



# SPFA-118

## Moisture Management

Spray Polyurethane Foam Alliance

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## ABOUT SPRAY POLYURETHANE FOAM ALLIANCE (SPFA)

Founded in 1987, the Spray Polyurethane Foam Alliance (SPFA) is the voice, and educational and technical resource, for the spray polyurethane foam industry. A 501(c)6 trade association, the alliance is composed of contractors, manufacturers, and distributors of polyurethane foam, related equipment, and protective coatings; and who provide inspections, surface preparations, and other services. The organization supports the best practices and the growth of the industry through a number of core initiatives, which include educational programs and events, the SPFA Professional Installer Certification Program, technical literature and guidelines, legislative advocacy, research, and networking opportunities. For more information, please use the contact information and links provided in this document.

## DISCLAIMER

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## DOCUMENT HISTORY

| Date         | Sections Modified      | Description of Changes             |
|--------------|------------------------|------------------------------------|
| January 1999 |                        |                                    |
| August 2015  | All                    | Administrative changes             |
| January 2016 | Table 2                | Units in table headings corrected. |
| January 2021 | Front Cover and Header | New SPFA Logo                      |

## TECHNICAL OVERSIGHT COMMITTEE

### Mission Statement

The mission of the Technical Committee is to provide a wide range of technical service to the SPF (spray polyurethane foam) industry such as, but not limited to:

- (1) Review existing documents and serve as a clearing house to ensure the “Continuity of Value” of technical information published by SPFA and others concerning the products and services to the SPF industry;
- (2) Review, research, develop, and issue documents concerning new products, systems and services; and
- (3) To identify, explore, develop, and communicate an understanding of technical issues facing to the SPF industry.

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|----------------------------|--|
| West Roofing Systems, Inc. |  |
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## MOISTURE VAPOR TRANSMISSION

Water may be present in our environment in any of its three physical states: ice (solid), liquid, and vapor (gas). This paper discusses the effects of the interactions between water vapor, liquid water, building materials, and building components.

### WATER VAPOR TRANSMISSION

Water vapor will tend to migrate from regions of relatively high absolute humidity to regions of low absolute humidity. This type of vapor migration is normally of no particular concern to the building occupant or the designer unless the water vapor condenses into liquid water. Should water vapor condense within a building component (i.e., a wall or roof), water drippage into the interior or destruction of the building components may occur.

Building assemblies should, therefore, be designed to prevent the condensation of water vapor within those assemblies.<sup>1</sup>

Water vapor transfers through building walls or roof systems by two mechanisms: air leakage and diffusion. Air leakage is generally the major culprit in the transfer of water vapor. However, because spray-applied polyurethane foam (SPF) is seamless and closed cell, air leakage is less of a concern than diffusion.

A sheet of plastic or rubber may completely stop the flow of liquid water, but may permit the diffusion of water vapor because water in the gaseous state may penetrate what appears to be a solid membrane.

Water vapor transmission (assuming air leakage has been eliminated) is affected by the following factors:

- the chemical composition of the building materials
- the thickness of the building materials
- the absolute humidity on each side of the building component (absolute humidity differential)

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<sup>1</sup> Some design strategies, such as the self-drying roof concept, allow for limited amounts of moisture to condense within the building component with the expectation that the moisture will vaporize when conditions permit and that the net accumulation will never reach detrimental levels. This takes the traditional approach of avoiding condensation at design conditions. The underlying principles of water vapor flow, condensation, and evaporation are the same for either design method.

The following factors affect water vapor transmission:

### **CHEMICAL COMPOSITION**

The chemical composition of a building material has a profound effect on its ability to restrict water vapor diffusion. SPF, silicone, and acrylic coatings all have measurable water vapor diffusion rates. Metals and glass, on the other hand, restrict diffusion so much they can be considered true vapor barriers.

### **THICKNESS**

The greater the thickness of the materials, the lower the rate of water vapor diffusion. A material that might normally be considered a breathable material may successfully be used as a vapor retarder by increasing its thickness. (Conversely, a material normally considered a vapor retarder might be a breather if installed very thinly.)

### **ABSOLUTE HUMIDITY DIFFERENTIAL**

Water vapor always diffuses from the regions of high absolute humidity to the regions of low absolute humidity. The greater the difference in absolute humidity across a building component, the faster the diffusion rate.

Absolute humidity is a measure of the actual amount of water vapor contained in a unit volume of air. (Absolute humidity is distinct from “relative humidity,” which is the ratio of the absolute humidity of air to the water vapor holding capacity of air.)

Under the normal conditions seen in most building situations, warm air tends to have higher absolute humidity than cool air. This gives rise to the adage that “water vapor goes from hot to cold.” While this is true with many building situations, it is not necessarily so for buildings assembled with wet or moisture-laden components.

### **THE MEASURE OF WATER VAPOR TRANSMISSION**

The most common method of evaluating the water vapor diffusion rate of a material is by the ASTM E-96 method, “Standard Test Method for Water Vapor Transmission of Materials.” ASTM E-96 determines the water vapor permeance of a given material at a specified thickness. The permeance is often referred to as the perm rating; the higher the perm rating, the faster the diffusion rate.

There are a variety of test conditions to measure water vapor transmission. Therefore, the water vapor transmission rates for different materials reported in the literature may have been tested under differing conditions. Reported perm ratings should, therefore, be considered as approximations.

## **CLASSIFICATION OF MATERIALS BY MOISTURE VAPOR TRANSMISSION RATE**

Building materials may be classified as either vapor retarders (lower perm ratings) or vapor transmitters (higher perm ratings). The terms are relative because what may be a retarder in one case may be a transmitter in another. (Remember: Thickness is as important as chemical composition.)

A material can only be considered a vapor retarder when it is compared to the other materials with which it is used.

Consideration must be given to seam treatment for certain materials. While steel sheeting may be considered a vapor retarder (virtually total), a steel roof deck usually has so many seams and holes that it may be considered a vapor transmitter.

Usually, materials selected as vapor retarders have very low perm ratings (such as 6 mil polyethylene at 0.06 perms).

## **USING VAPOR RETARDERS/TRANSMITTERS TO PREVENT CONDENSATION**

As previously mentioned, water vapor transmission, per se, is not particularly a problem. However, water vapor condensation is a problem.

As discussed, water vapor concentration (absolute humidity) can build up within building components through the action of water vapor diffusion. This water vapor can then condense into liquid water if its temperature drops below the saturation temperature (dew point).

Water vapor condensation can be avoided by:

- preventing building component temperatures from dropping below the saturation temperature (dew point)
- reducing the water vapor entering the building component
- increasing the water vapor leaving the building component

Condensation problems are most seen at exterior building walls and roofs. The temperatures of these components vary with the exterior temperature, over which the designer/contractor has no control.

The designer/contractor *can* influence the temperature of building components with SPF's insulating quality. The water vapor entering a building component can be reduced by the use of vapor retarders. Furthermore, the use of breathable materials on the low humidity side can permit water vapor flow through the building component.

Using these three tools (insulation, vapor retarders, and flow through) in an appropriate arrangement can stop condensation.

The rule is to install the building materials such that relative vapor retardance increases toward the side with the higher absolute humidity (usually the warm side). Conversely, building materials

should be installed such that relative vapor transmitters are toward the side with the lower absolute humidity (usually the cold side).

If this practice cannot be followed, install a vapor retarder such that:

- The vapor retarder is positioned as close to the side with the highest absolute humidity as possible.
- The vapor retarder has an installed perm rating substantially less than that of the next lowest component.

For example, examine the following cases:

### **CASE 1**

SPF is installed over a built-up roof suspected of containing small amounts of water. (Normal occupancy building.)

The region of high absolute humidity will be the existing built-up roof. Water vapor diffusion will be in two directions: upward through breaks in the built-up membrane and the SPF toward the exterior and downward through the deck toward the interior.

Assuming a normal occupancy building, the interior temperatures will never drop below the saturation temperature; diffusion in the direction of the interior will never present a problem.

If night or winter temperatures are cool enough, the water vapor normally diffusing harmlessly through the foam may condense. It is important to provide a vapor transmitting covering system with a high perm rating to the exterior surface of the SPF to prevent the buildup of humidity within the foam; thus, avoiding condensation.

### **CASE 2**

SPF applied to a metal deck (seams sealed). (Normal occupancy building.)

The metal deck, because its seams are sealed, acts as an excellent vapor retarder. While temperatures might favor condensation (e.g., during winter), the metal deck would prevent the internal humidity from diffusing into the SPF. The perm rating of the covering system is not critical; its selection can be based on other factors.

### **CASE 3**

SPF applied to the top surface of a concrete deck over a swimming pool. (See Example Calculation.)

The interior of a building that houses an indoor swimming pool will have extremely high humidity. As the concrete deck itself has a fairly high perm rating, a vapor retarder should be applied to the underside of the deck.

The thickness of the SPF must provide sufficient insulation to avoid condensation on the underside of the deck.

Additionally, the covering system for the SPF should be a vapor transmitter to allow any water vapor that may have diffused through or by-passed the vapor retarder to diffuse out of the roofing system.

#### **CASE 4**

SPF foam applied to a freezer.

Freezers present a reversal in the direction of water vapor diffusion expected in normal occupancy buildings. There will be a long-term tendency for exterior water vapor to diffuse toward the freezer interior.

The high humidity side in this case is the exterior and that is where the vapor retarder belongs. Thus, a vapor retarding covering system (i.e., a low perm rating coating system) should be located on the exterior side of the foam.

#### **SUMMARY**

SPF roofing and wall insulation can be designed and installed to avoid the buildup of humidity and the subsequent problem of condensation.

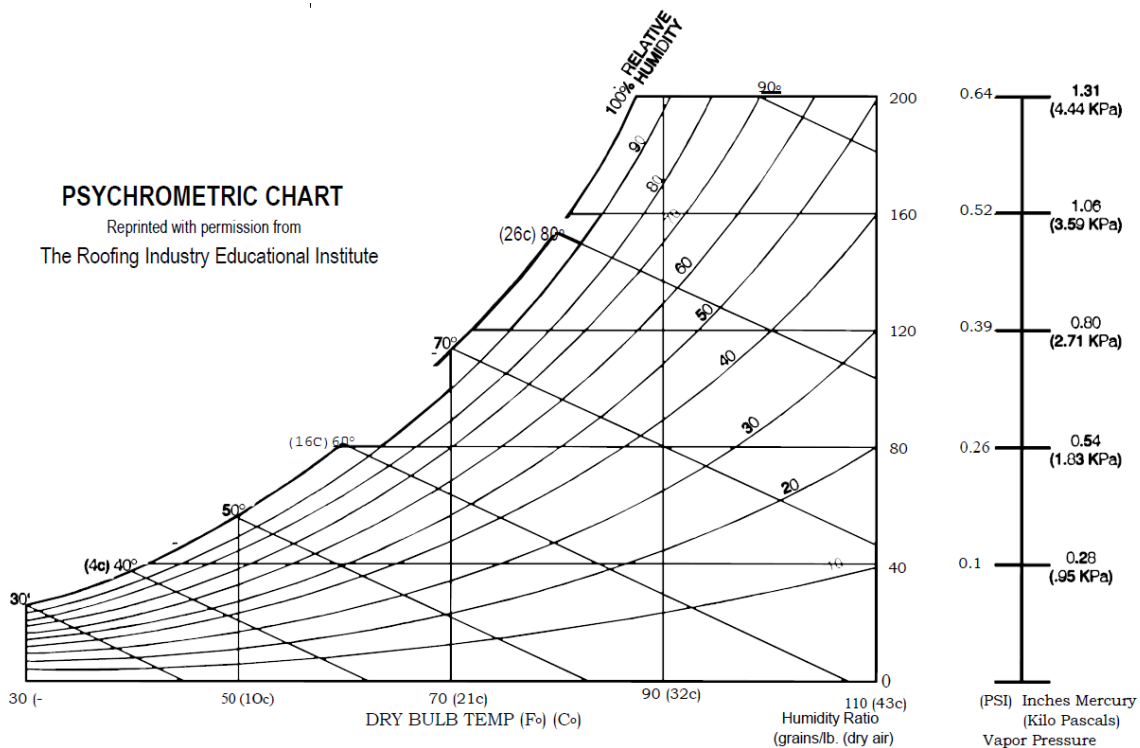
Existing building materials and interior/exterior conditions must be considered in order to:

- (1) determine the R-Value and, therefore, the thickness of SPF needed
- (2) select the SPF covering system
- (3) determine the need for a vapor retarder

An improperly placed vapor retarder could increase the likelihood and severity of condensation.

By thoroughly understanding the effects of water vapor diffusion and condensation and the correct use of insulation, water vapor retarding, and water vapor transmitting materials, designers and contractors can ensure that these problems will not occur.

## PSYCHROMETRIC CHART



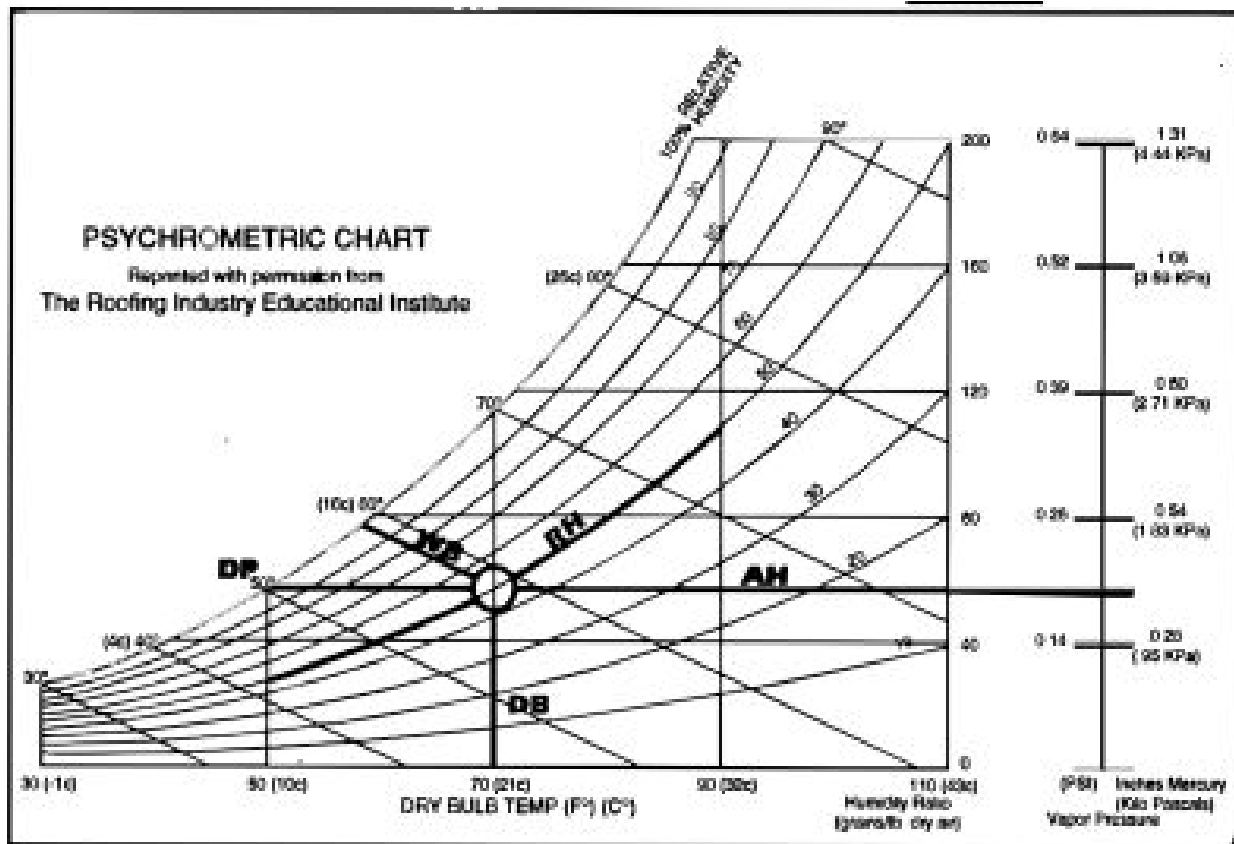
The psychrometric chart is used to determine and correlate the following properties of humid air:

- Dry bulb temperature
- Wet Bulb temperature
- Dew point
- Relative humidity
- Absolute humidity

**When two of these properties are known, the other three can be determined from the psychrometric chart.**

Normally, the measurements taken in the field to measure temperature and humidity are the dry bulb and wet bulb temperatures. The dry bulb temperature is the air temperature as measured by a normal thermometer. The wet bulb temperature is the air temperature as measured using a normal thermometer that has had a water wetted wick installed on the bulb end of the thermometer.

As an example, let's assume that the dry and wet bulb temperatures in a room read:  
 Dry Bulb (DB) 70.0°F Wet Bulb (WB) 58.5°F



From the psychrometric chart, the following information can be determined:

- Relative Humidity (RH) 50%
- Absolute Humidity (AH) 54 grains/lb dry air 0.37 in. Hg
- Dew Point (DP) 50°F

## EXAMPLE CALCULATION

### PROBLEM:

Water has been dripping from the exposed concrete ceiling over a swimming pool. The roof deck is 6 in. of structural concrete. The roofing system consists of a built-up roof over 1 in. fiberboard, which appears to be saturated. The roof is slightly pitched and no ponding occurs. It is proposed to tear off the built-up roof, spray apply 1 in. of SPF, and coat the foam with an acrylic coating. Will the proposed roof system stop the drippage and prevent future condensation problems? Design conditions: Interior: 75°F, 85% relative humidity.

**STEP 1: DETERMINE WATER VAPOR PRESSURE (ABSOLUTE HUMIDITY) AT THE INTERIOR AND EXTERIOR ROOF SURFACES.**

Inside is 75°F, with 85% relative humidity. From Table 2 (see page 17), the  $P_{sat}$  (saturation vapor pressure) for 75°F = 0.875 in. Hg (inches in mercury pressure).

At 85% relative humidity,  $P_i$  (inside vapor pressure) =  $0.875 \times 0.85 = 0.74$  in. Hg. (Absolute humidity may also be determined from the Psychrometric Chart.)

The exterior is 20°F with 90% relative humidity. From Table 2, the  $P_{sat}$  for 20°F = 0.103 in. Hg. At 90% relative humidity,  $P_e$  (exterior vapor pressure) =  $0.103 \times 0.90 = 0.093$  in. Hg.

**STEP 2: DETERMINE THERMAL AND VAPOR RESISTANCES.**

Find the thermal resistances and the perm ratings from Table 1, “Thermal Resistances and Perm Ratings for Construction Materials.” (See page 10) The vapor resistance can be determined by calculating the reciprocal of the perm rating.

| Component            | Thermal Resistance (R) | Perm Rating (M) | Vapor Resistance (1/M) |
|----------------------|------------------------|-----------------|------------------------|
| Exterior Air Film    | 0.17                   | --              | 0.00                   |
| Acrylic Coating      | 0.00                   | 2.5             | 0.40                   |
| Polyurethane Foam 1" | 6.00                   | 2.5             | 0.40                   |
| Concrete Deck        | 0.50                   | 0.5             | 2.00                   |
| Inside Air Film      | 0.61                   | --              | 0.00                   |
|                      | 7.28                   |                 | 2.80                   |

**STEP 3: CALCULATE TEMPERATURES AT ROOF COMPONENT SURFACES.**

Use the following formula to calculate temperatures within the proposed roof structure:

$$T_x = T_i - \frac{\sum R_x}{\sum R} (T_i - T_e)$$

Where:

$T_x$  = Temperature at surface x

$T_i$  = Inside temperature

$T_e$  = Exterior Temperature

$\sum R_x$  = Sum of R-Values between the inside and surface x

$\sum R$  = Total R-Value

Let:

0 = Inside condition

1 = Inside Air Film-Deck Surface

2 = Deck-SPF Interface

3 = SPF-Coating Interface

4 = Coating-Exterior Air Film Surface

5 = Exterior condition

$T_0$  = 75°F (Inside condition)

$T_1 = 75 - (0.61/7.28)(75 - 20) = 70^\circ\text{F}$

$T_2 = 75 - ((0.61 + 0.5)/7.28)(75 - 20) = 67^\circ\text{F}$

$T_3 = 75 - ((0.61 + 0.5 + 6)/7.28)(75 - 20) = 21^\circ\text{F}$

$T_4 = 75 - ((0.61 + 0.5 + 6 + 0)/7.28)(75 - 20) = 21^\circ\text{F}$

$T_5$  = 20°F (Exterior condition)

**STEP 4: CALCULATE VAPOR PRESSURES (ABSOLUTE HUMIDITIES) AT THE ROOF COMPONENT SURFACES.**

Use the following formula to calculate vapor pressures within the proposed roof structure:

$$P_x = P_i - \left( \sum \frac{1}{M_x} P_i - P_e \right)$$

Where:

$P_x$  = Vapor pressure at surface x

$P_i$  = Inside vapor pressure

$P_e$  = Exterior vapor pressure

$\sum(1/M_x)$  = Sum of vapor resistance values between the inside and surface x

$\sum(1/M)$  = Total vapor resistance value

$P_0$  = 0.74 in. Hg (Inside condition)

$P_1$  = 0.74 - (0/2.8)(0.74 - 0.093) = 0.74 in. Hg

$P_2$  = 0.74 - ((0 + 2.0)/2.8)(0.74 - 0.093) = 0.28 in. Hg

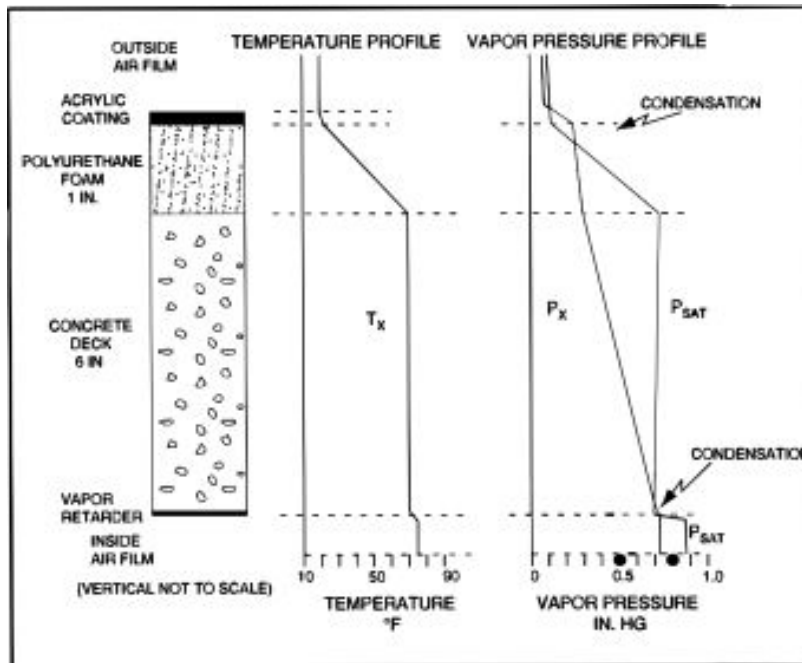
$P_3$  = 0.74 - ((0 + 2.0 + 0.40)/2.8)(0.74 - 0.093) = 0.19 in. Hg

$P_4$  = 0.74 - ((0 + 2.0 + 0.40 + 0.40)/2.8)(0.74 - 0.093) = 0.093 in. Hg

$P_5$  = 0.093 in. Hg (Exterior condition)

**STEP 5: TRANSPOSE THE TEMPERATURE AND VAPOR PRESSURE (ABSOLUTE HUMIDITY) VALUES ONTO THE TABLE FROM STEP 2; COMPARE WITH THE SATURATION VAPOR PRESSURE.**

| Component            | Thermal Resistance (R) | Perm Rating (M) | Vapor Resistance (1/M) | Temperature (T <sub>x</sub> ) | Calculated Vapor Pressure (P <sub>x</sub> ) | Saturation Vapor Pressure (P <sub>sat</sub> ) |
|----------------------|------------------------|-----------------|------------------------|-------------------------------|---------------------------------------------|-----------------------------------------------|
|                      |                        |                 |                        | 20                            | 0.093                                       | 0.103                                         |
| Exterior Air Film    | 0.17                   | --              | 0.00                   | 21                            | 0.093                                       | 0.108                                         |
| Acrylic Coating      | 0.00                   | 2.5             | 0.40                   | 21                            | 0.19                                        | 0.108                                         |
| Polyurethane Foam 1" | 6.00                   | 2.5             | 0.40                   | 67                            | 0.28                                        | 0.667                                         |
| Concrete Deck        | 0.50                   | 0.5             | 2.00                   | 70                            | 0.74                                        | 0.739                                         |
| Inside Air Film      | 0.61                   | 1               | 0.00                   | 75                            | 0.74                                        | 0.875                                         |
|                      | 7.28                   |                 | 2.80                   |                               |                                             |                                               |



The table in Step 5 summarizes all the information and calculations from Steps 1-4. In addition, the last column,  $P_{sat}$ , gives the saturated vapor pressure for the temperature at the corresponding surface. The saturated vapor pressure is read off Table 2 for the appropriate surface temperature ( $T_x$ ).

Of significance in this data is that the calculated vapor pressure ( $P_x$ ) exceeds the saturation vapor pressure ( $P_{sat}$ ) at two locations:

- (1) Underside of the deck
- (2) SPF interface coating

Where the calculated vapor pressure exceeds the saturated vapor pressure, condensation is likely to occur.

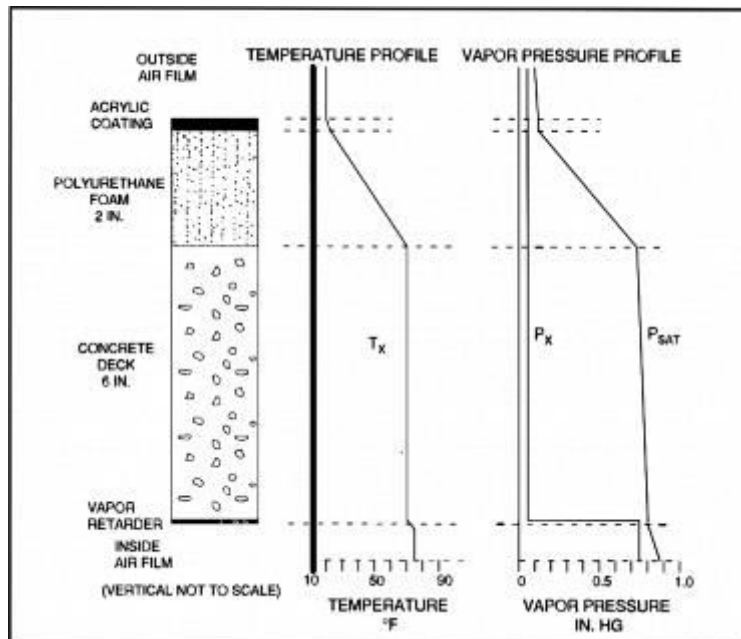
In this case, condensation is likely to occur at the deck underside and at the SPF-coating interface. These two condensation points reflect two different condensation problems and must be treated separately.

- (1) Underside of deck. Condensation on this surface is the result of too low a temperature (below the dew point). This cannot be corrected by the use of a vapor retarder, but may be corrected by increasing the surface temperature through the use of additional insulation. Increasing the SPF thickness from 1 in. to 2 in. will solve this problem.
- (2) SPF-coating interface. Condensation at this plane is because of water vapor diffusing up through the deck and SPF, and reaching a temperature below the dew point. Corrective action would be to install a vapor retarder on the bottom of the deck.

**STEP 6: MODIFY DESIGN AND RECHECK.**

Repeat Steps 1–5 for the system consisting of 2 in. SPF, acrylic coating, and a 30 mil butyl vapor retarder applied to the underside of the deck.

| Component         | Thermal Resistance (R) | Perm Rating (M) | Vapor Resistance (1/M) | Temperature ( $T_x$ ) | Calculated Vapor Pressure ( $P_x$ ) | Saturation Vapor Pressure ( $P_{sat}$ ) |
|-------------------|------------------------|-----------------|------------------------|-----------------------|-------------------------------------|-----------------------------------------|
|                   |                        |                 |                        | 20                    | 0.093                               | 0.103                                   |
| Exterior Air Film | 0.17                   | ---             | 0                      | 21                    | 0.093                               | 0.108                                   |
| Acrylic Coating   | 0                      | 2.5             | 0.40                   | 21                    | 0.096                               | 0.108                                   |
| SPF 2 in.         | 12.0                   | 1.25            | 0.8                    | 70                    | 0.10                                | 0.739                                   |
| Concrete Deck     | 0.5                    | 0.5             | 2.0                    | 72                    | 0.12                                | 0.791                                   |
| Vapor Retarder    | 0                      | 0.015           | 67                     | 72                    | 0.74                                | 0.791                                   |
| Inside Air Film   | 0.61                   | ---             | 0                      | 75                    | 0.74                                | 0.875                                   |
|                   | 13.28                  |                 | 70.2                   |                       |                                     |                                         |



With the revised design (2 in. SPF and a vapor retarder), none of the calculated vapor pressures ( $P_x$ ) exceed the saturated vapor pressures ( $P_{sat}$ ). This design should be safe from the problems associated with condensation.

| TABLE 1                                                                |         |             |
|------------------------------------------------------------------------|---------|-------------|
| THERMAL AND MOISTURE TRANSMISSION PROPERTIES OF CONSTRUCTION MATERIALS |         |             |
| Material                                                               | R-Value | Perm Rating |
| Built-up Roof Membrane Decks                                           | 0.33    | 0.0         |
| Steel Deck (forgetting seams)                                          | Negl.   | 0.0         |
| Steel Deck (considering seams)                                         | Negl.   | >1.0        |
| Uncracked Concrete Structural Deck (6 in.)                             | 0.5     | approx. 0.5 |
| <b>Films, Felts, and Foils</b>                                         |         |             |
| Aluminum Foil                                                          | Negl.   | 0.0         |
| Polyethylene 4-mil                                                     | Negl.   | 0.08        |
| Polyethylene 6-mil                                                     | Negl.   | 0.06        |
| Polyvinylchloride (PVC) 4-mil                                          | Negl.   | 0.5         |
| Kraft Paper Laminate                                                   | Negl.   | 0.25        |
| Asphalt Saturated Felt No. 15                                          | 0.06    | 1.0         |
| Asphalt Saturated and Coated Felt No. 43                               | 0.06    | 0.3         |
| <b>Construction Boards</b>                                             |         |             |
| Plywood: ¼ in. Exterior                                                | 0.32    | 0.7         |
| Plywood: ½ in. Exterior                                                | 0.64    | 0.35        |
| Gypsum Wall Board 3/8 in.                                              | 0.32    | 50.0        |
| <b>Insulations</b>                                                     |         |             |
| Cellular Glass 1 in.                                                   | 2.9     | 0.0         |
| Polyurethane 1 in.                                                     | 5.6-6.3 | 2-3         |
| Extruded Polystyrene 1 in.                                             | 5.0     | 1.2         |
| Expanded Polystyrene 1 in.                                             | 3.9-4.4 | 2-5.8       |
| Mineral Fiber 1 in. (unprotected)                                      | 3.2     | 116.0       |
| Cork Board 1 in.                                                       | 3.9     | 2.1-2.6     |
| <b>Coatings</b>                                                        |         |             |
| Acrylic 30 mils                                                        | Negl.   | 2-3         |
| Asphalt Mastic 60 mils                                                 | Negl.   | 0.003-0.004 |
| Butyl 30 mils                                                          | Negl.   | 0.015       |
| Chlorinated Synth. Rubber 15-30 mils                                   | Negl.   | 0.2-0.4     |
| Silicone 20 mils                                                       | Negl.   | 2.9         |
| Urethane 20-35 mils                                                    | Negl.   | 0.3-2.5     |
| <b>Air Surface (Horizontal)</b>                                        |         |             |
| Still Air: Heat Flow upward                                            | 0.61    |             |
| Still Air: Heat Flow downward                                          | 0.92    |             |
| Moving Air: 15 mph wind (winter)                                       | 0.15    |             |
| Moving Air: 7.5 mph wind (summer)                                      | 0.25    |             |

**Note:** These figures represent approximations from a variety of published sources. When determining moisture vapor drives for a particular system, use thermal resistance and perm ratings provided by the manufacturer for each specific product

| TABLE 2                            |                            |            |                            |            |                            |
|------------------------------------|----------------------------|------------|----------------------------|------------|----------------------------|
| WATER VAPOR PRESSURE AT SATURATION |                            |            |                            |            |                            |
| Temp<br>°F                         | P <sub>sat</sub><br>in. Hg | Temp<br>°F | P <sub>sat</sub><br>in. Hg | Temp<br>°F | P <sub>sat</sub><br>in. Hg |
| -20                                | .013                       | 30         | .165                       | 80         | 1.03                       |
| -18                                | .014                       | 32         | .180                       | 82         | 1.10                       |
| -16                                | .016                       | 34         | .197                       | 84         | 1.18                       |
| -14                                | .018                       | 36         | .212                       | 86         | 1.25                       |
| -12                                | .020                       | 38         | .229                       | 88         | 1.34                       |
| -10                                | .022                       | 40         | .248                       | 90         | 1.42                       |
| -8                                 | .025                       | 42         | .268                       | 92         | 1.51                       |
| -6                                 | .027                       | 44         | .298                       | 94         | 1.61                       |
| -4                                 | .030                       | 46         | .312                       | 96         | 1.71                       |
| -2                                 | .034                       | 48         | .336                       | 98         | 1.82                       |
| 0                                  | .038                       | 50         | .362                       | 100        | 1.93                       |
| 2                                  | .042                       | 52         | .390                       | 102        | 2.05                       |
| 4                                  | .046                       | 54         | .420                       | 104        | 2.18                       |
| 6                                  | .051                       | 56         | .452                       | 106        | 2.31                       |
| 8                                  | .057                       | 58         | .486                       | 108        | 2.45                       |
| 10                                 | .063                       | 60         | .522                       | 110        | 2.60                       |
| 12                                 | .069                       | 62         | .560                       | 112        | 2.75                       |
| 14                                 | .077                       | 64         | .601                       | 114        | 2.91                       |
| 16                                 | .085                       | 66         | .644                       | 116        | 3.08                       |
| 18                                 | .093                       | 68         | .690                       | 118        | 3.26                       |
| 20                                 | .103                       | 70         | .739                       | 120        | 3.45                       |
| 22                                 | .113                       | 72         | .791                       |            |                            |
| 24                                 | .124                       | 74         | .846                       |            |                            |
| 26                                 | .137                       | 76         | .905                       |            |                            |
| 28                                 | .150                       | 78         | .967                       |            |                            |

**LIST OF ABBREVIATIONS**

|                  |                                                                    |                                                    |
|------------------|--------------------------------------------------------------------|----------------------------------------------------|
| AH               | Absolute Humidity                                                  | in. Hg (or grains H <sub>2</sub> O/lb dry air)     |
| DB               | Dry bulb temperature                                               | °F                                                 |
| DP               | Dew point temperature                                              | °F                                                 |
| M                | Permeance (perm rating)                                            | grains H <sub>2</sub> O/ft <sup>2</sup> -hr-in. Hg |
| P <sub>i</sub>   | Interior vapor pressure                                            | in. Hg                                             |
| P <sub>e</sub>   | Exterior vapor pressure                                            | in. Hg                                             |
| P <sub>sat</sub> | Saturated water vapor pressure<br>at a given temperature condition | in. Hg                                             |
| P <sub>x</sub>   | Vapor pressure at surface “x”                                      | in. Hg                                             |
| R                | Thermal resistance (R value)                                       | ft <sup>2</sup> -°F-hr/Btu                         |
| RH               | Relative humidity                                                  | percent                                            |
| T <sub>i</sub>   | Interior temperature                                               | °F                                                 |
| T <sub>e</sub>   | Exterior temperature                                               | °F                                                 |
| T <sub>x</sub>   | Temperature at surface “x”                                         | °F                                                 |
| WB               | Wet bulb temperature                                               | °F                                                 |

## **ADDITIONAL INFORMATION**

- “1989 ASHRAE Handbook – Fundamentals,” American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA, 1989.
- “ASTM C 755: Standard Recommended Practice for Selection of Vapor Barriers for Thermal Insulations,” ASTM, Philadelphia.
- “ASTM E 96: Standard Test Method for Water Vapor Transmission of Materials,” ASTM, Philadelphia.
- Fricklas, R.L. and Wayne Tobiasson. “Moisture in Roofs, A Condensed Version” RIEI, Englewood, CO, 1987.
- Griffin, C.W. “Manual of Built-up Roof Systems,” 2nd ed., McGraw-Hill, New York 1982 Packard, Robert, Ed. Architectural Graphic Standards, 7th ed., John Wiley & Sons, New York, 1981.
- Powell, Frank J. and Henry E. Robinson. “The Effect of Moisture on the Heat Transfer Performance of Insulated Flat Roof Constructions,” Building Science Series 37, National Bureau of Standards, 1971.
- “The NRCA Roofing and Waterproofing Manual,” 3rd ed., NRCA, Rosemont, IL, 1989.
- Schwartz, N.V., M Bomberg, M.K. Kumaran. “Water Vapor Transmission and Moisture Accumulation in Polyurethane and Polyisocyanurate Foams,” Water Vapor Transmission Through Building Materials and Systems: Mechanisms and Measurement, ASTM, Philadelphia, 1989.
- Tobiasson, Wayne. “Vapor Retarders for Membrane Roofing Systems,” Proceedings of the 9<sup>th</sup> Conference of Roofing Technology, NRCA, Rosemont, IL, 1989.

## OTHER PROGRAMS AND SERVICES OFFERED BY SPFA

### PROFESSIONAL TRAINING

The SPFA Professional Program offers individual certification and company accreditation in five areas: Contractor, Distributor, Elastomeric Coating Supplier, Foam Supplier, and Independent Inspector. The objectives of the program are to **PROVIDE** an established set of criteria, to **IDENTIFY** and **RECOGNIZE** individuals and companies, and to **ENCOURAGE** individual and company responsibility for the quality of work through self-education.

### TECHNICAL DOCUMENTS

|          |                                                                                                                                            |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------|
| SPFA-102 | A Guide for Selection of Protective Coatings over Spray Polyurethane Foam Roofing Systems                                                  |
| SPFA-103 | Spray Polyurethane Foam Insulation Systems for Metal Service Vessels Operating Between -30°F and 200°F                                     |
| SPFA-104 | Spray Polyurethane Foam Systems for New and Remedial Roofing                                                                               |
| SPFA-107 | Spray Polyurethane Foam Blisters – Their Causes, Types, Prevention and Repair                                                              |
| SPFA-110 | Spray Polyurethane Foam Aggregate Systems for New and Remedial Roofing                                                                     |
| SPFA-111 | Spray Polyurethane Foam Systems for Cold Storage Facilities Operating Between -40°F and 50°F                                               |
| SPFA-112 | Spray Polyurethane Foam for Building Envelope Insulation and Air Seal                                                                      |
| SPFA-113 | Contractor/Applicator Handbook                                                                                                             |
| SPFA-116 | Spray-Applied Polyurethane Foam and Elastomeric Coating Systems (10 min. VHS Video)                                                        |
| SPFA-117 | Spray-Applied Polyurethane Foam and Aggregate Roof Systems (10 min. VHS Video)                                                             |
| SPFA-118 | Moisture Vapor Transmission                                                                                                                |
| SPFA-119 | Glossary of Terms Common to the Spray Polyurethane Foam Industry                                                                           |
| SPFA-121 | Spray Polyurethane Foam Estimating Reference Guide                                                                                         |
| SPFA-122 | The Renewal of Spray Polyurethane Foam and Coating Roof Systems                                                                            |
| SPFA-124 | Wind Uplift Brochure                                                                                                                       |
| SPFA-125 | P-Rating Brochure                                                                                                                          |
| SPFA-126 | Thermal Barriers for the Spray Polyurethane Foam Industry                                                                                  |
| SPFA-127 | Maintenance Manual for Spray Polyurethane Foam Roof Systems                                                                                |
| SPFA-129 | SPF Roofing “Seamless Roofing and Insulation” (8-page Color Brochure)                                                                      |
| SPFA-130 | SPF Roofing “Sustainable Roofing” (4-page Color Brochure)                                                                                  |
| SPFA-131 | Whole Wall Rating/Label for Metal Stud Wall Systems with SPF; Steady State Thermal Analysis                                                |
| SPFA-132 | The SPF Roofing Systems (11.5 min. informative video offering a comprehensive pictorial review of this most extraordinary roofing concept) |
| SPFA-133 | Maintenance Manual for Spray Polyurethane Foam Roof Systems (Spanish Version)                                                              |
| SPFA-134 | Guideline for Insulating Metal Buildings with Spray Polyurethane Foam                                                                      |
| AX-171   | Course 101-R Chapter 1: Health, Safety and Environmental Aspects of Spray Polyurethane Foam and Coverings (Video and Text)                 |

- The **SPFA website** is a direct communication to all member suppliers and contractors with web access. Up-to-date information is offered, and, as a member, you may link into the website: [www.sprayfoam.org](http://www.sprayfoam.org).
- A **“Support Line” 800-number** is available for your use to answer technical questions (800-523-6154). The SPFA sponsors research and development and product testing that allows for approval of generic types of spray foams, coverings, and related products.