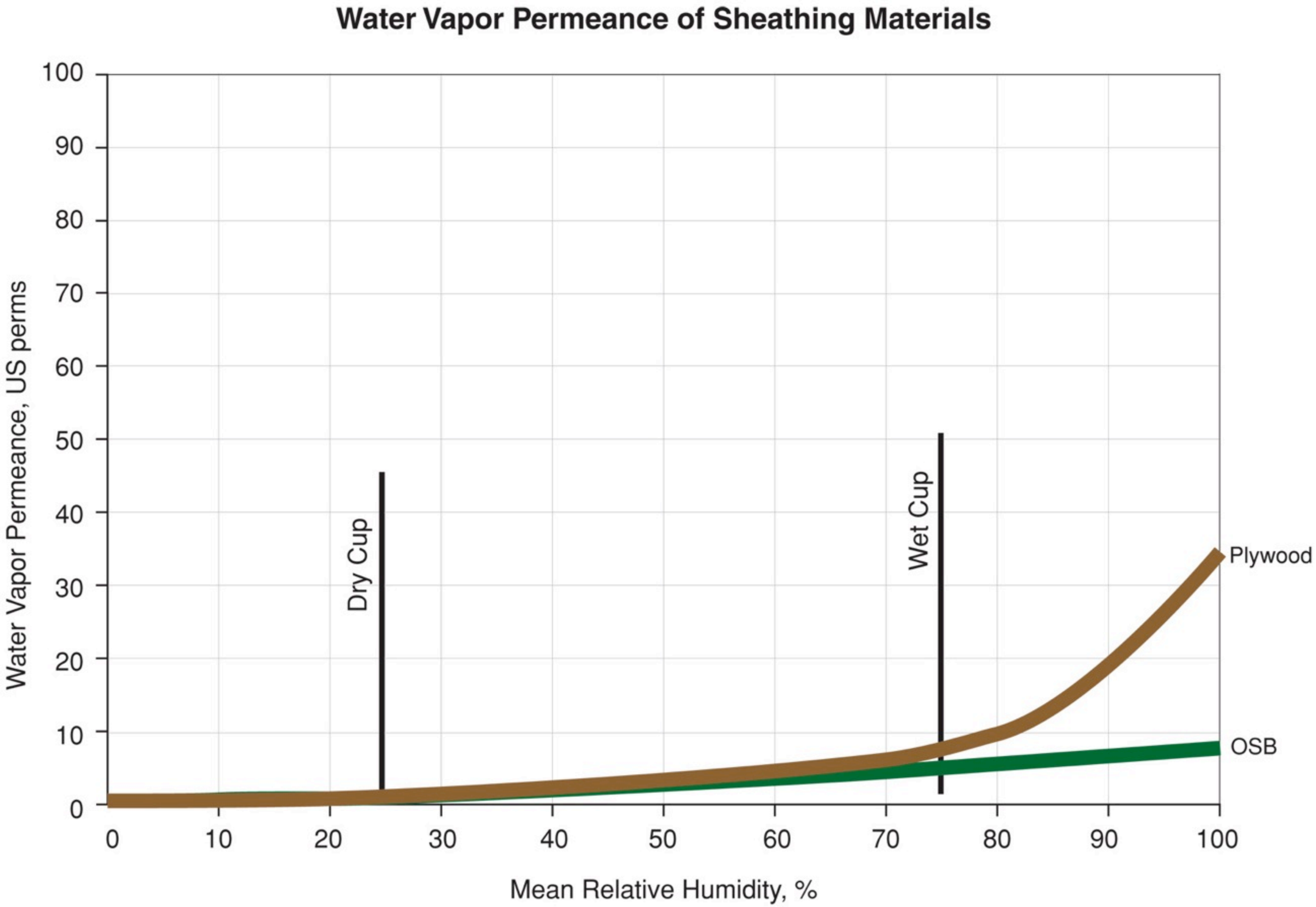


A - Single-layer of absorbed molecules
B - Multiple layers of absorbed molecules
C - Interconnected layers (internal capillary condensation)
D - Free water in pores, capillary suction
E - Supersaturated regime

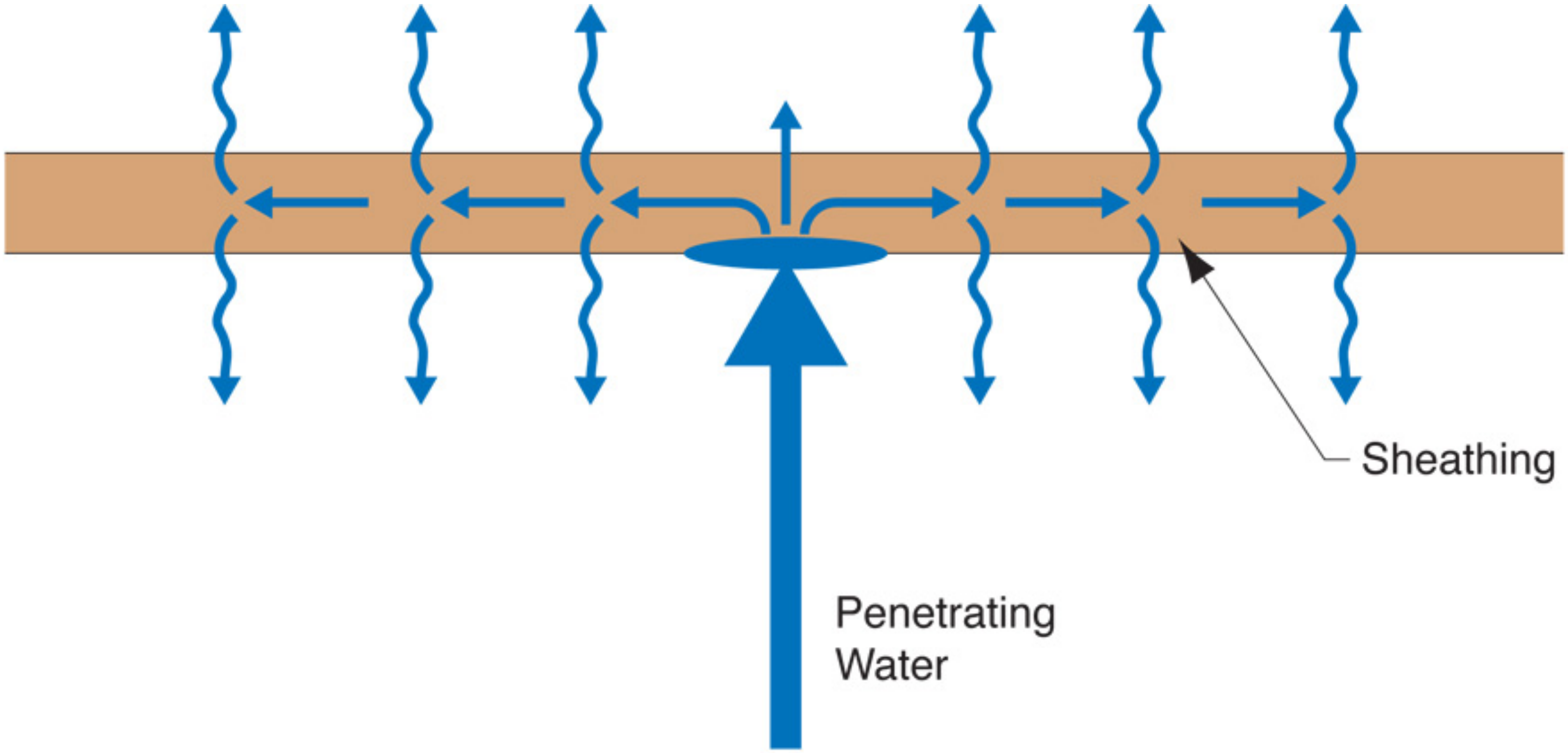
Relationship between Dry Cup and Wet Cup
Adapted from Joy & Wilson, 1963

R-11 3½"
OWENS-CORNING
Fiberglas
Building
Insulation
FIBERGLAS
ASSURED THERMAL
PERFORMANCE

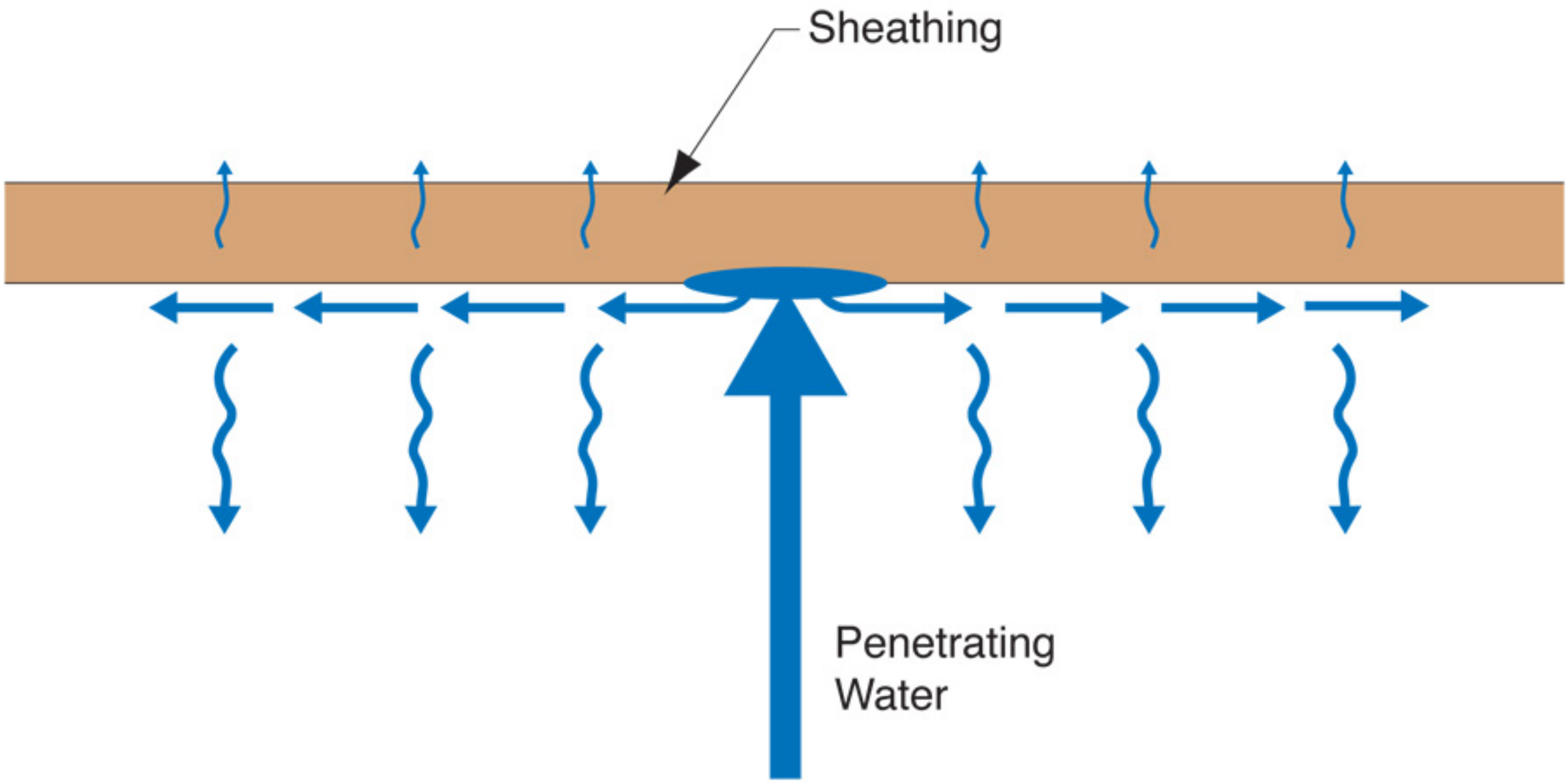

Water Vapor Permeance vs. Relative Humidity
Water Vapor Permance, US perms
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
μ2
μ1
Dry cup limits
Wet cup limits
Dry cup
Wet cup
Dry cup test results
Wet cup test results
0
10
20
30
40
50
60
70
80
90
100
Mean Relative Humidity, %
μ1 = Dry cup permeance
μ2 = Wet cup permeance



Water Vapor Permeance of Sheathing Materials
Water Vapor Permeance, US perms
100
90
80
70
60
50
40
30
20
10
0
Dry Cup
Wet Cup
Plywood
OSB
0
10
20
30
40
50
60
70
80
90
100
Mean Relative Humidity, %



Sheathing
Penetrating
Water


Sheathing
Penetrating
Water


panago
QUILTED TREASURES

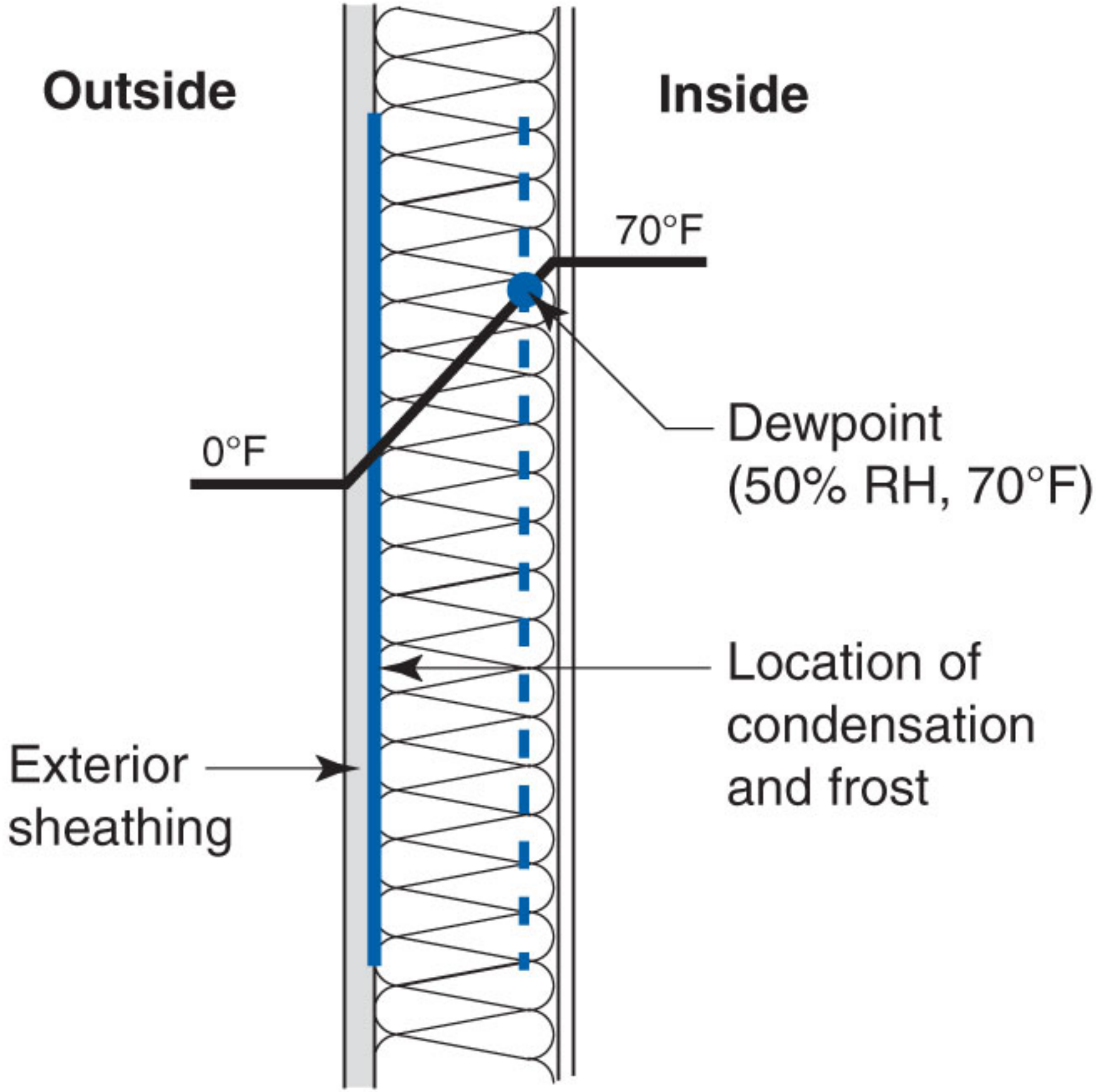

panago
QUILTED TREASURE

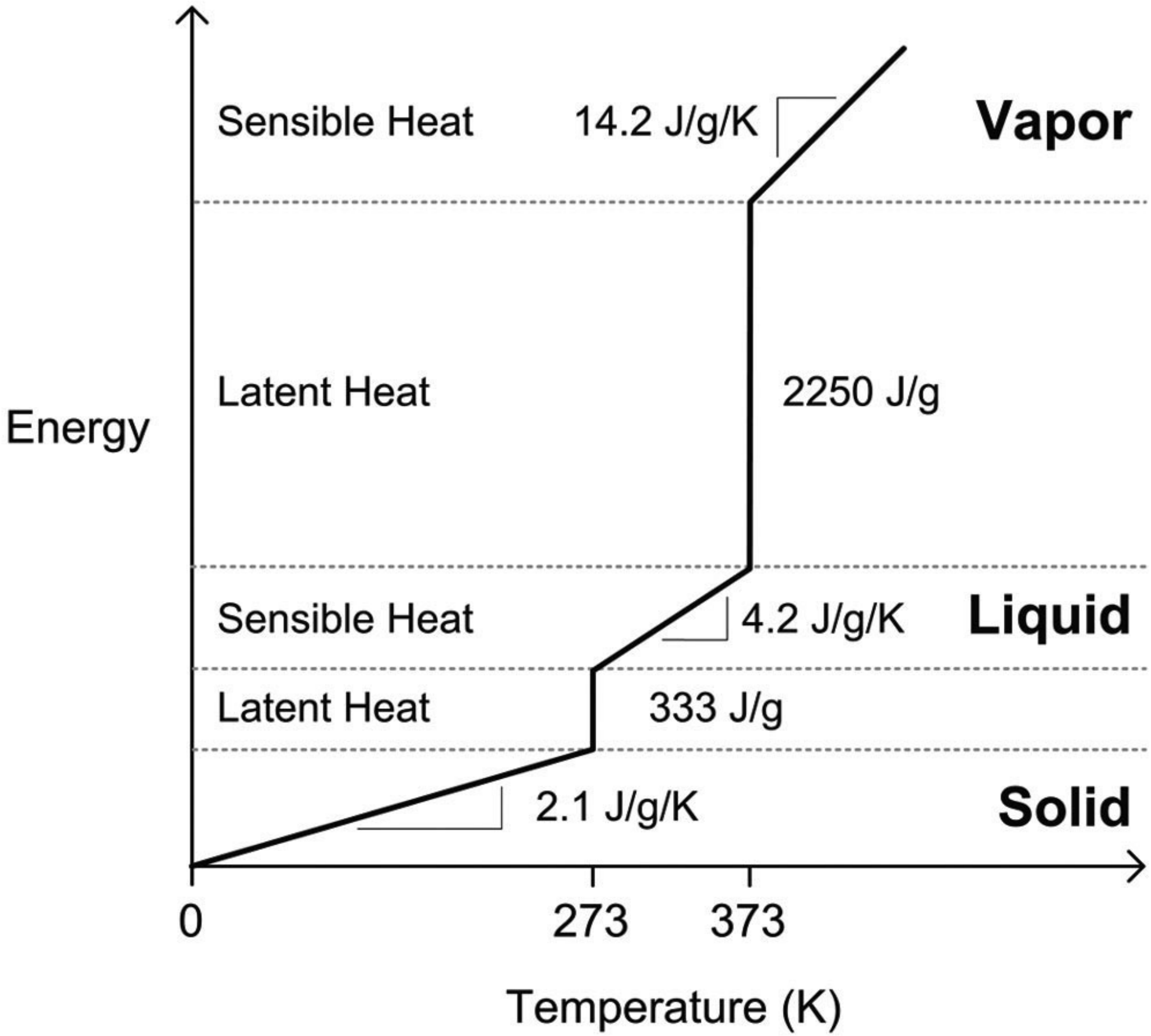

Tyvek
DrainWrap
The miracles of science
Styrofoam


EVÊTEMENT
HOUSEW
N-6
N-7


W1
W3

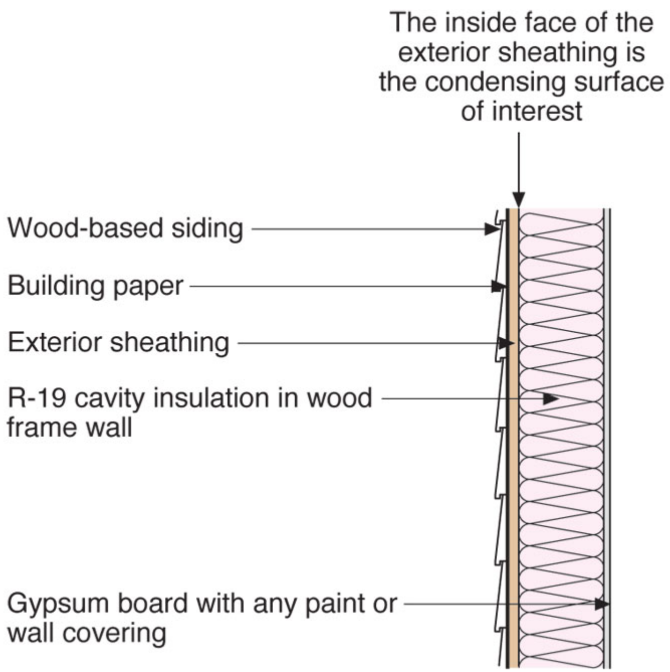

LOWER
N-2

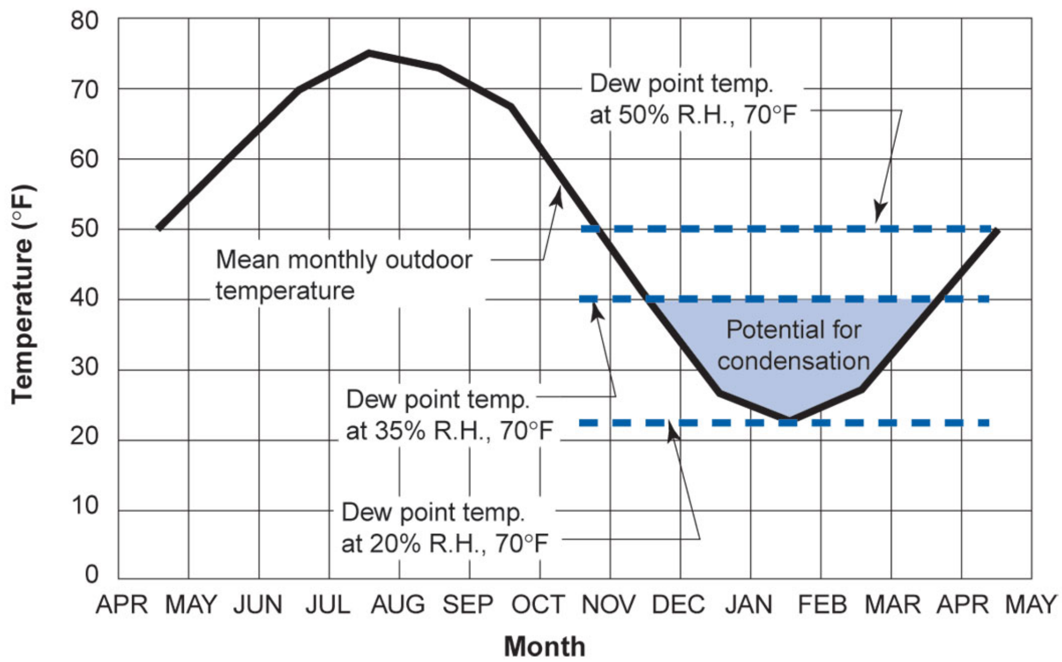

Outside
Inside
70°F
Dewpoint
(50% RH, 70°F)
0°F
Location of
condensation
and frost
Exterior
sheathing

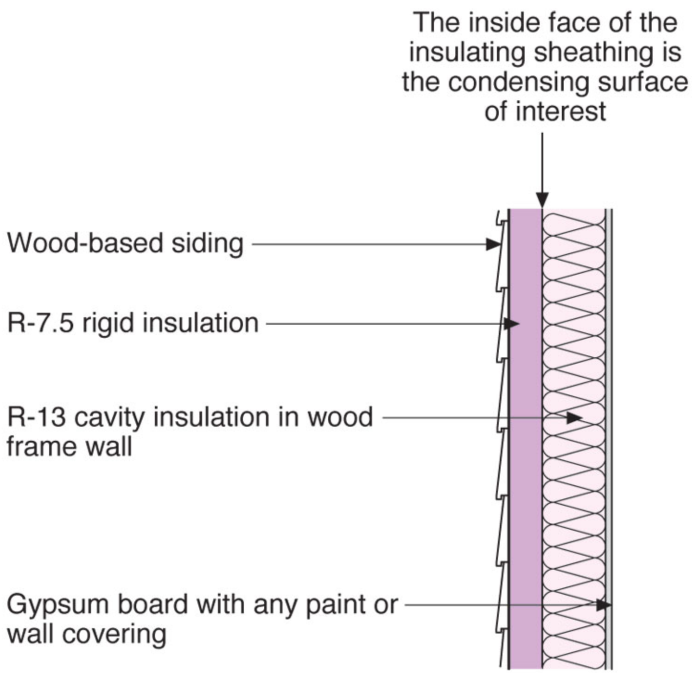


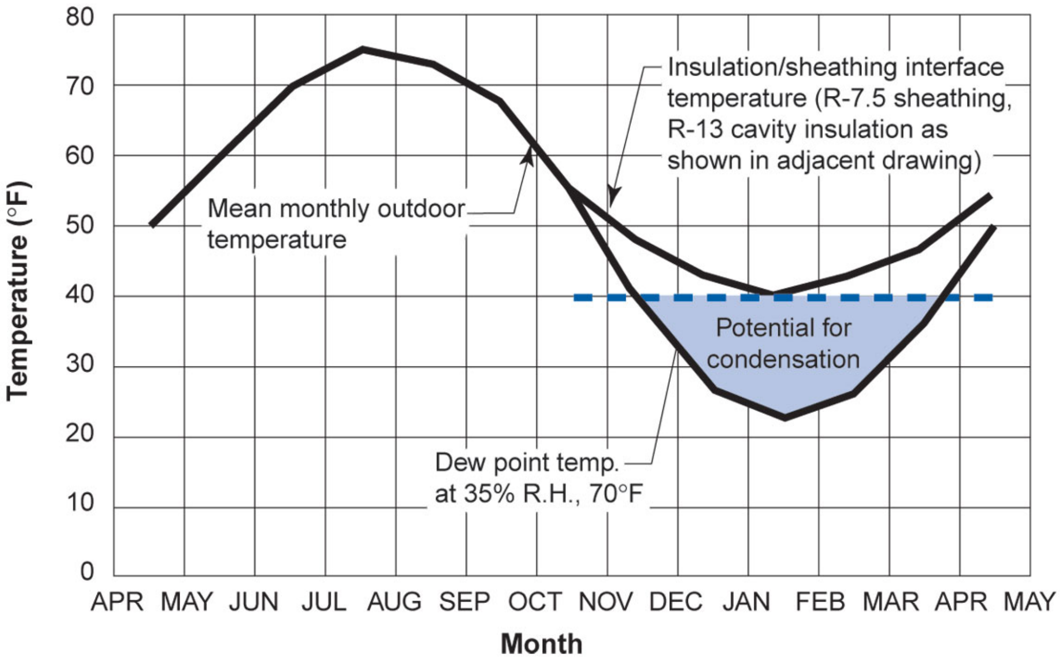
Simple linearized energy-temperature relation for water

From Straube & Burnett, 2005


The inside face of the exterior sheathing is the condensing surface of interest
Wood-based siding
Building paper
Exterior sheathing
R-19 cavity insulation in wood frame wall
Gypsum board with any paint or wall covering


Temperature (°F)
80
70
60
50
40
30
20
10
0
APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY
Month
Dew point temp. at 50% R.H., 70°F
Mean monthly outdoor temperature
Potential for condensation
Dew point temp. at 35% R.H., 70°F
Dew point temp. at 20% R.H., 70°F


The inside face of the insulating sheathing is the condensing surface of interest
Wood-based siding
R-7.5 rigid insulation
R-13 cavity insulation in wood frame wall
Gypsum board with any paint or wall covering


Temperature (°F)
80
70
60
50
40
30
20
10
0
APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY
Month
Insulation/sheathing interface temperature (R-7.5 sheathing, R-13 cavity insulation as shown in adjacent drawing)
Mean monthly outdoor temperature
Potential for condensation
Dew point temp. at 35% R.H., 70°F

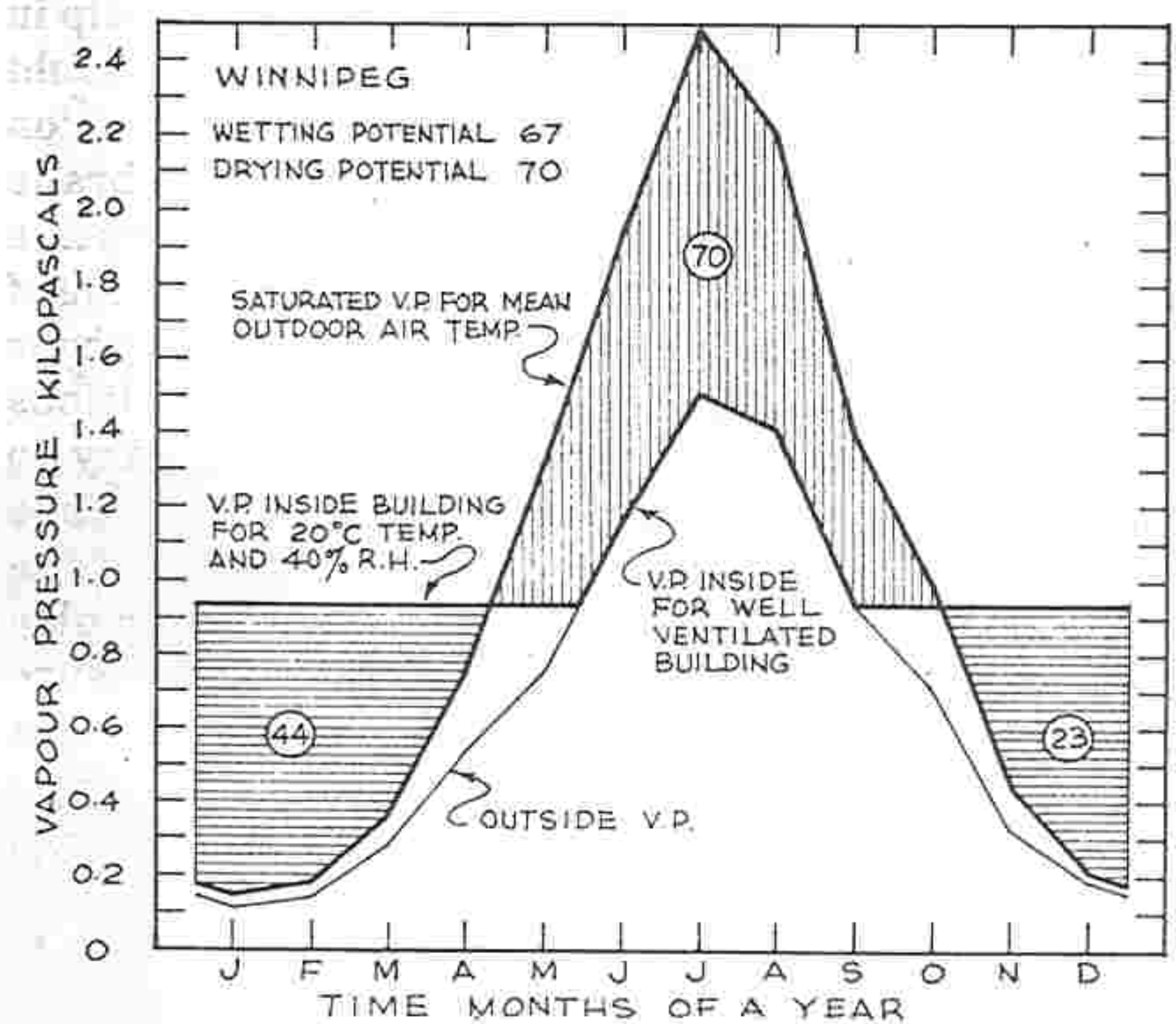
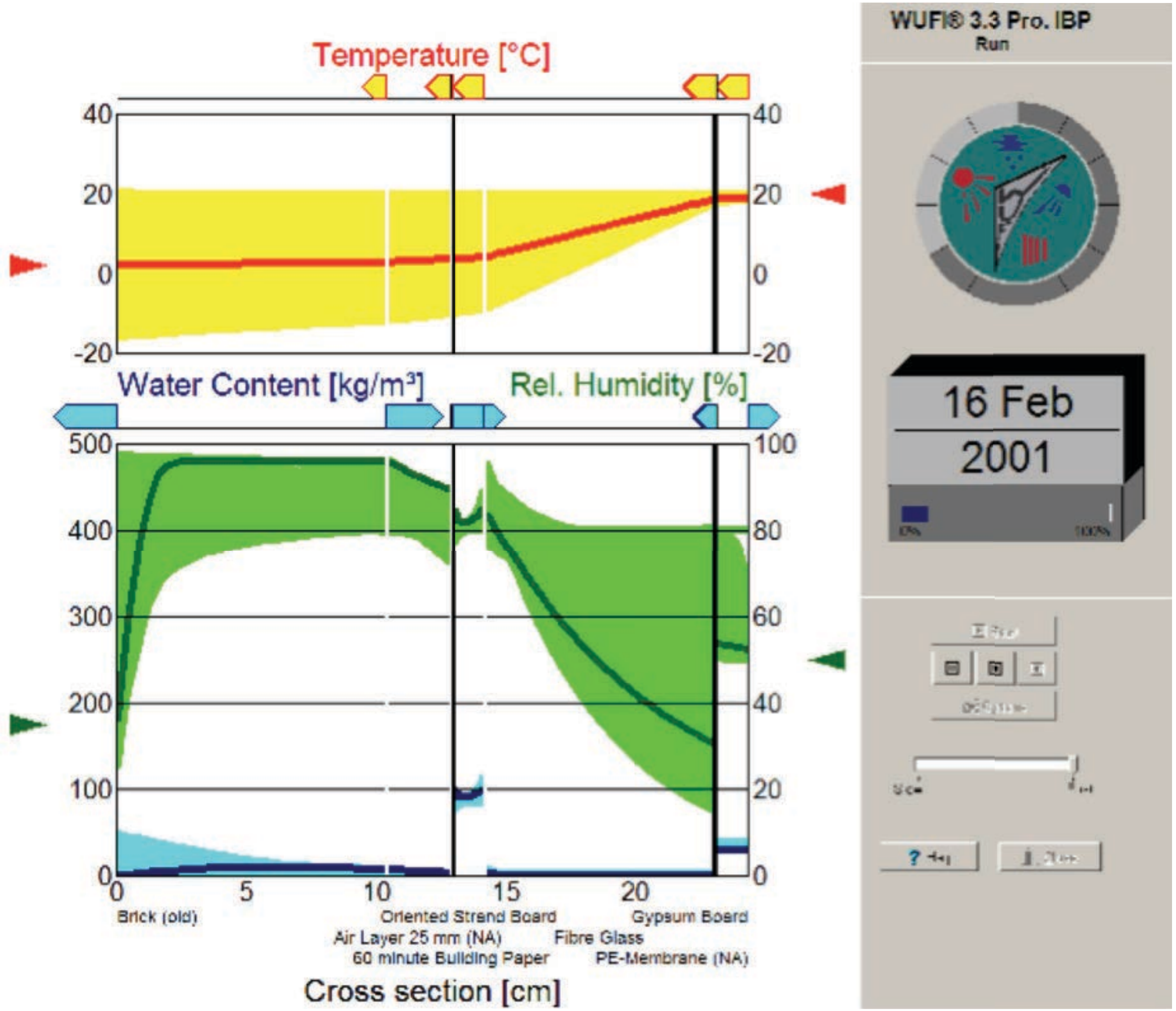
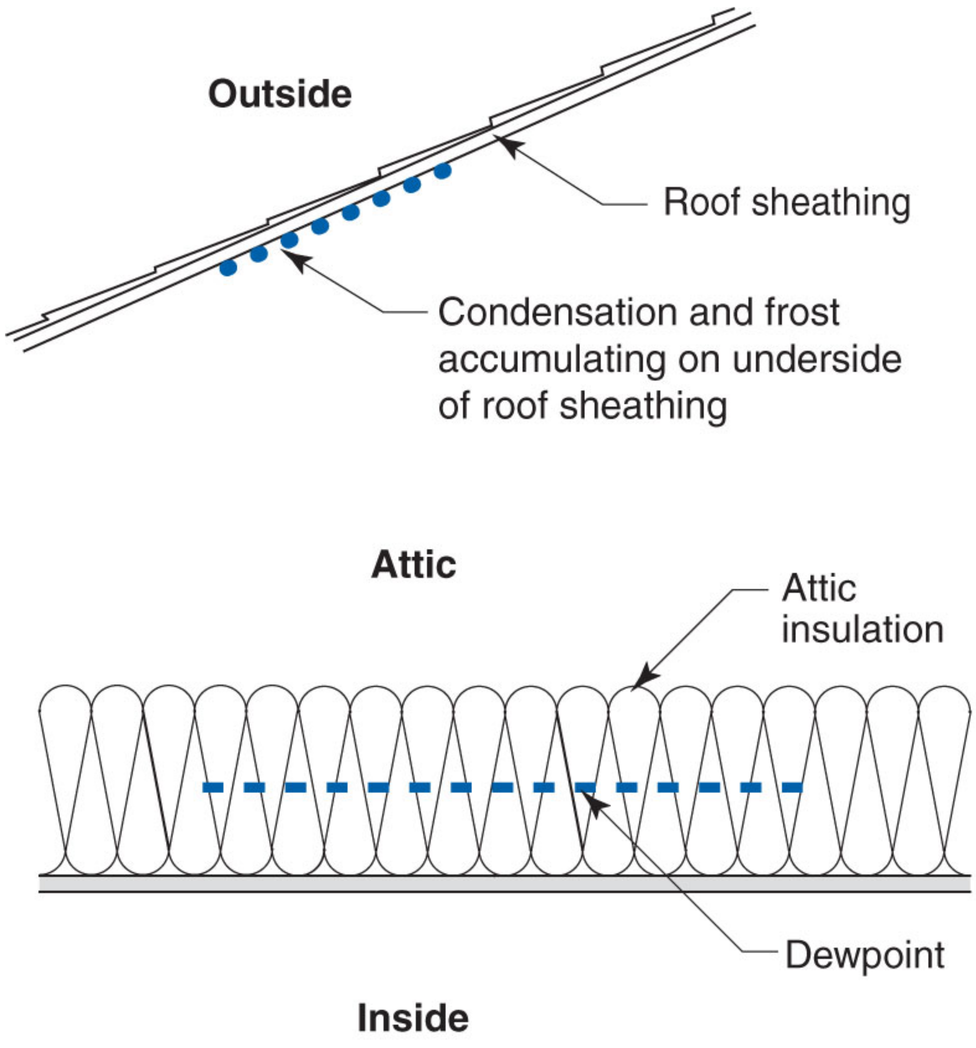
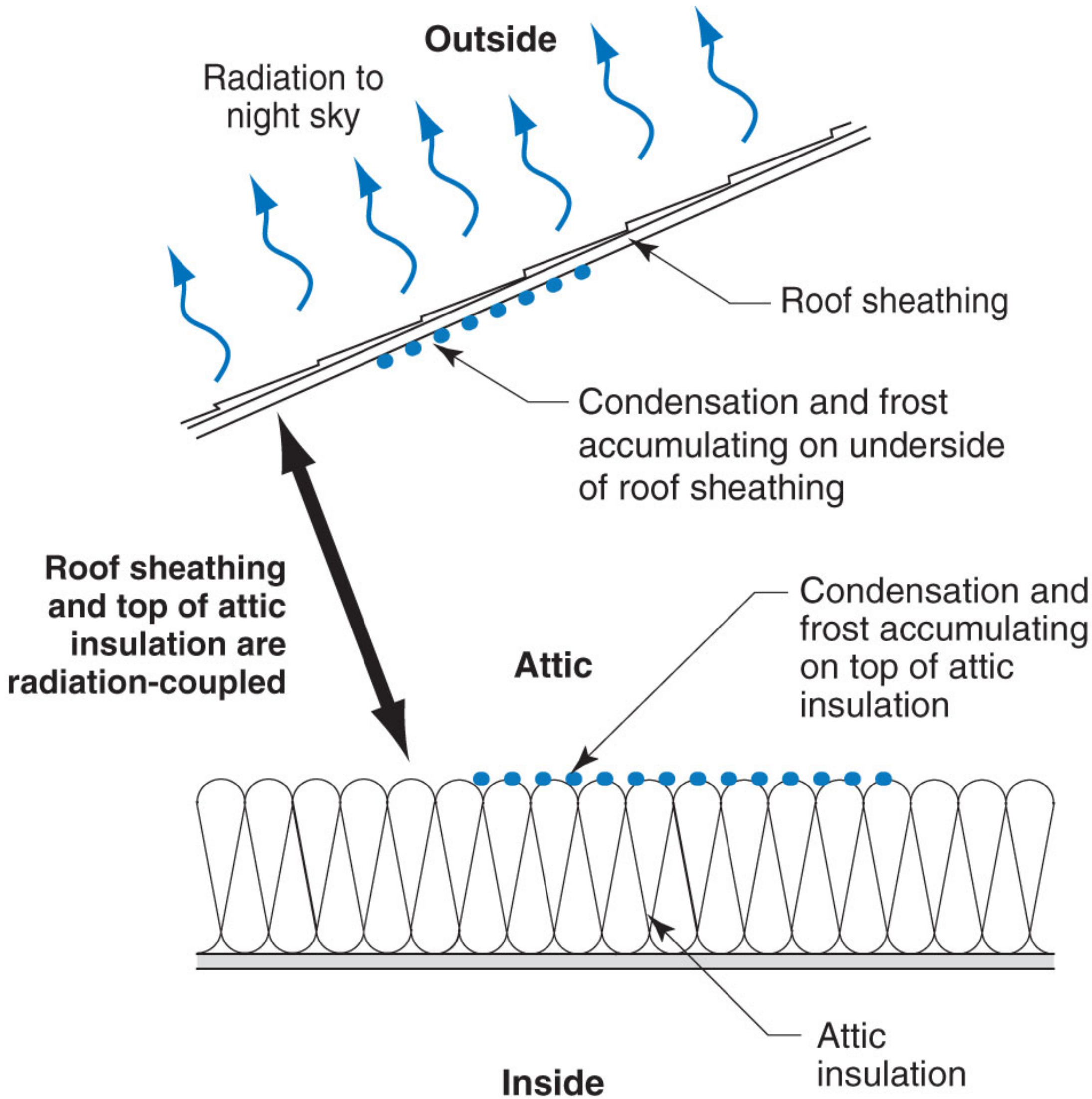


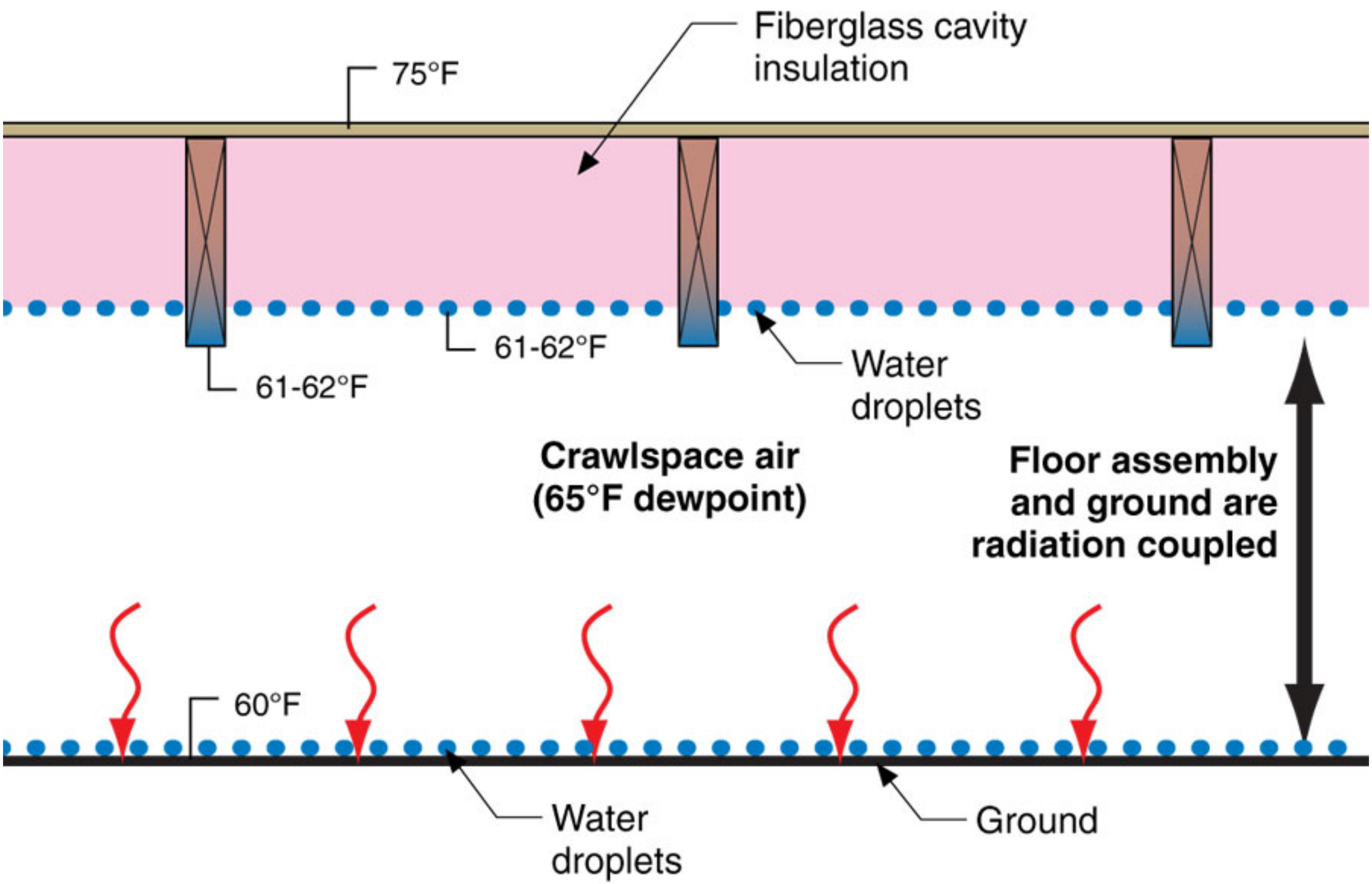
Figure 8-7. Outside vapour pressure, saturated vapour pressure and inside vapour pressure for Winnipeg.

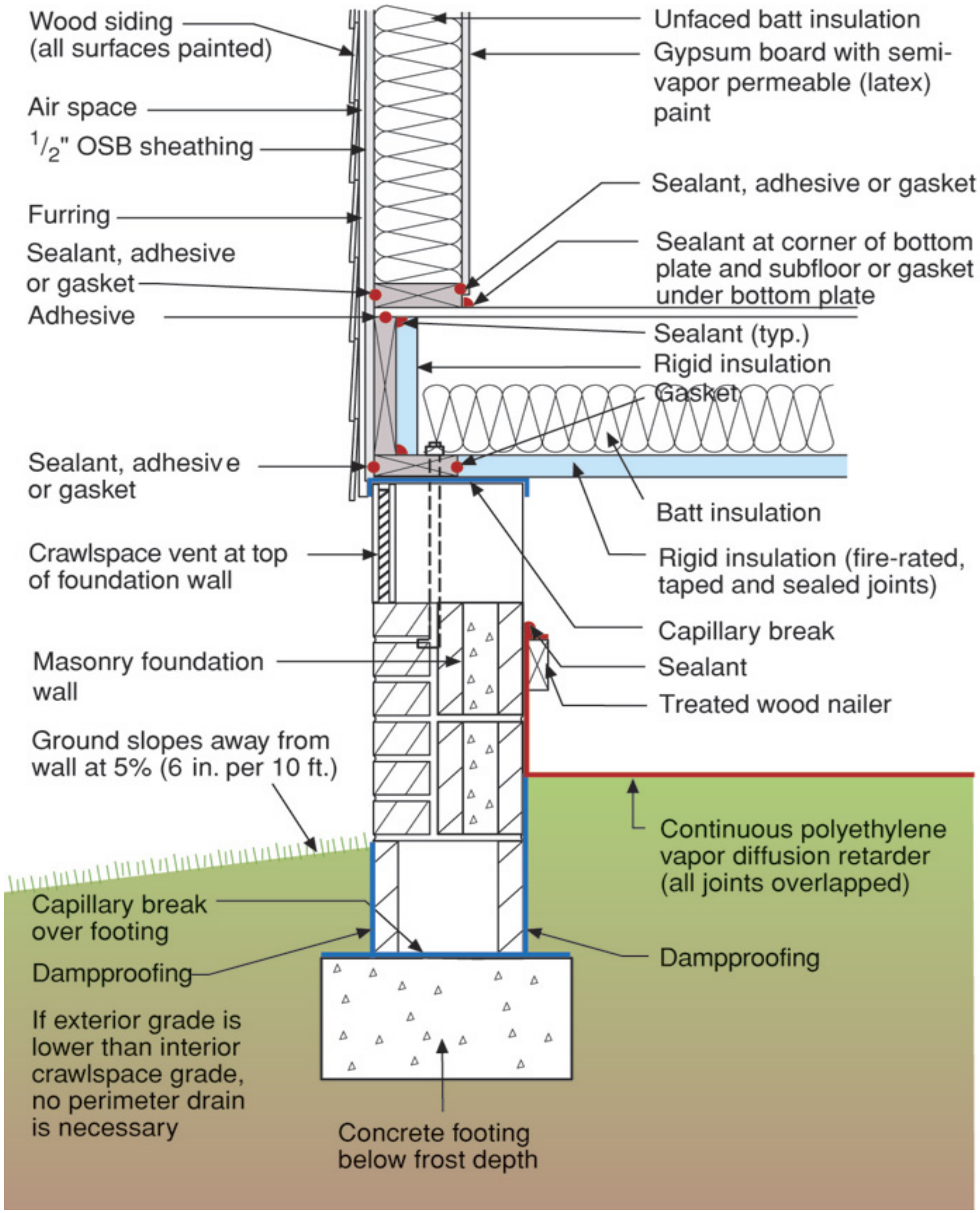


Temperature [°C]
40
20
0
-20
Water Content [kg/m³]
Rel. Humidity [%]
500
400
300
200
100
0
5
10
15
20
Brick (old)
Oriented Strand Board
Gypsum Board
Air Layer 25 mm (NA)
Fibre Glass
60 minute Building Paper
PE-Membrane (NA)
Cross section [cm]
WUFI® 3.3 Pro. IBP
Run
16 Feb
2001

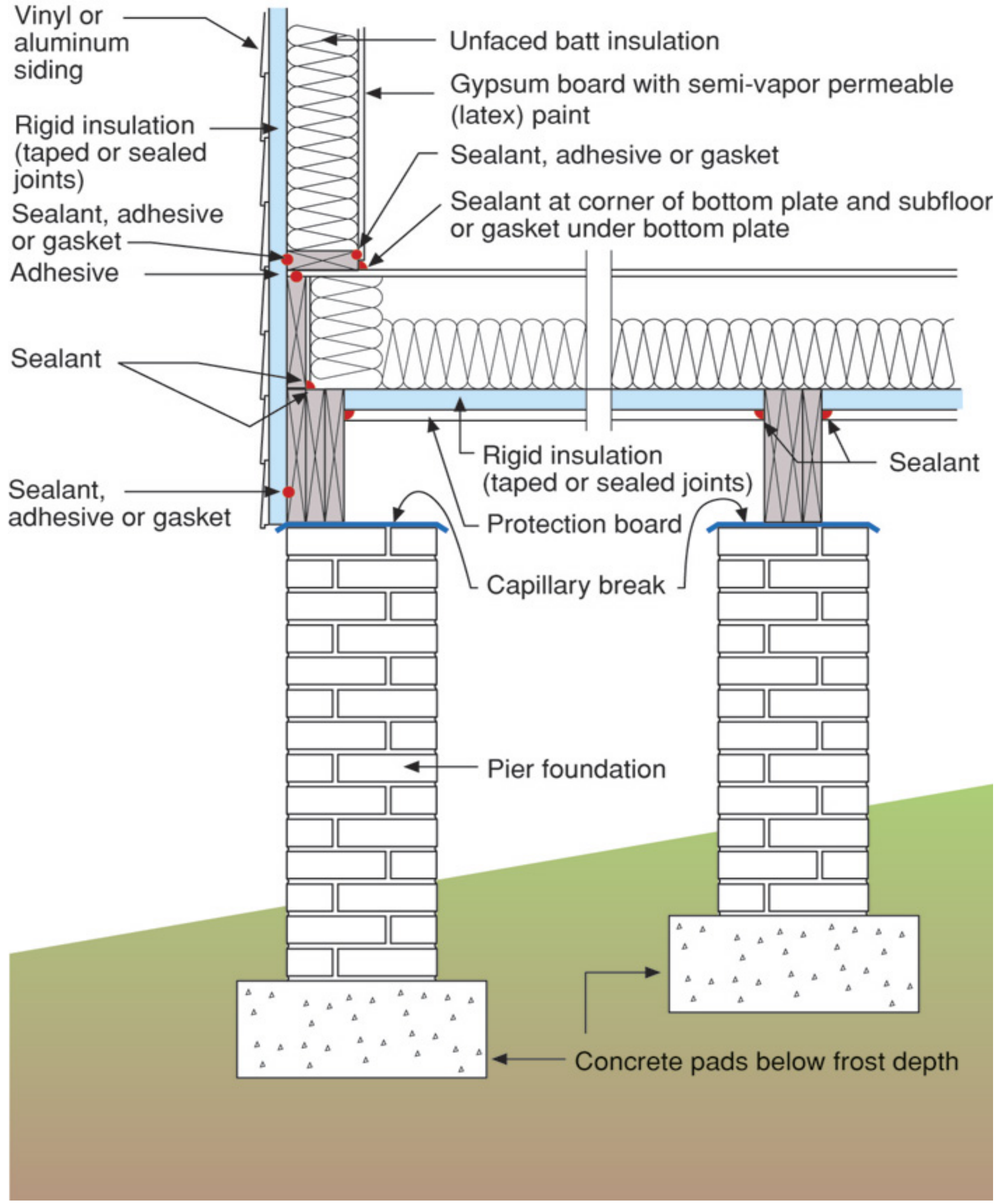

Outside
Roof sheathing
Condensation and frost accumulating on underside of roof sheathing
Attic
Attic insulation
Dewpoint
Inside


Outside
Radiation to night sky
Roof sheathing
Condensation and frost accumulating on underside of roof sheathing
Roof sheathing and top of attic insulation are radiation-coupled
Attic
Condensation and frost accumulating on top of attic insulation
Attic insulation
Inside

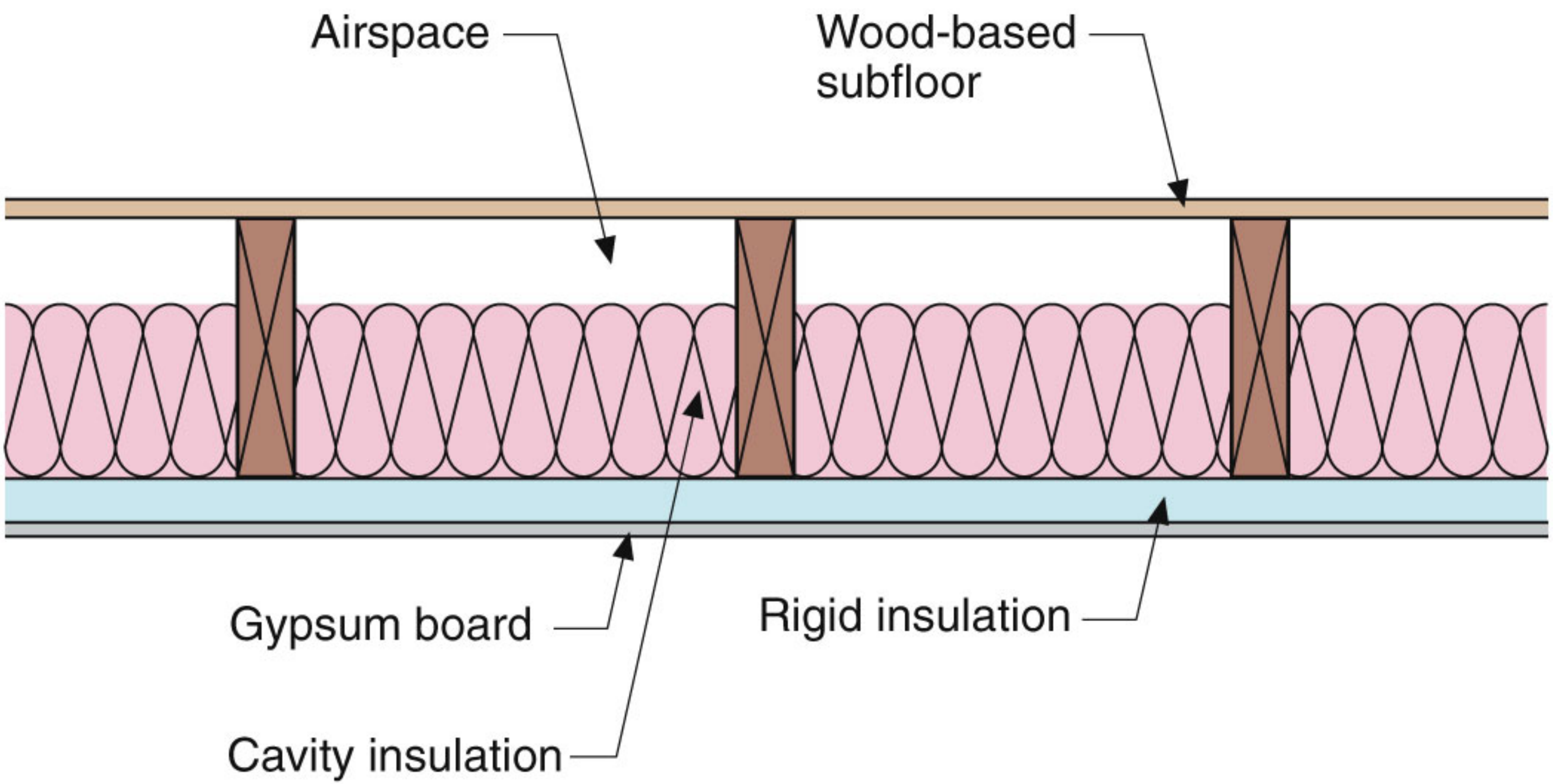

75°F
Fiberglass cavity insulation
61-62°F
61-62°F
Water droplets
Crawlspace air (65°F dewpoint)
Floor assembly and ground are radiation coupled
60°F
Water droplets
Ground

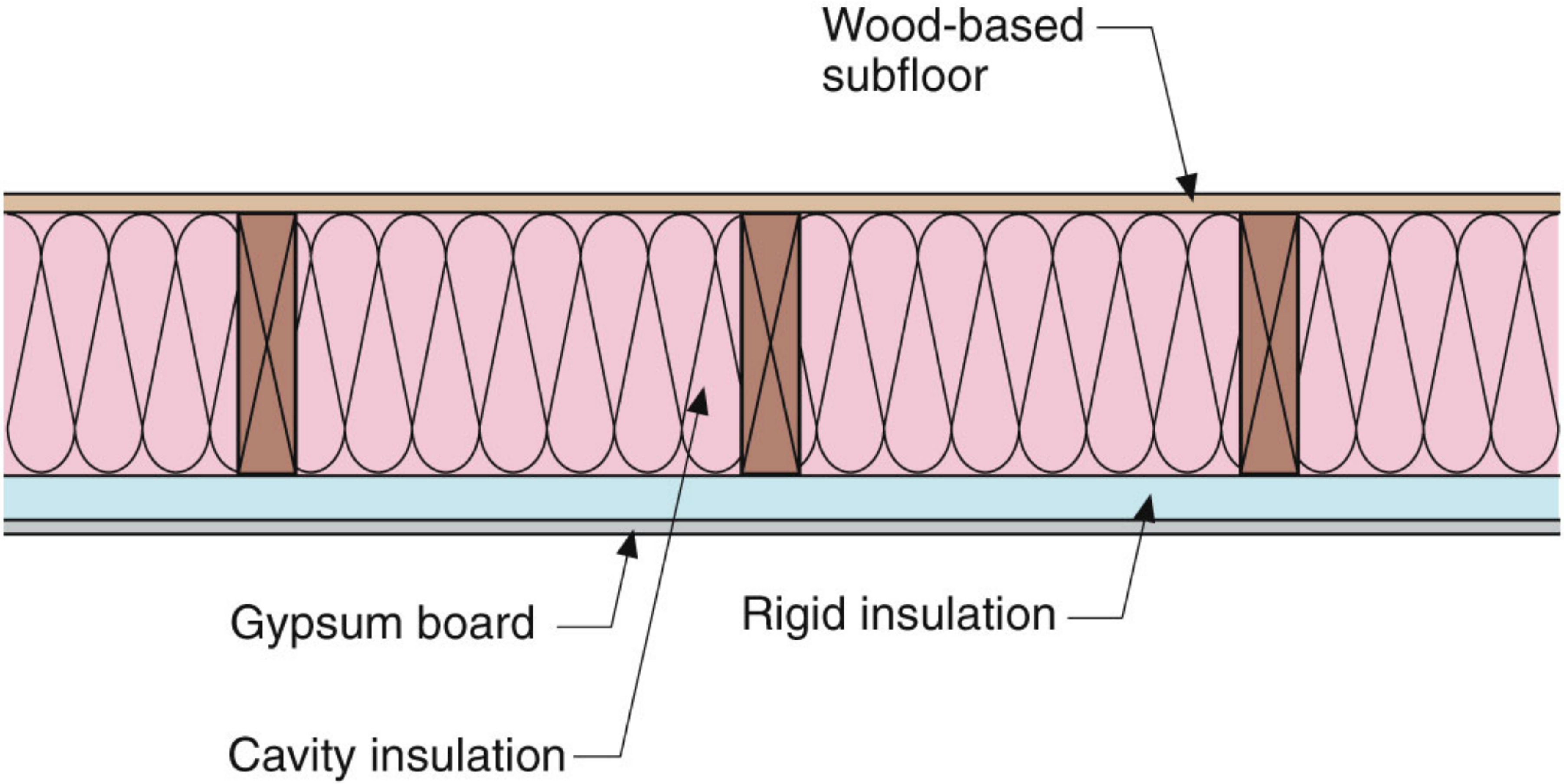


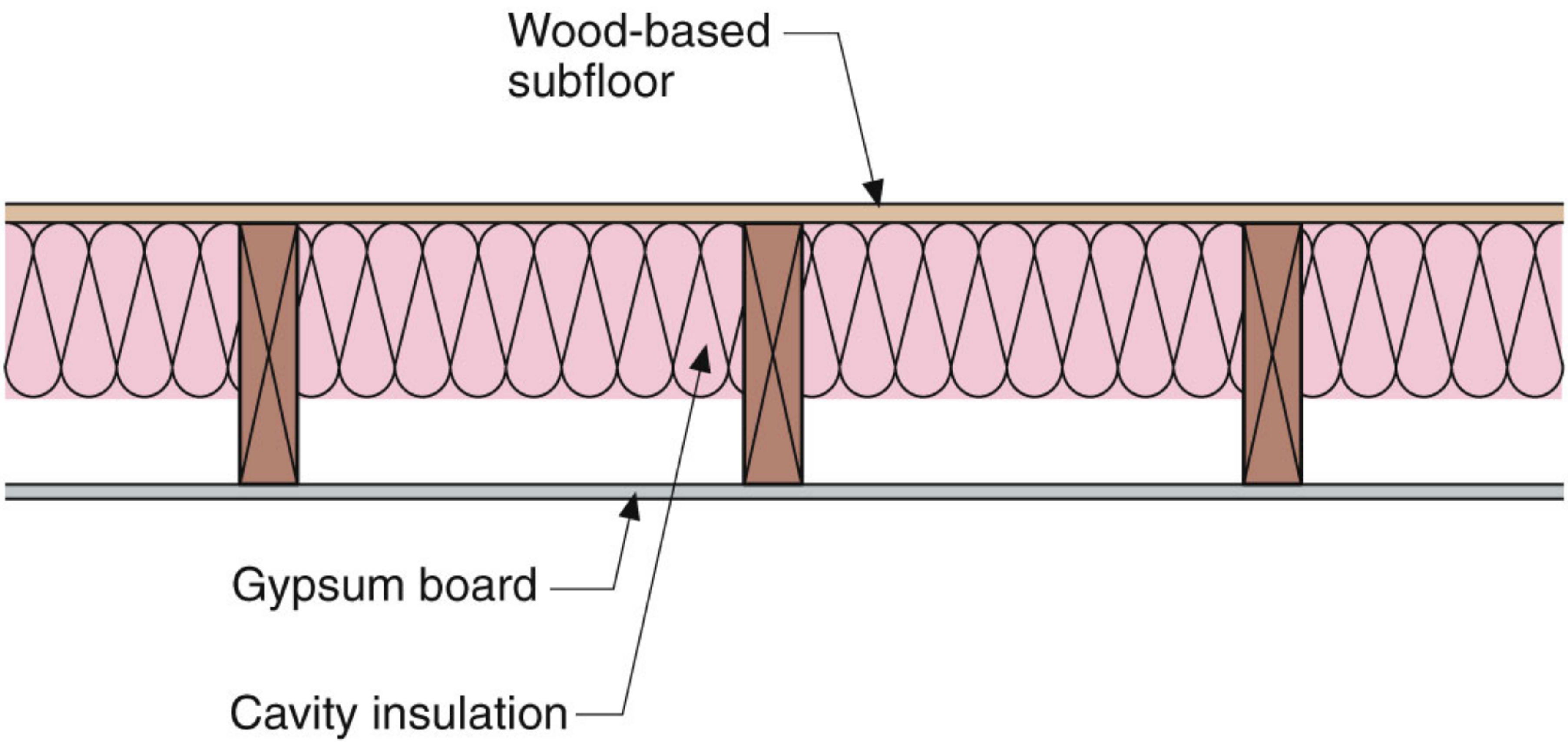
Wood siding
(all surfaces painted)
Air space
1/2" OSB sheathing
Furring
Sealant, adhesive
or gasket
Adhesive
Sealant, adhesive
or gasket
Crawlspace vent at top
of foundation wall
Masonry foundation
wall
Ground slopes away from
wall at 5% (6 in. per 10 ft.)
Capillary break
over footing
Dampproofing
If exterior grade is
lower than interior
crawlspace grade,
no perimeter drain
is necessary
Concrete footing
below frost depth
Unfaced batt insulation
Gypsum board with semi-
vapor permeable (latex)
paint
Sealant, adhesive or gasket
Sealant at corner of bottom
plate and subfloor or gasket
under bottom plate
Sealant (typ.)
Rigid insulation
Gasket
Batt insulation
Rigid insulation (fire-rated,
taped and sealed joints)
Capillary break
Sealant
Treated wood nailer
Continuous polyethylene
vapor diffusion retarder
(all joints overlapped)
Dampproofing

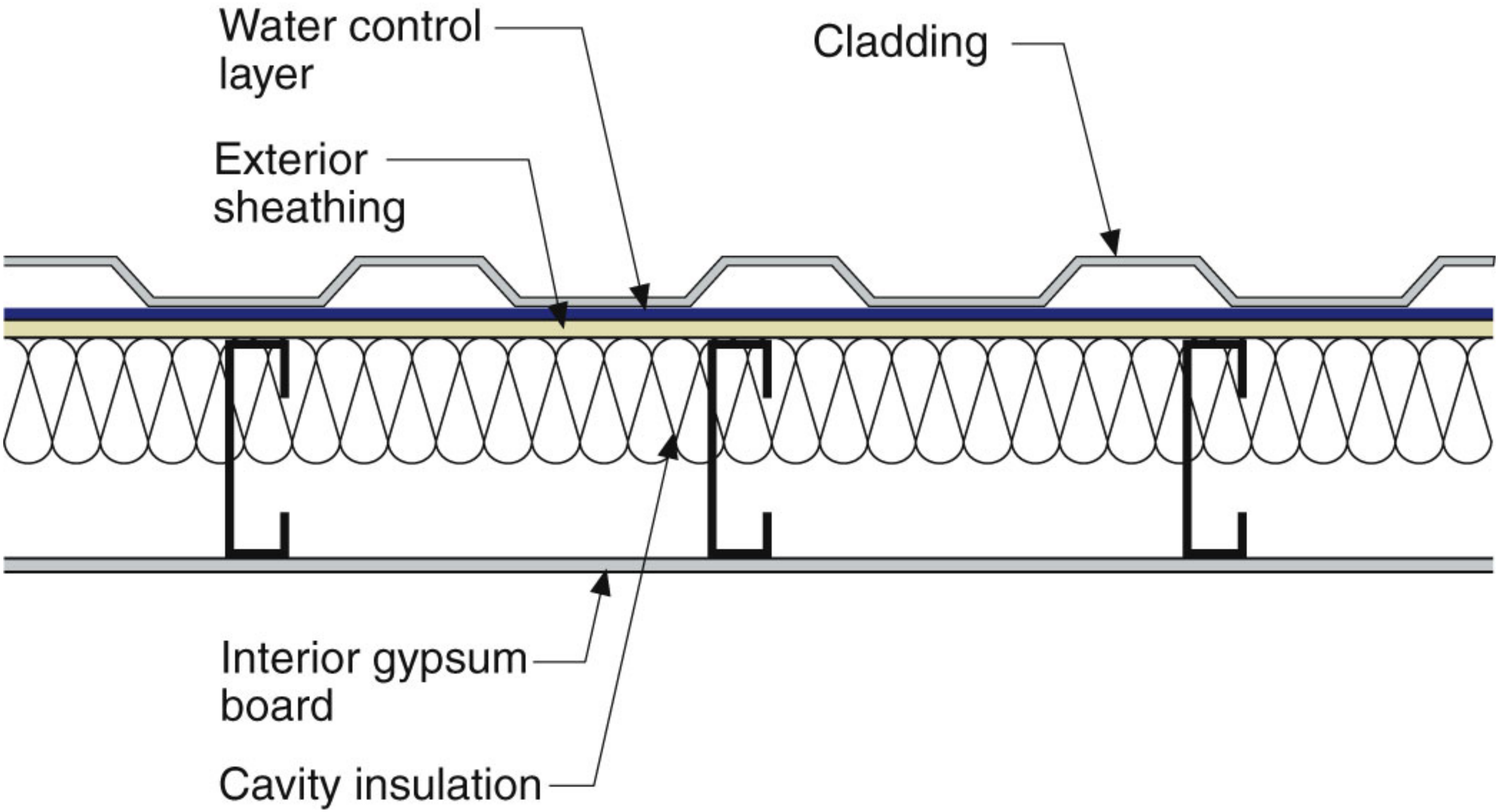


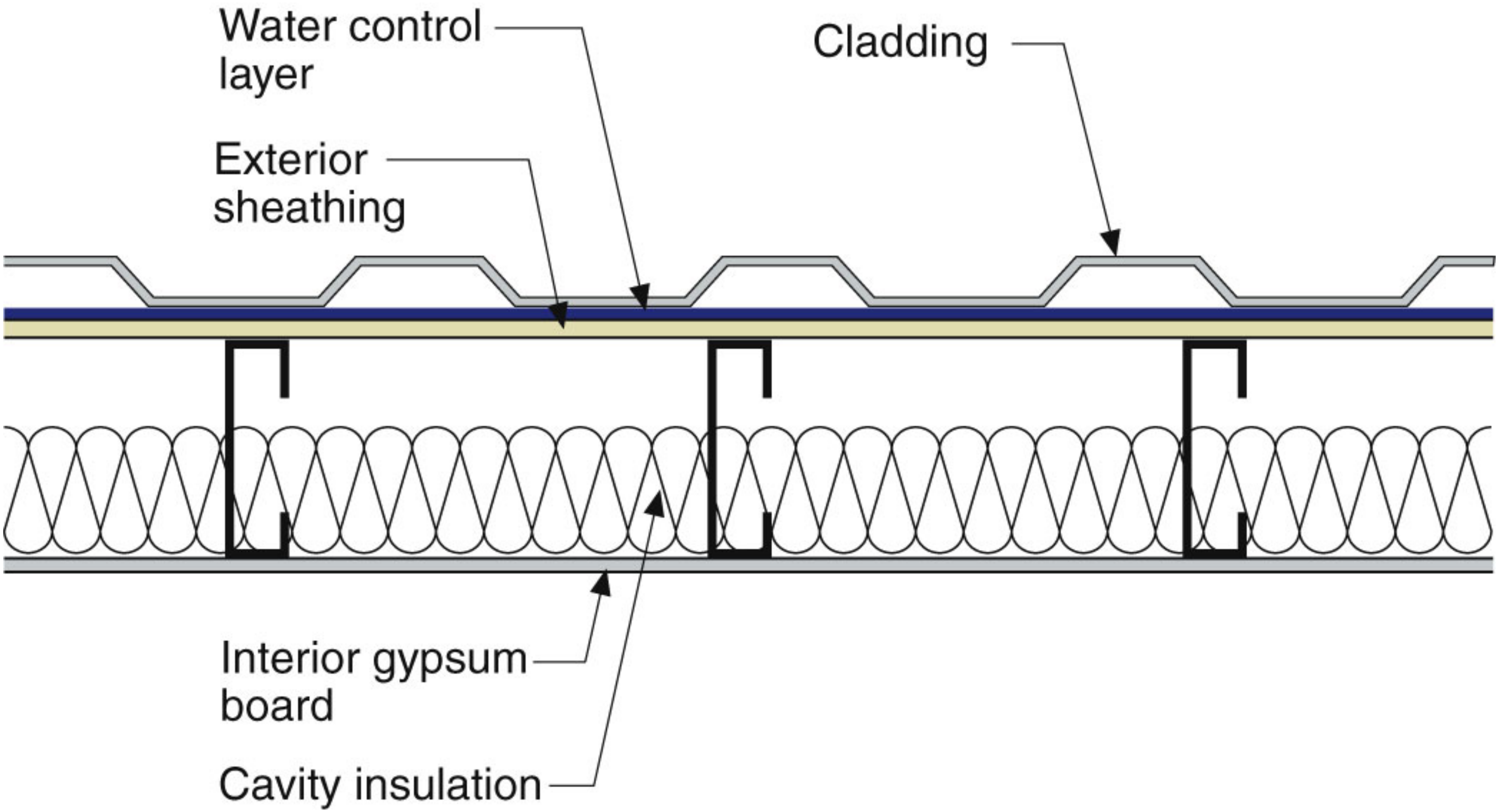
Vinyl or
aluminum
siding
Unfaced batt insulation
Gypsum board with semi-vapor permeable
(latex) paint
Rigid insulation
(taped or sealed
joints)
Sealant, adhesive or gasket
Sealant, adhesive
or gasket
Sealant at corner of bottom plate and subfloor
or gasket under bottom plate
Adhesive
Sealant
Rigid insulation
(taped or sealed joints)
Sealant
Sealant,
adhesive or gasket
Protection board
Capillary break
Pier foundation
Concrete pads below frost depth

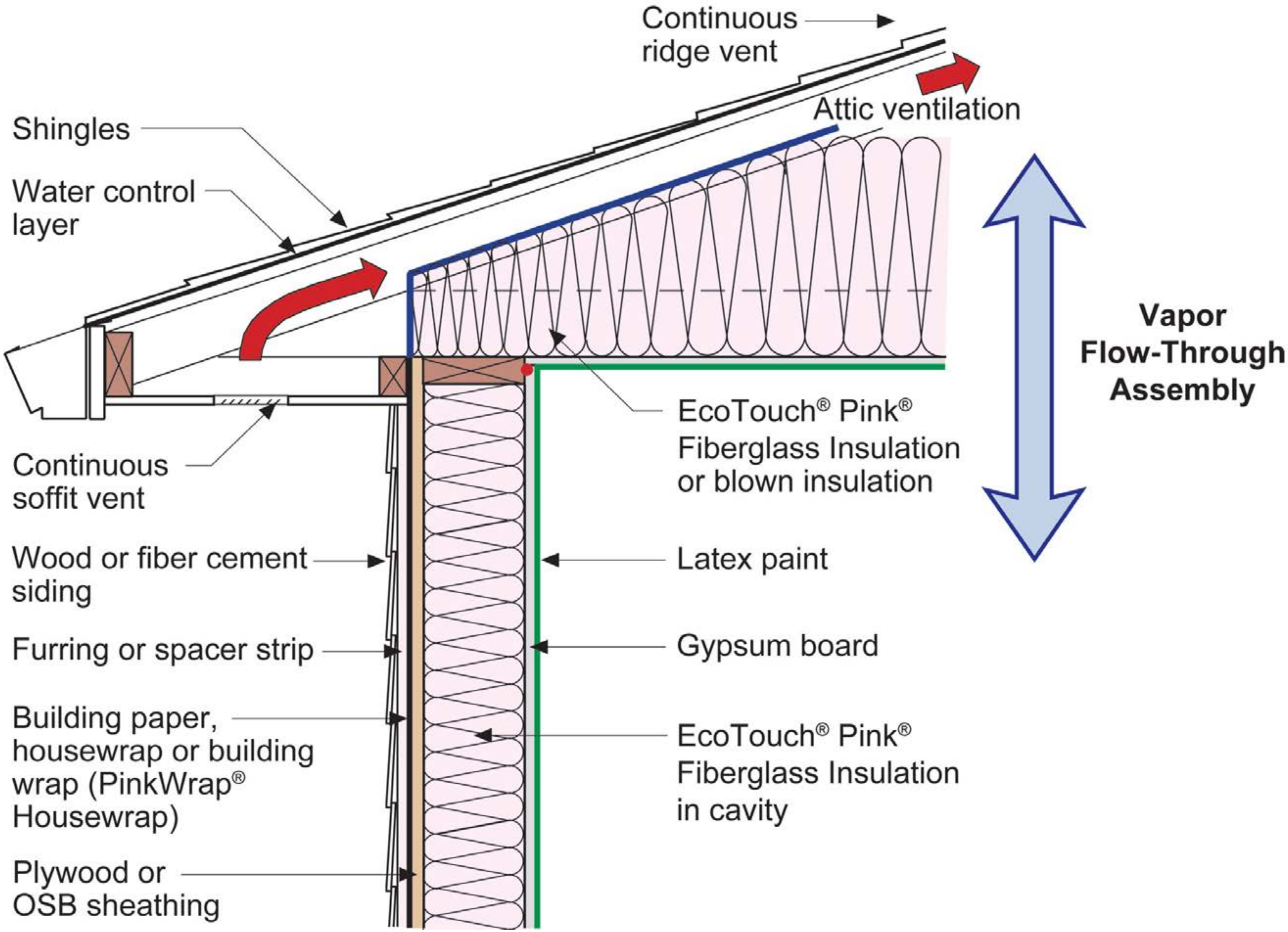

Airspace
Wood-based subfloor
Gypsum board
Rigid insulation
Cavity insulation

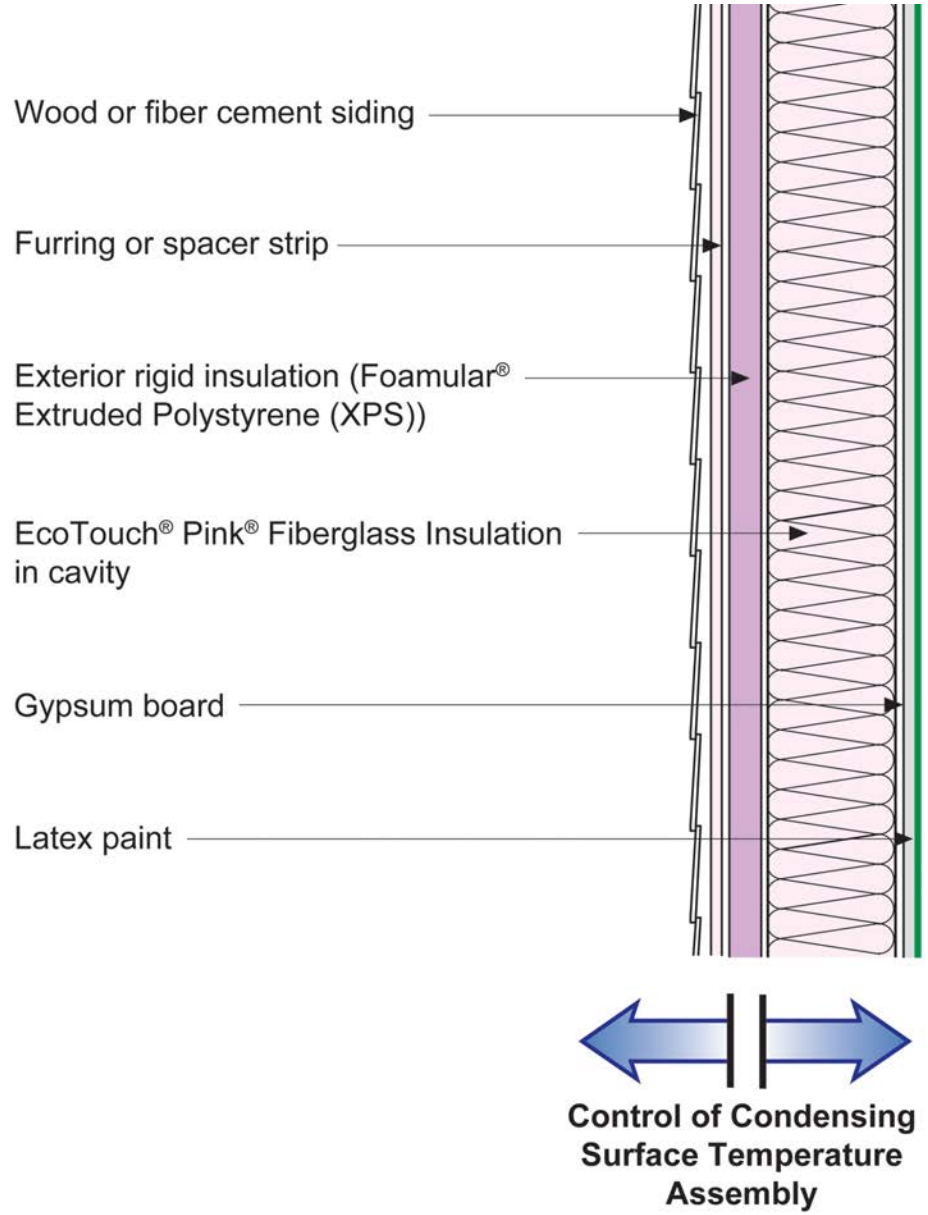

Wood-based subfloor
Gypsum board
Rigid insulation
Cavity insulation

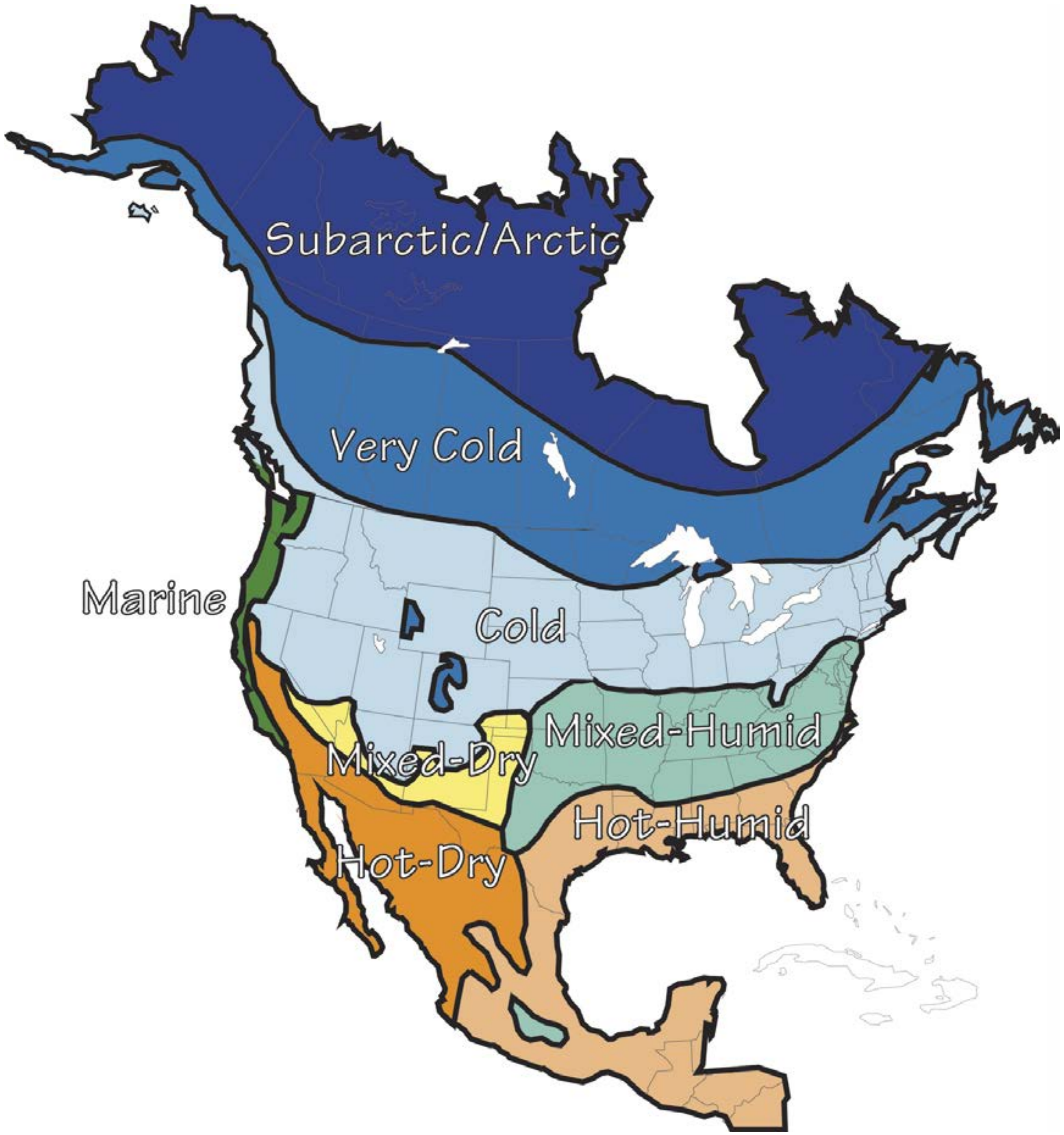

Wood-based
subfloor
Gypsum board
Cavity insulation

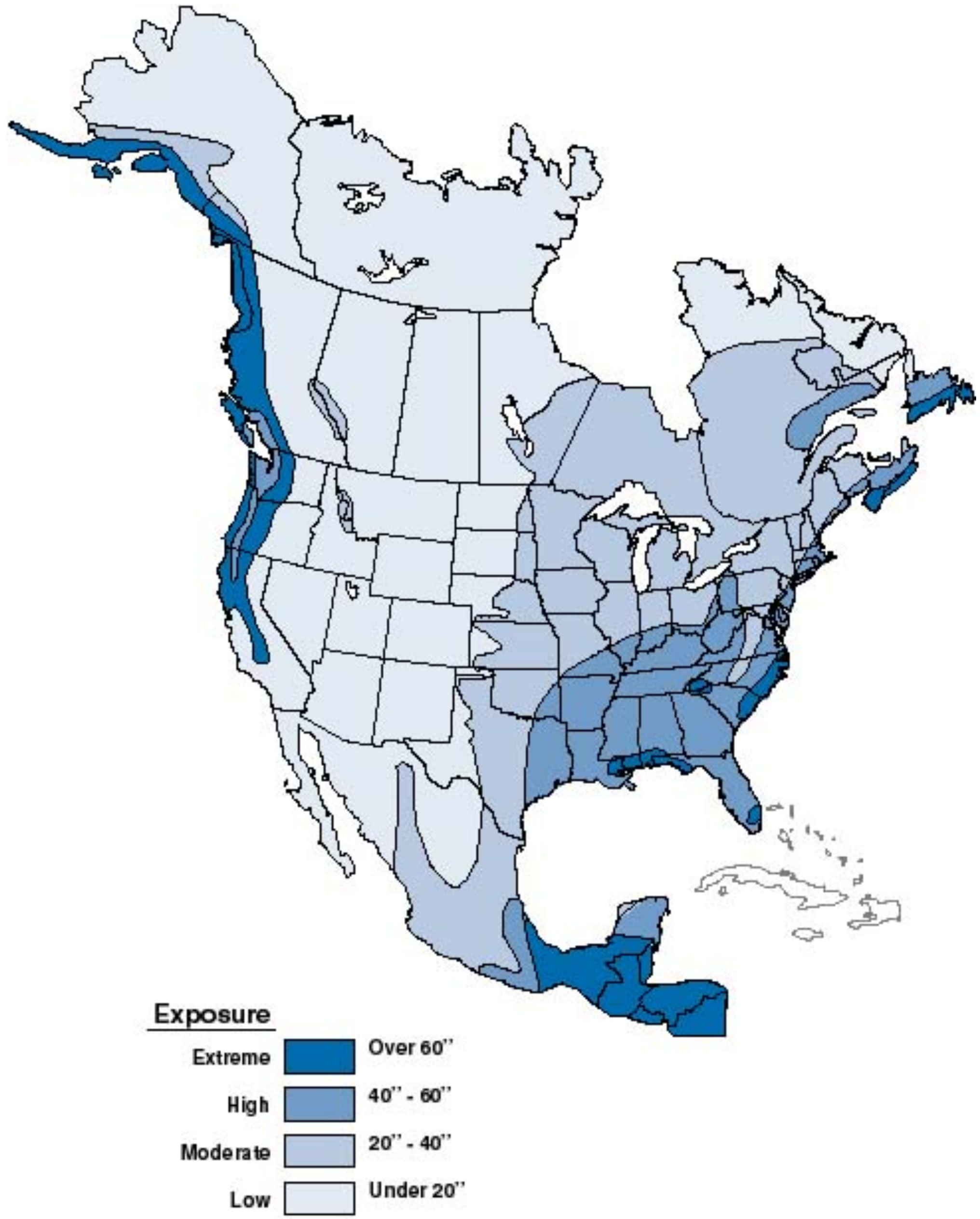

Water control layer
Cladding
Exterior sheathing
Interior gypsum board
Cavity insulation


Water control layer
Cladding
Exterior sheathing
Interior gypsum board
Cavity insulation

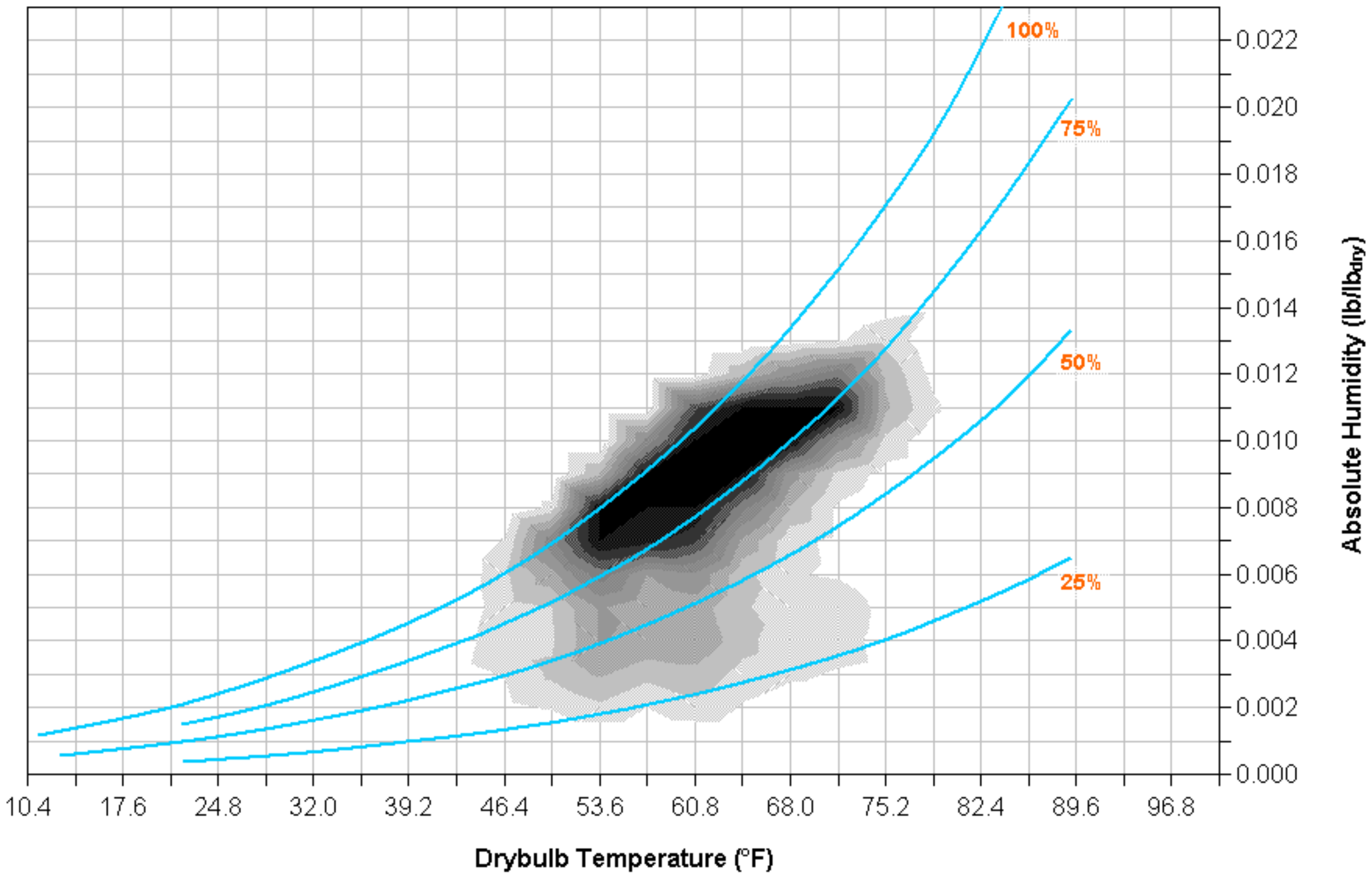

Continuous ridge vent
Attic ventilation
Shingles
Water control layer
Vapor Flow-Through Assembly
Continuous soffit vent
EcoTouch® Pink® Fiberglass Insulation or blown insulation
Wood or fiber cement siding
Latex paint
Furring or spacer strip
Gypsum board
Building paper, housewrap or building wrap (PinkWrap® Housewrap)
EcoTouch® Pink® Fiberglass Insulation in cavity
Plywood or OSB sheathing

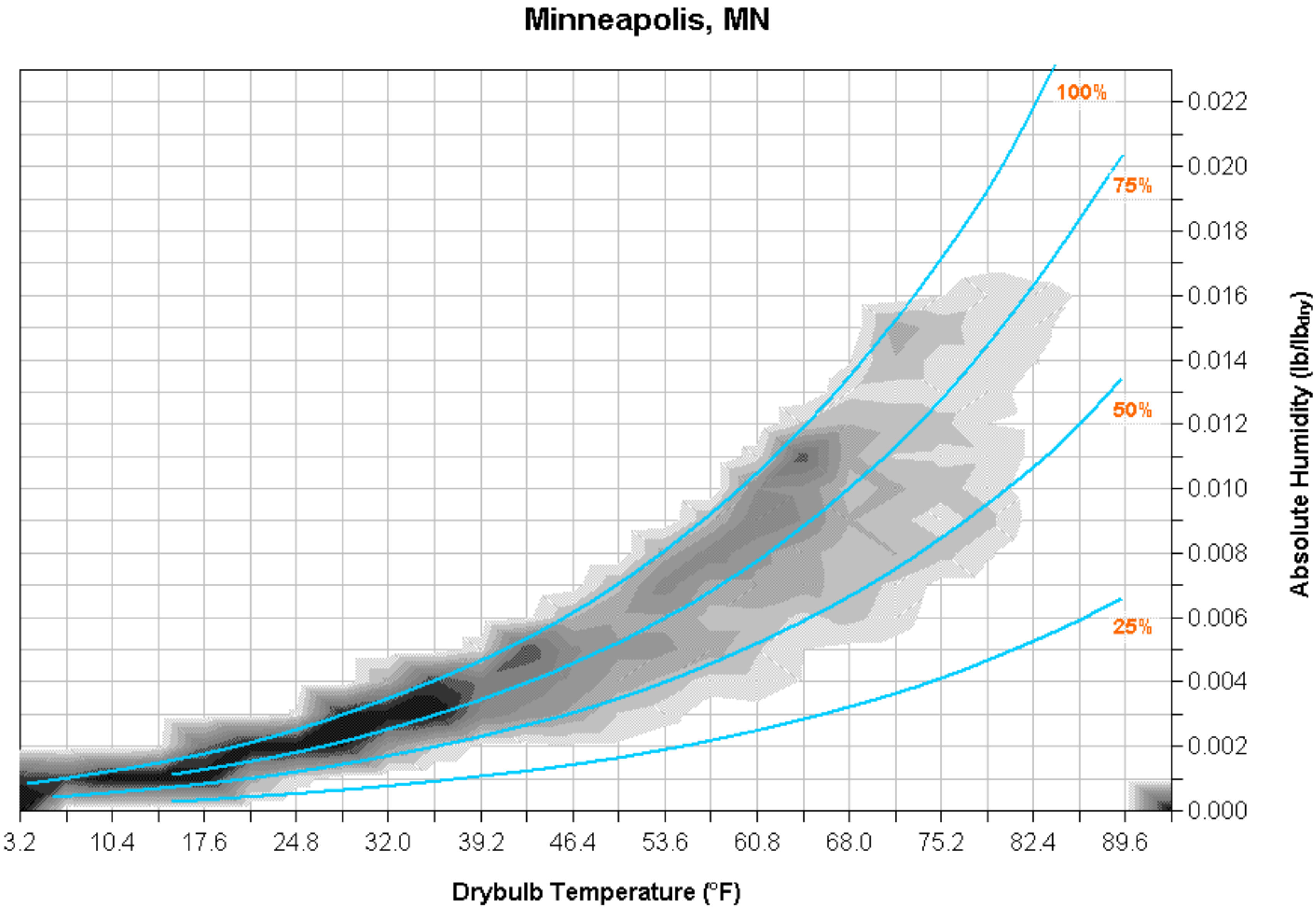

Wood or fiber cement siding
Furring or spacer strip
Exterior rigid insulation (Foamular®
Extruded Polystyrene (XPS))
EcoTouch® Pink® Fiberglass Insulation
in cavity
Gypsum board
Latex paint
Control of Condensing
Surface Temperature
Assembly


Subarctic/Arctic
Very Cold
Marine
Cold
Mixed-Humid
Mixed-Dry
Hot-Humid
Hot-Dry

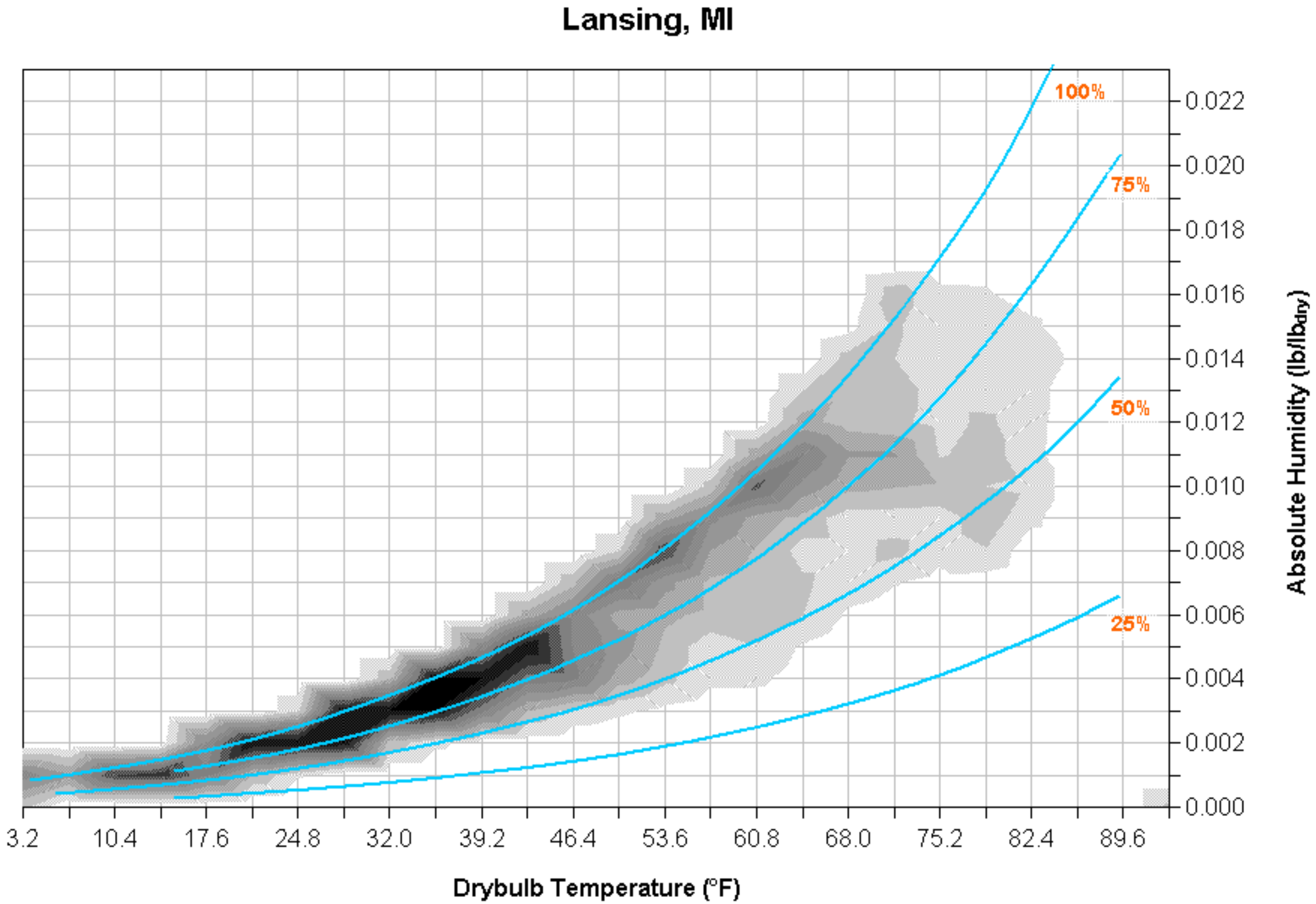

Exposure
Extreme
Over 60"
High
40" - 60"
Moderate
20" - 40"
Low
Under 20"

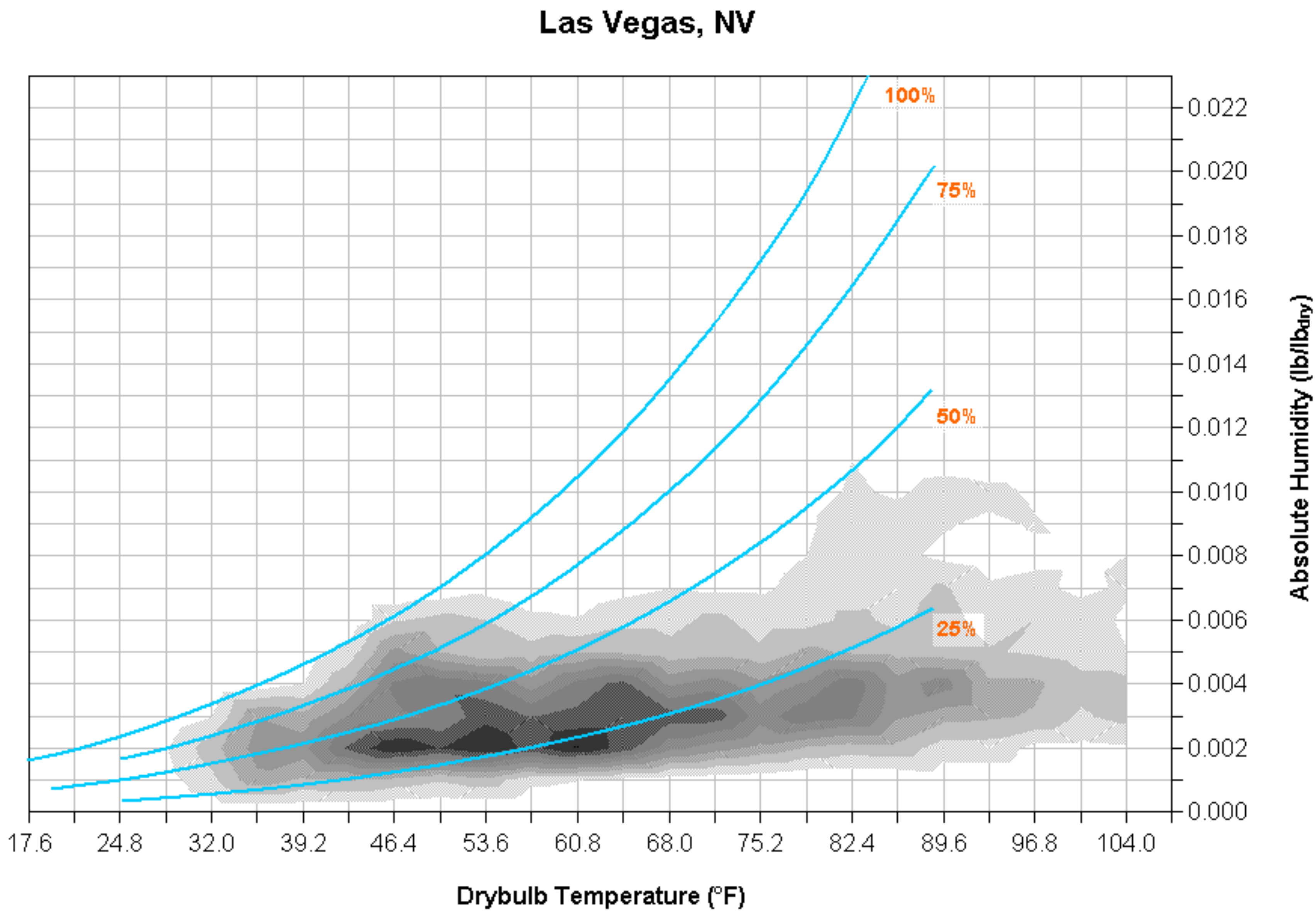
Los Angeles, CA

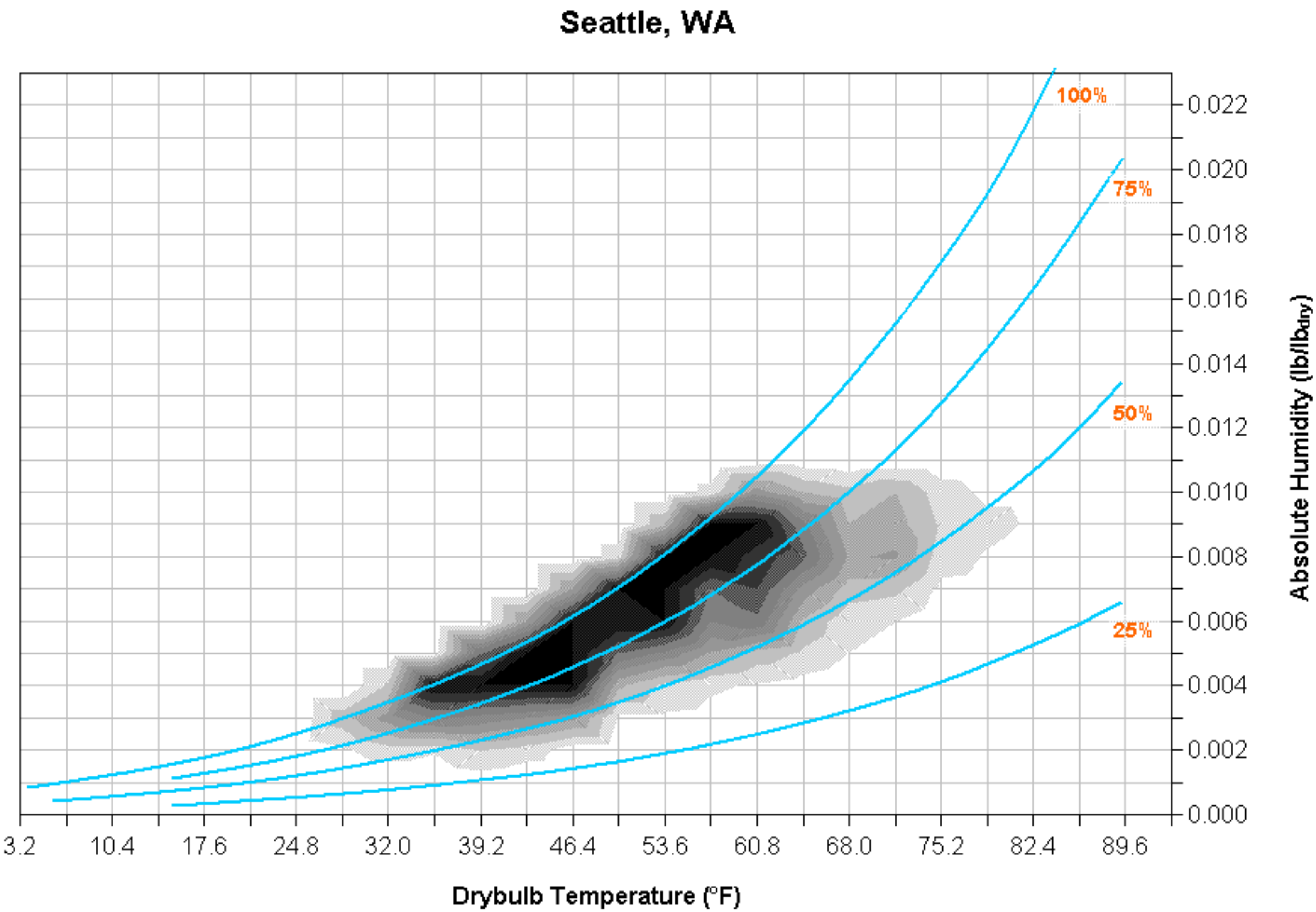




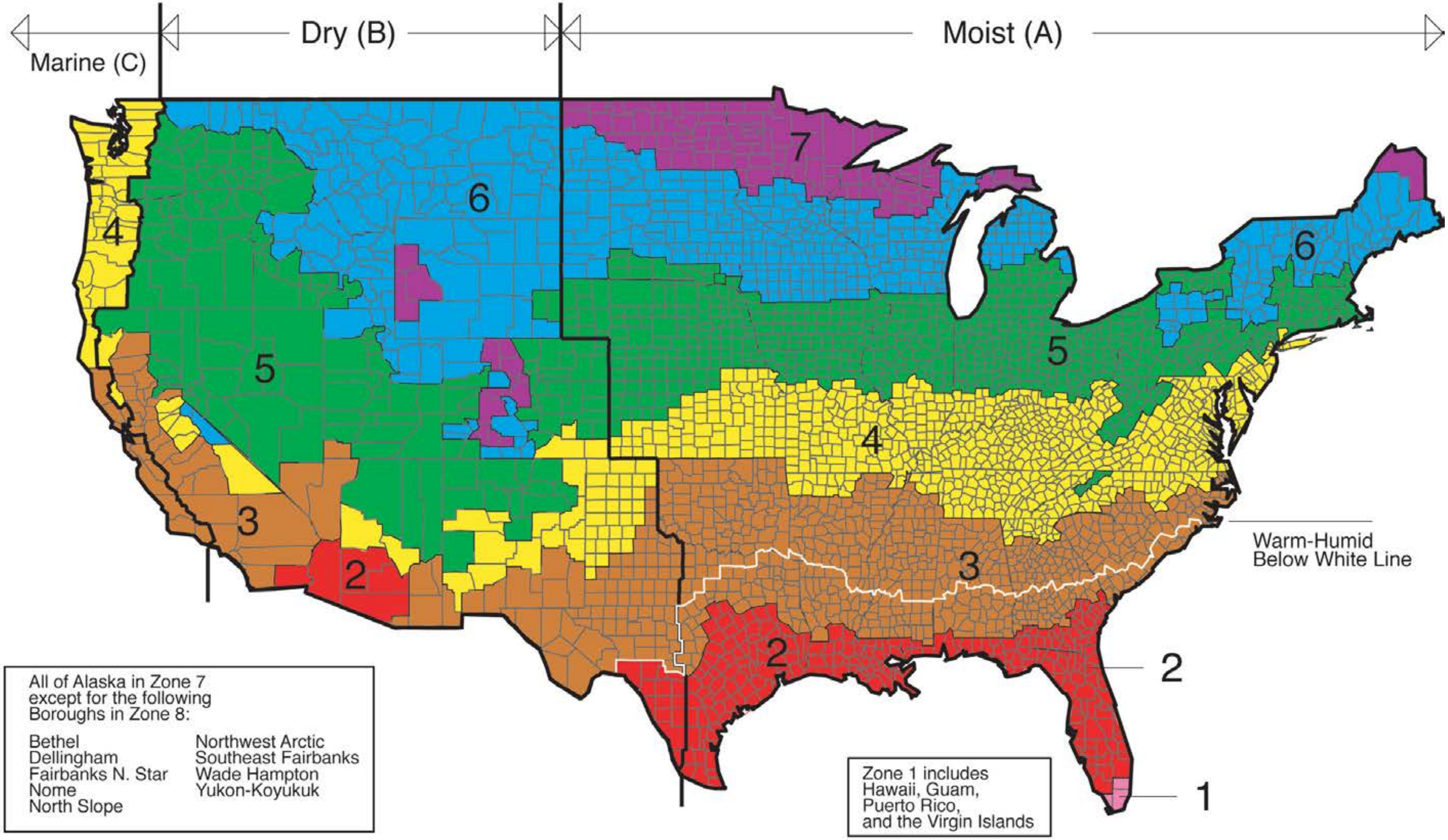
Minneapolis, MN
100%
75%
50%
25%
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Absolute Humidity (lb/lb$_{dry}$)
3.2
10.4
17.6
24.8
32.0
39.2
46.4
53.6
60.8
68.0
75.2
82.4
89.6
Drybulb Temperature (°F)


Lansing, MI
100%
75%
50%
25%
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Absolute Humidity (lb/lb$_{dry}$)
3.2
10.4
17.6
24.8
32.0
39.2
46.4
53.6
60.8
68.0
75.2
82.4
89.6
Drybulb Temperature (°F)


Las Vegas, NV
100%
75%
50%
25%
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Absolute Humidity (lb/lbdry)
17.6
24.8
32.0
39.2
46.4
53.6
60.8
68.0
75.2
82.4
89.6
96.8
104.0
Drybulb Temperature (°F)

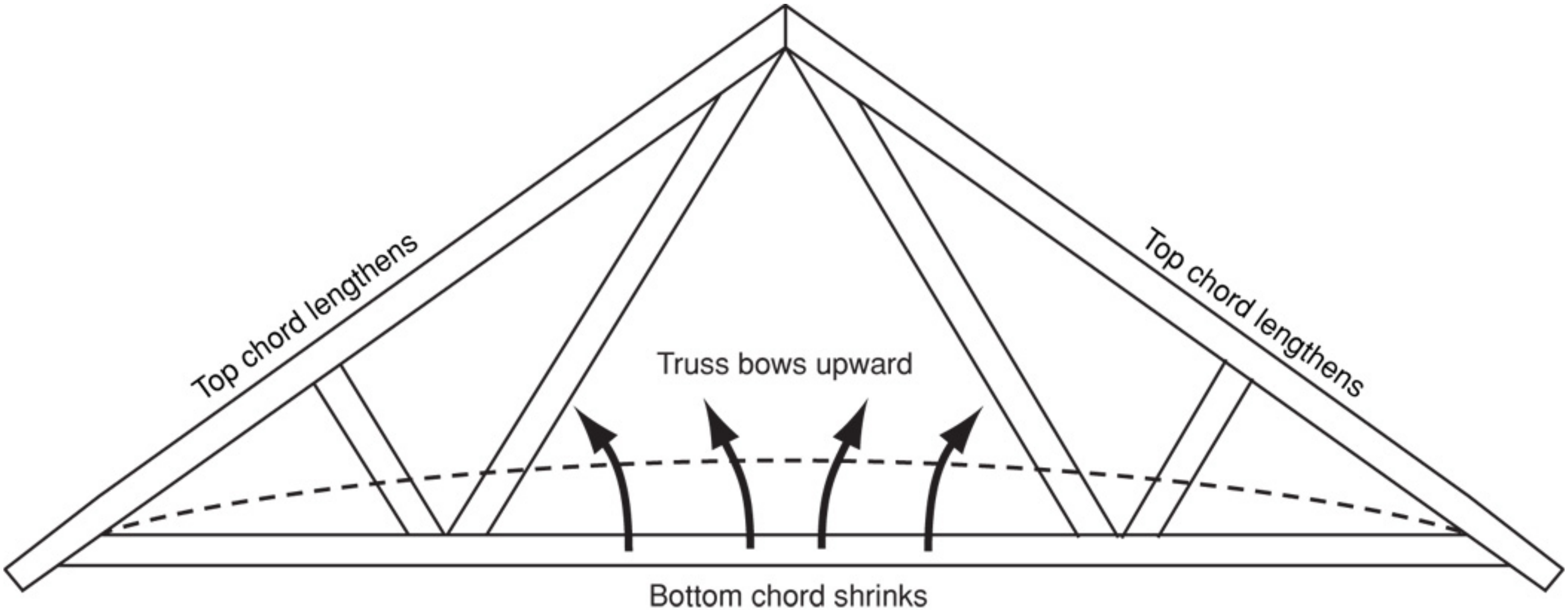

Seattle, WA
100%
75%
50%
25%
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Absolute Humidity (lb/lbdry)
3.2
10.4
17.6
24.8
32.0
39.2
46.4
53.6
60.8
68.0
75.2
82.4
89.6
Drybulb Temperature (°F)

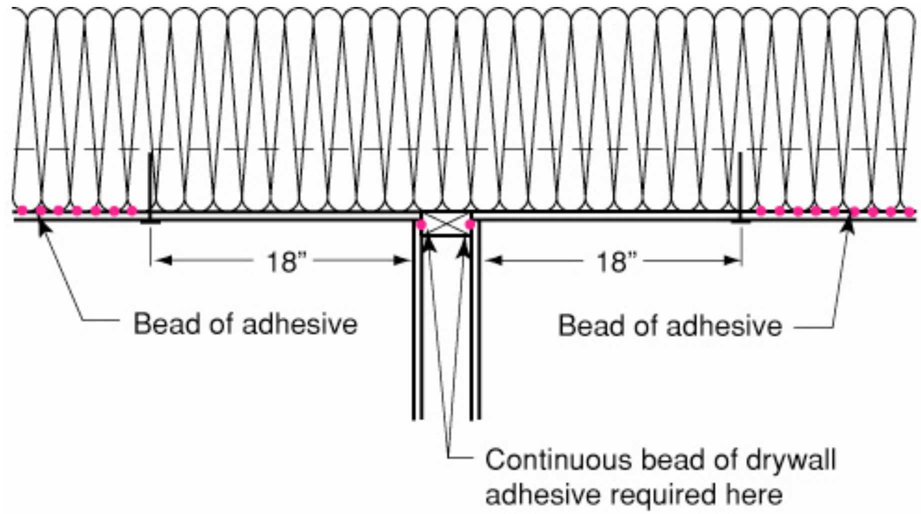
Don’t Do Stupid Things



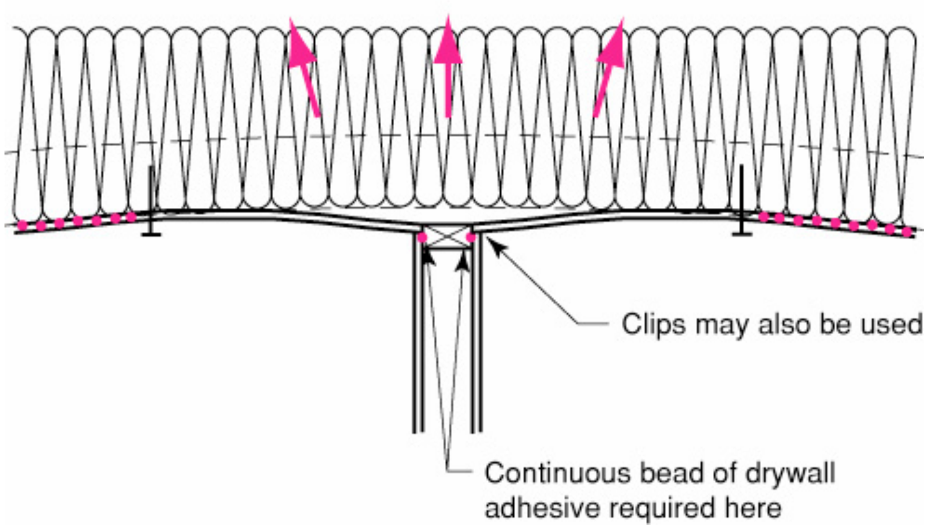
Marine (C)
Dry (B)
Moist (A)
7
6
6
4
5
5
4
3
3
2
2
2
1
Warm-Humid
Below White Line
All of Alaska in Zone 7
except for the following
Boroughs in Zone 8:
Bethel
Dellingham
Fairbanks N. Star
Nome
North Slope
Northwest Arctic
Southeast Fairbanks
Wade Hampton
Yukon-Koyukuk
Zone 1 includes
Hawaii, Guam,
Puerto Rico,
and the Virgin Islands


6537

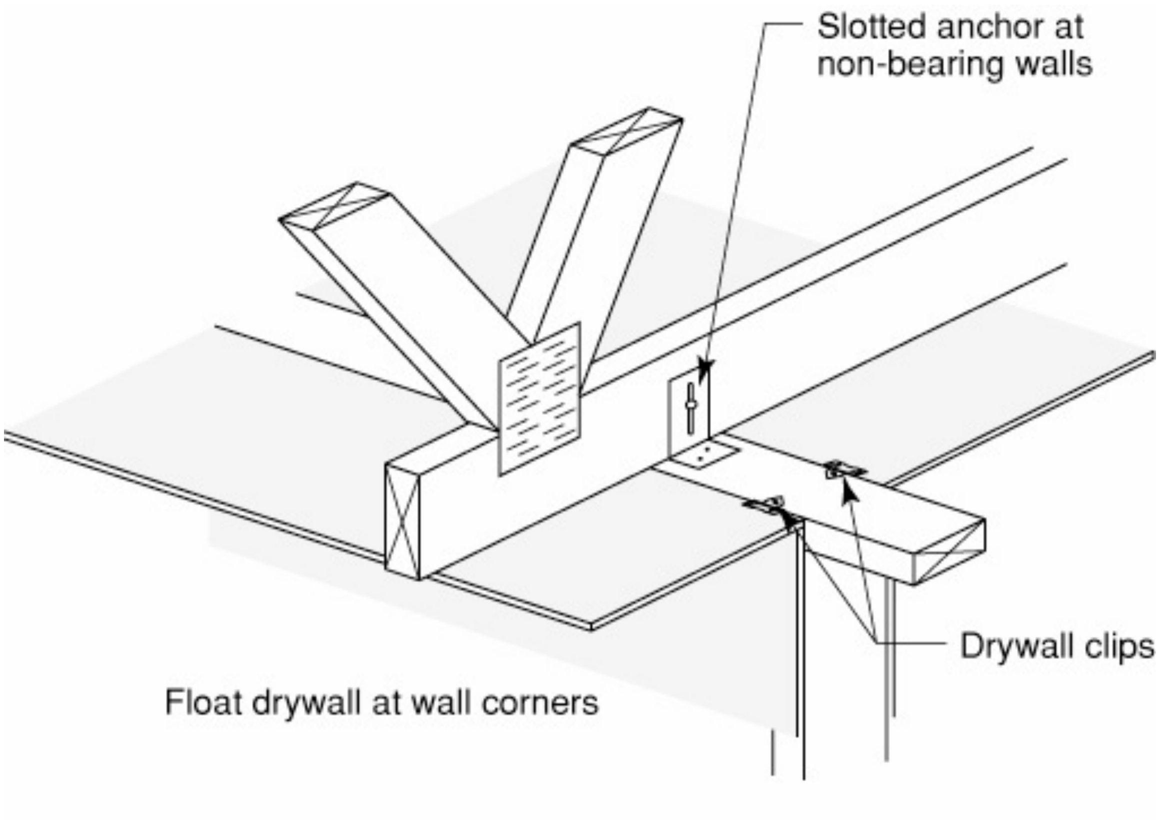

Top chord lengthens
Top chord lengthens
Truss bows upward
Bottom chord shrinks



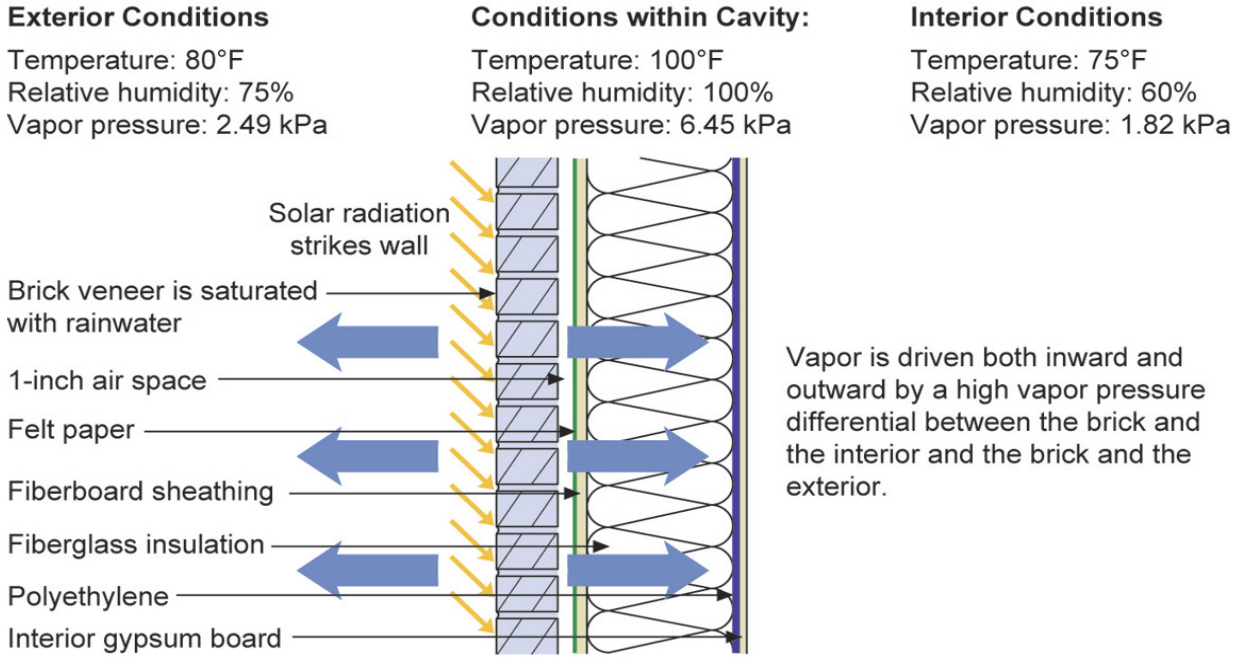
18"
18"
Bead of adhesive
Bead of adhesive
Continuous bead of drywall adhesive required here



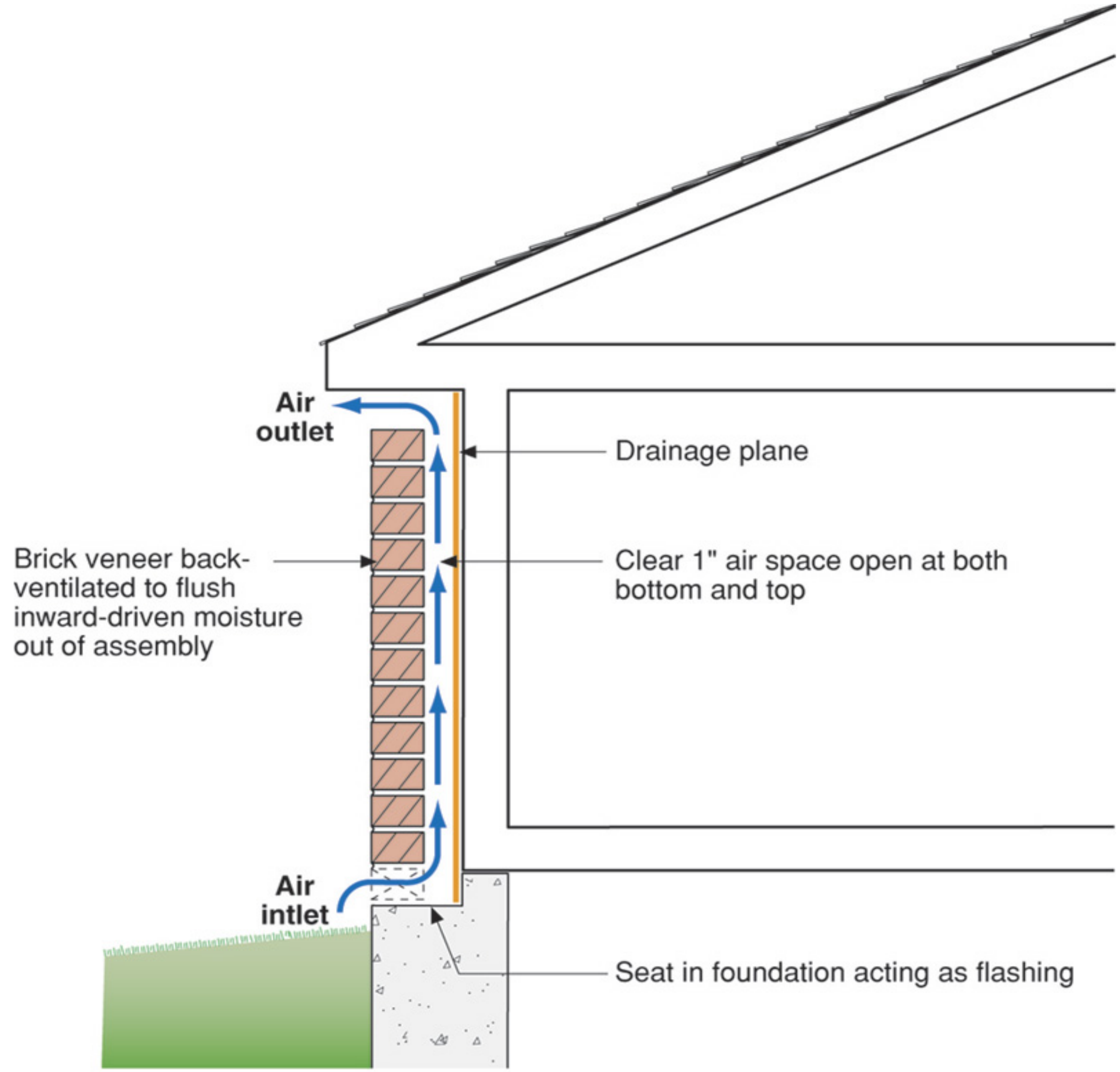
Clips may also be used
Continuous bead of drywall adhesive required here


Slotted anchor at
non-bearing walls
Drywall clips
Float drywall at wall corners

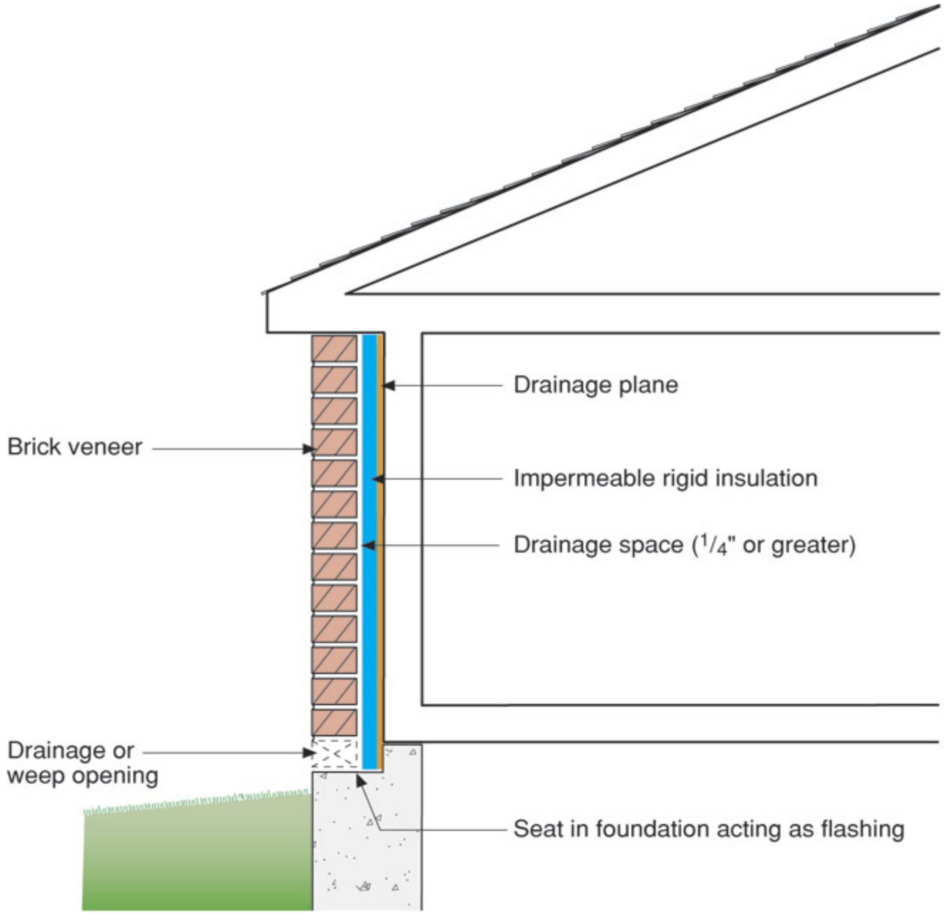

10-4-8
STRUCTURAL GRADE
ermo-pl
INSULATIVE SHEATHING
FOR ADDED ENERGY
PERFORMANCE



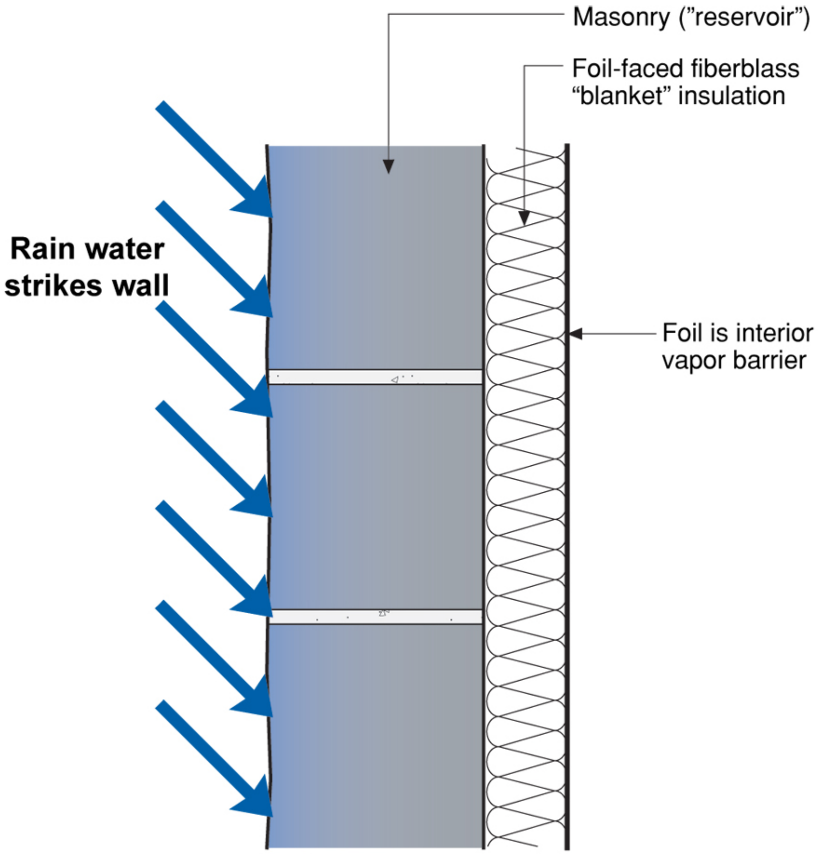
- It is not a good idea to install a vapor barrier (polyethylene) on the inside of an air conditioned assembly. Vinyl wall coverings and foil-backed batt cavity insulation should also be avoided.
- Vapor permeable exterior sheathings, housewraps or building papers should not be used with absorptive claddings such as brick veneers unless a ventilated cavity is provided in conjunction with high inward drying potentials (i.e. no interior polyethylene vapor barriers).
- Failure will occur when brick is installed over a frame wall constructed with felt paper, fiberboard sheathing and an interior polyethylene vapor barrier. Kraft-faced fiberglass batts should be used in place of unfaced batts and a polyethylene vapor barrier. OSB, plywood or foam sheathing should be used in place of the fiberboard sheathing.
- Similar problems occur with stucco.



- To effectively uncouple a brick veneer from a wall system by using back ventilation, a clear cavity must be provided along with both air inlets at the bottom and air outlets at the top

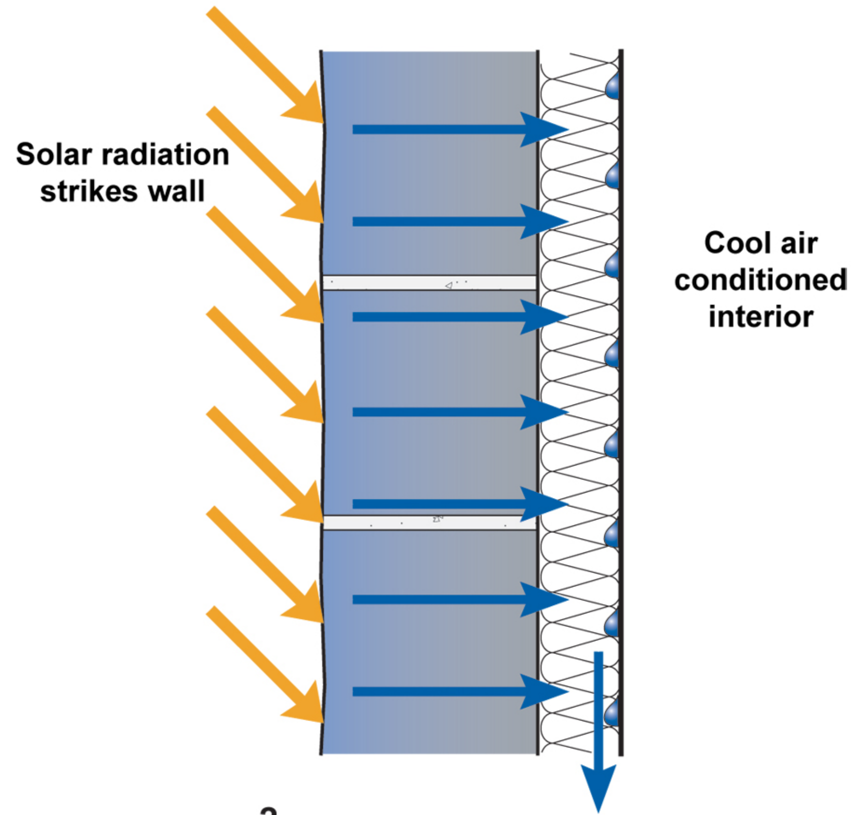


- To effectively uncouple a brick veneer from a wall system by using a condensing surface, the drainage plane must also be a vapor barrier or a vapor impermeable layer (i.e. rigid insulation) must be installed between the drainage plane and the brick veneer. Alternatively, the rigid insulation can be configured to act as both the drainage plane and vapor impermeable layer.
- When a condensing surface is used to uncouple a brick veneer from a wall system, a ventilated air space is no longer necessary — i.e. the presence of mortar droppings is no longer an issue. Additionally, the width of the drainage space is almost irrelevant.



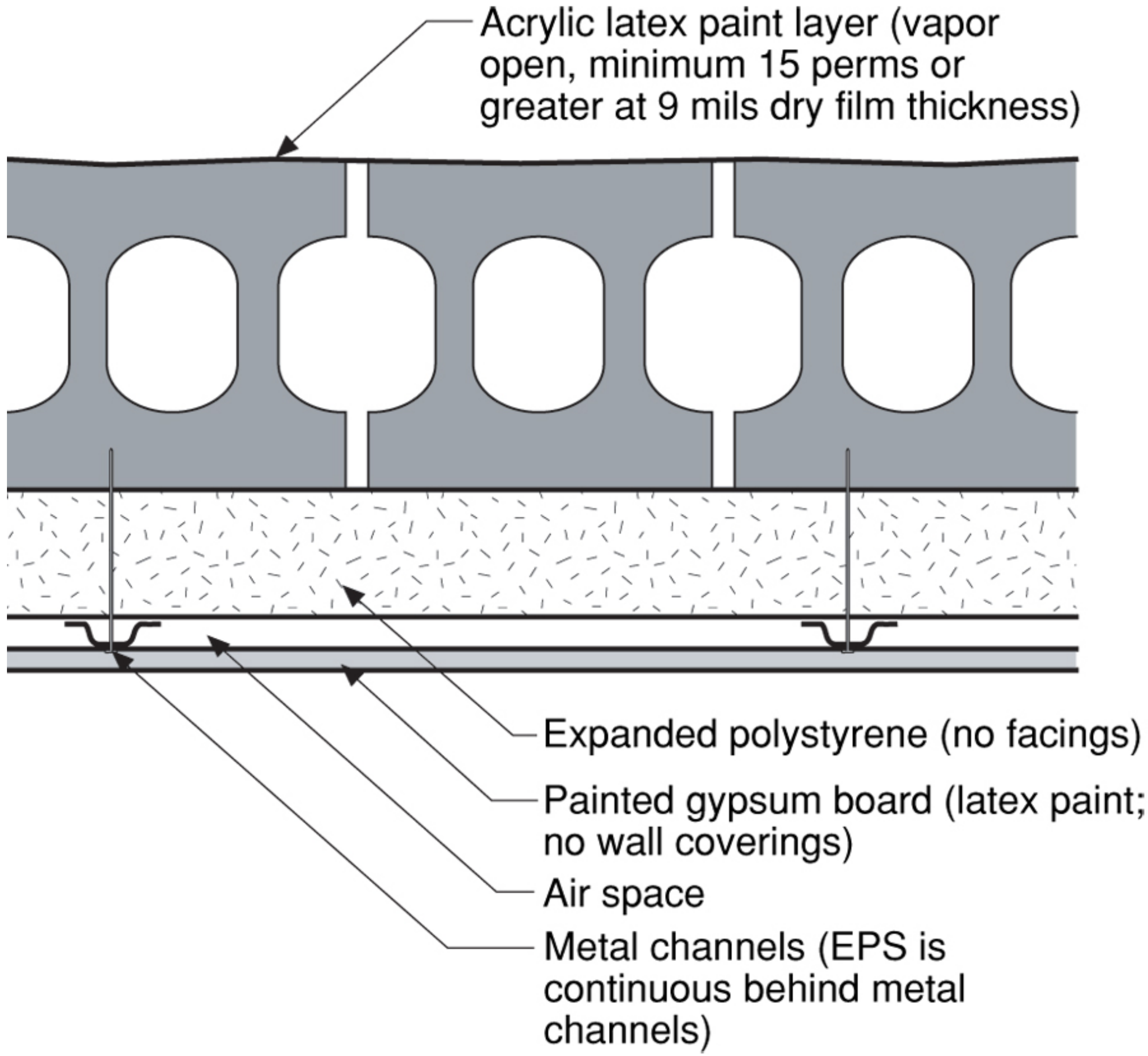
1.

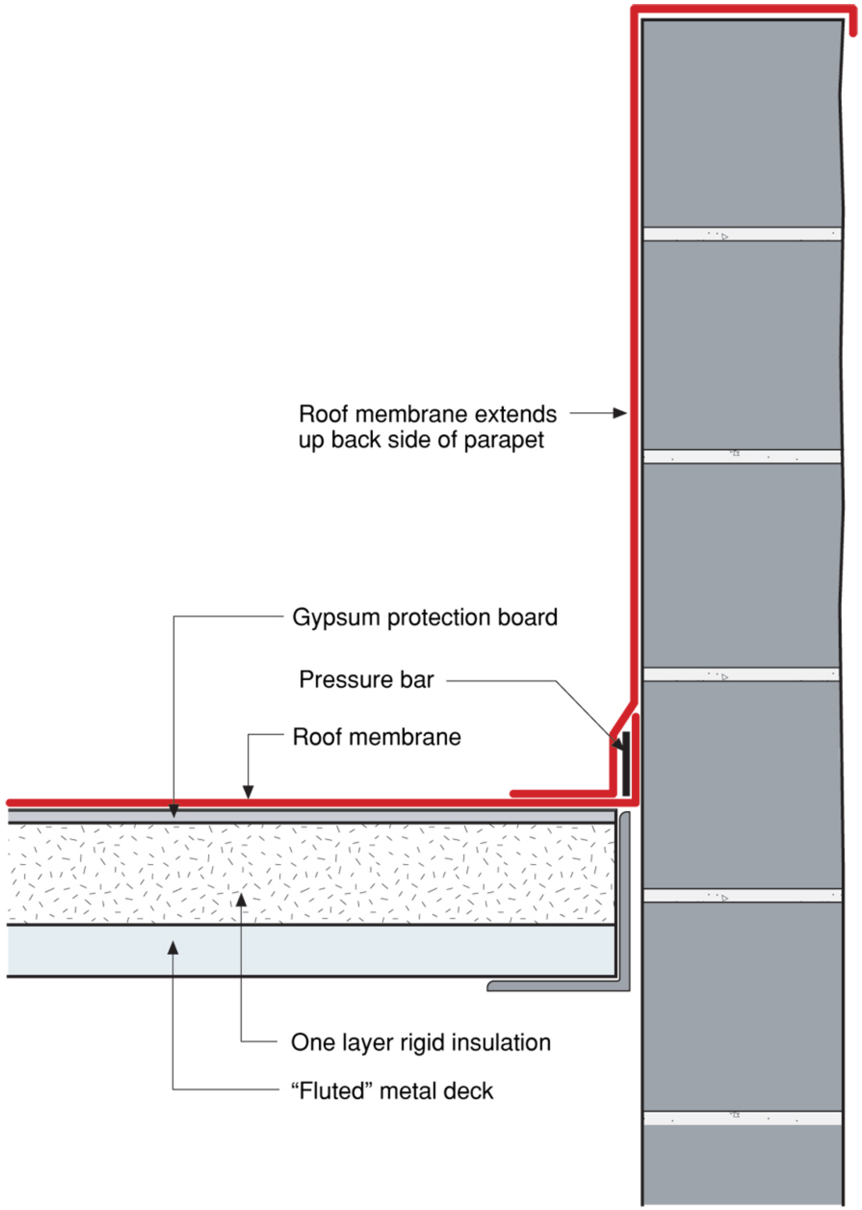
- Rain water is deposited on exterior face of masonry
- Rain water enters masonry through paint layer

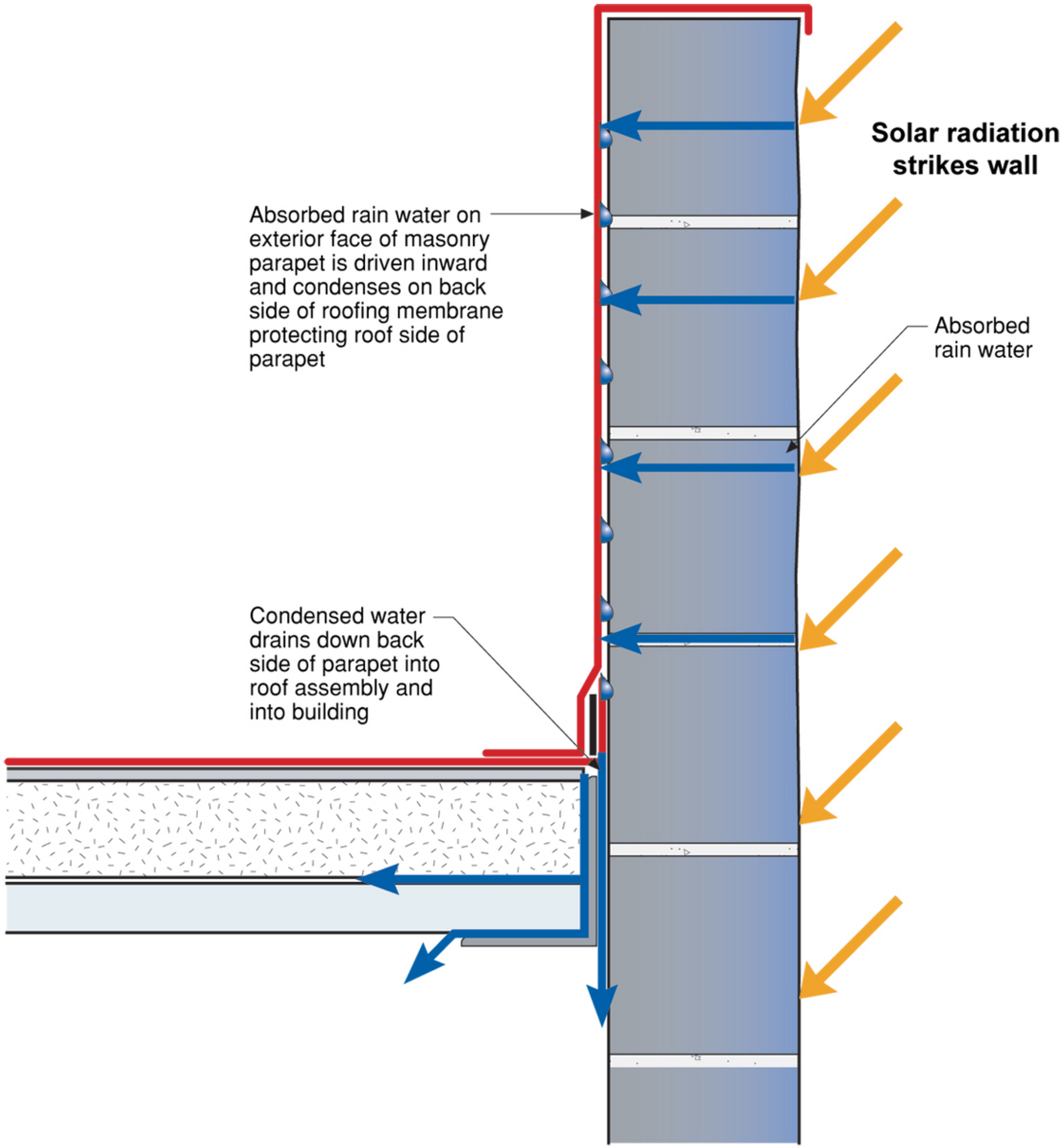


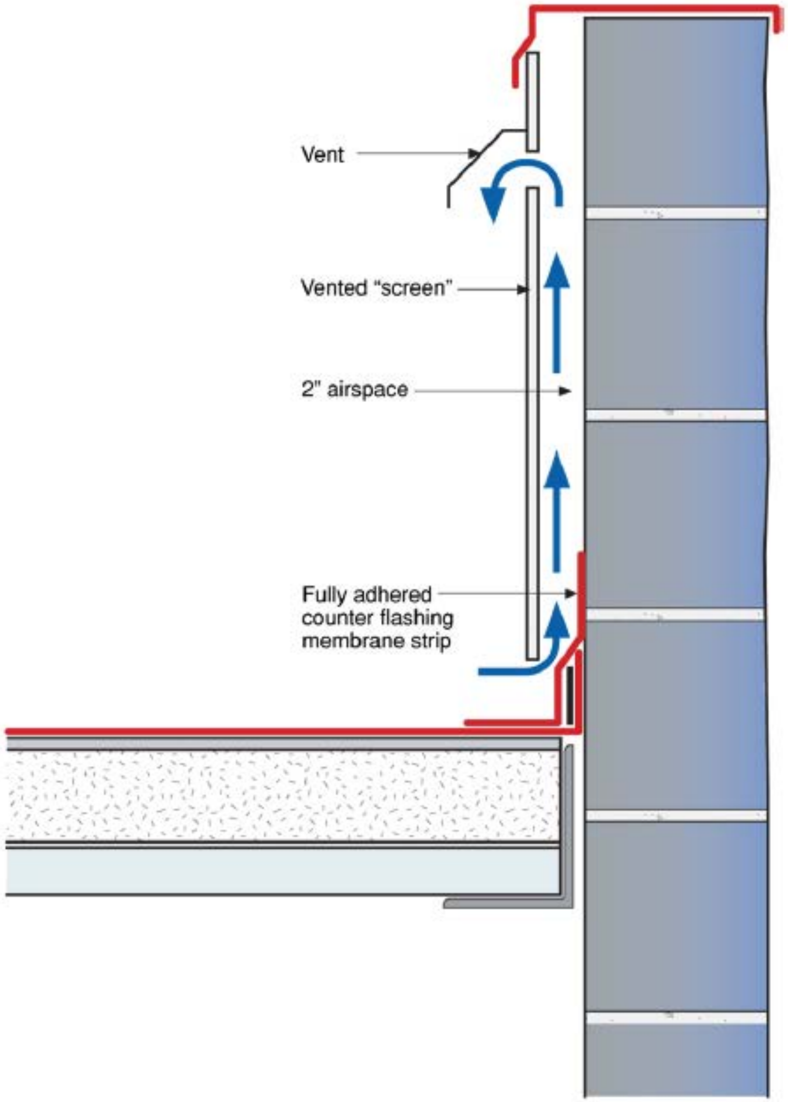
2.

- Solar radiation heats exterior while A/C cools interior
- Moisture is driven inward, condenses on foil vapor barrier and runs down wall


Acrylic latex paint layer (vapor open, minimum 15 perms or greater at 9 mils dry film thickness)
Expanded polystyrene (no facings)
Painted gypsum board (latex paint; no wall coverings)
Air space
Metal channels (EPS is continuous behind metal channels)


Roof membrane extends
up back side of parapet
Gypsum protection board
Pressure bar
Roof membrane
One layer rigid insulation
“Fluted” metal deck


Solar radiation strikes wall
Absorbed rain water on exterior face of masonry parapet is driven inward and condenses on back side of roofing membrane protecting roof side of parapet
Absorbed rain water
Condensed water drains down back side of parapet into roof assembly and into building


Vent
Vented "screen"
2" airspace
Fully adhered
counter flashing
membrane strip