

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

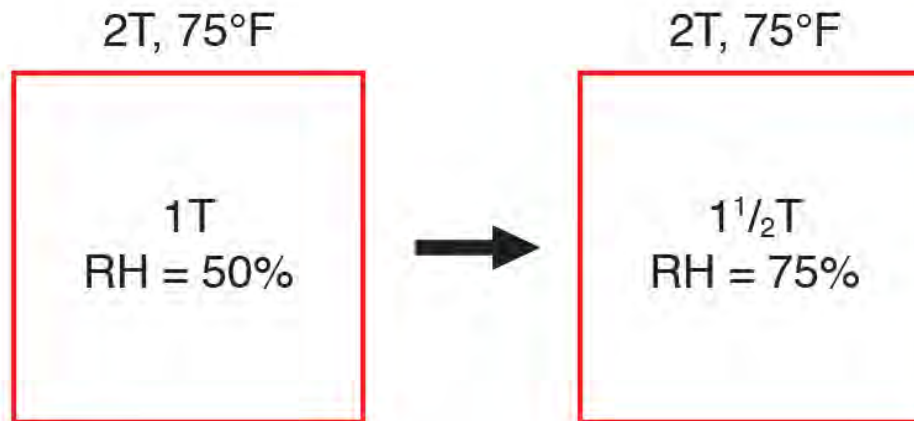
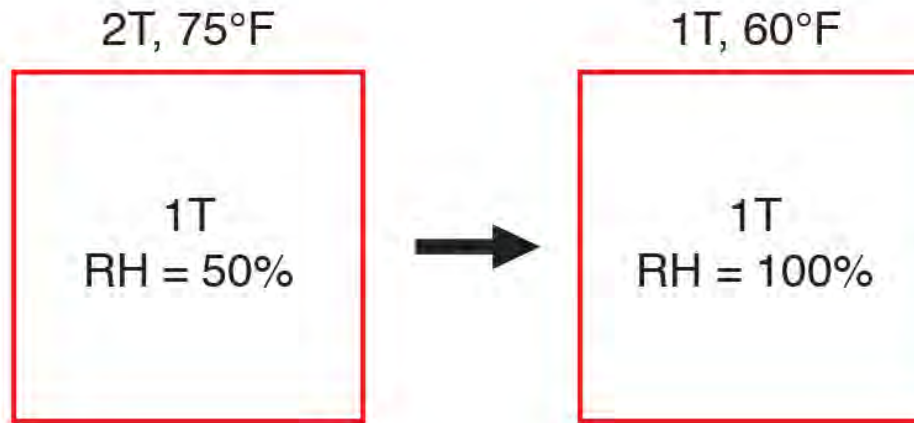
# Building Science

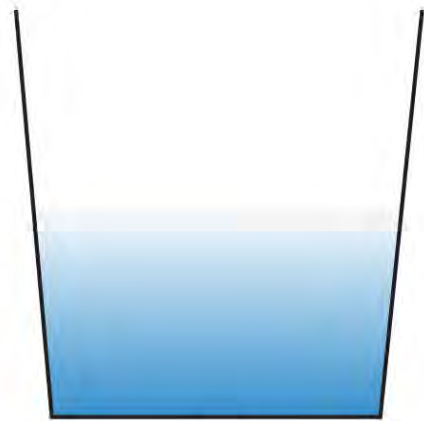
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Don't Sweat the Small Stuff...

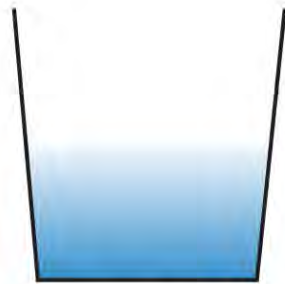
# Sweating Ducts

# Relative Humidity Vapor Pressure





90°F  
50% RH



75°F  
50% RH



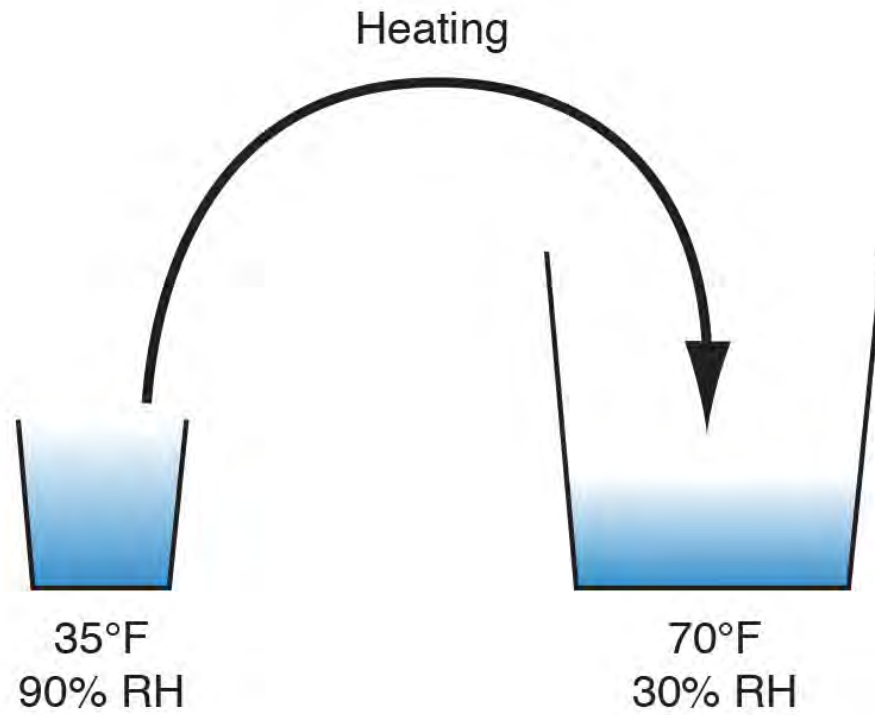
60°F  
50% RH

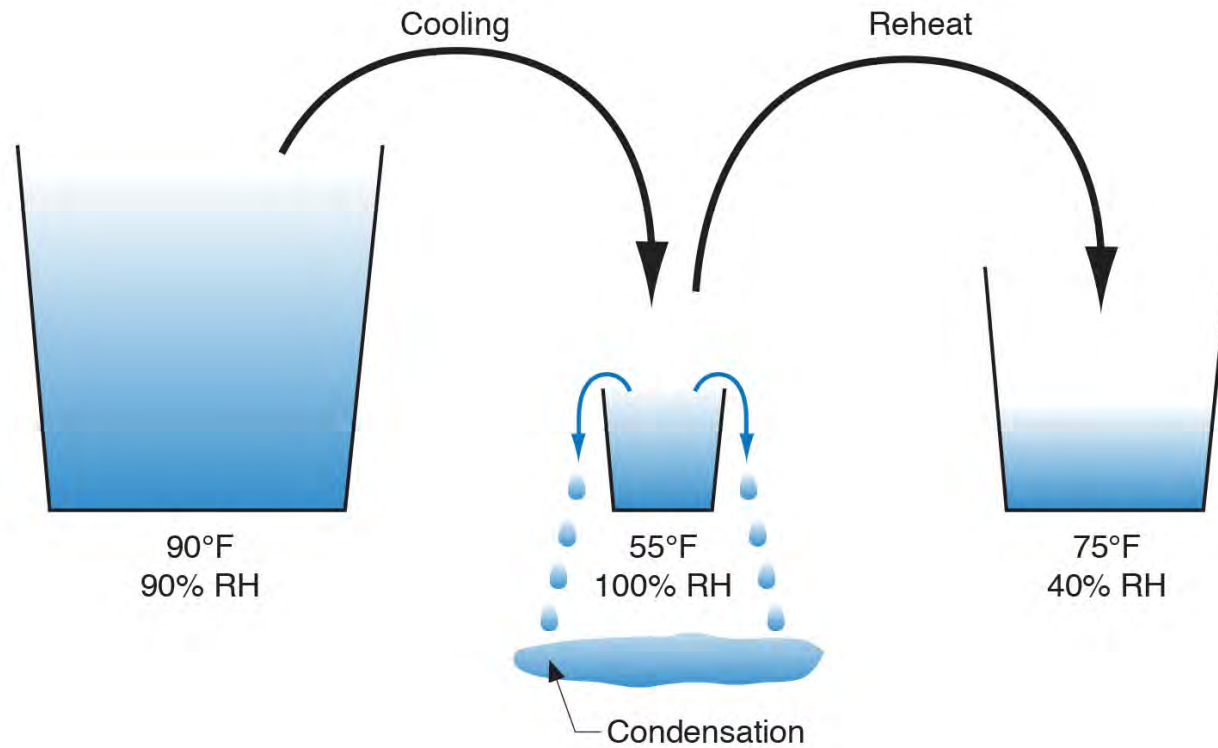


45°F  
50% RH



30°F  
50% RH

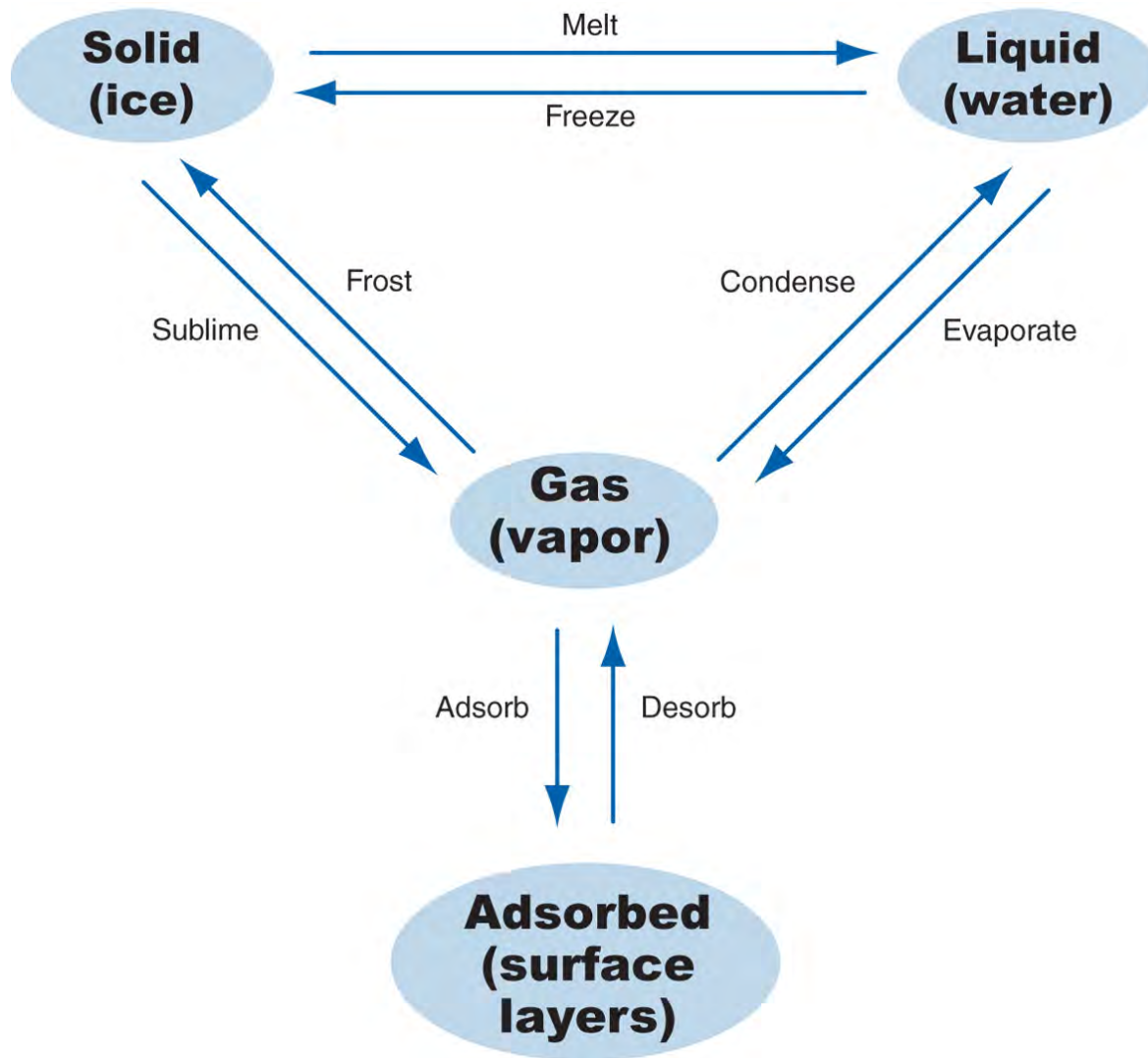


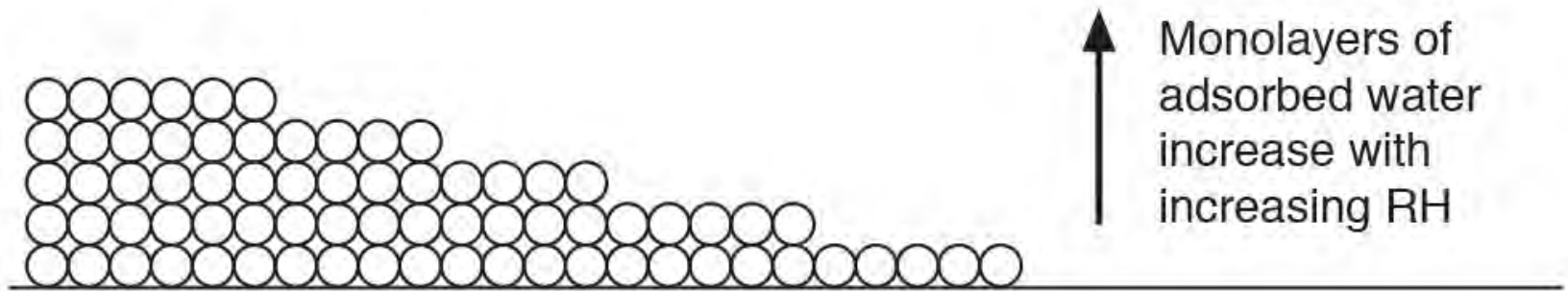


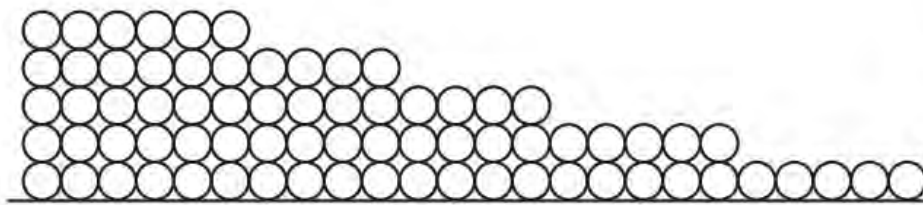
# Mold



# Phases of Water





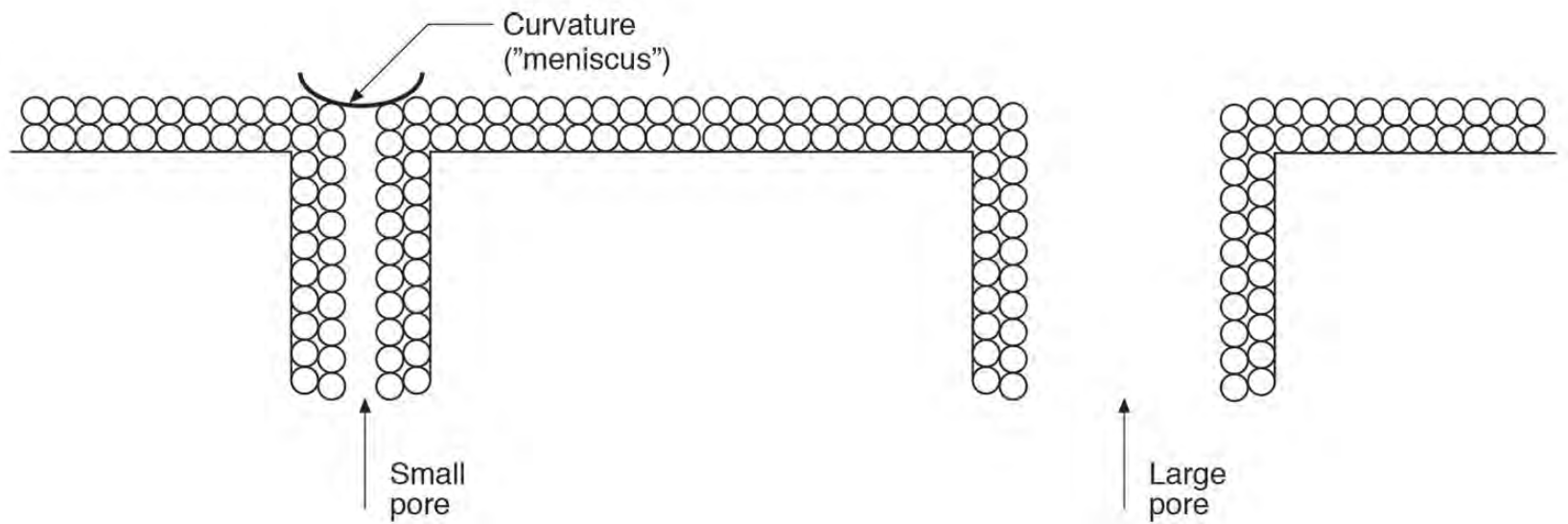


Monolayers  
flow along surface  
following concentration gradient



# Kelvin Equation

$$\ln \frac{p}{p_0} = \frac{2\gamma V_m}{rRT}$$





Sweating Ducts

Tile Roofs

Light Colored Roofs

Cool Roofs

Radiant Barriers

ACCA Manual J, S and D

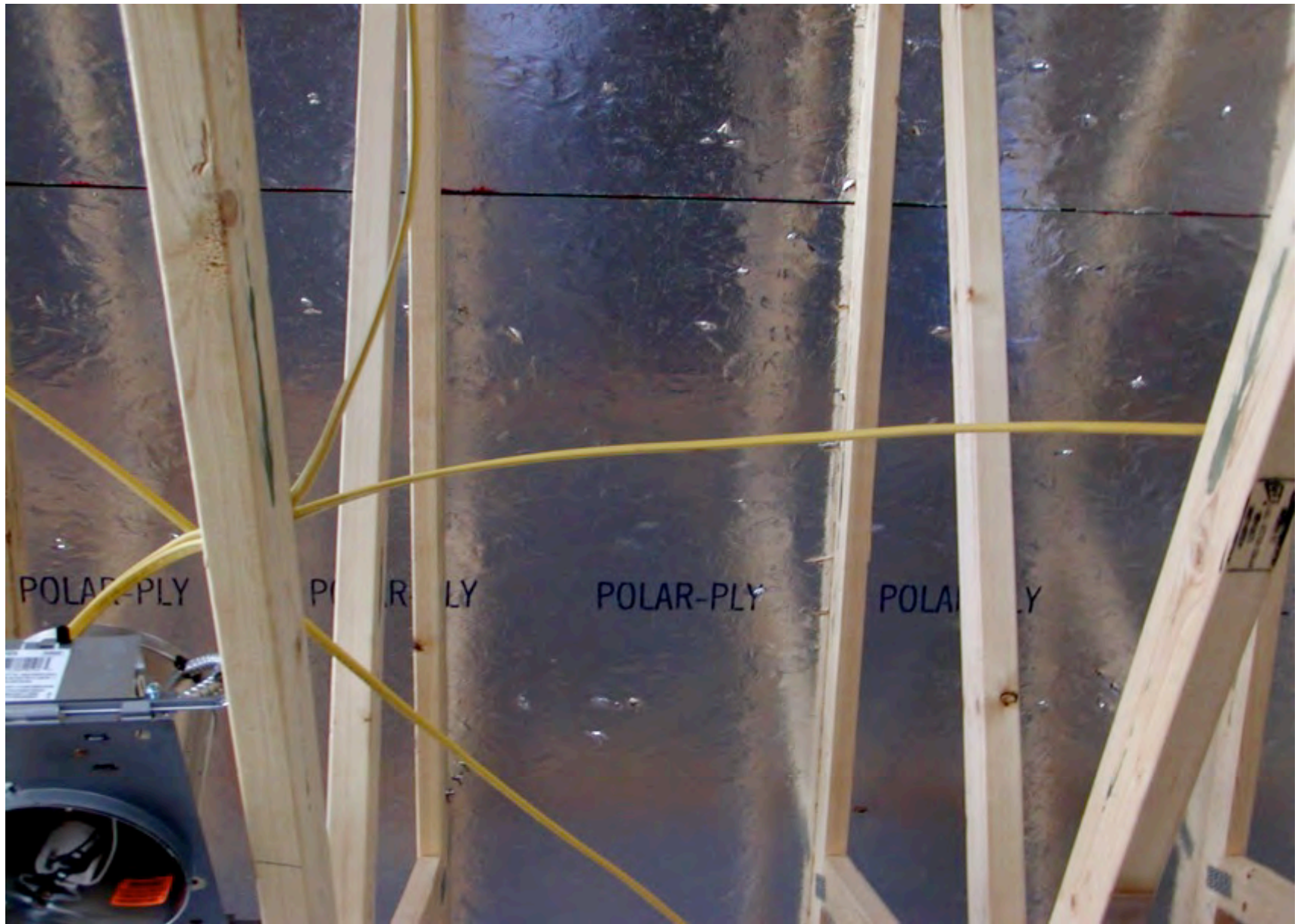
ASHRAE 62.2 and Energy Star Indoor Air  
Plus

Ductwork Attic Dehumidification System













# Closet Mold



Closet Mold

R-30 to R-38 to R-49.....



Closet Mold

R-30 to R-38 to R-49.....

ASHRAE 62.2 and Energy Star Indoor Air  
Plus

ASHRAE Standard 62.2 calls for 7.5 cfm per person plus 0.03 cfm per square foot of conditioned area

Occupancy is deemed to be the number of bedrooms plus one

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Occupancy is deemed to be the number of bedrooms plus one

Outcome is often bad – part load humidity problems, dryness problems, energy problems

IRC 2015, 2018 and 2021 calls for 7.5 cfm per person plus 0.01 cfm per square foot of conditioned area

Occupancy is deemed to be the number of bedrooms plus one

## ASHRAE Standard 62.2

0.03 cfm/ft<sup>2</sup> plus 7.5 cfm/occupant

## IRC/IMC

0.01 cfm/ft<sup>2</sup> plus 7.5 cfm/occupant

30 percent credit for balanced/distributed

2500 ft<sup>2</sup> 3 bedroom (occupancy 4)

ASHRAE    75 cfm + 30 cfm = 105 cfm

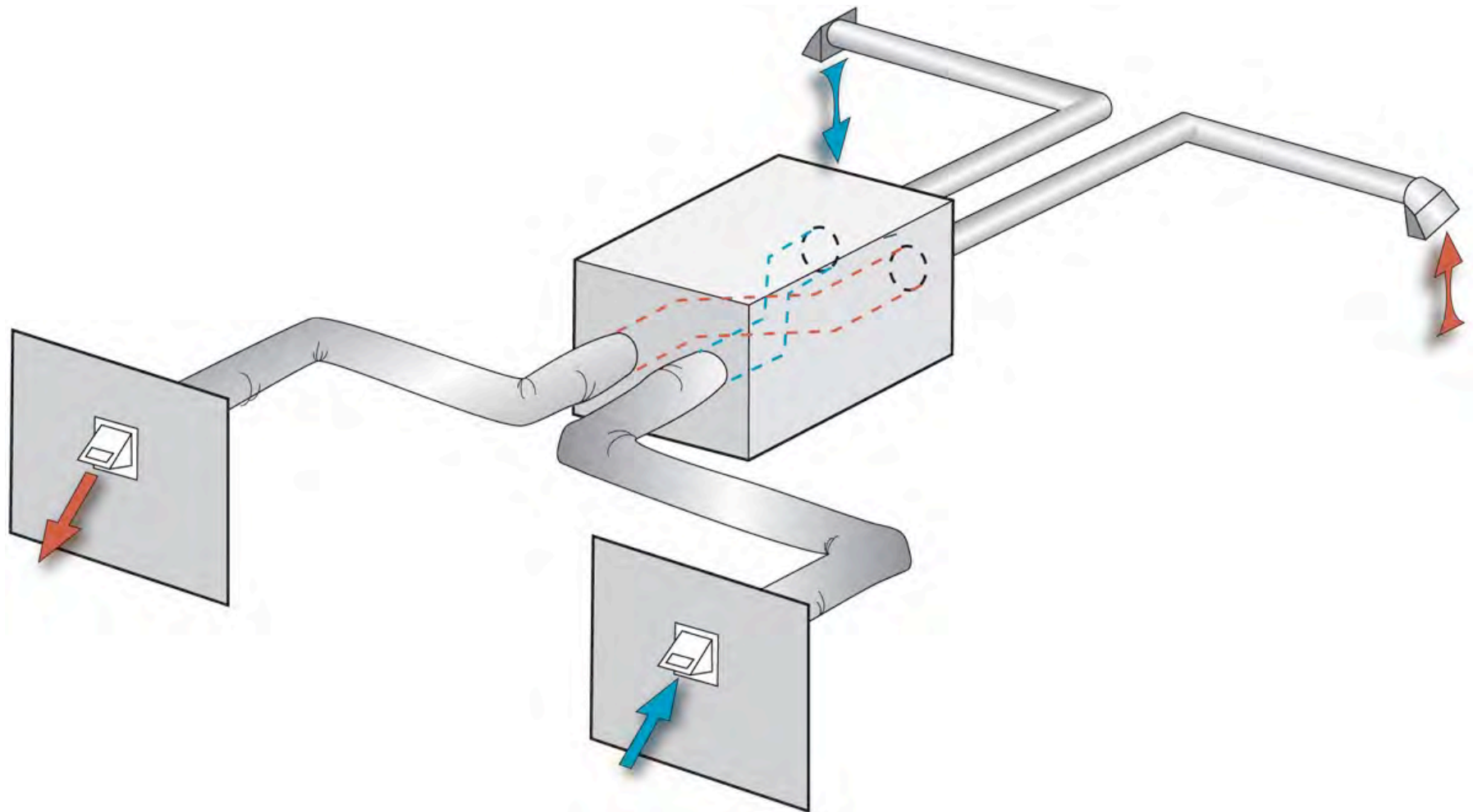
IRC/IMC    25 cfm + 30 cfm = 55 cfm (or 38.5 cfm)

Huge part load humidity problem....

Mold not just in closets....

You will need a dehumidifier....

Probably an ERV...

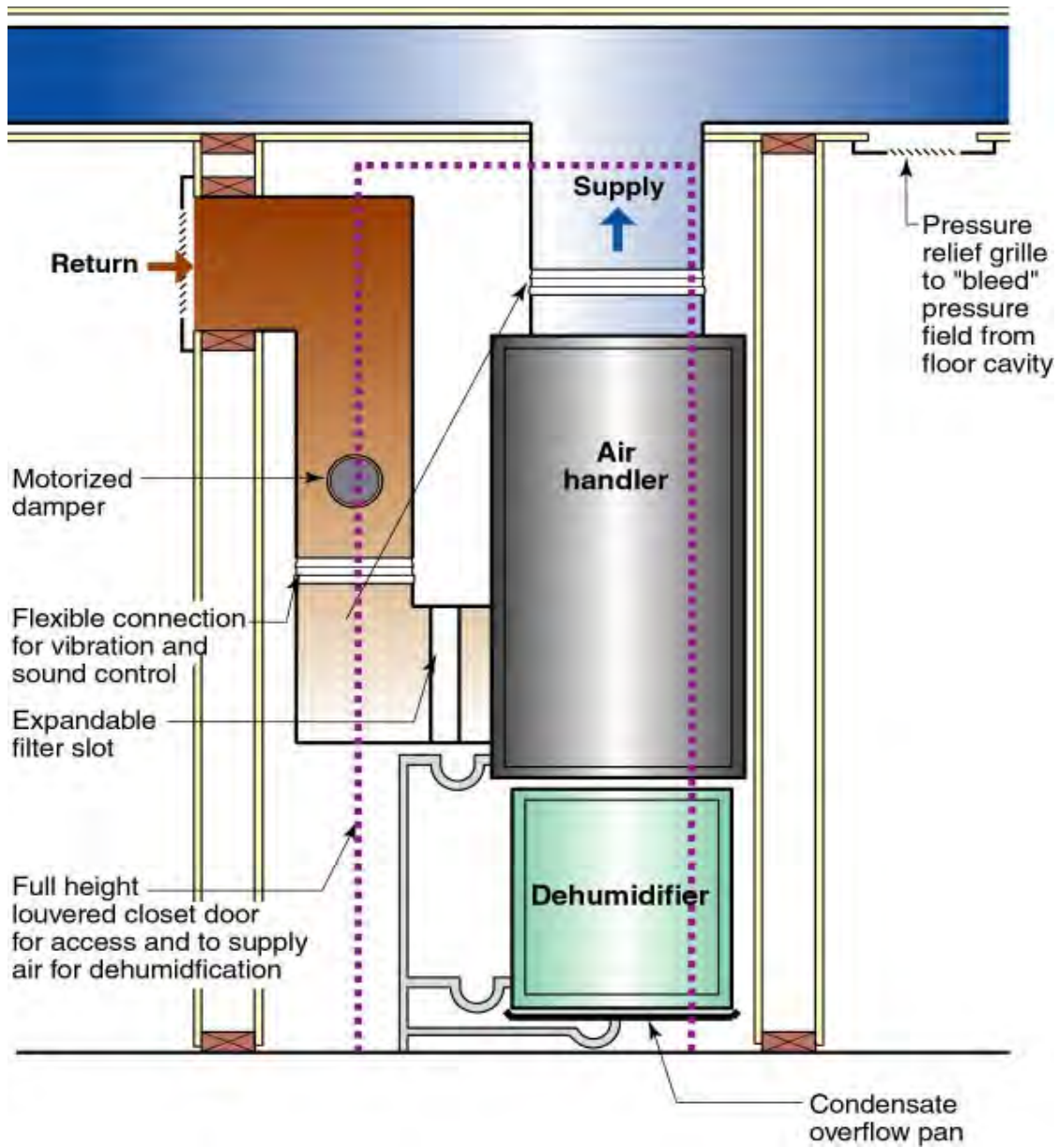


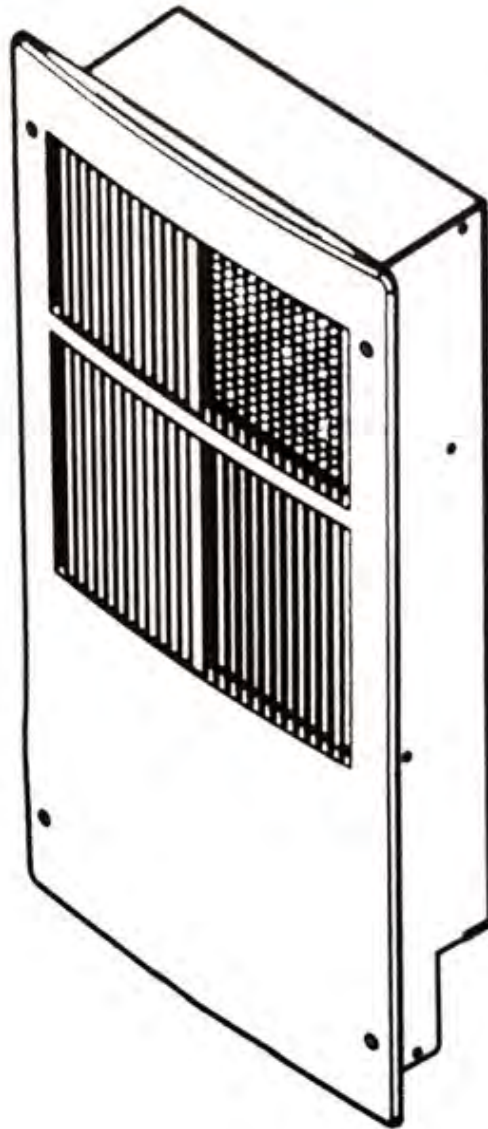








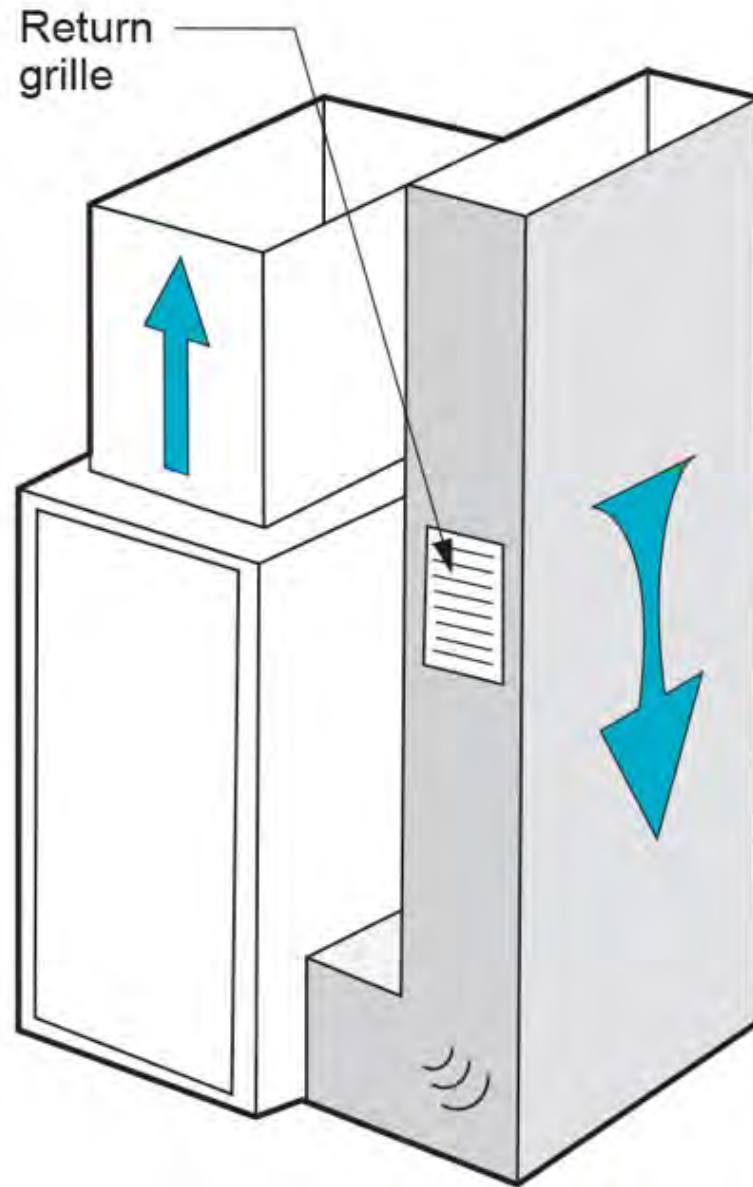




# Mechanical Room Mold

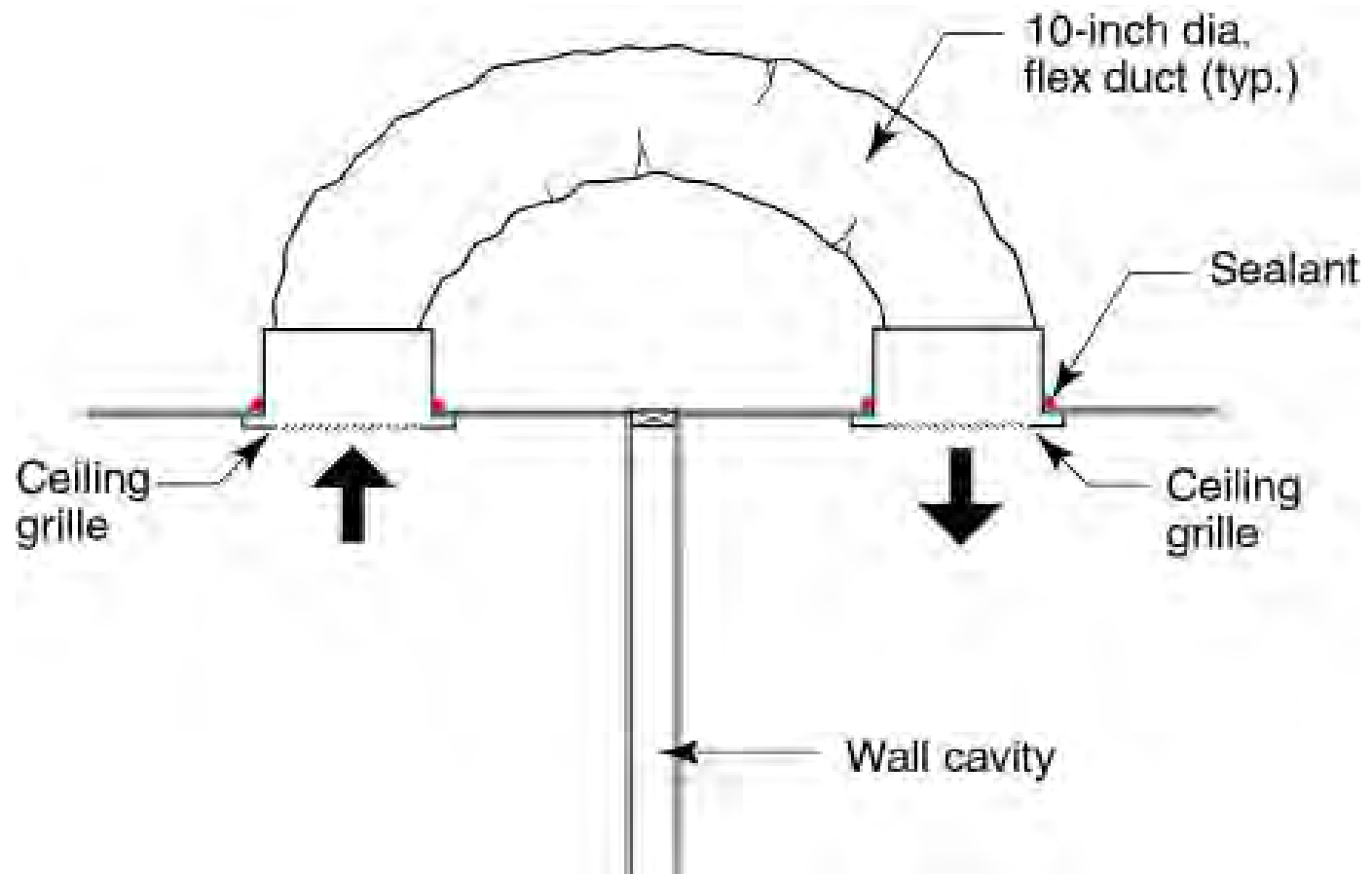


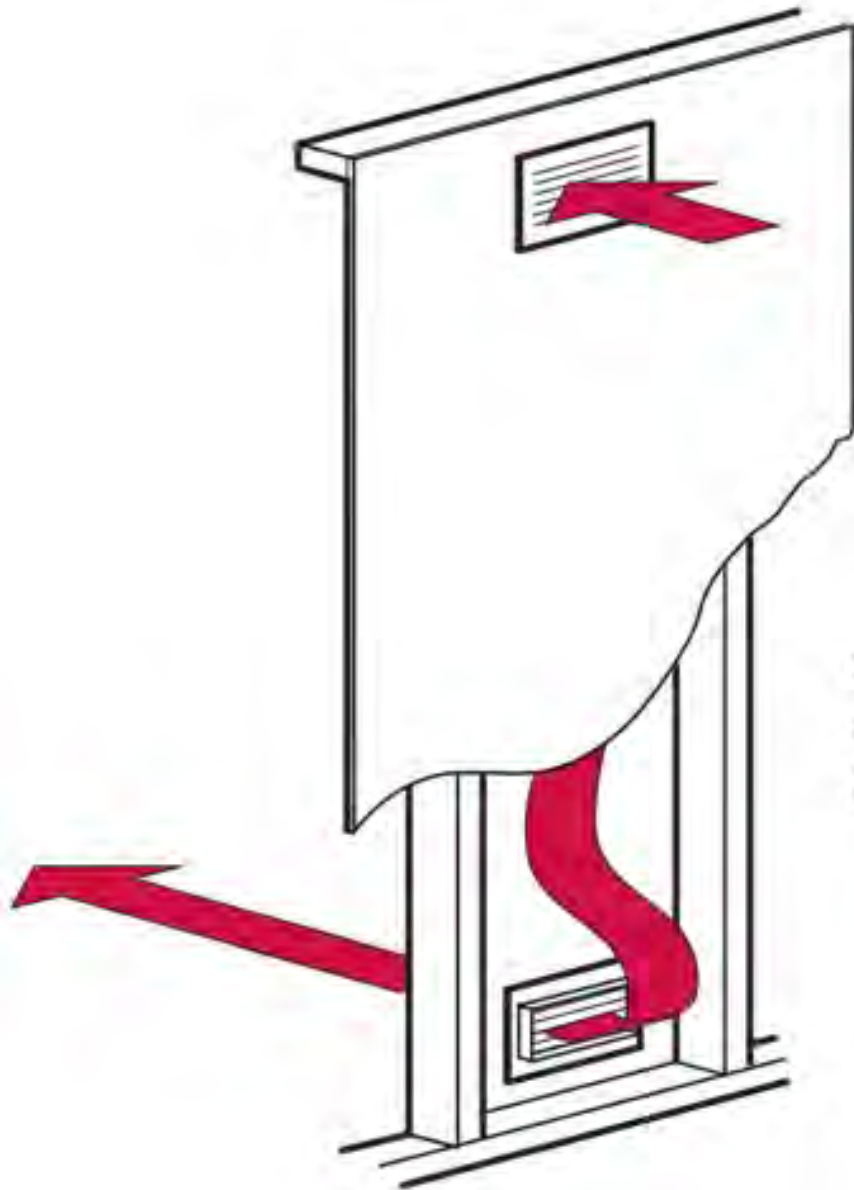






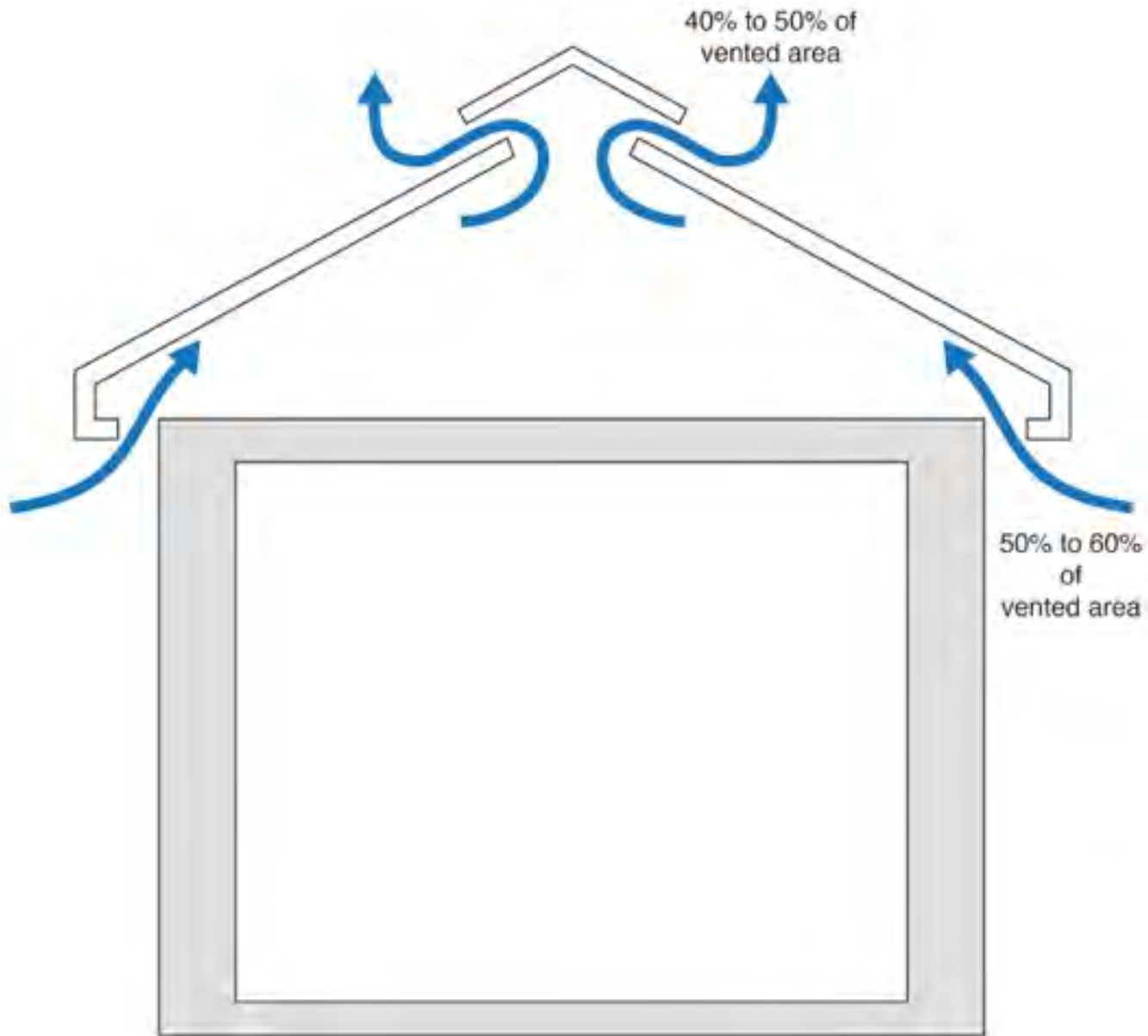


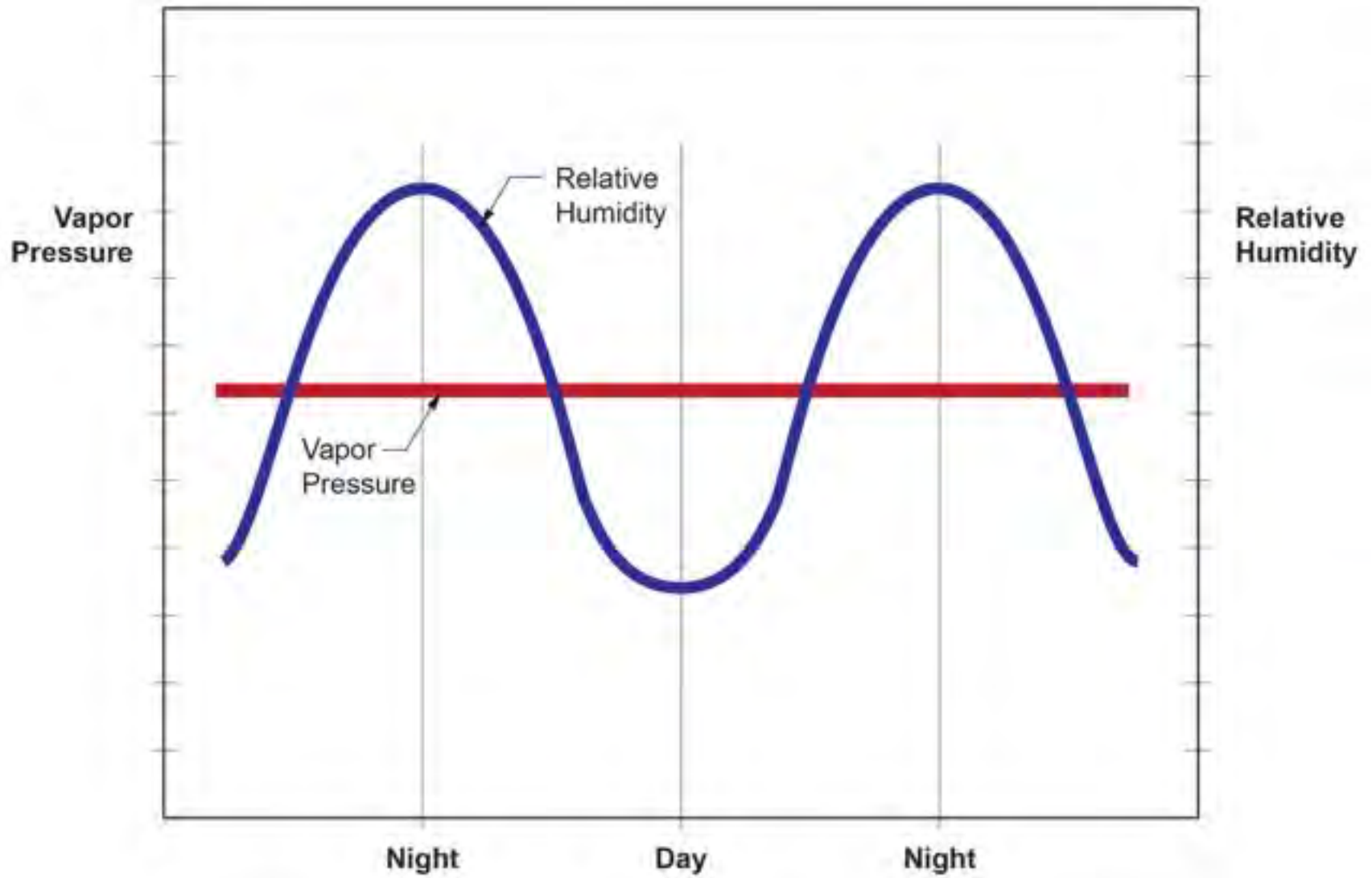


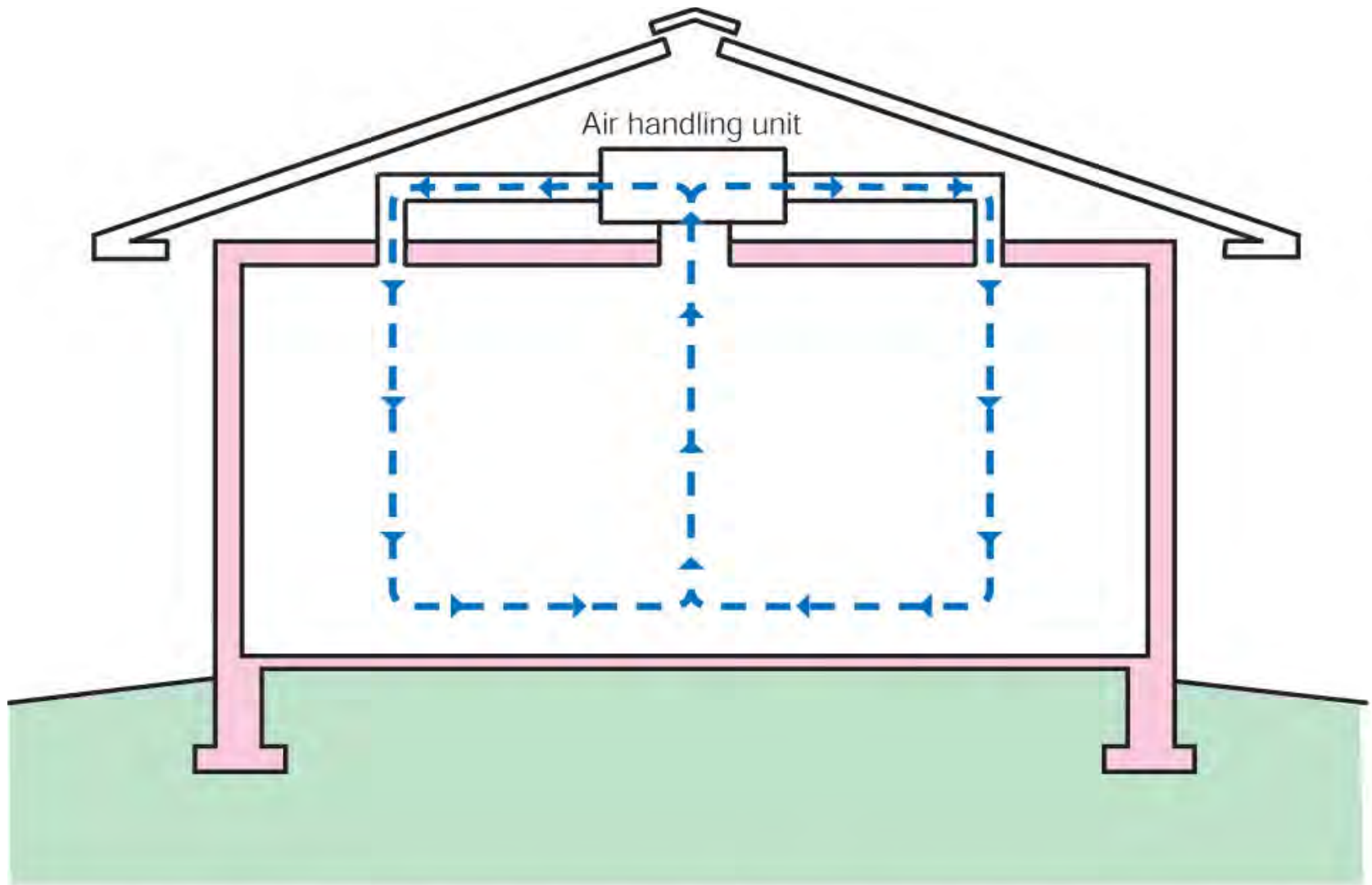


Cavity is sealed tight,  
drywall glued to studs and  
plates on both sides

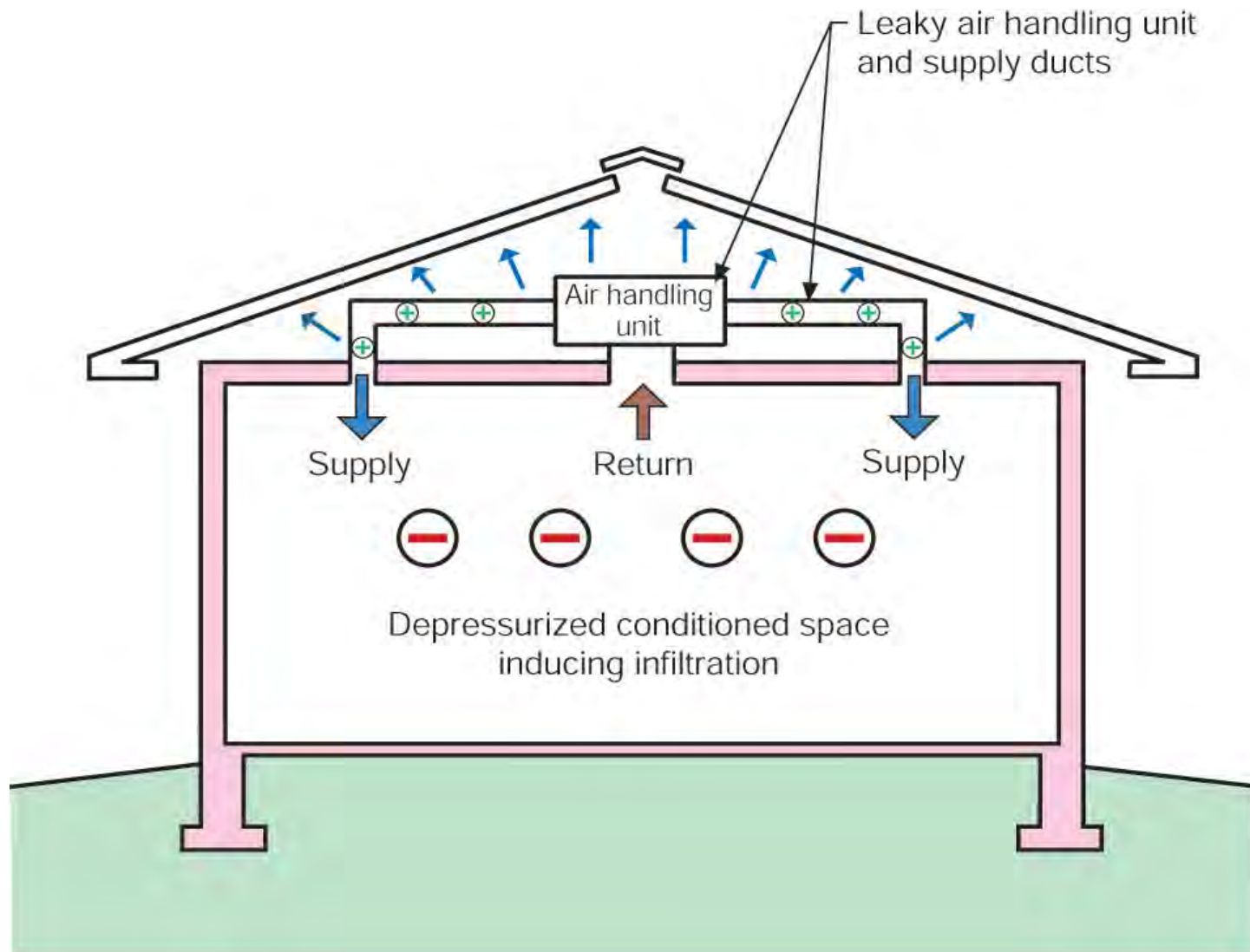






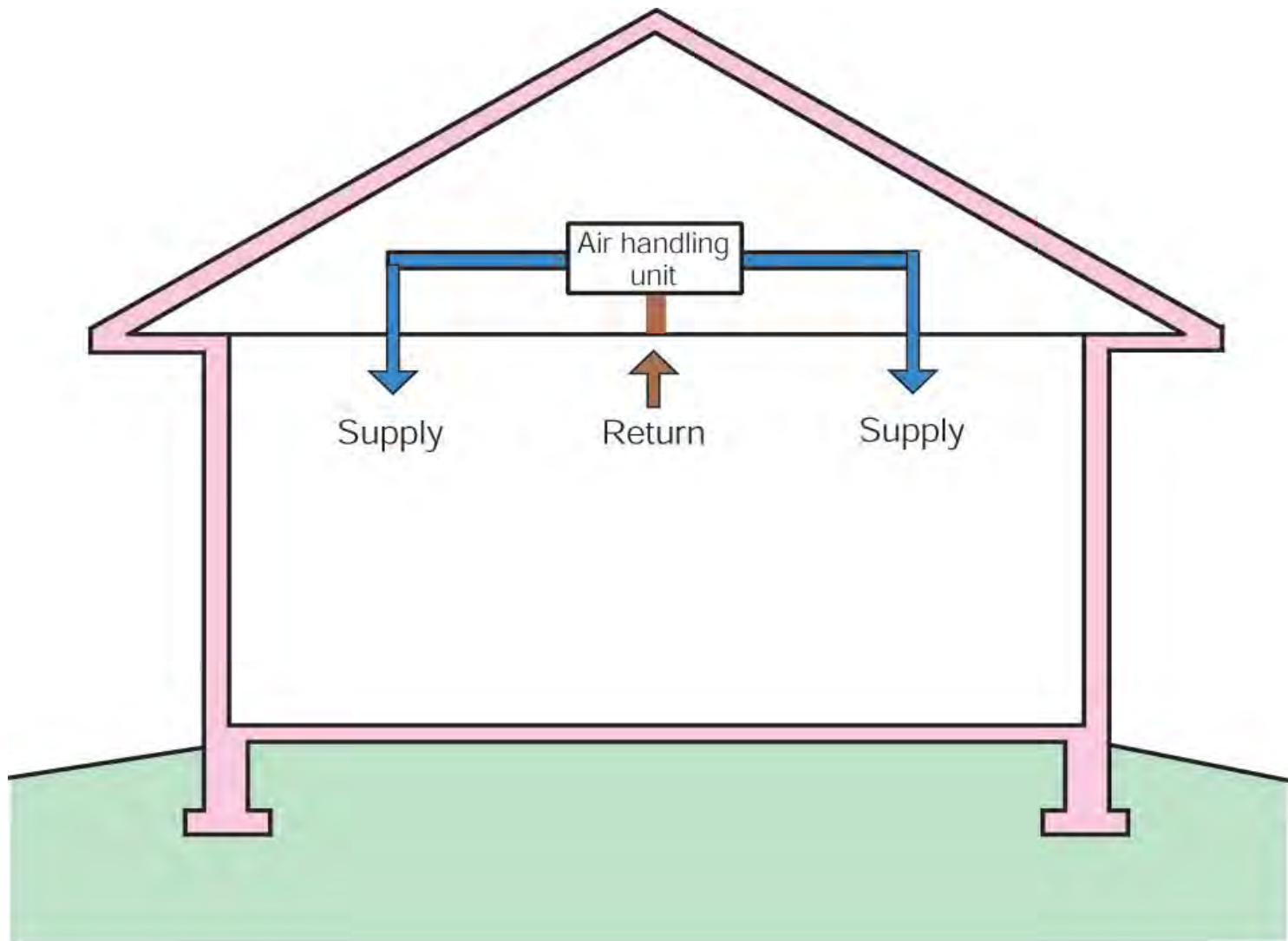


Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

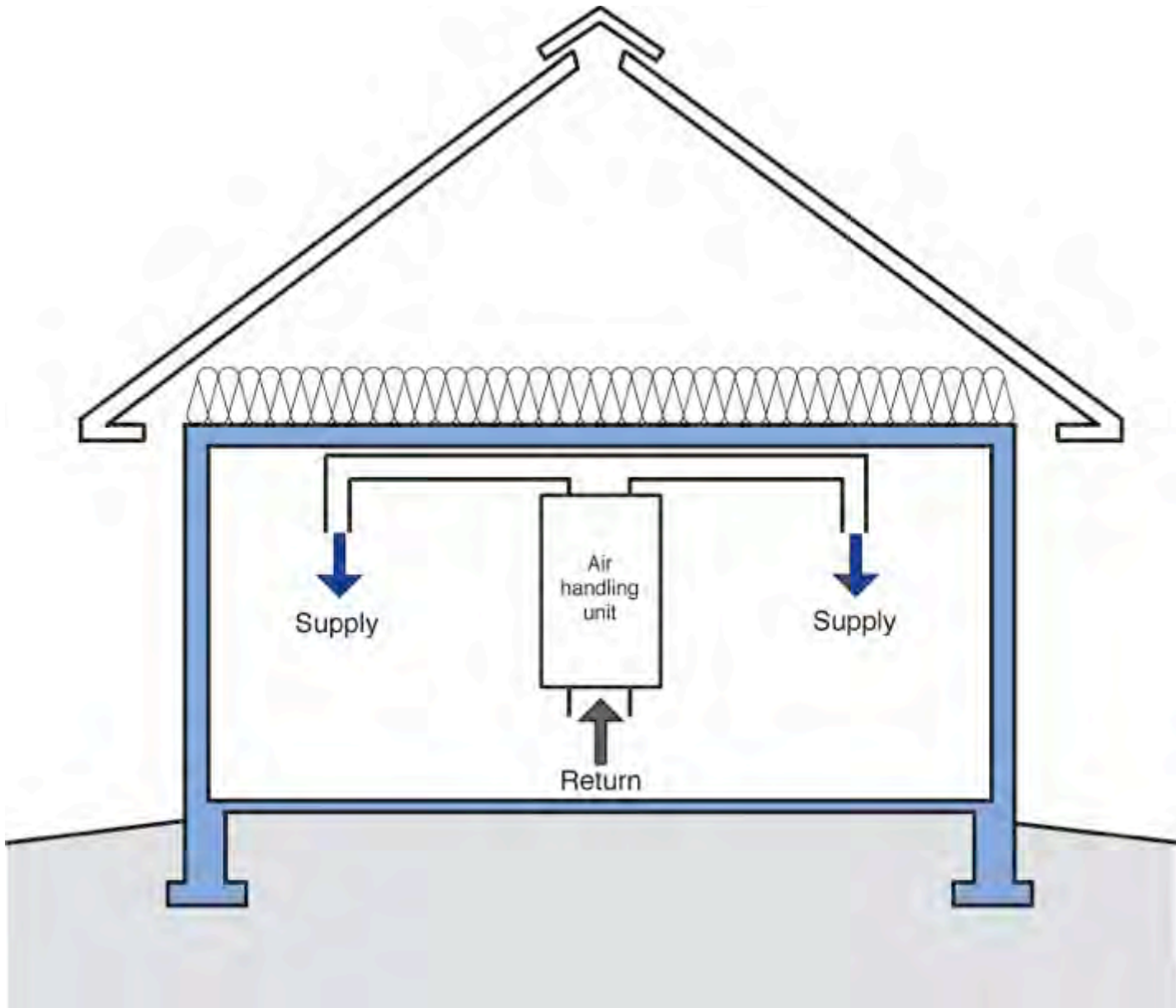


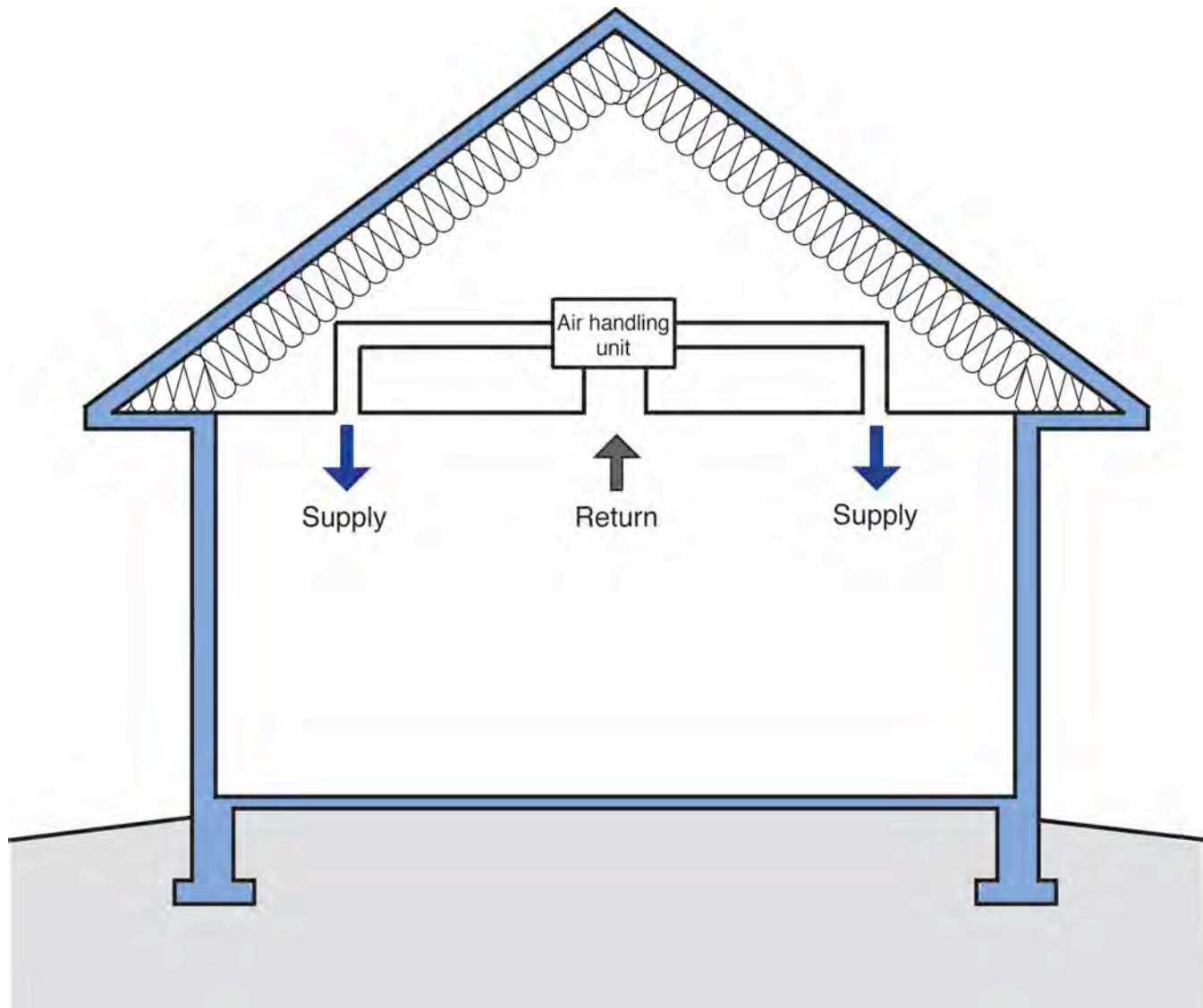
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# Hygric Buoyancy

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	$0.09 \cdot 10^{-6}$	131.29	0
Total Molecular Mass of Air			28.97

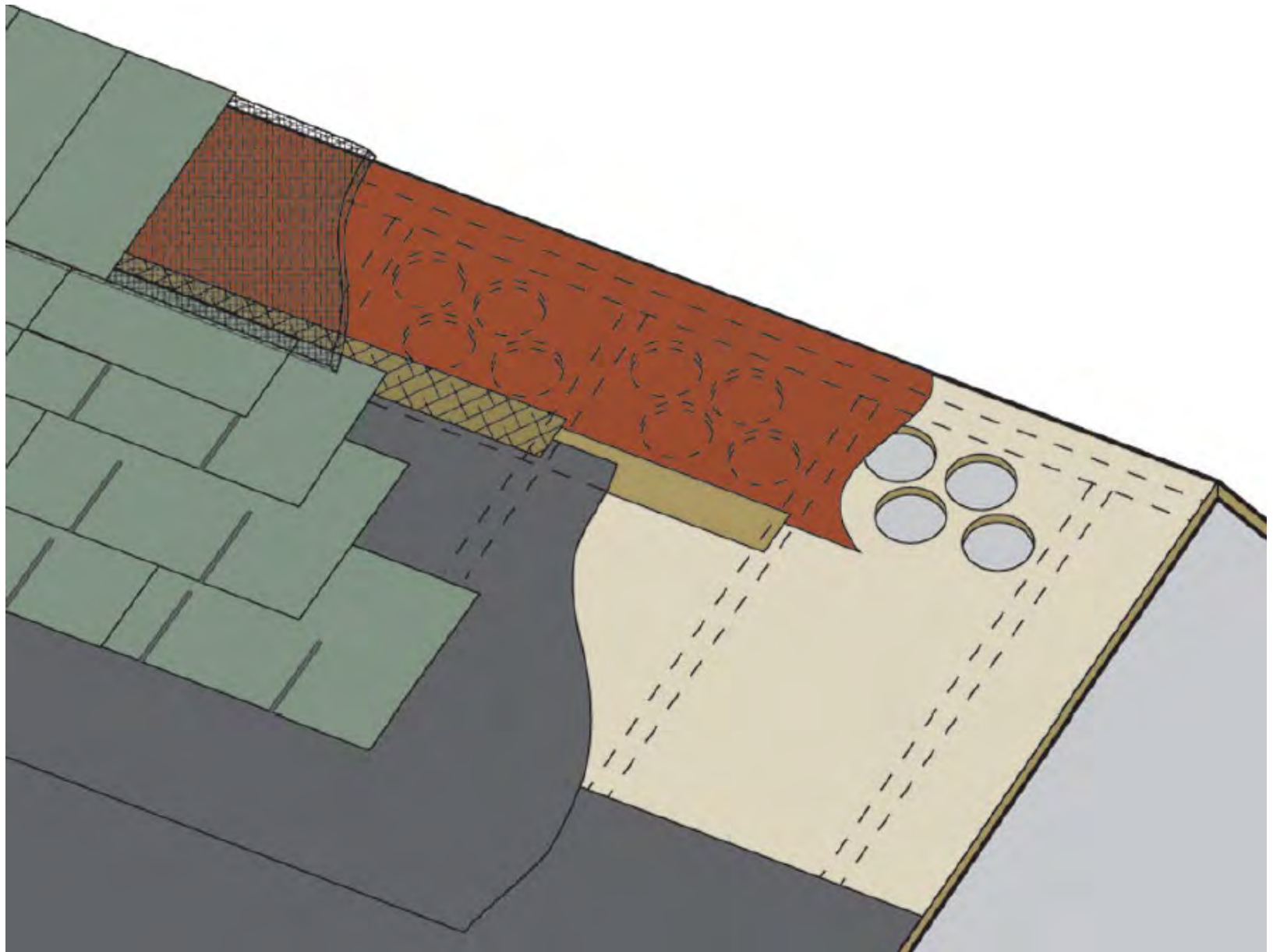


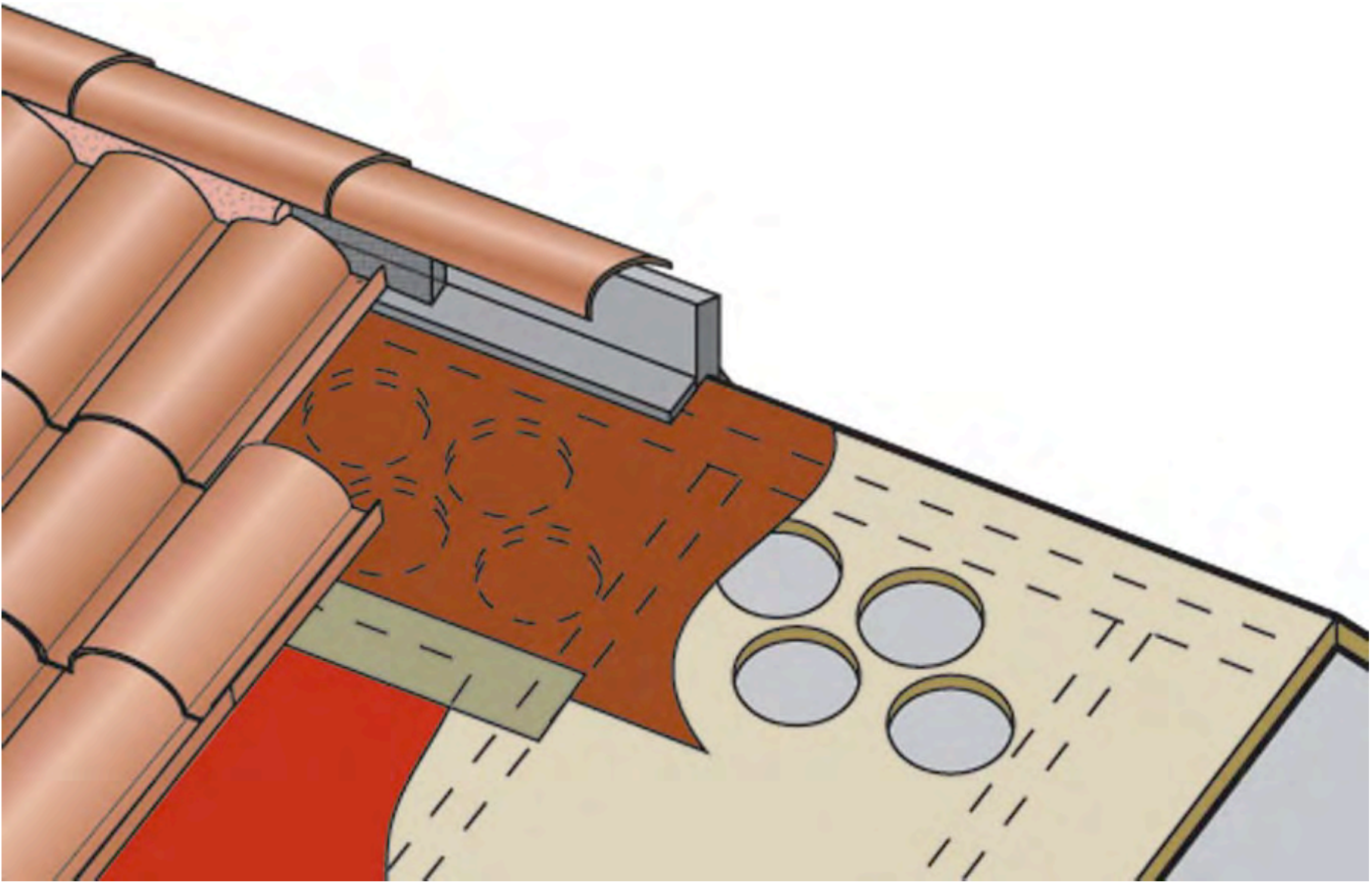
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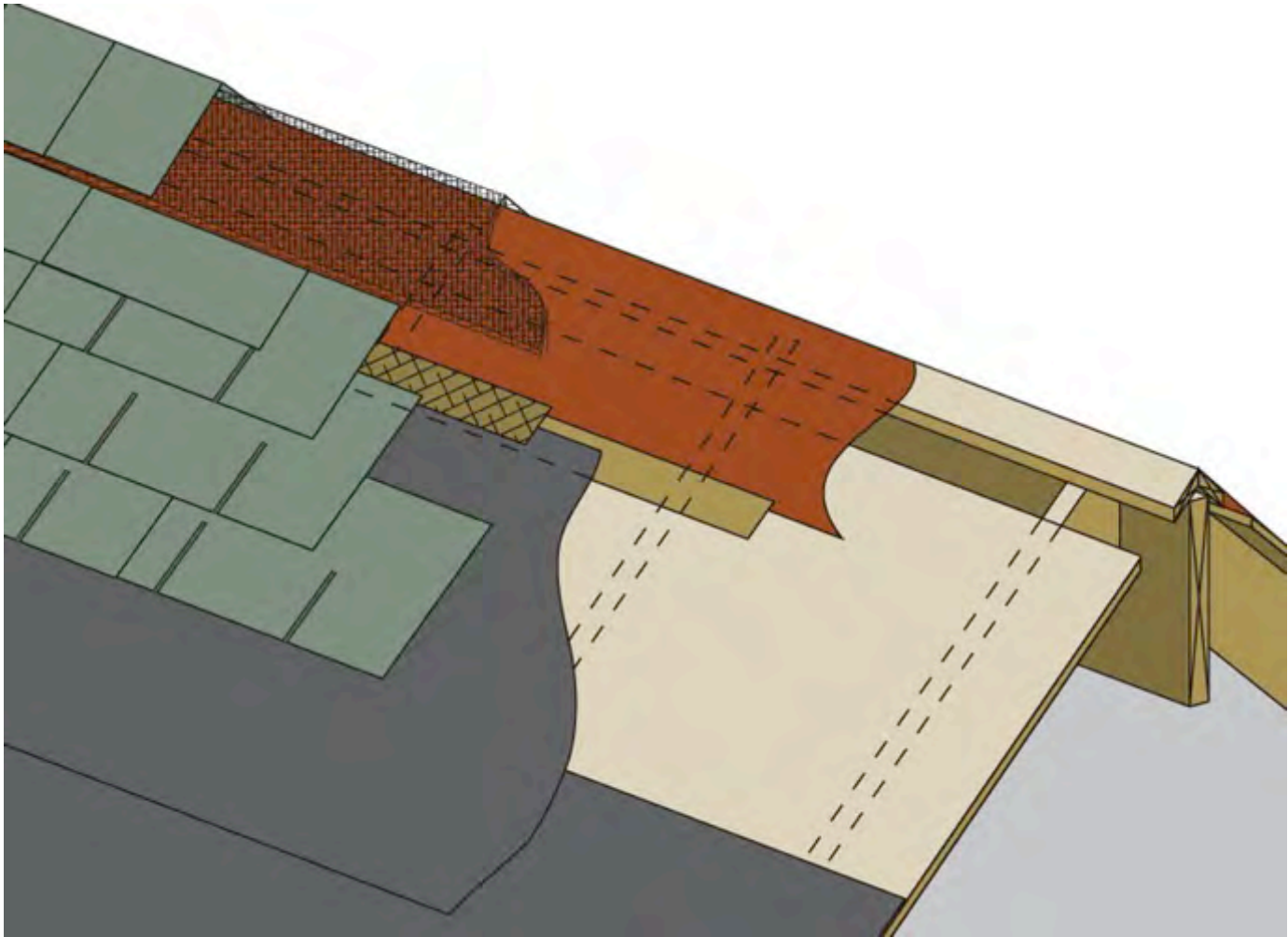
Note Water Vapor (H<sub>2</sub>O) is 18  
 Dry Air is 29

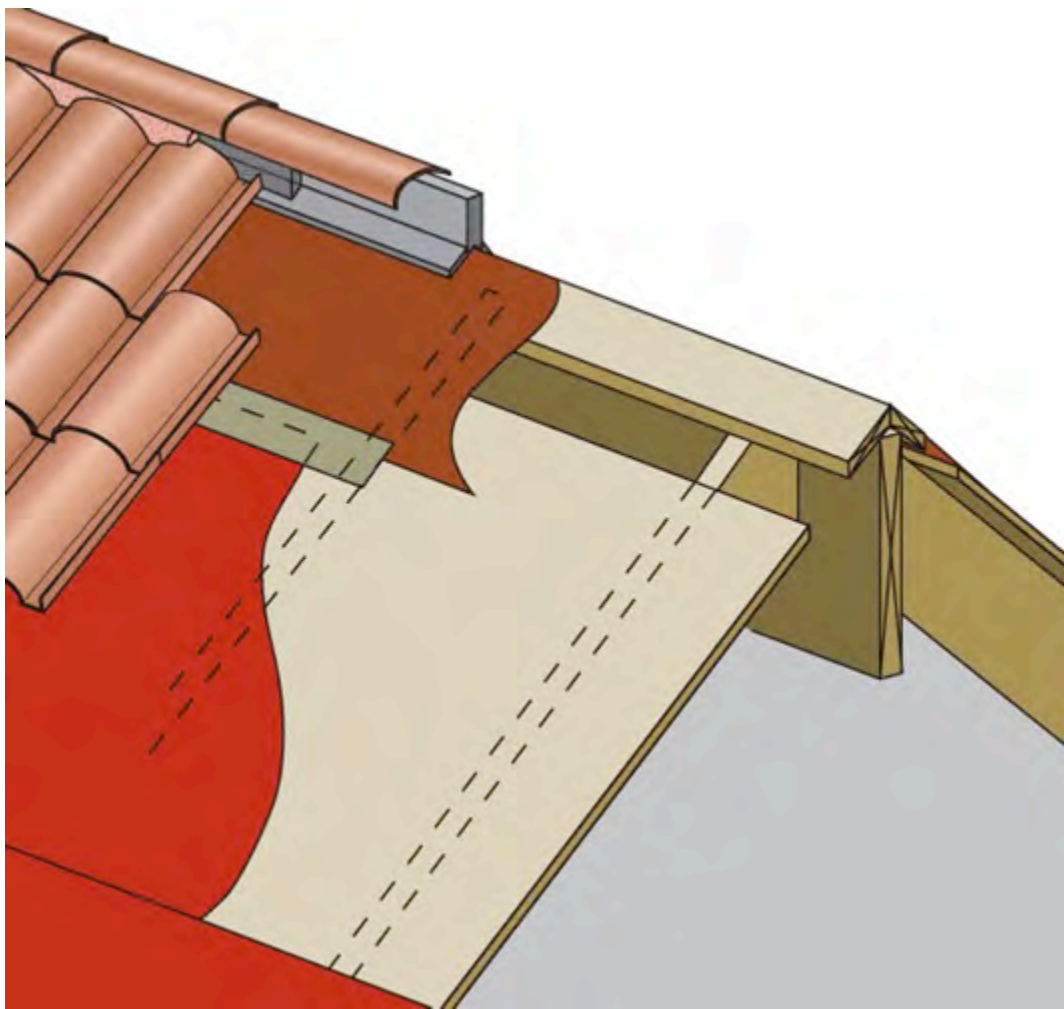


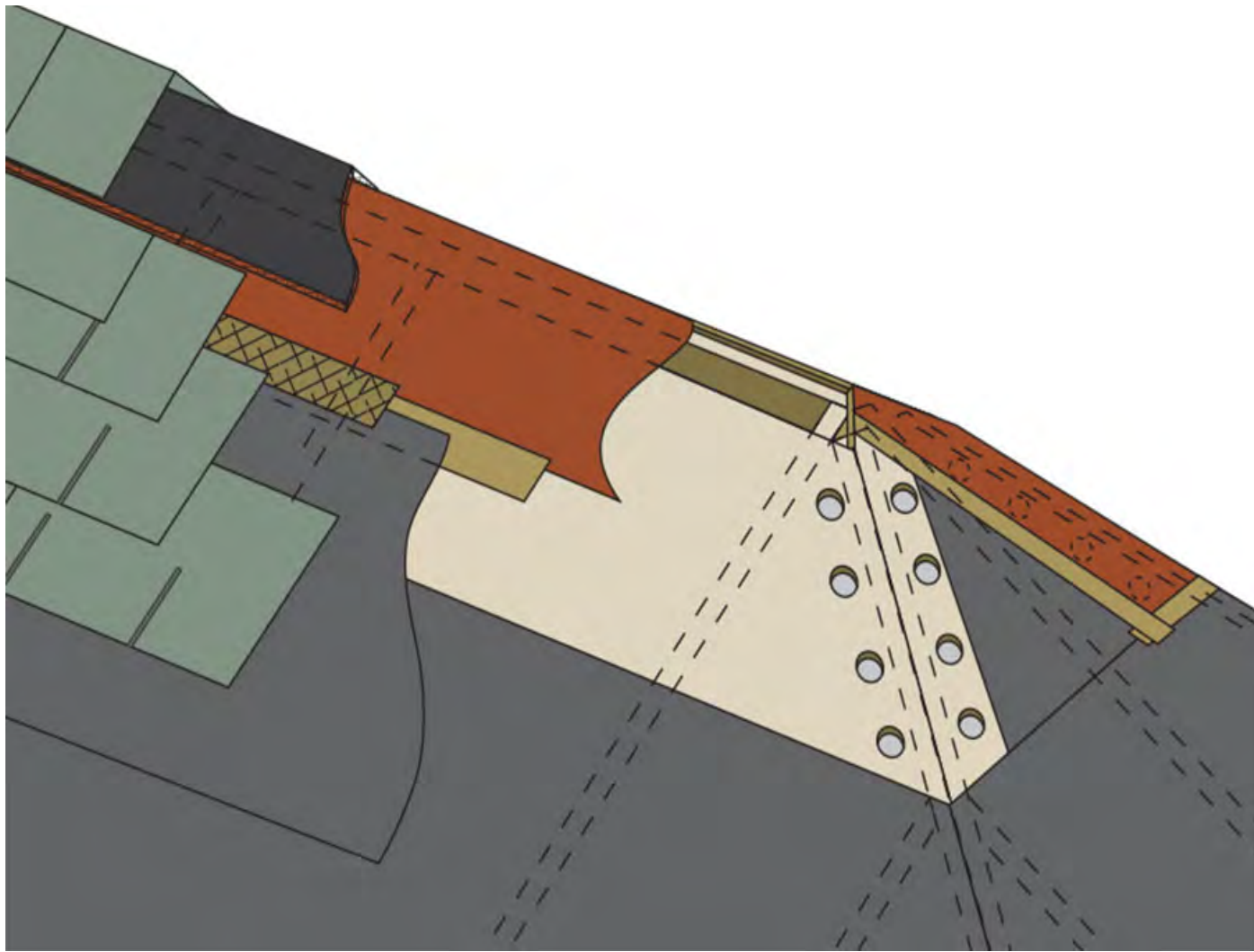
















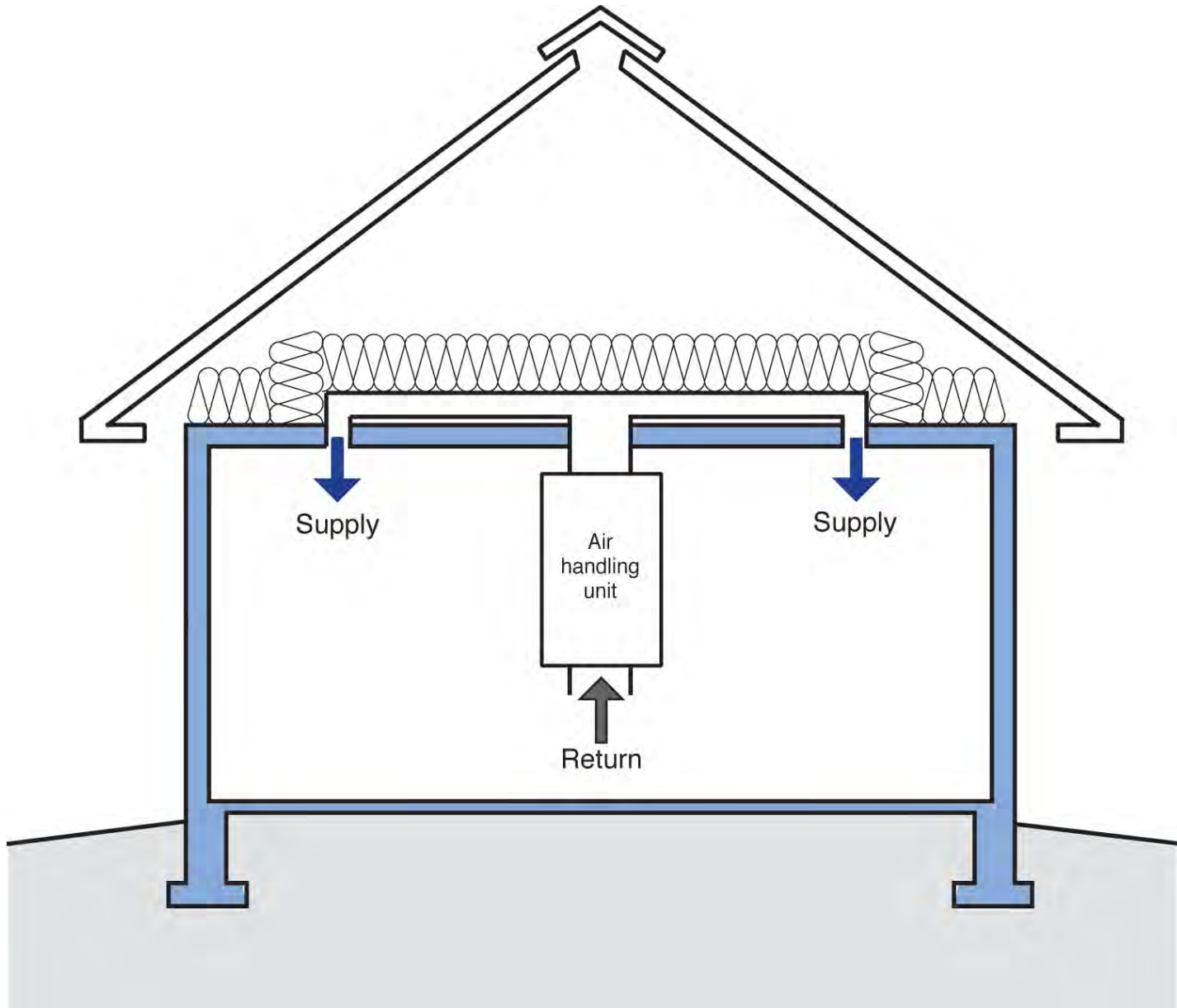


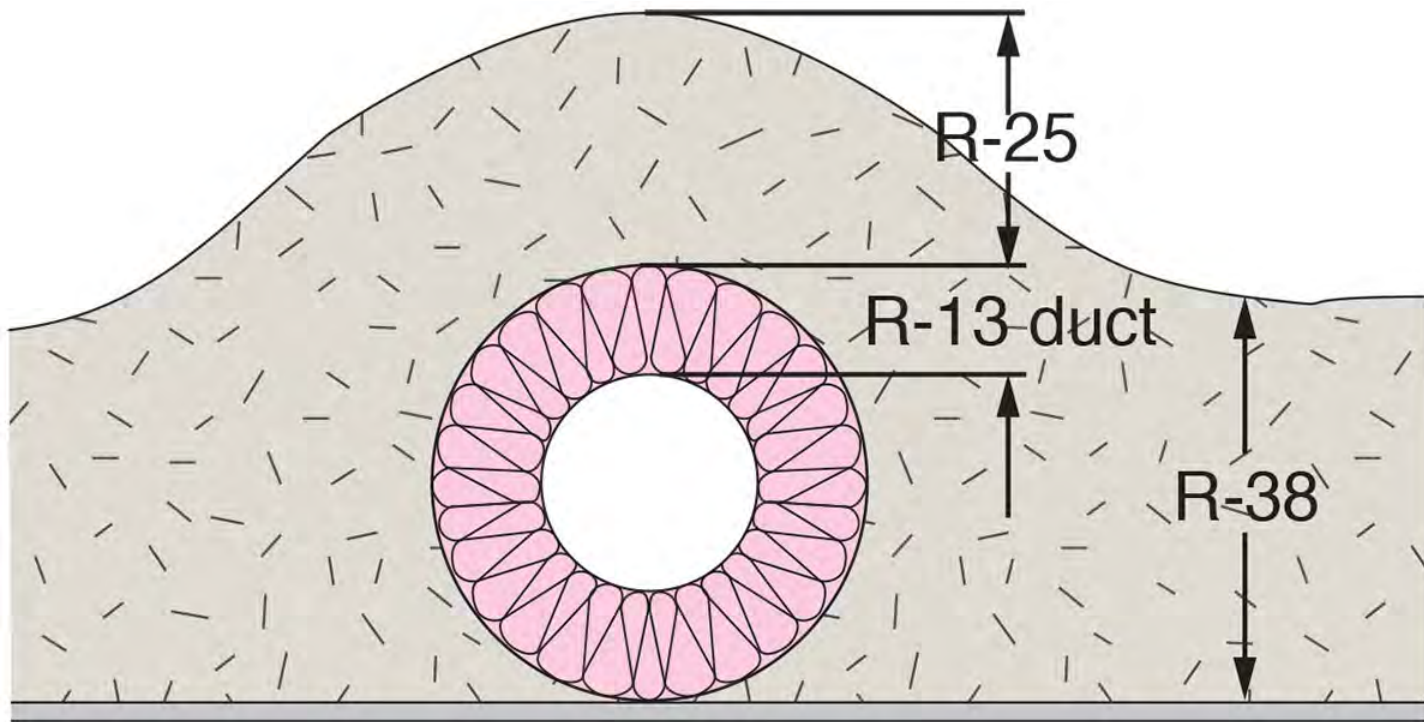






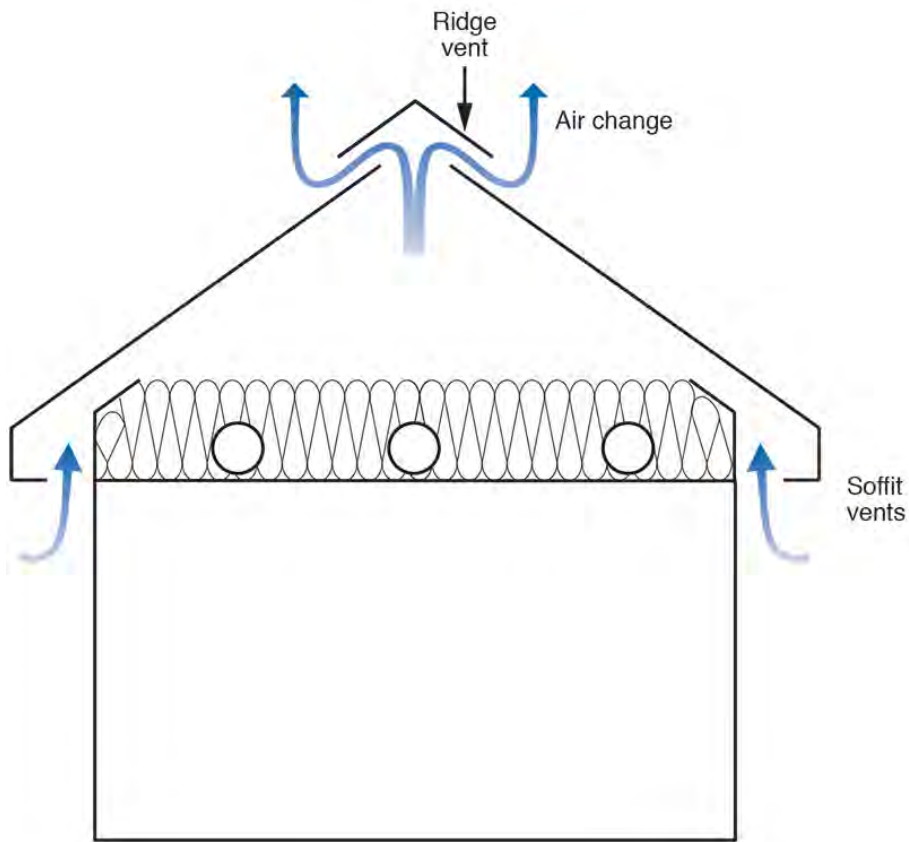
# Burying Ducts



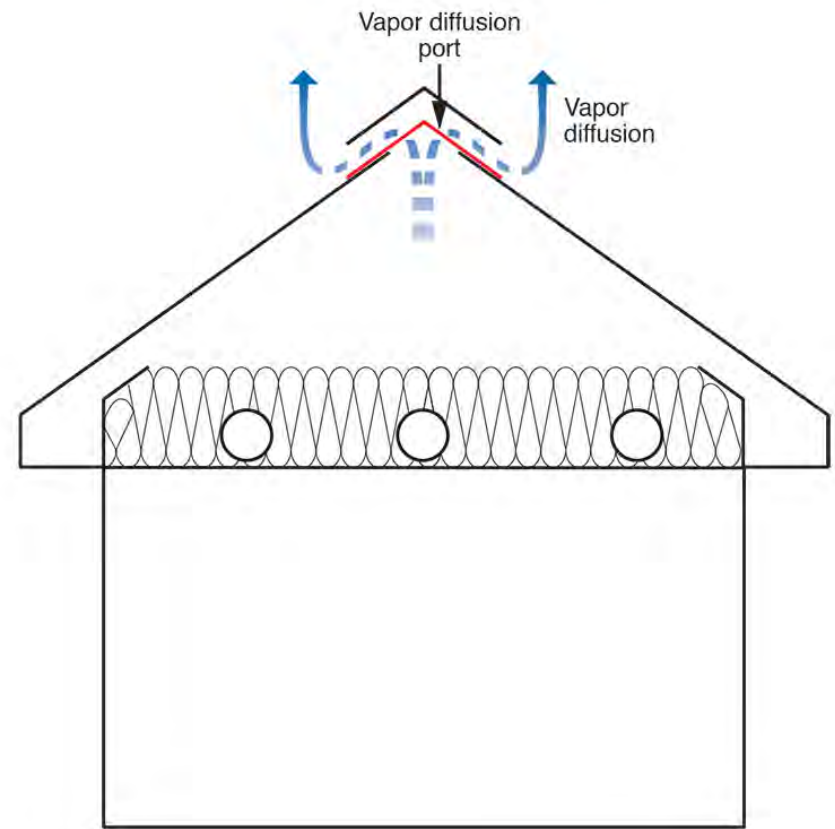




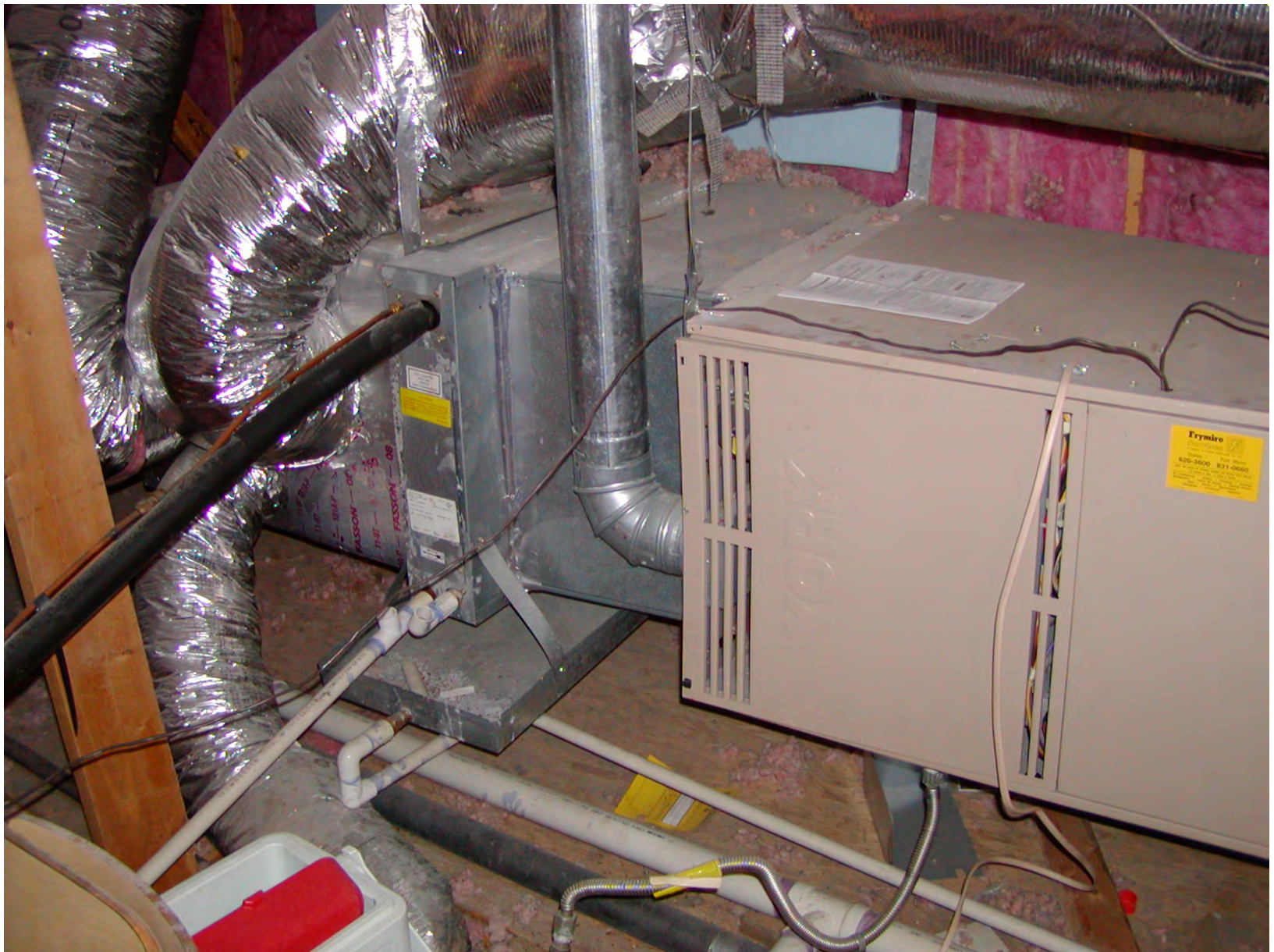




Classic vented attic



Unvented attic with vapor diffusion port





# Mechanical Systems

# Mechanical Systems

## Cooling System To Make It Cold

# Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

# Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

Heating System To Make It Warm



# Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

Heating System To Make It Warm

Energy Recovery System To Keep It Cold  
and Dry and Warm and Comfortable

# Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

Heating System To Make It Warm

Energy Recovery System To Keep It Cold  
and Dry and Warm and Comfortable

Distribution System To Make It Uniform

## Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

Heating System To Make It Warm

Energy Recovery System To Keep It Cold  
and Dry and Warm and Comfortable

Distribution System To Make It Uniform

Range Hoods Are A Special Kind of Hell

Don't Try to Combine Them.....

