
# Hybrid Systems That Work

Mac Sheldon
Mac@SheldonConsulting.com

# ANTITRUST POLICY STATEMENT FOR SPRAY POLYURETHANE FOAM ALLIANCE MEETINGS

- It is and shall remain the policy of the Spray Polyurethane Foam Alliance ("SPFA"), and it is the continuing responsibility of every SPFA member company, SPFA meeting or event participant, as well as SPFA staff and leadership to comply in all respects with federal and state antitrust laws. No activity or discussion at any SPFA meeting or other function may be engaged in for the purpose of bringing about any understanding or agreement among members to (1) raise, lower or stabilize prices; (2) regulate production; (3) allocate markets; (4) encourage boycotts; (5) foster unfair or deceptive trade practices; (6) assist in monopolization; or (7) in any way violate or give the appearance of violating federal or state antitrust laws.

- Any concerns or questions regarding the meaning or applicability of this policy, as well as any concerns regarding activities or discussions at SPFA meetings should be promptly brought to the attention of SPFA's Executive Director and/or its legal counsel.

# Why Hybrids?

- Board stock or ccSPF used on exterior reduces thermal bridging of studs.
  Code
  R-Value is installed in the cavities.
- Fiberglass or other air-permeable insulations don’t work in many applications.
- Hybrids are perceived as less expense than using foam only.
- SPF is a very effective air seal.
- ccSPF can add more R-Value in a

# Fiberglass alone doesn't work in many applications

# Potential problems with Hybrids

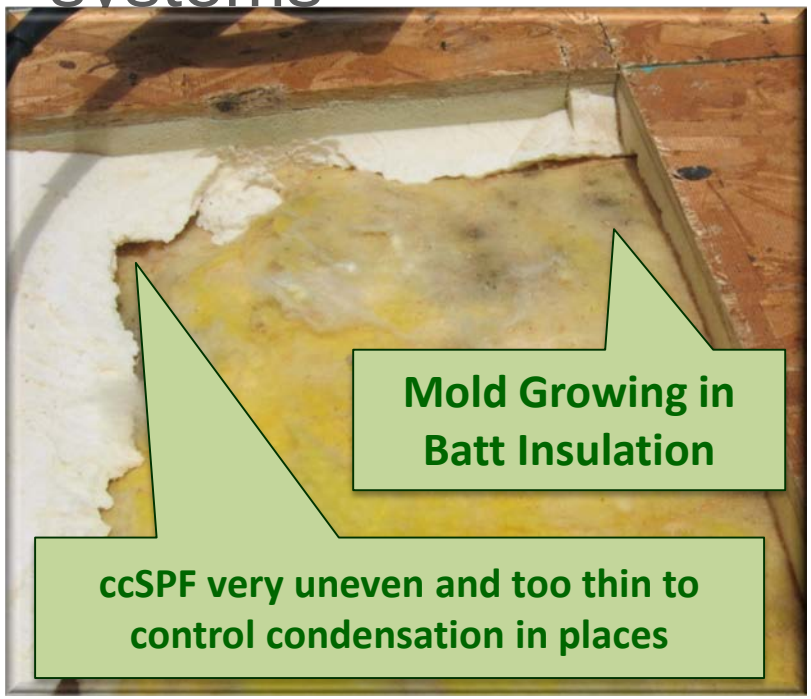
- When the ratio of ccSPF R-Value to fibrous insulation R-Value is too low, the assembly may not control condensation.
- Condensation generally occurs on the surface of the foam, not in the fiberglass or other fibrous insulation.
- Problems are often blamed on the foam when actually the assembly design and installation was at fault.

# Potential problems with Hybrids

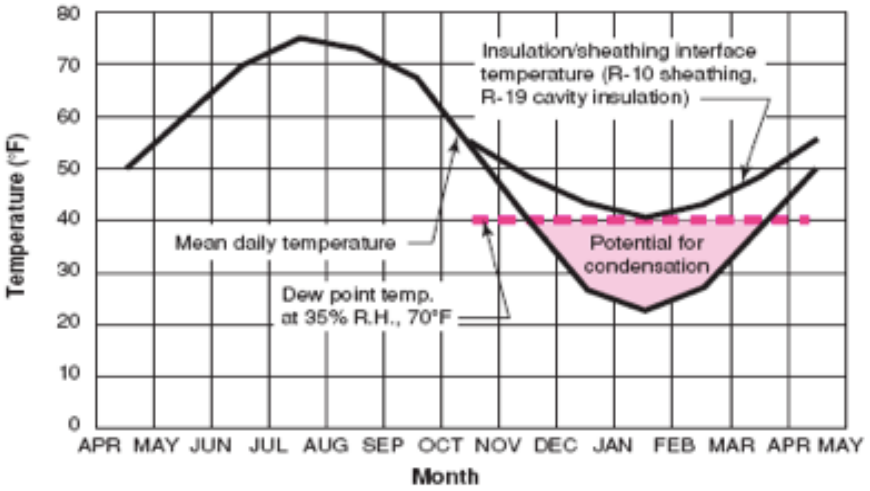
- Poorly executed Hybrid applications:
  - Improper design – Ratio is not correct
  - Lumpy foam
  - ccSPF sprayed too thin
  - ccSPF sprayed unevenly so fibrous insulation batts don’t fit the cavity.

# Hybrid Insulation in Cold Climates Must Be Engineered

- We have seen several failures of hybrid roof insulation systems



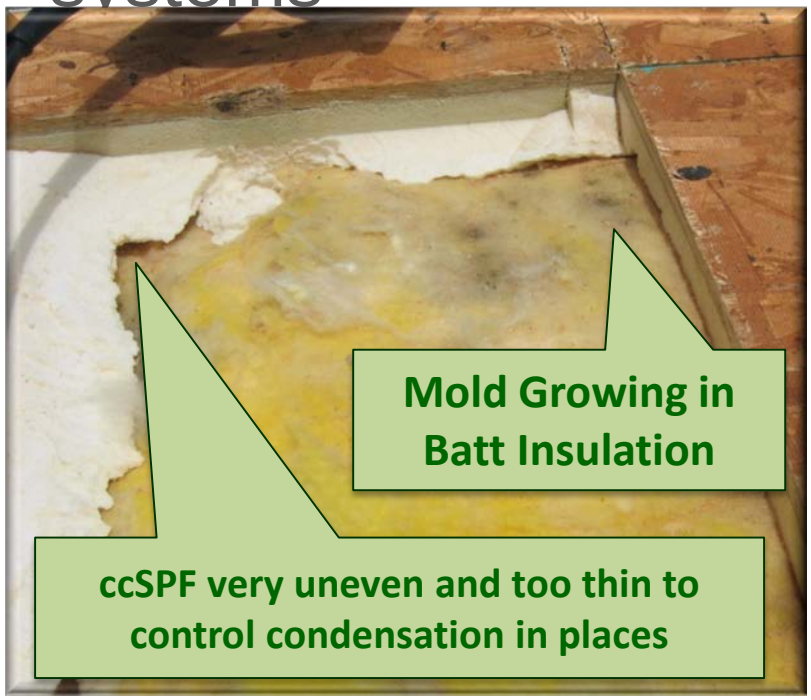

- Air Permeable Insulation cannot control movement of moisture laden air to the condensing surface



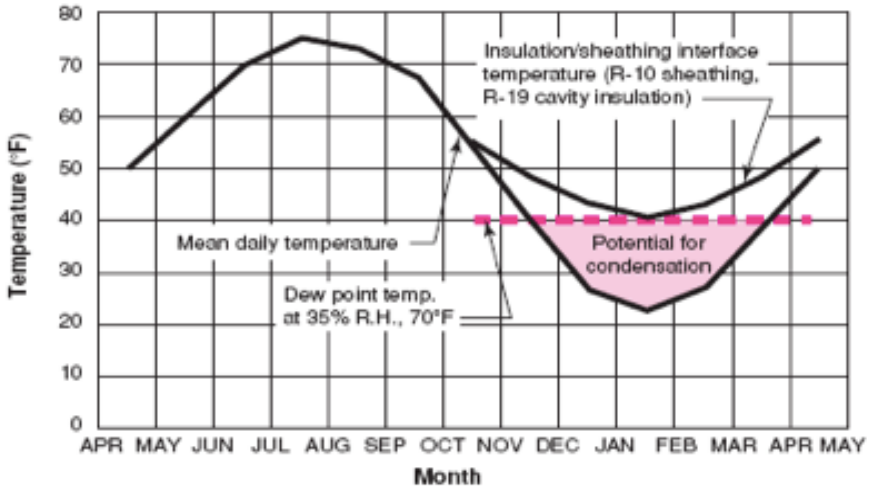
# Hybrid Insulation in Cold Climates Must Be Engineered

**Any Hybrid Insulation System in Zones 4C, 5, 6, 7 or 8 must be carefully engineered for condensation avoidance.**

systems

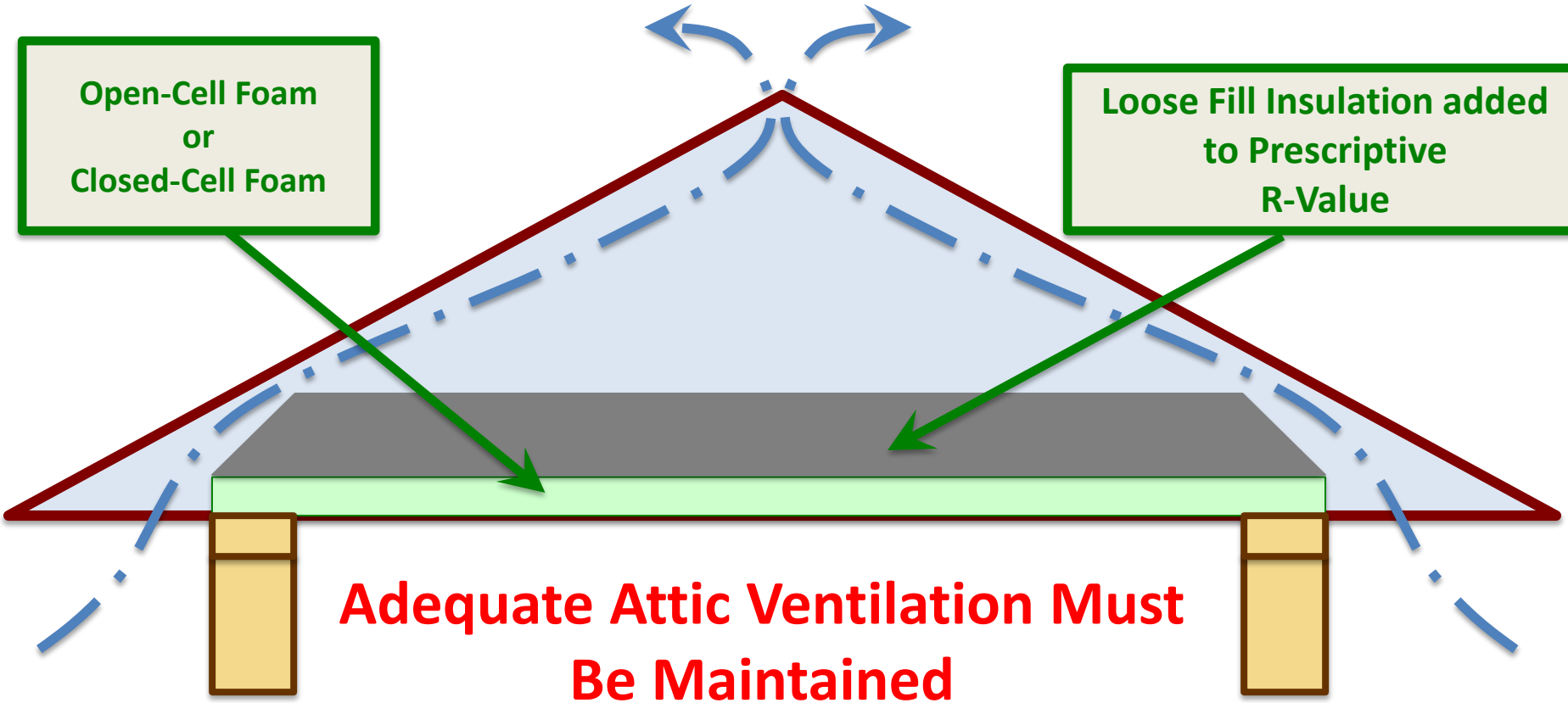



moisture laden air to the condensing surface



# Hybrid Insulation in Roofs

- Hybrid Insulation Systems on the Floor of the Attic in a Vented Attic Assembly Work very well!

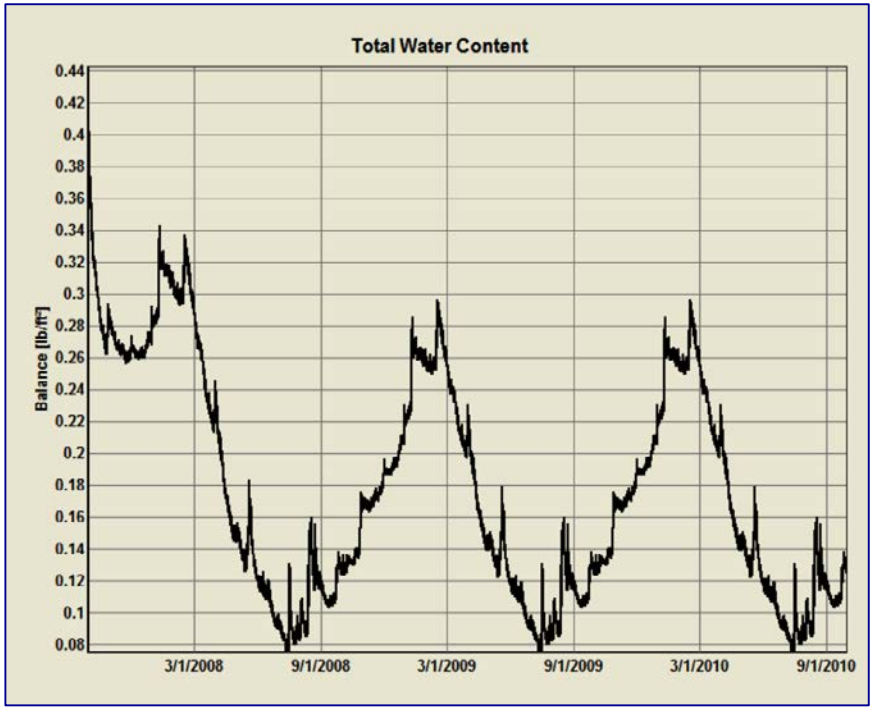


# Methods of Design

- WUFI
  - Pinpoint through-the-assembly hygro-thermal analysis modeling tool
  - Very powerful
  - Very complex
  - Requires high skill level
- Dew Point Method
  - Simple
  - Usually overly conservative
- Modified Dew Point
  - BSC method
  - Uses average temp of two or three coldest months to calculate outdoor design temp
- Experience
  - Could take years or decades for failure to occur or be seen
  - Variations in building materials can change performance dramatically

# WUFI

- Developed by Fraunhofer Institute in Germany and Oak Ridge National Lab in the US.
- Currently the industry standard
- Highly documented
- Poor materials library



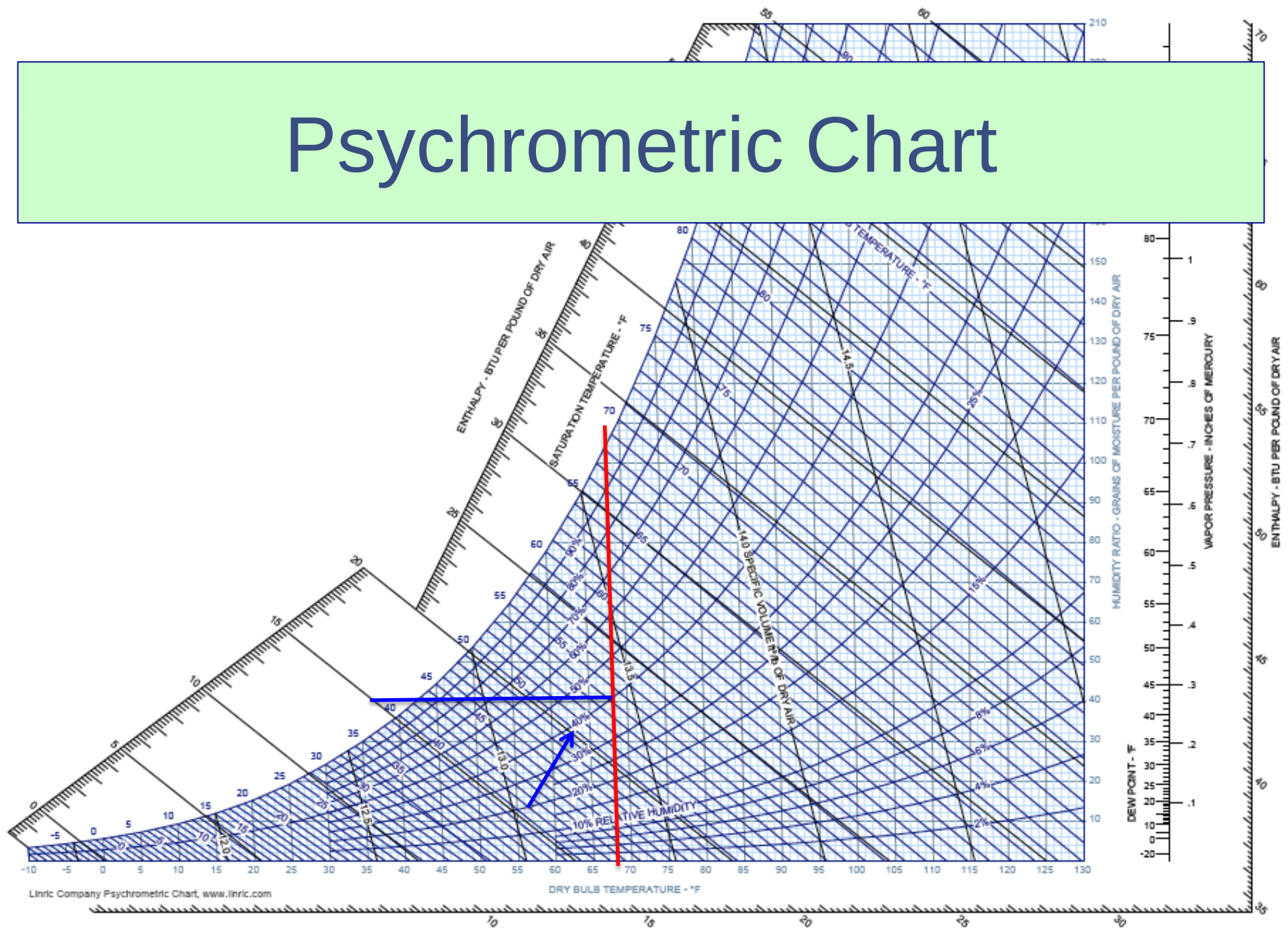

Example showing initial drying and year-over-year seasonal repeatability

# Dew Point Method

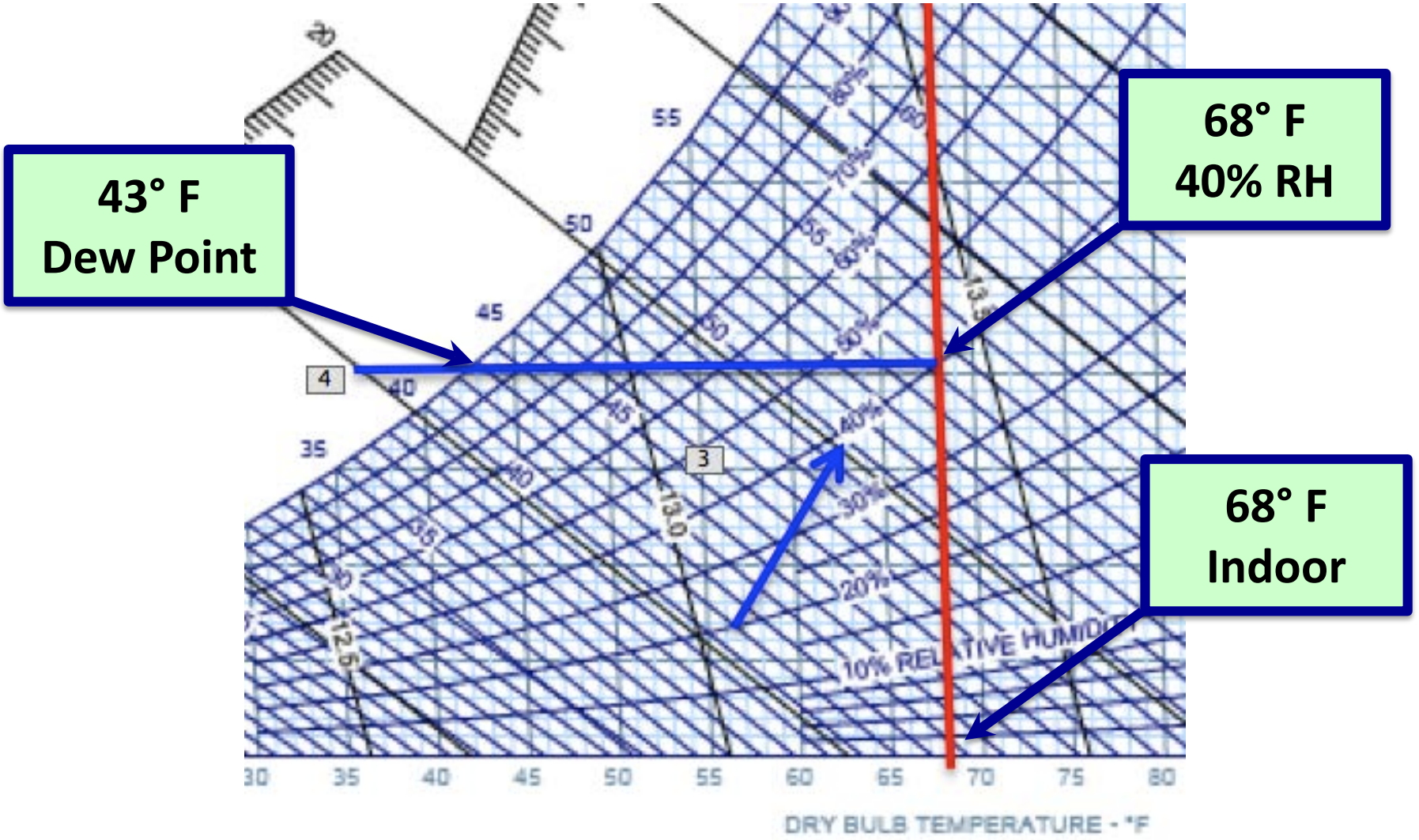
- Uses simple calculation, often based on 68°F indoor temp with 40% RH
- Psychrometric chart is used to find dew point

- If ASHRAE winter design temp is used, it's often too conservative as this low temp rarely lasts long enough to actually allow condensation.

# Psychrometric Chart



# Psychrometric Chart



# Dew Point

- Dew Point is the temperature at which water vapor in the air will condense into liquid water on a surface.
- If the inner surface of the foam (board stock or ccSPF) is below the dew point of the inside air, and if water vapor contacts it either through diffusion (very slow process) or is carried in air currents (faster process) it can form liquid water on the surface of the foam.

# Dew Point

- There are two ways of controlling condensation on the inner surface of the foam:
  - Reduce the water vapor concentration (Relative Humidity) in the interior air.
  - Design the assembly to have an interior foam surface temperature higher than the dew point of the interior air.


The dew point of the room air is reached when fog forms on windows or mirrors.

# Example of Calculating Surface Temperature of the Foam

- 1 – Find the total number of Rs

  1” X R-7.0 (ccSPF) +
  4.5” X R-3.5 (FG) = R-23 Assembly R-Value

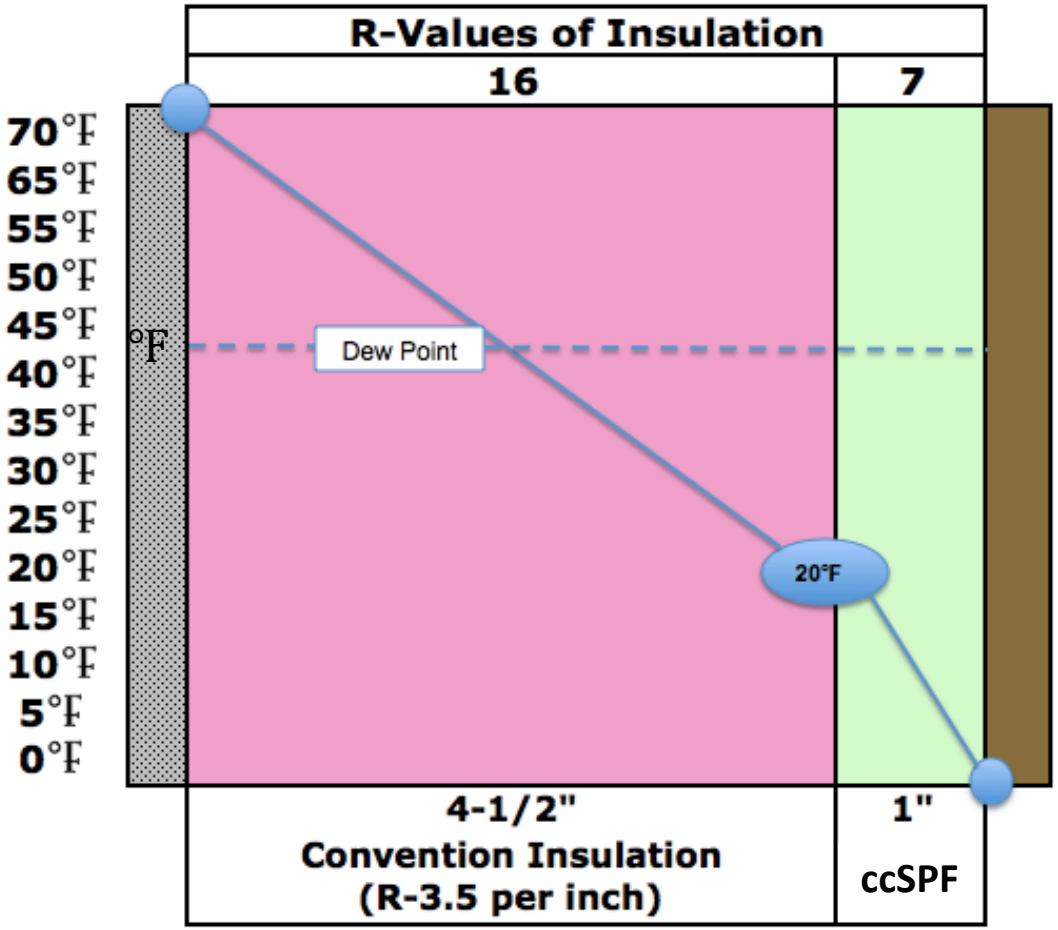
- 2 – Divide the difference between IAT and OAT by the Rs

  70 degrees (ΔT) ÷ 23 Rs = 3 degrees per R

- 3 – To find the surface temperature of the foam, multiply the Rs from foam times 3 degrees per R then add this value to the outside temperature
  R-7.0 foam X 3° per R = 21 Degrees + OAT (0°F) = 21°F in this example  (The outdoor temp is 0°F in this example)

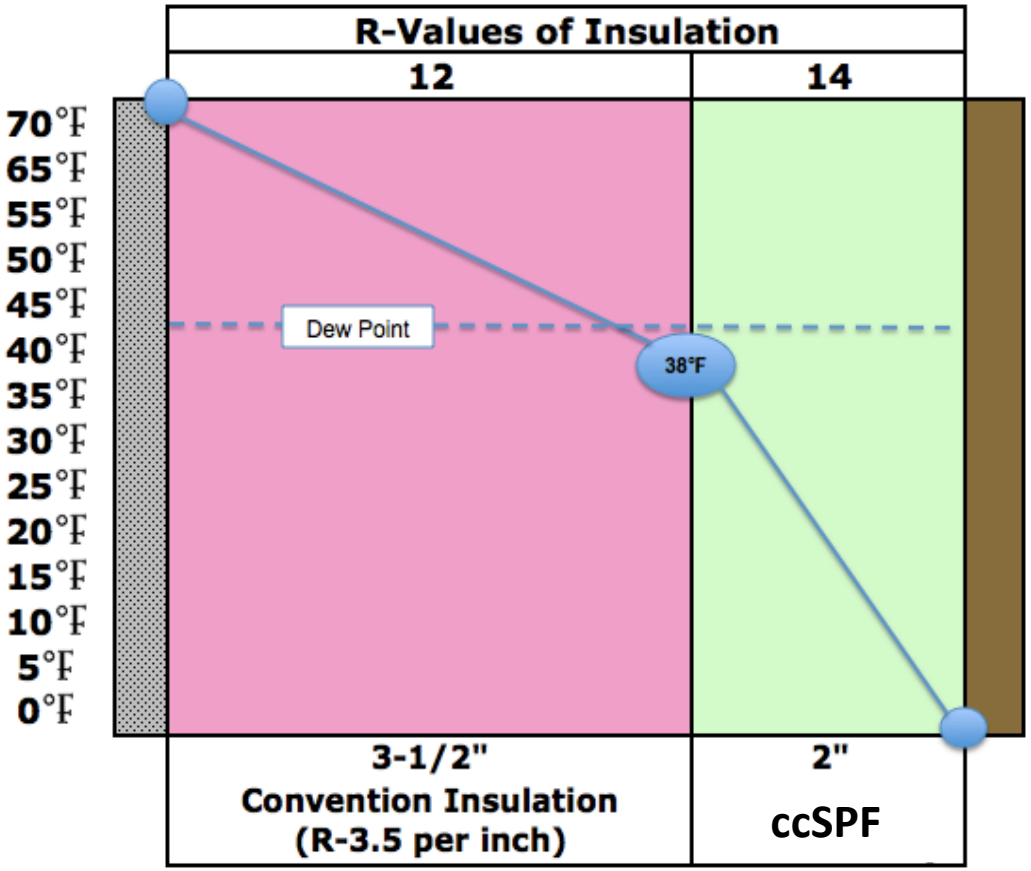
# Ratio of Hybrid

- 1” of Closed-Cell Foam plus 4-1/2” of conventional, air permeable insulation at R-3.5 per inch
- Surface of foam is well below the dew point at 0°F outside and 70°F/40% RH inside



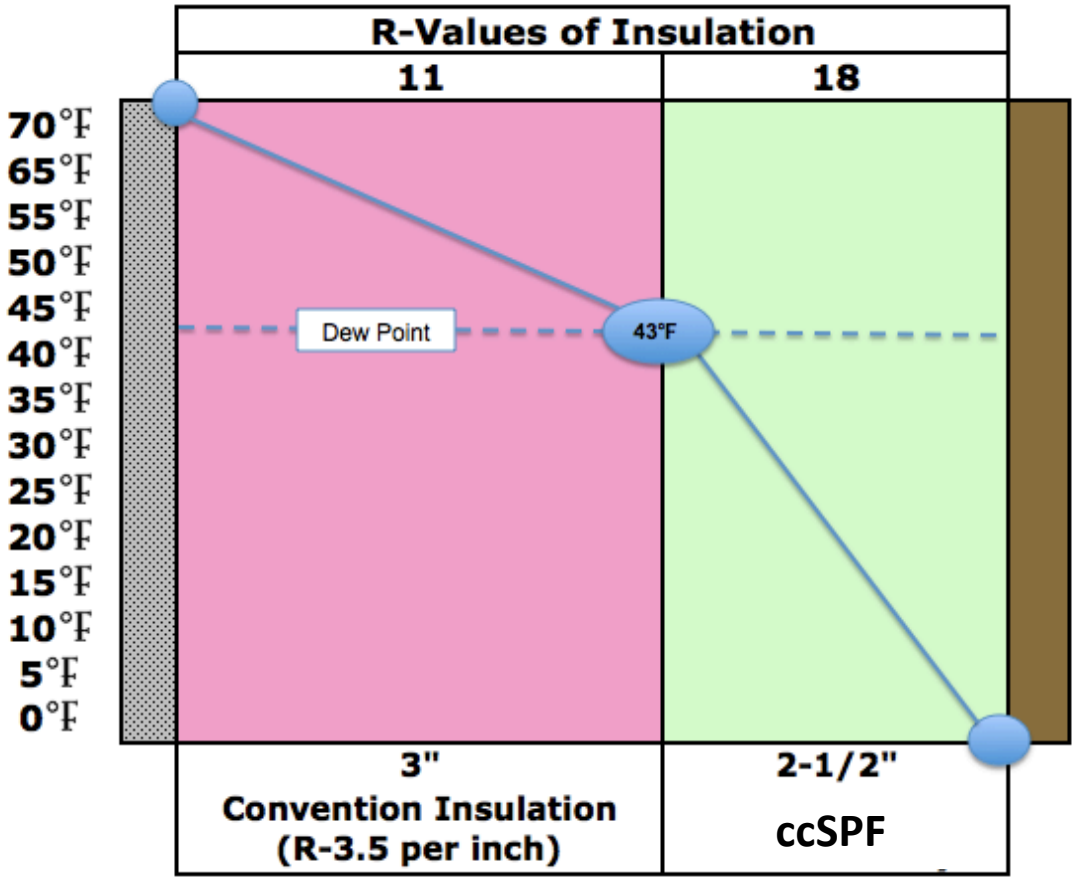
# Ratio of Hybrid

- 2” of ccSPF plus 3-1/2” of conventional, air permeable insulation at R-3.5 per inch
- Surface of foam is still below the dew point at 0°F outside and 70°F/40% RH inside, but safer



# Ratio of Hybrid

- 2-1/2” of ccSPF plus 3” of conventional, air permeable insulatior at R-3.5 per inch
- Surface of foam is at the dew point at 0°F outside and 70°F/40% RH inside, and this is considered safe except in Zone 8 (Alaska)




# ASHRAE 99% Winter Design Conditions

**TABLE D101—continued**
**DEGREE DAY AND DESIGN TEMPERATURES[a] FOR CITIES IN THE UNITED STATES**

| STATE | STATION[b] | HEATING DEGREE DAYS (yearly total) | DESIGN TEMPERATURES | | | DEGREES NORTH LATITUDE[c] |
|---|---|---|---|---|---|---|
| | | | Winter | Summer | | |
| | | | 97 1/2% | Dry bulb 2 1/2% | Wet bulb 2 1/2% | |
| SD | Huron | 8,223 | -14 | 93 | 75 | 44°30′ |
| | Rapid City | 7,345 | -7 | 92 | 69 | 44°00′ |
| | Sioux Falls | 7,839 | -11 | 91 | 75 | 43°40′ |
| TN | Bristol | 4,143 | 14 | 89 | 75 | 36°30′ |
| | Chattanooga | 3,254 | 18 | 93 | 77 | 35°00′ |
| | Knoxville | 3,494 | 19 | 92 | 76 | 35°50′ |
| | Memphis | 3,232 | 18 | 95 | 79 | 35°00′ |
| | Nashville | 3,578 | 14 | 94 | 77 | 36°10′ |
| TX | Abilene | 2,624 | 20 | 99 | 74 | 32°30′ |
| | Austin | 1,711 | 28 | 98 | 77 | 30°20′ |
| | Dallas | 2,363 | 22 | 100 | 78 | 32°50′ |
| | El Paso | 2,700 | 24 | 98 | 68 | 31°50′ |
| | Houston | 1,396 | 32 | 94 | 79 | 29°40′ |
| | Midland | 2,591 | 21 | 98 | 72 | 32°00′ |
| | San Angelo | 2,255 | 22 | 99 | 74 | 31°20′ |
| | San Antonio | 1,546 | 30 | 97 | 76 | 29°30′ |
| | Waco | 2,030 | 26 | 99 | 78 | 31°40′ |
| | Wichita Falls | 2,832 | 18 | 101 | 76 | 34°00′ |
| UT | Salt Lake City | 6,052 | 8 | 95 | 65 | 40°50′ |

# ASHRAE 99% Winter Design Conditions

| | | | | | | |
|---|---|---|---|---|---|---|
| IA | Burlington | 6,114 | -3 | 91 | 77 | 40°50′ |
| | Des Moines | 6,588 | -5 | 91 | 77 | 41°30′ |
| | Dubuque | 7,376 | -7 | 88 | 75 | 42°20′ |
| | Sioux City | 6,951 | -7 | 92 | 77 | 42°20′ |
| | Waterloo | 7,320 | -10 | 89 | 77 | 42°30′ |
| KS | Dodge City | 4,986 | 5 | 97 | 73 | 37°50′ |
| | Goodland | 6,141 | 0 | 96 | 70 | 39°20′ |
| | Topeka | 5,182 | 4 | 96 | 78 | 39°00′ |
| | Wichita | 4,620 | 7 | 98 | 76 | 37°40′ |
| WA | Olympia | 5,236 | 22 | 83 | 66 | 47°00′ |
| | Seattle-Tacoma | 5,145 | 26 | 80 | 64 | 47°30′ |
| | Seattle[d] | 4,424 | 27 | 82 | 67 | 47°40′ |
| | Spokane | 6,655 | 2 | 90 | 64 | 47°40′ |
| MN | Duluth | 10,000 | -16 | 82 | 70 | 46°50′ |
| | Minneapolis | 8,382 | -12 | 89 | 5 | 44°50′ |
| | Rochester | 8,295 | -12 | 87 | 75 | 44°00′ |
| WI | Green Bay | 8,029 | -9 | 85 | 74 | 44°30′ |
| | La Crosse | 7,589 | -9 | 88 | 75 | 43°50′ |
| | Madison | 7,863 | -7 | 88 | 75 | 43°10′ |
| | Milwaukee | 7,635 | -4 | 87 | 74 | 43°00′ |

# Modified Dew Point Method

- Uses simple calculation, often based on 68°F indoor temp with 40% RH
- Psychrometric chart is used to find dew point
- Less accurate than WUFI but less conservative than Dew Point Method

- Uses average temperature for the coldest three months of the year.
  - This method assumes it won't stay very, very cold for extended periods of time.
  - Also assumes small amounts of condensation will re-evaporate.


# Building Science Corporation

## BSC Method for Determining Hybrid Insulation Thicknesses

| Cold Climate Location | | | |
|---|---|---|---|
| | December | January | February |
| Avreage High | 35 | 34 | 39 |
| Average Low | 9 | 7 | 11 |
| Average | 22 | 20.5 | 25 |

| Three Month Average Temp | 22.5 |
|---|---|

| Hybrid | | |
|---|---|---|
| | Roof | Walls |
| Total Rs | 49 | 20 |
| ccSPF - R | 21.0 | 9.9 |
| ocSPF - R | 28.0 | 10.1 |

# 2015 IRC

**TABLE R806.5**
**INSULATION FOR CONDENSATION CONTROL**

| CLIMATE ZONE | MINIMUM RIGID BOARD ON AIR-IMPERMEABLE INSULATION *R*-VALUE[a, b] |
|---|---|
| 2B and 3B tile roof only | 0 (none required) |
| 1, 2A, 2B, 3A, 3B, 3C | R-5 |
| 4C | R-10 |
| 4A, 4B | R-15 |
| 5 | R-20 |
| 6 | R-25 |
| 7 | R-30 |
| 8 | R-35 |

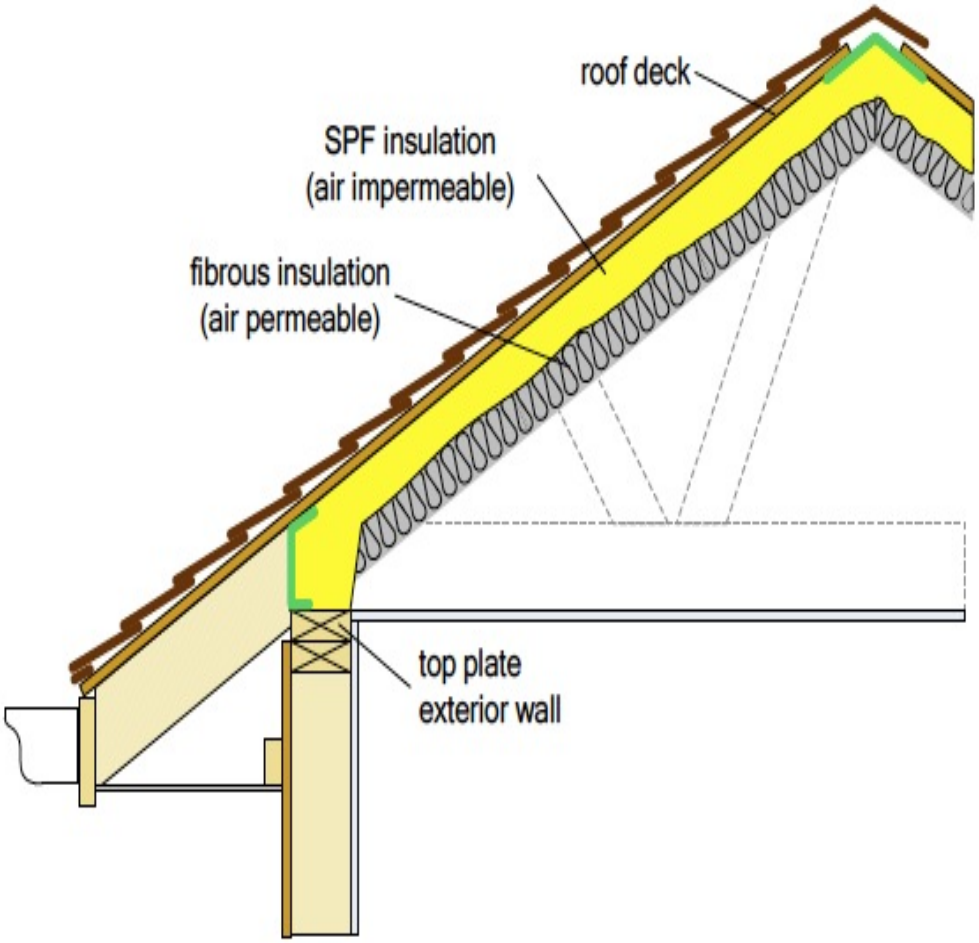
a. Contributes to but does not supersede the requirements in Section N1102.

b. Alternatively, sufficient continuous insulation shall be installed directly above the structural roof sheathing to maintain the monthly average temperature of the underside of the structural roof sheathing above 45°F (7°C). For calculation purposes, an interior air temperature of 68°F (20°C) is assumed and the exterior air temperature is assumed to be the monthly average outside air temperature of the three coldest months.


# COMMON PROBLEMS WITH WITH HYBRIDS

# Gravity

- Attaching the fibrous insulation to the spray foam is often very difficult.
- Over time the fibrous insulation will settle or pull away from the foam.

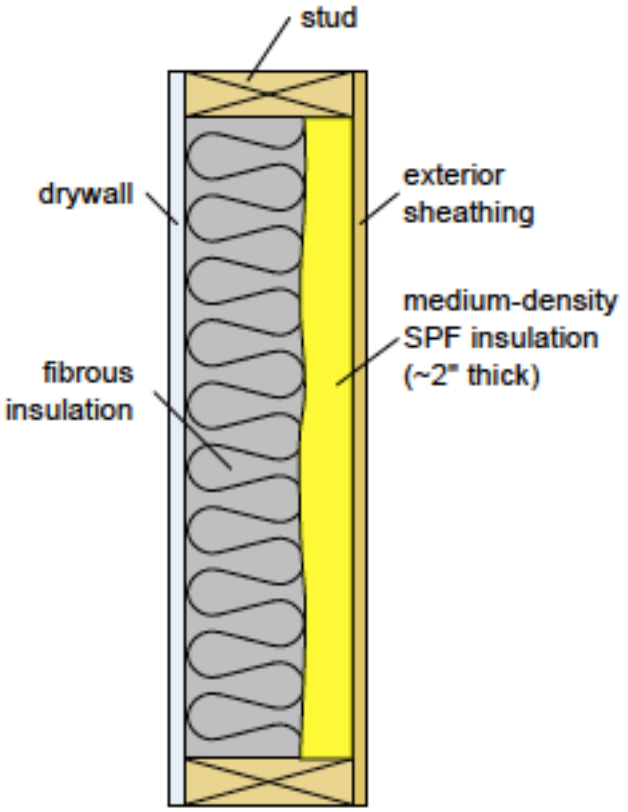



(b) without roof deck ventilation

SPRAYFOAM 2016
CONVENTION AND EXPO
FEBRUARY 8-11
SPRAY POLYURETHANE FOAM ALLIANCE
SPFA
FOAM•IT•RIGHT
PCP
PROFESSIONAL CERTIFICATION PROGRAM
ORLANDO, FLORIDA

# Vapor Retarders

- The building code requires interior vapor retarders in cold climates.
- The ccSPF is a strong vapor retarder but it's on the cold side of the assembly.
- Using a second vapor retarder on the interior side of the assembly can contribute to problems.




(a) Design Approach A
(No interior-side vapor retarder)

# Lumpy foam and less than meticulous fiberglass installation leads to failure

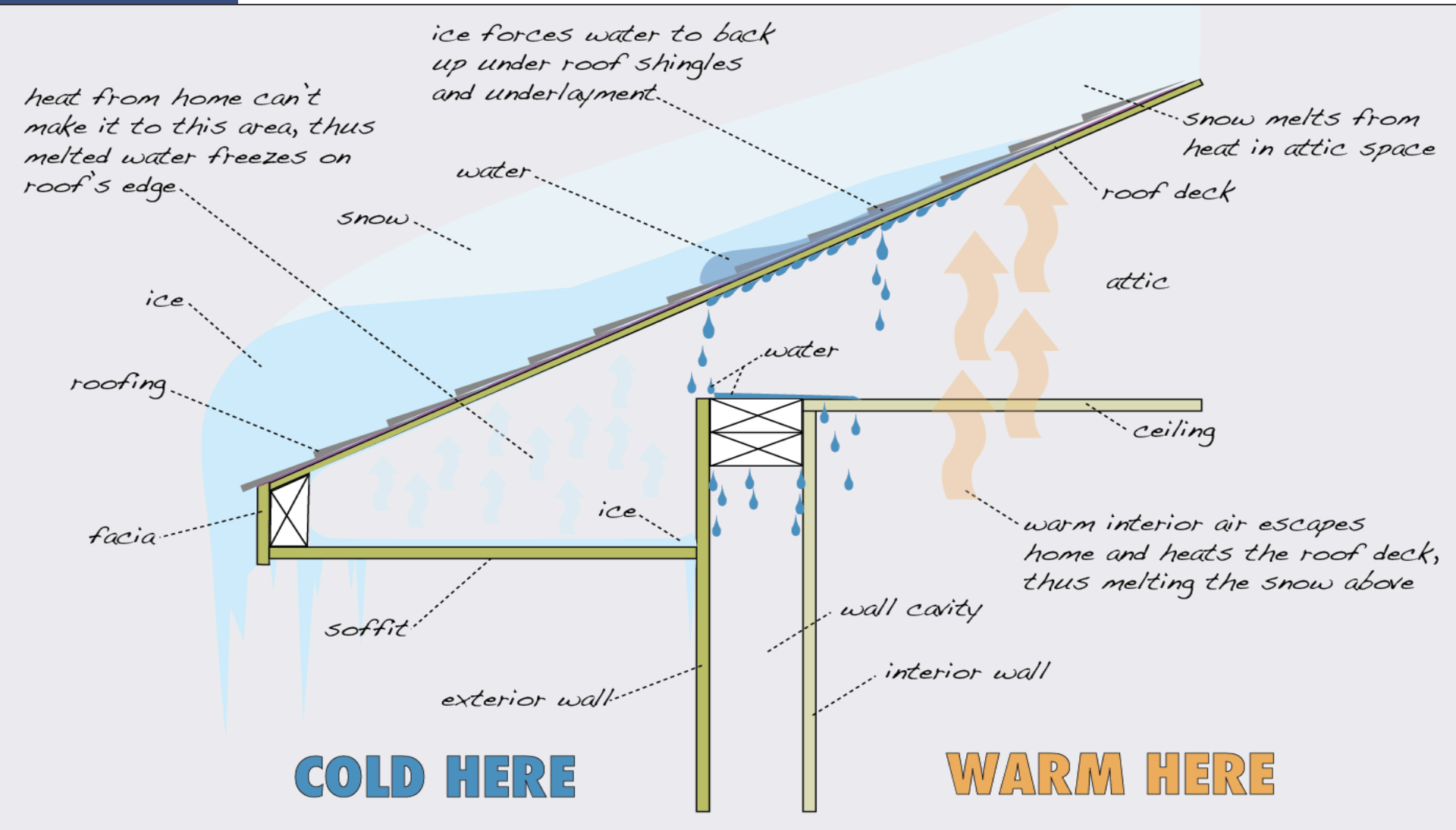
SPRAYFOAM 2016
CONVENTION AND EXPO
FEBRUARY 8-11
SPFA
FOAM•IT•RIGHT
PCP
ORLANDO, FLORIDA

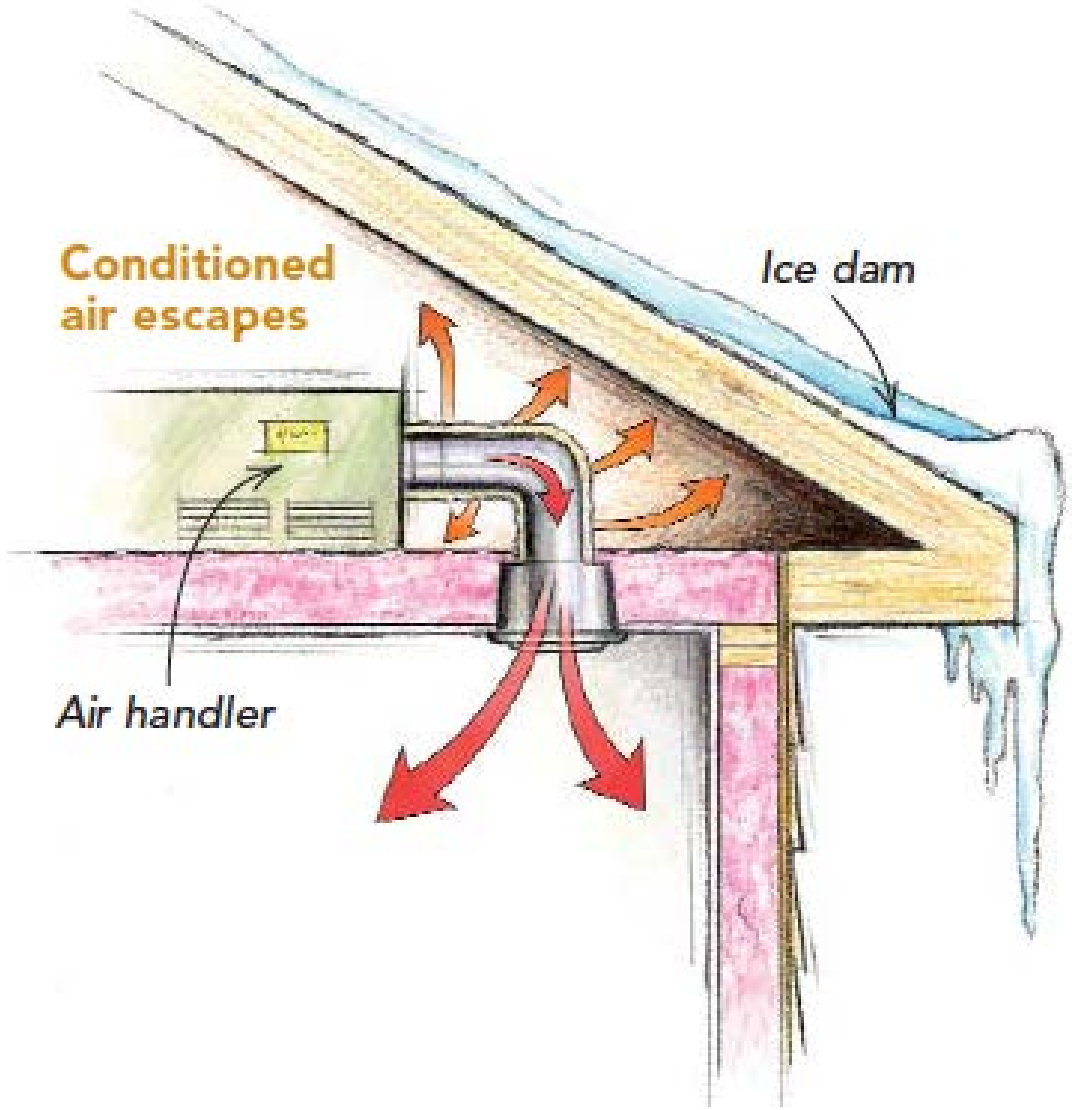
# Anything unusual in the wall cavity can cause problems.

# Mother Nature's Hybrid

SPRAYFOAM 2016
CONVENTION AND EXPO
FEBRUARY 8-11
SPFA
FOAM•IT•RIGHT
PCP
ORLANDO, FLORIDA

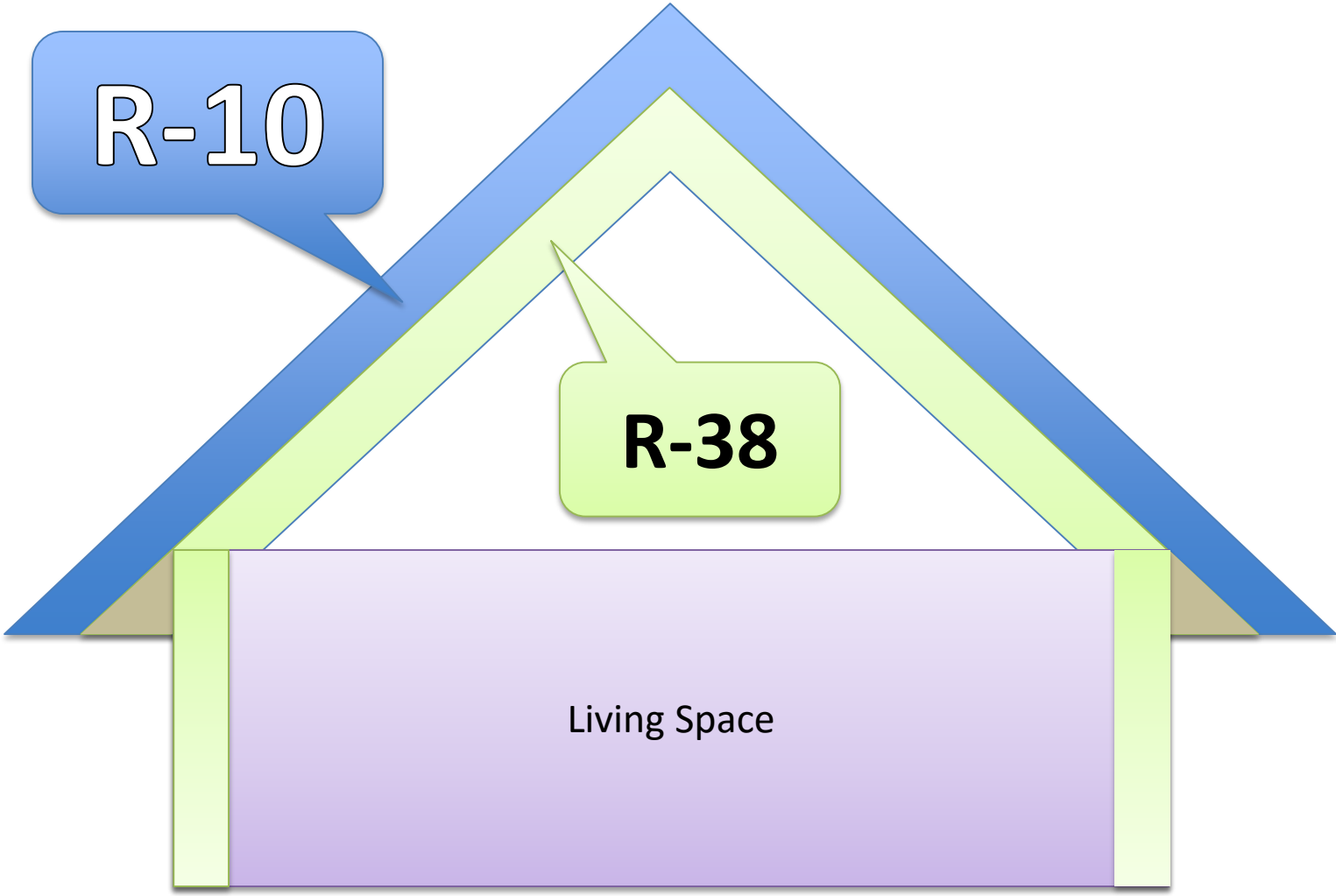
# Anatomy of an Ice Dam




Conditioned
air escapes
Ice dam
Air handler

SPRAYFOAM 2016
CONVENTION AND EXPO
FEBRUARY 8-11
SPFA
FOAM•IT•RIGHT
PCP
ORLANDO, FLORIDA

# Snow = ~**R-1** per inch



# Shingle Temperature Must Remain Below Freezing

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | | Foam Rs | | | |
| 0 ˚F | 10.0 " | 38 | 12 " | 16 ˚F | Safe |

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | Shingle Temp | |
| | | | | |


# RECOMMENDATIONS FOR HYBRID INSULATION SYSTEMS

# Proper design

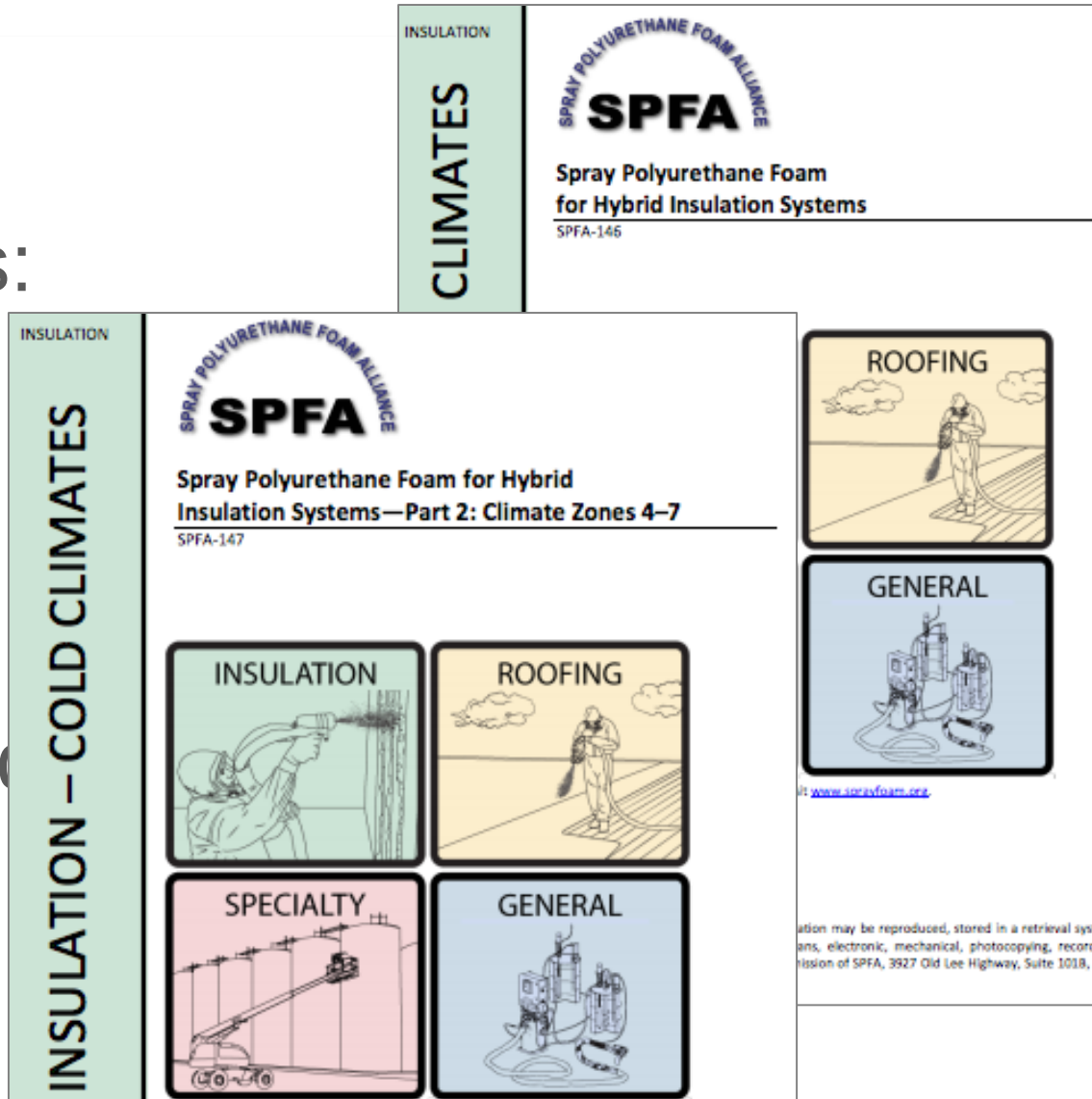
- Hybrids in DOE climate zones I – III are generally not a problem.
- Hybrid assemblies in DOE climate zones IV – VIII **must be carefully engineered**
- Attic hybrids where the insulation is applied to the floor of the attic are fine no matter the ratio.
- Better to use a full-filled wall cavity of ocSPF in most applications.  Pay attention to vapor.

# Proper Execution

- Foam must be as smooth as possible if batts are used.  Blown-in is better than batts.
- Pay attention to thickness.
- Consider using ocSPF instead of a hybrid. It’s one trade and product, not two.

# Follow the SPFA Best Practice Guides for Hybrids

- SPFA Technical Papers on Hybrids:
  - SPFA146 Climate Zones I – III
  - SPFA 147 Climate Zones IV – VII
- Industry Vetted and approved.



# Air Sealing Package

- Don’t forget to air-seal.  The foam will only control air infiltration in the areas it’s applied.




# Build It Tight And Ventilate Right!


# Hybrid Systems That Work

**Mac Sheldon**

**Mac@SheldonConsulting.com**