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

Building Science

Adventures In Building Science

www.buildingscience.com

Unvented Attics…..

Unvented Attics…..

Dehumidification….

Unvented Attics…..

Dehumidification….30 year story…

Florida….1992

Florida….2022

West Palm Beach…

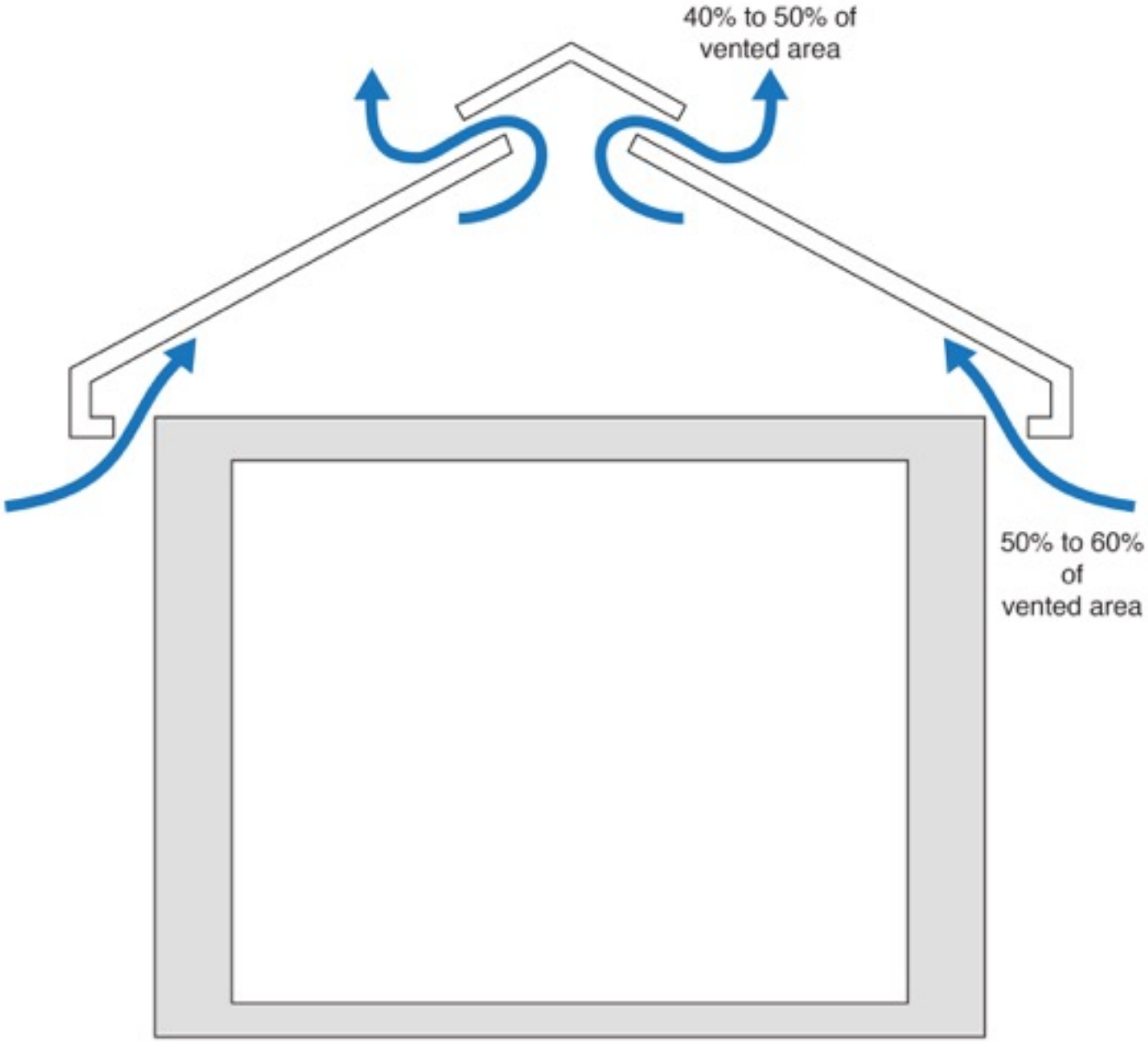
Las Vegas…..

Houston….

Juneau…..

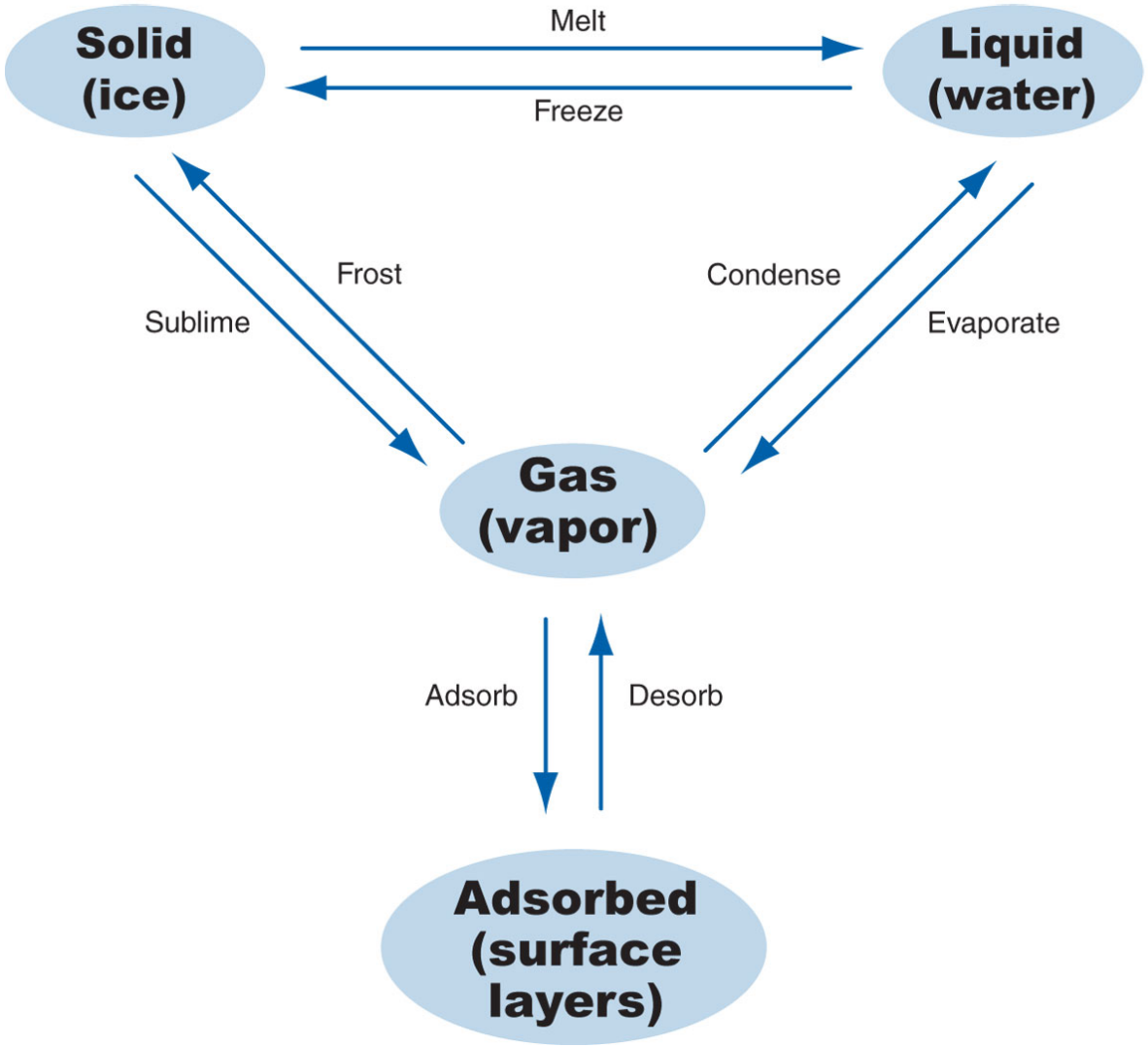
League City…

Ft. Myers…


40% to 50% of
vented area
50% to 60%
of
vented area

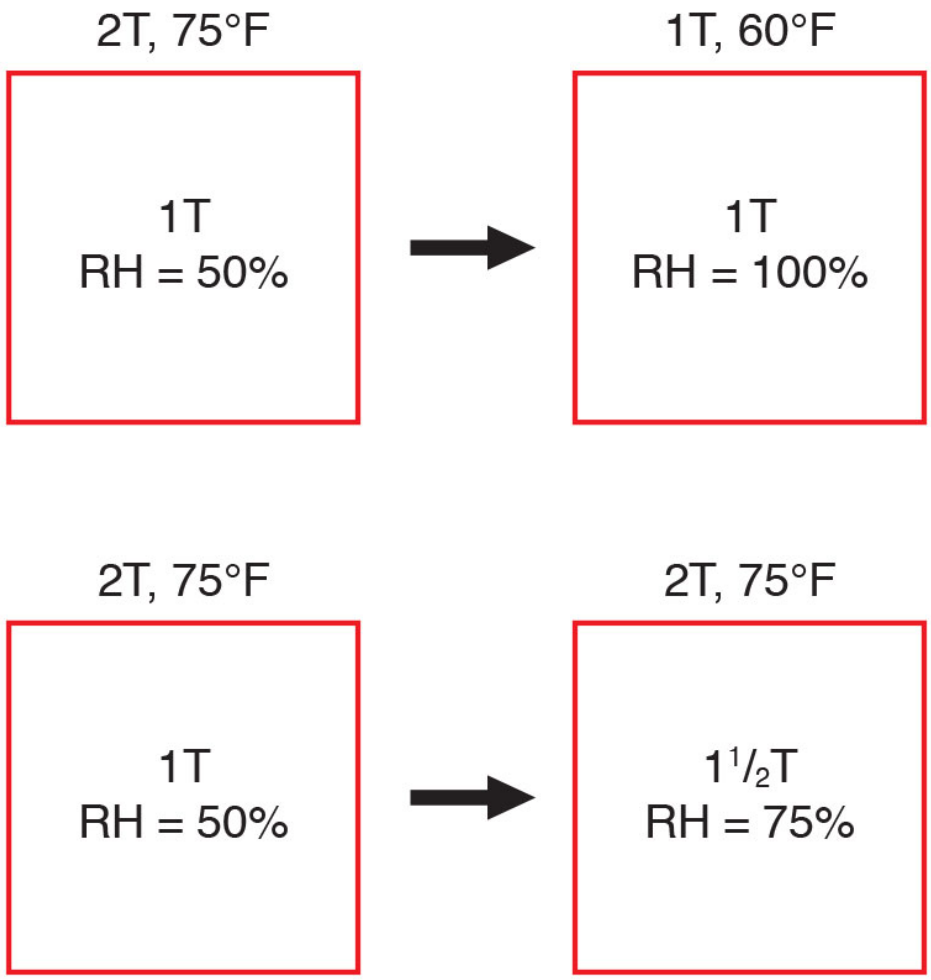
Houses With Vented Attics Get Wet…

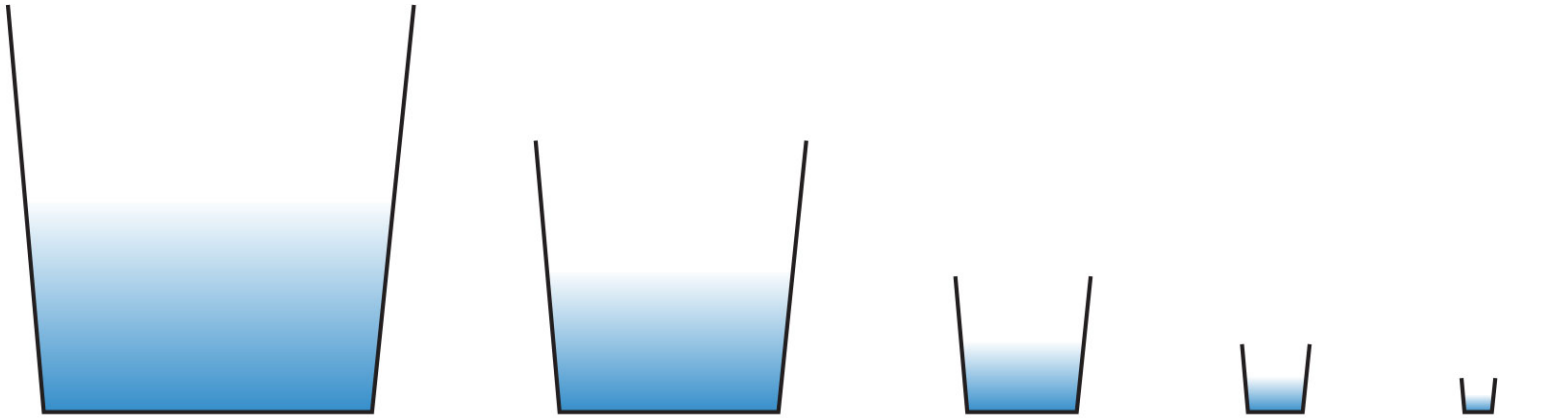
Everywhere…except Vegas….

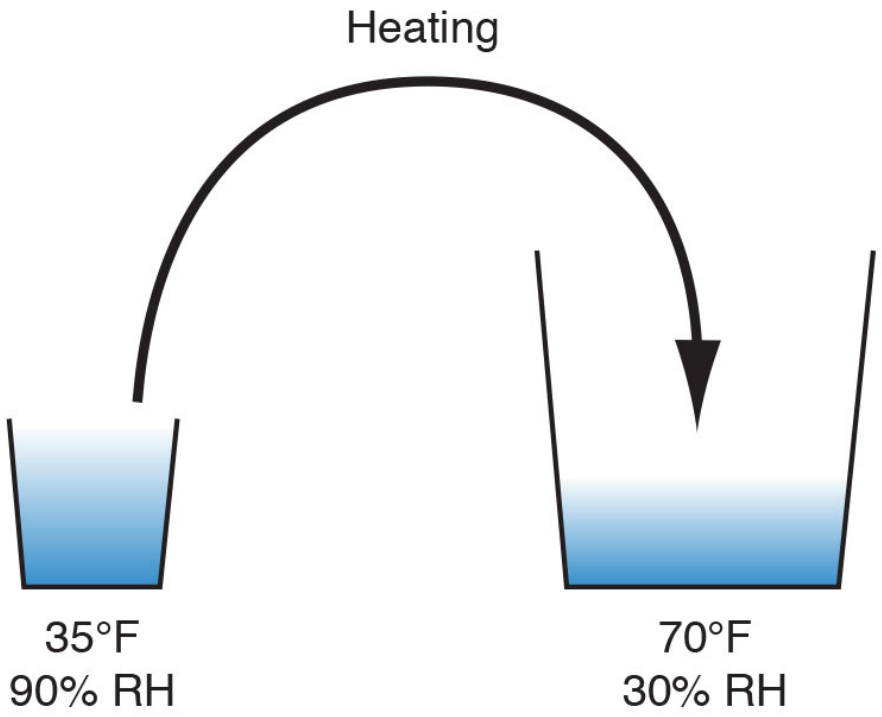

Solid (ice)
Melt
Freeze
Liquid (water)
Frost
Sublime
Condense
Evaporate
Gas (vapor)
Adsorb
Desorb
Adsorbed (surface layers)

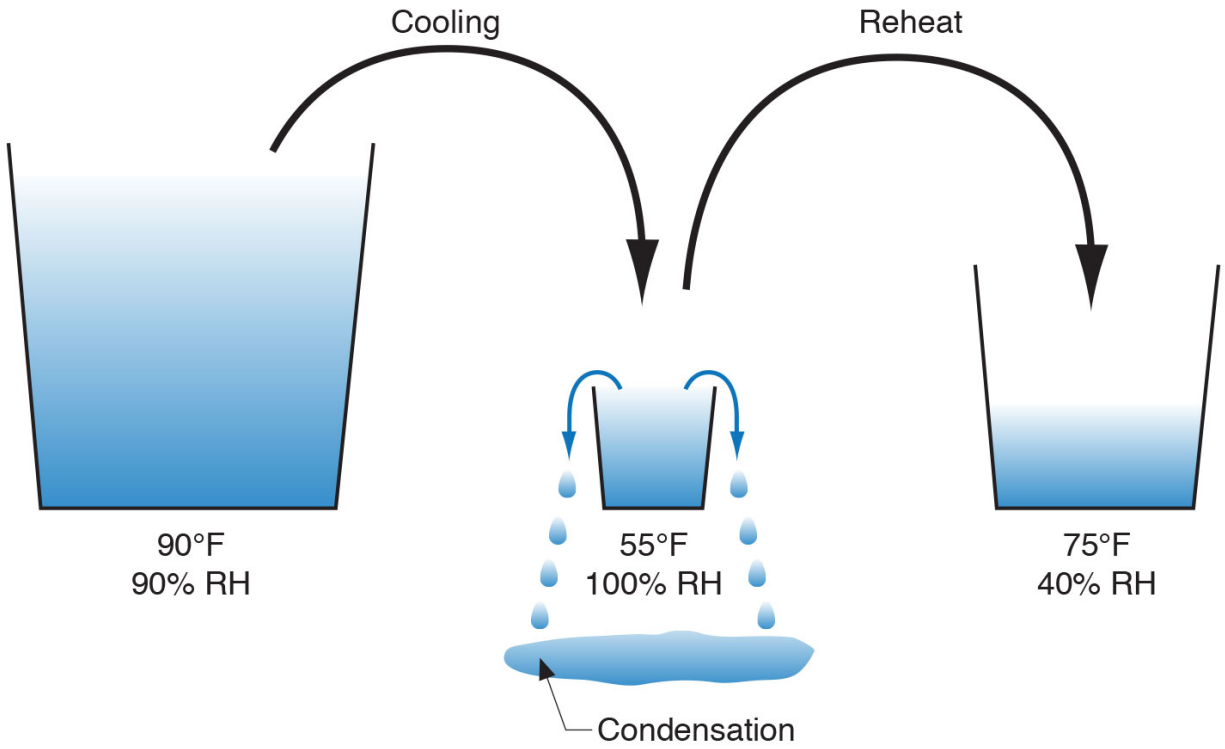
Relative Humidity

Vapor Pressure

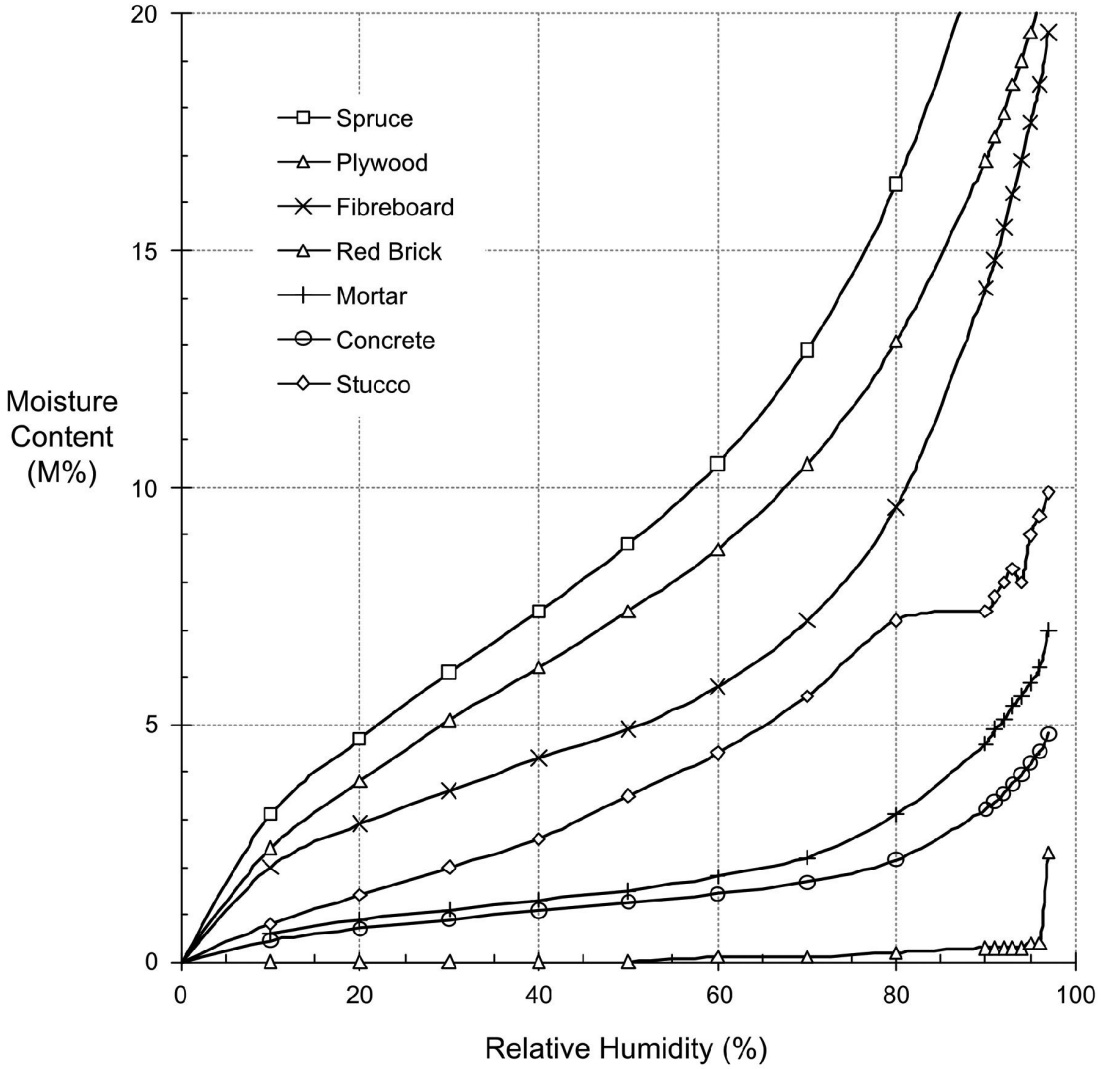

2T, 75°F
1T
RH = 50%
1T, 60°F
1T
RH = 100%
2T, 75°F
1T
RH = 50%
2T, 75°F
1 1/2T
RH = 75%


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

Sorption



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

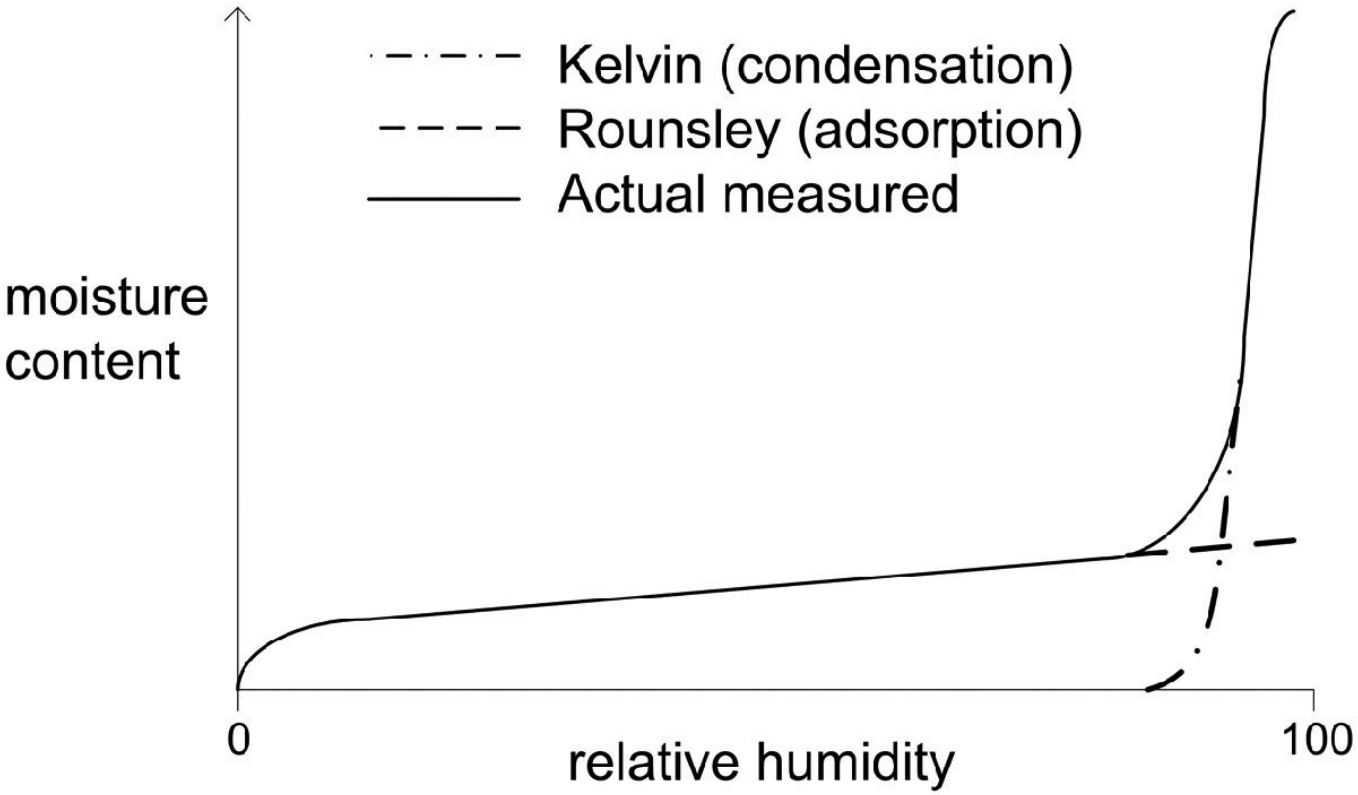
BET Theory

BET Theory

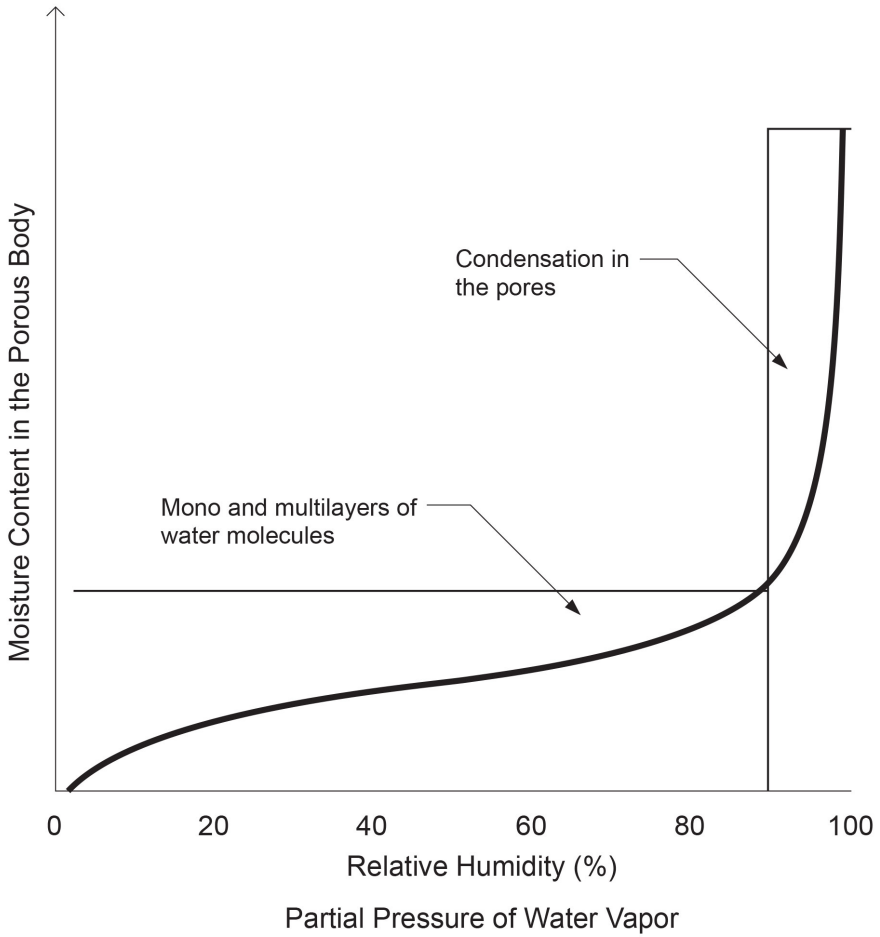
Stephen Brunauer

Paul Emmett

Edward Teller



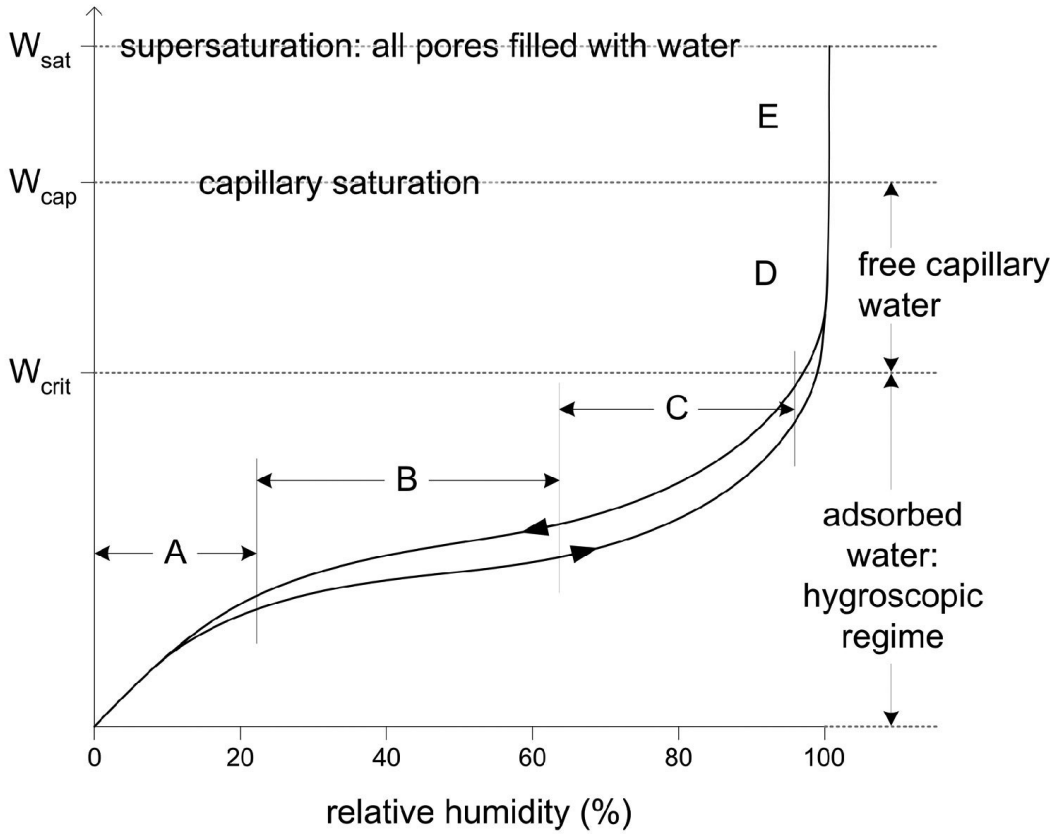
Typical predicted sorption isotherm according to Kelvin equation and modified BET theory
From Straube & Burnett, 2005



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.

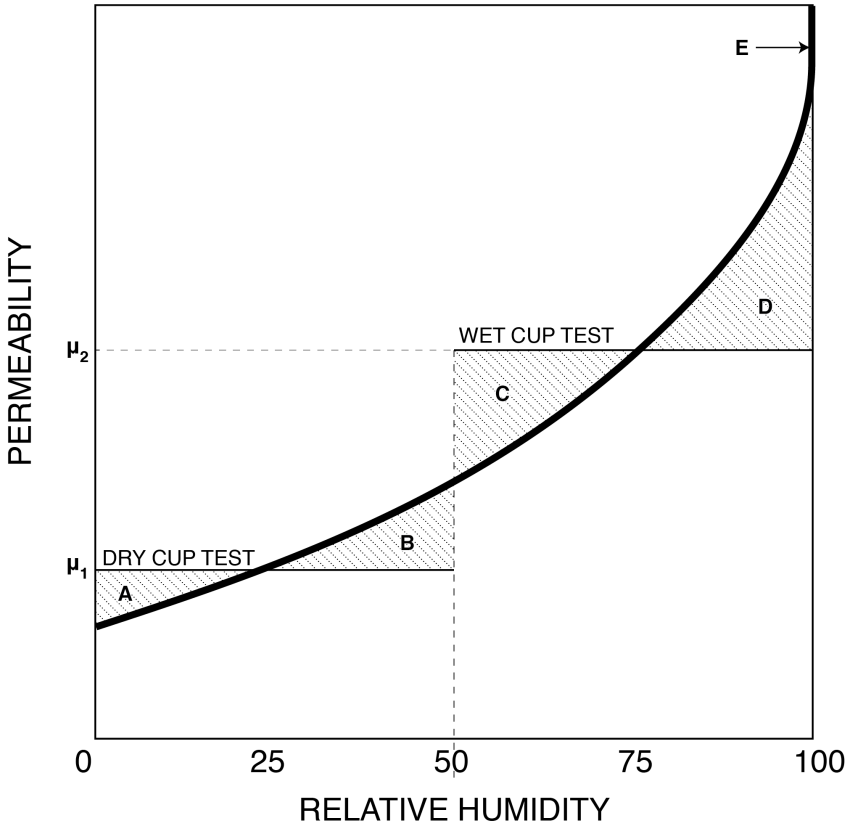
Sorption Curve

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

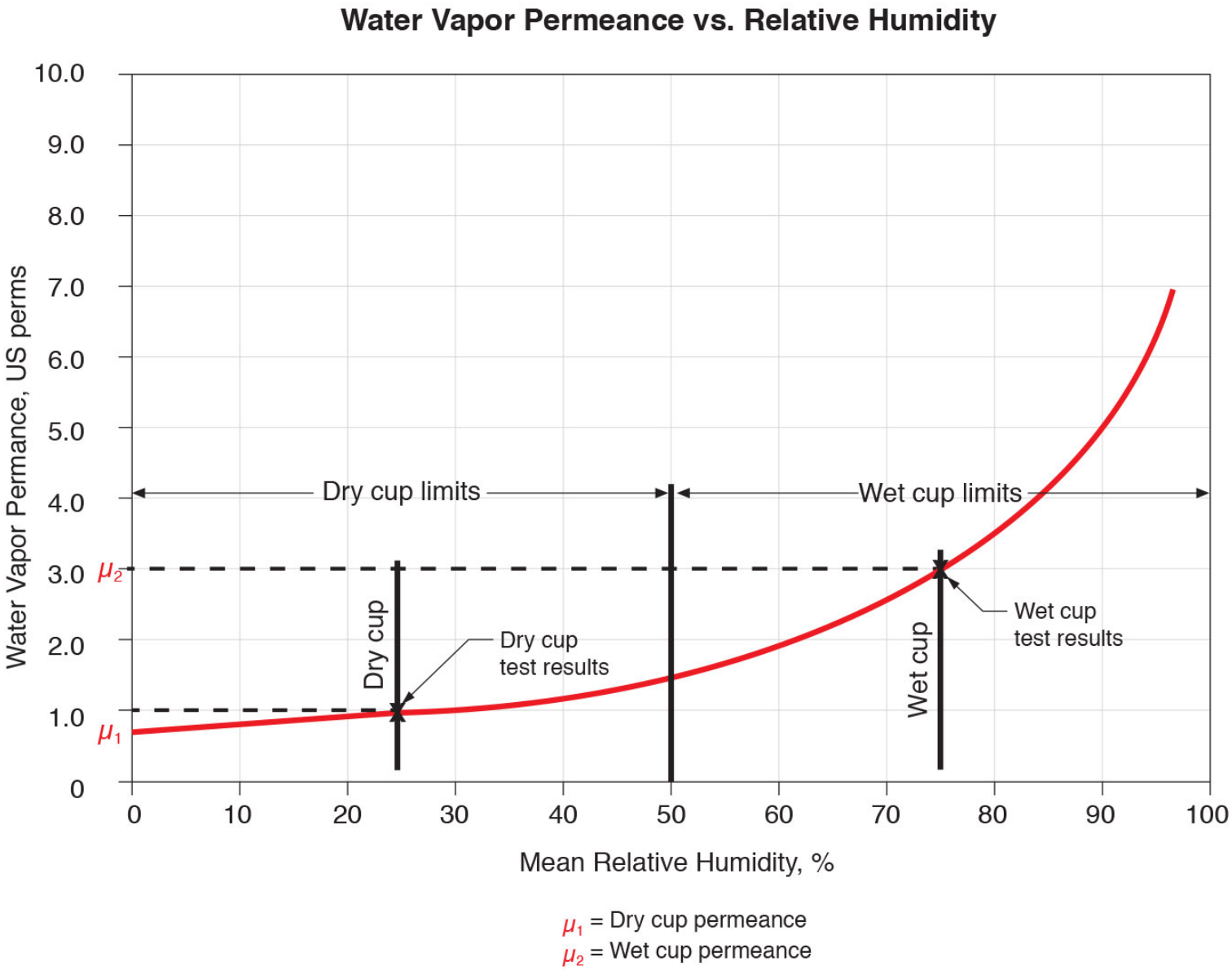
Regimes of moisture storage in a hygroscopic porous material
From Straube & Burnett, 2005

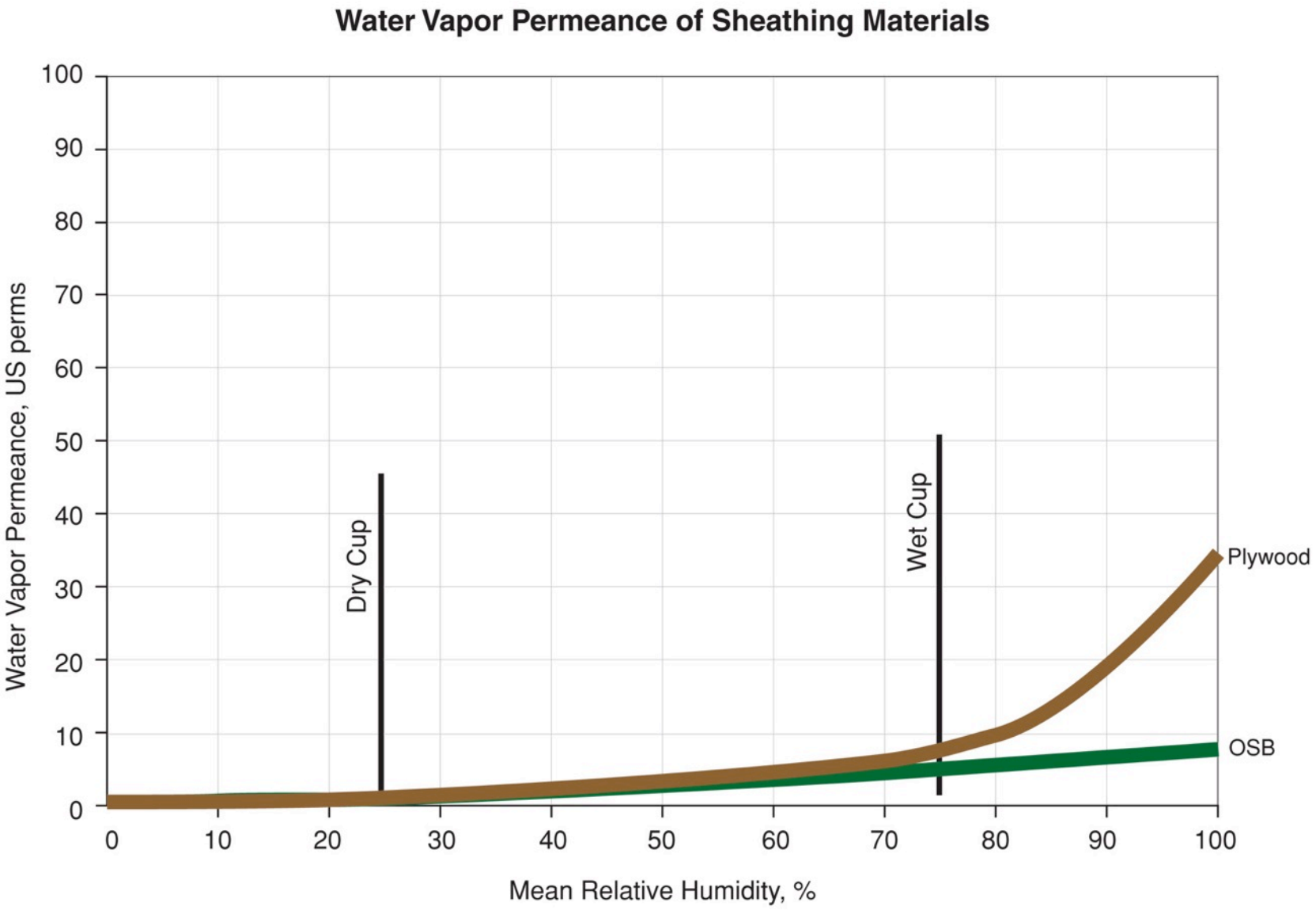


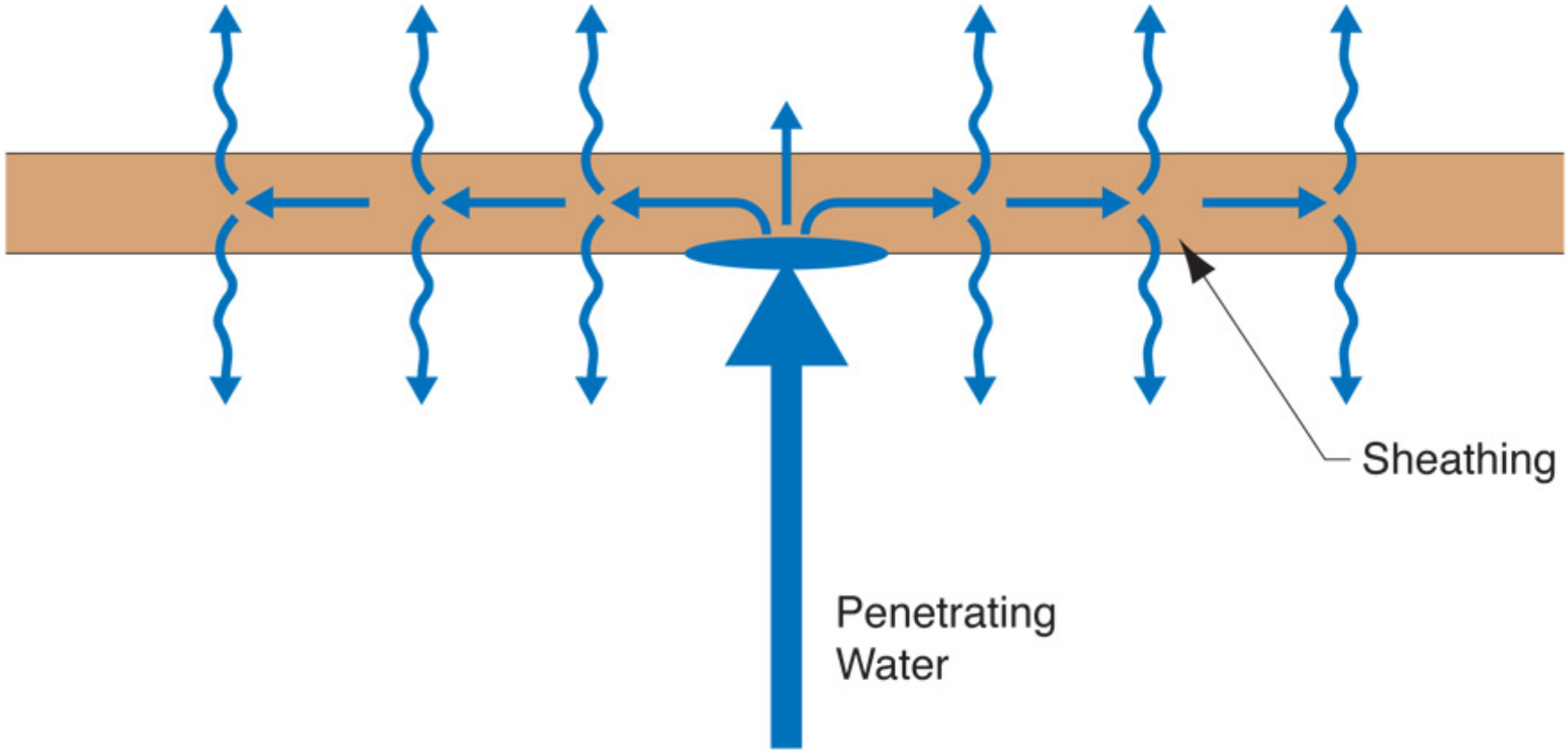
A - Single-layer of absorbed molecules
B - Multiple layers of absorbed molecules
C - Interconnected layers (internal capillary condensation)
D - Free water in pores, capillary suction
E - Supersaturated regime

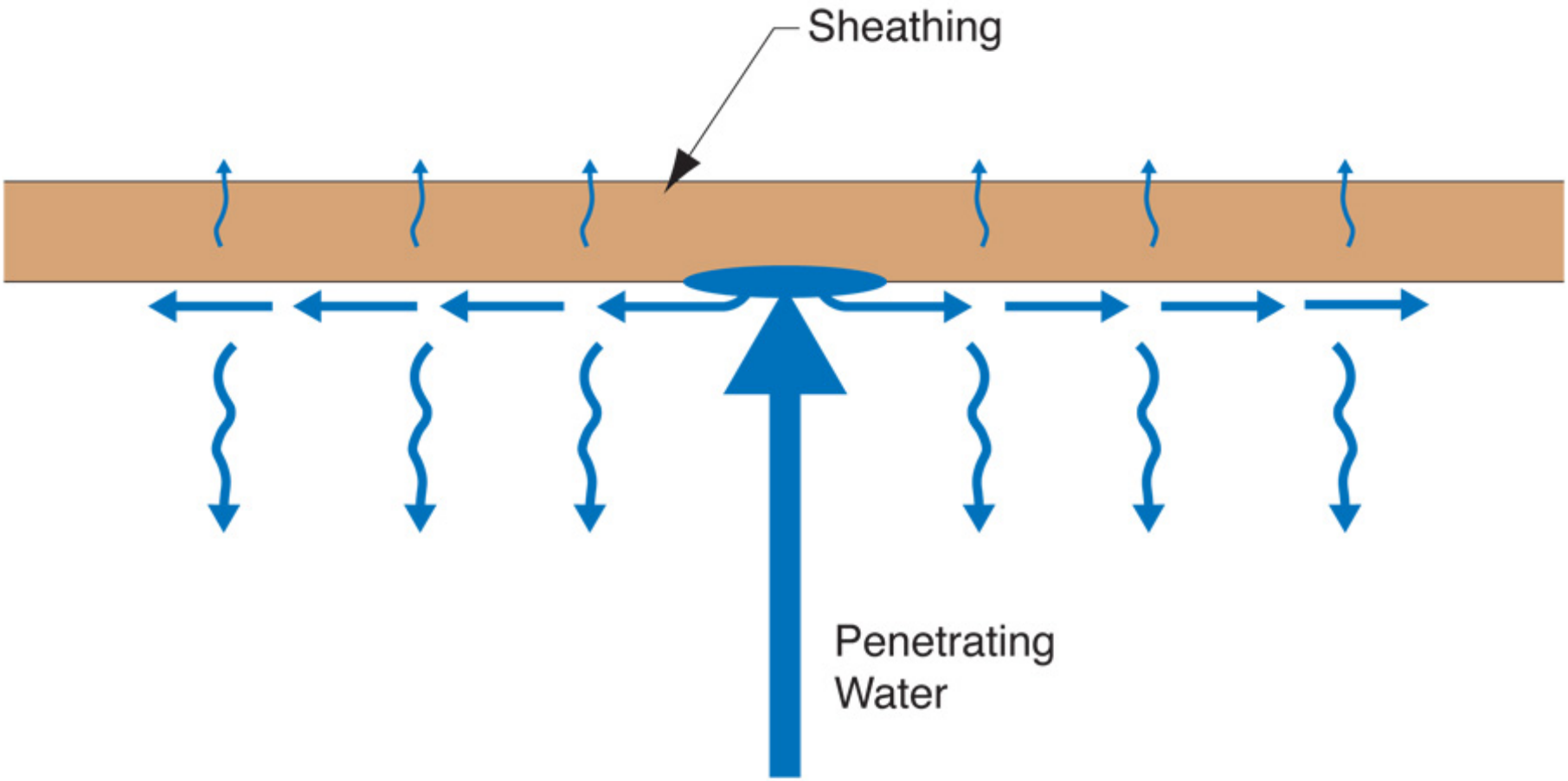
Relationship between Dry Cup and Wet Cup
Adapted from Joy & Wilson, 1963

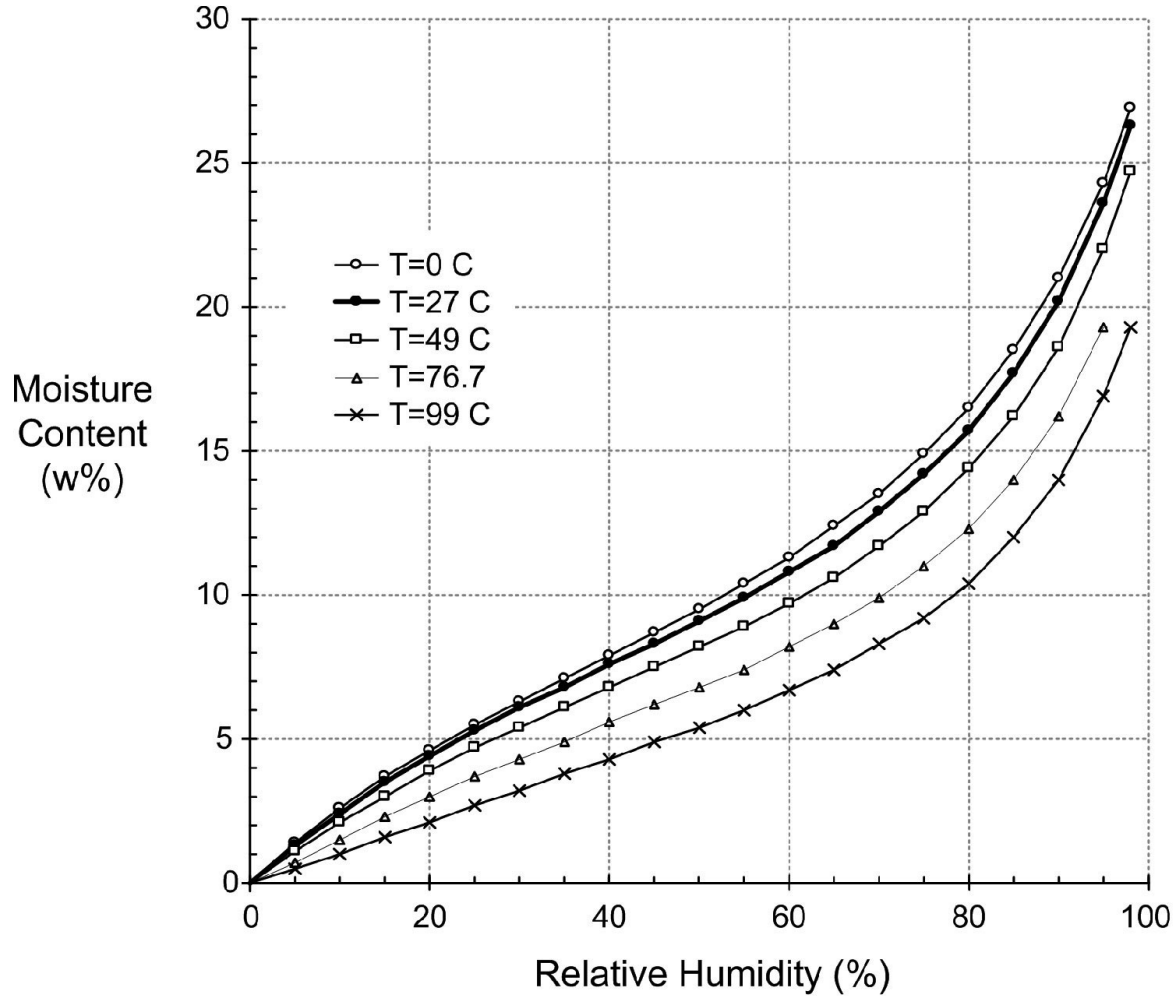

OWENS-CORNING
Fiberglas
Building
Insulation
FIBERGLAS
R-11
3½"
ASSURED THERMAL
PERFORMANCE
WARNING: The FACING on this insulation will BURN AND SHOULD NOT BE LEFT EXPOSED. Special care should be taken when working close to the facing.
C0206867702K


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
μ_2
μ_1
Dry cup limits
Wet cup limits
Dry cup
Dry cup
test results
Wet cup
Wet cup
test results
0
10
20
30
40
50
60
70
80
90
100
Mean Relative Humidity, %
μ_1 = Dry cup permeance
μ_2 = Wet cup permeance

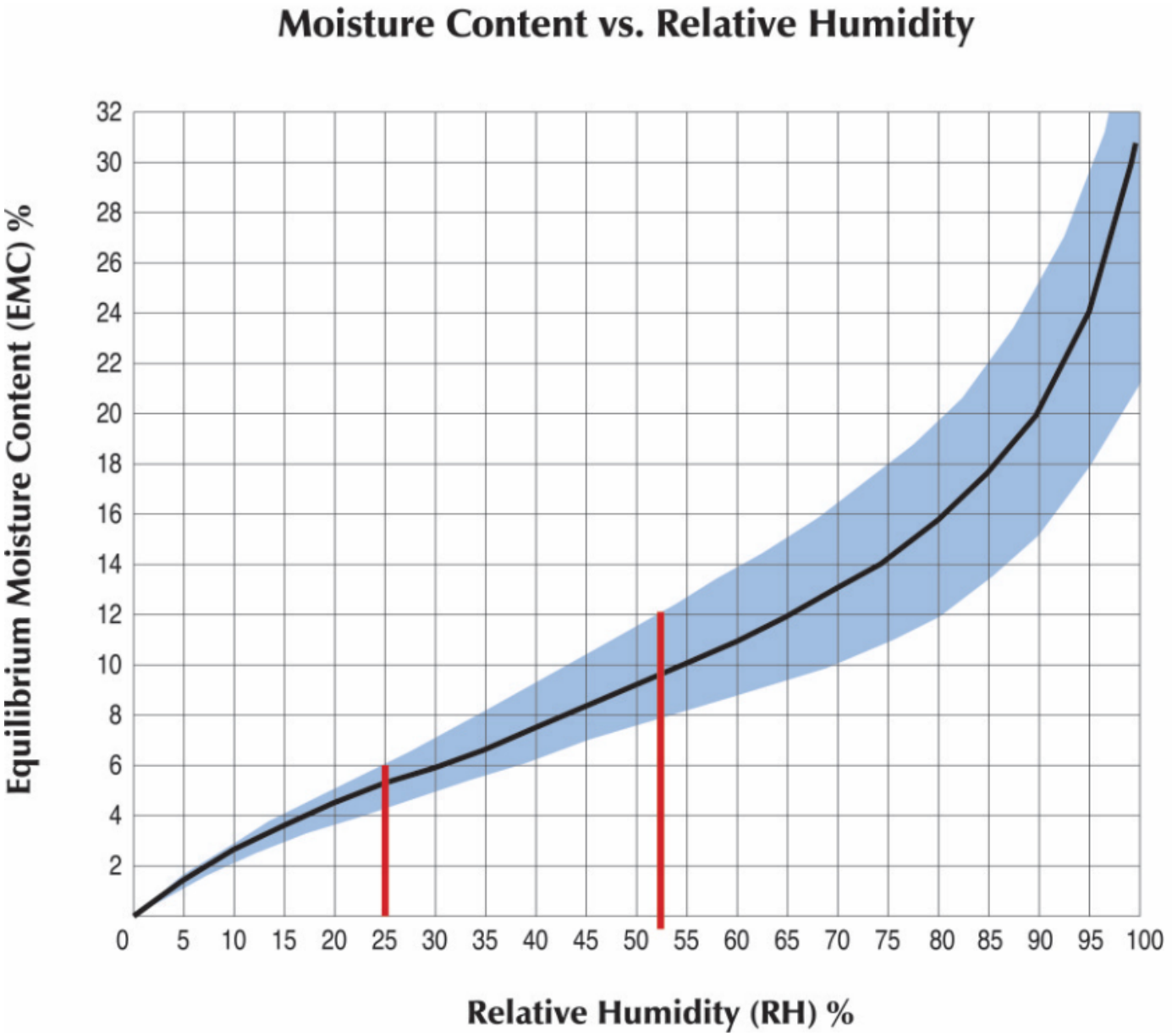

Water Vapor Permeance of Sheathing Materials
Water Vapor Permeance, US perms
100
90
80
70
60
50
40
30
20
10
0
Dry Cup
Wet Cup
Plywood
OSB
0
10
20
30
40
50
60
70
80
90
100
Mean Relative Humidity, %

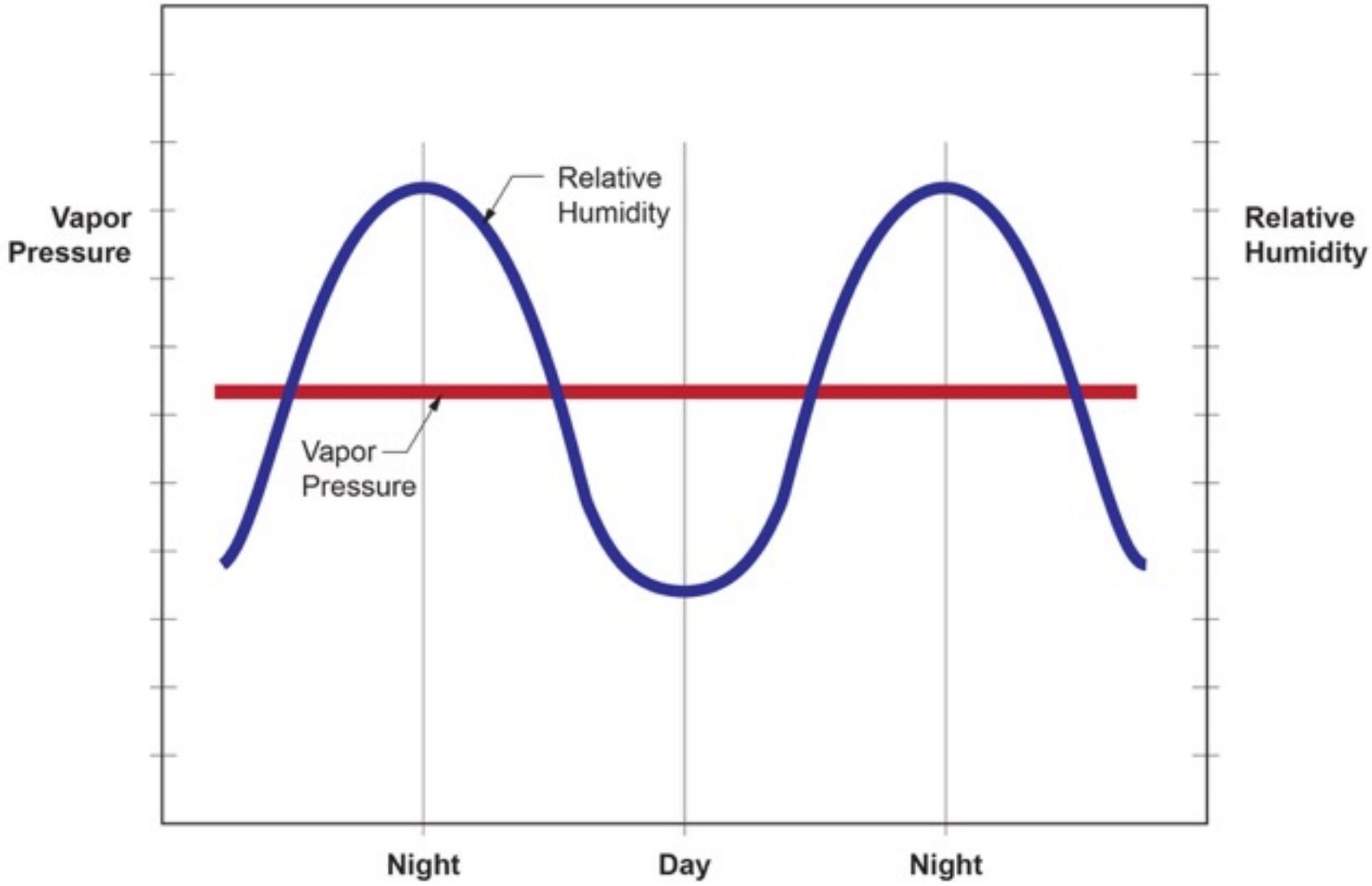

Sheathing
Penetrating
Water


Sheathing
Penetrating
Water



Average sorption isotherm for wood as a function of temperature
From Straube & Burnett, 2005

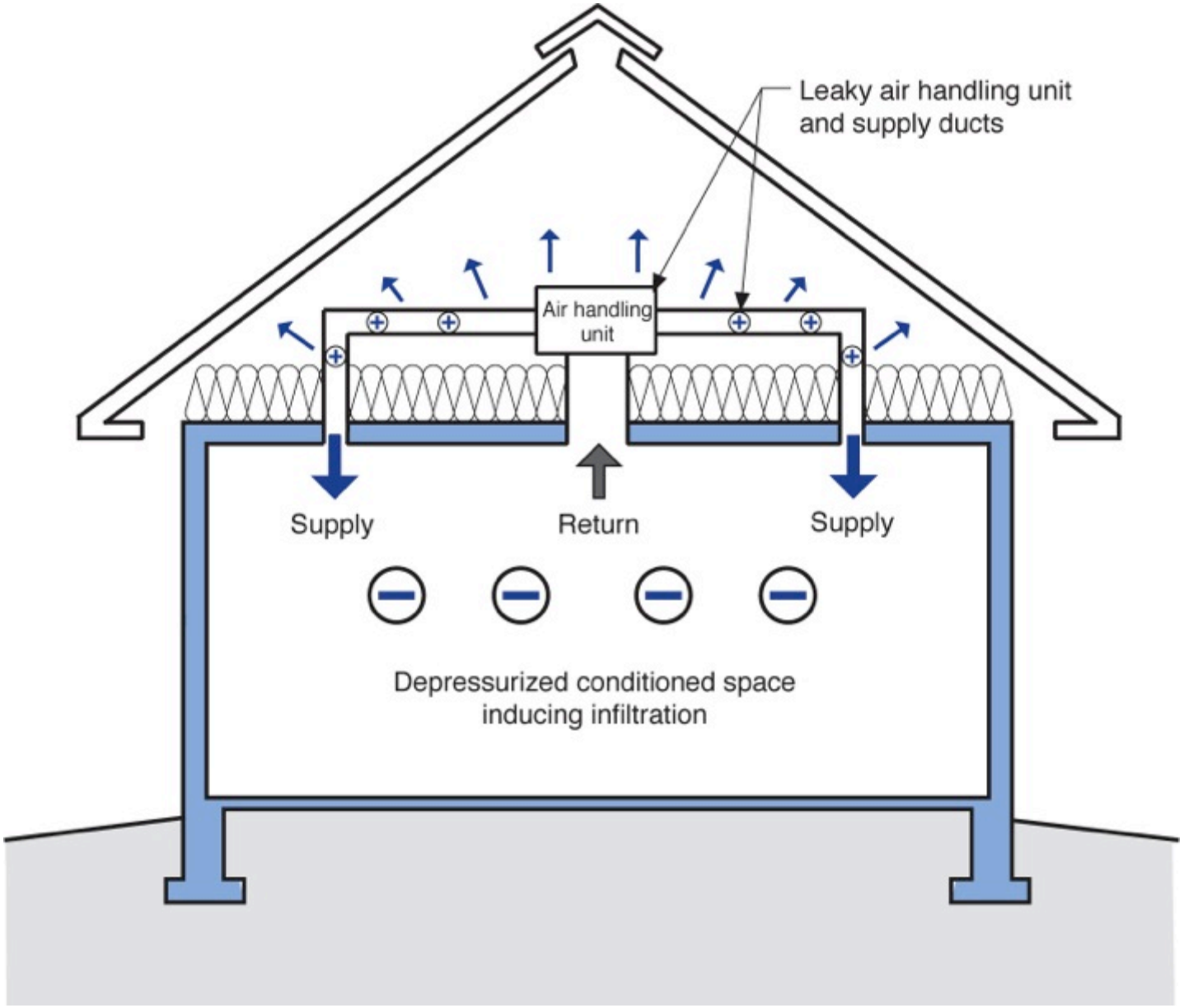

Moisture Content vs. Relative Humidity
Equilibrium Moisture Content (EMC) %
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Relative Humidity (RH) %

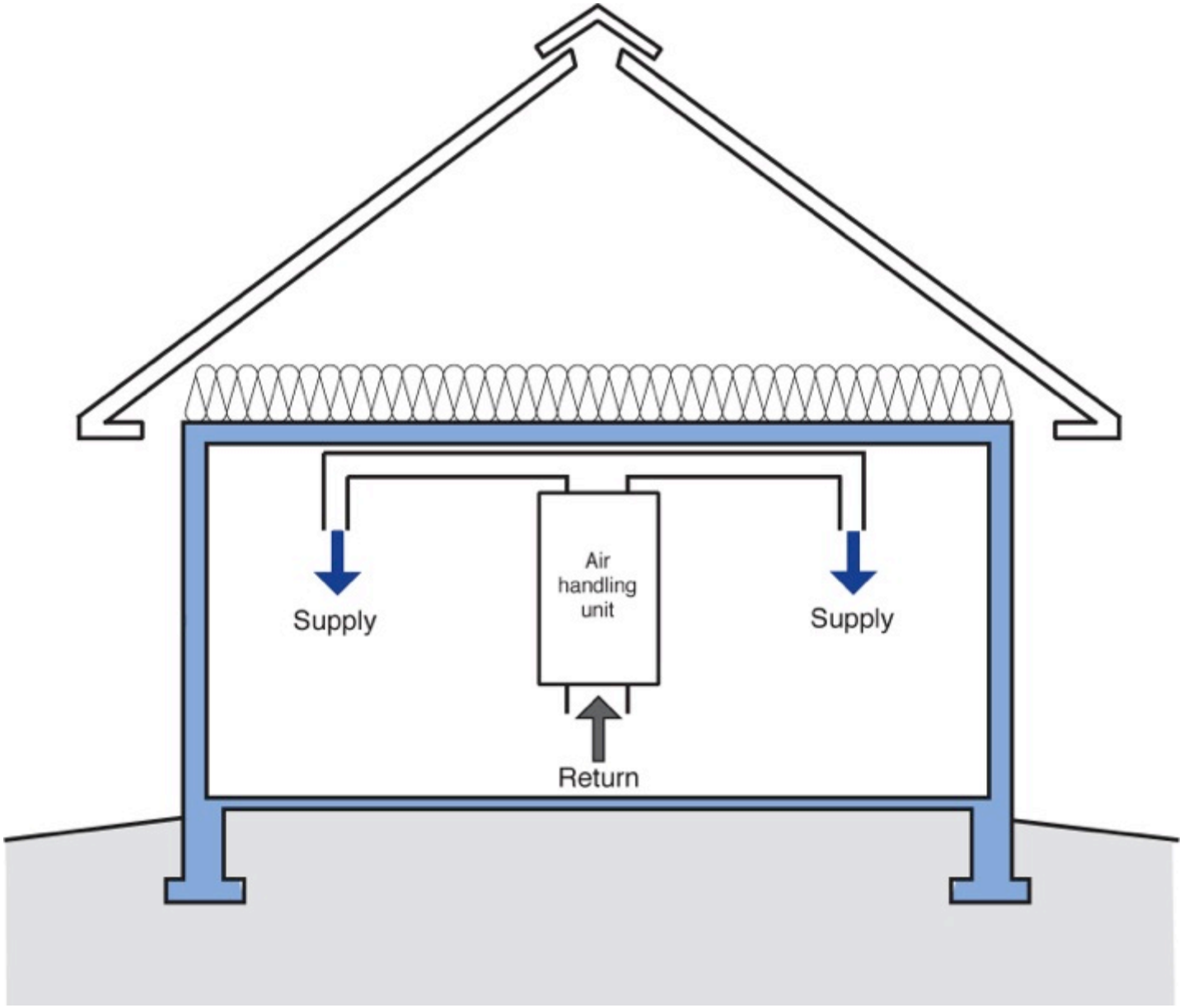

Vapor Pressure
Relative Humidity
Relative Humidity
Vapor Pressure
Night
Day
Night

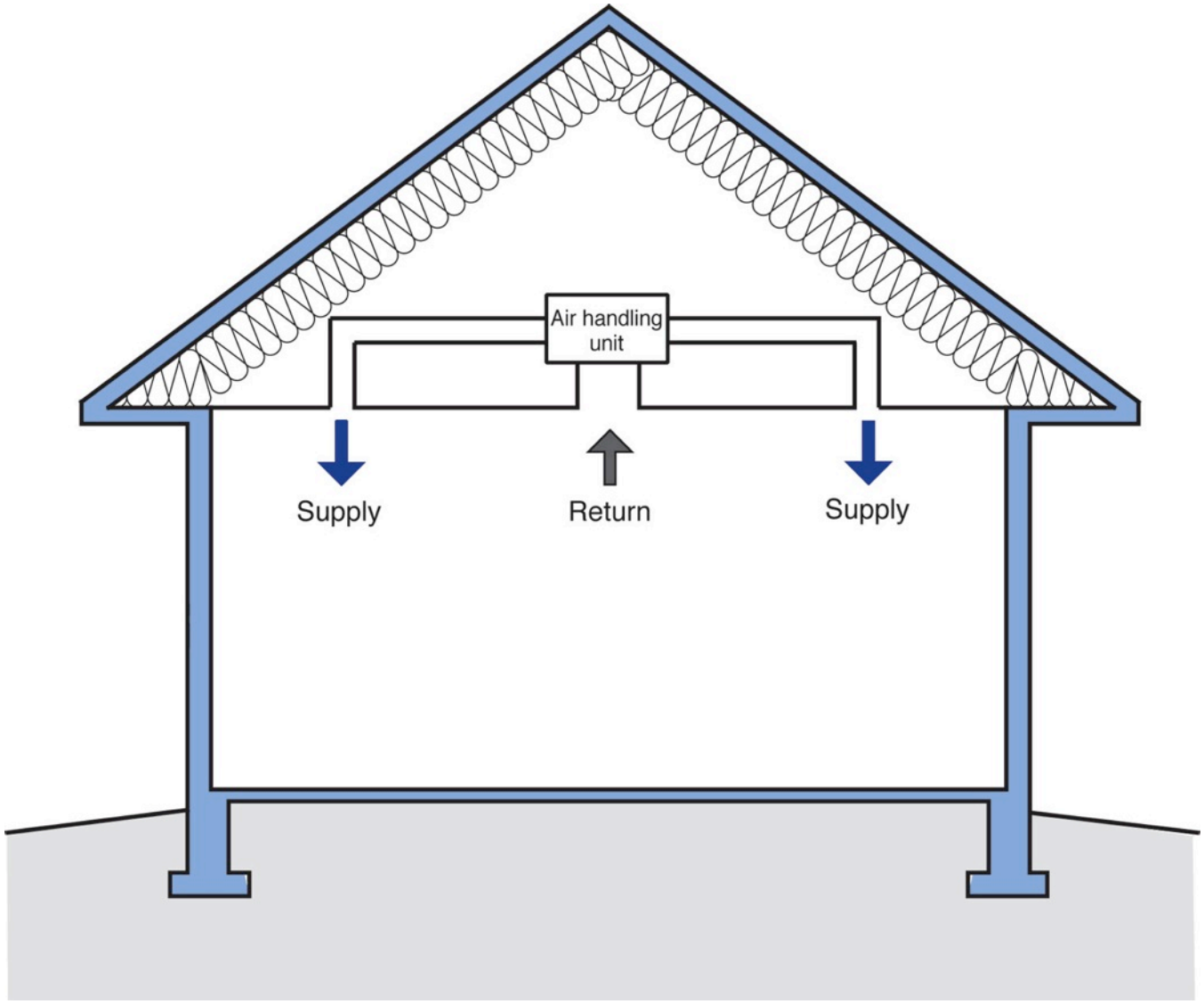
Houses With Vented Attics Suck

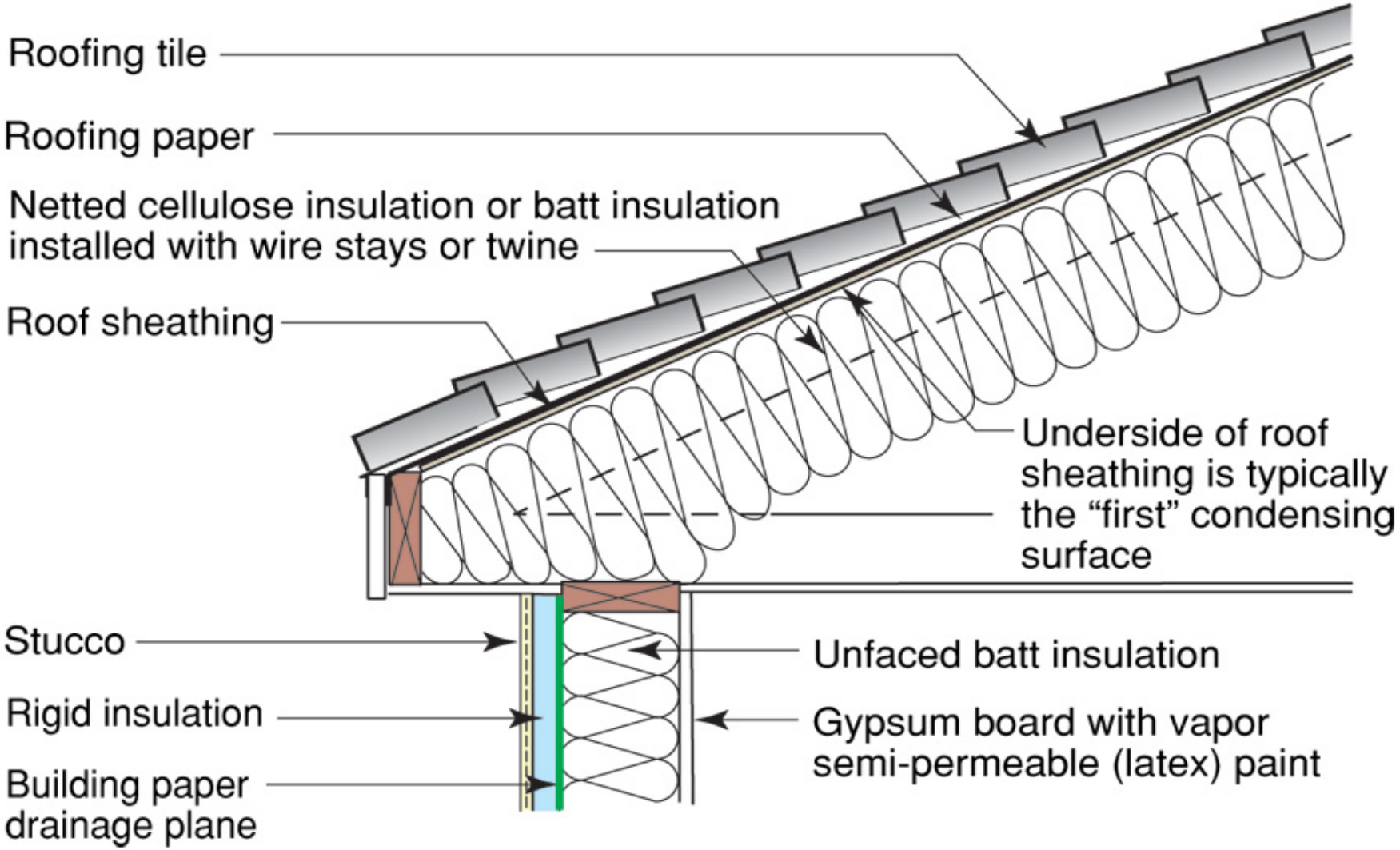
Houses With Vented Attics Suck

Not all the Time…..but.....


Leaky air handling unit
and supply ducts
Air handling
unit
Supply
Return
Supply
Depressurized conditioned space
inducing infiltration

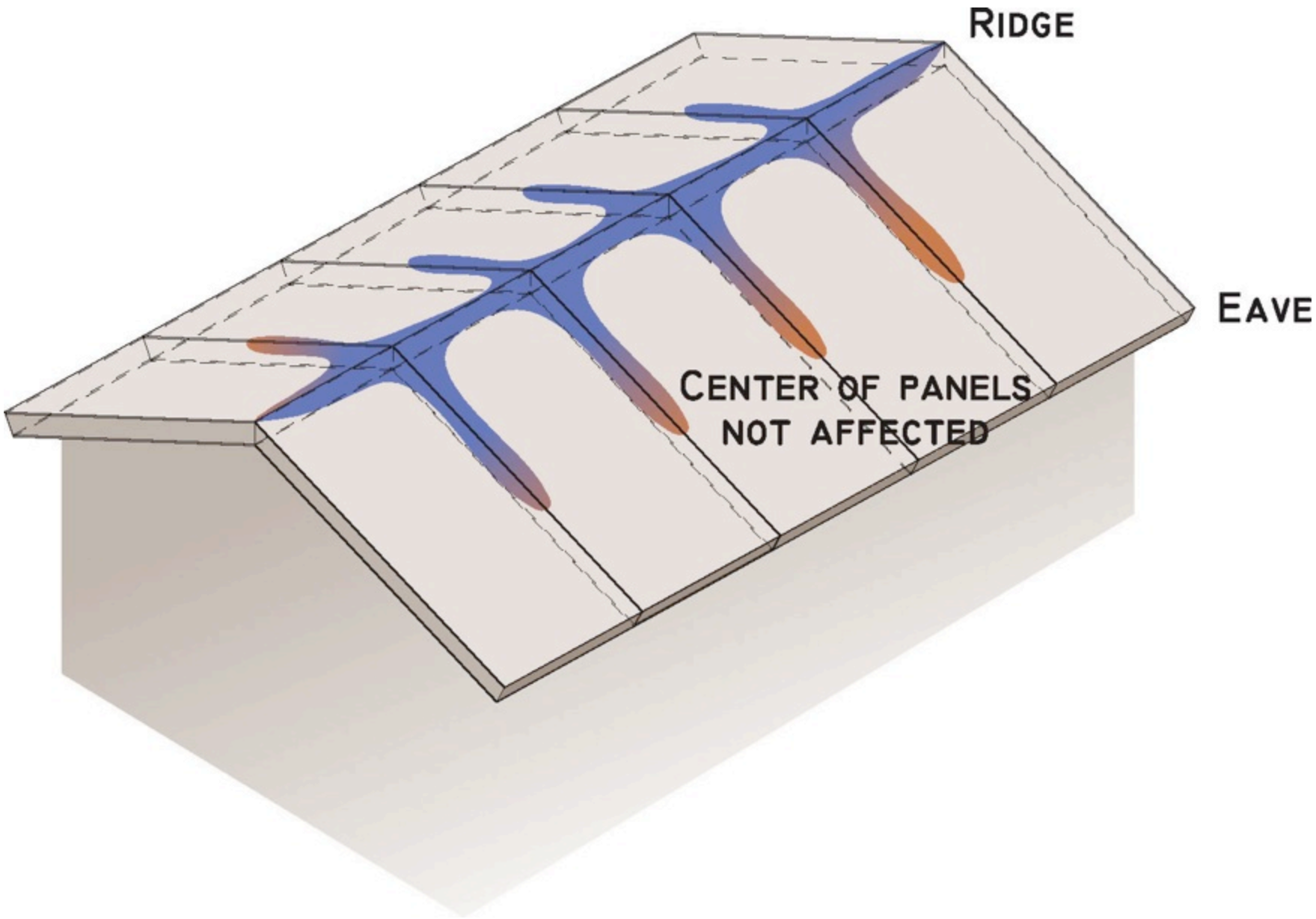

Supply
Air handling unit
Supply
Return


Air handling unit
Supply
Return
Supply

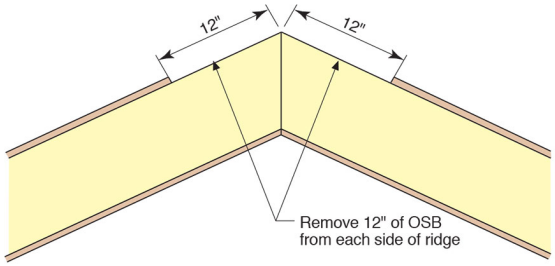

Roofing tile
Roofing paper
Netted cellulose insulation or batt insulation installed with wire stays or twine
Roof sheathing
Underside of roof sheathing is typically the "first" condensing surface
Stucco
Rigid insulation
Building paper drainage plane
Unfaced batt insulation
Gypsum board with vapor semi-permeable (latex) paint


APR 20 2004

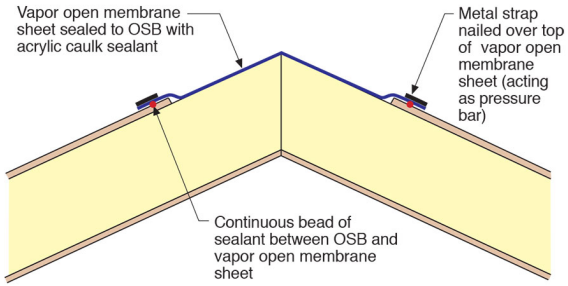

8/22/01 09:32


RIDGE
EAVE
CENTER OF PANELS
NOT AFFECTED

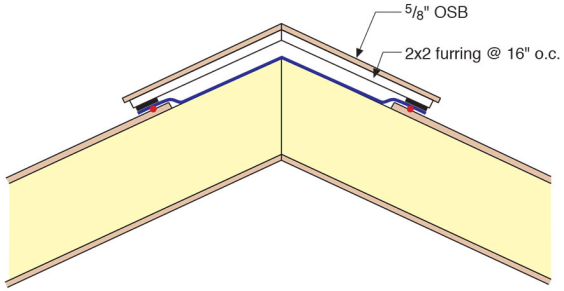
Step 1
- Remove strip of OSB from each side of ridge



Step 2
- Create air seal with strip of vapor open membrane (tape seams)
- Vapor open membrane sheet sealed to OSB with acrylic caulk sealant
- Hold vapor open membrane sheet in place with metal strapping



Step 3
- Construct wood ridge vent with 2x2 furring

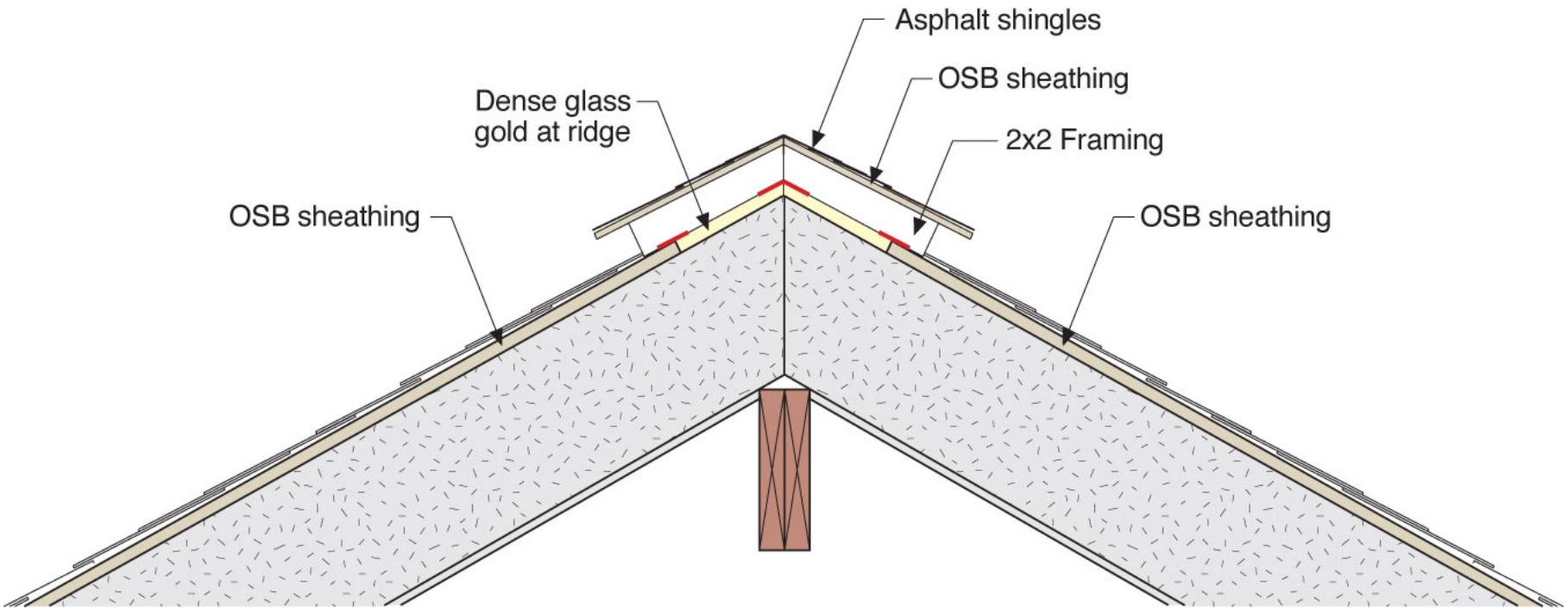



GRACE
Ice & Water Shield
Tyvek
DuPont
Attic Wrap


Tyvek
AtticWrap


GRACE
Ice & Water Shield®


JUL 9 2006


Asphalt shingles
OSB sheathing
Dense glass
gold at ridge
2x2 Framing
OSB sheathing
OSB sheathing

Hygric Buoyancy

Components in Dry Air	Volume Ratio compared to Dry Air	Molecular Mass - *M* *(kg/kmol)*	Molecular Mass in Air
Oxygen	0.2095	32.00	6.704
Nitrogen	0.7809	28.02	21.88
Carbon Dioxide	0.0003	44.01	0.013
Hydrogen	0.0000005	2.02	0
Argon	0.00933	39.94	0.373
Neon	0.000018	20.18	0
Helium	0.000005	4.00	0
Krypton	0.000001	83.8	0
Xenon	$0.09\ 10^{-6}$	131.29	0
Total Molecular Mass of Air			28.97

Components in Dry Air	Volume Ratio compared to Dry Air	Molecular Mass - *M* *(kg/kmol)*	Molecular Mass in Air
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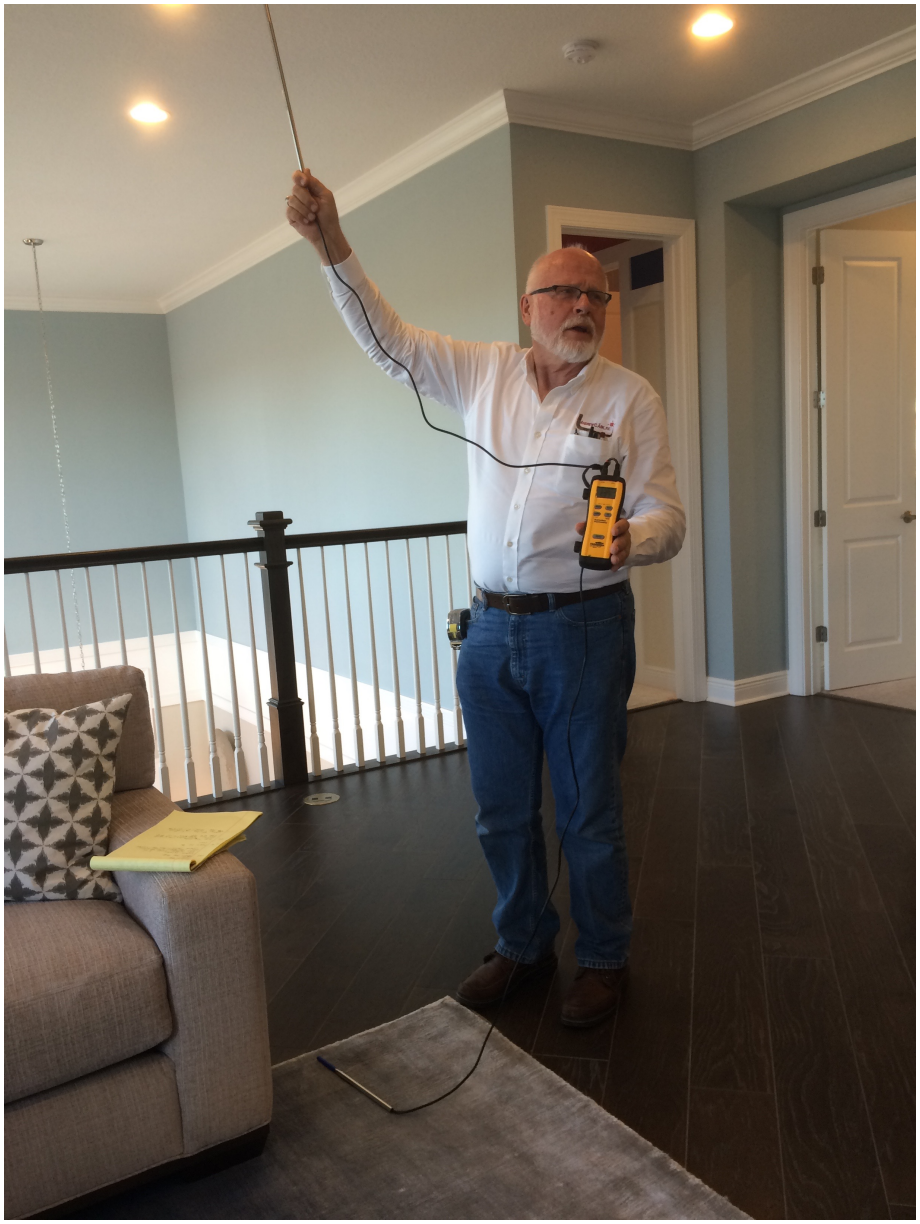
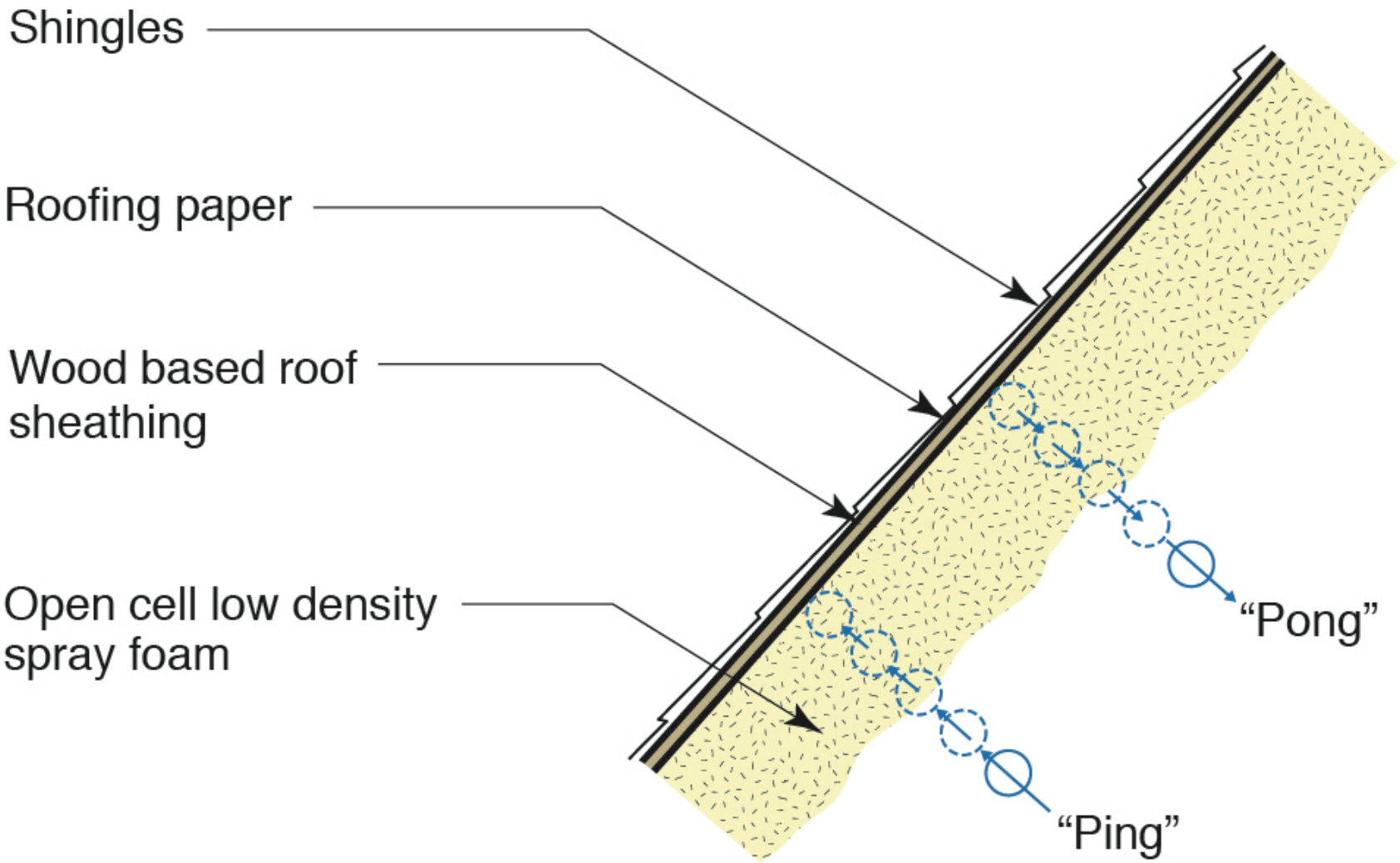
Helium	0.000005	4.00	0
Krypton	0.000001	83.8	0
Xenon	$0.09\ 10^{-6}$	131.29	0
Total Molecular Mass of Air			28.97

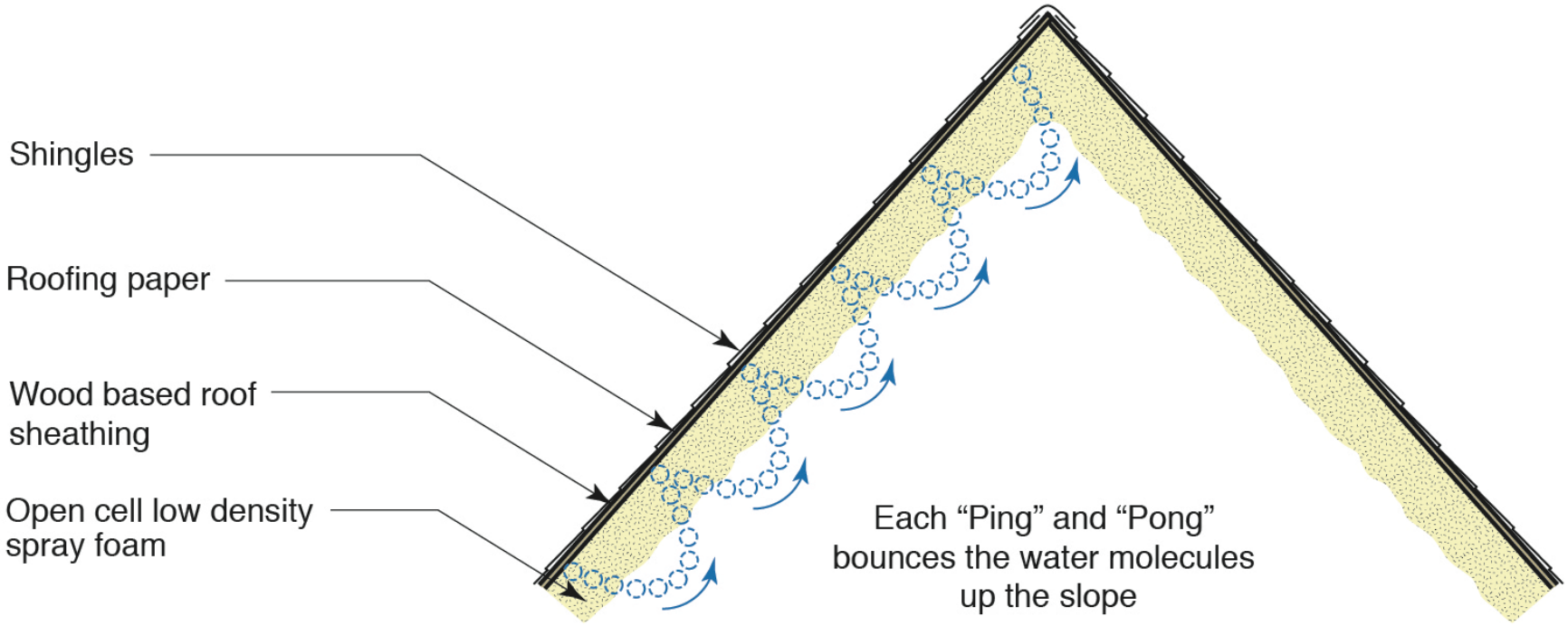
Note Water Vapor (H2O) is 18

Dry Air is 29




RETURN
SUPPLY
55.4
53.1
PARAM
SYNC
H/Δ/M/M
AUTO-OFF
PRESS FOR 1 SECOND
Dual In-Duct Psychrometer
TEET/ΔT
Fieldpiece
SDP2


Shingles
Roofing paper
Wood based roof sheathing
Open cell low density spray foam
"Pong"
"Ping"


Shingles
Roofing paper
Wood based roof sheathing
Open cell low density spray foam
Each “Ping” and “Pong” bounces the water molecules up the slope

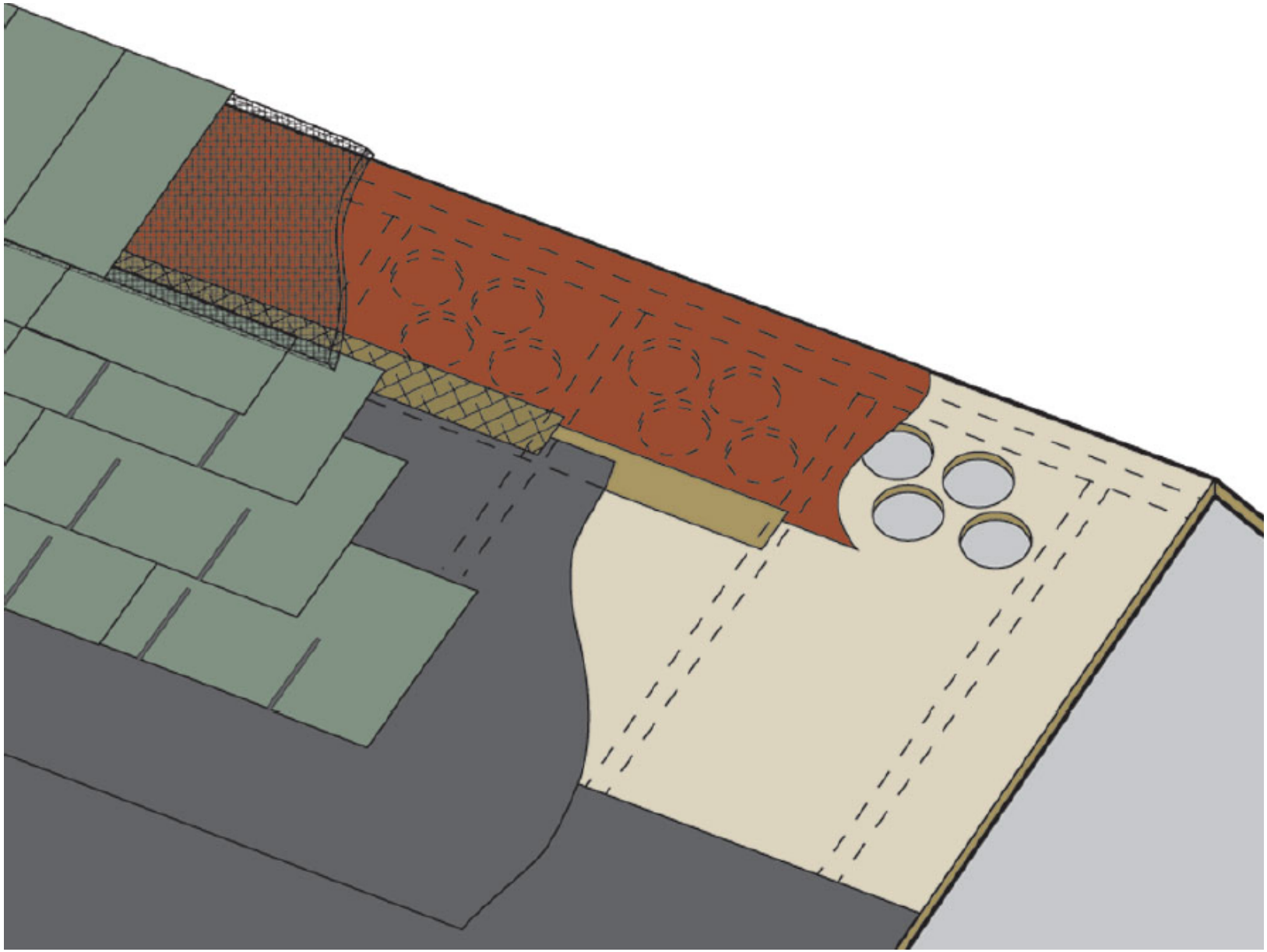
Conditioned Attics Not Unvented Attics

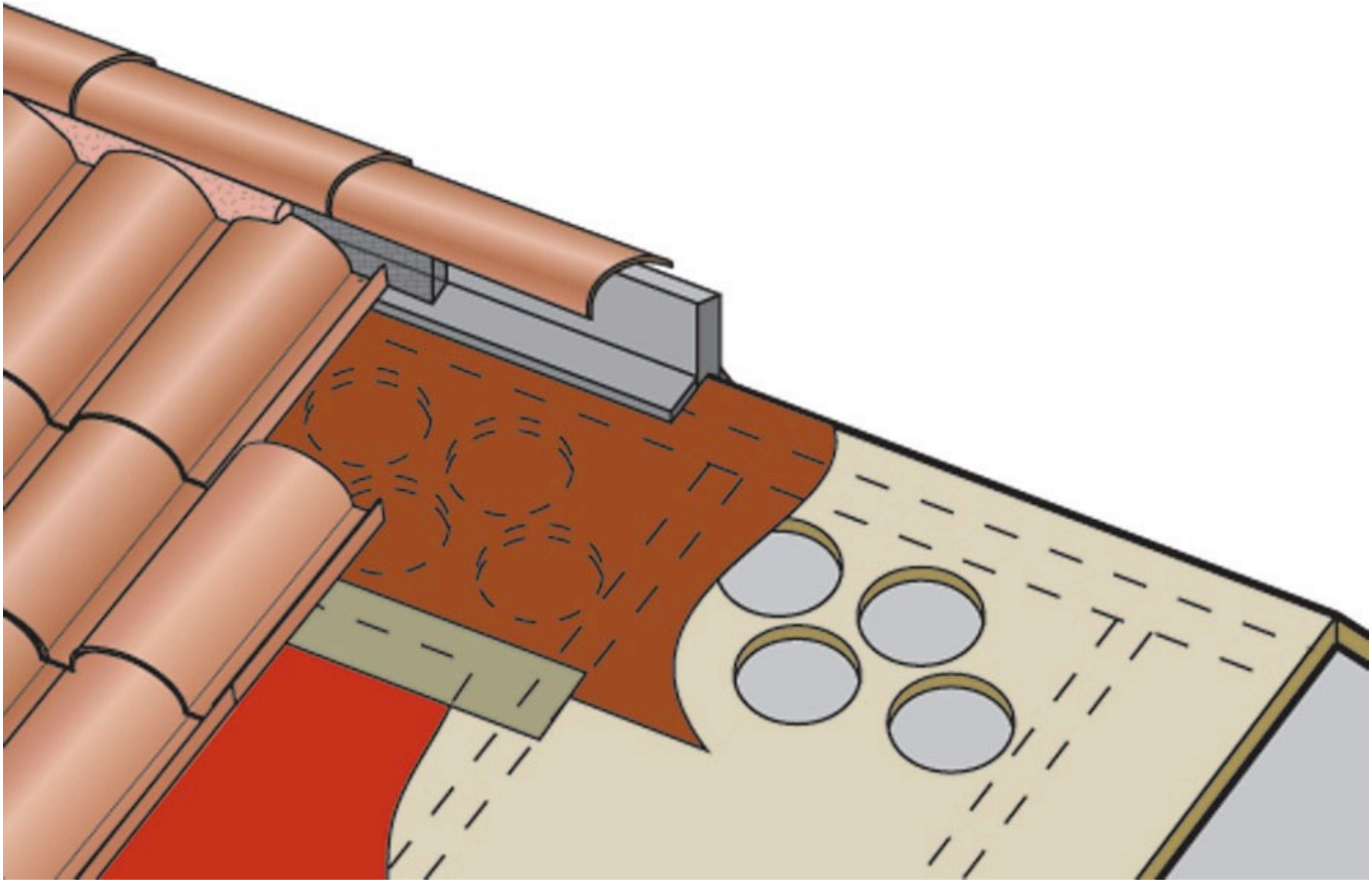
Need Supply Air

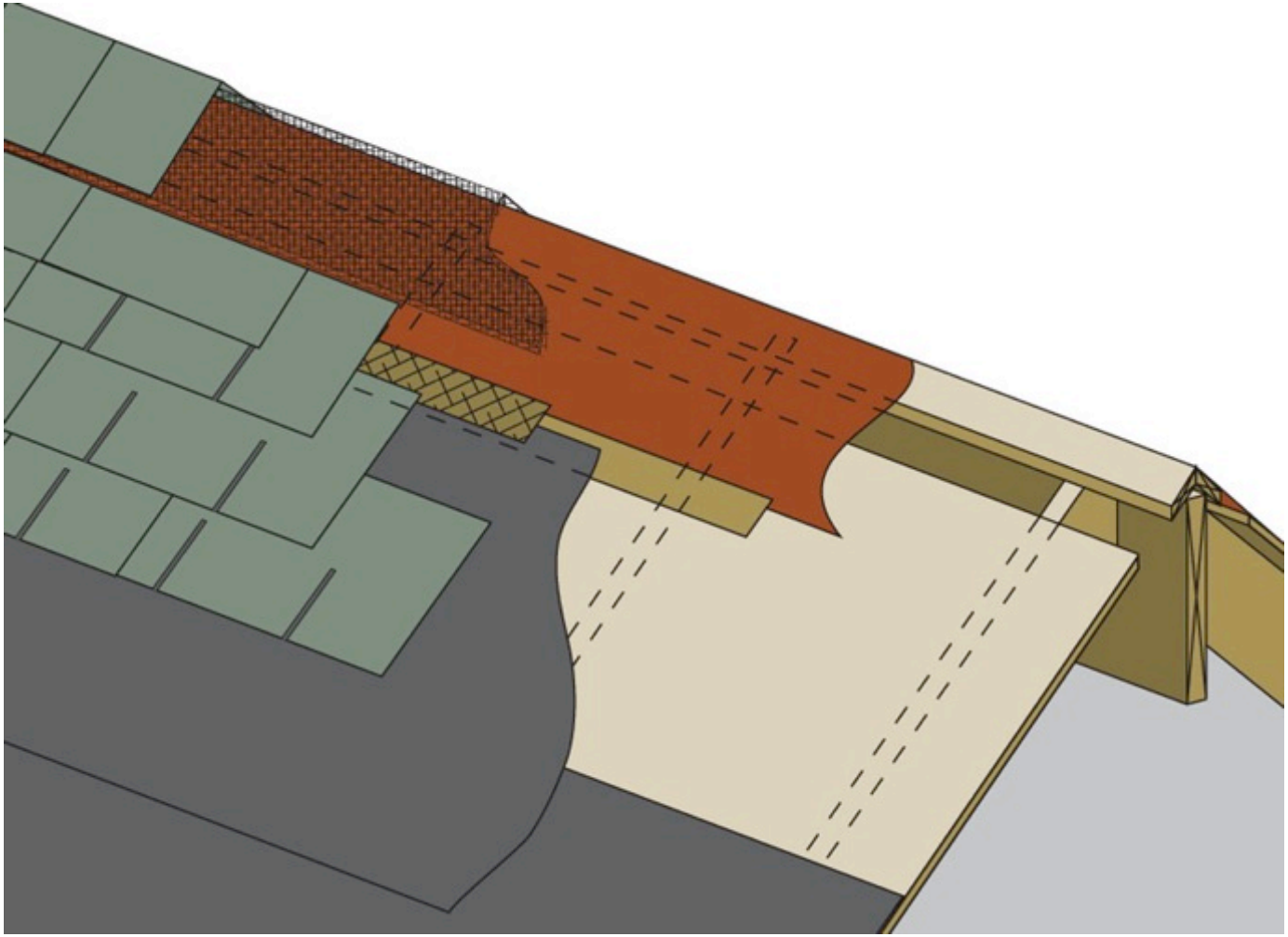
Conditioned Attics Not Unvented Attics

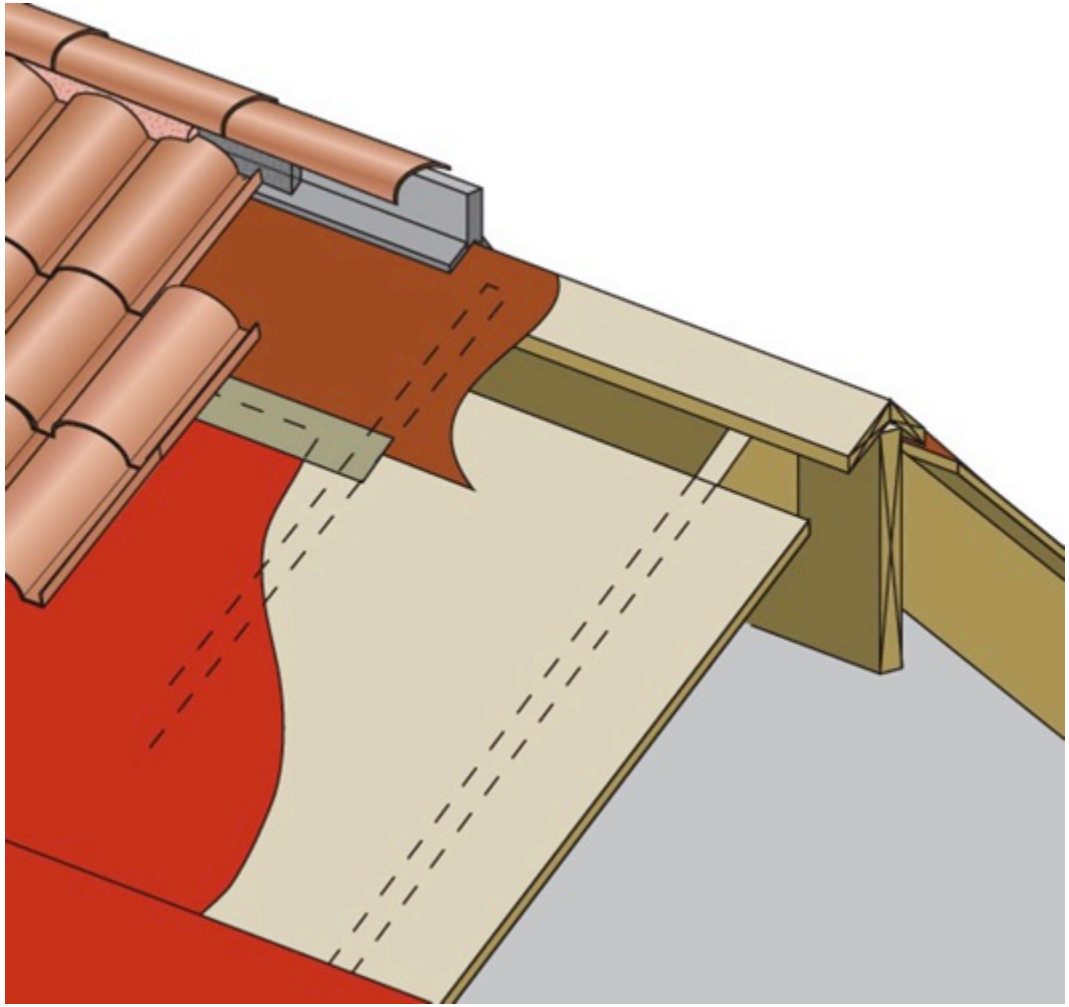
Need Supply Air

50 cfm/1000 ft2 of Attic










2013


3M
All Weather
Flashing Tape 8067
Dow
Styrofoam


DELTA®
DELTA®
DELTA®
Made by Dörken GmbH & Co. KG, D-58311 Herdecke


PROPINK
High Performance
Attic System
OWENS CORNING
R-30

Sweating Ducts

Sweating Ducts

Light Colored Roofs

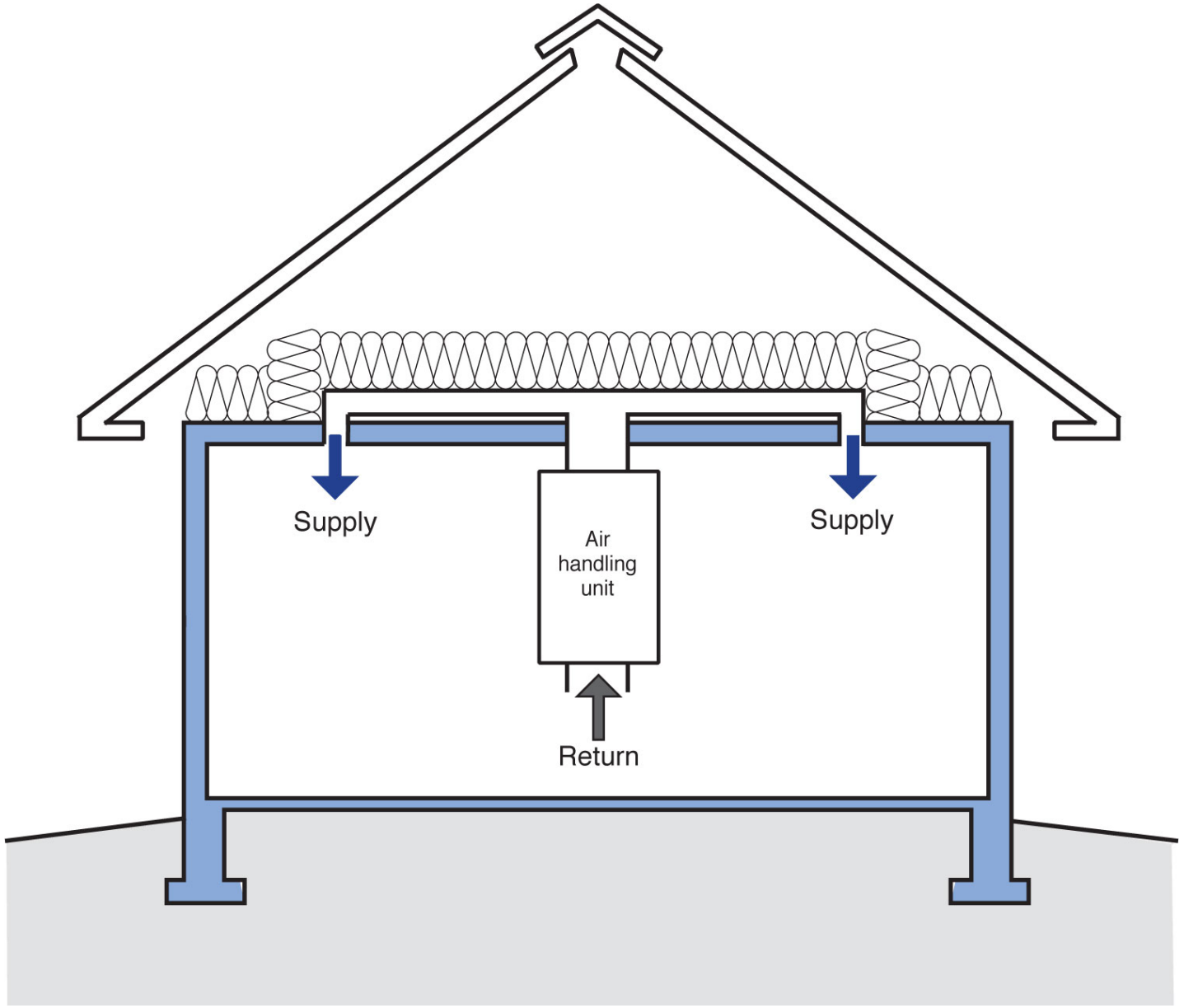
Cool Roofs

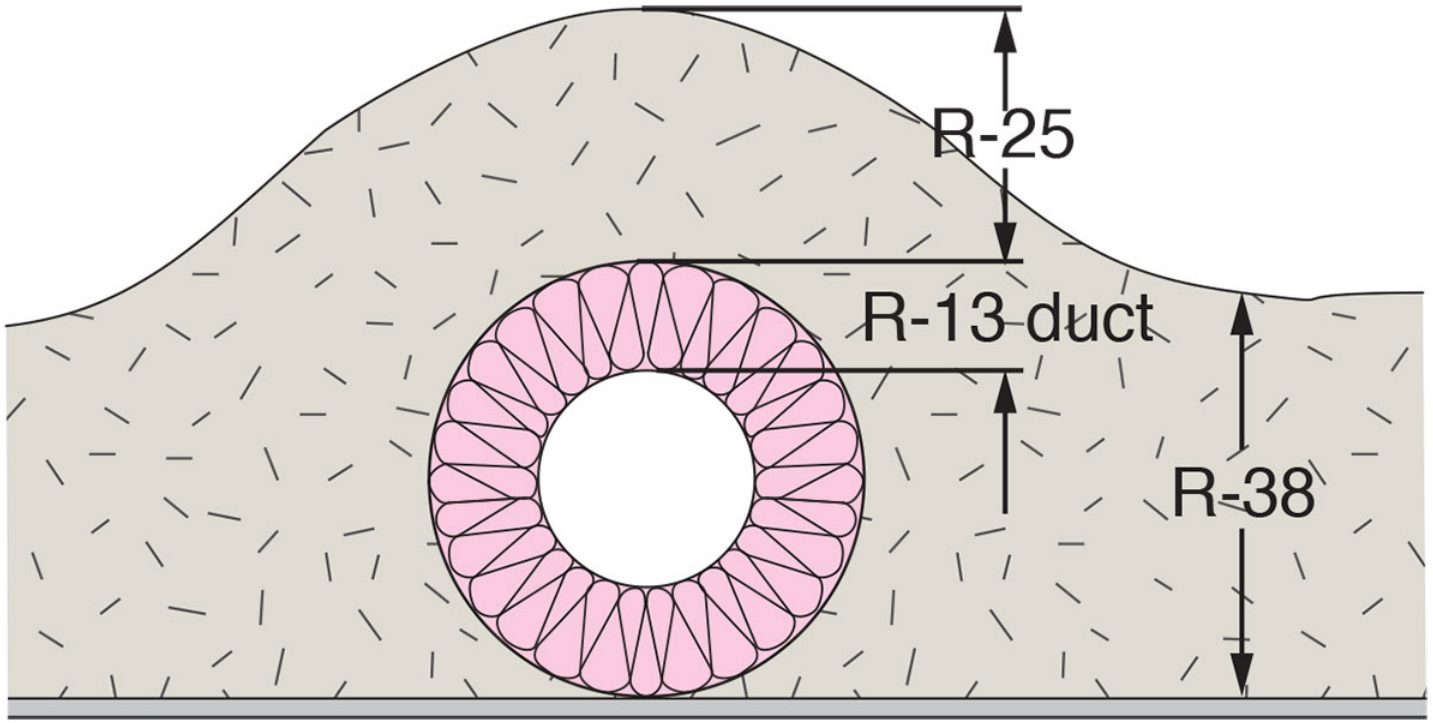
Radiant Barriers

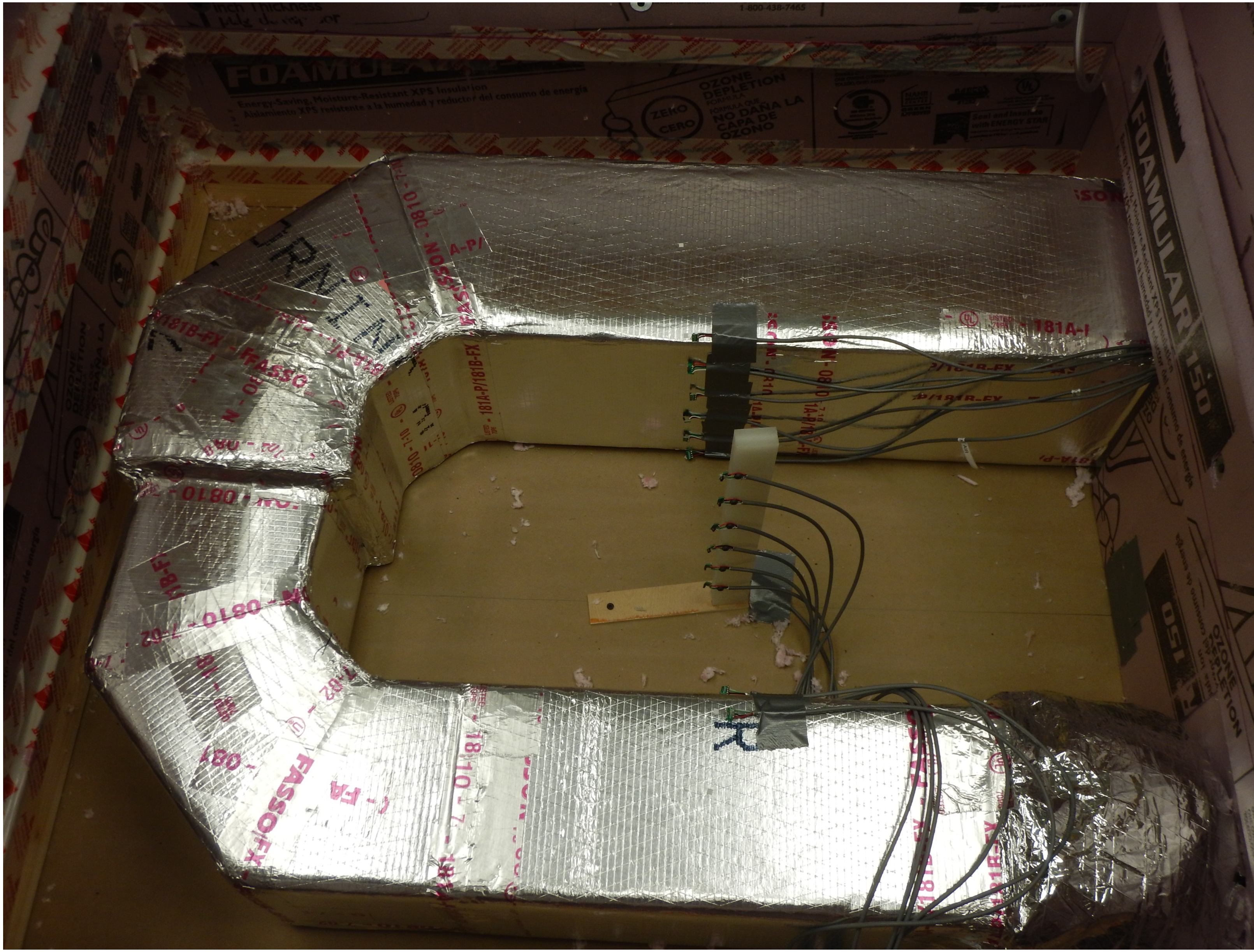
ACCA Manual J, S and D

Ductwork Attic Dehumidification System

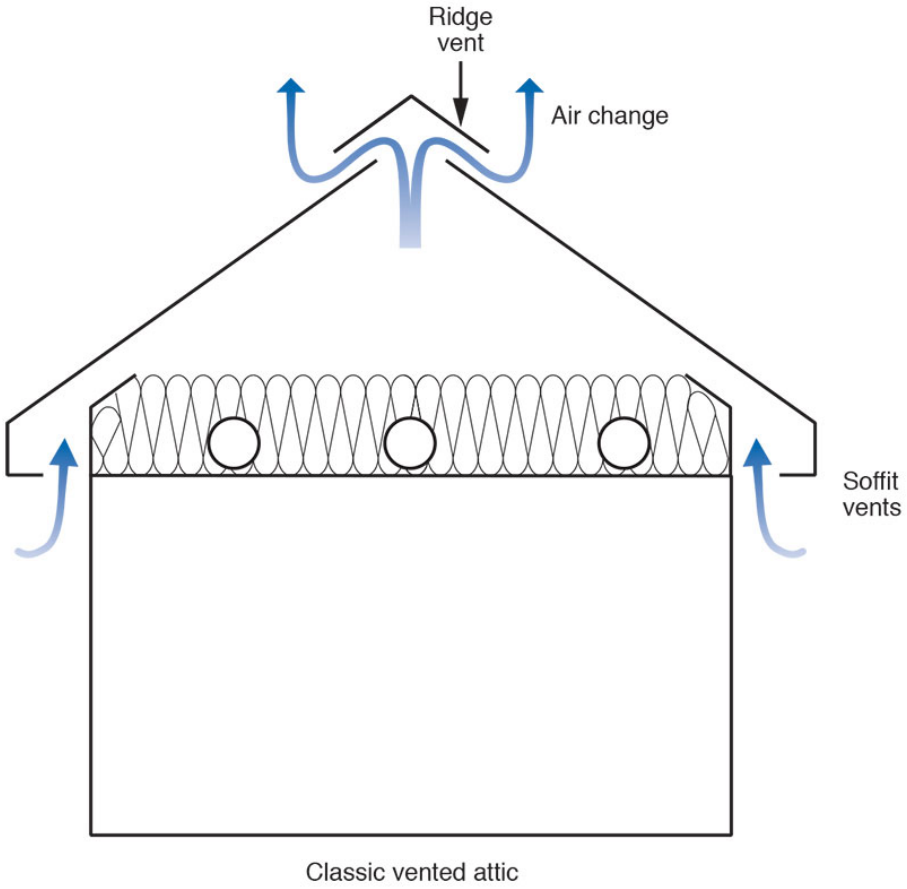
Burying Ducts


Supply
Air handling unit
Supply
Return

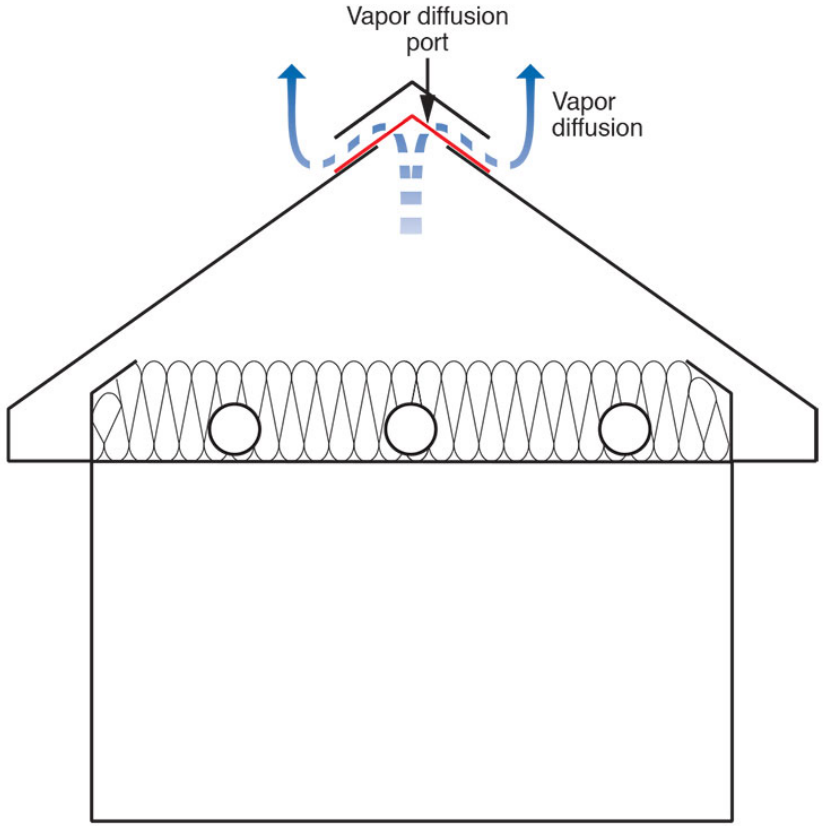

R-25
R-13 duct
R-38


FOAMULAR 150
OZONE DEPLETION
ZERO
CERO
NO DAÑA LA CAPA DE OZONO
FASSO-FX

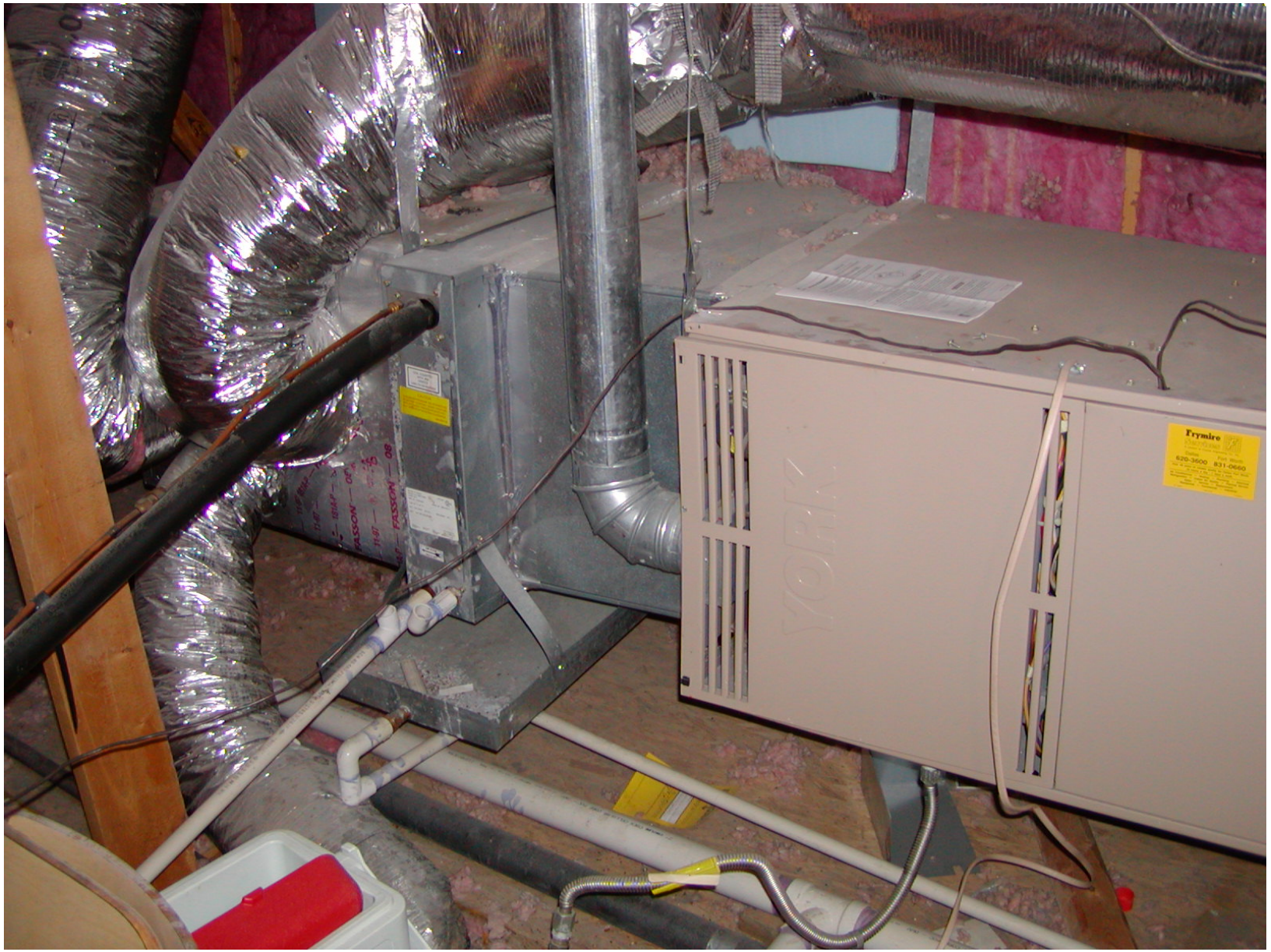

R-5.0
1 inch thick
CERO
CAPA DE OZONO
OWENS CORNING
FOAMULAR 150



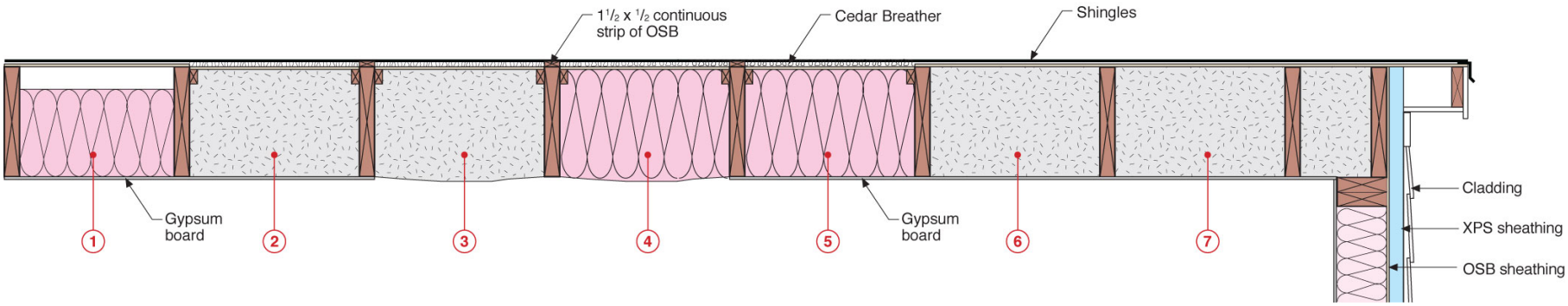
Classic vented attic



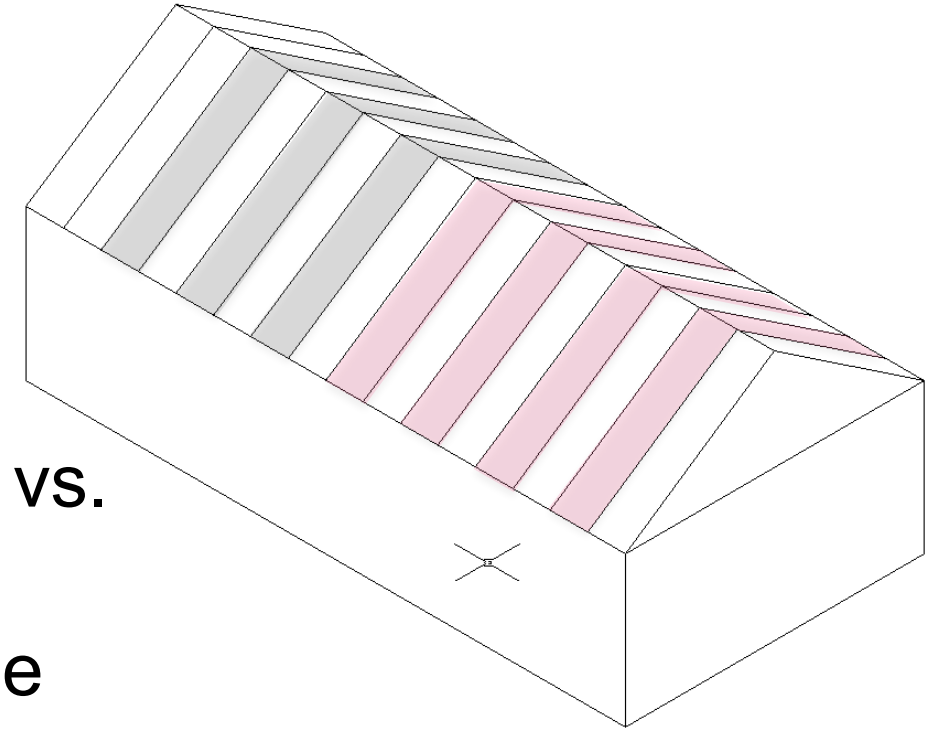
Unvented attic with vapor diffusion port


Frymire
620-3600
831-0660

Cold Climates


1½ x ½ continuous strip of OSB
Cedar Breather
Shingles
Gypsum board
Gypsum board
Cladding
XPS sheathing
OSB sheathing
1
2
3
4
5
6
7


PROPINK
R-30
OWENS CORNING



- Diffusion vent at ridge vs. no diffusion vent
- Fiberglass vs. cellulose
- Vapor retarder: variable perm vs. fixed perm
- “Control” comparison R806.4 spray foam + fibrous

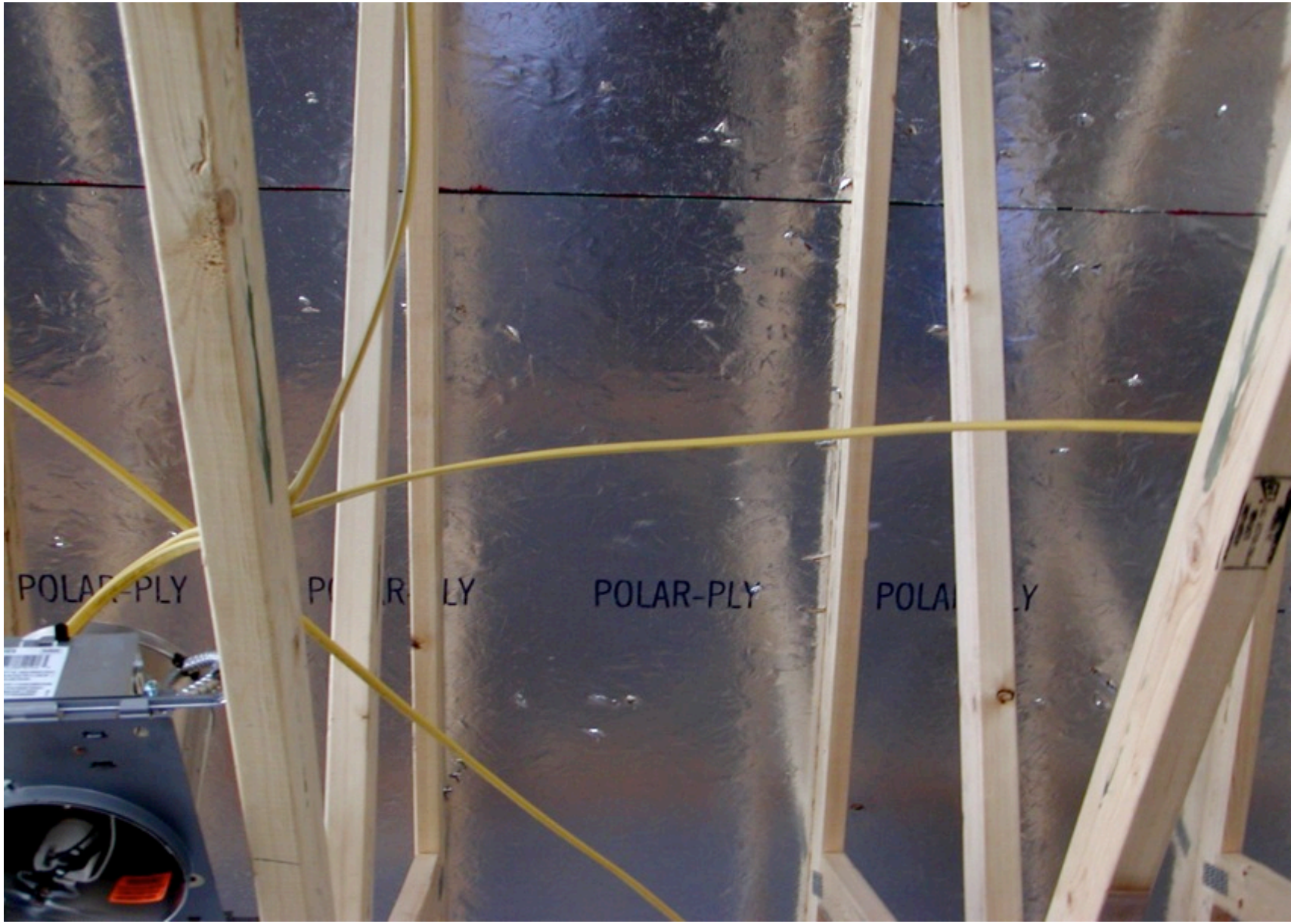
Code Change

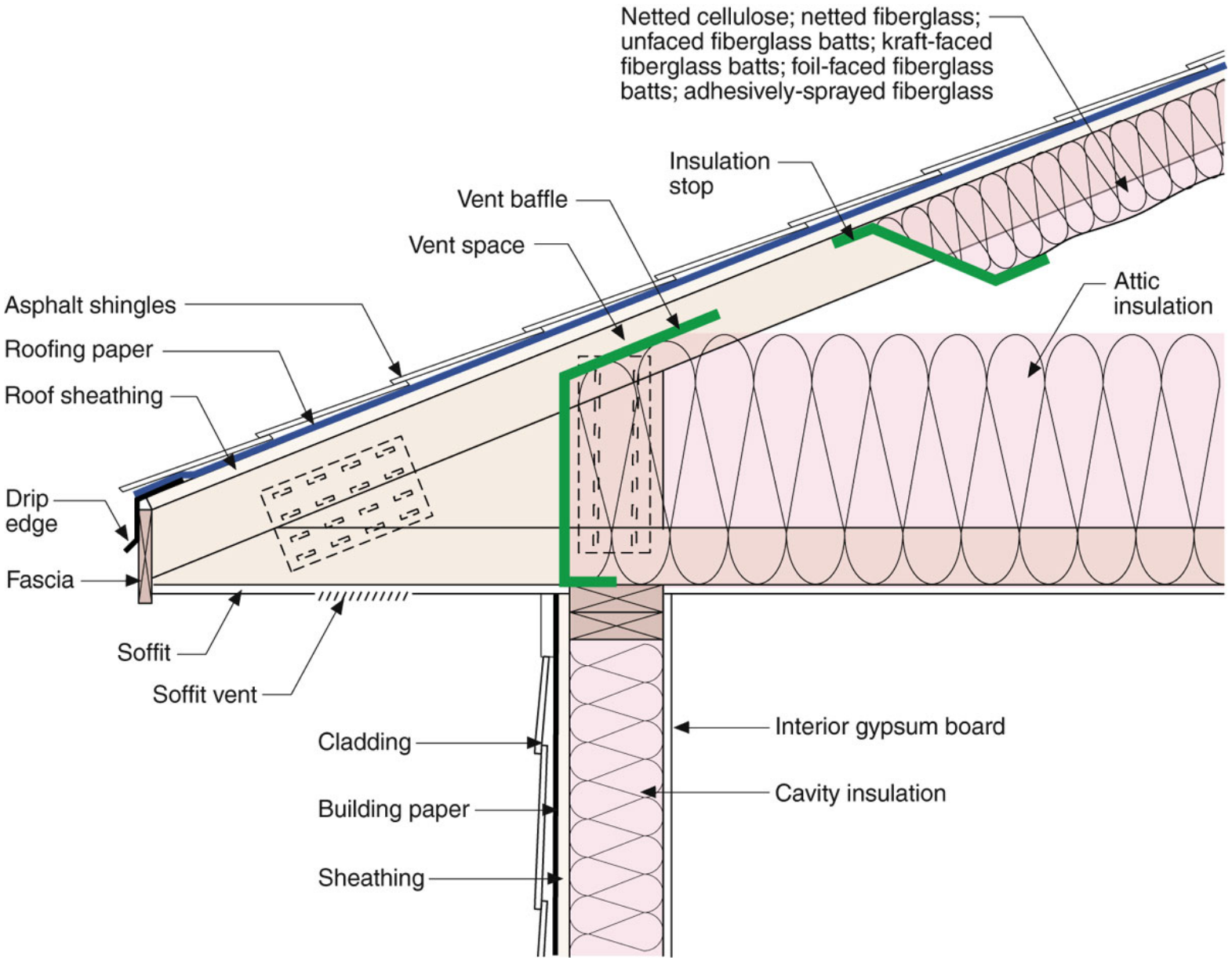
R806.5 Unvented attic and unvented attic enclosed rafter assemblies.

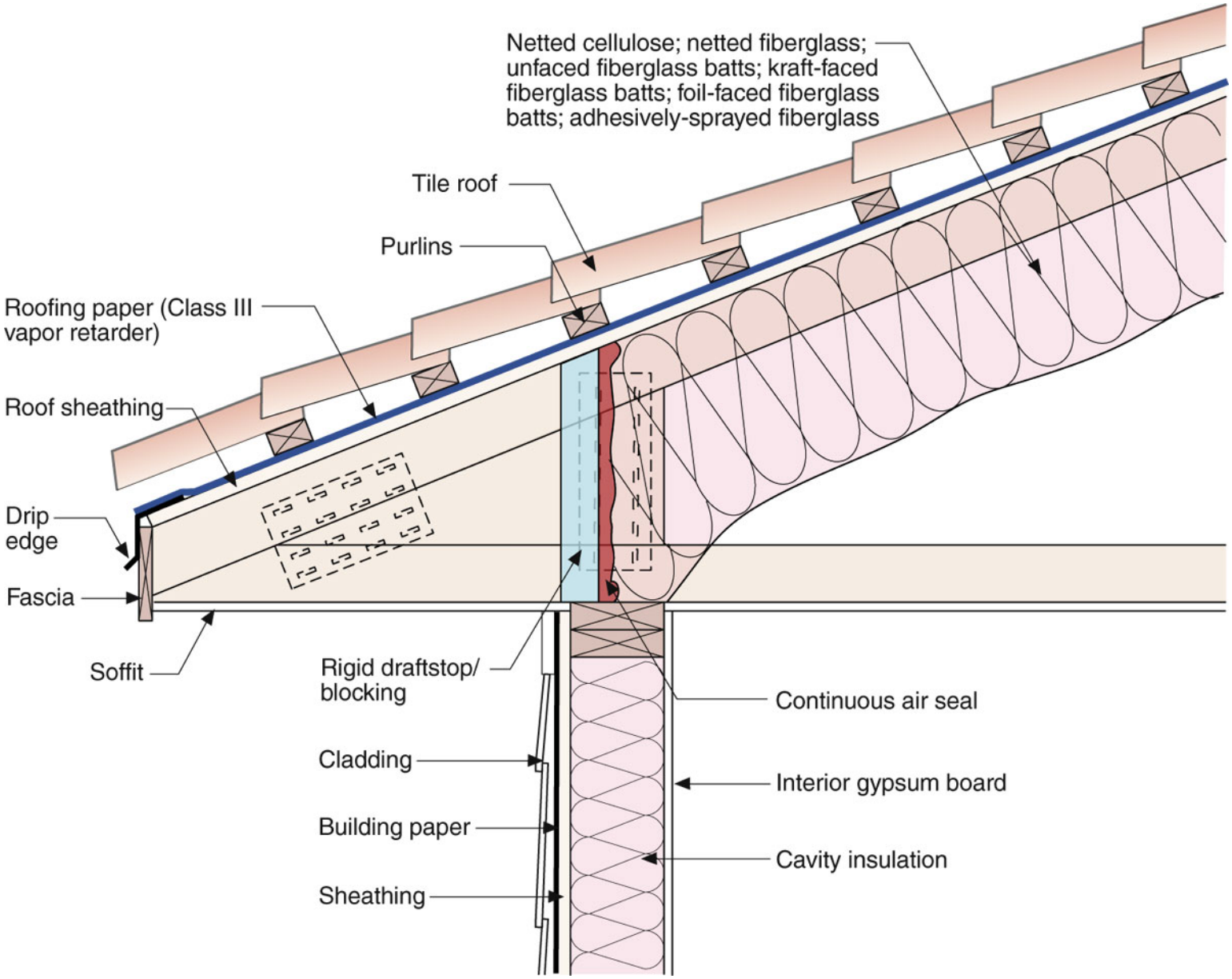
- vapor diffusion port
- port area 1:150 of the ceiling area
- vapor permeance greater than 20 perms
- roof slope greater than 3:12
- insulation under the roof deck or at the ceiling
- air supply 50 cfm/1000 ft2 ceiling area when insulation installed directly under the roof deck
- IECC Climate Zones 1, 2 and 3

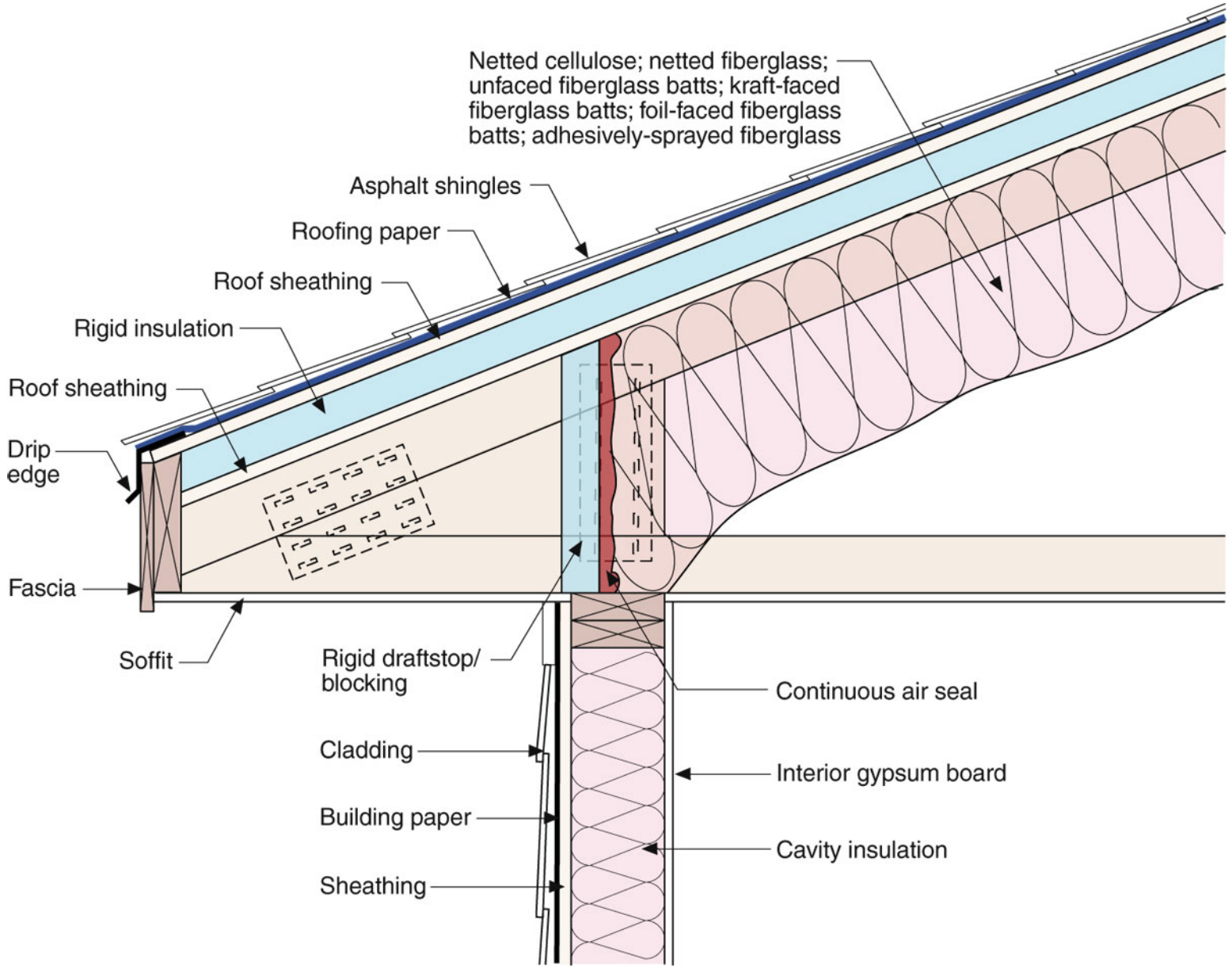
Vapor Diffusion Port: A passageway for conveying water vapor from an unvented attic to the atmosphere.

California


POLAR-PLY
POLAR-PLY


Netted cellulose; netted fiberglass; unfaced fiberglass batts; kraft-faced fiberglass batts; foil-faced fiberglass batts; adhesively-sprayed fiberglass
Insulation stop
Vent baffle
Vent space
Attic insulation
Asphalt shingles
Roofing paper
Roof sheathing
Drip edge
Fascia
Soffit
Soffit vent
Cladding
Building paper
Sheathing
Interior gypsum board
Cavity insulation


Netted cellulose; netted fiberglass; unfaced fiberglass batts; kraft-faced fiberglass batts; foil-faced fiberglass batts; adhesively-sprayed fiberglass
Tile roof
Purlins
Roofing paper (Class III vapor retarder)
Roof sheathing
Drip edge
Fascia
Soffit
Rigid draftstop/ blocking
Continuous air seal
Cladding
Interior gypsum board
Building paper
Cavity insulation
Sheathing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Continuous air seal
Cladding
Interior gypsum board
Building paper
Cavity insulation
Sheathing