

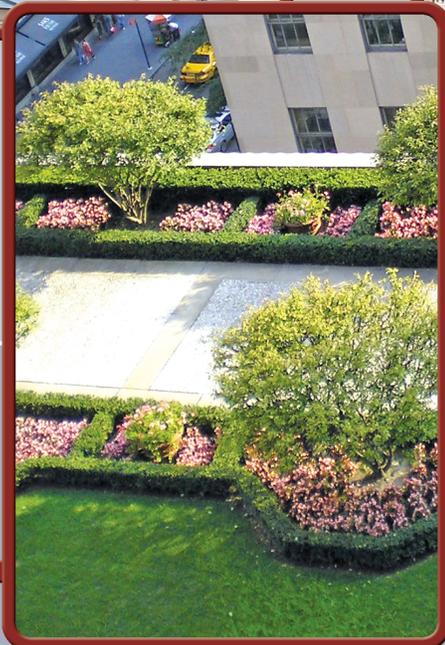
PROCEEDINGS

# 30<sup>th</sup> RCI International Convention and Trade Show

March 5-10, 2015

Grand Hyatt San Antonio and  
San Antonio Convention Center

San Antonio, Texas



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# PROCEEDINGS OF THE RCI 30TH INTERNATIONAL CONVENTION & TRADE SHOW

March 5-10, 2015 • Grand Hyatt San Antonio and San Antonio Convention Center • San Antonio, TX

## TABLE OF CONTENTS

FENESTRATIONS.....	1
<i>Karim P. Allana, RRC, RWC, PE</i>	
SELECTION AND USE OF SEALANTS ON THE EXTERIOR BUILDING ENVELOPE.....	9
<i>Terence A. DaCosta, EIT; and Elizabeth P. Lewis, PE, LEED GA</i>	
DEVELOPMENT OF A STANDARD TEST METHOD TO DETERMINE THE WIND RESISTANCE OF VEGETATED ROOF ASSEMBLIES.....	19
<i>Sudhakar Molleti, PhD; Appupillai “Bas” Baskaran, PhD, PEng; and Fenella de Souza, PhD</i>	
REROOFING OVER A WET CONCRETE SUBSTRATE .....	29
<i>Edis T. Oliver, PE, and Alonso Caro Jr., RRC, RRO, CDT</i>	
QUANTIFYING THE HYDROLOGICAL PERFORMANCE OF EXTENSIVE VEGETATIVE ROOFS .....	43
<i>Jenny Hill, Matt Perotto, and Catherine Yoon</i>	
WATERSTREET AT CELEBRATION CONDOMINIUMS: A CASE STUDY OF HOW TO DESIGN FOR A WET CLIMATE.....	53
<i>James W. Ripley, RRC, RWC, REWC, RBEC, RRO, RA, NCARB; and Tyler Hall</i>	
WHETHERABILITY: HOW DO ARCHITECTURAL DESIGN STUDENTS CONSIDER THE BUILDING ENVELOPE?.....	65
<i>Elizabeth J. Grant, RA PhD; Matthew J. Innocenzi, RRC, RWC, REWC, RBEC, PE, NCARB, and James Jones, PhD</i>	
PRODUCT DISCLOSURE: AN EMERGING CHALLENGE FOR THE BUILDING ENVELOPE CONSULTANT.....	75
<i>James L. Hoff, DBA</i>	
CONSULTANT AND CONTRACTOR COLLABORATION: UNDERSTANDING ROLES AND RESPONSIBILITIES FOR SUCCESSFUL BUILDING ENVELOPE CONSTRUCTION AND REHABILITATION PROJECTS .....	85
<i>Quinn A. Ferrall, RRC, RWC, RRO, PE, CDT, and Christopher W. Giffin, RRC, AIA</i>	
INNOVATIVE REPAIRS TO TERRA COTTA PARAPETS AND CORNICES .....	99
<i>Steven P. Bentz, RRC, RWC, REWC, RBEC, PE, CDT, and Michael G. Payne, EIT</i>	
THE GREAT DEBATE: NONREFLECTIVE VS. REFLECTIVE ROOFING MEMBRANES.....	111
<i>Robert Anderson, CSI</i>	
UNDERSTANDING LOW-SLOPED (HYDROSTATIC) STANDING-SEAM METAL ROOFS.....	125
<i>Stephen L. Patterson, RRC, PE, and Charles L. Smith, Jr.</i>	
WIND LOAD DESIGN SPECS AND AIR BARRIER PERFORMANCE LEVELS .....	137
<i>Benjamin Meyer, RA, LEED AP</i>	
GLAZING FAILURES AND WAYS TO PREVENT THEM .....	149
<i>Brian Hubbs, PEng, and James Higgins</i>	
STRATEGIES FOR ENERGY-EFFICIENT AND FIRE-RESISTANT BUILDING ENCLOSURE DETAILS .....	163
<i>Eric K. Olson, PE; Andrew E. Jeffrey, PE, LEED AP; and Brian D. Kuhn, PE, LEED Green Associate</i>	
INNOVATIVE WATERPROOFING SOLUTIONS FOR BLINDSIDE APPLICATIONS USING PREFABRICATED MODIFIED-BITUMINOUS SHEET MEMBRANES .....	173
<i>Jean-François Côté, PhD; Rémi Saucier, TP; and Hank Staresina</i>	
THE ENVIRONMENTAL IMPACT OF ROOFING SYSTEMS: TEN LIFE CYCLE INDICATORS .....	181
<i>Jonathan Dickson, PEng, BSSO, LEED GA; Duncan Rowe, PEng, LEED AP BD+C; Russell Richman, PEng; and Matthew Bowick, LEED AP</i>	
WEATHER-RELATED EFFECTS ON THE INSTALLATION OF FULLY ADHERED SINGLE-PLY SYSTEMS .....	195
<i>Zebonie Sukle and Todd Nathan, RRC, RRO</i>	
THE PROBLEMS WITH AND SOLUTIONS FOR VENTILATED ATTICS .....	203
<i>Graham Finch, PEng; Marcus Dell, PEng; Robert Lepage, PEng; Lorne Ricketts, EIT; and James Higgins</i>	
NOT ALL GLASS-MAT SHEATHINGS ARE CREATED EQUAL .....	217
<i>David L. Bowen, LEED GA, and Steve Velten</i>	
STUCCO DETAILING FOR BUILDINGS WITH UNIQUE GEOMETRY .....	227
<i>Richard W. Mosco, AIA, and Lee Cope, PE</i>	

# 30<sup>th</sup> RCI International Convention and Trade Show

## WEATHER-RELATED EFFECTS ON THE INSTALLATION OF FULLY ADHERED SINGLE-PLY SYSTEMS

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## ABSTRACT

This presentation is about the relationship between temperature and dew point differentials and the impacts they may have on the performance of adhesives. Two case studies will be evaluated along with supporting lab data to highlight the importance of understanding environmental conditions and the role they play in proper adhesive drying.

Due to environmental concerns and code restrictions with solvent-based single-ply adhesives, the use of water-based (WB) and low-VOC, solvent-based (LVOC) adhesives is becoming much more popular in the low-slope roofing market. At the same time, the roofing industry has become concerned with the longer drying times exhibited by WB and LVOC products because both react differently to environmental conditions than solvent-based adhesives. This is especially true during changes in ambient temperatures and dew points on the roof.

While there is a general industry consensus that most of these issues revolve around WB adhesive drying rates, it has been found that similar problems may also apply to LVOC adhesive products. These concerns have taken the form of blistering and/or inadequate adhesion of the single-ply membrane to the substrate when using WB and LVOC adhesives in certain environmental conditions.

Learning objectives:

- Understand how environmental and application conditions such as temperature, relative humidity (RH), and coverage rates impact using adhesives
- Understand the implications of using fully adhered specifications during the spring and fall seasons
- Gain a better understanding of how environmental conditions impact flash times of adhesives
- Understand the implications and impacts on future codes

## SPEAKER

*ZEBONIE SUKLE — JOHNS MANVILLE TECHNICAL CENTER*

ZEBONIE (ZEB) SUKLE is the single-ply engineering manager for Johns Manville Roofing Systems. In this capacity, she manages the team with responsibility for TPO, PVC, and EPDM membranes, accessories, and fasteners. Sukle represents JM on the SPRI board and is actively involved in the roofing industry. She has been recognized for her contributions to JM for product improvements, development, engineering excellence, and innovations.

*TODD NATHAN, RRC, RRO — JOHNS MANVILLE ROOFING SYSTEMS*

TODD NATHAN is the senior manager of technical services and is responsible for the guarantee service and field technical functions for JM Roofing Systems. He formerly was JM Roofing Systems' contractor channel manager and various other technical positions within the Johns Manville Contractor Services Group. Todd has been with JM since 1991. Prior to that, he worked for eight years for a roofing contractor. Todd is a Registered Roof Observer and Registered Roof Consultant, having earned those distinctions from RCI in November 2001 and May 2002, respectively.

# WEATHER-RELATED EFFECTS ON THE INSTALLATION OF FULLY ADHERED SINGLE-PLY SYSTEMS

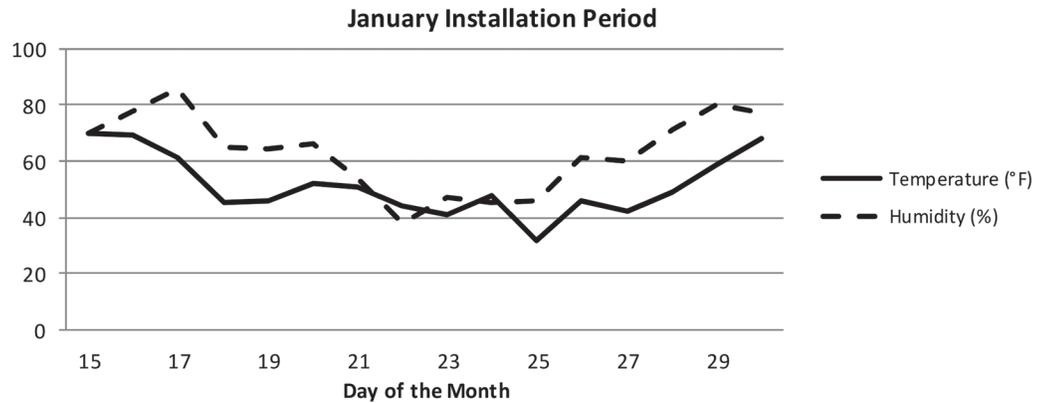
Due to environmental concerns and code restrictions with solvent-based single-ply adhesives, the use of water-based (WB) and low-VOC, solvent-based (LVOC) adhesives is becoming much more popular in the low-slope roofing market.

At the same time, the roofing industry has become concerned with the longer drying times exhibited by WB and LVOC products. The primary reason is that both react differently than standard solvent-based adhesives as temperatures and humidity levels change on the roof.

While there is a general industry consensus that most of these issues revolve around WB adhesive drying rates, it has been found that similar problems may also apply to LVOC adhesive products.

From an installation standpoint, these concerns have taken the form of blistering and/or inadequate adhesion of the single-ply membrane to the substrate when using WB and LVOC adhesives in certain environmental conditions.

What's needed is a better understand-



**Figure 1 – Average temperatures during installation. Information obtained from Weather Underground.**

ing of the influence of temperature, relative humidity (% RH), and dew point on the drying behavior of WB and LVOC adhesives for roofing applications.

The ultimate objective of this research—and the topic of this paper—is to present a simple method and formula to predict the required drying times of WB and LVOC adhesives. Most importantly, research has found that when temperatures and dew points converge, the drying times of WB adhesives are significantly extended. When

this happens, performance issues in the field tend to increase. Evidence of this concern will

first be reviewed in a case study that helped to drive our initial research.

The case study was conducted on a fleece-backed TPO roof in the southeastern United States. The construction period was from January 2013 to March 2013, using WB adhesive. During the application period for the adhesive, the daytime temperatures were above 40°F and rising. The specific application period of concern was from mid-January to the end of January. *Figure 1* illustrates the average temperatures and humidity during that period.

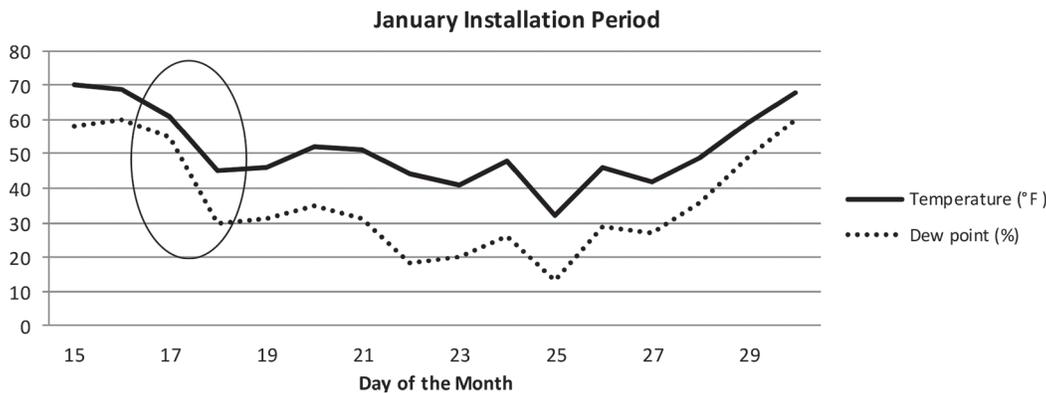
Several days after the installation of the adhesive, field engineers were called to the job to review concerns of loose membrane on the roof (see *Figure 2*).



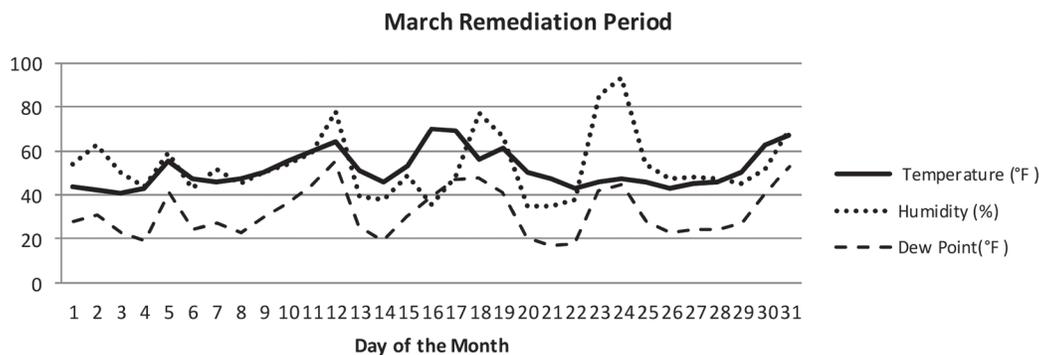
**Figure 2 – Evidence of adhesion loss occurred within several days of installation.**



**Figure 3 – Field test cut shows moisture beads present in the fleece-backed material.**



**Figure 4 – Circled area indicates critical application period when installation and roof performance were affected.**



**Figure 5 – Environmental conditions during March remediation.**

After visual inspection of the membrane, roof cuts were taken in several places on the roof. It was found that the adhesive was still tacky, and there was no adhesion to the substrate. Further evaluation of the system showed moisture was present (see Figure 3).

A second environmental factor that should be considered when installing adhesives is dew point. During the critical period of installation, it was observed that the temperature difference between ambient temperature and dew point was 6°F to 9°F, which is slightly higher than the industry rule of thumb of 5°F. The area circled in Figure 4 identifies this critical period.

One of the key findings of this study is that in lower temperatures and higher dew point conditions, the drying times of WB adhesives may be extended from 1.0 to 1.5 hours or more. In addition, ambient rooftop conditions may change during application and further extend drying out periods. For this reason, roofing contractors, roof consultants, and specifiers must be aware of these prolonged drying times and take precautionary measures in the field to ensure proper adhesion of the single-ply membrane to the substrate.

From the roofing contractor’s perspective, the data shows that under certain environmental conditions, the installation times of adhered single-ply roofing systems may be increased significantly. This can have a major effect on production times and project schedules. In addition, the relationships between temperature and dew point add yet another factor to the quality of a specified roofing installation.

To address these issues of performance, it is recommended that architects, specifiers, and roof consultants take into consideration what types of adhesives they are using for a particular project, the geographic location, and the time of year. Moreover, should construction delays occur, the adhesive specified for a mid-summer application may perform quite differently under environmental conditions common in the late fall, winter, and spring months.

Regarding the case study presented above, in order to address the issue of loss of membrane adhesion to the substrate, a change in adhesive had to be made to complete the job. This remediation occurred in March when temperatures and humidity conditions were even more severe than the

conditions observed in January (see Figure 5). LVOC adhesive was selected for these conditions, which also resulted in the need to switch the membrane to smooth-backed TPO.

Partly due to the difficulties illustrated above, some roofing manufacturers are taking additional precautions to ensure that their adhesives are installed in appropriate environmental conditions. For example, at least one major manufacturer will only distribute WB adhesives from April to October in order to avoid performance problems resulting from installing that product in colder temperatures.

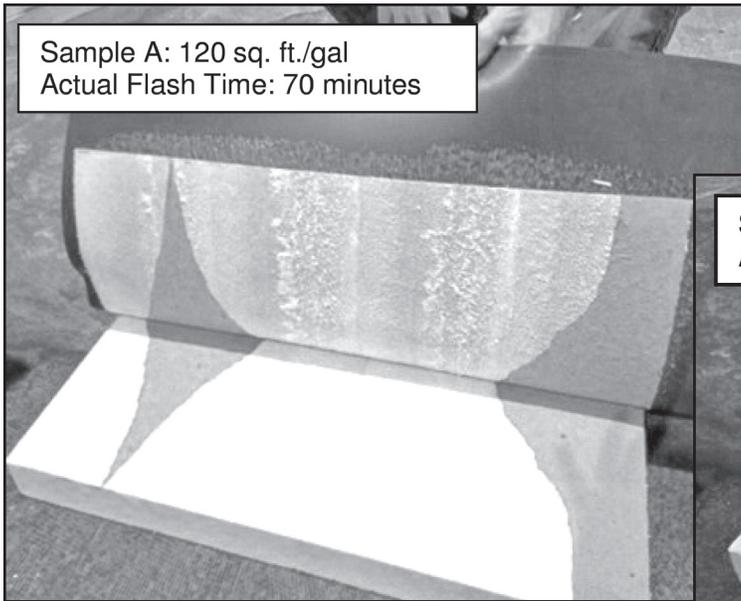
Another reason for winter distribution restrictions relates to transportation of the product. Most WB and LVOC adhesives are manufactured in the Midwest, and there is a possibility the adhesives may freeze in transit. This is an issue that an architect in Southern California would most likely not consider in his or her specifications.

However, it is of vital importance from a roofing manufacturer’s standpoint.

From the roofing contractor’s perspective, there’s little that can be done when adhesives delivered to the job site are not ideal for current rooftop environmental conditions. However, it is the contractor’s responsibility to plan ahead and ensure that adhesives appropriately applied during the day are not exposed to temperatures that dip below 32°F the night after installation. It is important to note that rooftop conditions may be several degrees lower than ambient conditions.

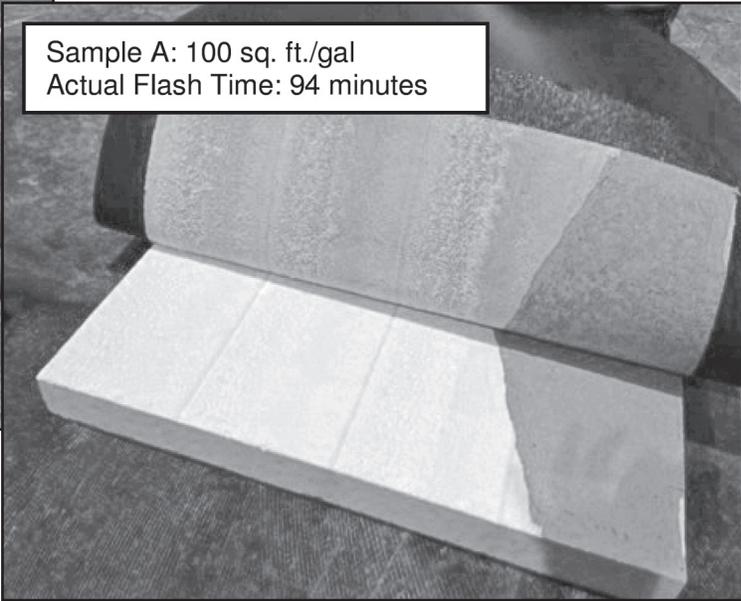
Applicators may also have to wait an inordinately long period of time for adhesives to set up, which may severely hamper job scheduling. That’s why it’s important that the industry give roofing professionals the analytical tools to predict drying times, while requesting that architects build more flexibility into their adhesive specifications.

If a WB product is required but does not flash off adequately, the contractor may experience issues with the final application, and the architect and property owner may be left with a final product that is not acceptable. These problems may include



Sample A: 120 sq. ft./gal  
Actual Flash Time: 70 minutes

*Figure 6 – Representative samples tested with good adhesion.*



Sample A: 100 sq. ft./gal  
Actual Flash Time: 94 minutes

blisters and improper adhesion of the membrane to the roof insulation. Poor adhesion or lack of adhesion is seen primarily with WB, while lack of adhesion and blistering are the most common issues seen with LVOC.

**LABORATORY TESTING**

As stated above, one of the objectives of this single-ply roofing adhesive study is to determine the impact of environmental conditions (temperature, dew point, and relative humidity) on adhesive performance. For this reason, it was also required that labo-

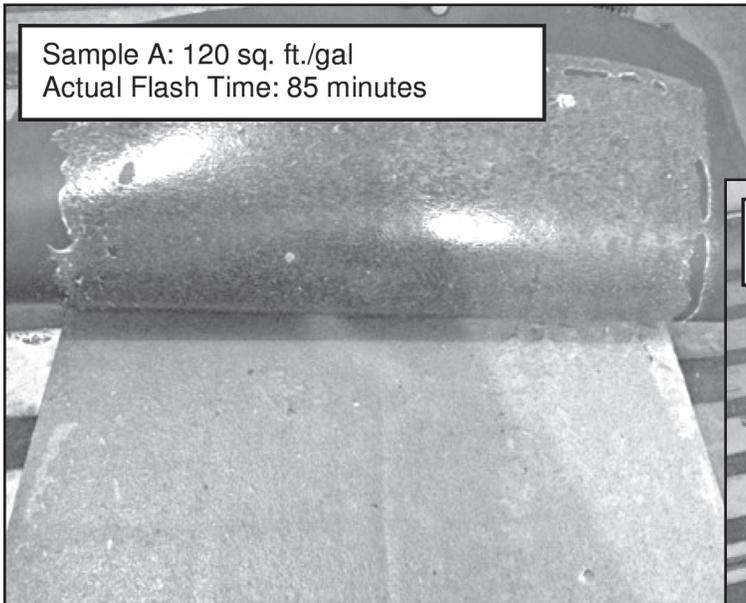
ratory testing be conducted.

Four WB and three LVOC adhesives were purchased from local distributors for laboratory testing. The substrate for each test sample consisted of 2 in. of (51 mm) polyisocyanurate insulation (ASTM C1289, Type II, Class 1, Grade 2: fiberglass-reinforced paper facer, 20 psi). Laboratory testing in an environmental chamber included a variety of adhesive coverage rates.

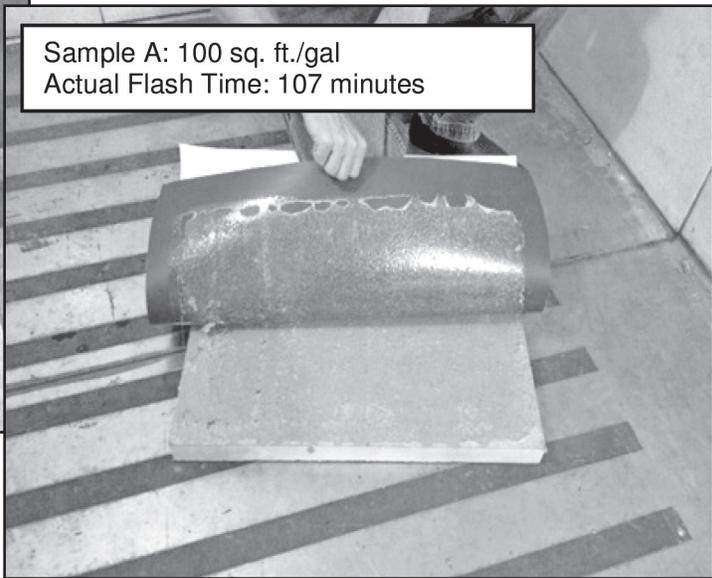
All commercially available adhesives were applied as specified by product labeling and data sheets. These instruc-

tions followed an industry-standard application of two-sided contact adhesive with polyisocyanurate.

The first laboratory test was conducted using WB adhesive samples conditioned at 60°F and 45% RH. Typical coverage rates were between 100-120 sq. ft. (9.3-11.1 sq m) per gallon, which represents average field-coverage rates for WB adhesives. The differences in coverage rates were used to determine if they were related to observed performance differences. "Performance" was defined by flash time and percent adhesion after one hour.

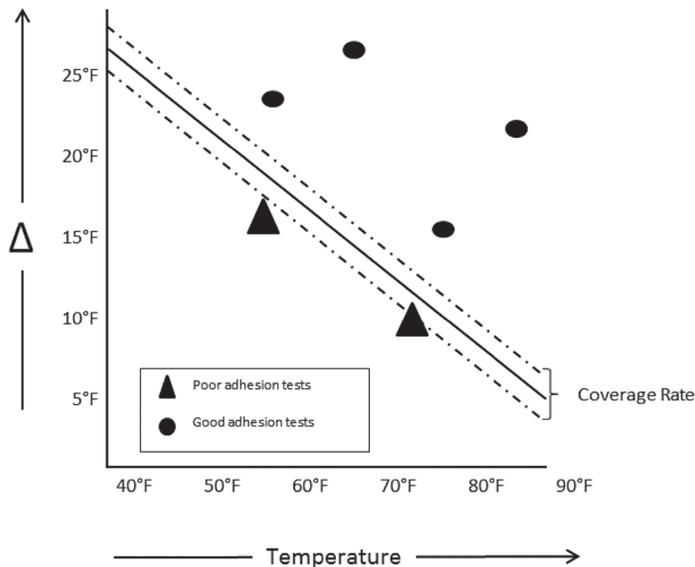


Sample A: 120 sq. ft./gal  
Actual Flash Time: 85 minutes



Sample A: 100 sq. ft./gal  
Actual Flash Time: 107 minutes

*Figure 7 – Two representative samples tested with poor adhesion.*



**Figure 8 – Chart showing temperature and difference ( $\Delta$ ) relationship and effect on adhesion properties.**

In the standard tests, researchers would have classified the adhesive as dry, and then would have rolled the membrane into the adhesive and let the sample sit in the conditioned environment. The single-ply membranes would then be peeled back to determine the level of adhesion for each sample. Obviously, if the samples were allowed to sit for longer, greater adhesion values would have resulted.

Actual drying time was indicated by the traditional “touch” tests to ensure there was no stringing of adhesive coming off the substrate. Estimated drying time was incorporated into a regression analysis (a statistical process for estimating the relationships among variables) based on coverage rate, temperature, and relative humidity to give an estimated drying time. The equation generated in this work followed fairly consistently with observed drying times. Throughout the testing, “bad” performance was defined as limited polyisocyanurate facer delamination, while “good” perfor-

point of 22°F.

In Figure 7, the same test was then performed at 75°F and 75% RH, with a temperature delta between the temperature and dew point of 8 °F. In both of these test conditions the adhesion between the substrate and membrane was poor, and the actual flash time of the adhesive increased by 13% to 20%.

Figure 8 charts temperature versus “delta,” the difference between the actual temperature and the dew point. The y-axis represents the delta values, with the x-axis being temperature. The dots and triangles indicate the testing that was done at various temperature and humidity settings. The triangles indicate test conditions that produced poor adhesion results, and the black dots indicate tests that demonstrated successful adhesion results.

It was observed that as temperatures increased (80°F), the sensitivity to the delta between temperature and dew point was not as strong. However, as shown in the

performance was indicative of strong polyisocyanurate facer delamination.

As seen in Figure 6, Sample A, using a coverage rate of 120 sq. ft. (11.1 m<sup>2</sup>) per gallon, was the quickest to dry at 70 minutes; while Sample A with a coverage rate of 100 sq. ft. (9.3 m<sup>2</sup>) per gallon was slowest to set up at 94 minutes. This test was conducted at 60°F and 45% RH with a difference between the temperature and dew

point, when temperatures decrease, there needs to be a larger delta (a larger difference between the actual temperature and the dew point) to get good adhesion. At 60°F, instead of a temperature/dew point difference of 5°F, a more appropriate value may be anywhere from 10°F to 15°F.

A regression analysis equation for WB adhesives has been developed using the lab testing data, with the formulation’s average accuracy among the four tested samples at about 10%. Figure 9 is an example of what a formula may look like that could be used to estimate flash time as a function of coverage rate, temperature, and RH.

Along these lines, a predictive application tool based on laboratory and field research has been developed by Johns Manville and is now available for use.<sup>1</sup>

When considering the laboratory findings, it is important to remember that all of the samples were tested in a static laboratory environment. The effects of wind and sun (IR and UV radiation) would undoubtedly accelerate drying time in real-world conditions, so the drying times here are probably worst-case scenarios. It is also better to over-dry contact adhesives than to put them together wet.

To summarize this portion of the study, Figure 10 shows an example of how this equation can be used to predict drying times between summer and winter conditions in Atlanta, Georgia. According to the calculations, drying conditions between summer and winter can vary by as much as 35 minutes. This understanding, coupled with the shorter working days in winter months, clearly demonstrates the concerns regarding applying adhesives in conditions that are less than ideal.

In addition, laboratory tests were conducted using LVOC adhesive samples. One of these tests was conditioned at 60°F and 70% RH at a dew point of 50°F or delta 10°F. The second set of samples was conditioned at 60°F and 83% RH at a dew point of 55°F or delta 5°F. Coverage rates were between 55 square feet and 70 square feet (5.1 m<sup>2</sup> – 6.5 m<sup>2</sup>) per gallon.

This testing shows that LVOC adhesives do not appear to have the same sensitivity to temperature/dew point differentials as WB adhesives. The main observation regarding these tested samples was the need to ensure that the adhesive was fully dry upon installation.

Following these tests, several LVOC

**Flash Time WB = A – B(CR) – C(T) + D(% RH)**

CR = Coverage Rate  
T = Temperature  
% RH = Relative Humidity  
A = Constant  
B, C, & D = Coefficients

**Figure 9**

**Example:**

Summer average temperature 77°F with 70% RH

Flash time = 100 minutes +/- 10%

Winter average temperature 43°F with 70% RH

Flash time = 135 minutes +/- 10%

Source: [http://www.engineeringtoolbox.com/us-outdoor-design-temperature-humidity-d\\_296.html](http://www.engineeringtoolbox.com/us-outdoor-design-temperature-humidity-d_296.html)

**Figure 10**

samples were installed wet at both 75°F and 75% RH and 60°F and 45% RH. The samples were peeled back after one hour of drying and again after an additional 48 hours of drying. The most noticeable issue for samples installed wet was the adhesive surface appeared skinned over after one hour of drying time. The samples failed the “touch” test and the membrane moved (slid) when pressure was applied. All samples exhibited little to no adhesion to the substrate.

### DIFFERENCES BETWEEN WB AND LVOC ADHESIVES

Not surprisingly, the drying times for WB and LVOC adhesives were different. However, LVOC was surprisingly consistent for the lower temperatures (50°F to 60°F), with drying ranges from 31 minutes to 51 minutes, depending on adhesive type. Testing will need to be done at additional temperatures to help develop predictive modeling necessary for all conditions.

The main takeaway is that the ability to get a more uniform coverage rate positively influenced drying times. The additional variable that was observed in this experiment was the sensitivity of drying behavior due to the puddling of adhesives. Thicker adhesive areas tend to increase drying times and often are the reasons for blistering on fully adhered attached membranes.

### CONCLUSIONS

The regression analysis (*Figure 9*), as a function of temperature, relative humidity and coverage rate, was relatively successful in predicting the accuracy of WB adhesives, up to an R-Sq of 72% when removing the variable of adhesive spreadability. However, additional testing will need to be evaluated in order to optimally characterize LVOC adhesive material performance.

From a field installation perspective, roofing professionals need to show greater concern on applications where temperature and dew point are converging. When these

values are close to intersecting, poor adhesion of the membrane to the substrate is likely to occur when using WB adhesives. Poor adhesion will, in turn, often lead to a rise in field performance issues.

During periods of warmer weather (80°F) and higher relative humidity, the risks of adhesion problems are reduced. However, the opposite is true as temperatures drop and delta values increase.

While the industry rule-of-thumb has always been a 5°F difference between temperature and dew point, this differential may need to be adjusted to as high as 15°F when temperatures begin to drop below 60°F.

Although coverage rate, temperature, and relative humidity showed promise in predicting flash times, in a controlled environment, further work is needed to understand the effects of other environmental conditions such as cloud cover, sun, and ambient rooftop temperatures.

For all of the reasons above, it is also recommended that architects build more flexibility into their adhesive specifications and consider the ramifications of construction schedules and the unpredictability of environmental conditions, even in mild climates.

Everyone complains about the weather—but no one can change it or predict exact environmental conditions during every hour of a roofing project. Better to build in a margin for error than wind up with adhesives that don't stick. 

### NOTE

1. JM Roof TechXpert from the Apple iTunes and Google App stores.



# 30<sup>th</sup> RCI International Convention and Trade Show

## THE PROBLEMS WITH AND SOLUTIONS FOR VENTILATED ATTICS

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JAMES HIGGINS; AND MARCUS DELL, PENG**

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## ABSTRACT

We have noticed an upward trend of moisture problems within sloped wood-frame roofs, particularly in the Pacific Northwest. The problems consist of mold and fungal contamination within the attics of many newer single- and multi-unit complexes. Investigations and testing of these attics have found that the usual problem of air leakage from indoors and ducts is only one of the common culprits. Instead, wetting from external sources—either from moisture in the outdoor ventilation air, night sky condensation, and in some cases, water seepage through asphalt shingle roofs—is a contributing factor. In some climatic zones, more ventilation can make matters worse.

## SPEAKER

*MARCUS DELL, PENG — RDH BUILDING ENGINEERING LTD.*

MARCUS DELL has been a practicing professional engineer for over 25 years, with the last 17 years as a managing principal at RDH Building Engineering. This work career has resulted in exposure to thousands of projects. While the majority of these projects have been in Western Canada, several have been international. Dell has presented at numerous RCI conferences, is a board member of the Western Canada Chapter, and assists with technical reviews for *Interface* journal.

## NONPRESENTING COAUTHOR

*GRAHAM FINCH, PENG — RDH BUILDING ENGINEERING LTD.*

GRAHAM FINCH is a building science engineer who specializes in research and investigation work. His work experience includes a wide range of projects, including building enclosure condition assessments, forensic investigations, research studies, energy assessments, building monitoring programs, field review, and testing services for new and existing buildings. He is regarded as an industry leader in evaluating thermal energy and hygrothermal (heat, air, and moisture) performance of building enclosure systems. His theoretical training, coupled with his practical experience and proficiency with state-of-the-art analysis software, have enabled him to perform thermal and hygrothermal analyses of a wide variety of enclosure systems and components in cities around the world.

# THE PROBLEMS WITH AND SOLUTIONS FOR VENTILATED ATTICS

## ABSTRACT

Over the past several years in the Pacific Northwest, there has been a trend toward increased reporting and repair of moisture problems within attics below sloped wood-frame roofs. The problem consists of seasonally wetted roof sheathing and mold contamination occurring within the wood-frame attics of many newer houses, townhouses, and multifamily building complexes. Often these problems are attributed to rainwater ingress through the roof assembly, inadequate ventilation of the attic space, and/or condensation associated with air leakage from the conditioned indoor spaces or from ducts. However, detailed investigation and testing of many of these attics has found that these factors cannot account for the observed problems. Instead, wetting from other sources, including condensation of outdoor attic ventilation air caused by night sky cooling (and, in some cases, rainwater ingress through asphalt shingles) is hypothesized. These roofs and attics are generally constructed to meet current building code and third-party roofing warranty requirements.

These roofing problems are proving to be a significant burden

on homeowners and warranty insurers. Numerous warranty claims have been filed for moisture ingress and mold issues within attics. Repairing moisture damage within attics is costly and a significant inconvenience to property owners and the warranty provider. Furthermore, the success of many of these repair efforts has been poor, with mold growth recurring a few years after a full remediation and air-sealing work have taken place. This suggests a presence of other underlying wetting mechanisms.

In an effort to further understand the

cause of attic moisture problems and to develop potential remediation solutions, the authors undertook a research study and field monitoring program in Vancouver, BC. The study investigated sheathing moisture absorption caused by night sky cooling and ventilation air condensation, as well as the impact of shingle underlayment types on potential exterior moisture sources. The study included both a controlled field exposure study to measure the moisture contents, temperatures, condensation, and mold growth on several roof test huts, as



**Figure 1 – Locally stained and wet sheathing and frost due to condensation of humid air leaking from a poorly sealed bathroom exhaust fan and duct.**



**Figure 2 – A wood-frame attic with widespread stained, wet, and deteriorated sheathing from persistent indoor and exhaust duct air leakage and poor attic ventilation.**



**Figure 3 – Locally stained, wet, and deteriorated sheathing from water ingress around a plugged dryer exhaust duct boot.**



**Figure 4 – Stained and damp sheathing only on the north slope of a very well-ventilated wood-frame attic not obviously linked to conventional wetting mechanisms and hypothesized to be caused by night sky condensation of outdoor ventilation air. Note that the staining is more apparent on the sapwood than the heartwood.**