

# SPRI Tackles the Latest Single-Ply Issues:

## Water-Based Adhesives and Moisture Under Membranes

By Bob LeClare

Single-ply roofing membrane systems have been used successfully to waterproof low-sloped roofs worldwide for more than 40 years. These systems include thermoset (EPDM), thermoplastic (PVC, PVC/Elvaloy, TPO), and modified-bituminous membranes.

SPRI, the association representing sheet membrane and component suppliers to the commercial roofing industry, reports that in the past five years alone, there have been several billion square feet of single-ply membrane sold in North America, the great majority of which have performed without issue<sup>1</sup> (Photo 1).

In order for any roofing membrane to remain in place and provide a watertight covering, various methods of attachment are used. Attachment methods range from ballasting with smooth river stone or pavers; to mechanically fastening with screws, plates, and/or metal bars; to applying various types of bonding adhesives.

In the early years of single-ply membrane use, adhered membrane systems accounted for a relatively small percentage

of installed assemblies. However, adhesives have always played an important role in bonding the membrane to vertical surfaces in flashing applications, such as parapet walls. In today's single-ply roofing market, adhering the membrane to the horizontal substrate surface has grown substantially.

### BONDING AGENTS FOR FULLY ADHERED SYSTEMS

Various adhesive types are currently used to adhere single-ply membranes to approved substrates. The most common adhesives used today as bonding agents include solvent-based, waterborne, and 100% solids-reactive products, including two-part and moisture-cured or activated adhesives. All of these products have unique characteristics, each with well-defined applica-

tion, storage, and usage specifications relating to ambient conditions and design consideration suitability.

The use of waterborne bonding adhesives began in earnest in the 1980s. As water may be classified as a universal vehicle for suspending polymers and molecules, its use in latex production presented an opportunity for designing adhesives that



*Photo 1 – SPRI reports that in the past five years alone, there have been several billion sq. ft. of single-ply membrane sold in North America, the vast majority of which have performed without issue. (Photo courtesy of GAF, Wayne, NJ.)*

performed as specific bonding agents for single-ply membranes. Formulating chemists focused on engineering waterborne adhesives to sufficiently bond EPDM, PVC, and, more recently, TPO membranes to various substrates such as, but not limited to, roofing insulation, wood, concrete, lightweight insulating concrete, and other types of surfaces.

Beginning with regulations in California in the late 1980s, requirements and guidelines have become more restrictive in the amounts of volatile organic compounds (VOCs) that can be released into the atmosphere.

For example, the South Coast Air Quality Management District, located in the Los Angeles basin area of California, adopted Rule 1168 in 1989, which restricted the VOC content that can be present in bonding adhesives used with single-ply membrane systems to less than 250 grams per liter. This regulation and others like it have accelerated the development and use of waterborne bonding adhesives in the single-ply roofing market.

#### WATER-BASED BONDING ADHESIVES

Waterborne bonding adhesives have been used successfully in the single-ply roofing industry for more than 20 years. As with solvent-based adhesives, waterborne bonding adhesives have advantages and limitations. The following section summarizes the limitations and advantages of using waterborne adhesives with single-ply membrane roofing systems.

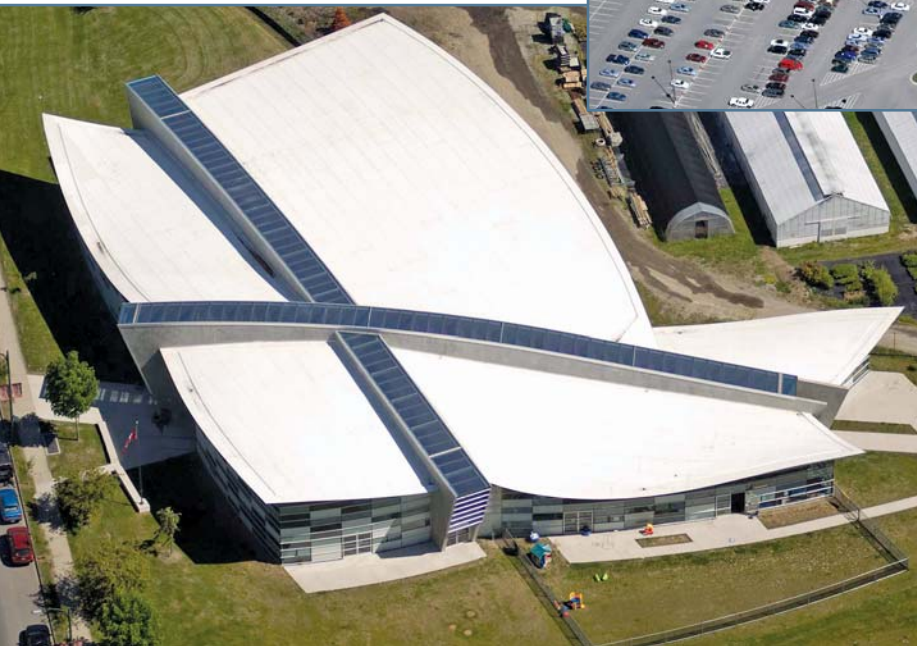
#### LIMITATIONS OF WATER-BASED ADHESIVES

1. It is necessary to protect the adhesives from freezing during application, storage, and shipping. Allowing the adhesive to freeze may destroy the protective layer surrounding the polymer in the water suspension, leading to coagulation of the system and destroying the adhesive's bonding performance and functionality.
2. Extended drying time of the adhesive (per manufacturer's recommendations) is necessary when installation occurs during times of increased relative humidity and moisture-saturated air, which slows the evaporation rate of water.
3. Apply adhesive only when the temperature is at least 40°F to 50°F and rising (per manufacturer's recommendations). The ambient temperature must not go below 32°F at any time, else freezing may occur during the adhesive-drying period.
4. Store products at temperatures above 60°F and, preferably, no higher than 90°F.
5. Shipping in northern climates in winter months requires heated vans to protect from freezing.
6. Recognize that reaching adequate green strength and ultimate cure may require longer than solvent-based adhesives when applied in a one-sided "wet lay-in" method.
7. Handling and application methods and requirements may differ from manufacturer to manufacturer. It is therefore extremely important to carefully read and follow each manufacturer's specific application instructions.

It should also be pointed out that many of the limitations listed above are not merely specific to waterborne bonding adhesives; these limitations may be found in other single-ply roofing adhesives as well.



*Riverside Casino and Golf Resort in Riverside, IA, chose a light-colored EPDM single ply. (Photo courtesy of Carlisle SynTec, Carlisle, PA.)*



*Most of the buildings used for housing, training, or events for the 2010 Winter Olympics were protected by single-ply roofing—almost 3,000,000 sq. ft. of it. (Photo courtesy of Carlisle SynTec, Carlisle, PA.)*

## ADVANTAGES OF WATER-BASED ADHESIVES

1. Odor is typically extremely limited or nonexistent, allowing for use on air-sensitive projects.
2. They meet all VOC regulations issued and/or adopted in many areas of the U.S. and worldwide.
3. They are versatile and can be used with smooth-back or fleece-backed membranes in one-sided, “wet lay-in” or two-sided contact-mode applications, as per manufacturer’s installation recommendations.
4. Excellent application characteristics typically allow for extremely consistent and easy adhesive application when manufacturers’ instructions are followed. Additionally, most products are formulated for a high coverage rate in square feet per gallon.
5. No “red-diamond” shipping label is required, allowing for less restrictive warehouse storage versus flammable, solvent-based adhesives, which must be stored in an explosion-proof room.
6. “Wet lay-in” applications, when applicable, increase the speed of installation and allow membrane re-positioning.
7. Spray or roller-applied techniques are available as needed.

As with any membrane adhesive, the training of applicators on proper waterborne adhesive installation recommendations and specifications is critical to success.

As regulations restricting the use of high-VOC, solvent-based adhesives spread both domestically and internationally, the use and sale of waterborne bonding adhesive products will continue to grow in the single-ply membrane market, building on their many years of successful use in the industry.

## MOISTURE ACCUMULATION UNDER ROOF MEMBRANES

In 2011, SPRI Technical Director Mike Ennis and Manfred Kehrer, senior researcher at Oak Ridge National Laboratory (ORNL) published a document titled “The Effects of Roof Membrane Color on Moisture Accumulation in Low-Slope Commercial Roof Systems.” The paper can be directly downloaded from SPRI’s home page at [www.spri.org](http://www.spri.org). The paper is based on a SPRI

field study, a SPRI/ORNL roof drying study, and a WUFI transient-moisture model analysis (Photo 2).

The WUFI-ORNL/IBP hygrothermal-model analysis is an operating-system-based personal computer program for the hygrothermal (heat and moisture) analysis of building envelope constructions. WUFI-ORNL/IBP is an advanced hygrothermal model that was specifically tailored to the needs of architects and building envelope designers. The software is an easy-to-use, menu-driven program for use on a personal computer. It can provide customized solutions to moisture engineering and damage assessment problems for various building envelope systems.

The model was jointly developed by the Fraunhofer Institute for Building Physics (IBP) in Holzkirchen, Germany, and ORNL in Oak Ridge, TN.

The increasing demand for better-performing calculation methods to assess the moisture behavior of building components prompted this international collaboration. This hygrothermal-design model can assess the response of building envelope systems in terms of heat and moisture loads and can also provide a useful and fair method for evaluating and optimizing building envelope designs. This state-of-the-art model is discussed in detail and can be downloaded at [www.ornl.gov/btc/moisture](http://www.ornl.gov/btc/moisture).

The full SPRI document includes both conclusions and recommendations for future study of moisture accumulation under membranes with respect to membrane color.

It is generally the architect’s or designer’s responsibility to require the use of a vapor retarder as needed and locate it in the



Photo 2 – The objective of SPRI’s field study was to examine roof systems using highly reflective membranes in heating climates. (Photo courtesy of Duro-Last Roofing Inc., Saginaw, MI.)

proper place within the system. This decision will depend heavily on climate and building use.

Generally, a calculation should be made to ensure that the vapor retarder is located within the system where it is warmer than the dew point. It also helps to use two layers of insulation and stagger the joints to make it more difficult for moisture to reach the underside of the roof membrane.

SPRI’s paper goes into some detail on dew point calculations (see Figure 1). The authors list the following considerations that should be made to ensure an accurate dew point calculation:

- Interior and exterior temperature and RH
- The R-value and water vapor permeability of the components of the roof assembly
- Potential for direct-air movement through the assembly
- Comparison of dew point with actual conditions at each layer

The objective of SPRI's field study was to examine roof systems using highly reflective membranes in heating climates by cutting into them and examining them for moisture accumulation. The SPRI field study protocol included the following:

- Heating climate
- Test cuts during winter
- Test cuts before 10:30 a.m.
- Single layer of insulation
- Mechanically attached system
- No vapor retarder
- Roof system in place for at least five years
- The building must be climate-controlled

The results of the SPRI field study were as follows:

- Ten roof systems were investigated.
- In seven of the cases, no moisture or damage to the polyisocyanurate foam insulation or facer were noted.
- In three of the cases, condensation was apparent on the back side of the highly reflective membrane.
  - The level of condensation as described by the observer was "damp" to "wet."
  - Minimal damage had occurred to the polyisocyanurate foam insulation.
  - Consequential impact was limited on the facer of the product and described by the observer as "stained" and, in one case, "wrinkled" but still laminated to the insulation.
  - The foam itself was dry, with no rust on the steel roof deck.

From this portion of the field study, SPRI concluded that, although there were signs of moisture condensation in three of the ten roofs observed, there was minimal effect on the roofing assembly that would affect its integrity, insulating value, or performance. In the final analysis, no detrimental effect to the roof system was noted.

The authors included more than 12 detailed charts and figures to document this portion of the research, as well as the SPRI/ORNL roof-recover drying-rate study. All of this information is directly downloadable from SPRI's Web site.

### CONCLUSIONS

SPRI's overall conclusions and recommendations for future studies include these:

- Situations where moisture accumulation occurs are design issues.
- When designing a roof system, membrane color and other variables, such as building conditions, insulation levels, and local weather conditions must be considered in order to prevent moisture condensation and subsequent accumulation within the assembly.
- Within the parameters used in this study, roof systems with white membranes and those with black membranes both went through wetting and drying periods throughout the year, with both systems returning to a dry state during the course of the year.
- Modeling using transient moisture models such as WUFI can and should be used by design professionals to assess the tendency of various roof designs to allow for moisture accumulation.
- It is recommended that further investigation should be conducted in climate zones 6, 7, and 8.

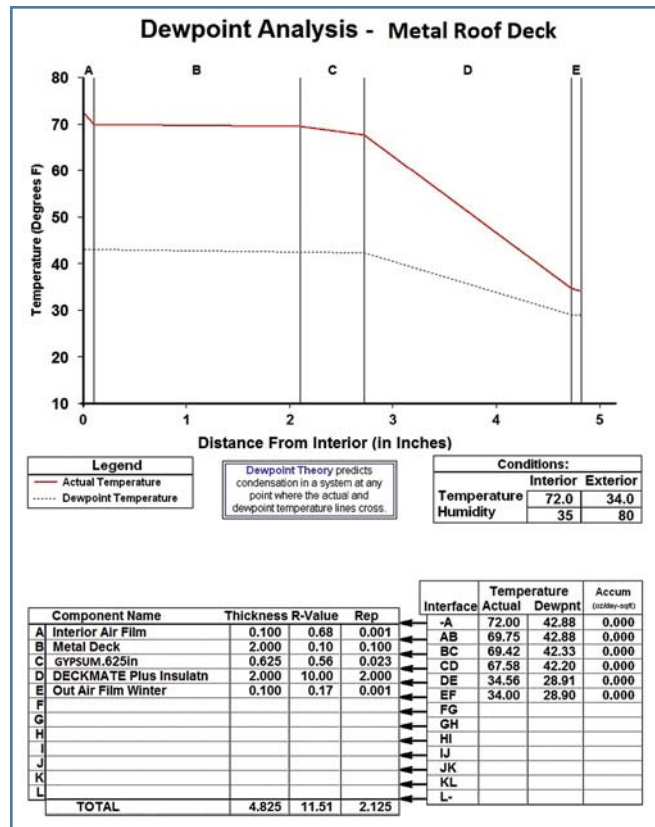


Figure 1 – Dew point analysis for a metal roof deck (charts and figures courtesy of SPRI).

- It is also recommended that possible ventilation effects due to wind pressure and, hence, uplift of the membrane, be investigated.

### FOOTNOTE

1. Michael Ennis, "SPRI Responds to Professional Roofing Article on TPO Membranes," www.professional-roofing.net, Dec. 2010.

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Bob LeClare is vice president of sales for the W.P. Hickman Company. LeClare holds a bachelor's degree from Purdue University and has over 25 years of experience in architectural metals and the roofing industry. He is a member of RCI, the Construction Specifications Institute (CSI), and the Roofing Industry Committee on Weather Issues (RICOWI) and is president-elect of SPRI, chairing its ES-1 task force. LeClare has given presentations on roof edge performance for numerous organizations, including RCI, CSI, RICOWI, NRCA, as well as at the International Roofing Expo (IRE).