What is a Vapor Retarder?

A vapor retarder is defined as a material or membrane that has a permeance (perm) rating of 0.5 or less when tested in accordance with the American Society for Testing and Materials (ASTM) standard E96, *Standard Test Methods for Water Vapor Transmission of Materials*. Permeance is a measure of how quickly water diffuses through a material. Materials with a perm rating of 0.0 allow virtually no moisture diffusion.

Vapor retarders are used as part of a roof assembly to prevent moisture migration and condensation within that assembly. Moisture migration or condensation can be a concern within an occupied building and also during building construction. In all cases, the vapor retarders should be installed on the warm side of the insulation.

Types of Vapor Retarders

Vapor retarders can be classified as either bituminous or non-bituminous in make-up. Bituminous vapor retarders are typically 2 plies of a glass fiber roofing felt manufactured in accordance with ASTM D2178 Type IV. The roofing felts are applied to an approved substrate in either hot asphalt or a compatible adhesive.

Non-bituminous vapor retarders can consist of plastic sheets or films, kraft paper, kraft laminates and aluminum foil combinations. Follow the installation instructions of the vapor retarder supplier when using these products.

Unless no other alternative exists, a vapor retarder should not be installed directly to a metal deck. As vapor retarders are vulnerable to punctures or other damage from construction traffic when installed directly to a metal deck, this type of installation is usually ineffective.

Roof systems to include a vapor retarder and to be installed over a metal deck typically require a layer of low-thermal substrate (e.g. DensDeck, wood fiber) prior to the application of the vapor retarder. Contact the manufacturer to ensure the material can span the deck rib openings and to obtain general installation recommendations. Also refer to the Insulation Specifications section of the Insulfoam Roofing Manual for additional general installation considerations.

Wood, Tectum®, lightweight insulating concrete and gypsum decks should not have bituminous vapor retarders applied directly to them. A nailed, asphalt base sheet is commonly applied prior to the application of the vapor barrier. Bituminous vapor retarders can be applied directly to a primed structural concrete roof deck.

For projects that include vapor retarder installations, other trades should be notified that care should be exercised when working on or over a vapor retarder.

Determining the need for a Vapor Retarder

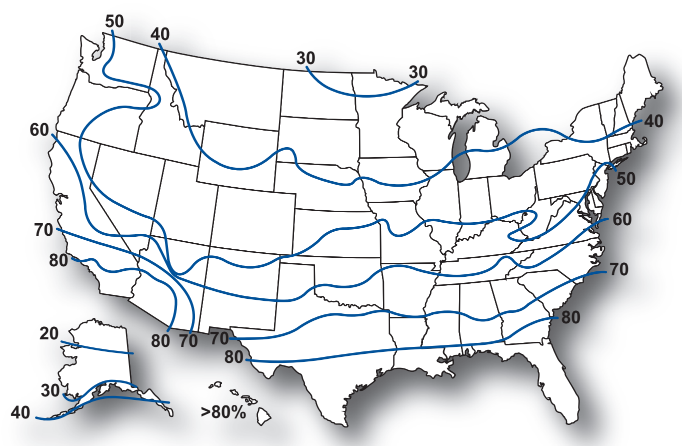
The need for a vapor retarder in the roofing system should be determined by a professional roof system designer.

There are several guidelines and methods used to determine the need for a vapor retarder.

The relative humidity and dew point temperature values are constantly changing in a normal building environment. The need for a vapor retarder, and the design values used, should be based on conservative assumptions and probable conditions.

1. A commonly used rule of thumb is to consider the inclusion of a vapor retarder when both of the following conditions are met:
   - The interior winter relative humidity is expected to be 45% or higher, and
   - The outside average January temperature is below 40 °F.

2. The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) developed an analytical method based on an indoor temperature of 68 °F. When interior relative humidity levels exceed the applicable amount on the following CRREL Map, additional consideration should be given to the use of a vapor retarder. For additional information on the CRREL method go to ***www.crrel.usace.army.mil/***.



3. Another more analytical method for determining the need for a vapor retarder is to calculate the temperatures of each surface within the roof system. If the calculations show the dew point occurring inside the roof insulation layer, a vapor retarder should be considered on the warm side of the insulation. If the calculations show condensation occurring below the level where a vapor retarder can be installed, additional insulation (R-Value) or other adjustments to the building's HVAC system are required.

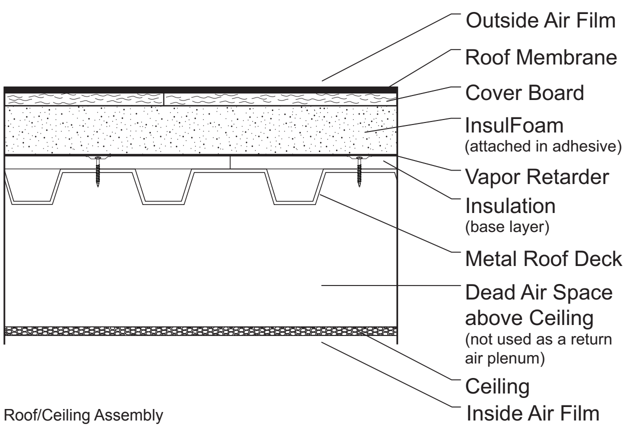
Example Calculation

The following information and example are included in this manual to provide a greater understanding of dew point calculations and theory.

Note: The R-Values of the InsulFoam products are published at 25, 40 and 75 °F. For dew point calculations, Insulfoam recommends that the designer use an R-Value that most closely represents the average temperature of the InsulFoam insulation when vapor drive is the strongest (winter time).

Known Information: A proposed office building in Colorado will have a metal deck and is to be covered with a single ply roof system incorporating 2.6" InsulFoam VIII insulation and a cover board. To accommodate the vapor retarder over the metal deck, a base layer of low-thermal insulation will be needed. The building's interior conditions are 70 °F and 50% relative humidity. The winter design temperature for this building's location is -10 °F.

The following diagram is a cross section of the building's roof/ceiling assembly:



Roof/Ceiling Assembly

To determine the dew point temperature for a given assembly, the interior temperature and relative humidity must be known. Respectively, these values are also commonly referred to as design temperature and design relative humidity.

A psychrometric chart is used to identify the dew point temperature for a set of circumstances. The following simplified psychrometric chart is provided for use with the example. The dew point temperature is located at the intersection of the appropriate design temperature column and relative humidity row.

% Internal Relative Humidity	Design Interior Temperature (°F)														
	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
100	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
90	30	33	37	42	47	52	57	62	67	72	77	82	87	92	97
80	27	30	34	39	44	49	54	58	64	68	73	78	83	88	93
70	24	27	31	36	40	45	50	55	60	64	69	74	79	84	88
60	20	24	28	32	36	41	46	51	55	60	65	69	74	79	83
50	16	20	24	28	33	36	41	46	50	55	60	64	69	73	78
40	12	15	18	23	27	31	35	40	45	49	53	58	62	67	71
30	8	10	14	16	21	25	29	33	37	42	46	50	54	59	62
20	6	7	7	9	13	16	20	24	28	31	35	40	43	48	52
10	4	4	5	5	6	8	9	10	13	17	20	24	27	30	34

Psychrometric Chart for Determining Dew Point

For the office building example with the 70 °F inside temperature and 50% inside relative humidity, the dew point temperature will occur at 50 °F or lower.

Unknown Information: Will the temperature at the bottom side of the vapor retarder remain warmer than the dew point temperature? In other words, is there enough insulation above the vapor retarder to keep the vapor retarder at a higher temperature than the dew point temperature of 50 °F?

Solution: The following equation is required to determine the temperature of the vapor retarder:

$$T_{vr} = T_i - \left[\left(\frac{\Sigma R_{vr}}{\Sigma R_t} \right) (T_i - T_o) \right]$$

Where:

T_{vr} = Vapor retarder temperature
T_i = Inside air temperature (design)
T_o = Winter temperature (design)
ΣR_{vr} = Total R-Value below the vapor retarder
ΣR_t = Total R-Value of all components

Calculate the roof/ceiling assembly's overall thermal resistance (ΣR_t) as well as the thermal resistance below the vapor retarder (ΣR_{vr}).

The following table gives the roof/ceiling assembly components and their respective R-Values.

Component	R-Value of each material	R-Value below the VR
Outside Air Film	0.17	–
Roof Membrane – EPDM	0.10	–
Cover Board – 1/2" Wood fiber	1.32	–
2.6 InsulFoam VIII	11.05	–
Vapor Retarder	0.12	–
Base Insulation – 1" Wood fiber	2.78	2.78
Steel Deck	0.00	0.00
Dead Air Space above Tile	0.94	0.94
Ceiling Tile	1.40	1.40
Inside Air Film	0.61	0.61
Total Resistance:	**18.49**	**5.73**

Notes:

- With an internal design temperature of 70 °F and an external design temperature of -10 °F, the temperature of the InsulFoam VIII within the system is most closely represented by the R-Value calculated at 40 °F or 4.25 per inch.
- The thermal resistance (R-Value) of roof/ceiling assembly components can be obtained from the material manufacturer or from an energy design handbook (e.g. *ASHRAE Fundamental Handbook*).

Calculate the temperature at the vapor retarder as follows:

$$T_{vr} = 70 - \left[\left(\frac{5.73}{18.49} \right) (70 - (-10)) \right]$$

$$T_{vr} = 45\ °F$$

Since the temperature at the vapor retarder is below the dew-point temperature, condensation within the system is possible.

For the example, additional insulation or thermal resistance (R-Value) would be added above the vapor retarder to raise its temperature above the dew-point temperature.

To calculate the InsulFoam VIII minimum R-Value required to raise the temperature of the vapor retarder above the dew point temperature, the following equation can be used:

$$R_{ins} = \left[\left(\frac{\Sigma R_{vr} (T_{dp} - T_o)}{(T_i - T_{dp})} \right) - \Sigma R_{ot} \right]$$

Where:

R_{Ins} = Minimum InsulFoam Insulation R-Value
ΣR_{vr} = Total R-Value below the Vapor Retarder
ΣR_{ot} = R-Value above the Vapor Retarder from other components (cover board, membrane, air film)
T_{dp} = Dew Point Temperature (design)
T_o = Winter Temperature (design)
T_i = Inside Temperature (design)

$$R_{ins} = \left[\left(\frac{5.73\ (50 - (-10))}{70 - 50} \right) - 1.59 \right]$$

$$R_{ins} = 15.6$$

The published R-Value for InsulFoam VIII is 3.92 per inch.

Therefore, for the example, the minimum thickness of InsulFoam VIII needed would be 4.0".

Considerations:

Building Code, Fire and Insurance Ratings

When a vapor retarder is to be used in a roof system, the designer needs to consider its effect on any building codes or roof system approvals (UL and FM).

When calculating the amount of insulation required above the vapor retarder, some designers may add 1-2 degrees to the dew point temperature as an additional safety factor. This approach will result in additional insulation above the vapor retarder.

The need for a vapor retarder in the roofing system should be determined by the roof system designer.

Reference the following resources for additional information on vapor retarders.

- *The NRCA Roofing and Waterproofing Manual – Fifth Edition*
- *ASHRAE Handbook of Fundamentals*
- Oak Ridge National Laboratory (ORNL)