

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

# Building Science

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## Roofs

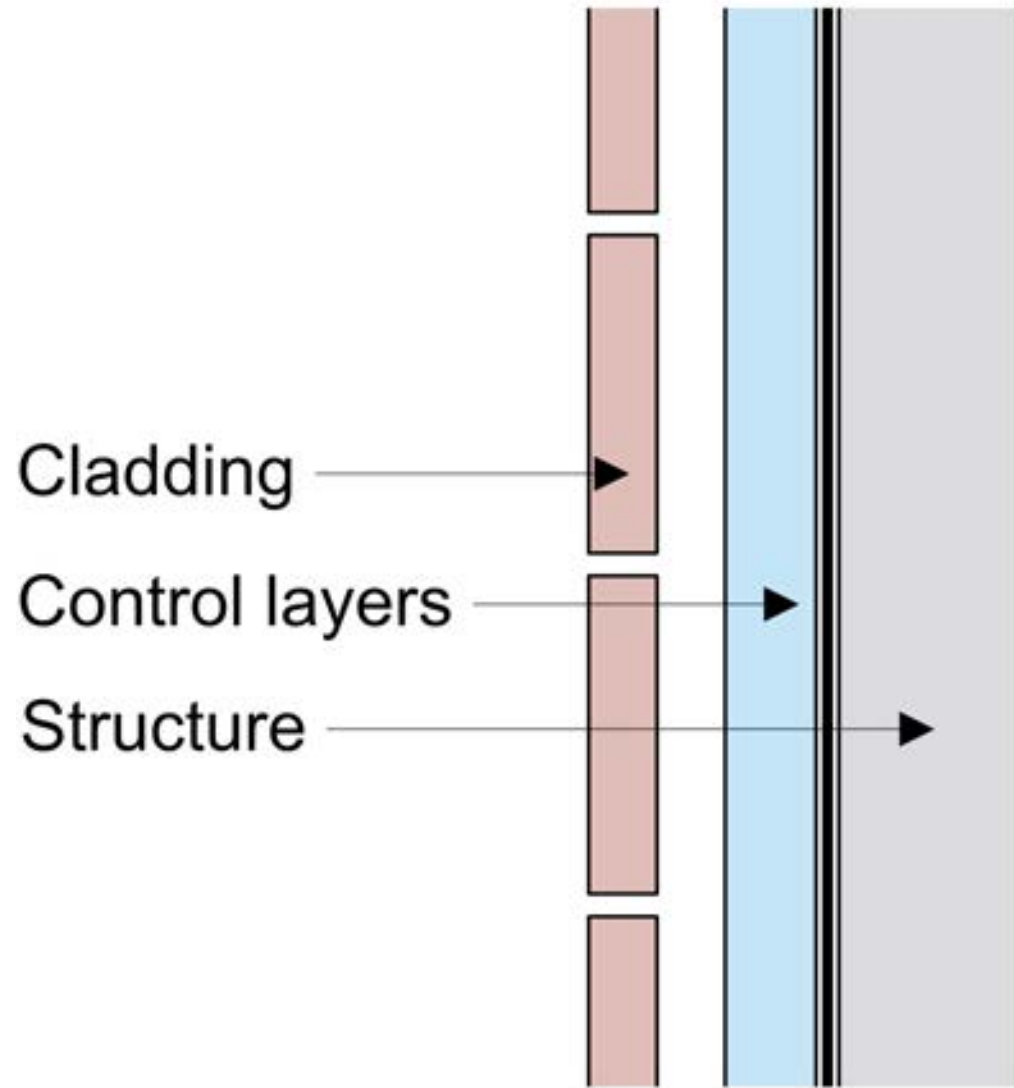
presented by [www.buildingscience.com](http://www.buildingscience.com)

Water Control Layer

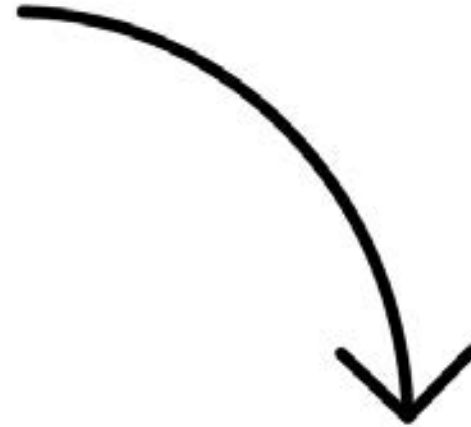
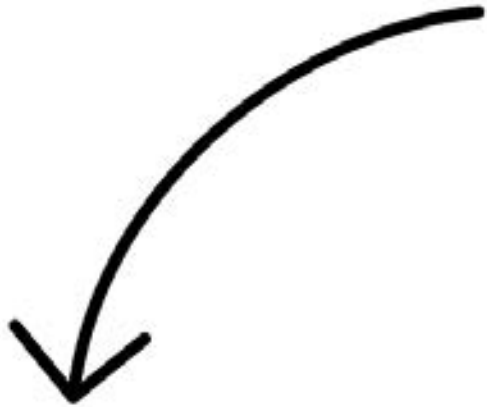
Air Control Layer

Vapor Control Layer

Thermal Control Layer



**Wall**

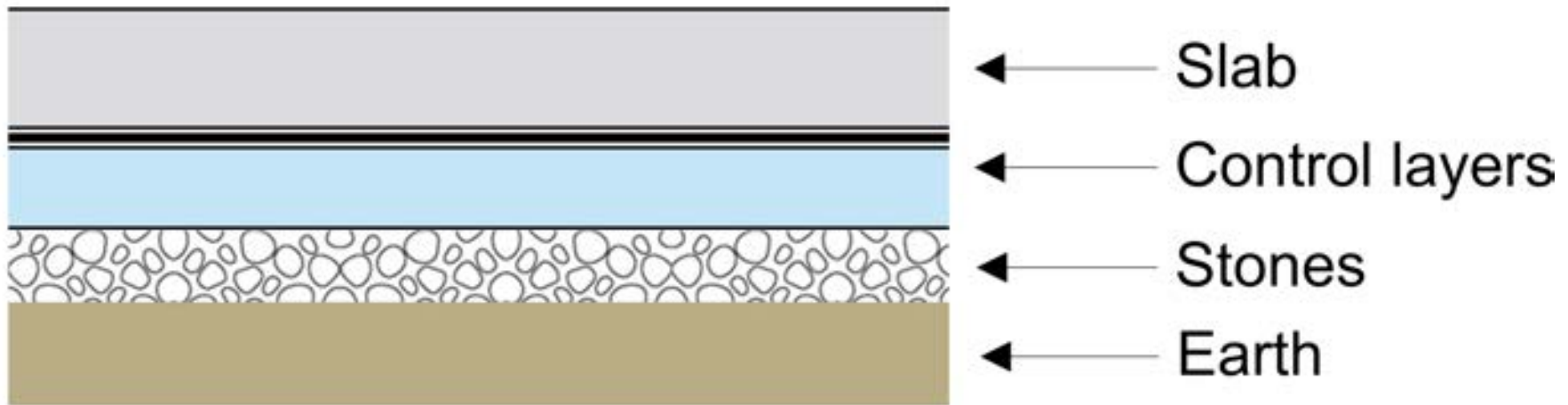


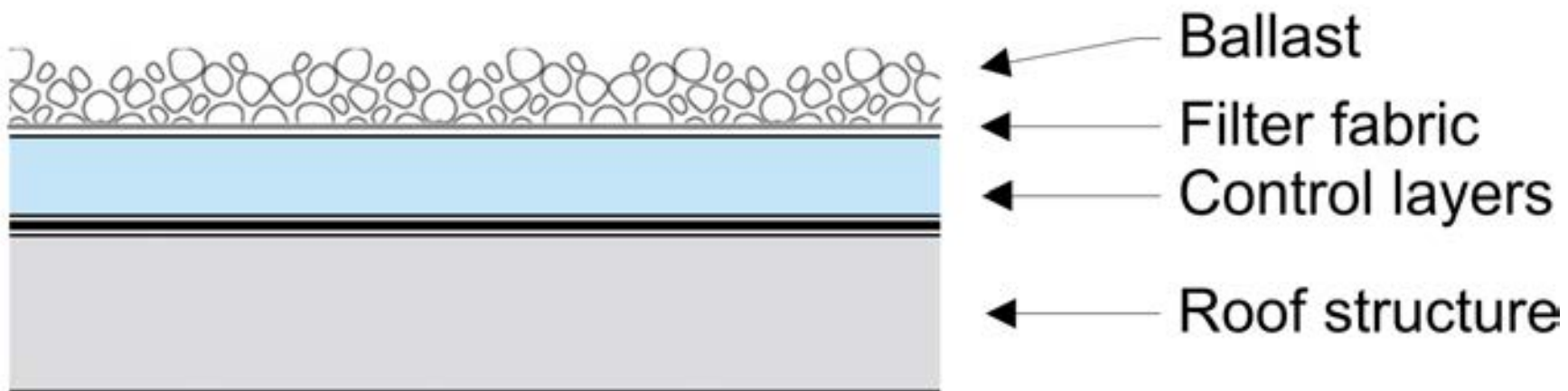
**Slab**

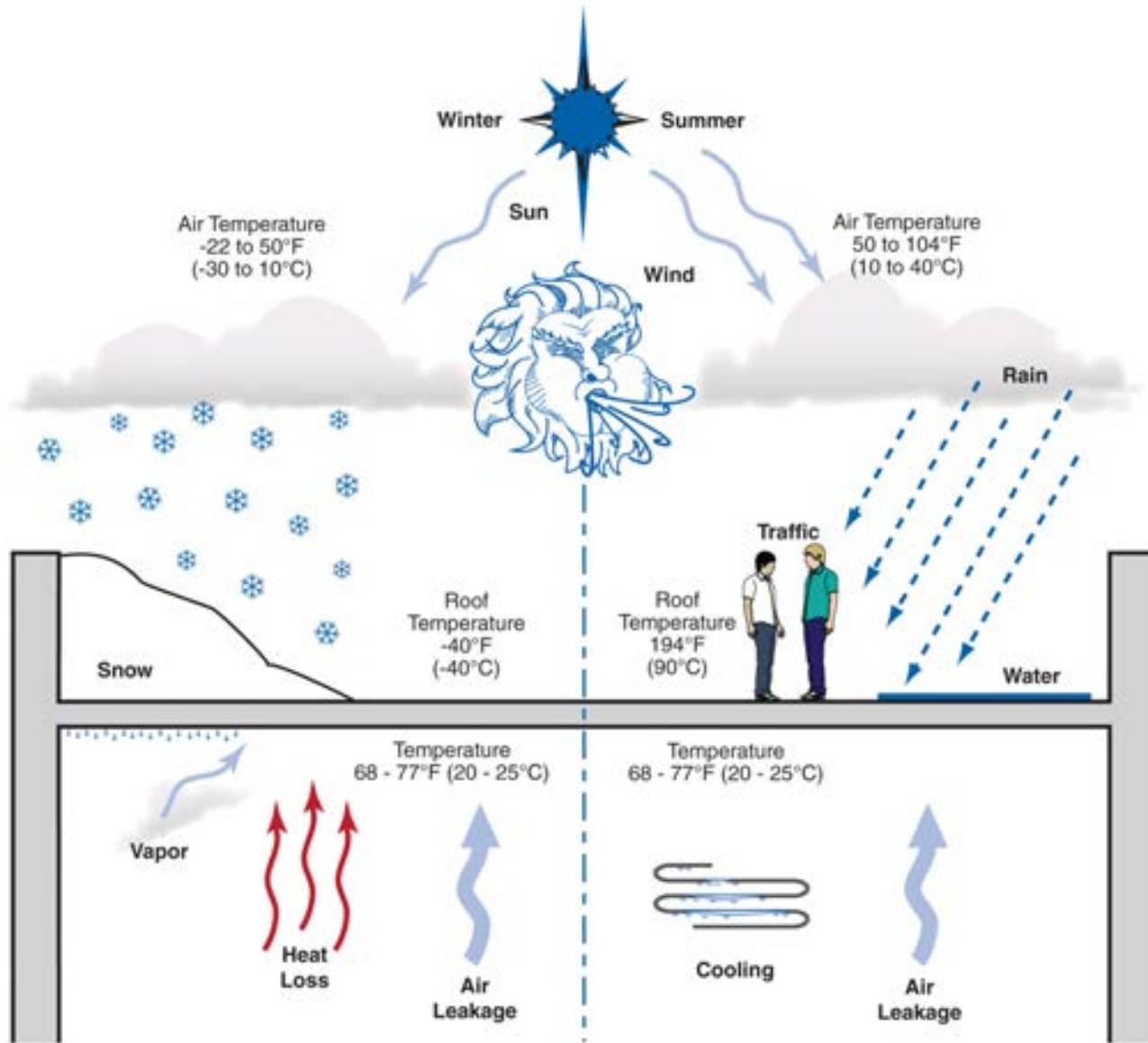


**Roof**

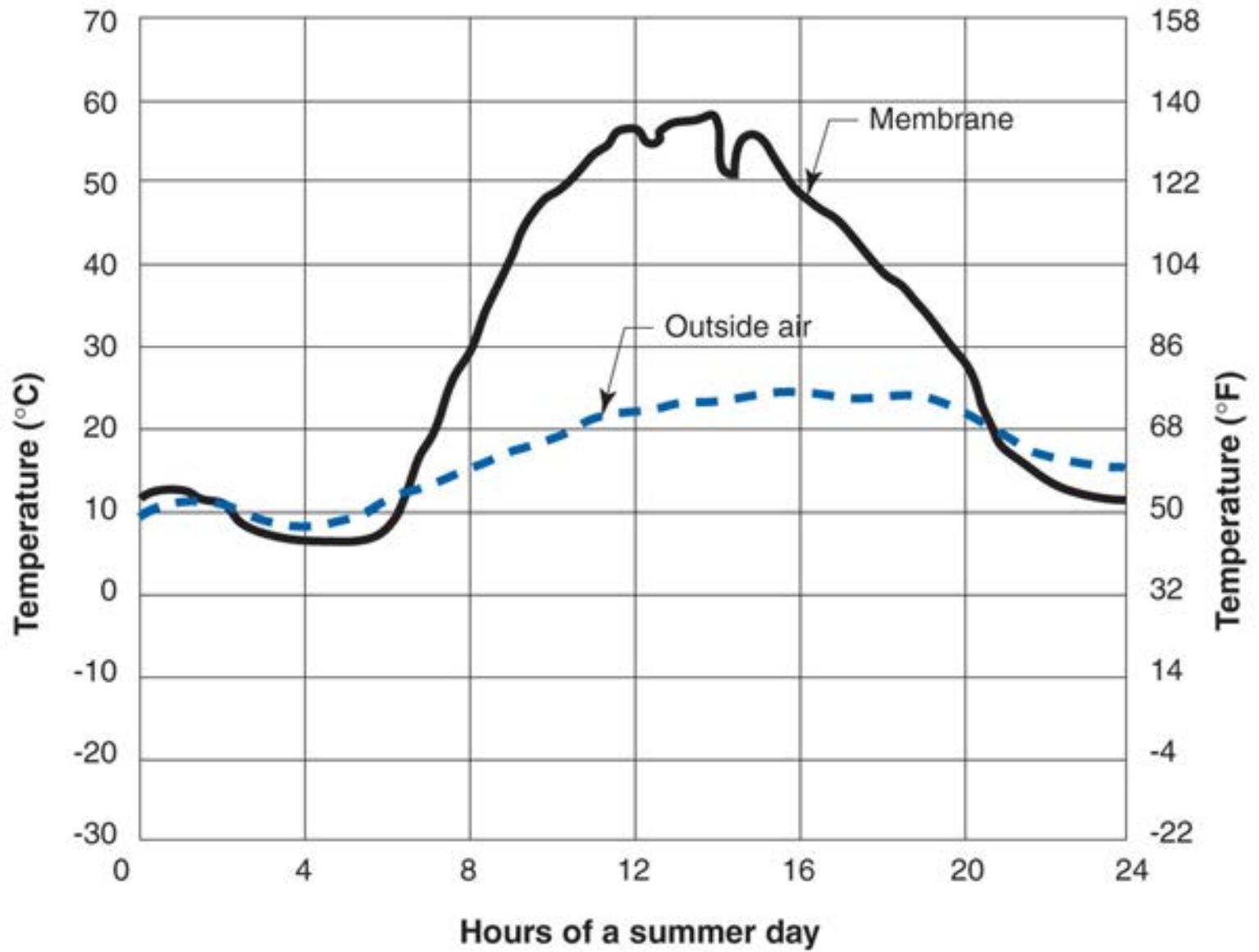




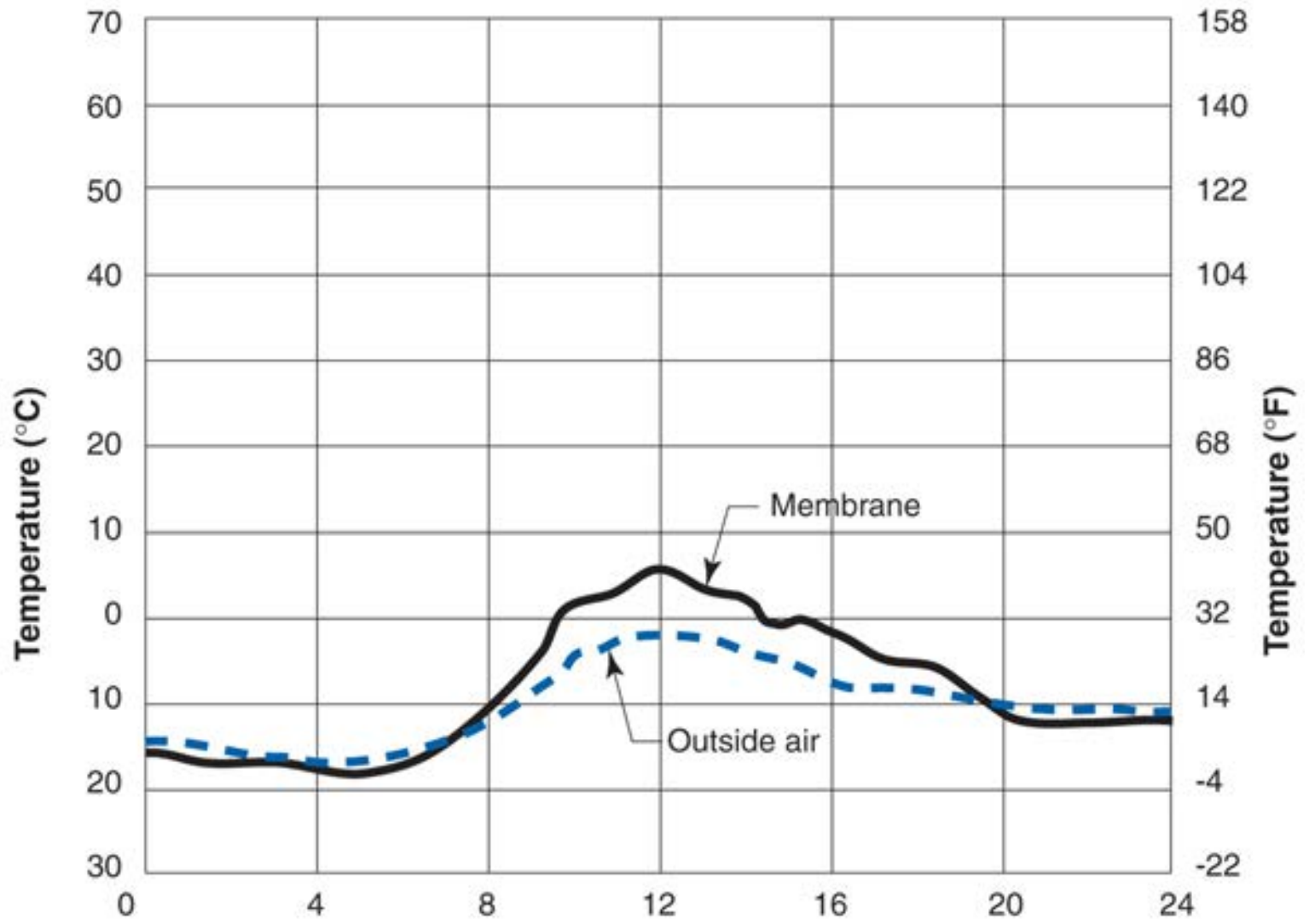




Adapted from Baker, M.: *Roofs*, 1980;  
 Courtesy National Research Council of Canada

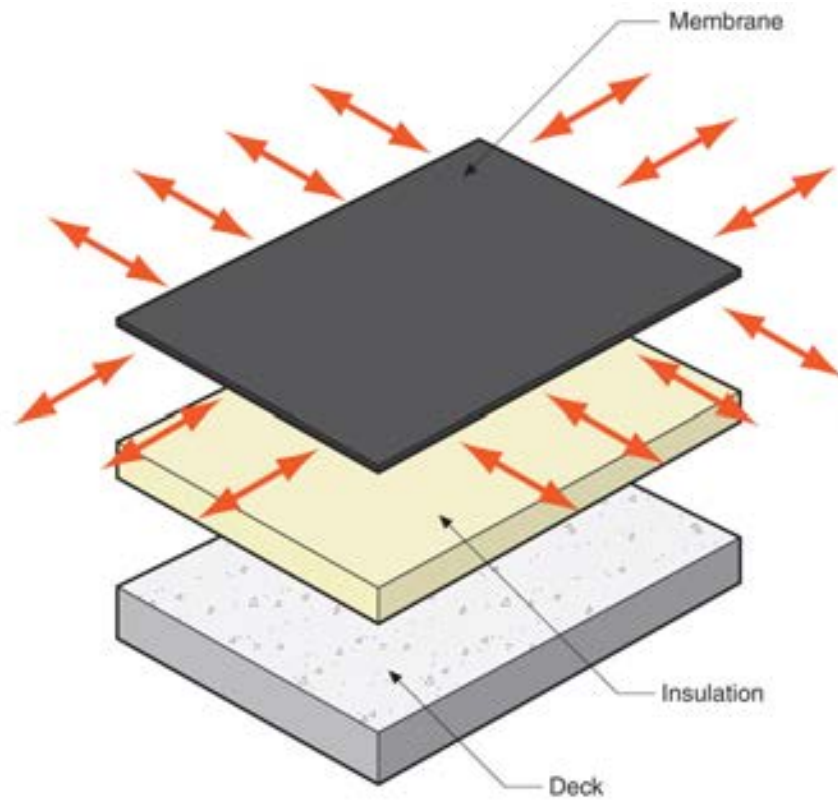
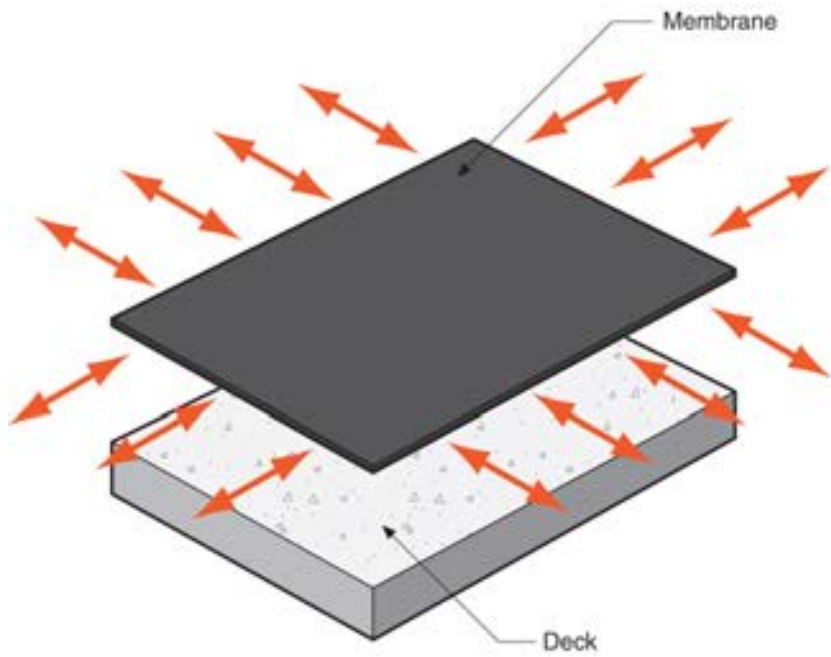


From Baker, M.; *Roofs*, 1980

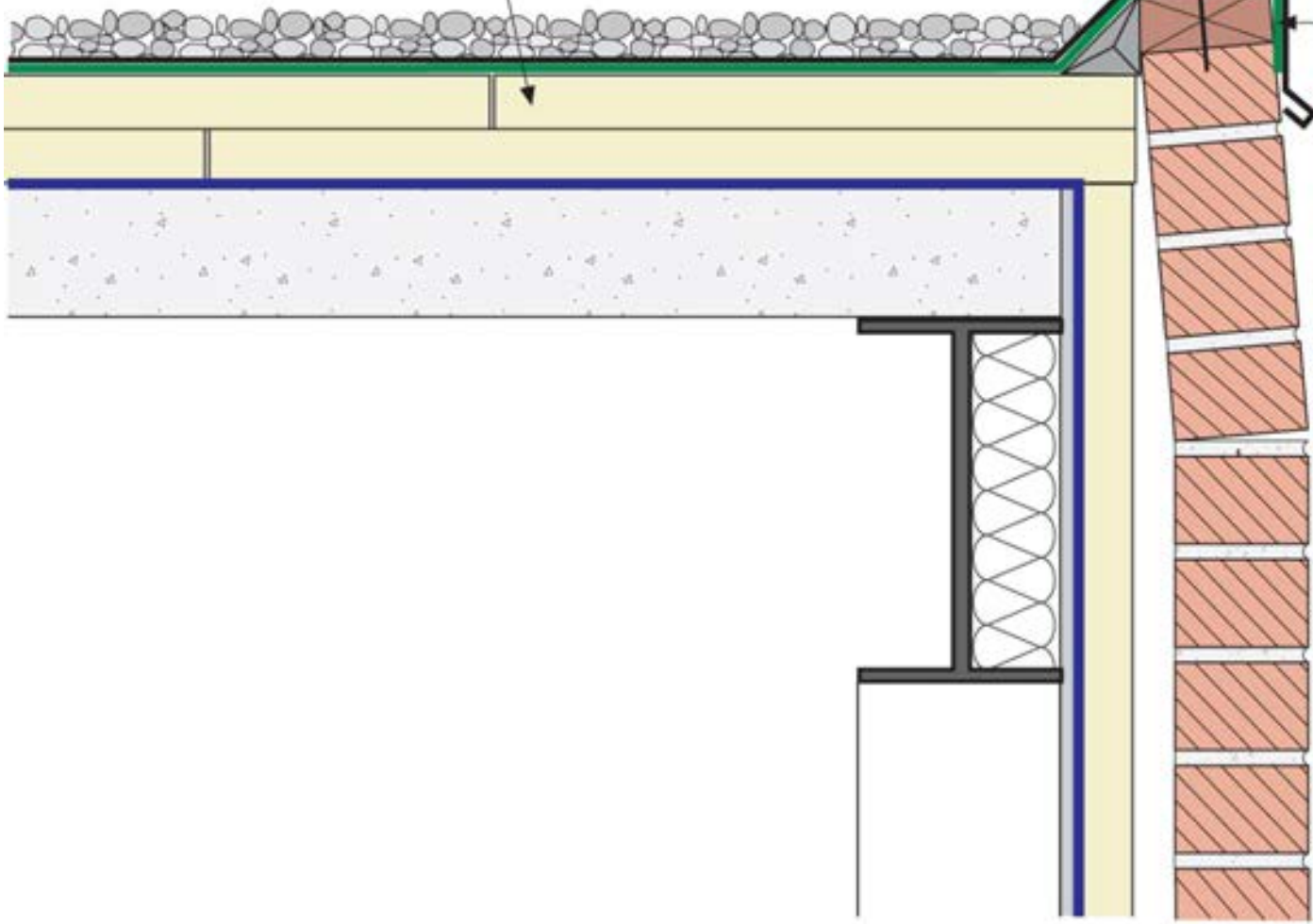


**Hours of a winter day**

*From Baker, M.; Roofs, 1980*



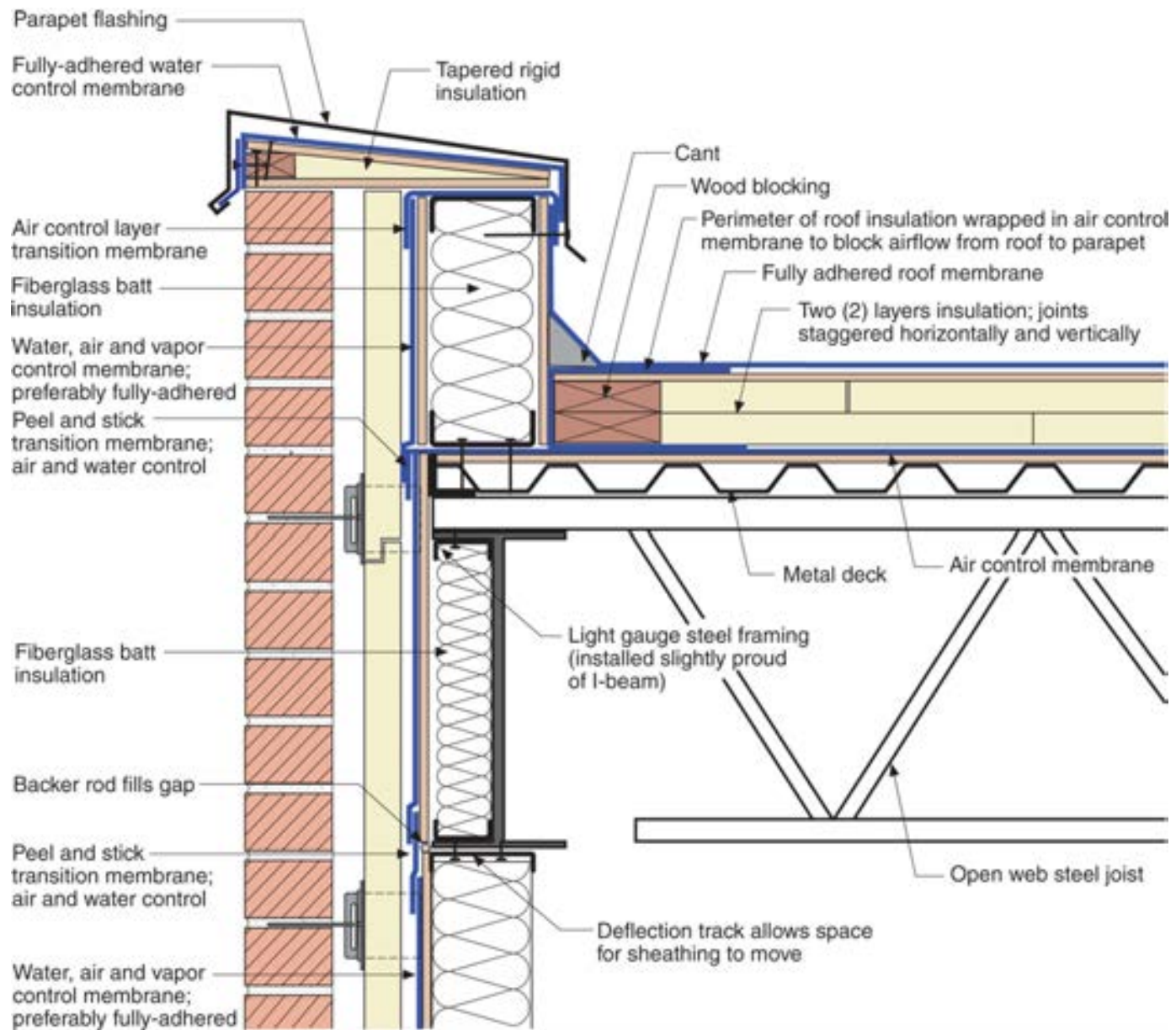
Insulation moved because of poor adhesion to deck and between layers



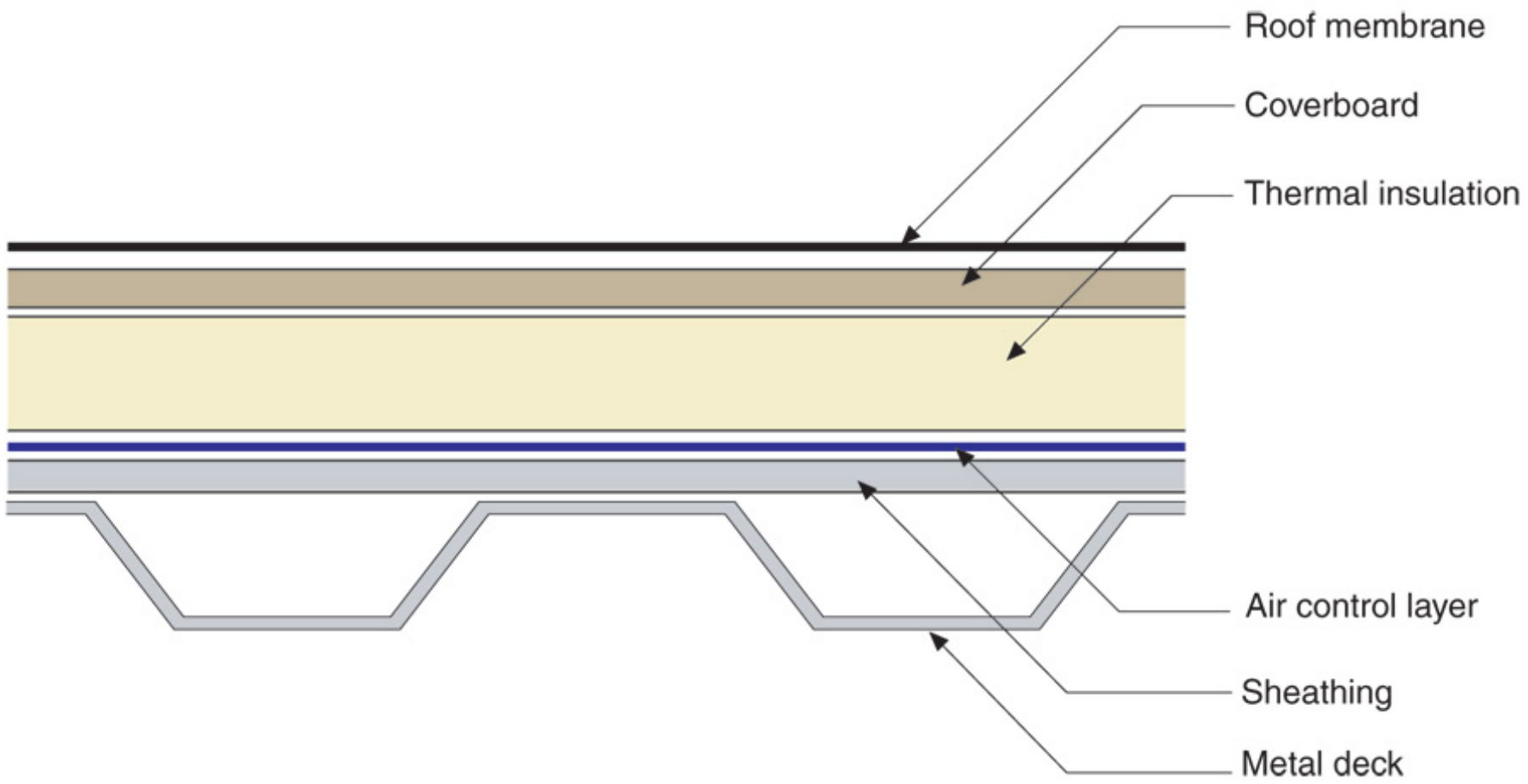
Top four courses of brick and wood blocking pulled inward by contracting membrane

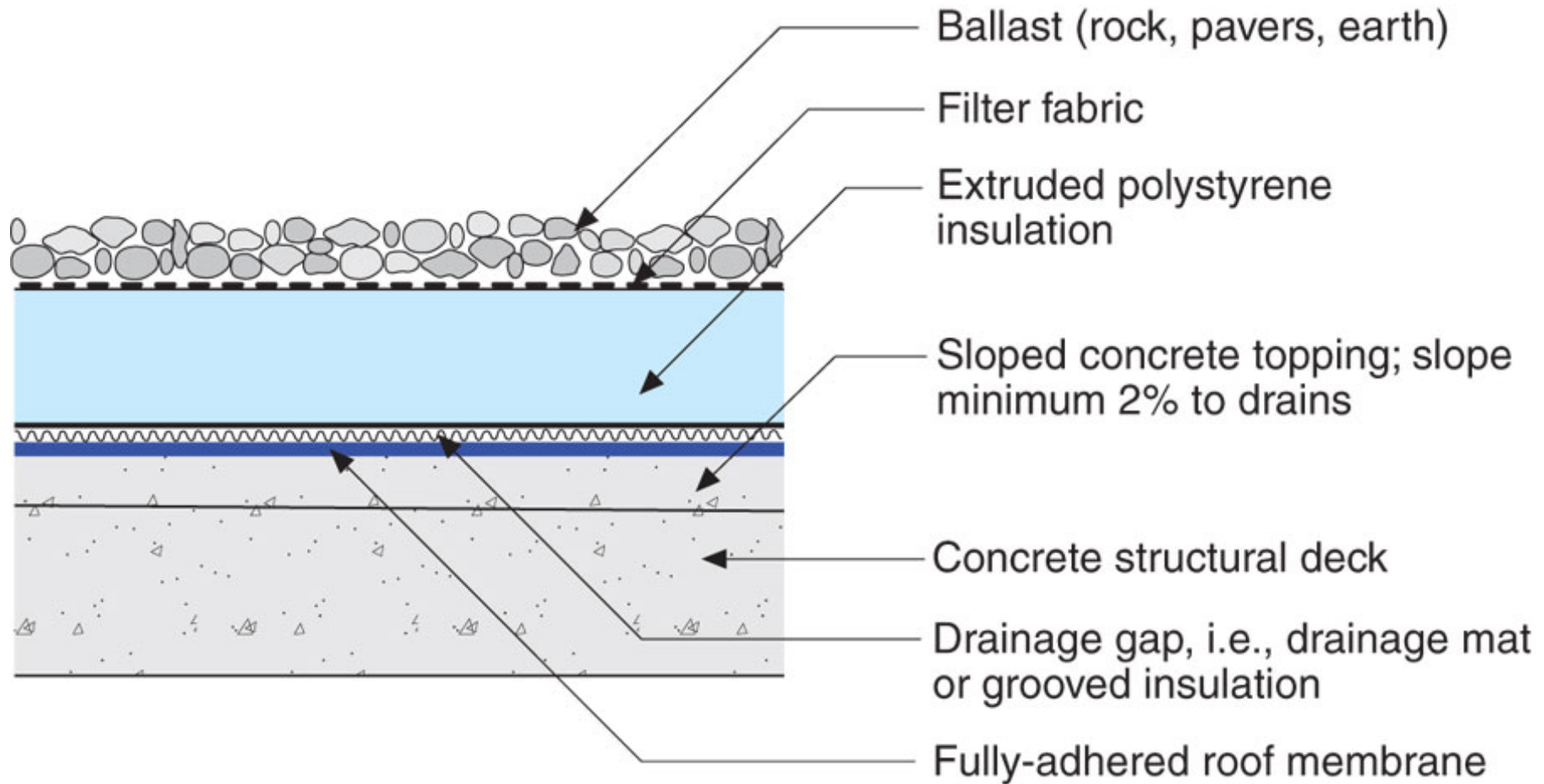
Adapted from Baker, M.; *Roofs*, 1980; Courtesy National Research Council of Canada

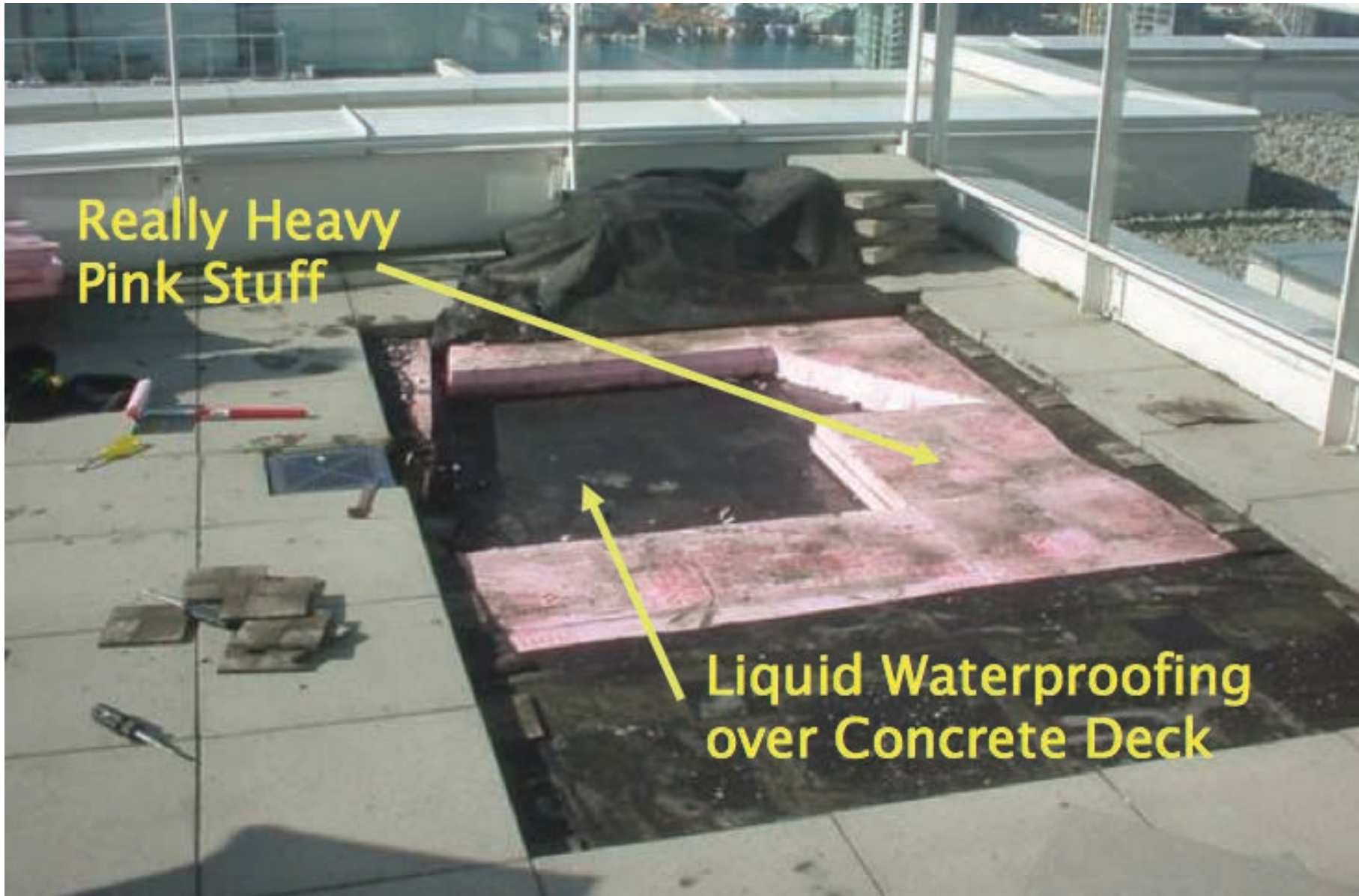






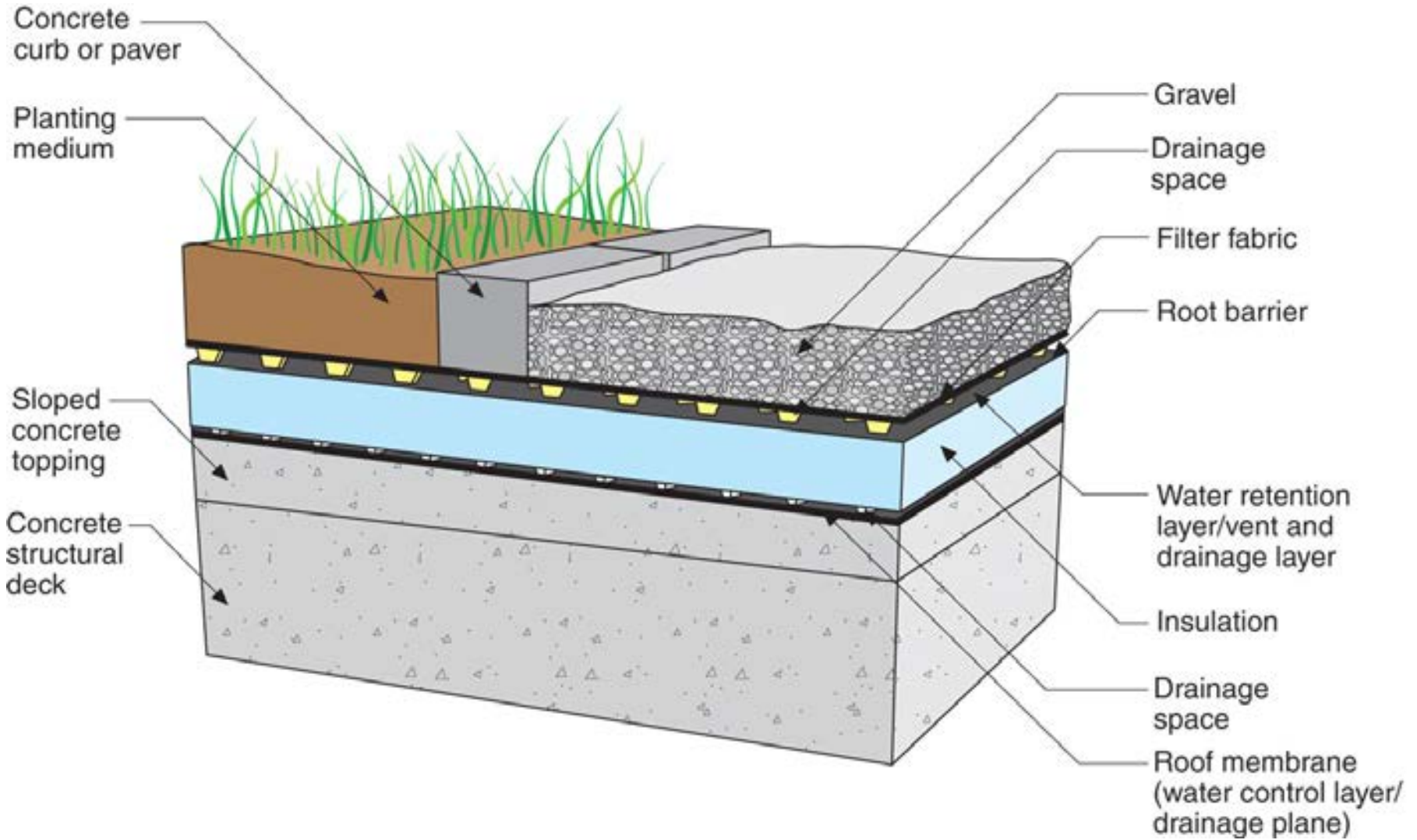






Really Heavy  
Pink Stuff

Liquid Waterproofing  
over Concrete Deck







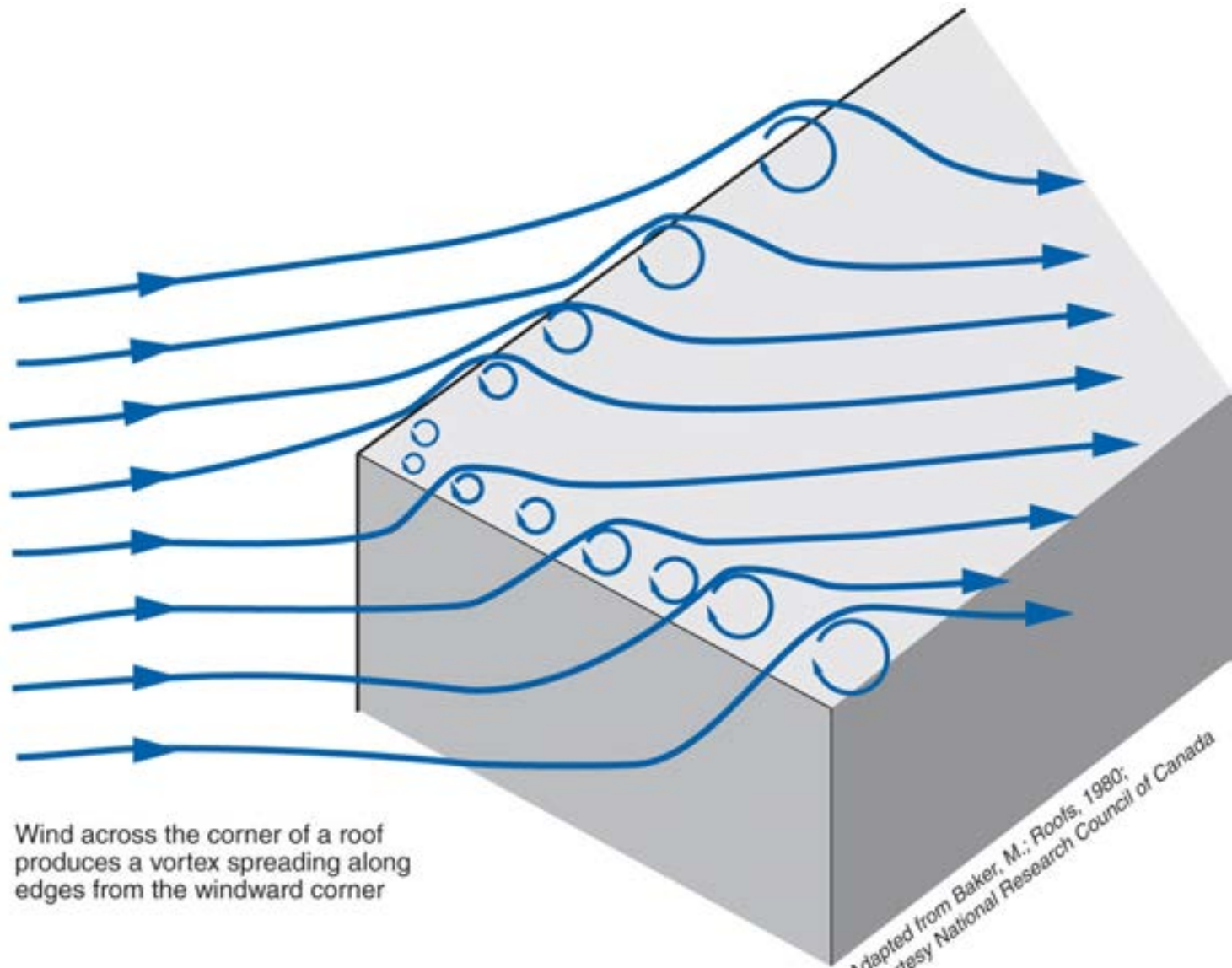






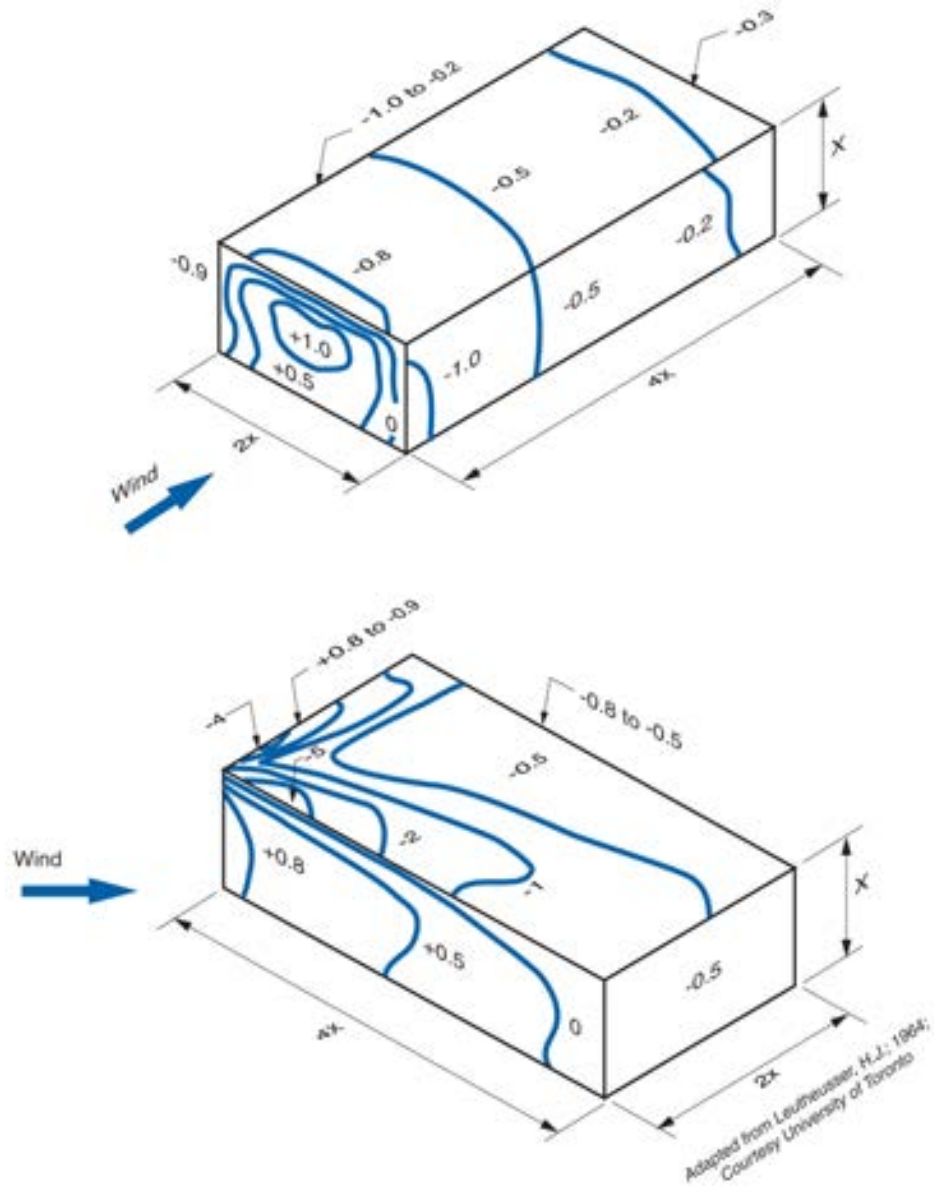


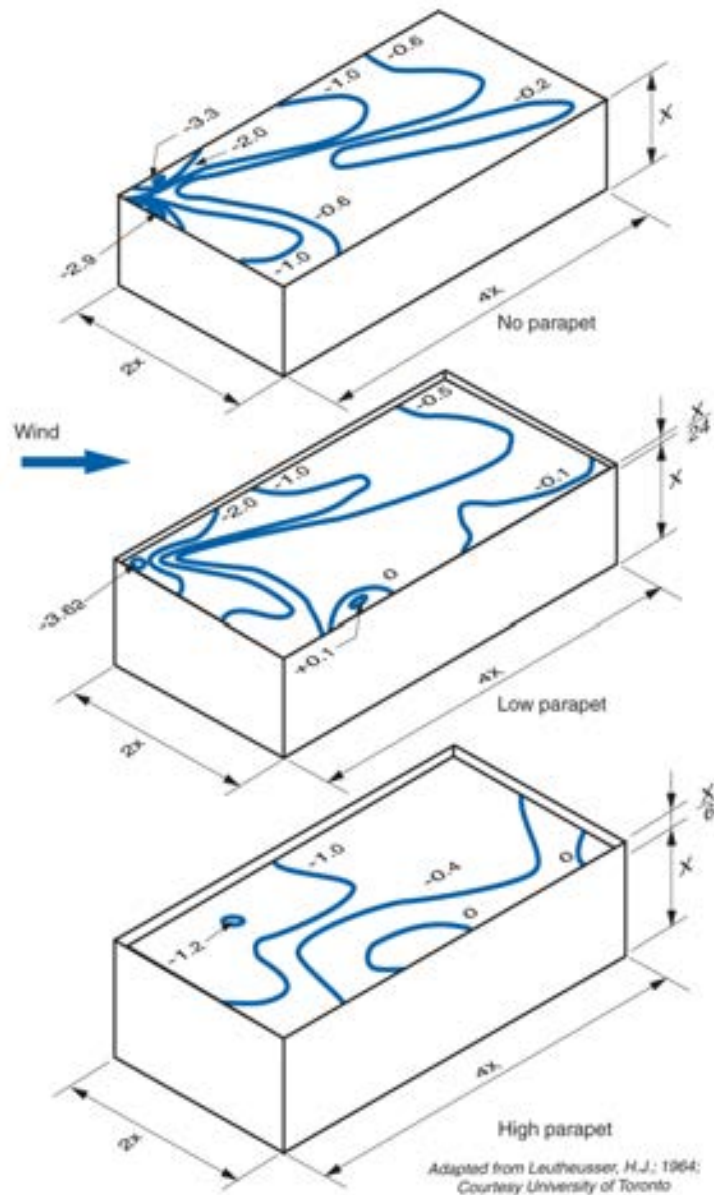


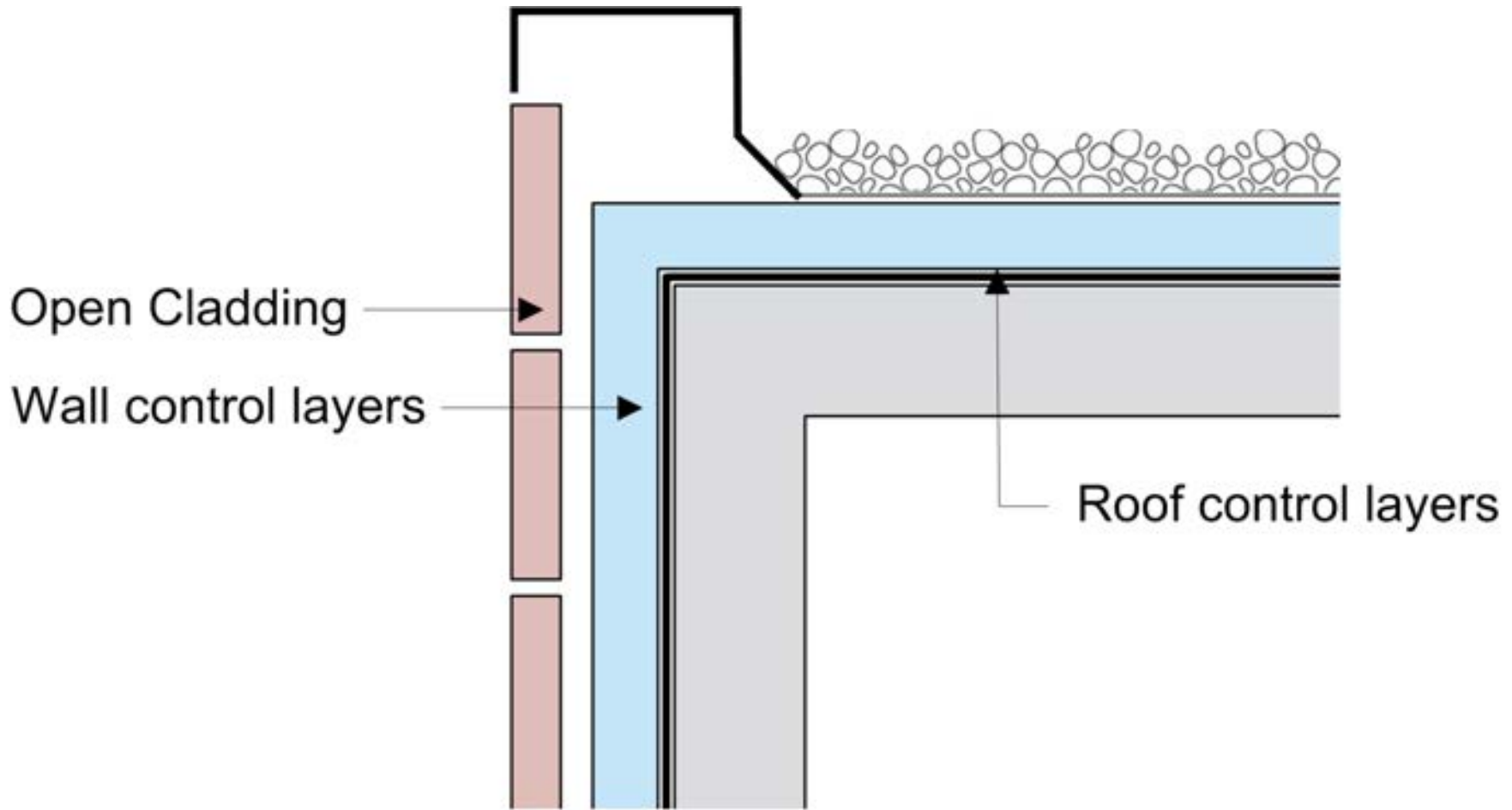


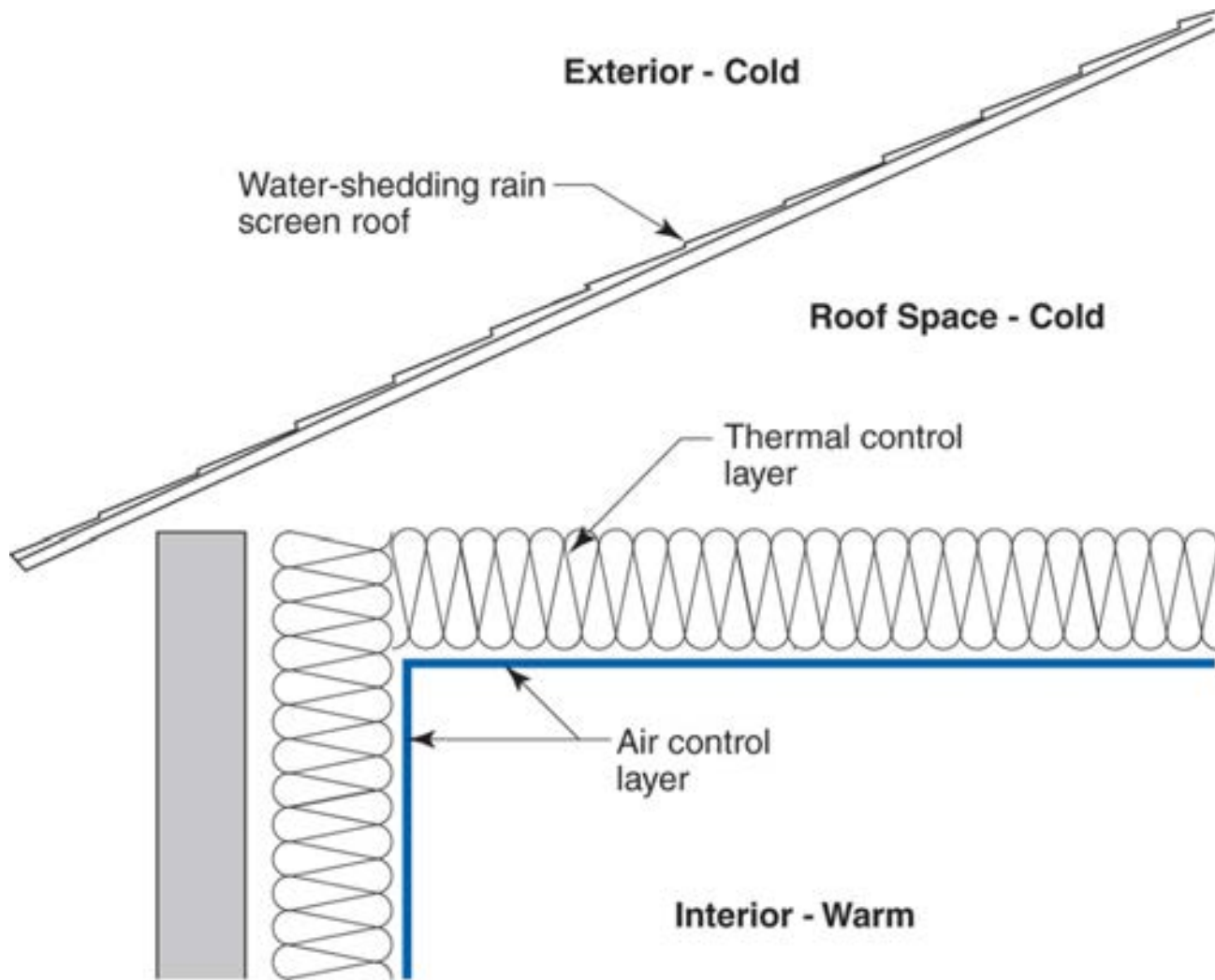
Wind across the corner of a roof produces a vortex spreading along edges from the windward corner

Adapted from Baker, M.: *Roofs*, 1980;  
Courtesy National Research Council of Canada

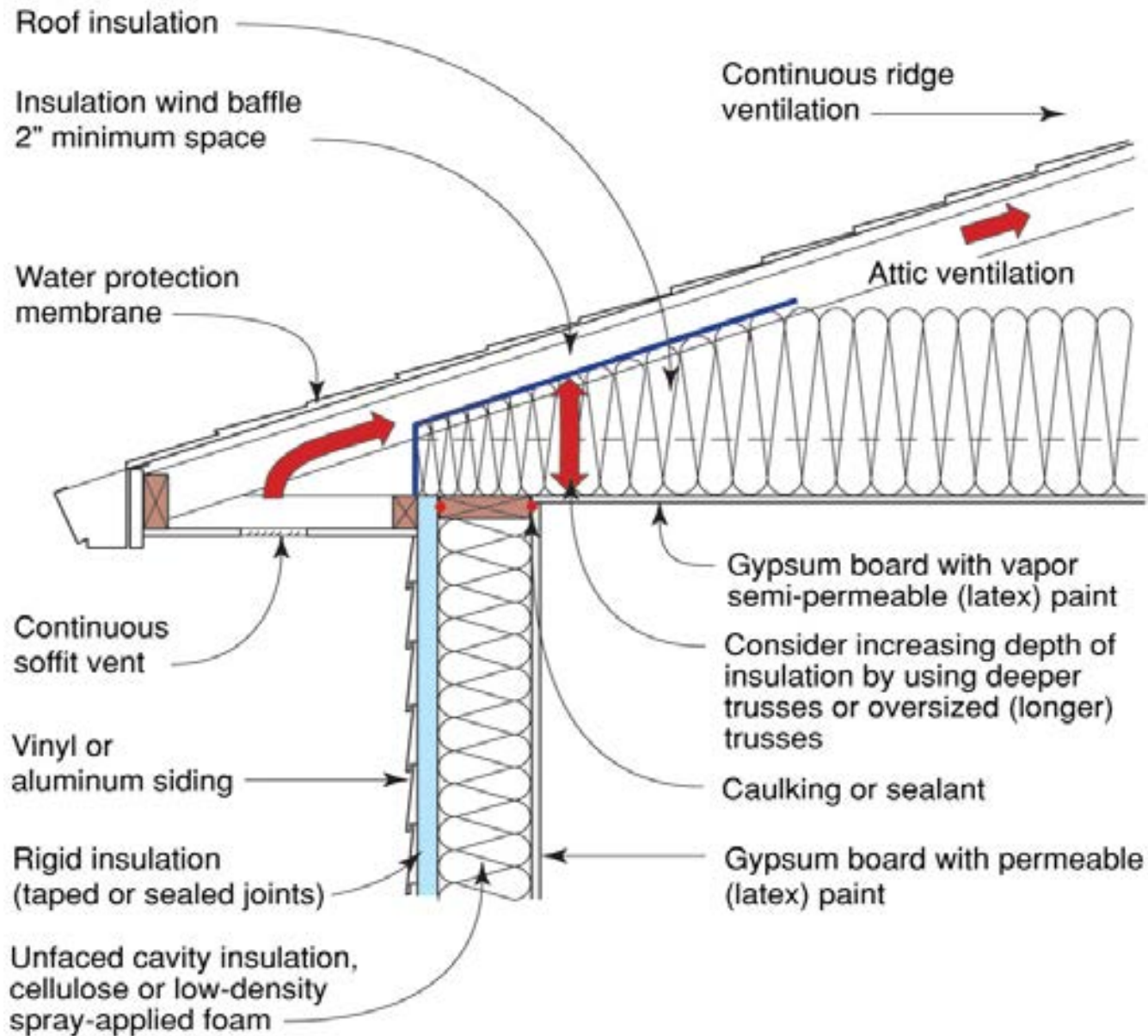


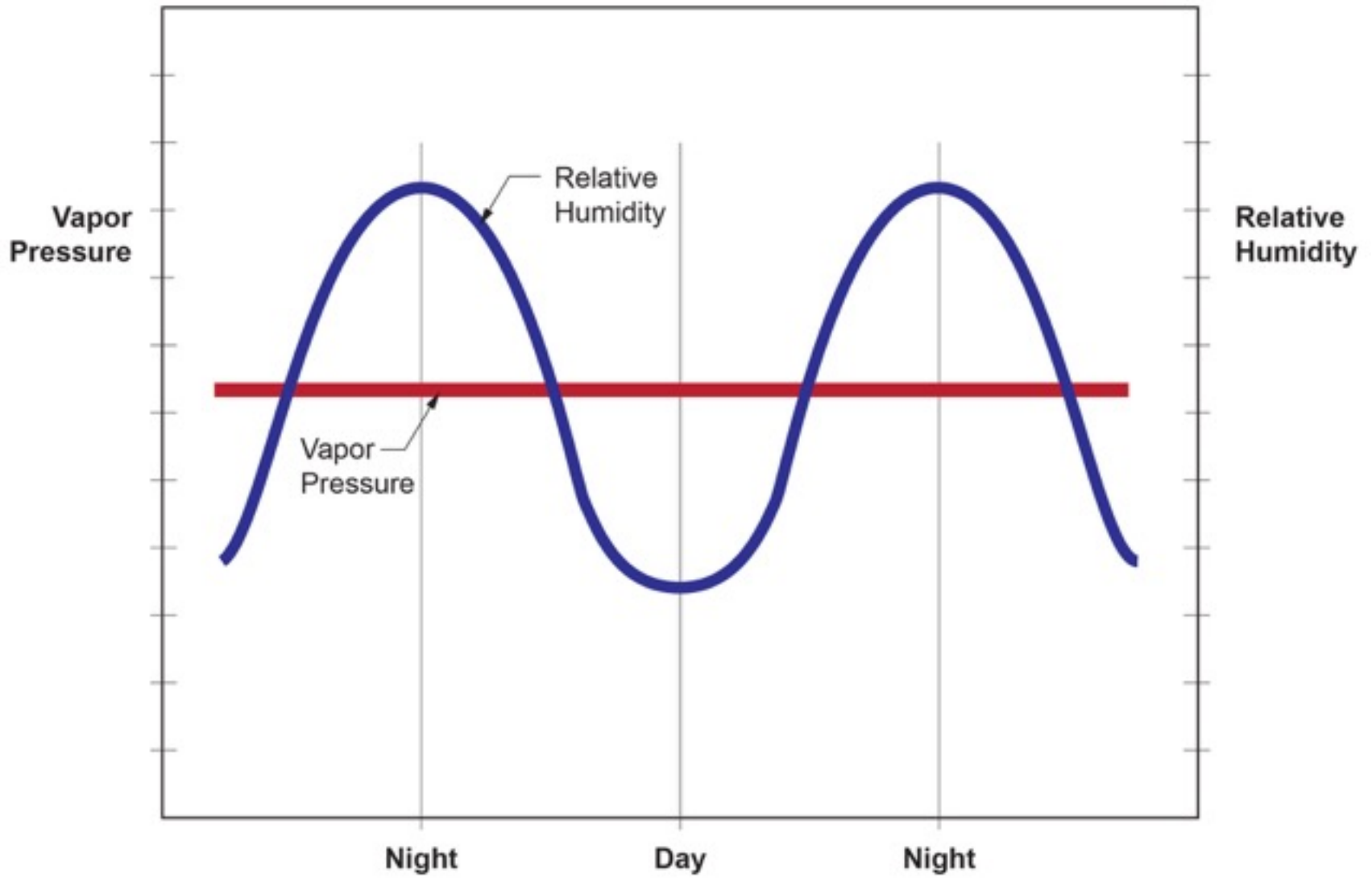






From Baker, M.; *Roofs*, 1980

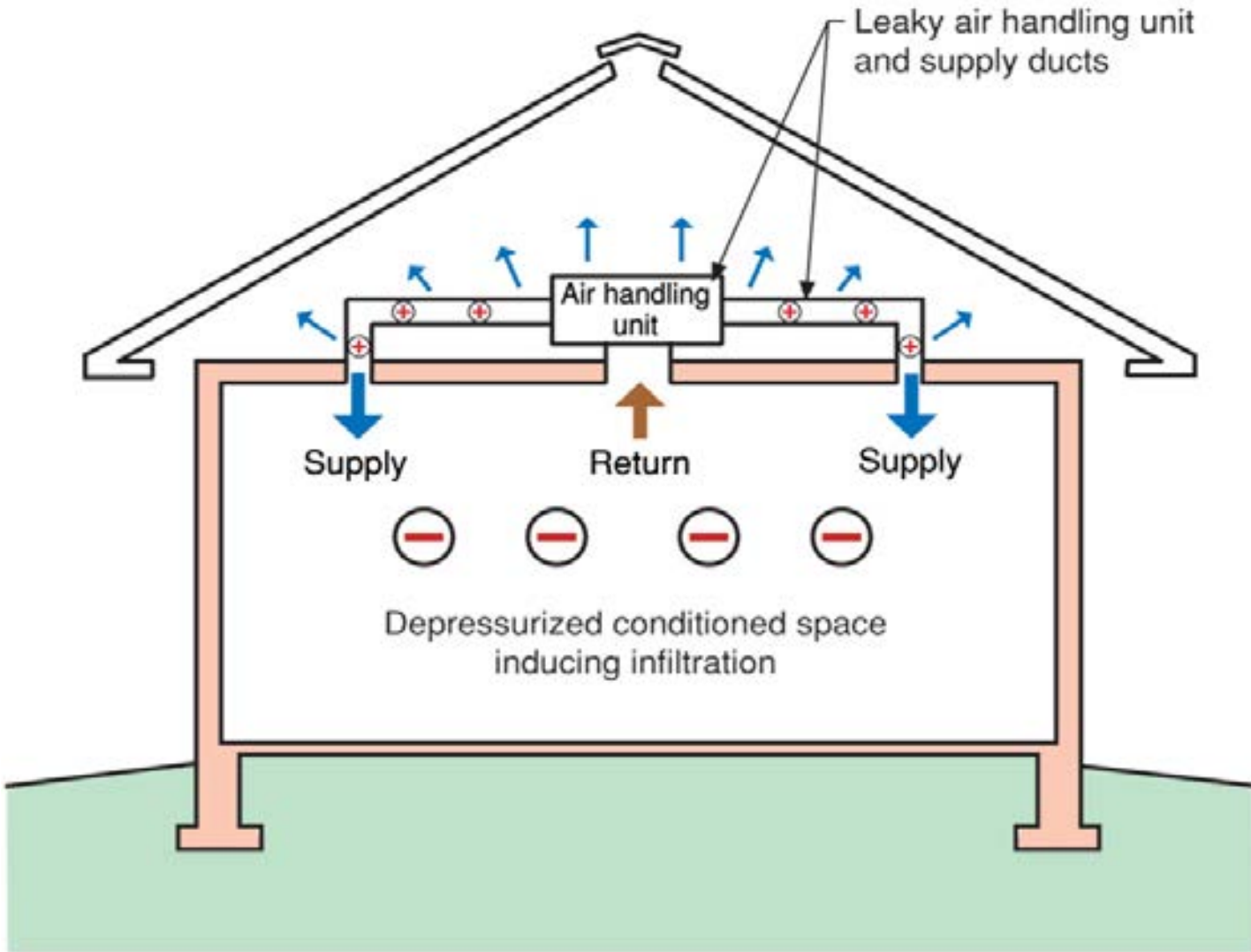












Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

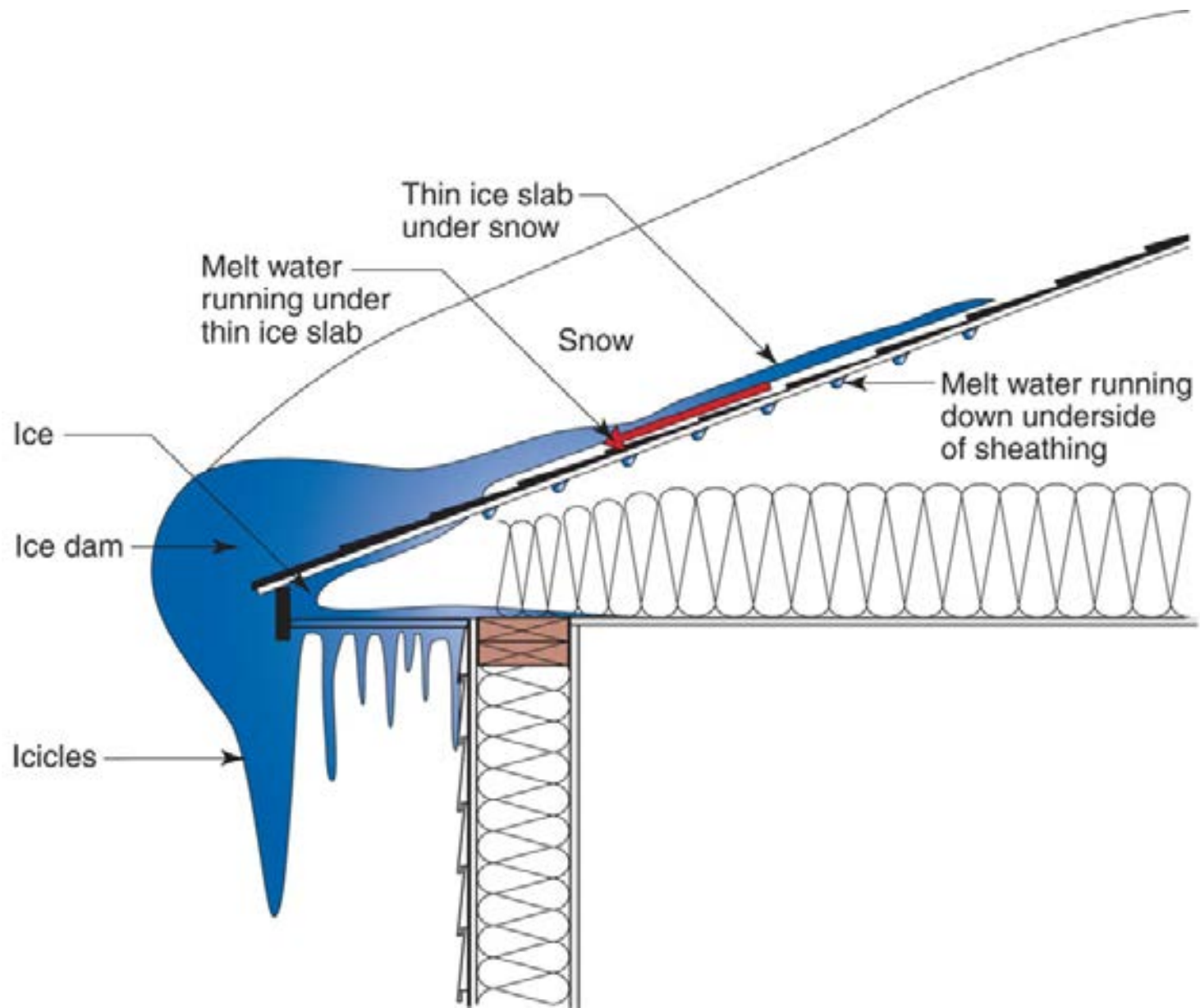


























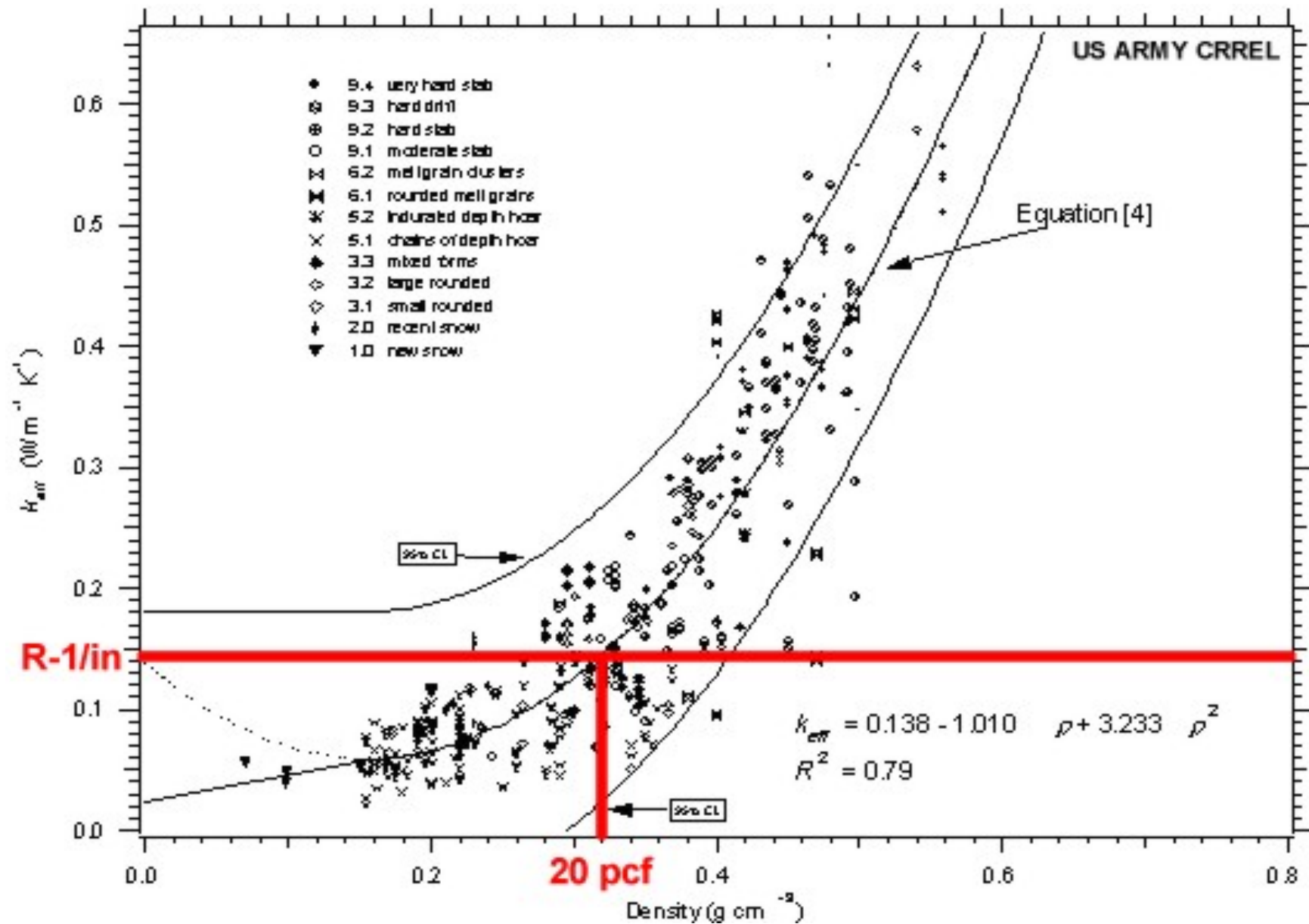








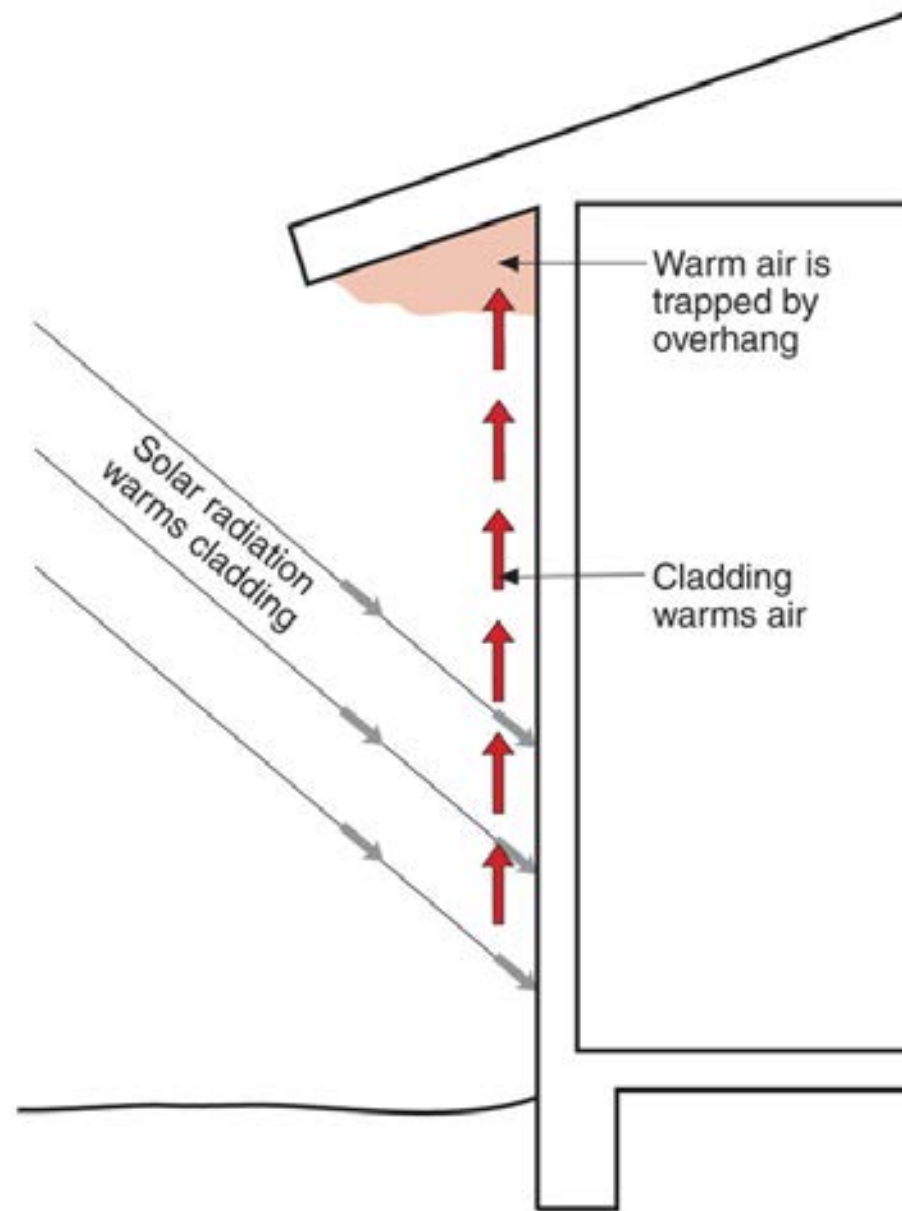












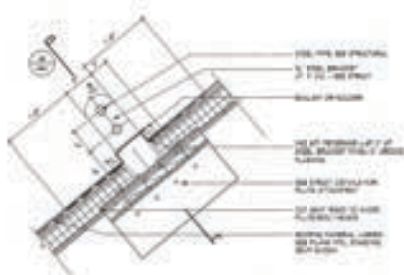




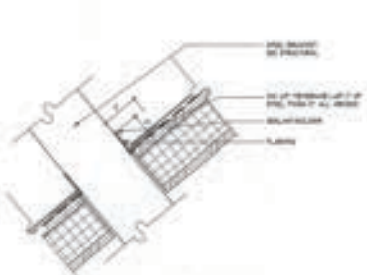




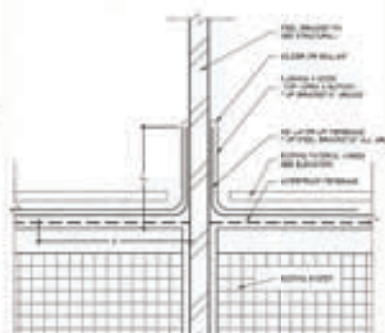




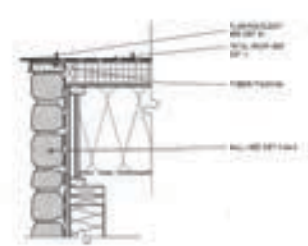
10 DETAIL - SNOW GUARD  
SCALE 1/2" = 1'-0"



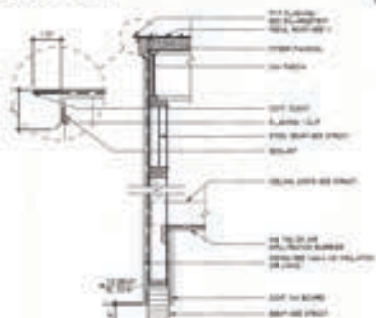
11 FLASHING DETAIL - SNOW GUARD  
SCALE 1/2" = 1'-0"



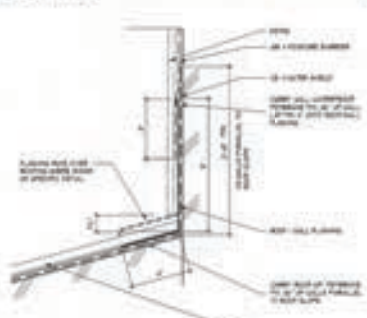
12 WATERPROOFING - SNOW GUARD  
SCALE 1/2" = 1'-0"



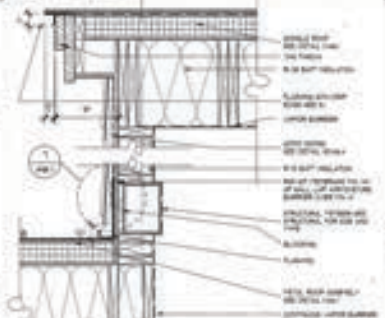
13 CLUB BAR RAKE DETAIL-NORTH END  
SCALE 1/2" = 1'-0"



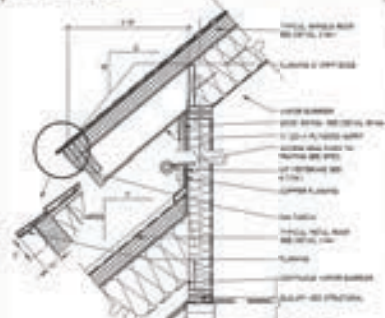
14 RAKE/SOFFT - OUTDOOR GRILLE-CLUB BAR  
SCALE 1/2" = 1'-0"



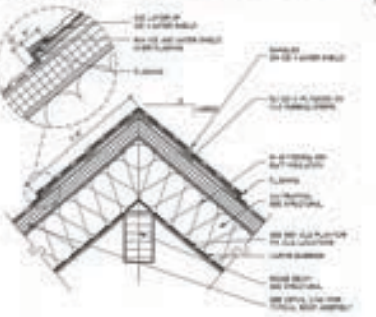
15 PARAPET WALL - ROOF WALL  
SCALE 1/2" = 1'-0"



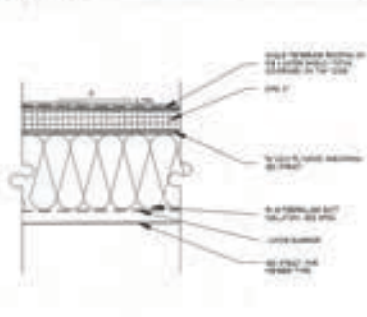
16 RIDGE RAKE DETAIL  
SCALE 1/2" = 1'-0"



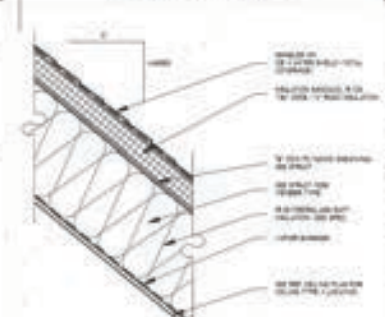
17 RIDGE EYE - METAL ROOF - WALL  
SCALE 1/2" = 1'-0"



18 RIDGE CAP DETAIL  
SCALE 1/2" = 1'-0"



19 FLAT ROOF - HIGH DOOR  
SCALE 1/2" = 1'-0"



20 TYPICAL ASPHALT SHINGLE ROOF  
SCALE 1/2" = 1'-0"



21 TYPICAL METAL ROOF  
SCALE 1/2" = 1'-0"

**COTTLE GRAYHEAL YAN ARCHITECTS INC.**

200 EAST WHEAT AVE. ST. ASHTON, CO. 80601  
719.251.2821  
719.251.2822

11.10.07  
10.10.07  
10.10.07  
10.10.07

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**SUNDECK RESTAURANT**

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ASPEN COLORADO

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SHEET 1A-10  
ISSUED FOR CONSTRUCTION DOCUMENTS

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**ROOF DETAILS**

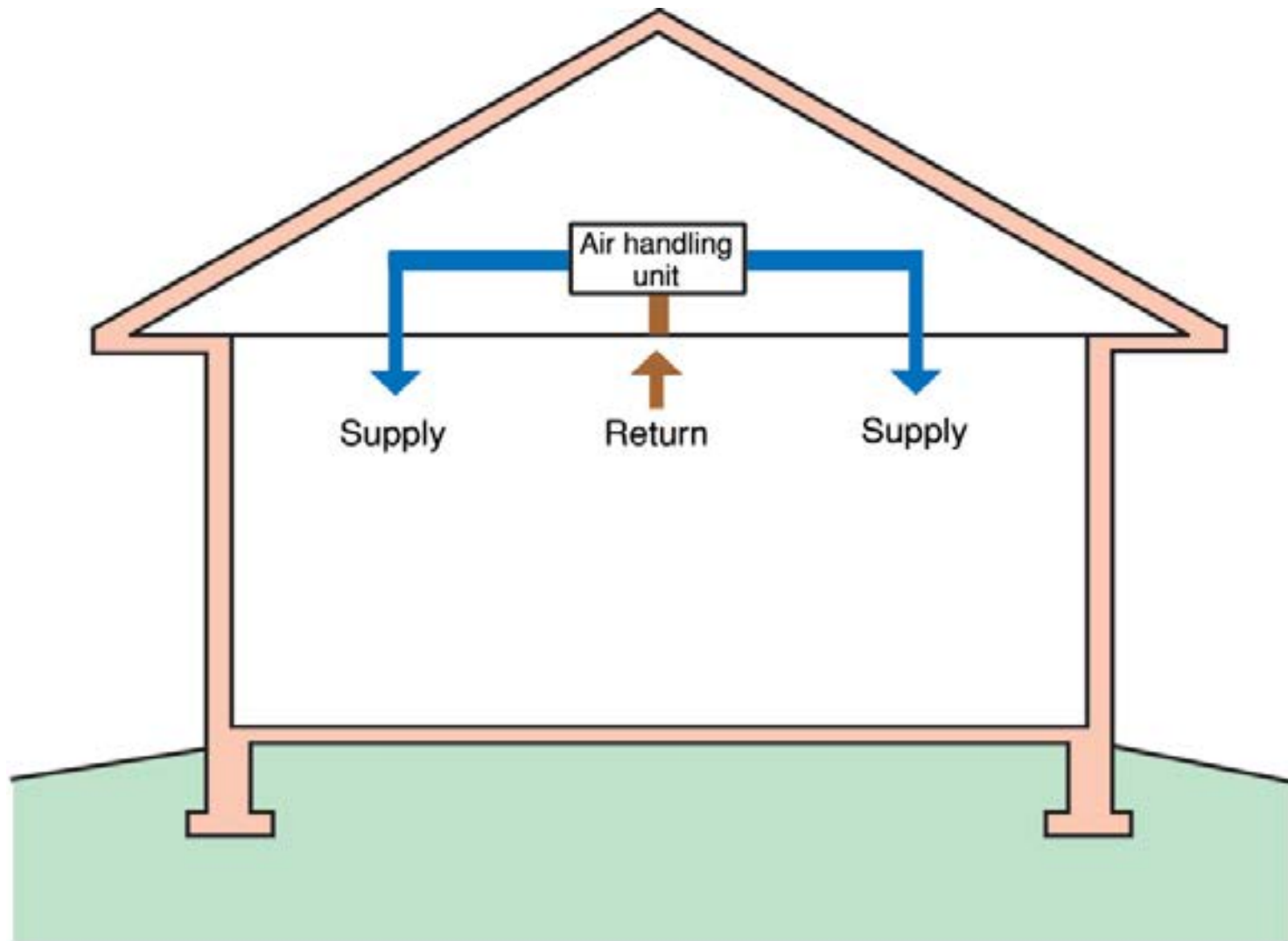
DRAWN BY: \_\_\_\_\_  
CHECKED BY: \_\_\_\_\_

A6.1

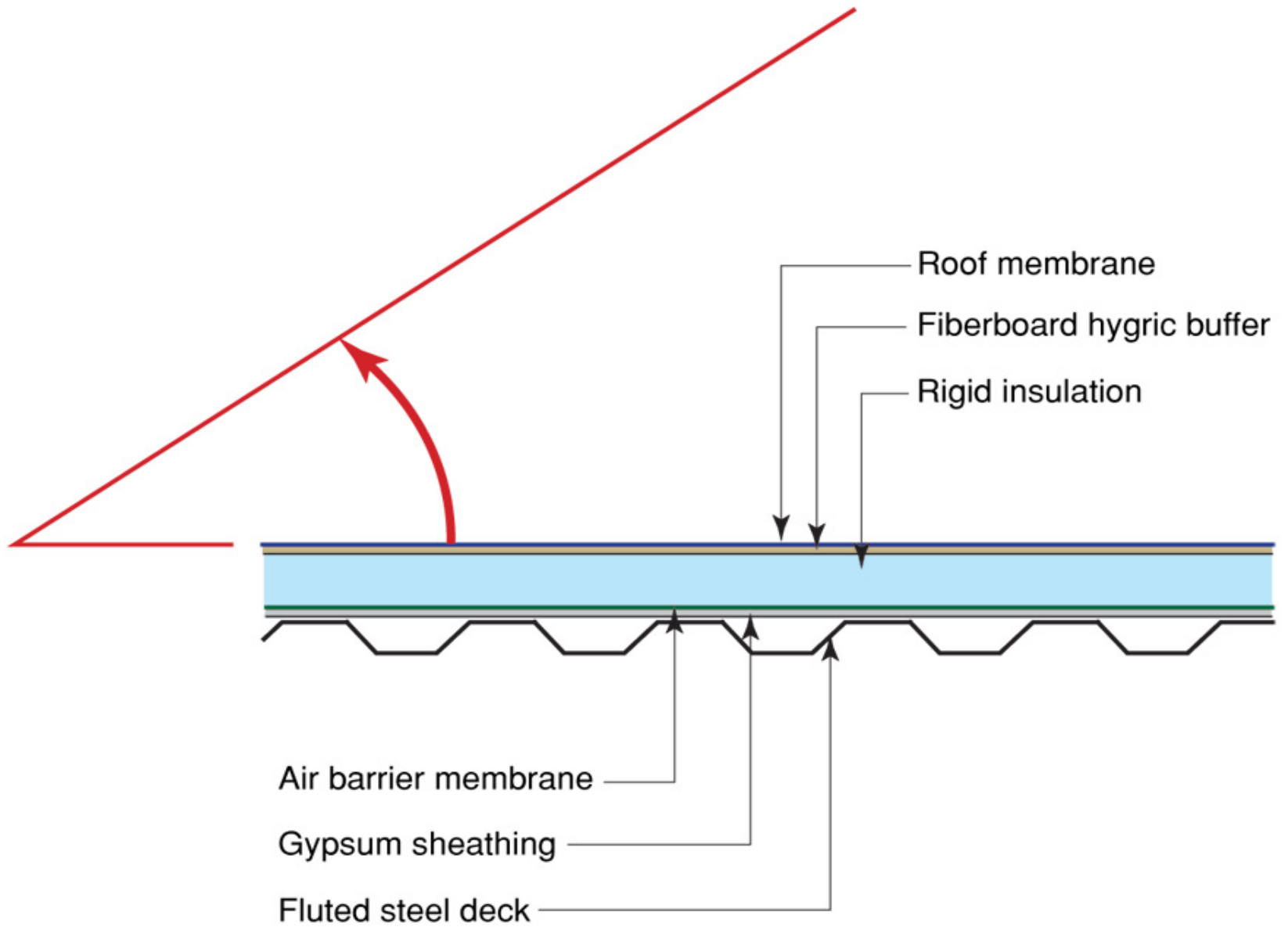


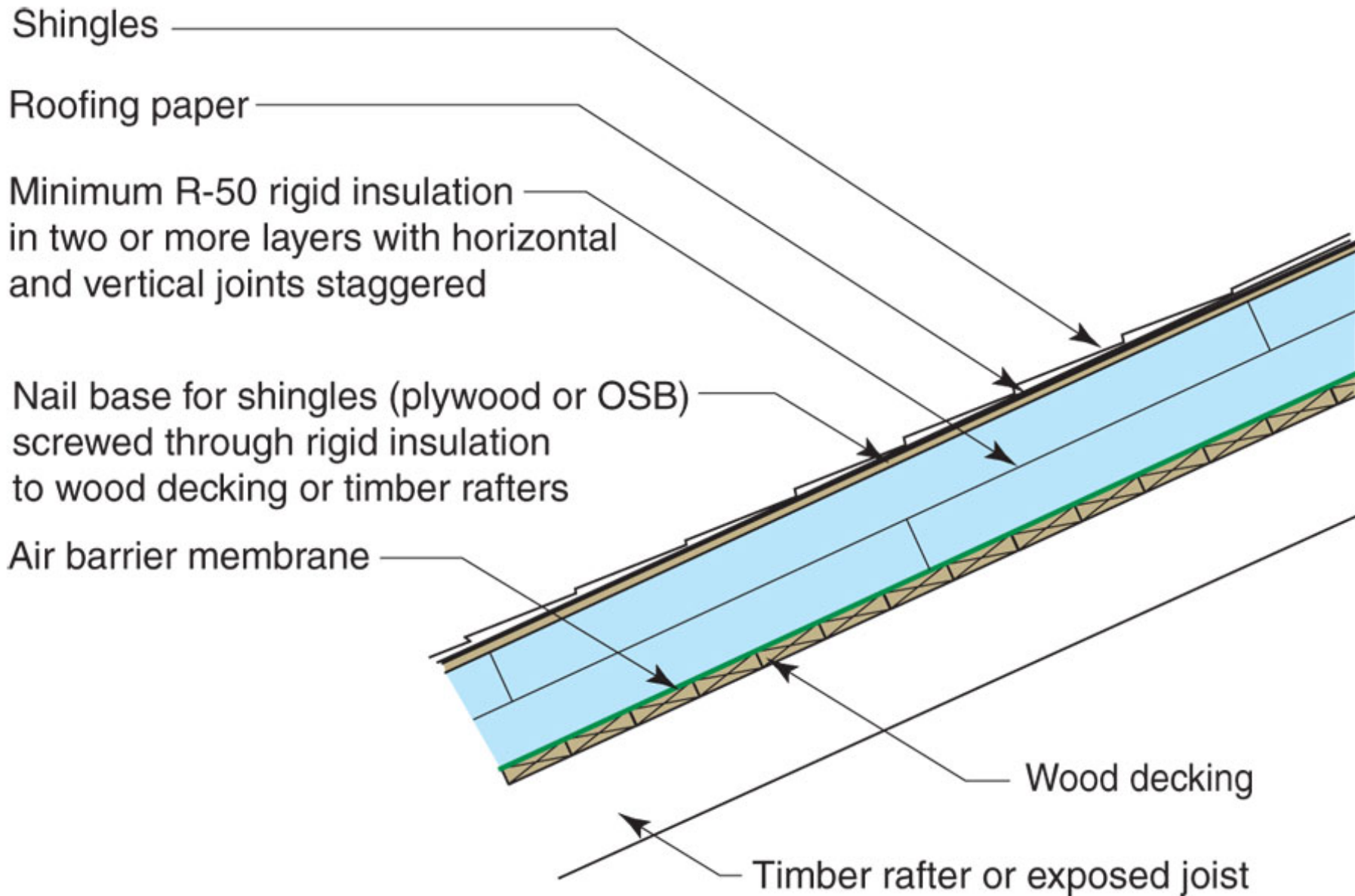


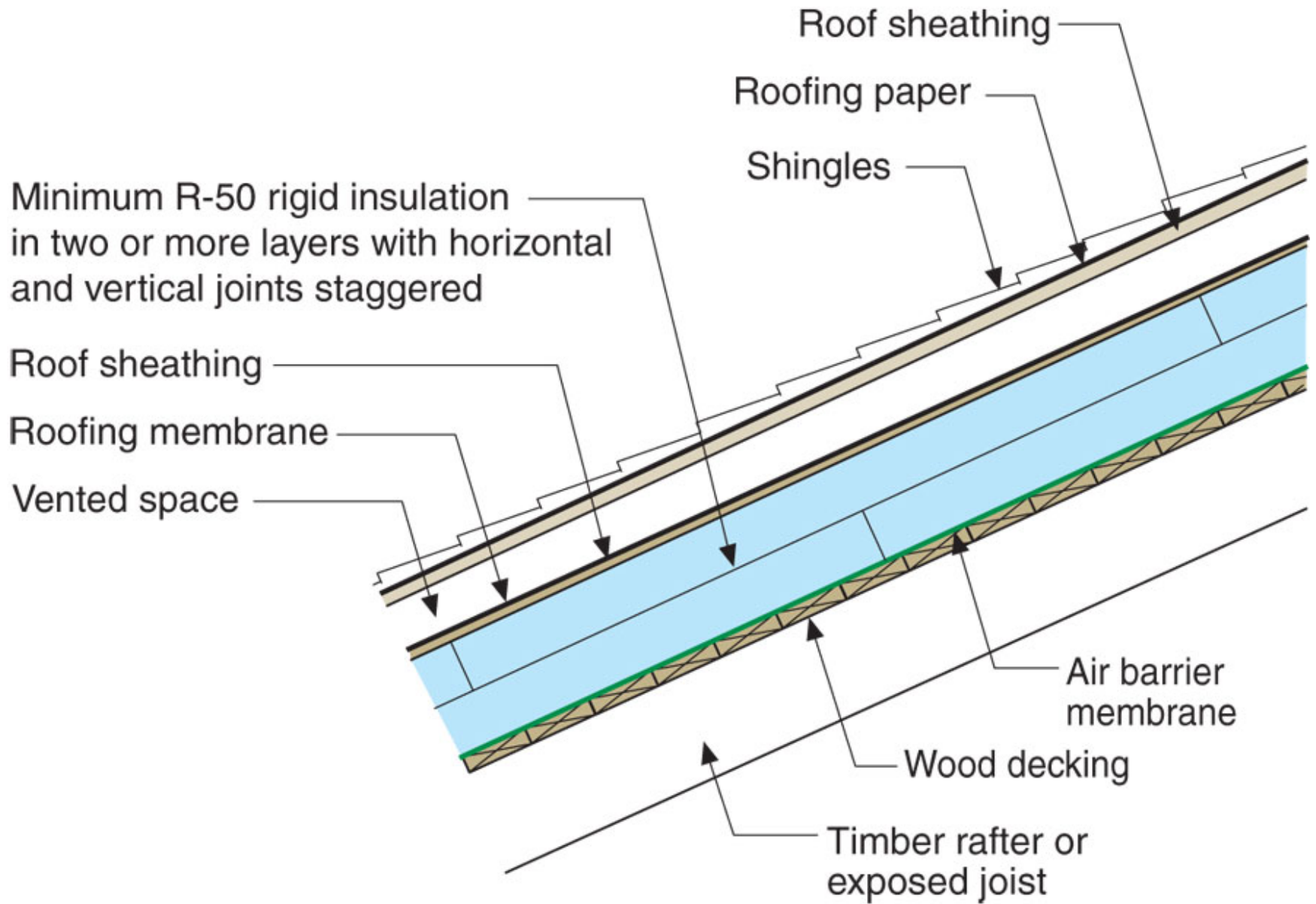


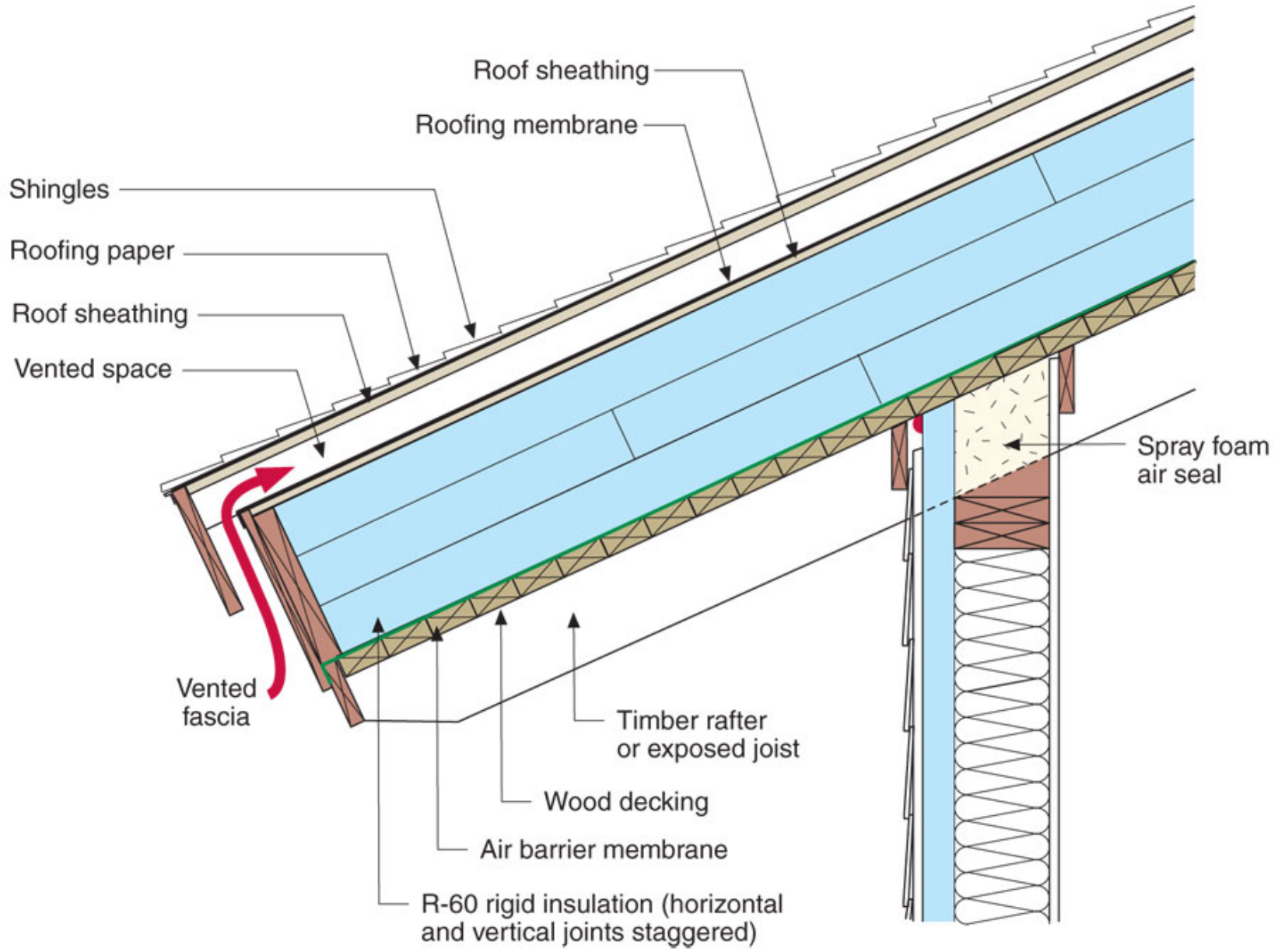


Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.





















































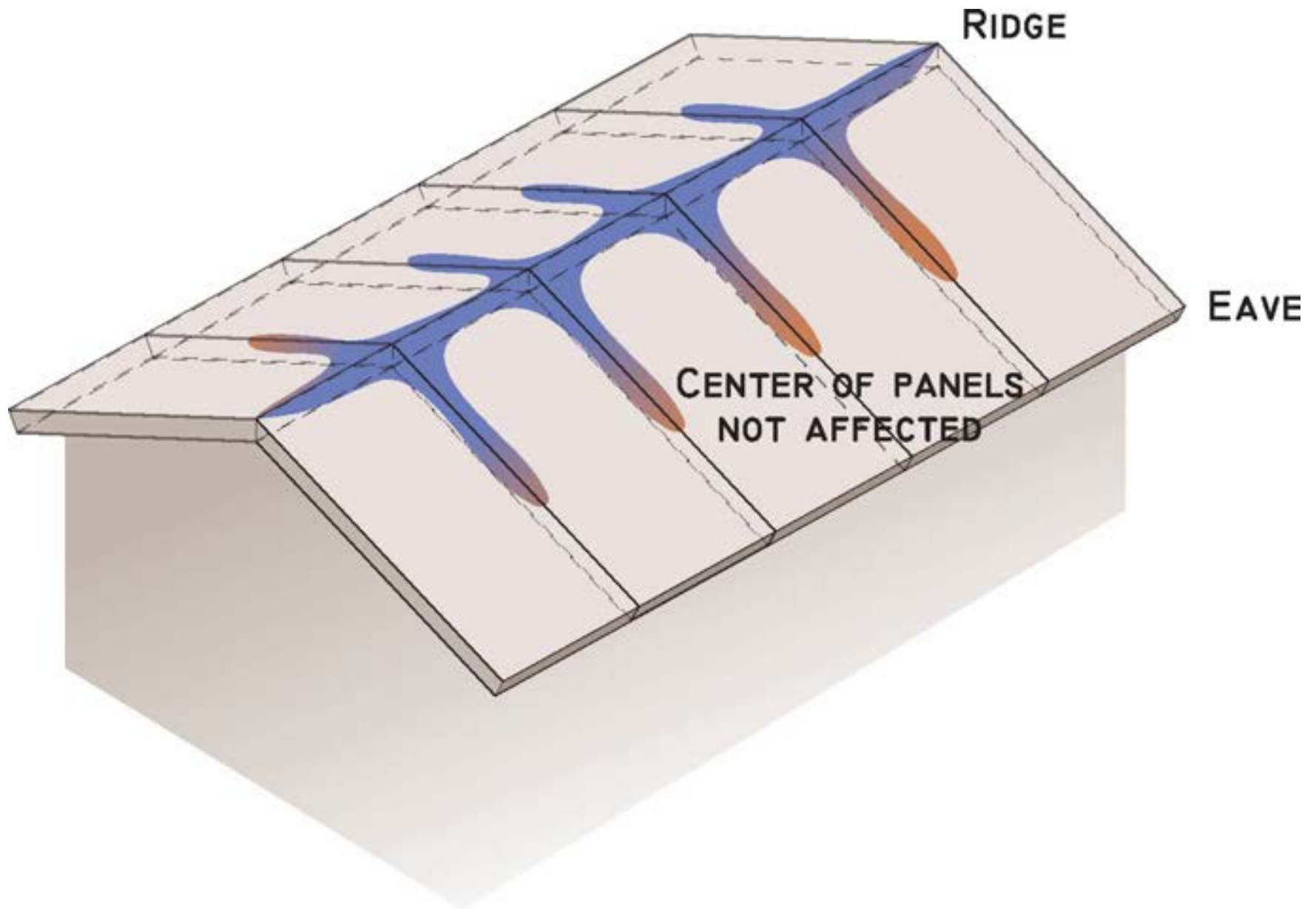








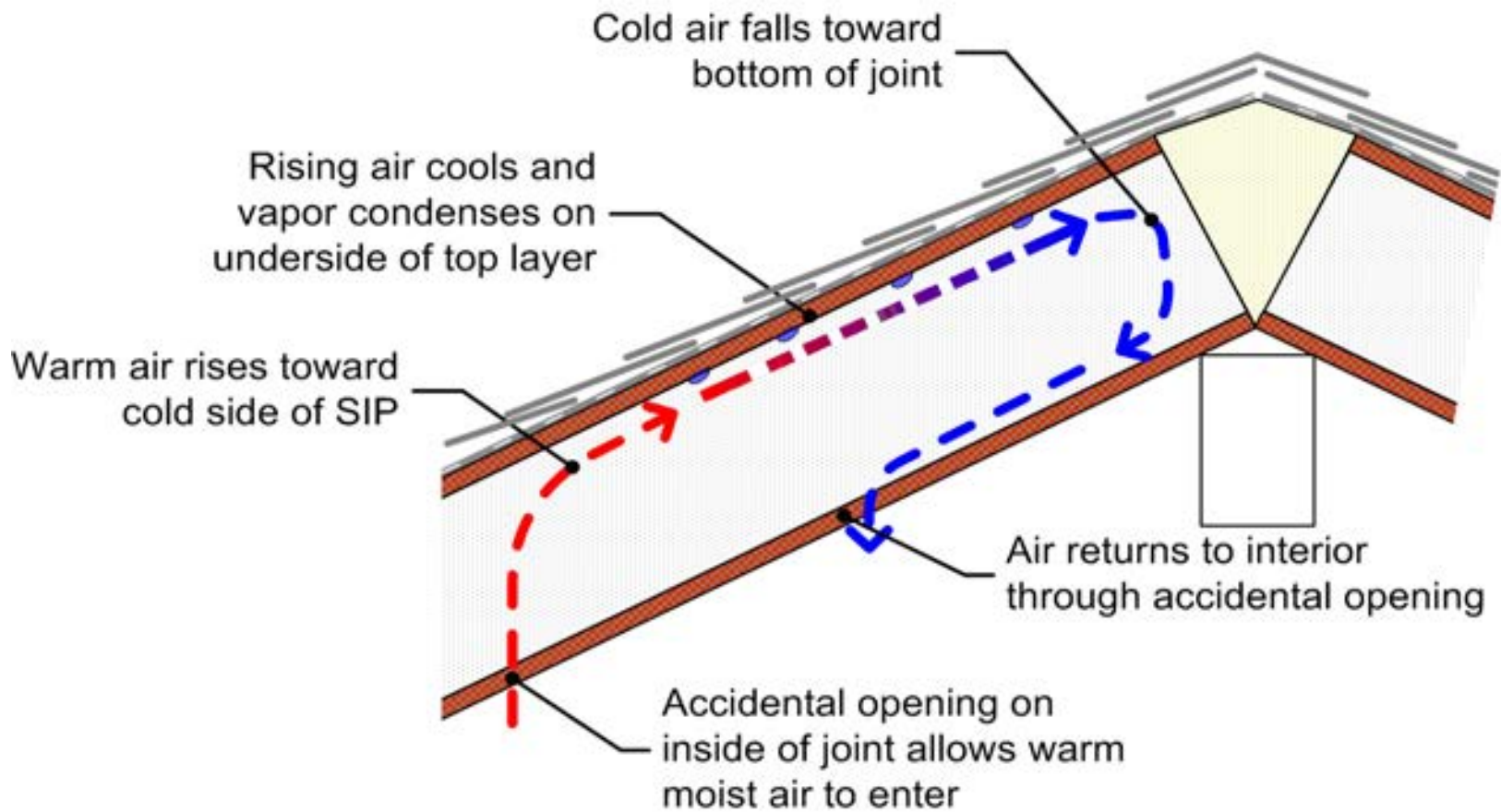


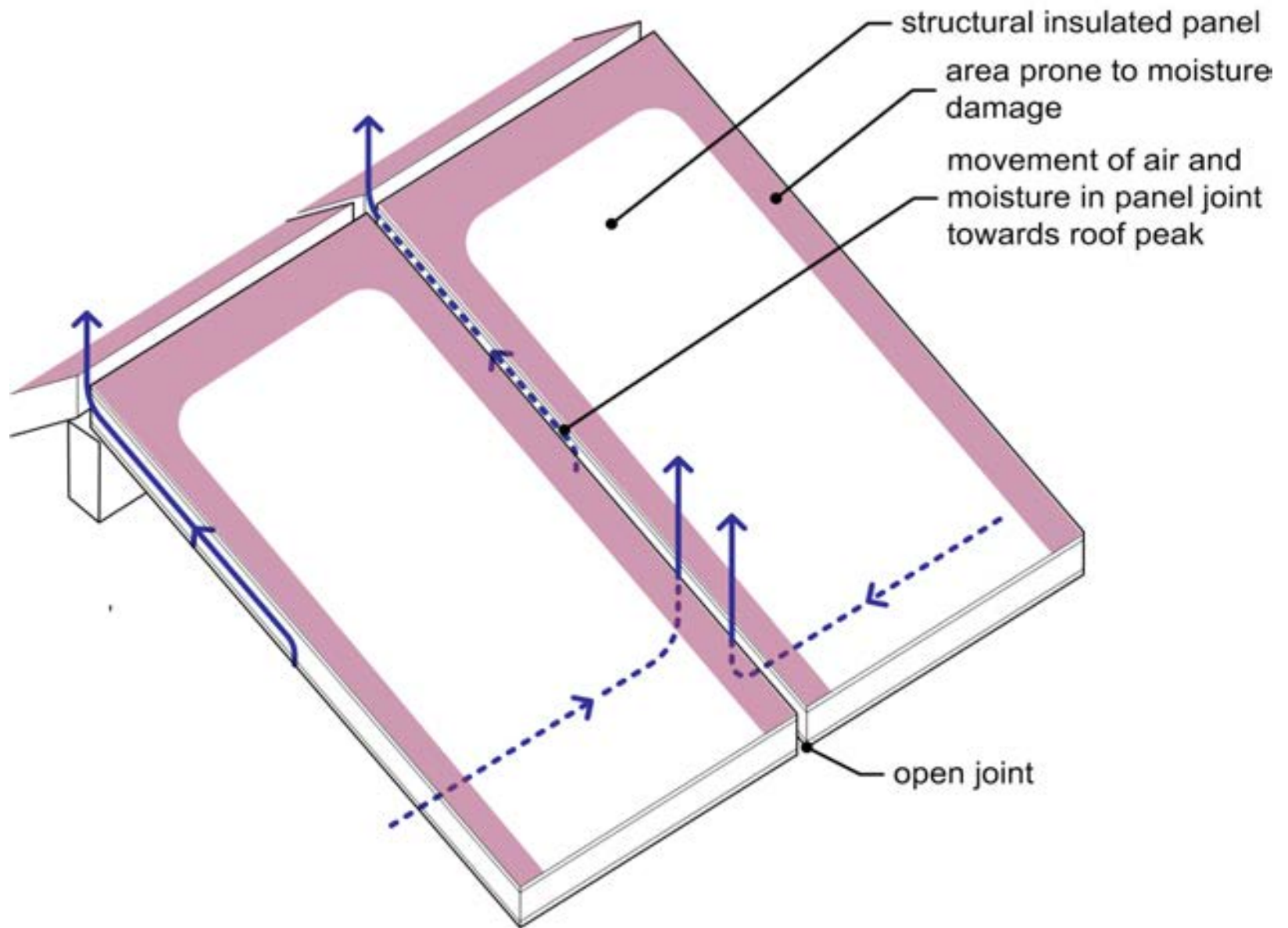


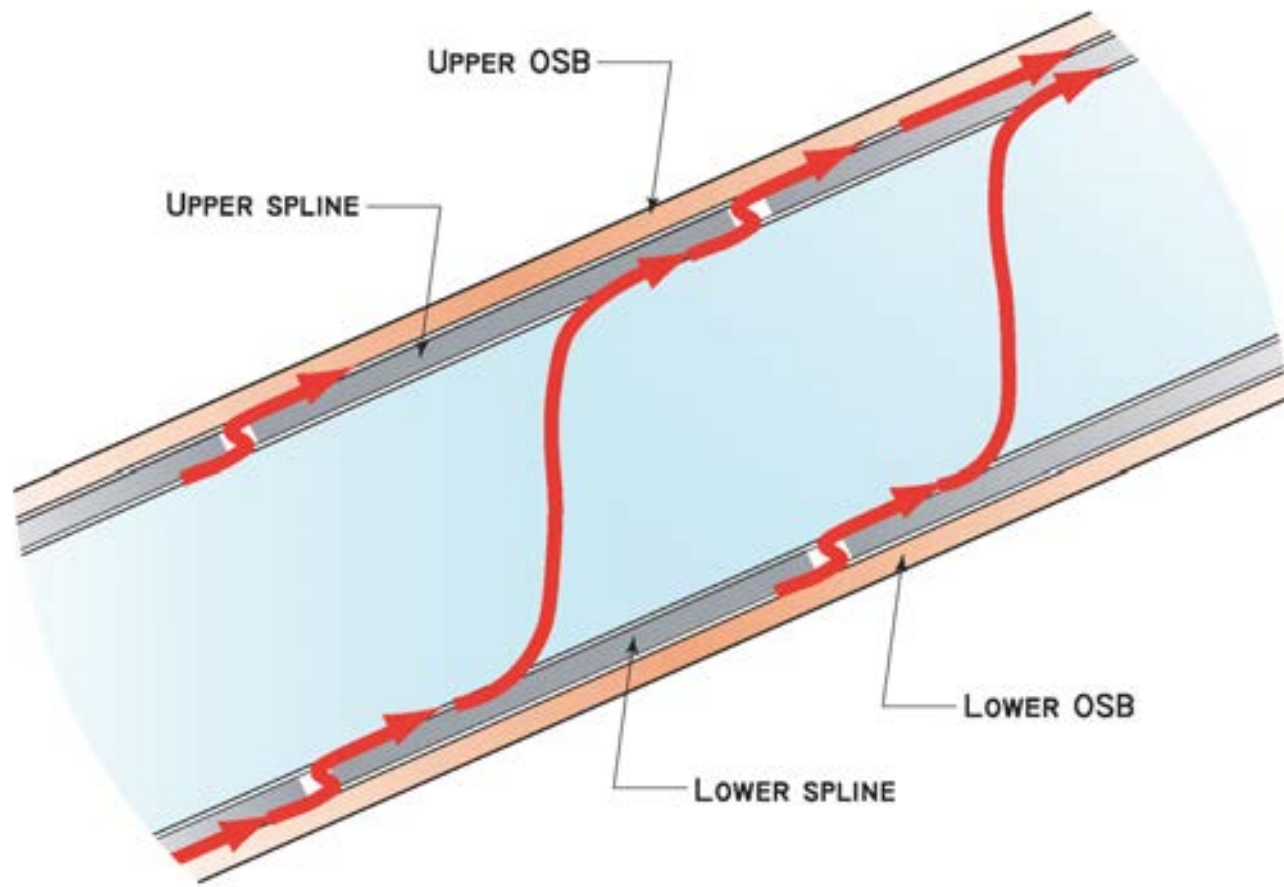




































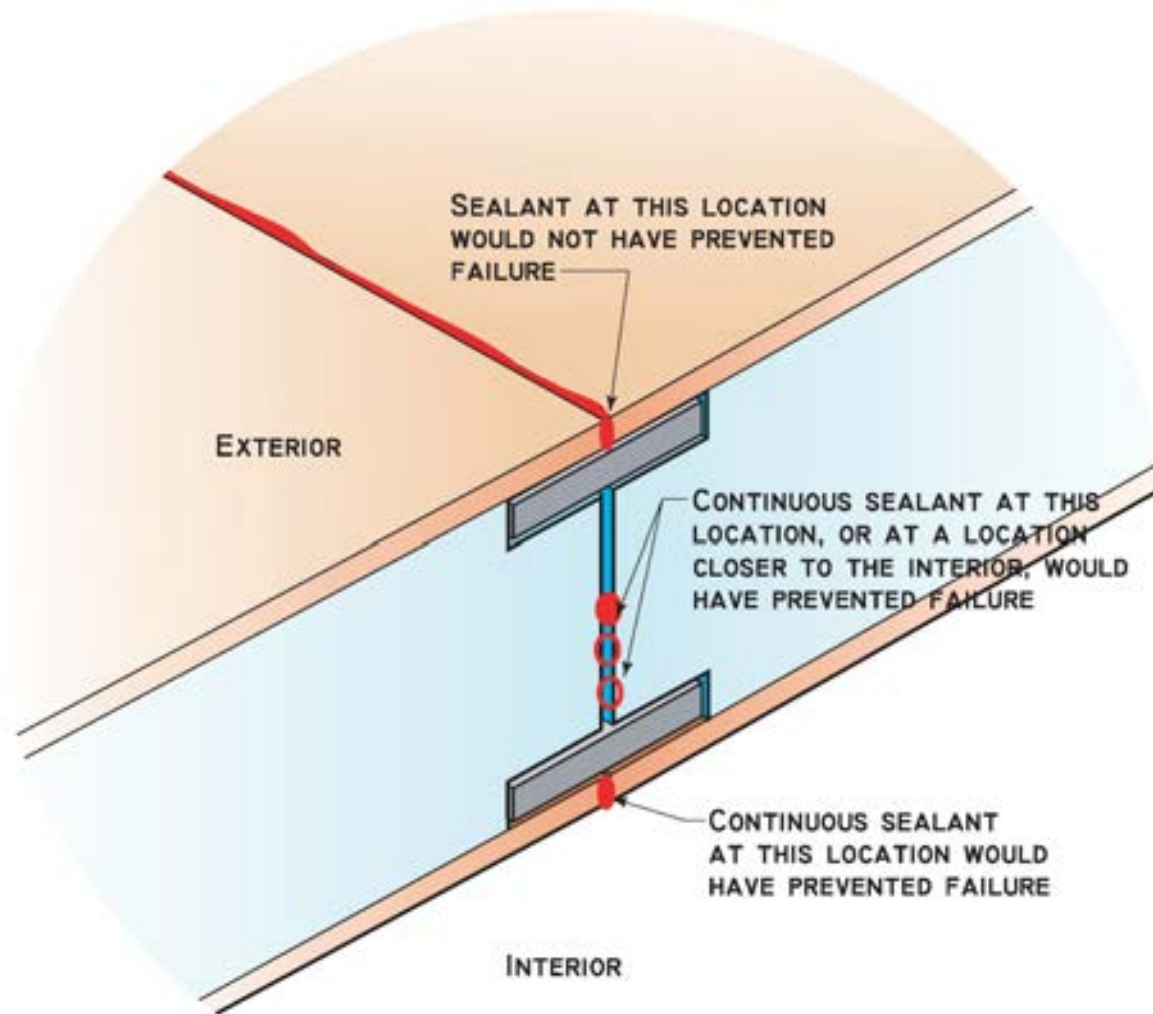


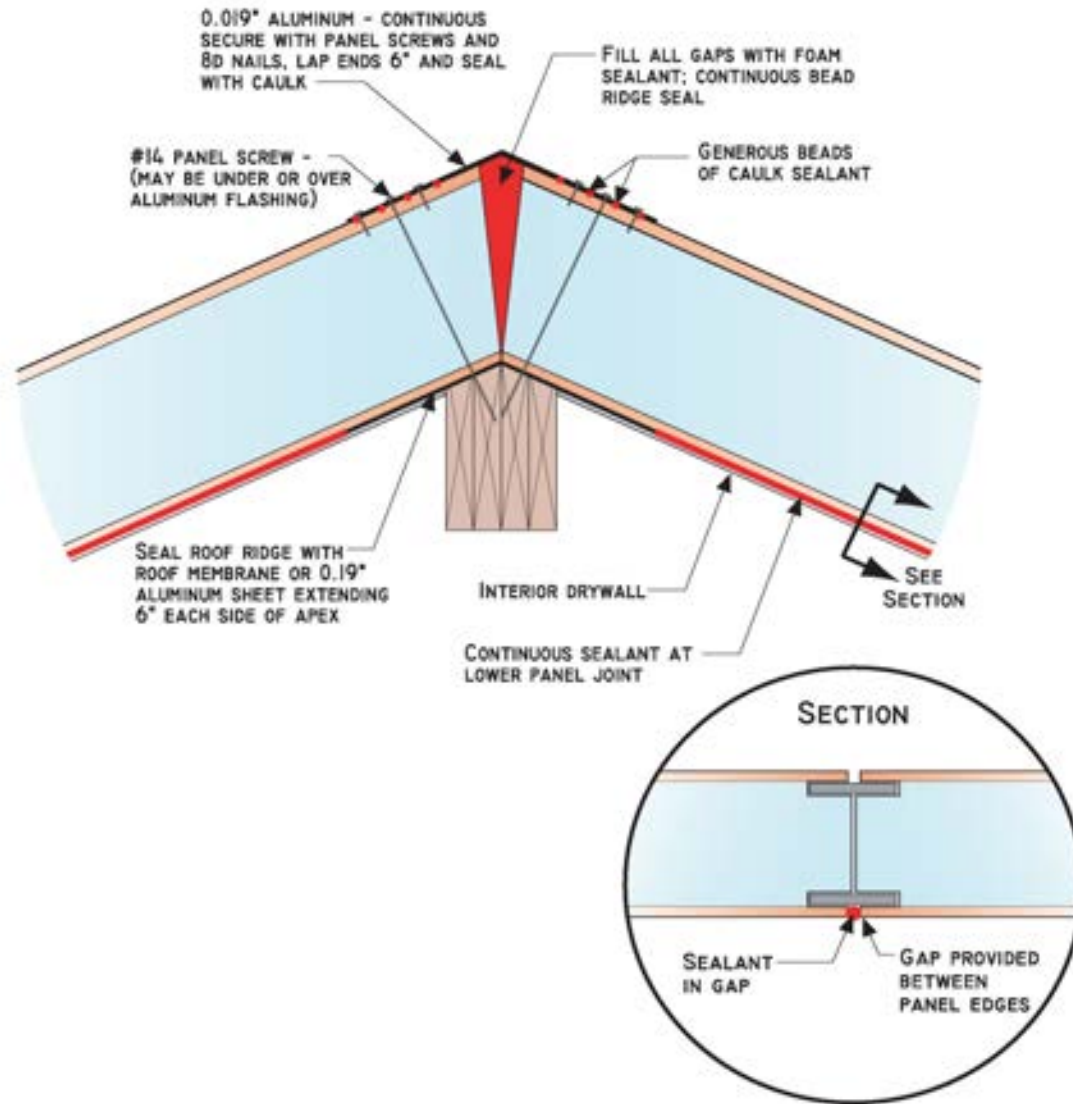






















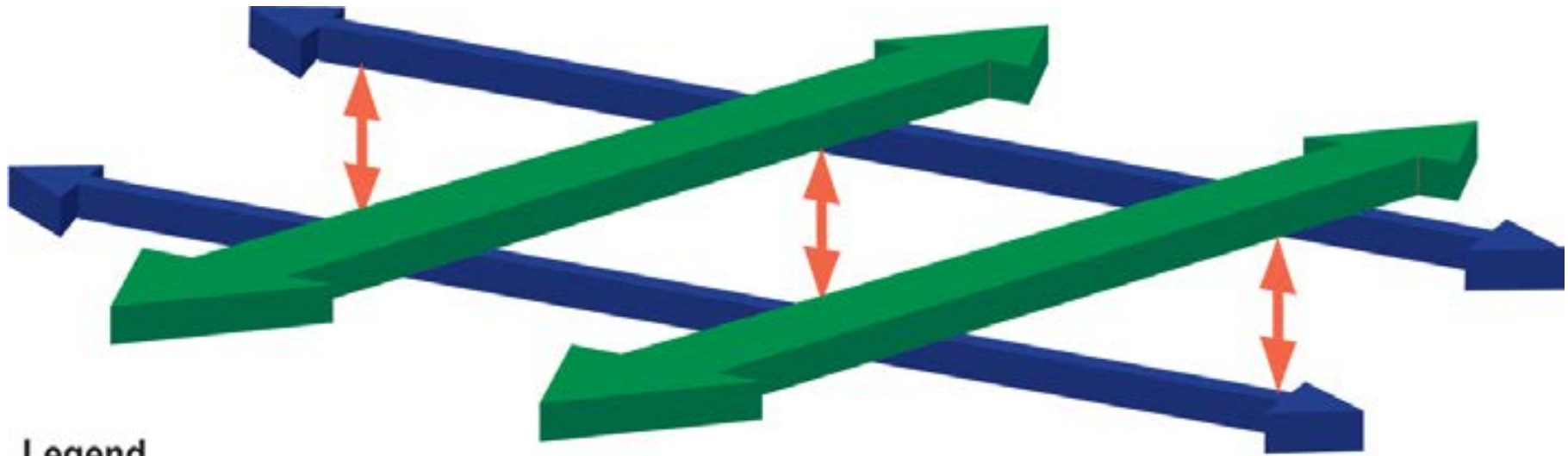











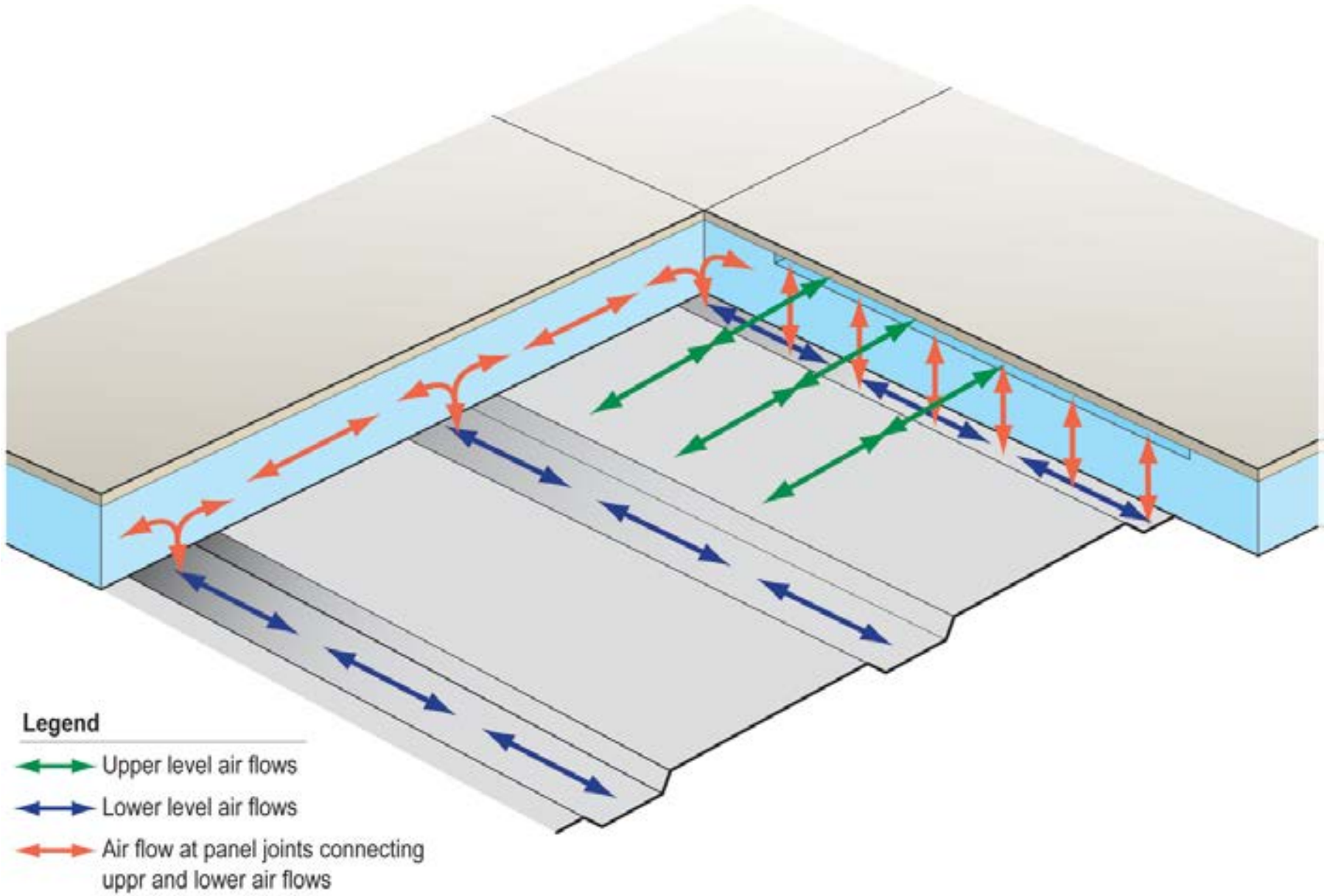


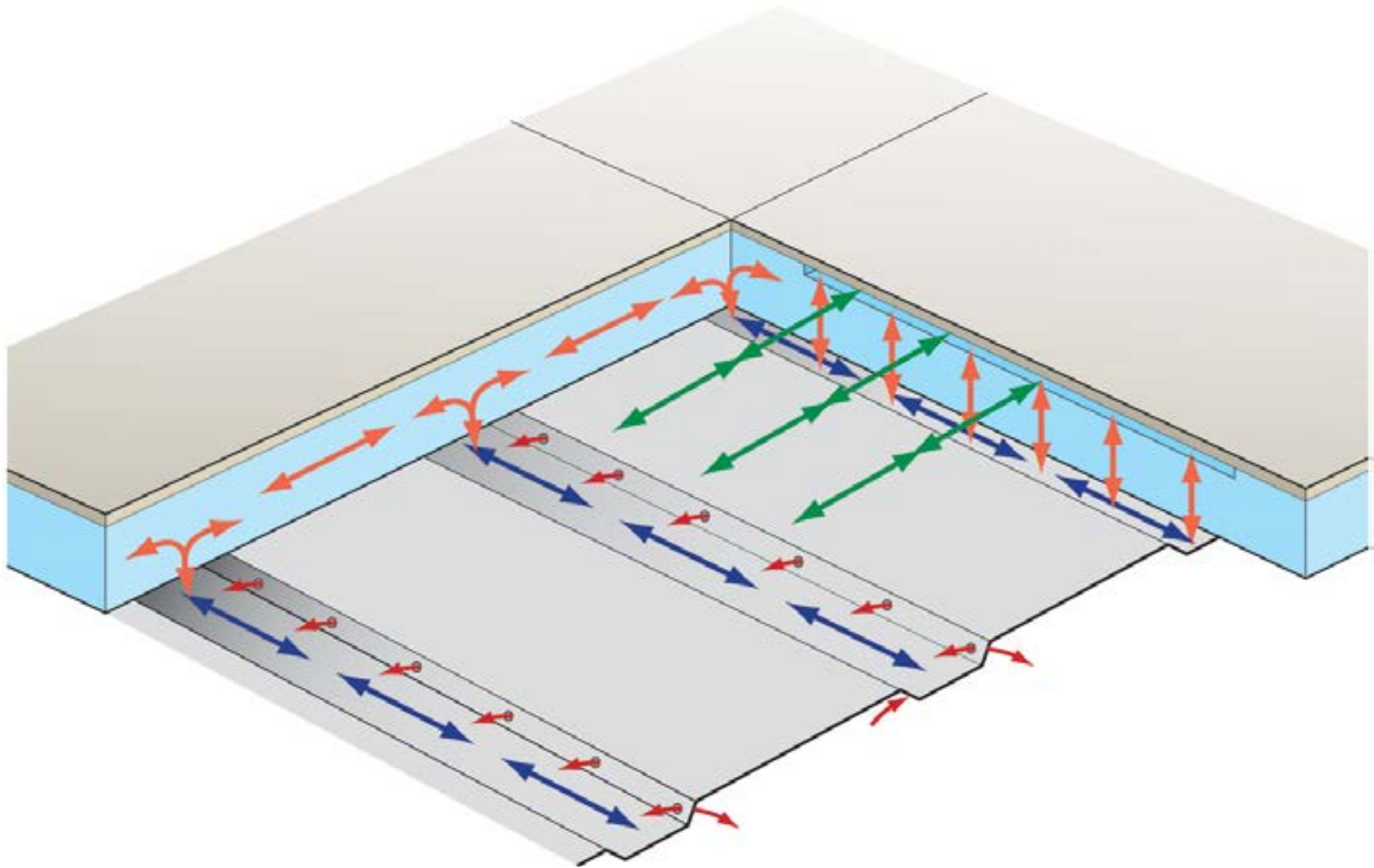


**Legend**

-  Upper level air flows
-  Lower level air flows
-  Air flow at panel joints

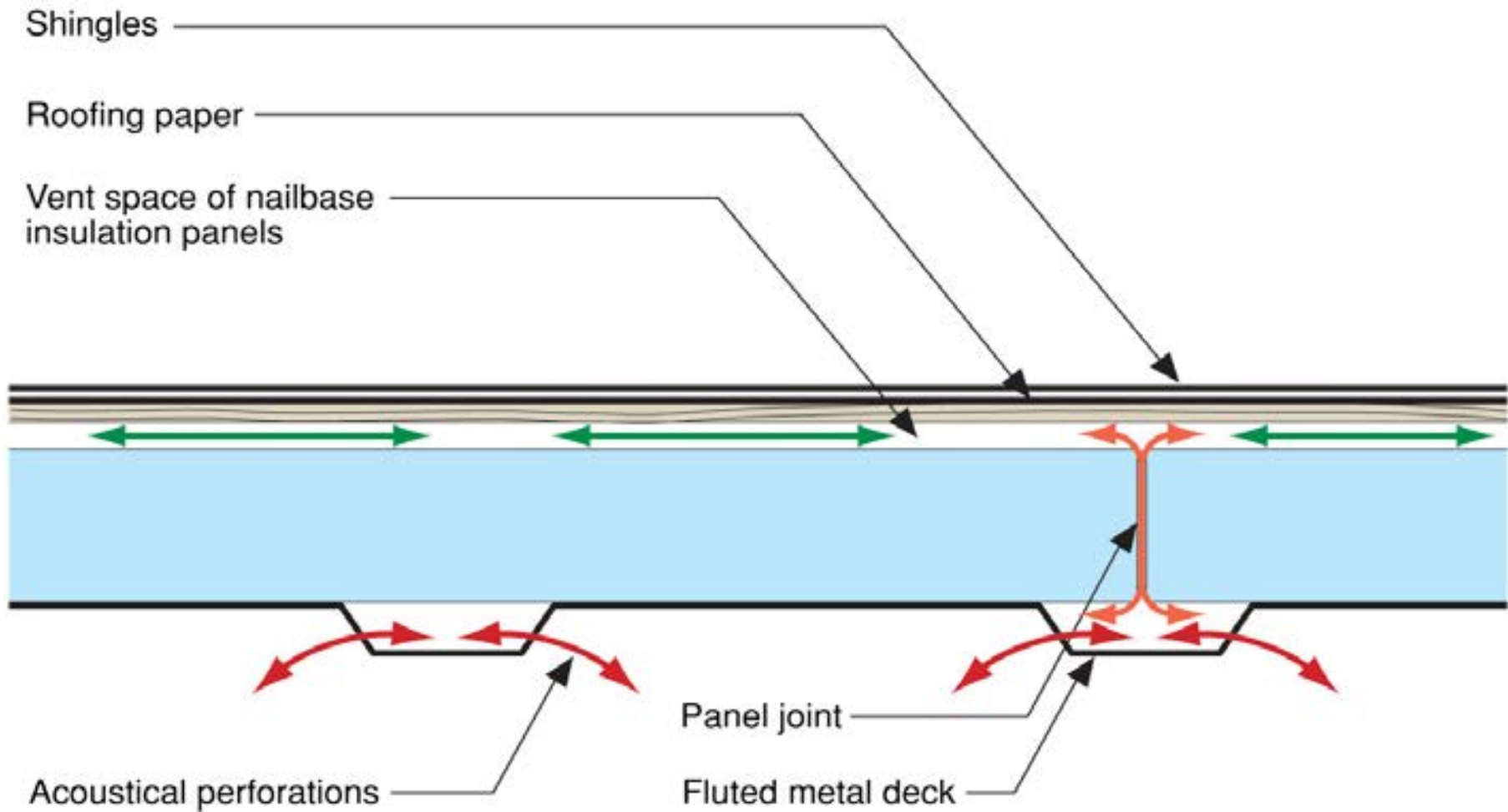


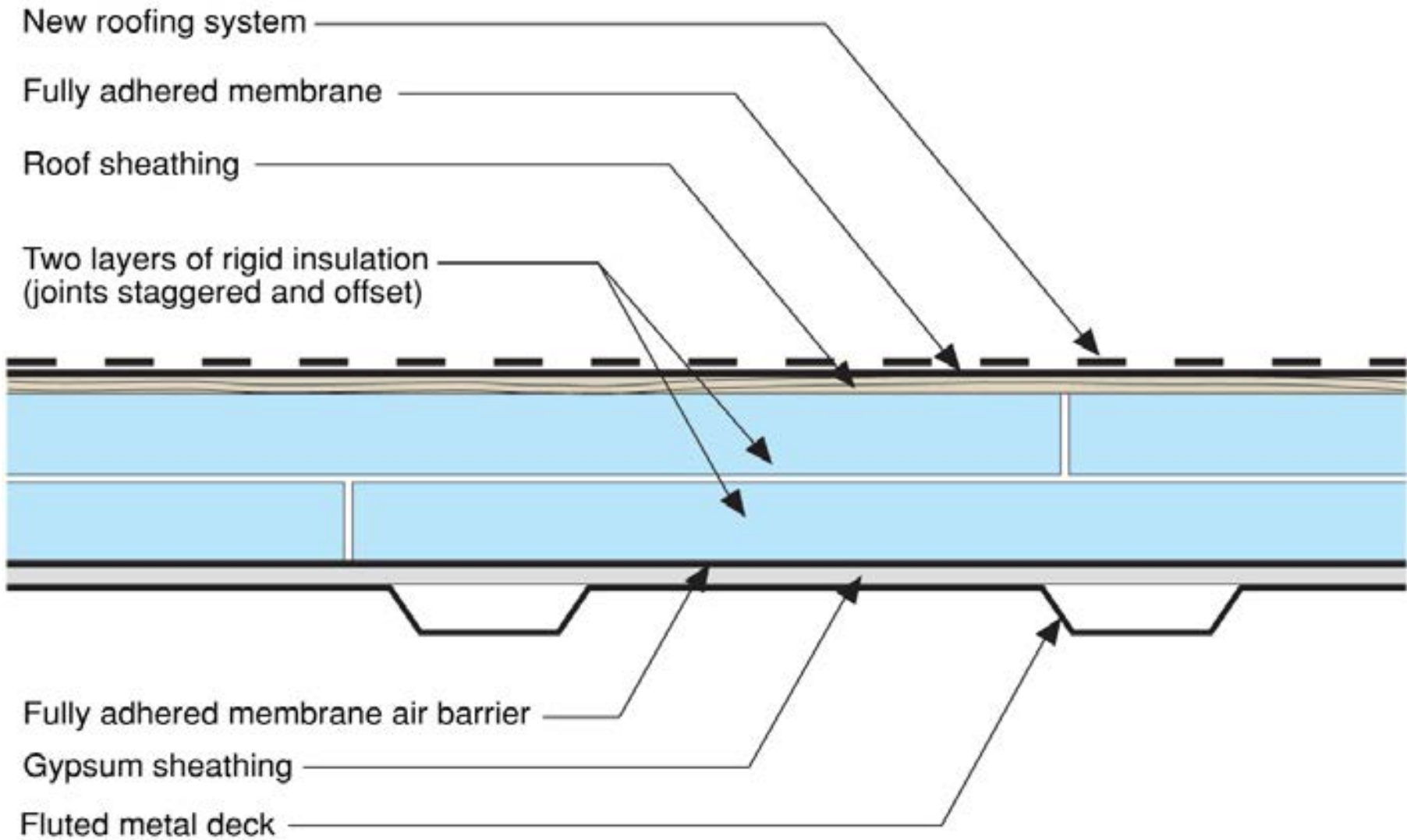


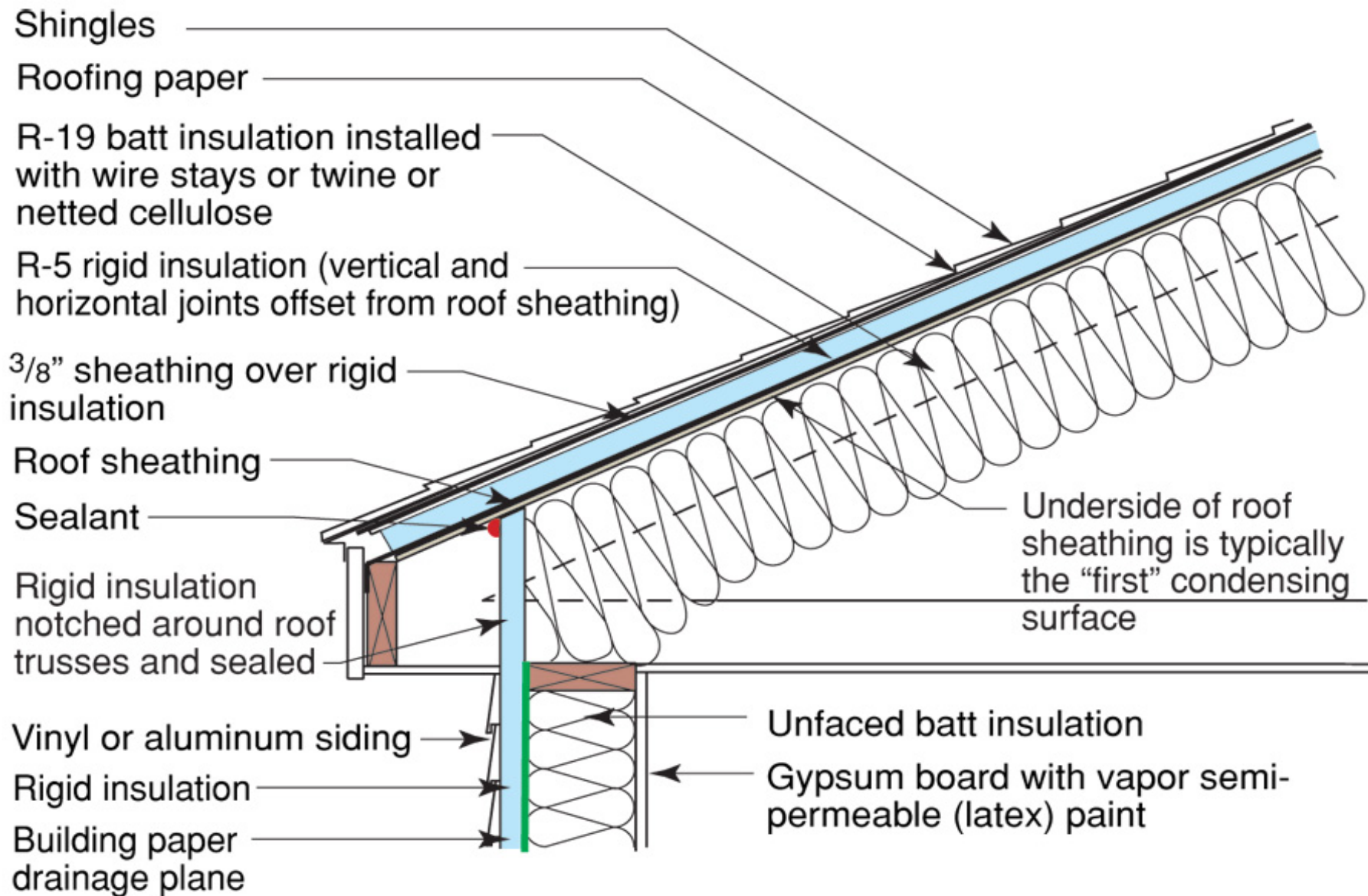




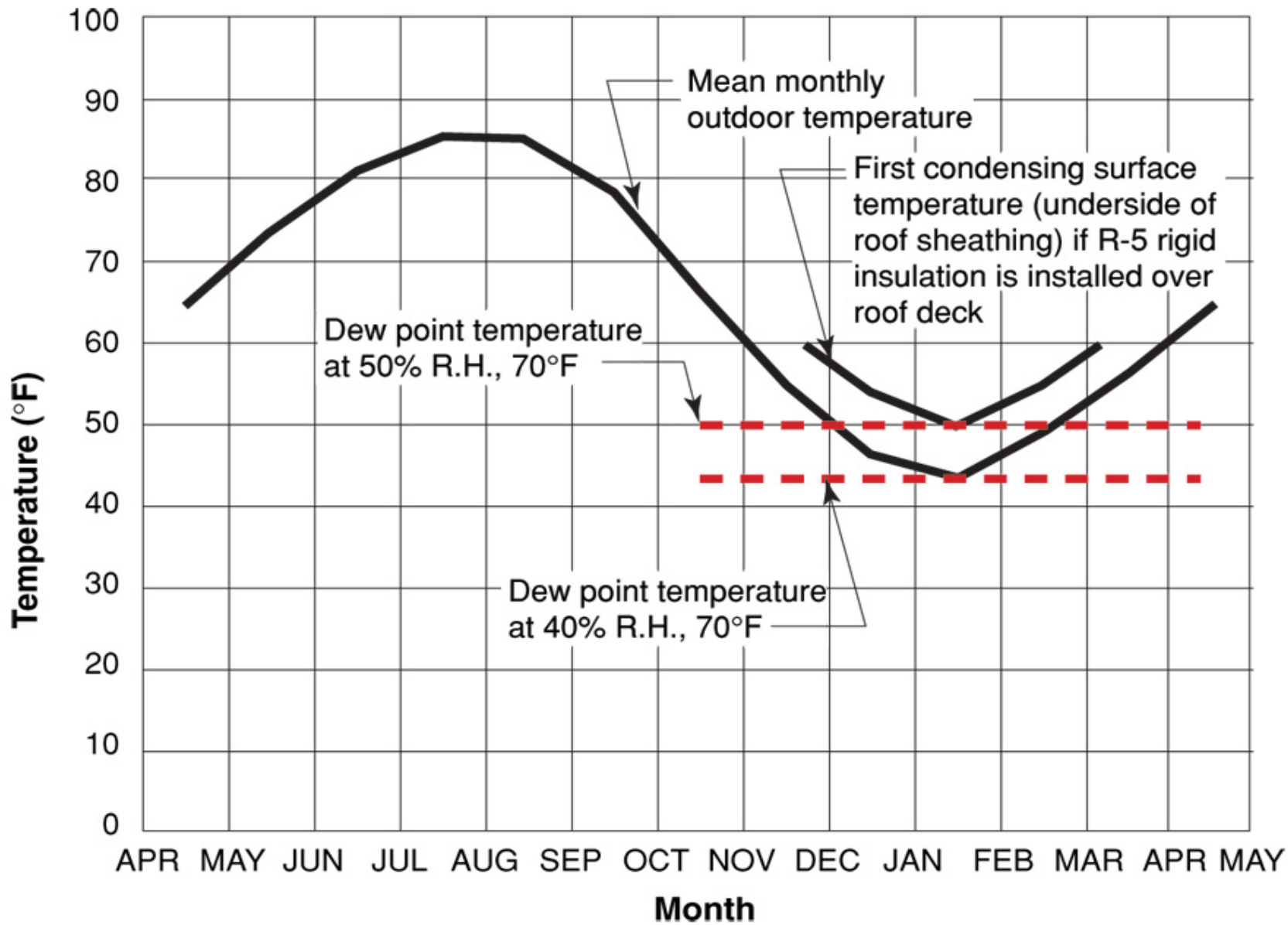


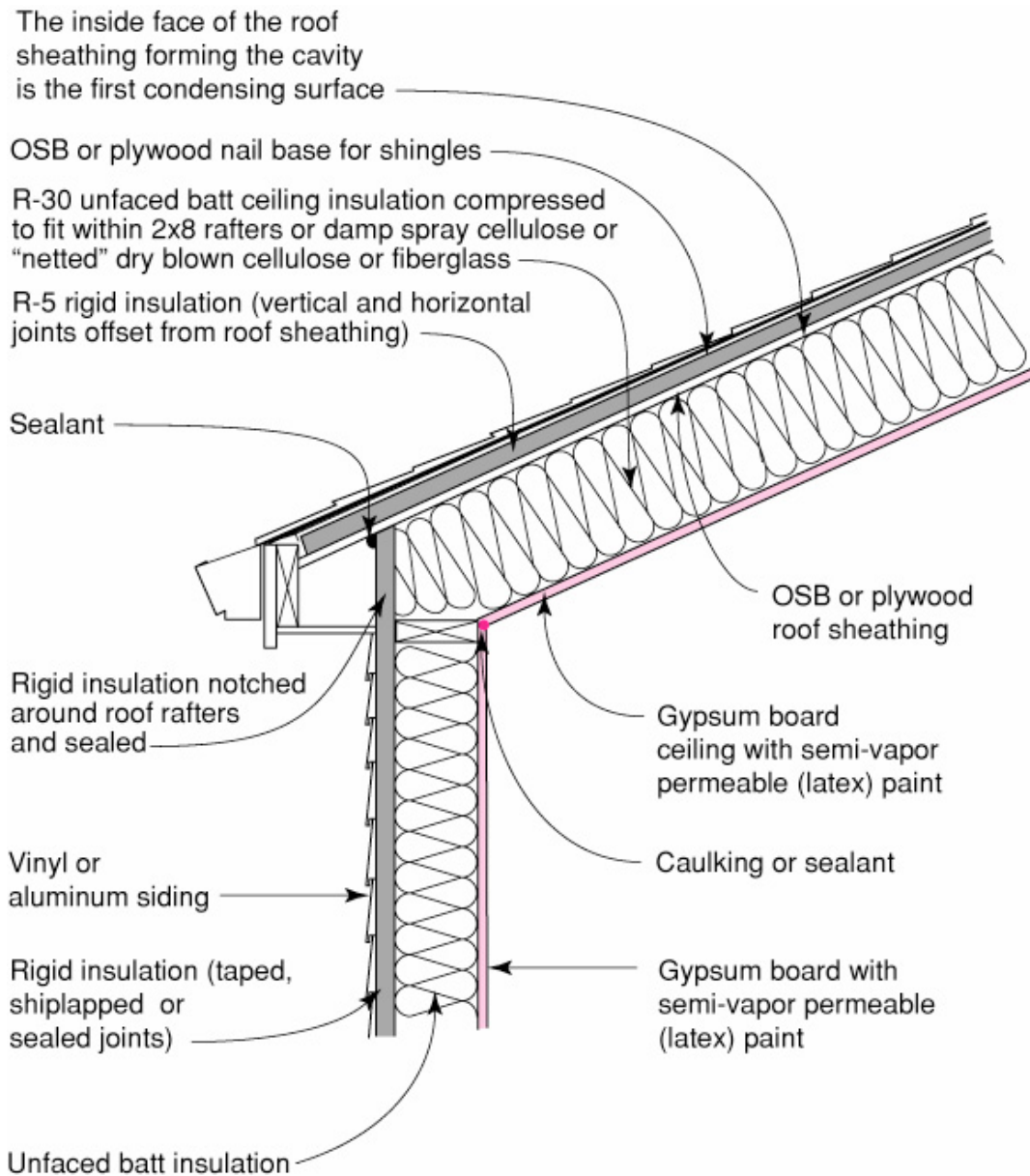


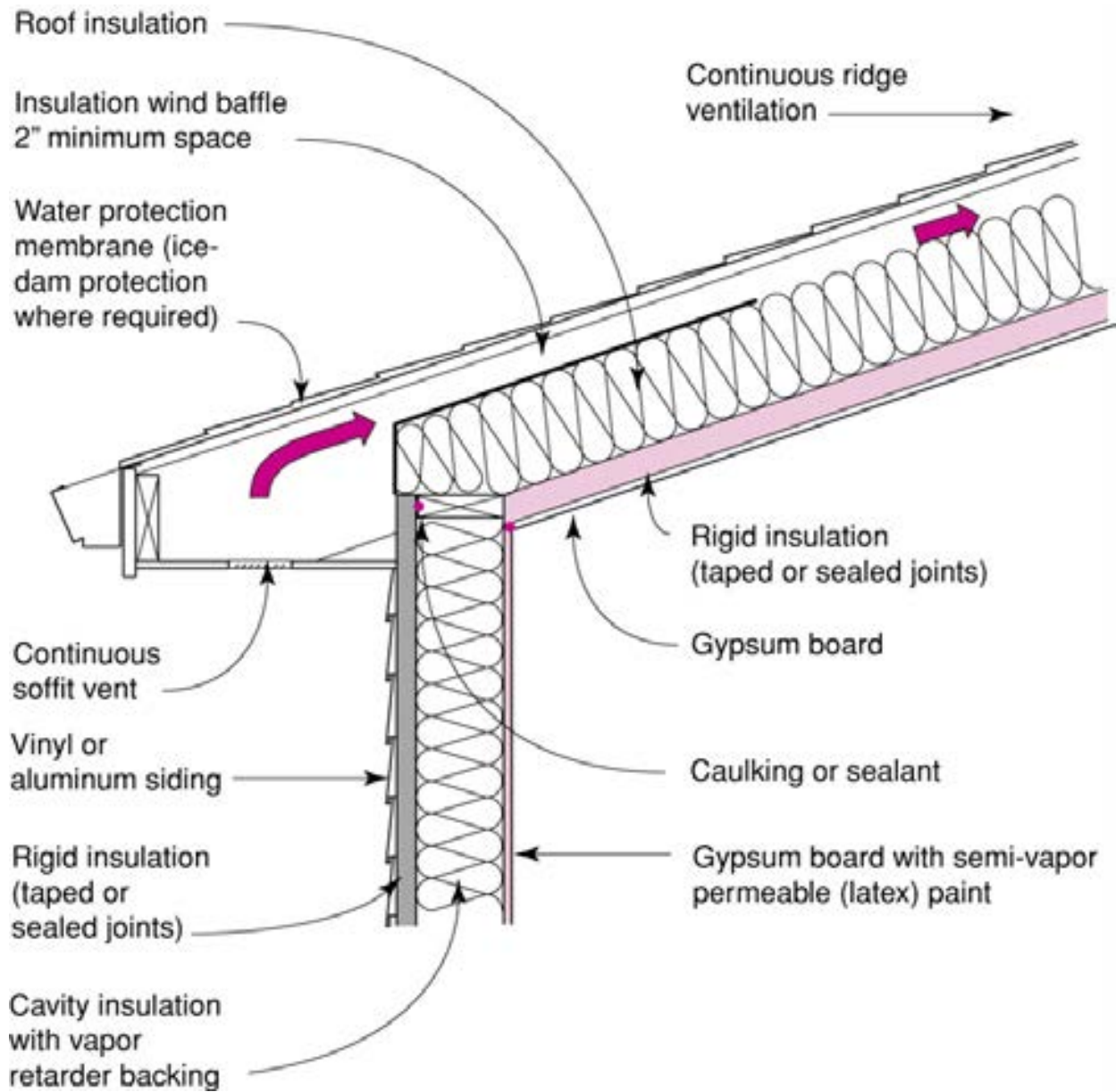




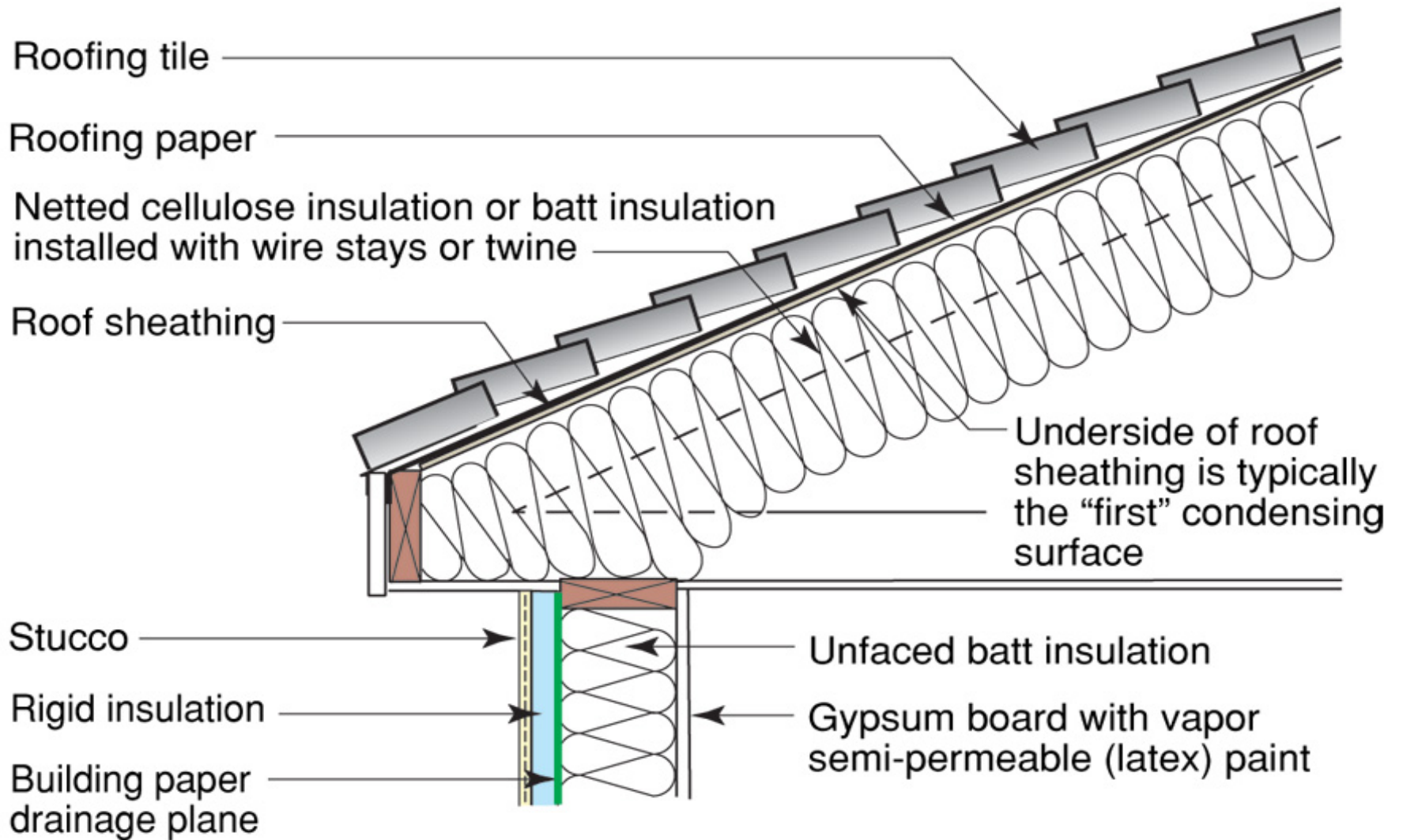










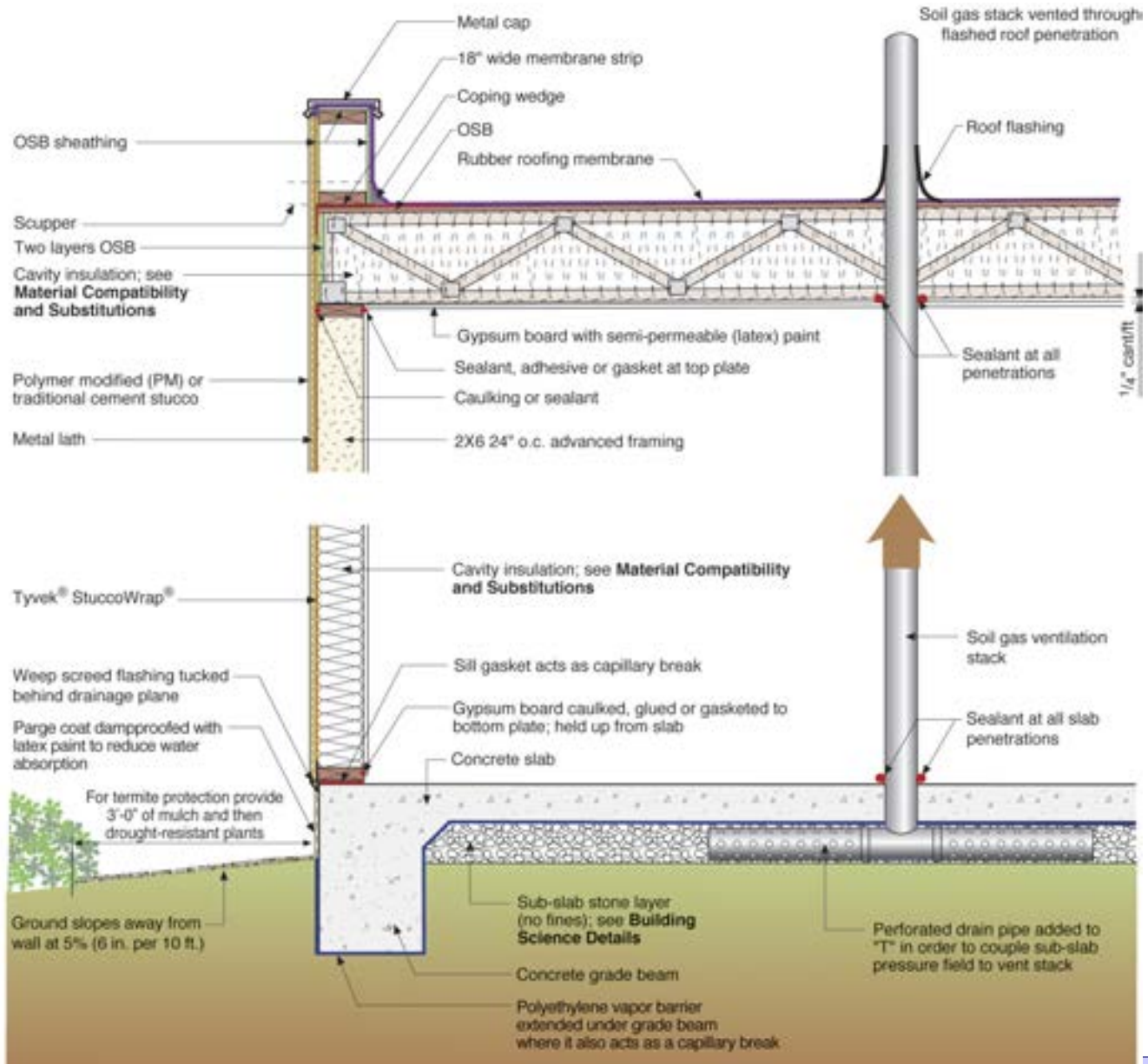


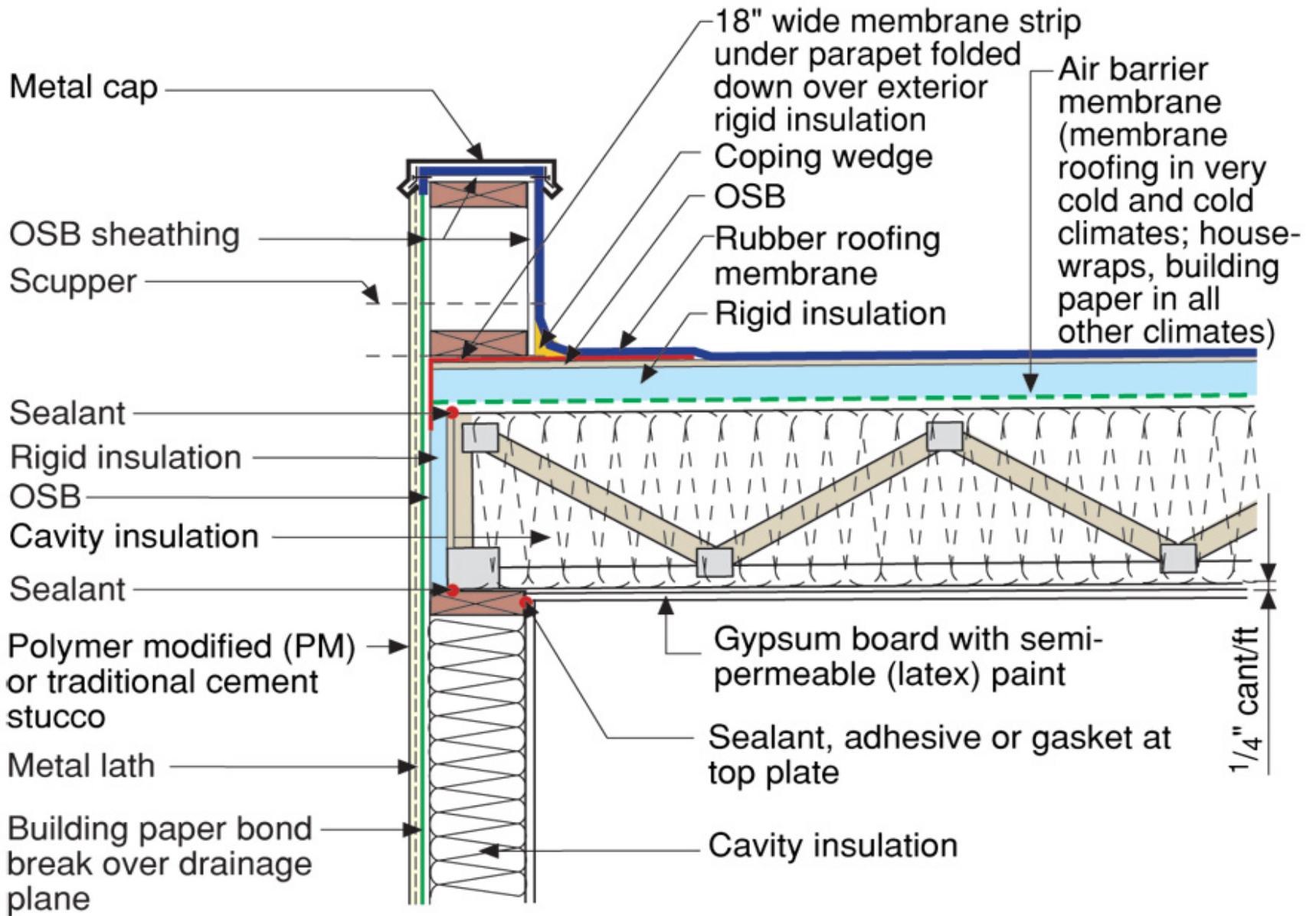




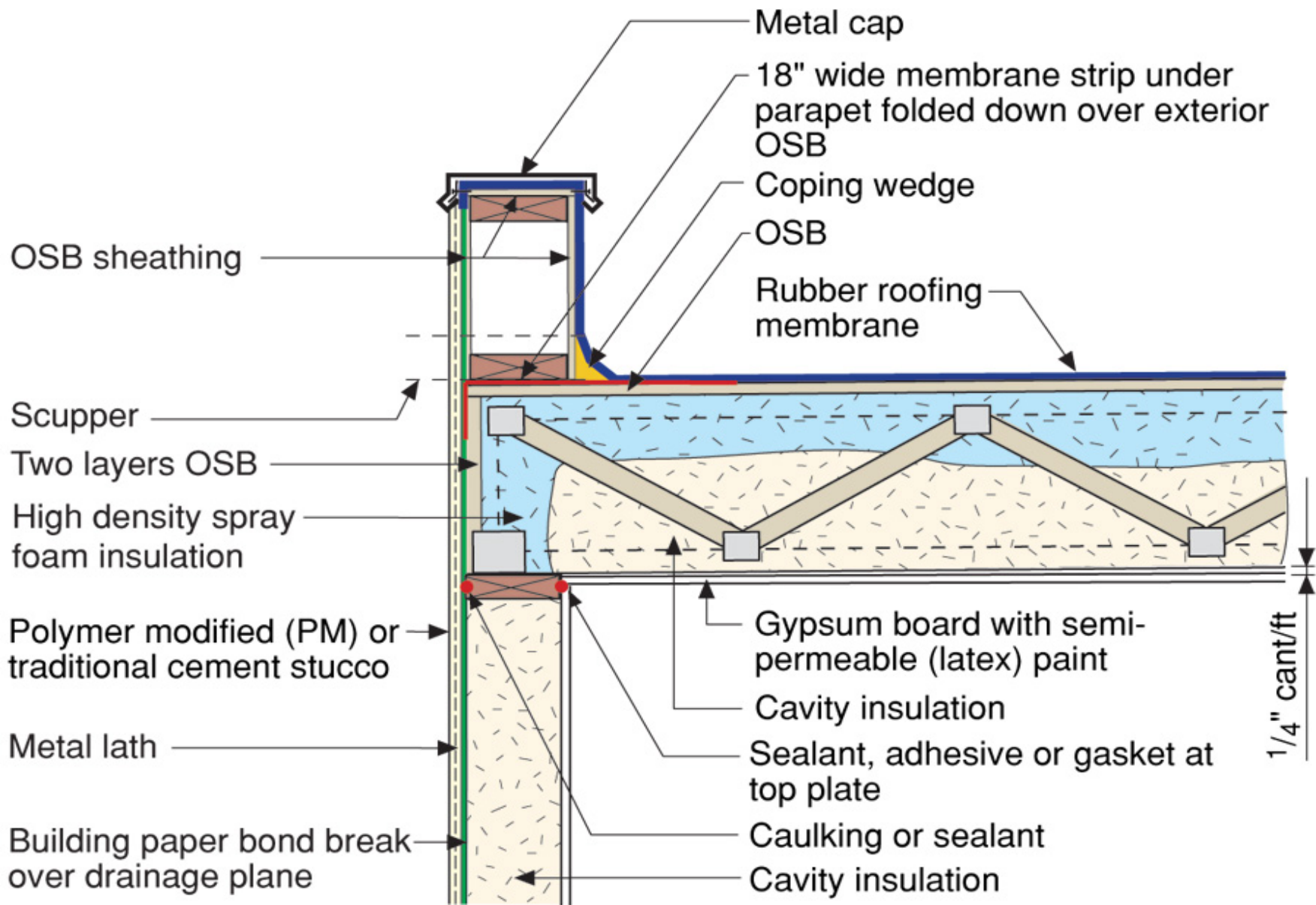




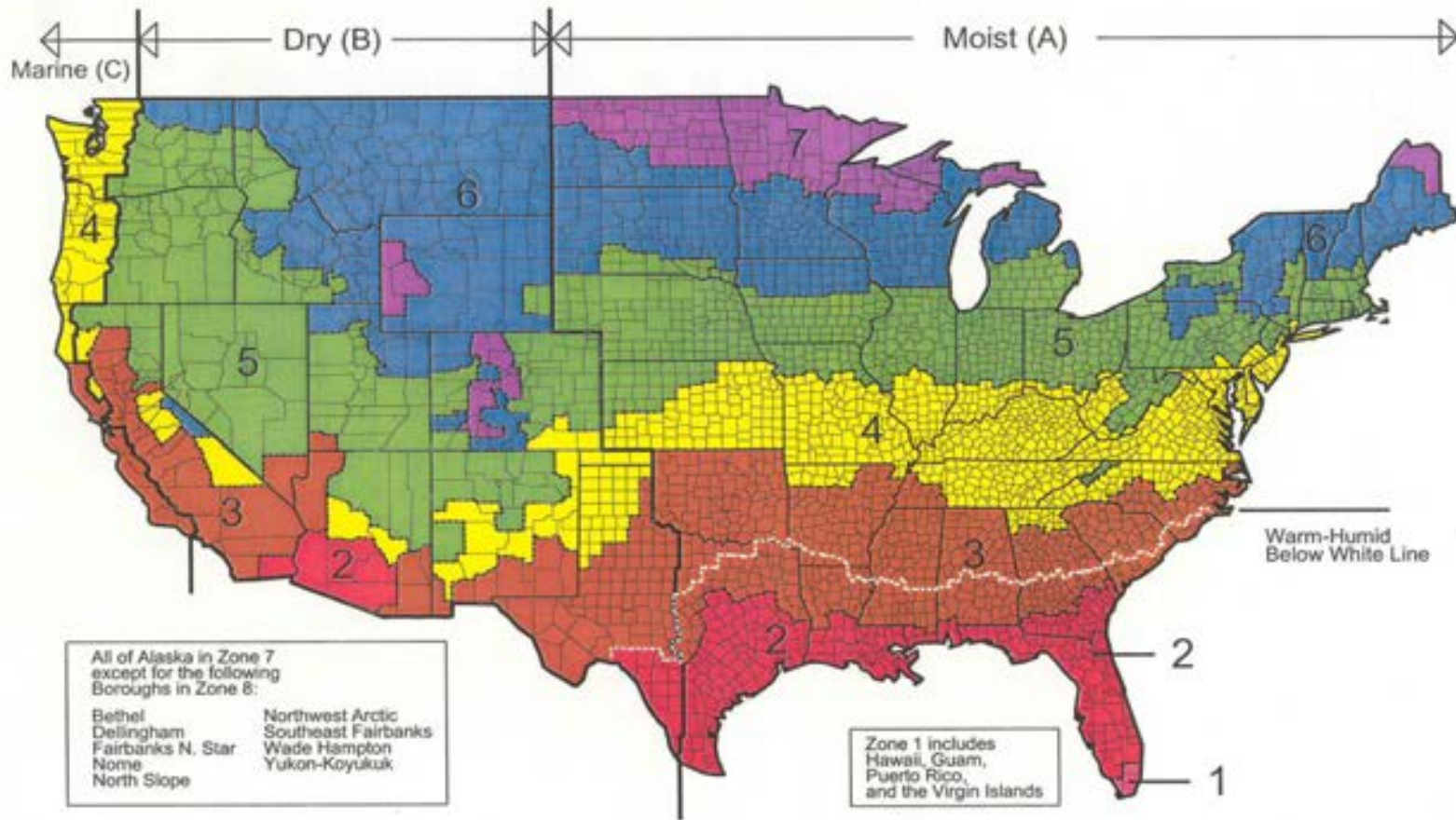




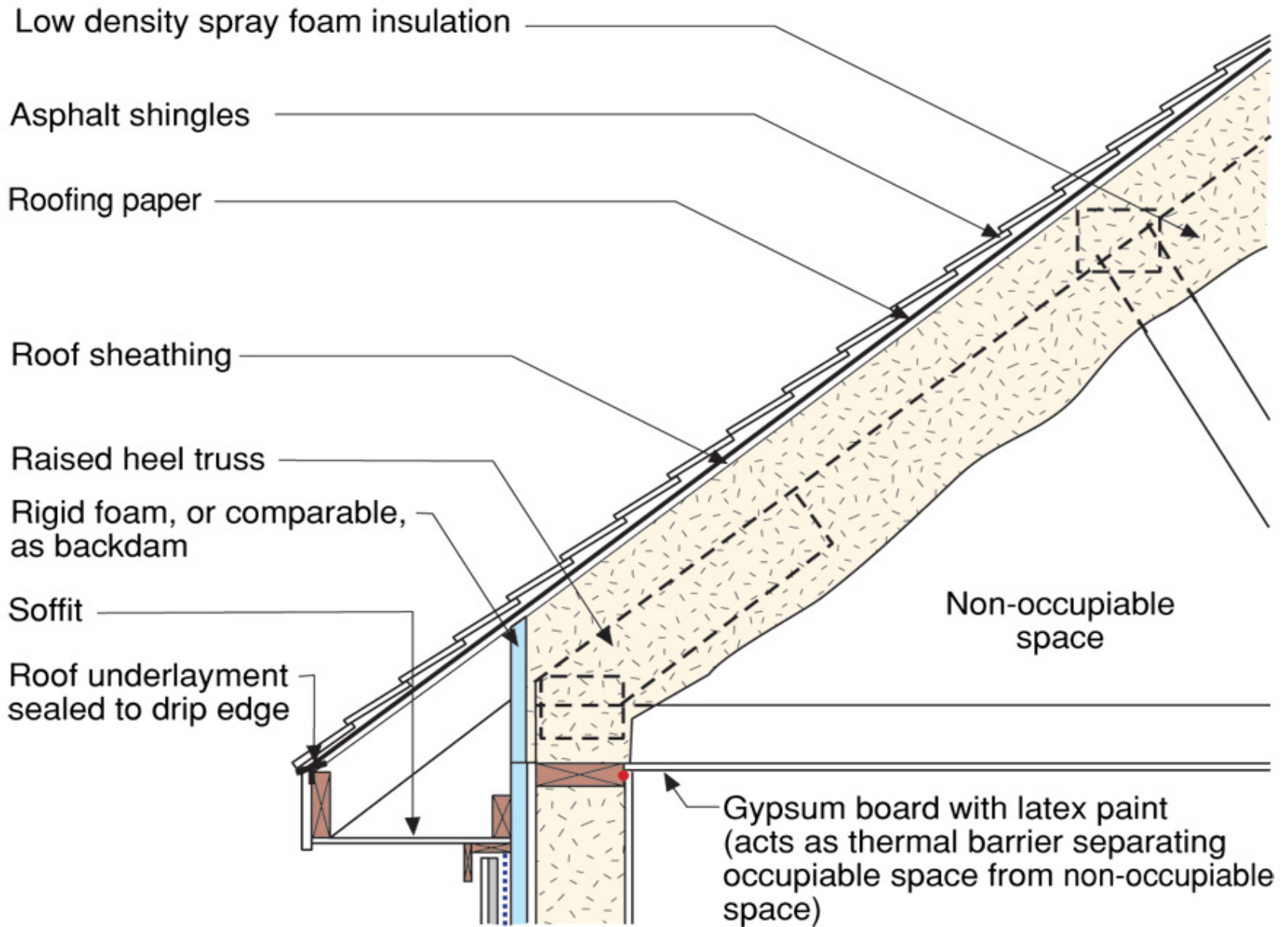




# Map of DOE's Proposed Climate Zones



March 24, 2003







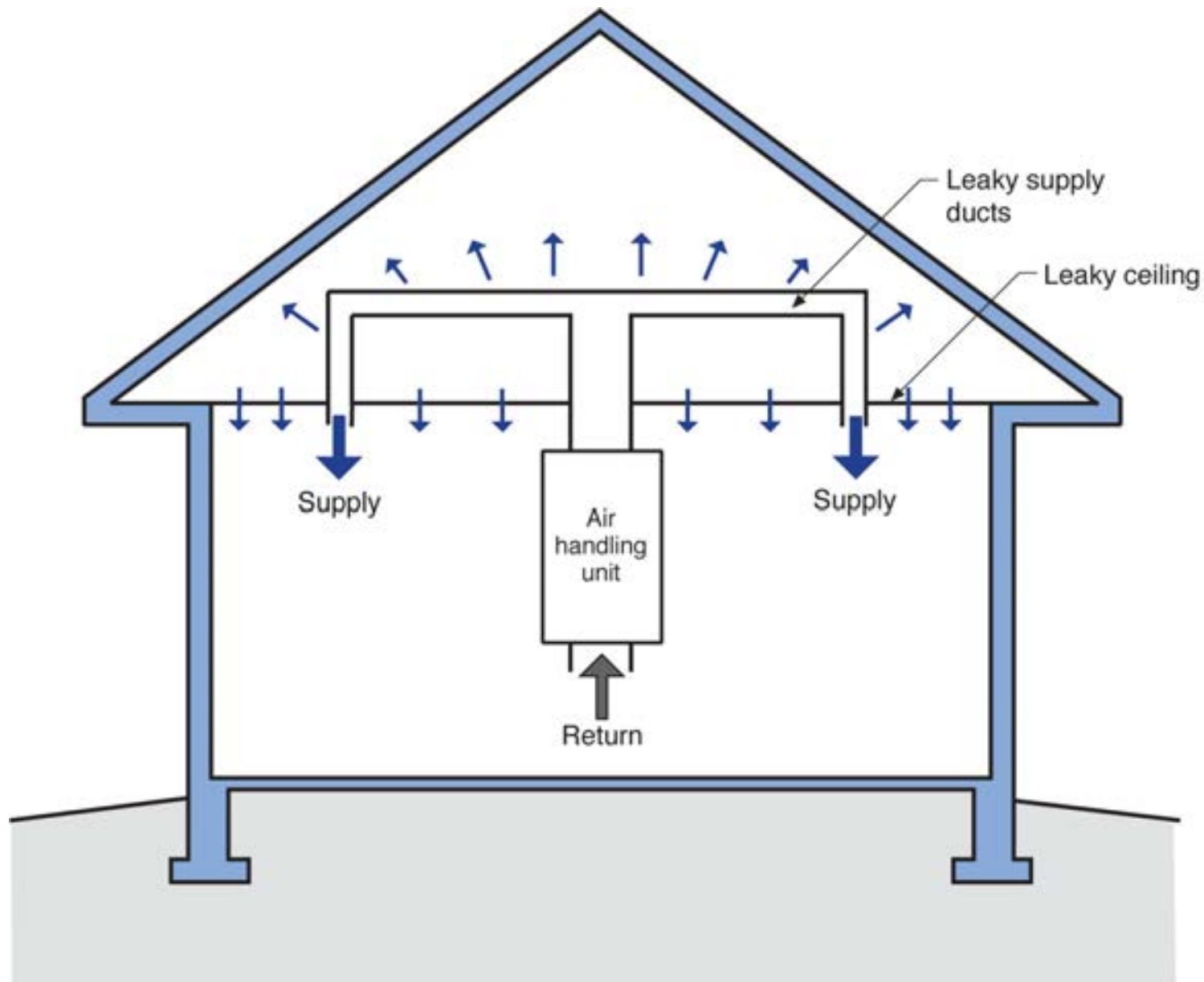


















Conditioned Attics Not Unvented Attics  
Need Supply Air

Conditioned Attics Not Unvented Attics  
Need Supply Air  
50 cfm/1000 ft<sup>2</sup> of Attic

# 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

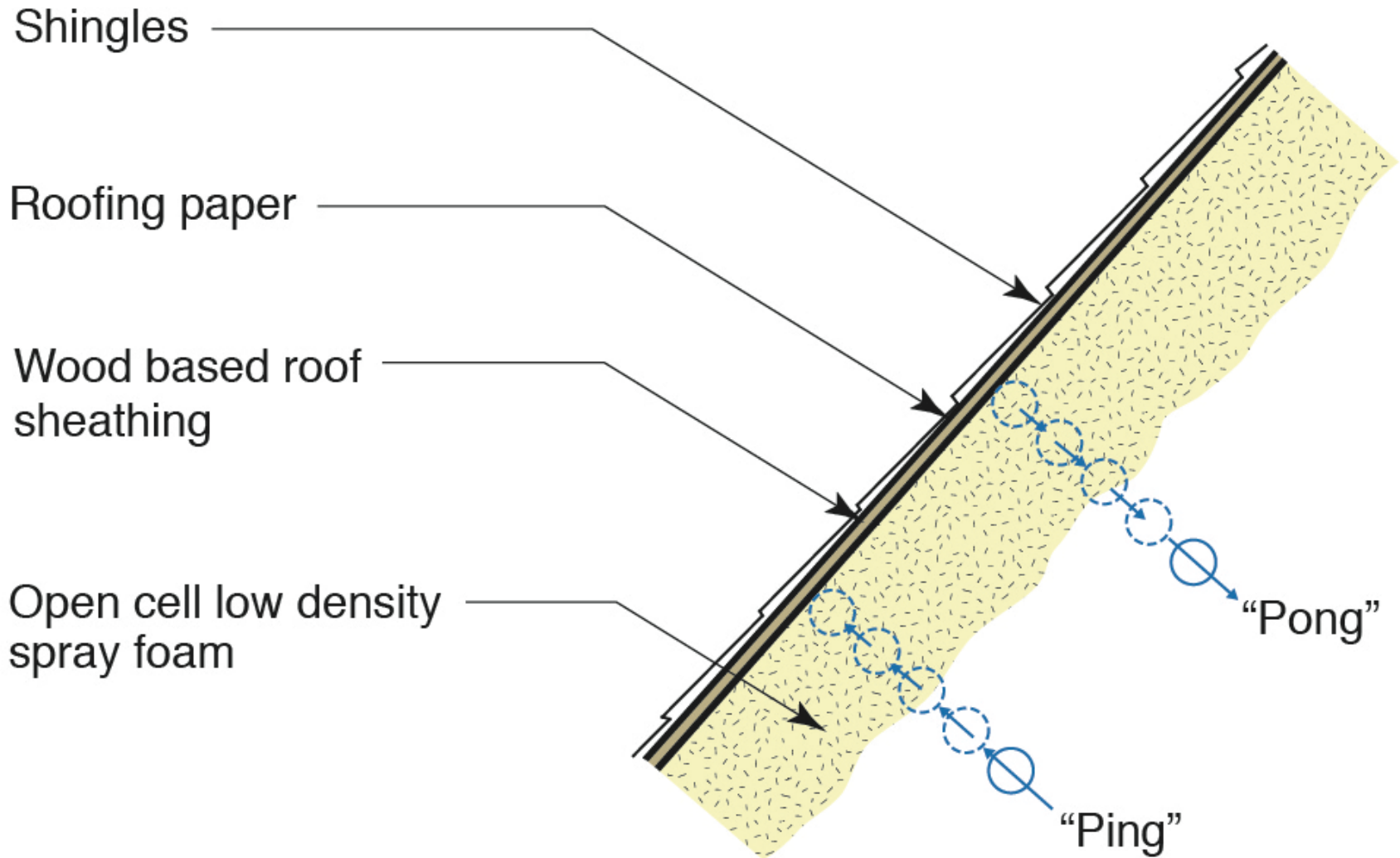
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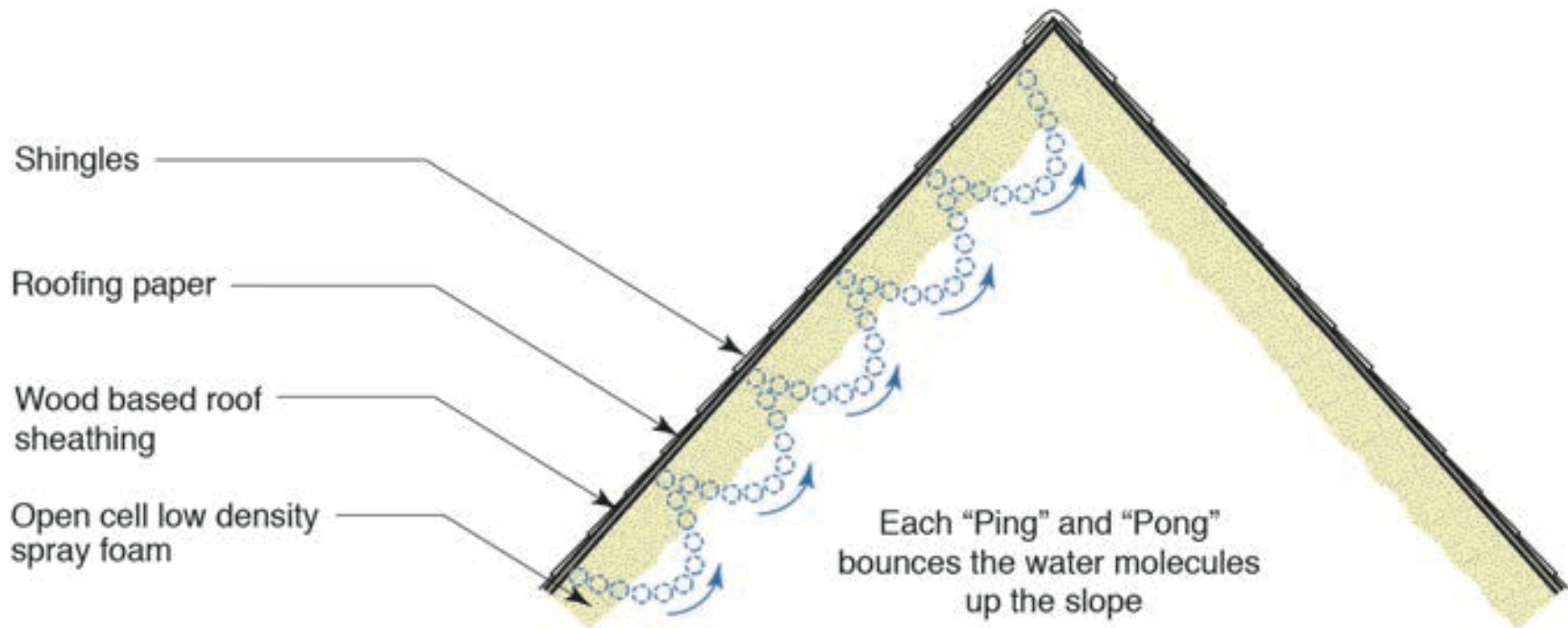
Note Water Vapor (H<sub>2</sub>O) is 18  
 Dry Air is 29







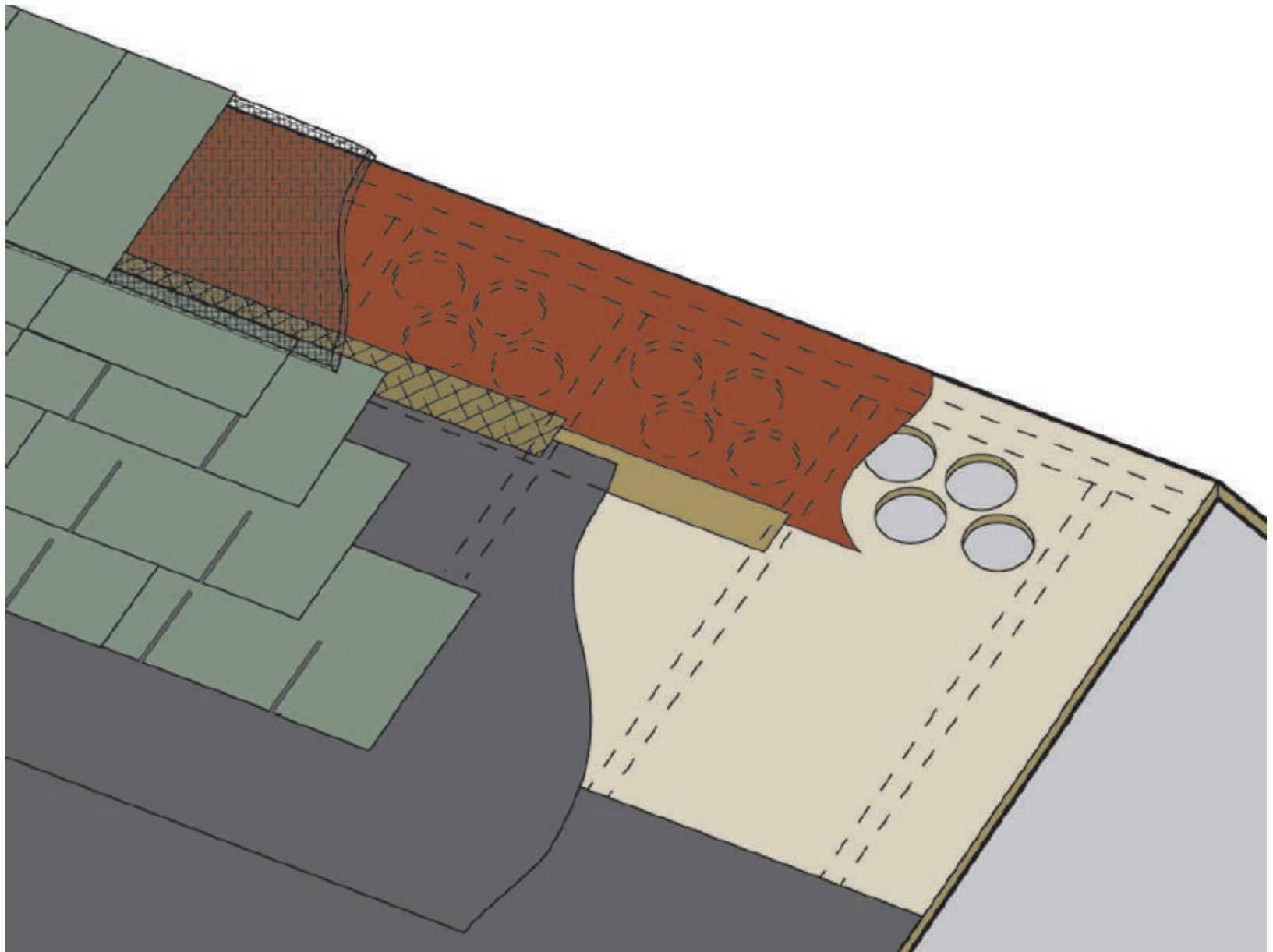




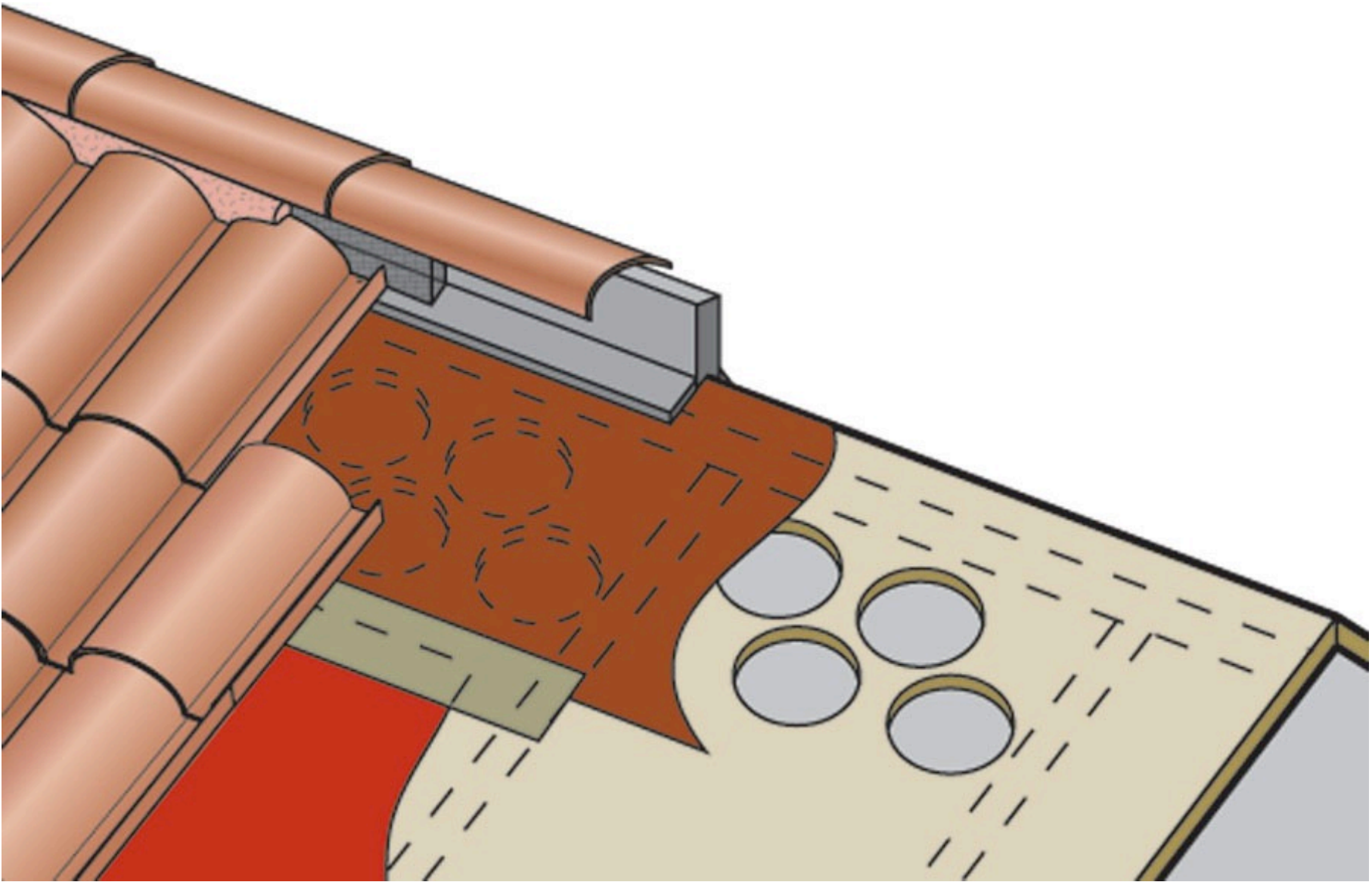


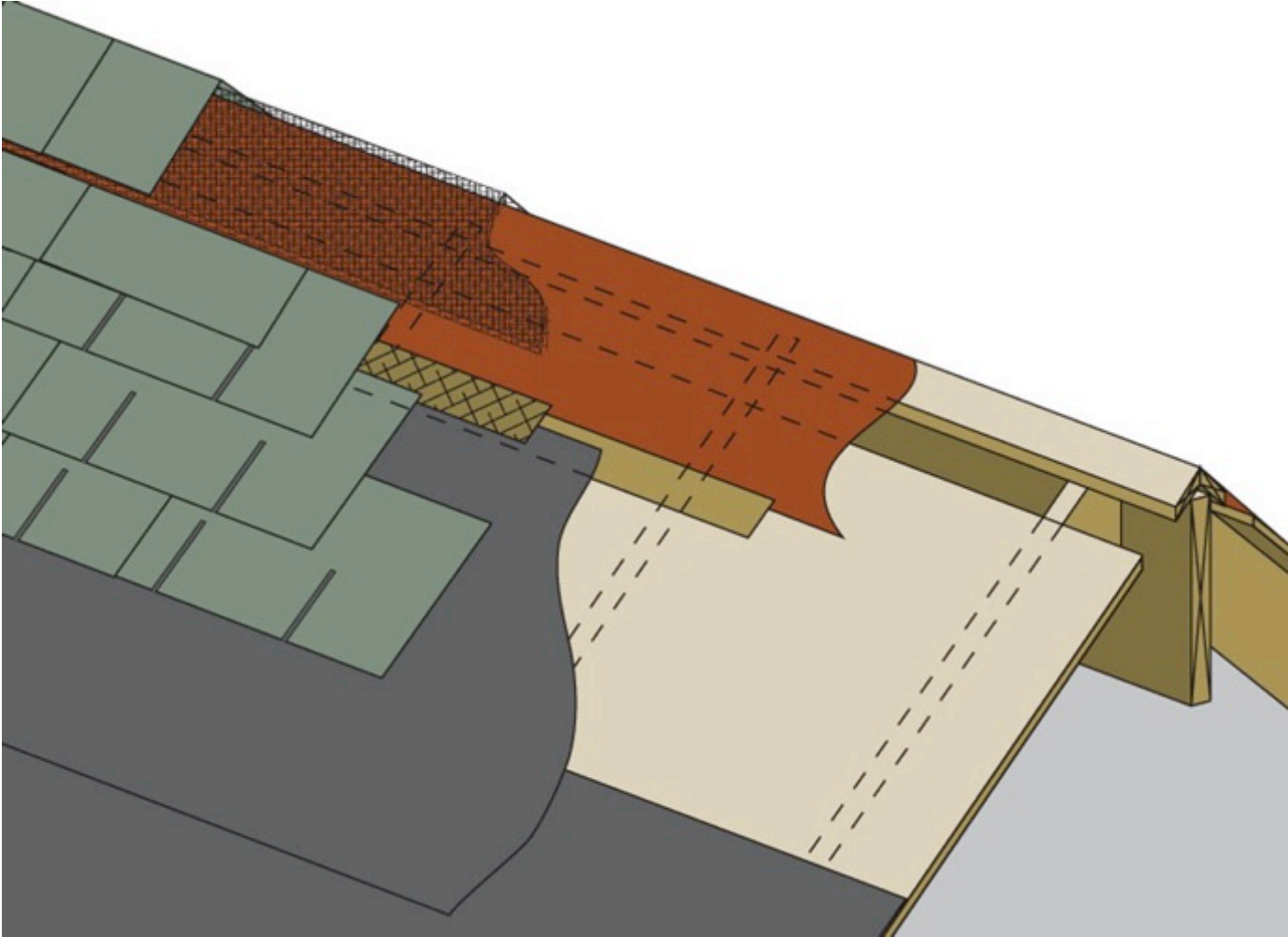


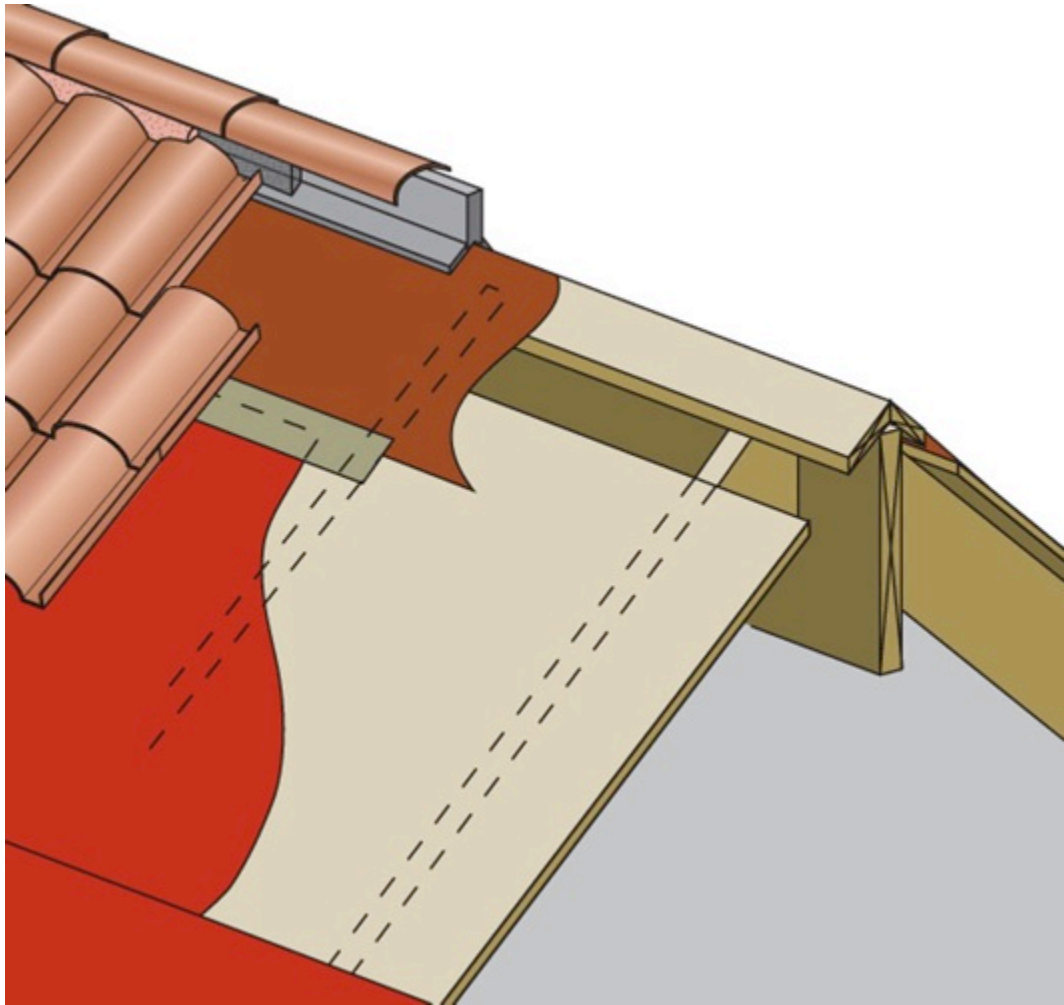






















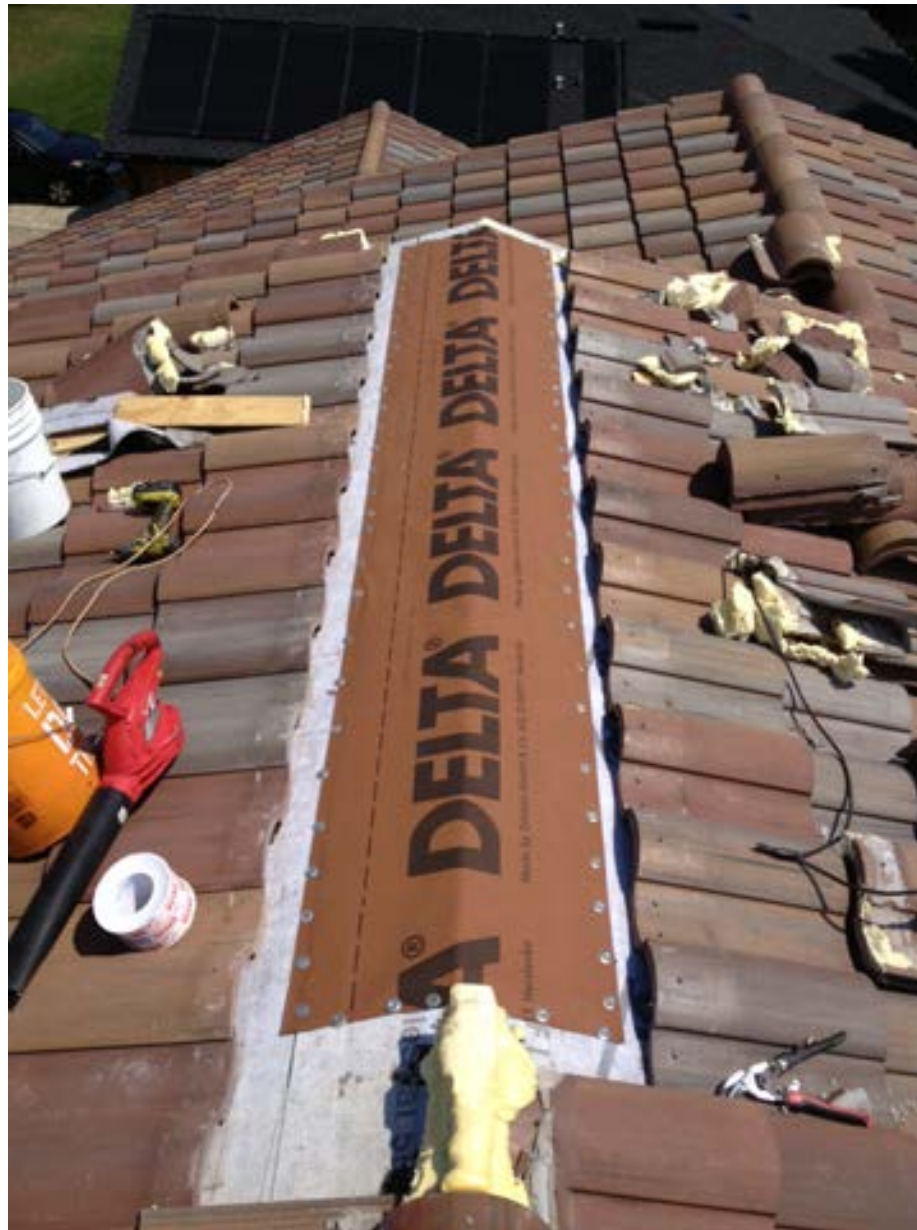














# Code Change



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

- vapor diffusion port
- port area 1:600 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 ft<sup>2</sup> ceiling area when insulation installed directly under the roof deck
- Climate Zones 1, 2 and 3

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

# Sweating Ducts



Sweating Ducts

Light Colored Roofs

Cool Roofs

Radiant Barriers

ACCA Manual J, S and D

ASHRAE 62.2

# Ductwork Attic Dehumidification System

