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:

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

Where:
R_{Ins} = Minimum InsulFoam Insulation R-Value
$\sum R_{vr}$ = Total R-Value below the Vapor Retarder
$\sum R_{ot}$ = 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)