

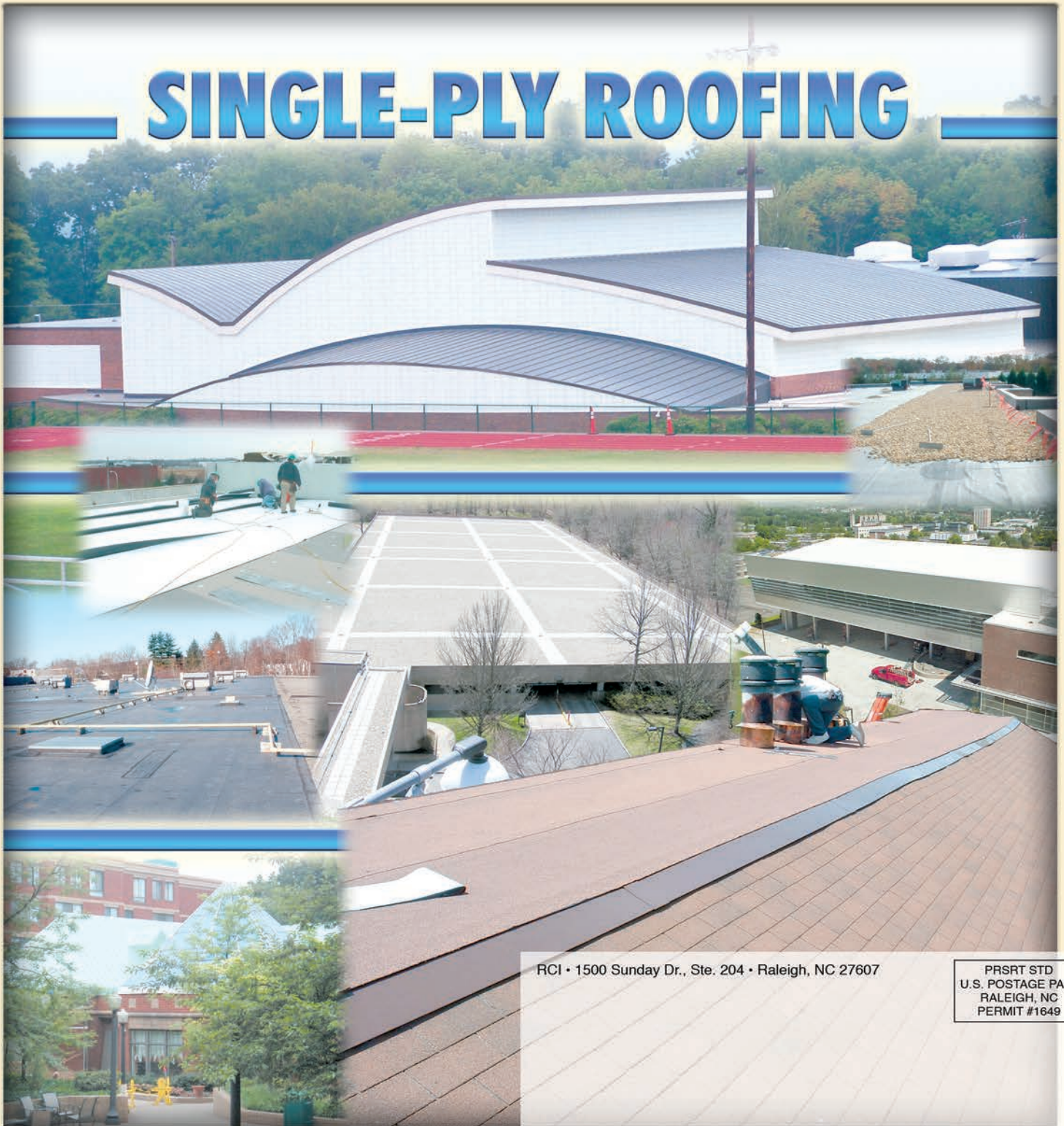


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SINGLE-PLY ROOFING



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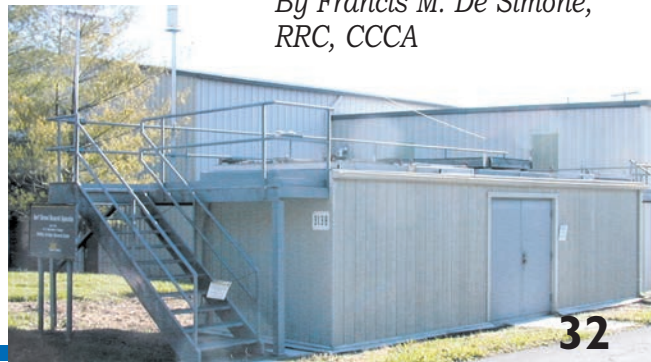
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By Francis M. De Simone, RRC, CCA



On the Cover: Clockwise, starting at the top: 1) Dark grey PVC made to look like standing seam metal on the Minisink School, Slate Hill, NY (photo courtesy of Sarnafil). 2) Ballasted EPDM being installed [courtesy of Dedicated Roof and Hydro-Solutions, LLC (DRH)]. 3) Traditional white PVC roof over isocyanurate insulation on the dining hall at SUNY Binghamton, NY (Sarnafil). 4) Self-adhered modified bitumen on a condominium (DRH). 5) Green PVC roof made to look like copper on the Hyatt residence in Teaneck, NJ (Sarnafil). 6) EPDM overlaid on a built-up roof (DRH). 7) TPO being installed (DRH). Center: 8) Ballasted FiberTite roof on Xerox headquarters parking garage in Stamford, CT (courtesy Wiss, Janney, Elstner Associates).

About This Issue: Few markets have been so rife with experimentation as the single-ply roofing industry. Today, single-ply roofing – EPDM, PVC, and TPO – holds a 50% share of the market. Innovations include self-adhered membranes, wider and thicker sheets, and heat-welded seams. We examine some of the latest information about this form of low-slope roofing.



Thomas W. Hutchinson

Thomas W. Hutchinson, AIA, RRC,
President



THE VALUE OF TEAMWORK

As I prepare this message in early August, many of us are in the heat (no pun intended) of the summer construction season, spending a great deal of time on the roof. Perhaps many of you sport the same "farmer's tan" that I do. Besides oppressive heat and humidity, there is nothing that makes a project more unbearable than when everyone is at odds.

I unfortunately have heard one too many times that some roof consultants seem to feel that, in order to prove themselves to the owner, they must verbally berate the roofing contractor in the owner's presence. Besides being embarrassed by these actions, I feel sorry for the consultants. What a poor way to practice any type of profession. These consultants are well known to the roofing contractor industry, and when very good contractors have concerns, it's a concern to RCI.

The most successful projects are those in which all parties to the project understand one another's goals.

Owners most often want a watertight roofing system of a certain quality. They desire good value, minimal interruption, and a timely installation. They realize that both the consultant and the contractor work to earn a reasonable profit.

The consultant desires a project that can challenge his skills, be brought in on time, within budget, without incident, and be profitable. He desires a contractor who will review and acknowledge the effort that has gone into the drawings and specifications, but who also understands that sometimes things aren't as clear as intended and that questions will arise. These inquires should receive the same respect we would desire from the owner. Properly prepared submittals go a long way toward sending a message of professionalism. If something major is in error, a call to the contractor to personally discuss the concern is the way a leader would act.

The contractor endeavors to complete the project on time, within the amounts he estimated, and for the project to be watertight and profitable. He wants to understand the consultant's design intent and to accom-

plish the work as desired. He knows that often, unknown conditions arise and hopes that the consultant will be there to help determine the best course of action. If action is required with the roof consultant absent, he photographs the concern and informs him later. Promptly reviewed pay requests and requests for information are appreciated.

The preconstruction meeting is a good opportunity for all parties to review their expectations and concerns, and review the general scope of work.

In the field, presenting oneself as a professional and respecting everyone on the job is the first step in receiving respect. When it's 3:30 in the afternoon and 95 degrees with 85% humidity, if you observe a concern, leave it for the next day. The crews are most likely exhausted and may not take a consultant's comments with the same level of understanding as they might the next morning. The better scenario might be to purchase a case of cold Gatorade for the crew or bring some doughnuts once in a while. That's how I would want to be treated.

I have had some wonderful experiences because of the teams involved; most recently, the roof restoration on the Dole Mansion in Crystal Lake, IL. The owner's representative, Diana Kenny, could not have been more appreciative of the work done by the contractor and myself. The vision I had and which I delineated on the 12 sheets of drawings I prepared would have gone unrealized if it were not for the excellence exhibited by the contractor, Smart Roofing.

While I have had hundreds of squares of nonconforming or wet new roofing removed, denied pay requests, and assessed hundreds of thousands of dollars of liquidated damages to contractors, I believe it has been done professionally and fairly. I still work with each of those contractors and have attended their weddings, celebrated the birth of their children, and enjoyed numerous successful projects since.

Knowledge, compassion, understanding, appreciation, fairness, and communication are all parts of the teamwork equation. Striving to be better is a daily task. Being part of a team helps make others better. Are you part of the team or part of the concern?

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ISSUES TO CONSIDER REGARDING

SELF-ADHERING TPO SINGLE-PLY MEMBRANES

By Helene Hardy Pierce
Edward Nebesnak
William Woodring
David Scott

ABSTRACT

Self-adhering roofing systems in the single-ply industry are growing in use, providing the benefits of fully-adhered membranes without the need for field-applied adhesives. Their use presents installation considerations that the roofing professional should include when designing and installing these systems. Data will be presented on the physical characteristics of the membranes themselves and how these characteristics can affect the waterproofing quality of the installed system. Following this discussion of physical performance characteristics, a review of installation considerations, flashing details and how they can be designed and installed, and issues specific to this type of roofing system and its installation will be presented. While much of the data

and discussion relate to self-adhering TPO membranes, the general concepts and considerations are applicable to all self-adhering, single-ply membranes.

INTRODUCTION

Growth in the single-ply industry during the past two decades has been significant, with current estimates placing single-ply membranes as representing over 1.7 billion square feet (17 million squares) per year. Advancements in the materials and systems have continued on pace as the market has matured and the performance of these products has been proven. Single-ply roofing systems are best delineated by type of membrane and by installation method. Thermoset membranes (EPDM) and thermoplastic membranes (most commonly TPO

and PVC) represent the membrane types, while installation methods are typically separated into mechanically-attached, fully-adhered, and ballasted.

Each of these assemblies has its own advantages and disadvantages, and designers and building owners typically choose the membrane and installation method that best fits the needs of the building. *Table 1* lists several of the advantages and disadvantages of each type of installation method.

As the industry has matured, several innovations in the application of these systems have been developed. Examples include paver systems for ballasted roofing, the use of taped seams for thermoset membranes, and the use of fleece-backed membranes to act as a separator layer or to pro-

TABLE 1

	SYSTEM TYPE		
	MECHANICALLY ATTACHED	FULLY ADHERED	BALLASTED
ADVANTAGES	<ul style="list-style-type: none">• Light weight• Easily maintained• Moderate cost	<ul style="list-style-type: none">• Light weight• Easily maintained• Wind performance	<ul style="list-style-type: none">• Low cost• Fast installation time
DISADVANTAGES	<ul style="list-style-type: none">• Frequency of fastening for wind uplift resistance• Penetration into structural deck	<ul style="list-style-type: none">• Fumes/odors of adhesives• Higher installed cost/more labor intensive	<ul style="list-style-type: none">• Leak detection• Cost of overburden removal for repairs• High installed weight

TABLE 2						
PRODUCT	THICKNESS OF TPO MATERIAL OVER SCRIM		WEATHERING (CAP) LAYER THICKNESS		TOTAL THICKNESS	
	Avg. mils	Std. dev.	Avg. mils	Std. dev.	Avg. mils	Std. dev.
A	12.4	0.8	15.6	1.3	42.6	1.4
B	15.9	0.3	22.0	0.4	45.5	0.4
C	16.0	1.1	22.0	1.8	45.4	1.3
D	11.6	0.4	20.3	0.7	42.5	0.5

vide for the installation of fully-adhered membranes in hot asphalt.

A more recent innovation in the single-ply roofing industry is the use of a factory-applied adhesive on the back or underside of the membrane to provide a fully-adhered system without the use of additional adhesives. Traditionally, fully-adhered membranes are adhered using either a solvent-based adhesive, a water-based adhesive, or hot asphalt. The introduction of “self-adher-

ing” membranes (“self” implying that additional adhesives are not required) provides another alternative to the roofing professional looking for the performance characteristics of a fully-adhered membrane.

SELF-ADHERING MEMBRANES – THE DATA

Consideration of the disadvantages of traditional fully-adhered systems led manufacturers to consider the application of butyl technology to develop fully-adhered

membranes that have a factory-applied adhesive layer. Butyl technology has a proven performance record, and combined with thermoplastic polyolefin (TPO) membranes, building owners and roofing professionals are provided the benefits of a fully-adhered membrane that has none of the fume/odor issues that can accompany installations utilizing either adhesives or asphalt. These membranes are available with a heat-welded seam if so desired, or with adhesive in the full seam area.

Advantages of self-adhering membranes include:

- **Environmentally friendly installation**
 - There is no adhesive to apply, no open “dry” time, and there are no adhesive solvents or fumes.
 - There are no empty bonding adhesive buckets that need to be disposed of; however, release paper does require disposal and attention on the jobsite.
 - Use of white membranes can provide an Energy Star® rated roof.
- **Improved installation quality**
 - Factory application of adhesive ensures consistent and uniform application.
 - The installation of these membranes utilizes many of the same basic techniques understood and mastered by roofing contractors and their crews.
 - Self-adhering membrane roofing system details are either the same or very similar to details used on conventional roofing systems.
 - Clean, worker-friendly environments reduce installation errors caused by over- or under-application of membrane adhesive.
- **Cost-effective**
 - The size of the crew needed for installation is reduced compared to traditional fully-adhered systems.
 - Ease of application speeds installation.

1 Day Aged Commercial Cleaner Study (Not Rolled vs. Rolled @ Room Temp)

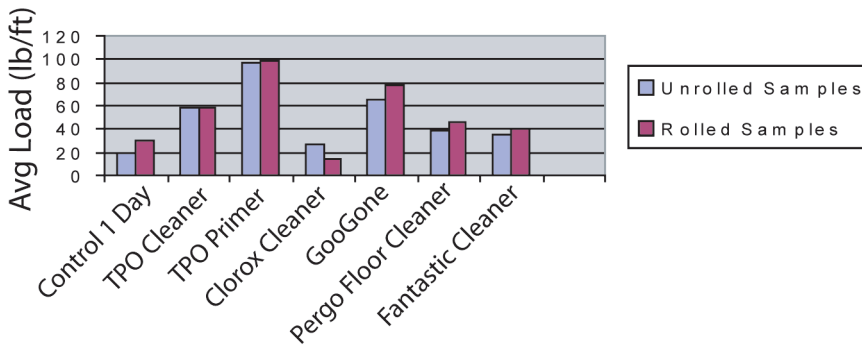


FIGURE 1

7 Day Aged Commercial Cleaner Study (Not Rolled vs. Rolled @ Room Temp)

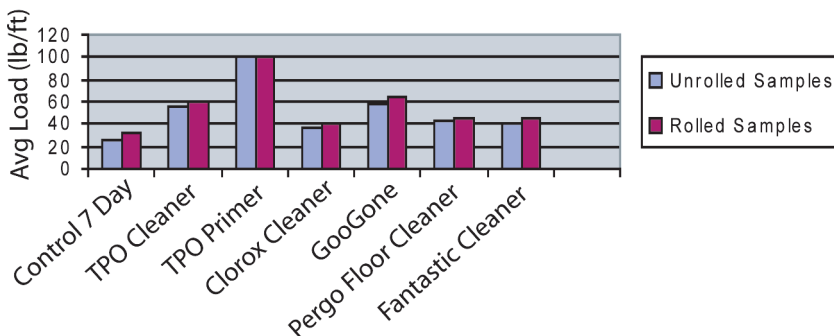


FIGURE 2

These advantages and similarities are easily understood by roofing professionals; however, the cautious do well to consider what other “data” are available to show that manufacturers have indeed done their homework.

In order to understand the backbone of self-adhering membranes, one simply needs to consider the traditional, smooth-backed TPO membranes they are built upon. The standard 45-, 60- or even 80-mil membrane installed every day in mechanically-attached, fully-adhered, or ballasted systems is used as the membrane in these products. There is not a change in thickness or other physical properties of the actual membrane in exchange for the adhesive layer. Because the membrane itself is not thinner, the performance of a self-adhering membrane in terms of weathering layer, reflectivity, puncture resistance, tear resistance, etc. remains the same. *Table 2* illustrates the composition and thickness of polymer over the scrim, weathering layer, and total thickness of several commercially available 45-mil TPO membranes.

So what are the issues that should be addressed when considering self-adhering membranes? The general performance and physical attributes of the TPO material itself? How well they adhere to different surfaces? Can different cleaning methods affect the performance of an adhesive seam? Is adhesion improved by weighted rolling? Do self-adhering membranes exhibit similar performance to other fully-adhered membranes when subjected to uplift pressures? Following are the results of several different studies conducted to address these types of questions and to provide a basis for evaluating and understanding the performance of these membranes.

Many TPO membranes do not require "cleaning" of the lap prior to heat welding seams unless the membrane has been exposed for a period of time or been contaminated. Self-adhering seams may require the lap area to be primed with TPO primer to ensure a strong bond. Several commercially available cleaners were tested to evaluate the strength of the resulting lap when other cleaners were used. Additionally, the effects of rolling the lap with a hand roller or not rolling the lap after adhering the membrane to the underlying membrane were measured. *Figures 1* and *2* illustrate the results of this study.

Note: On a self-adhering lap roof system, some manufacturers will allow the use of a 3" seam tape where the membrane does not have an adhesive to form a seam, e.g., with a heat weldable grade membrane, a 3" tape may be permissible in the lap area.

All of the samples were prepared and conditioned at room temperature and tested in peel for their lap strength. Review of

these data shows that statistically there is no significant difference in lap strength of samples that were either rolled or not, both after 24 hours and after seven days. Even with these data, to ensure a watertight lap during actual jobsite conditions, it is recommended the laps be rolled to provide full and consistent contact of the adhesive to the underlying membrane. From a performance standpoint, the reader should consider that greater than 25 lb./ft. of strength is desirable.

There is a clear improvement in the performance of the lap when a cleaner is used

that contains solvents; both the TPO cleaner and primer are xylene-based, and the GooGone (a commercial hand cleaner) contains petroleum distillates. All of the other cleaners consist of mostly surfactants in a water base, and none contains any organic solvents to aid in adhesion. Additionally, care should be taken with cleaners containing a surfactant because a residue film can be left on the membrane that may interfere with adhesion.

Another area that needs to be understood is the adhesion characteristic of the membrane. *Table 3*, summarizes the results

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TABLE 3

SAMPLE DESCRIPTION	PRODUCT	AVERAGE LOAD LBF/FT.	STANDARD DEVIATION	FAILURE MODE
LAP, CLEANED WITH TPO CLEANER	A	47.4	4.0	Interfacial at core
	B	50.7	3.5	Interfacial at cap
MEMBRANE TO UNPRIMED PLYWOOD	A	34.2	5.10	Interfacial at plywood
	B	9.7	3.3	Interfacial at plywood
MEMBRANE TO PLYWOOD PRIMED WITH TPO PRIMER	B	43.7	7.0	Interfacial at plywood

(Note: “Core” is the underside of membrane and “Cap” is the top surface of membrane, where the “Core” has the adhesive layer.)

of measuring the adhesion of two different commercially-available, self-adhering membranes. Results are from lap-peel tests, as well as from material installed on a plywood substrate, both primed and unprimed. The results are after 30 days of conditioning at room temperature.

The adhesion of the back of the membrane to the top surface of a membrane cleaned with TPO cleaner (lap area) is statistically similar between products after 30 days of aging at room temperature; however, the differences in the adhesion to plywood indicate that the roofing professional should be aware of all priming recommendations and requirements when using these products. To put these numbers into perspective, Table 4 provides a comparison for reference between these products and self-adhering asphaltic underlayments.

Another performance characteristic of the membrane to consider is its wind uplift resistance performance. First, the uplift resistance of a fully-adhered assembly, whether incorporating a mechanically-attached substrate or an adhered substrate, is not affected by the thickness of the membrane, but by the adhesion of the membrane to the substrate and the performance of the substrate itself. This is different than the performance of mechanically-attached membranes that may realize improved performance with thicker membranes.

In general, the resistance to wind uplift

of a fully-adhered membrane or system incorporating a mechanically-attached substrate is determined by the performance of the substrate, e.g., the mode of failure is that of the insulation or fastener, not the failure of the membrane to stay adhered. With self-adhering membranes, this generality holds true with a notable exception – if the substrate is not suitable and interferes with the adhesive characteristics of the membrane, the assembly will provide lower wind uplift performance. Likewise, failure of a self-adhering membrane assembly incorporating a fully-adhered substrate is typically found in a cohesive or adhesive failure of the substrate unless the substrate is not suitable for attachment of a self-adhering membrane.

Comparison of testing data shows good wind uplift resistance for self-adhering membranes; however, the list of suitable substrates is more specific than for traditional, fully-adhered membranes. For this reason, attention to the testing data and system approvals of the manufacturer should be given by the roofing professional.

INSTALLATION CONSIDERATIONS

The installation of self-adhering TPO membranes, utilizing either a heat-welded or self-adhering seam, is similar to the installation of traditional fully-adhered membranes. The accessories are the same for both systems, including cleaner, primer,

pre-formed accessories, coated metal edges, etc. Loading of the roof and material handling by the contractor are similar; minimal weight has been added to each roll of membrane by the adhesive, although the width of self-adhering membranes is typically 5 - 6 feet. The heat welding of seams is done in the same manner as other TPO membranes and is of the same quality. Likewise, ensuring the quality of heat-welded seams is the same; by checking test welds for film-tearing bonds and by probing of finished seams for cold welds.

As indicated by the cleaner data, the true quality of a self-adhering seam is dependent upon the roofing mechanic properly preparing the seam prior to its installation.

These membranes can be installed in similar weather conditions as other installation methods used with TPO membranes; i.e., without precipitation in the immediate forecast and typically at 45°F and rising. If the temperature is colder, the self-adhering membrane installation should be delayed. Most manufacturers recommend a 40 - 45°F minimum temperature, regardless of installation type; however, mechanically-attached and ballasted systems can be installed successfully in colder weather.

The substrate preparation is the same; it must be suitable, sound, smooth, dry, clean, and free of debris, sharp projections, etc. As noted in the uplift resistance discussion, care must be taken to ensure that the substrate is suitable. Likewise, as its need to be clean, dry, and free of debris is important to ensure good adhesion.

Differences in the installation of the field of the roof are limited. The roofing contractor needs to be conscientious about the placement of membrane when using a heat-welded seam, because only one side of the membrane has no adhesive along the length of the roll. This can result in more waste on

TABLE 4

SELF-ADHERING ASPHALTIC PRODUCT	ASTM D-903 AS MODIFIED BY D-1970	ADHESION TO PLYWOOD @75F, LBF/FT. WIDTH
A	12 lbf/ft. width	30.9
B		21.0
C		40.7

TABLE 5

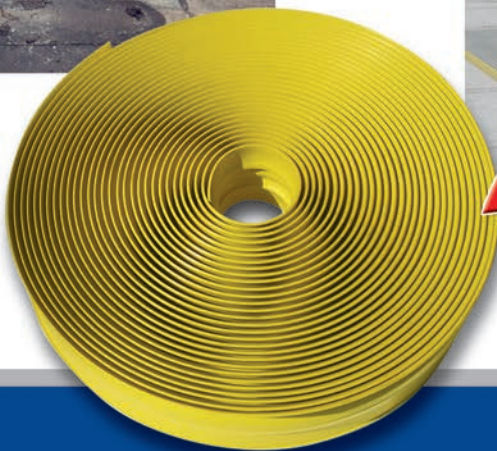
DETAIL	SELF-ADHERING MEMBRANE WITH HEAT-WELDED SEAMS	SELF-ADHERING MEMBRANE WITH SELF-ADHERING SEAMS
METAL EDGES	<ul style="list-style-type: none"> Coated metal – can use at the “gutter” edge, using the membrane to form a heat-welded seam; but cannot use at the rake edge without the use of a heat weldable membrane. Standard metal – use of cover strip as in standard details is acceptable. 	<ul style="list-style-type: none"> Coated metal – can only use with a flashing strip of heat-weldable membrane. Standard metal – use of cover strip as in standard details is acceptable.
TERMINATION BARS	<ul style="list-style-type: none"> Acceptable as in standard details, e.g., walls. 	<ul style="list-style-type: none"> Acceptable as in standard details, e.g., walls.
DRAINS	<ul style="list-style-type: none"> With a deep sump, install a target of non-adhering membrane over the self-adhering membrane to allow for heat welding of all four sides. 	<ul style="list-style-type: none"> Deep sumps are difficult to work with self-adhering membrane only – install a target of non-adhering membrane over the self-adhering membrane to allow for heat welding of all four sides.
WALLS	<ul style="list-style-type: none"> Vertical surfaces should be primed with a TPO primer. Flashing heights and top edge attachments are the same as standard details. Typically the heat-weldable seam is placed in the field of the roof and a self-adhering lap is on the vertical surface and may have a heat-welded flashing strip installed over the vertical lap. Securement of the field at the base of the wall should follow standard requirements. 	<ul style="list-style-type: none"> Vertical surfaces should be primed with a TPO primer. Flashing heights and top edge attachments are the same as standard details. Securement of the field at the base of the wall should follow standard requirements.
PENETRATIONS	<ul style="list-style-type: none"> Coated metal, e.g., pitch pockets, can use an unreinforced flashing heat welded to the membrane, including the vertical seam. Can use either a large, self-adhering target sheet or cover tape. 	<ul style="list-style-type: none"> Coated metal, e.g., pitch pockets, can use an unreinforced flashing heat welded to the membrane, including the vertical seam. Can use either a large, self-adhering target sheet or cover tape.

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the project because any cut-outs or interruptions in the membrane will increase the amount of flashing strip-ins, and any cut-out material cannot be used in flashing applications where a heat-welded seam is needed.

Membranes with a self-adhering lap typically have minimal waste in the field; however, a larger lap is required from the same sheet width. This results in the net area of coverage being reduced by approximately 5% and the use of cut-edge sealant along the finished lap edge may be recommended.

Endlaps in the field of the roof may be constructed with either a self-adhering overlap of typically 6" or by forming a lap with the self-adhering membrane and heat welding a flashing strip over the endlap.

Handling of these membranes when installing them requires attention to placement of the sheet and care in its handling. Once installed, repositioning is not advised because attempting to reposition the sheet can cause damage to the underlying substrate, such as delaminating the facer on the top insulation layer. Separately, if the adhesive on the sheet happens to stick to another portion of adhesive, it may have to be cut out and replaced. As with other paper-type debris generated by the roofing process, (e.g., wrappers), release paper/film can easily be blown about by a light breeze and care must be taken to dispose of any debris properly and quickly so it will not get under subsequent sheets that are applied.

FLASHING DETAILS


The detailing of roofing systems utilizing a self-adhering membrane can follow two routes – either staying “true” to the use of self-adhering membranes, or using standard smooth or fleece-back membrane in standard details. The decision between either of these choices depends on the roofing professional’s belief in the performance of tapes or his or her comfort with heat-welded details.

Regardless of which method is used, items such as flashing heights, attachment of the membrane at penetrations and walls, attachment at perimeter edges, and the use of TPO accessories such as pre-formed corners, typically mirror standard TPO details. Table 5 provides several specifics to consider when designing details for these types of systems.

CONCLUSIONS

Self-adhering TPO membranes have been used successfully in the roofing industry since 2002¹ and offer an alternative to other fully-adhered, single-ply membranes. While appreciating the benefits of self-adhering membranes, roofing professionals will be well served to understand the challenges and particular requirements of these systems. This understanding will help to ensure successful installations that will perform.

This paper has attempted to provide a general discussion of considerations for the use of self-adhering membranes. As with any membrane roofing system, the roofing

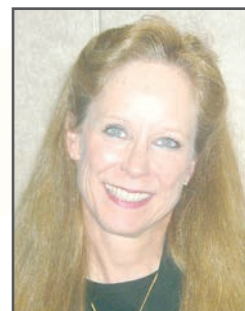
professional is best served by following the installation recommendations and requirements of the manufacturer of the specific product to be installed. 

¹Self-adhering TPO membranes were introduced to the commercial market in 2002; note that field applications of self-adhering single-ply membranes started during the late 1990s.

This article was originally presented as a paper at the April 2005 RCI 20th International Convention & Trade Show in Miami Beach, Florida.

Helene Hardy Pierce

Helene Hardy Pierce is director of contractor services at GAF Materials Corporation. Hardy Pierce was named a Fellow of RCI in 2005 and is on the board of the Roof Consultants Institute Foundation.



Edward Nebesnak

Edward Nebesnak, manager of research and development for GAF Materials Corporation, has over 25 years of experience in research and development of construction products, including roofing, fireproofing, and thermal and acoustical products. He has been granted nine patents and has six applied for and pending.



William Woodring

William J. Woodring is currently director of contractor field services at GAF, where he has held various positions in R&D, marketing, and field technical support for the past 36 years.



Dave Scott

Dave Scott, EverGuard specialist with GAF, has over 32 years of roofing experience. Scott has concentrated his career in the use of thermoplastic sheet membranes.



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Is PVC Really the

- Bad Boy -

of Sustainable Design?

By Andreas Floros Phelps, PE, LEED™ AP

The U.S. Green Building Council's discussion on whether or not to offer a LEED™ (Leadership in Energy and Environmental Design) credit for projects that refrain from using PVC (polyvinyl chloride) has re-energized the debate over PVC and the environment. The arguments for this 20-plus-year dispute provide us with an excellent opportunity to consider what really constitutes a sustainable material. We continually read about the latest and greatest "green materials" that have high recycled content or are made from 100% renewable resources, such as soybean roof coatings or shredded denim insulation. Behind the novelty of these "green" material fads is the often overlooked reality that these materials are expected to perform. Throughout the life of a building, "green" materials that do not

perform as well or as long as traditional materials may actually end up being less sustainable when considering the energy and materials required to repair prematurely failed systems or improve poorly performing systems. Along these lines, durability and performance should be two of the most important factors in selecting materials for critical building systems.

The case against PVC has been well documented. Reports of health problems due to phthalates and dioxins caused by PVC production and disposal resulted in the banning of PVC in some European cities in the late 1980s and early 1990s (most notably Berlin, Germany). All of these bans have since been repealed, and PVC currently makes up a large component of the roofing market in Europe. Despite the fact that PVC production requires half the fossil fuels required by other roofing membranes, the

chlorine required for PVC production results in a number of hazardous byproducts. Even if properly contained and disposed of, the main argument against PVC is that these hazardous materials are still being created and at some point end up in our environment.

Because of these concerns, PVC may not be appropriate for short-term or low importance applications such as packaging or furniture. A building's roof, however, is integral to the ability of a building to function and subject to a wide spectrum of loading, including wind, rain, and solar radiation. PVC is well suited to address the major factors affecting the roof lifespan, including the durability of the roofing material, easy installation, and resistance to environmental loads.

Some of the more established PVC roof membrane manufacturers have engineered

their products into high-performance systems. Their products and installation procedures are continually evolving, learning from past mistakes, and working toward providing the best quality with the most efficient use of time and materials. Manufacturers' standard details and factory-fabricated membranes and accessories eliminate the contractor guesswork and variations in

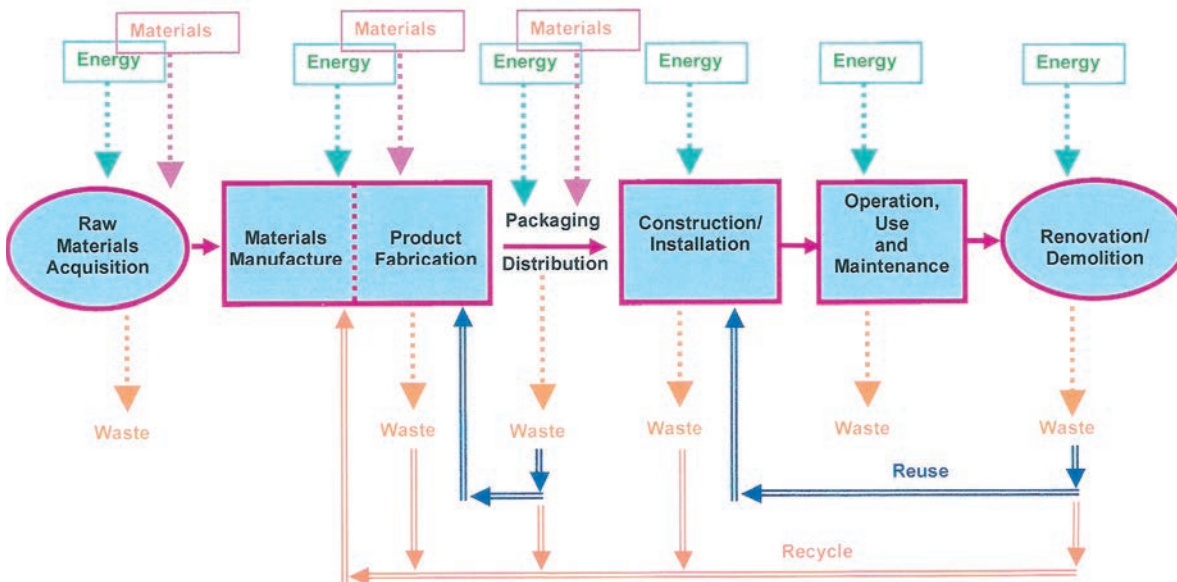


Figure 1: Schematic of Product Life-Cycle Stages

quality associated with field-fabricated membranes. PVC membranes can be fully adhered or loosely-laid, installed over almost any substrate, and can be used in a variety of roof assemblies. The installation process, which consists of heat-welding large sheets of membrane together, is clean, easy, and familiar to contractors. There is no need to deal with the fumes and kettles associated with bitumen-based systems. In comparison with other single-ply roofing systems, the heat-welded seams in PVC do not rely on any adhesives or tapes as with EPDM systems and are much less susceptible to the cold welds or burn-throughs associated with TPOs.

PVC roof systems also provide some of the best options for cool roofs and garden roofing assemblies. The high reflectance and emittance provided by cool roofing membranes can decrease surface temperatures on a hot summer day from +180°F to around 110°F, which consequently reduces cooling costs, slows breakdown of the materials, and minimizes contributions to the urban heat island effect.

Studies have shown that the expected lifespan of PVC roofing membranes increases more significantly than other roofing membranes when protected from extremely high service temperatures. In parts of the U.S., the estimated lifespan of a PVC roof can be almost doubled just by switching from a black to white membrane¹.

Bituminous roof systems require coatings to achieve the same reflectance and emittance values, and white EPDM should not be used since it requires less reliable UV stabilizers than its black counterpart. Decreasing the roof temperature also reduces cooling loads. Case studies by Lawrence Berkeley Laboratory illustrate that a 10,000 square foot roof in the Southeast U.S. can save anywhere from \$300 per year for a R-30 roof assembly to \$10,000 per year for a R-1 roof assembly simply by switching from a dark- to a light-colored exposed roof membrane.²

In terms of garden roofing systems, one manufacturer has tested samples of its membranes installed on planted roofs over 35 years ago in Europe and found them to still be in very good condition. In California, where cool roofs will be mandatory for low-slope commercial building beginning in October 2005, some designers would like to install a cool roof membrane that can be turned into a garden roof at some later date. Today, there is only one product that can serve both functions, and it is a PVC mem-

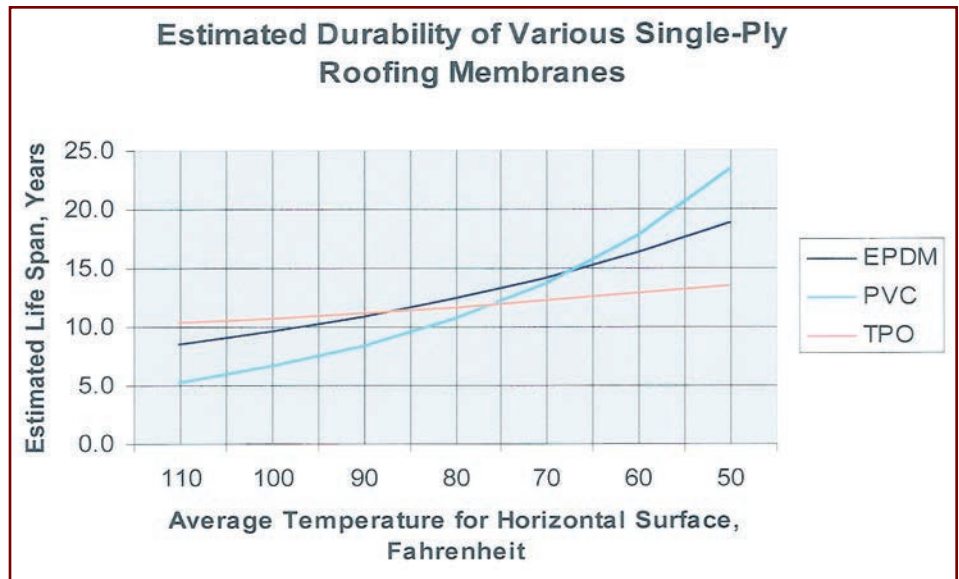



Chart 1: Derived from "Estimating the Durability of Roofing Systems," by C. G. Cash.

brane.

Once a PVC roofing system has been installed, it requires very little maintenance (in the neighborhood of \$0.025 per square foot per year, according to some manufacturers) and is easily repaired. When the roof eventually reaches the end of its useful life, it must be disposed of. PVC can be recycled, but different formulations and additives make this fairly difficult. Currently, the only program for recycling PVC roofing is in Germany, where the Association for Recycling of PVC Roof Membranes takes old PVC roofing, pulverizes it, removes reinforcing, and returns it to the original manufacturer for reuse on the back of membranes, walk pads, and other accessories.

So, what's the verdict? As with every good design, the answer completely depends on the specifics of the project. For short-term or low importance uses, the hazards of PVC production don't justify its use, especially since in most cases there are better suited materials. For long-term, high importance uses (such as roofing), and until newer systems are time tested, improved, and create their own performance history,

PVC may prove to be one of the more sustainable options for now.

Regardless of the debate on PVC, as we are learning more about life-cycle assessment and the full extent of sustainable design, the areas of durability, performance, and adaptability will become increasingly important. The products and systems that address these considerations will be the ones that lead us into the future of sustainable, high-performance design. 

1. Cash, C.G., "Estimating the Durability of Roofing Systems," *Durability 2000: Accelerated and Outdoor Weathering Testing*, ASTM STP 1385, J.D. Evans and W.D. Ketola, Eds., American Society for Testing and Materials, West Conshohocken, PA, 2000.
2. Backenstow, D. E., "Comparison of White Versus Black Surfaces for Energy Conservation," *Proceedings from the 8th Conference on Roofing Technology*, April 16-17, 1987.

Andreas Floros Phelps

Andreas Floros Phelps is a senior engineer with Simpson Gumpertz & Heger Inc. He received a bachelor's degrees and masters degree in architectural engineering from Penn State University. He has worked on numerous building envelope investigations and designs. Mr. Phelps has spent the last few years researching green roofs and other sustainable building technologies. Phelps is registered as a professional engineer with the state of California and is a LEED Accredited Professional.



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EPDM —

Solution to Airport Roof Problems

By Nick A. Lovato

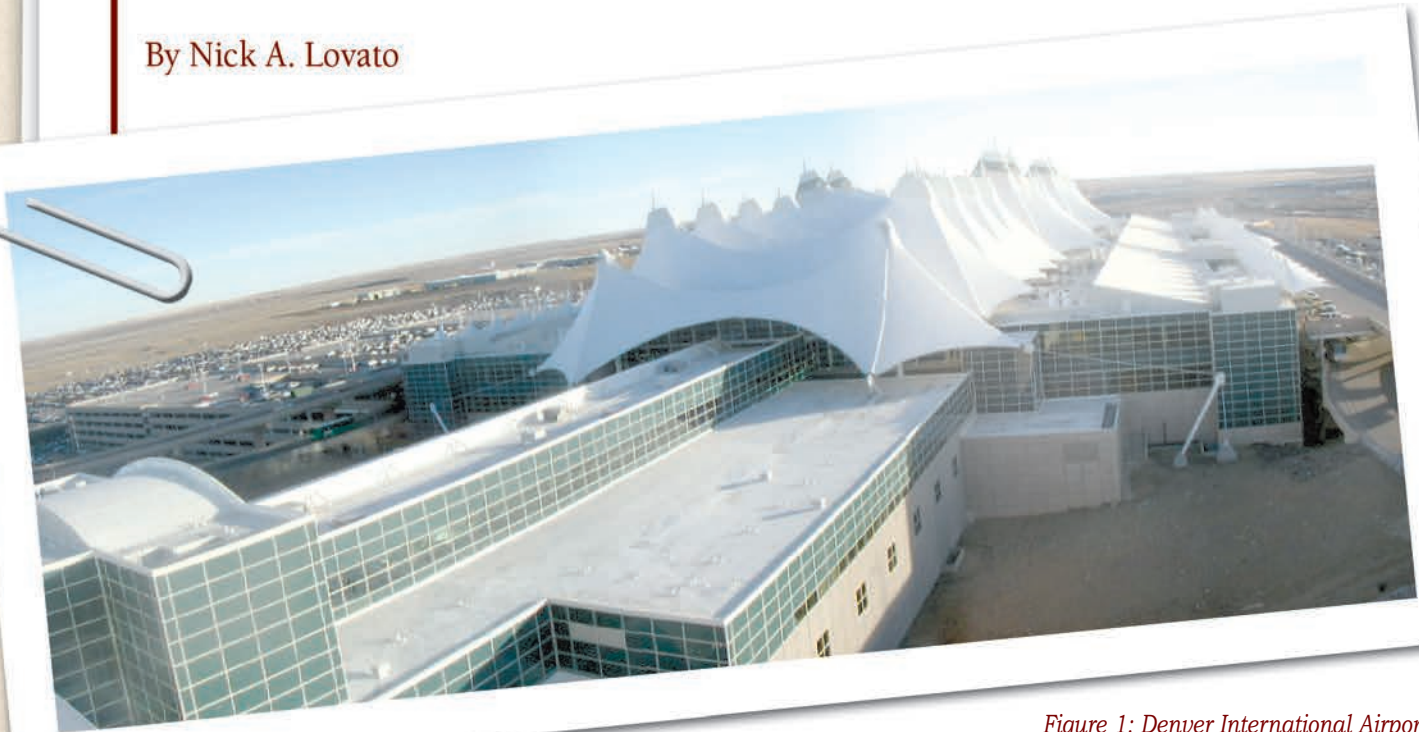


Figure 1: Denver International Airport.

ABSTRACT

As a result of a moderate hailstorm in June of 2001, the original eight-year-old reinforced PVC single-ply membrane on the flat roofs over the Jeppesen Terminal and passenger bridge at the Denver International Airport (DIA) experienced moderate to extensive hail damage. The subject roofs are adjacent to the impressive and renowned Bird Air tent roofs, which were not damaged by the hail. After careful consideration of many different roof systems, the roof membrane was replaced with a non-reinforced, fully-adhered, 90-mil ethylene propylene diene monomer (EPDM) that was painted with a white elastomeric roof coating. The evaluation, design, and construction of the new roof presented the owner, design team, and contractor with some unique challenges and experiences that are shared in this case study. The topics that will be discussed are:

1. Logistics of reroofing an aviation facility and the security challenges of post 9/11/2001,
2. Emergency measures that were taken to prevent further damage to the roof and building components prior to and during construction,
3. Results of the evaluation of the roof systems and existing conditions,

4. The selection process for the new roof membrane, recover board, and roof coating; and
5. Design parameters of the project.

For this project, the fully-adhered, 90-mil EPDM roof was determined to be the least intrusive and the best system to provide adequate resistance to hail and mechanical damage. The designers and owners expect the new EPDM roof to provide excellent service in a hail hazard zone and achieve a useful life that far exceeds the norm.

Client: City and County of Denver

Architect: DMJM H+N, Denver, CO

Roof consultant: CyberCon Engineering, Inc., Centennial, CO

Roofing contractor: Earl F. Douglass Roofing, Commerce City, CO

Product supplier, roofing membrane: Firestone Building Products Corp.

Product supplier, coverboard: Georgia Pacific

Product supplier, premanufactured coping: Peterson Aluminum

INTRODUCTION

This article will discuss the results of CyberCon's initial investigation of the roofs at the DIA, design considerations for reroofing, and some of the challenges that were encountered during the reroofing process. This paper will also discuss the characteristics, physical properties, and some of the pitfalls of the roofing products used and the rationale for selecting an elastomeric thermoset roofing membrane and dense, water resistant coverboard for reroofing. For most discerning readers, the information provided will be a quick refresher on polymer chemistry, mechanics of materials, moisture vapor transmission, thermal properties, and sound roofing practice. For the roof consultant in training, it is hoped that the information provided will inspire further study of the topics discussed.

DIA is a commercial air carrier facility 23 miles northeast of the metropolitan Denver area, on 34,000 acres of the high mountain desert prairie of Colorado. The airport has six active runways and handles approximately 104,000 enplanements each day. The terminal and concourse facilities represent a total of 5.45 million square feet with a total of 94 passenger-loading gates. The airport structures consist of a main terminal and three remote concourse buildings (A, B, and C), which are connected via an underground automated transportation system. Concourse A is connected to the North terminal via a pedestrian bridge.

An international airport presents challenges that are unique due to its 24/7 operations, ongoing public activity, security, and the sensitive nature of the airplanes. Special considerations are necessary for reroofing to address noise, odors, and risks to the operations of the facility.

Our findings and conclusions from the investigation of the original roof systems may also be of interest to the reader. The following will be discussed in more detail in the body of this article:

- Hail damage to weathered reinforcement PVC membranes.
- PVC degradation as a function of its environment and raw materials.
- Designing resistance to mechanical damage of a membrane.
- Long-term serviceability of a PVC membrane.
- Slip sheet damage below mechanically fastened single-ply membranes.
- Premature plasticizer migration.
- Heat degradation of polystyrene.

- Vapor diffusion and degradation of polyisocyanurate.
- Thermal profile of black EPDM membrane versus a high albedo coating.
- Failure of butyl-based glued seams on an elastomeric membrane.

In the final analysis, it was determined that a fully-adhered EPDM membrane, coated white, installed over a glass-faced gypsum coverboard, mechanically fastened over the existing polystyrene and polyisocyanurate rigid insulation, would be the best reroof option for the DIA. The new roof has passed severe hail and wind tests and has excellent weathering characteristics. It is anticipated that the roof coating will weather away at approximately 1 mil per year and therefore have to be reapplied in approximately 12 to 15 years. The serviceable life of the roof should extend well beyond 30 years. The life cycle cost was deemed to be comparable to other membrane systems, despite the anticipated cost of recoating the roof. The rationale for selecting an EPDM roof system will also be discussed in this article.

DEFINITIONS

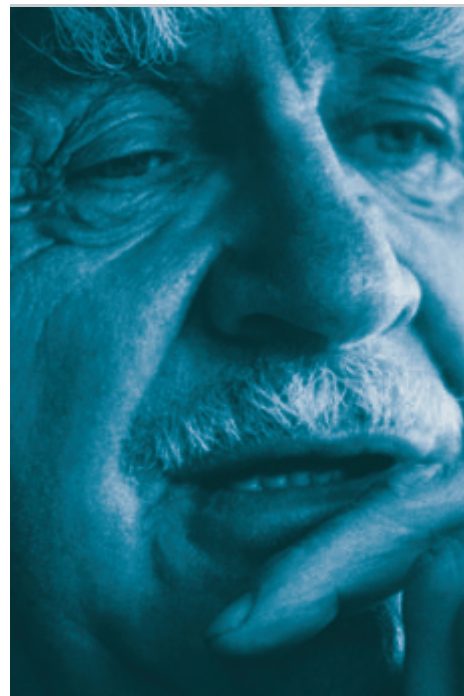
Absolute Humidity – A measure of the actual amount of water vapor contained in a unit volume of air; distinct from “relative humidity,” which is the ratio of air’s absolute humidity to the air’s water vapor holding capacity.⁹

Diffusion – The process whereby water vapor or gases migrate through permeable membranes or partitions by osmosis. Gases always migrate from regions of high concentrations to regions of low concentrations until equilibrium is reached.

Elastomer – A macromolecular material that, at room temperature, returns rapidly to approximately its initial dimensions and shape after substantial deformation by a weak stress and release of the stress.⁴

Glass Transition Temperature – The temperature at which a polymer becomes brittle, and above a certain point, the polymer is deemed prone to failure.²

Plasticizer – An important component in the formulation of PVC membranes to give them flexibility to withstand elongation, strain, and thermally-induced stresses normally experienced by a roof system. Most plasticizers are esters of phthalic acid. The molecular weight and compounds vary from one manufacturer to the next. The plasticizer content in a new membrane is around



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PROBLEMS WITH THE EXISTING ROOF SYSTEMS		
SYSTEM NO.	EXISTING CONDITIONS:	OBSERVATIONS:
1. Low-slope areas of terminal, east and west of the tent roof	Deck: Structural concrete (sloped at 1/4"/ft.) Insulation: 4" of extruded polystyrene (XEPS) Slip Sheet: Manninglass felt Membrane: 60-mil reinforced mechanically-attached PVC	<ul style="list-style-type: none"> • Extensive hail damage and mechanical damage from icicles falling off of tent roof • Plasticizer loss • Damaged slip sheet • Thermal degradation of PVC • Isolated heat degradation of polystyrene • Minor corrosion of fasteners • Consolidation of insulation in high-traffic areas
2. Low-slope roofs on North Terminal and Customs areas	Deck: Structural concrete (flat) Insulation: Tapered XEPS 4.5" start, (sloped at approximately 1/4"/ft.), total maximum thickness 16" Slip Sheet: Manninglass felt Membrane: 60-mil reinforced mechanically-attached PVC	<ul style="list-style-type: none"> • Extensive hail damage • Plasticizer loss • Damaged slip sheet • Thermal degradation of PVC • Isolated heat degradation of polystyrene
3. Mechanical and elevator penthouses at terminal	Deck: Metal (sloped at 1/4"/ft.) Barrier Board: 5/8" Type X gypsum Insulation: 2 layers of XEPS, 1" and 3" for a total thickness of 4" Slip Sheet: Manninglass felt Membrane: 60-mil mechanically-attached PVC	<ul style="list-style-type: none"> • Minor hail damage • Plasticizer loss • Damaged slip sheet • Thermal degradation of PVC
4. Steep-slope areas of Terminal East and West	Deck: Structural concrete (sloped at 3"/ft.) Insulation: 2.6" polyisocyanurate Membrane: 60-mil mechanically-attached PVC	<ul style="list-style-type: none"> • Extensive hail damage • Plasticizer loss • Thermal degradation of PVC • Minor corrosion of fasteners • Minor facer delamination
5. Passenger bridge (slope 0" to 1"/ft.) and barrel roof over Customs (0" to 3"/ft.)	Deck: Metal (sloped 0" to 3"/ft.) with fireproofing on bottom side Barrier Board: 5/8" Type X gypsum Insulation: 2.6" of polyisocyanurate Slip Sheet: Manninglass Membrane: 60-mil mechanically-attached PVC	<ul style="list-style-type: none"> • Extensive hail damage • Plasticizer loss • Thermal degradation of PVC
6. Airport Operations Building (AOB) above 10th floor offices	Deck: Structural Concrete (sloped at 1/4"/ft.) Insulation: 2.6" polyisocyanurate mechanically attached Membrane: Fully-adhered .060" un-reinforced EPDM	<ul style="list-style-type: none"> • Severe buckles and deformation of polyisocyanurate • Severe facer delamination • Degradation of insulation cell structure (1/4" to 1/2" of the top layer turned brown and friable). • Extensive failure of adhesive seams • Corrosion of fasteners
7. AOB Penthouse	Deck: Metal (sloped at 1/4"/ft.) fireproofing on bottom side Insulation: 2.6" polyisocyanurate, mechanically attached Membrane: Fully-adhered .060" unreinforced EPDM	<ul style="list-style-type: none"> • Deterioration of lap sealant <i>The rigid insulation was deemed salvageable</i>
8. AOB 6th floor offices	Deck: Structural concrete (flat) Insulation: Tapered polyisocyanurate (4" start, sloped at approximately 1/4"/ft.) Membrane: Fully-adhered .060" unreinforced EPDM	<ul style="list-style-type: none"> • Buckles and deformation of polyisocyanurate • Isolated facer delamination • Degradation of insulation cell structure (1/4" to 1/2" of the top layer turned brown and friable). • Failure of adhesive seams • Minor corrosion of fasteners

Table 1: Problems with existing roof systems.

36%. A loss of 10 to 12 percent can result in premature failure of the roof system. Low molecular weight plasticizers are more volatile than those that have higher molecular weight.¹

Thermoplastic - A material that becomes plastic or viscous when heated and semi-rigid when cooled. Asphalt and PVC are classic thermoplastic materials.

BACKGROUND

Construction of DIA

The construction of the terminal and Airport Operations Building (AOB) was completed in 1991 and the passenger

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Figure 2:
Hail-damaged membrane.

bridge was completed in 1993. The roofs on the terminal, AOB, and passenger bridge were replaced in 2002. Eight different roof systems were identified. The following is a brief description of the roof system components and the type of problems noted.

DISCUSSION

Thermoplastic PVC Membranes

As early as 1999, only eight years after the original roof was installed, the PVC roofs on DIA began showing signs of degradation and premature plasticizer loss. Melting of the extruded polystyrene rigid insulation was also noted, particularly in super insulated areas with southern exposure to the sun. In June of 2001, a moderate hailstorm hit the airport, causing extensive damage to the PVC membrane on the terminal. The membrane did not shatter (unlike some of the first-generation PVC roof systems); however, concentric cracks were noted in the membrane at points of hail impacts. In most cases, the cracks ran completely through the membrane, rendering the roof system unsuitable as a waterproofing system. In some instances, the cracks emanated from the underside of the single-ply membrane, but did not manifest on the top or exposed side of the membrane.

The damage noted was more extensive on the darker discolored sheets used to construct the PVC membrane, (which apparently had different run numbers), and in areas that were exposed to more solar radiation. New cracks developed in the membrane at hail impacts that were not noticeable during the first visual inspection. The visible cracks were repaired immediately with EPDM primer and EPDM peel-and-stick flashing tape. The repairs were paint-

ed white to prevent thermal degradation of the polystyrene insulation below.

Frequent inspections were performed to identify new cracks and to effect repairs to prevent water infiltration through the existing single-ply membrane. Fortunately, the re-roof project was performed during a drought, which was recorded as the driest period in the previous 50 years.

The original roof system specified and installed on the vast majority of the buildings at DIA was an off-white, 60-mil, polyester scrim reinforced, mechanically-fastened PVC single-ply membrane, which was produced using the calendaring process. PVC is a thermoplastic material, which means that it becomes softer (or more plastic) with heat and semi rigid with cold. PVC is known for its resistance to acids, alkalis, and many other chemicals, as well as its self-extinguishing properties when subjected to fire. It is soluble in certain solvents, such as tetrahydrofuran, which is used in PVC cements.³

One of the main reasons PVC was used on the airport is that it was perceived that the membrane might be exposed to jet fuel. It was also one of the few membranes on the market that had a UL fire rating for all roof slopes encountered at the airport. The membrane, with its heat-welded and solvent seams, was also touted to be superior to other conventional roof systems, despite the lack of a long-term performance history.

Much has been learned about thermoplastic PVC single-ply membranes since they were introduced in the U.S. from Europe in the late 1970s. The non-reinforced sheet is no longer produced or marketed due to the shattering phenomenon and hail damage that occurred with the product. All of the sheet goods marketed and sold in the U.S. today (except for flashing materials) are reinforced with polyester or fiberglass mats or scrims, which

have greatly improved the dimensional stability of the original non-reinforced products. The membrane can be manufactured white or tinted in various colors with pigments, which is an advantage when solar reflectivity or an architectural statement is desired. The heat welding of the seams, using hot air welders, is also fairly consistent and reliable.

PVC copolymers in their normal state are rigid, brittle, and easily shatter under stress. Plasticizers, fillers, pigments, processing oils, biocides, and stabilizers are compounded with the PVC resins to impart the desired physical properties to the membrane. Plasticizers are used to give the sheet flexibility and suppleness over a wide range of temperatures. Stabilizer packages are introduced to provide resistance to thermal and photochemical degradation.

Plasticizers begin to migrate out of the sheet and the chemical bonds begin to change as soon as the membrane leaves the production line. This phenomenon, known as weathering, is normally a very slow and gradual process, which under favorable conditions, allows a PVC membrane to provide a useful life commensurate with other conventional roof systems. The glass transition temperature and specific gravity are increased and shrinkage of the membrane occurs as a result of thermal degradation and plasticizer loss. Exposure to heat, ultraviolet radiation, and various absorbent



Figure 3:
Patches from hail damage.

compounds will accelerate the degradation of PVC. Thermal degradation is manifested by a brown color, as the membrane goes through dehydrochlorination of the polymer.² Plasticizer loss occurs by migration, evaporation, washout, hydrolysis, and exposure to microbes.¹

Polystyrene rigid insulation (which was used extensively on the airport) has an affinity for PVC plasticizers; therefore, the two roof components must be adequately divorced for the duration of the roof's useful life. PVC membranes should also be adequately divorced from asphalt-contaminated surfaces for the same reason.

As PVC weathers, it loses some of its elasticity and flexibility. It has been demonstrated that new PVC membranes will generally produce a tensile load of 4-6 pounds per inch when subjected to a 100°F temperature drop. As the membrane weathers and becomes more brittle, the thermal load profile can increase fourfold to 20 plus pounds per inch.¹ It has been suggested that the shrinkage and thermal load profile of a PVC membrane can be affected by the manufacturing process and raw materials used in the products.² The extent of the effects from manufacturing is beyond the scope of this article.

The shattering phenomenon that occurred with the first generation PVC non-reinforced membranes can be attributed to plasticizer loss, shrinkage, lack of flexibility, and increased thermal loads during sudden drops in temperature. Hail and impact

damage to reinforced thermoplastic membranes can also be attributed to the same changes in physical properties; however, the mat or scrim prevents a weathered membrane from shattering into thousands of smaller pieces. Isolated cracks through the membrane, generally in the form of concentric circles, are usually noted after a hail event or impact, which compromises the watertight integrity of the membrane. The kinetic energy of a missile is converted to strain energy in the membrane, compressive yield stress in the substrate, disintegration of the missile, and momentum after impact.

Hailstorms are usually preceded by a sudden drop in temperature, which, as discussed above, causes the membrane to shrink, resulting in thermally induced loads in the material. At the moment of impact, the membrane begins to deform, and, as with any material "under load," develops additional tensile stresses on the underside and compressive stresses on the top side of the membrane. If the strain exceeds the elastic limit of the material at the time of impact, cracks begin to emanate from the bottom side toward the top surface. An underside view of the membrane is needed to ascertain the full extent of hail damage,

since cracks may develop but not penetrate completely through the membrane.

Impact resistance of the membrane can be improved by providing a denser substrate below the membrane, which resists deformation and elongation, thus minimizing the strain energy imparted to the membrane. Bridged or unsupported areas are still vulnerable to damage.

The long-term serviceability of a PVC roof membrane is a function of its dimensional stability and flexibility throughout the temperature range it will experience during its anticipated serviceable life. The stability of these physical properties is a function of the raw materials, manufacturing process, and environment to which the roof system is exposed.

Polystyrene Rigid Insulation

The vast majority of insulation used on the original roof at the airport was extruded polystyrene, which ranged in thickness from 4" (R-20 on structurally sloped areas) to 14" (R-20 to R-70 on the flat decks with tapered insulation). Most of the insulation board was deemed salvageable, which represented a sizeable investment by the owner, the city, and the county of Denver.



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Figure 4: Melted XEPS.

The new roof system had to be compatible with the existing polystyrene rigid insulation. A new, ballasted, single-ply membrane over a coverboard would have been an economical choice on any other project. The owner's choice to eliminate any roof system with loose rocks, which could become missiles during high winds, was respected and other reroof options were considered.

Extruded polystyrene is a plastic foam, closed-cell rigid insulation with a fluorocarbon blowing agent. The polymer that makes up the cell walls is relatively impermeable to water vapor, which renders the product useful in areas that may become exposed to moisture, (i.e., foundation walls, roofs, wall cavities, protected membrane roof assemblies, etc). It has a fairly stable aged R-value of 5.0 per inch.

Extruded polystyrene is considered a sustainable roofing product and can be salvaged for subsequent membrane replacements, under favorable conditions. The product has a published service temperature range of -100 to 165°F; therefore, it must be protected from temperatures above this range. This can be accomplished with slip sheets, coverboards, and reflective membranes or coatings. Polystyrene will disintegrate when exposed to various solvents, including membrane adhesives, cold process cements, and other petroleum-based chemicals. A limited number of adhesives are suitable for laminating polystyrene boards to one another and to other products. Solvent-free, rubberized emulsion adhesives have been developed that are compatible with polystyrene.

When the existing membrane was removed, it was noted that some of the

extruded polystyrene rigid insulation boards had melted or deformed from heat, particularly where the slip sheet was damaged or missing, and in areas next to the reflective clerestory windows (refer to Figure 1 for view of window areas). To melt extruded polystyrene, the temperature needs to reach 165°F or greater, according to the manufacturer's published literature.

The ambient air temperature directly above the membrane was noted to be 95°F on a hot summer day. The melting indicates that the temperature between the membrane and the polystyrene

exceeded the air temperature by 60°F to 70°F, which is incongruous with static thermo profiles of building envelopes that have been presented in the past. The slip sheet protected the polystyrene somewhat, but did not prevent deformation of the insulation board. Insulation boards that were severely deformed or melted were replaced with like kind.

A single layer of 5/8" glass-faced gypsum board with a primed surface was installed over the existing polystyrene rigid insulation (secured with mechanical fasteners and Galvalume™ metal plates) to provide a dense, hail-resistant substrate for the new membrane and divorce the polystyrene from the elevated temperatures that were anticipated with the new black EPDM membrane. A couple of isolated areas, near clerestory reflective windows, experienced some heat degradation and had to be repaired (Figure 4).

The new black EPDM membrane was painted white to lower the surface temperature of the roof during the hot summer months, which will prevent the polystyrene from melting. During re-roofing (after the new black 90-mil EPDM membrane was installed, and prior to the application of the white elastomeric coating), and when the ambient air temperature reached

or exceeded 100°F, some severe deformation in the underlying polystyrene rigid insulation occurred in isolated areas (next to intersecting clerestory windows). The surface temperature of the black EPDM membrane was measured at 180°F at approximately 1:30 p.m. on a hot summer day. The membrane in these areas, next to the reflective windows, received much more solar radiation than other areas of the roof. As soon as the high-albedo, white roof coating was installed, the surface temperature dropped significantly to approximately 105°F, which prevented any further damage to the top layer of the polystyrene rigid insulation board.

Polyisocyanurate Rigid Insulation

Polyisocyanurate rigid insulation (PRI) with a permeable organic facer was used on some areas of the airport. When the roof was installed, hydrochlorofluorocarbons (HCFCs) were used as blowing agents for the plastic foam insulation boards. Various roof systems, using this product, were encountered:

- Mechanically-fastened reinforced PVC membrane over a single uniform layer of PRI over a structurally sloped concrete deck.
- Mechanically-fastened reinforced PVC membrane over a single uniform layer of PRI over a structurally sloped metal deck.
- Fully-adhered non-reinforced EPDM membrane over tapered PRI boards, mechanically fastened over a flat concrete deck.

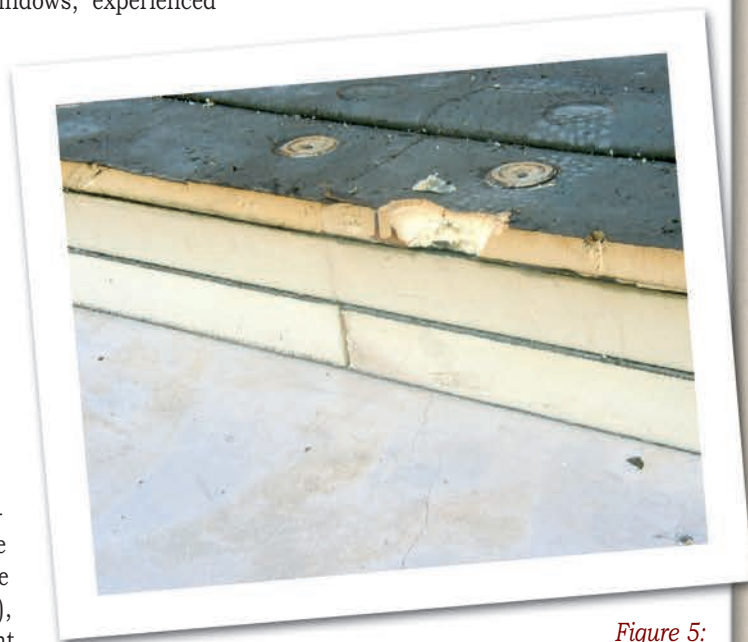
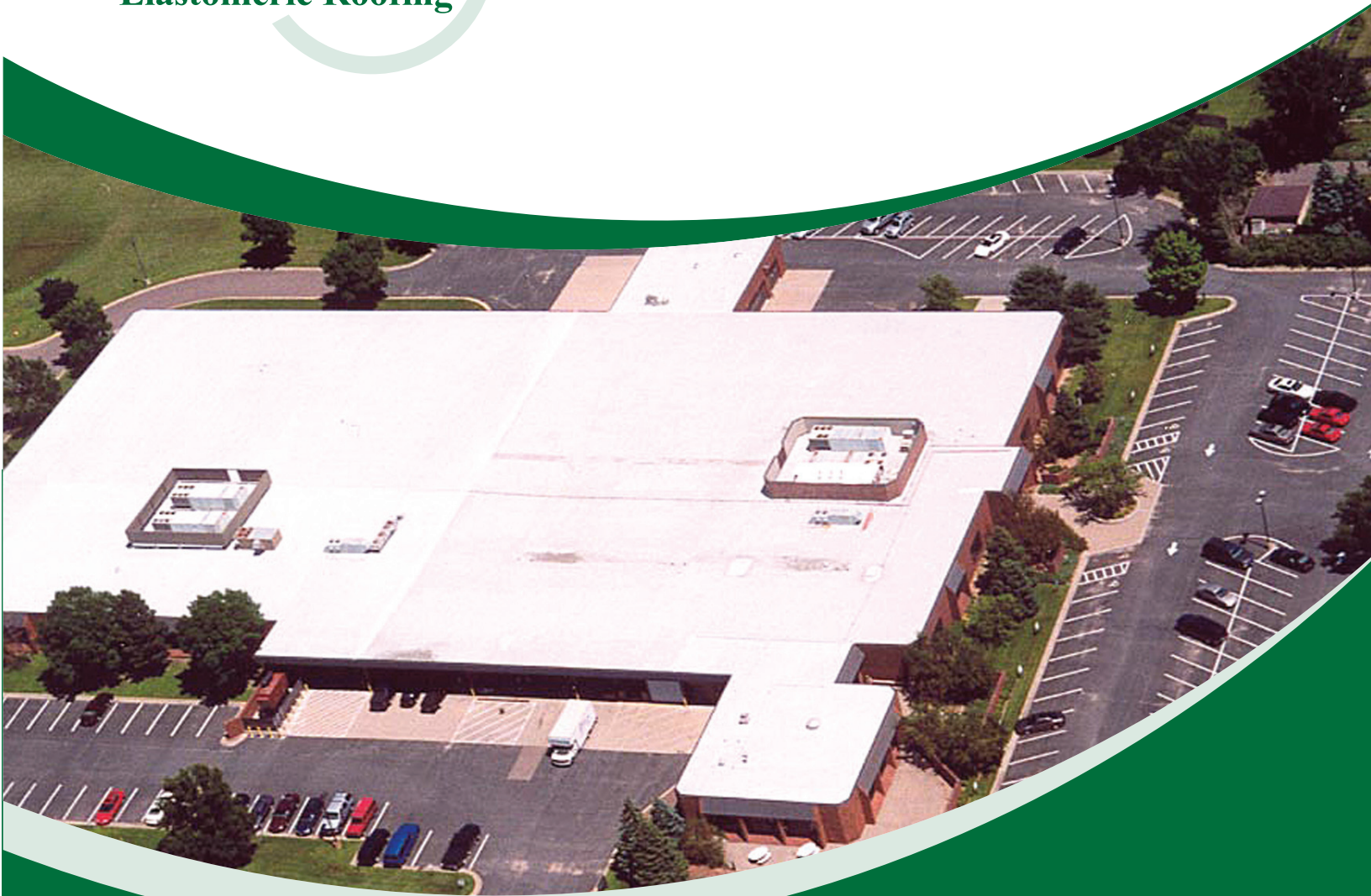


Figure 5: Damaged oxidized polyisocyanurate.

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- Fully-adhered, non-reinforced EPDM membrane over a single uniform layer of PRI, mechanically fastened over a structurally-sloped concrete deck.
- Fully-adhered non-reinforced EPDM membrane over a single uniform layer of PRI, mechanically fastened over a metal deck.

On the concrete deck areas, several problems (moderate to severe) were noted that were not evident on the metal deck areas. The organic facer was deteriorated, the membrane was delaminated from the facer, the insulation board was buckled in a convex fashion, the top 1/4" layer of the board was discolored and friable, the insulation fasteners and plates were corroded, and the glued EPDM seams were delaminated (refer to Figure 5). Each one of these problems can be attributed to the effects of moisture. Residual water from the poured-in-place concrete was the probable source of the initial moisture, causing the EPDM seams to fail within a relatively short time, which precipitated the damage to the insulation board and fasteners. More water entered the roof system via open seams, which exacerbated the deleterious effects of moisture on the roofing components. There was evidence that patches and repairs were made when leaks occurred, but the residual moisture was probably not removed.

The facer is a critical and integral part of polyisocyanurate rigid insulation products. It provides dimensional stability and fire resistance to the insulation board and a means to adhere a roof membrane to an otherwise unstable and friable material. If organic facers become wet, the fibers expand, allowing the dimensionally unstable plastic foam board to expand or contract, resulting in "bowing" or "cupping" of the board. When the cellulosic facer dries, it shrinks, imparting stress on the board. If the roof system goes through enough wetting and drying cycles, the structural integrity of the facer becomes compromised and a fully-adhered membrane will eventually become disbonded.

Polyisocyanurate foam is a cellular plastic insulation that entraps a gaseous blowing agent within microscopic cells of a polymer matrix. The cells of the foam are primarily closed, and due to the low thermal conductivity of the entrapped gas, the foam is an effective insulator. The cell walls are permeable and, with time, the blowing agent(s) can escape from the cells while ambient gases such as N₂, O₂, and H₂O vapor diffuse relatively quickly through the cell walls and permeate the foam. The resulting change in the gas composition of the foam over time, and the corresponding decrease in its insulating capability, are referred to as "aging" of the foam.⁸

Studies have shown that in the presence of heat and moisture, the aging process of plastic foam insulation products is accelerated and the physical properties – thermal conductivity, compressive strength, density, coefficient of linear expansion, and vapor permeability – are affected substantially above 120°F (49°C). Under dry conditions, polyisocyanurate foam insulation is dimensionally stable (<5% change in dimension and <15% by volume) up to 220°F (104°C). At temperatures above 120°F (49°C) and a relative humidity above 90%, the

product becomes dimensionally unstable: (5 to 20% dimensional changes in each direction and 15 to 60 percent change in volume can occur).¹

Over wet substrates, weathering, moisture gain, and dimensional changes in polyisocyanurate foam insulation products tend to be more pronounced with dark roofs, due to the elevated temperatures. The designer or installer of a roof system should properly evaluate the presence of moisture. Non-destructive moisture evaluations are highly recommended for recovers where trapped moisture is probable. Cementitious decks should be checked for moisture content if a vapor retarder is not used or specified. On new construction, vapor retarders are recommended over concrete decks to prevent the residual moisture from affecting the roof system components. Studies are being done on the drying effects of loose-laid, pressure-equalized venting single-ply roof systems. The long-term viability is still being researched.¹¹

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

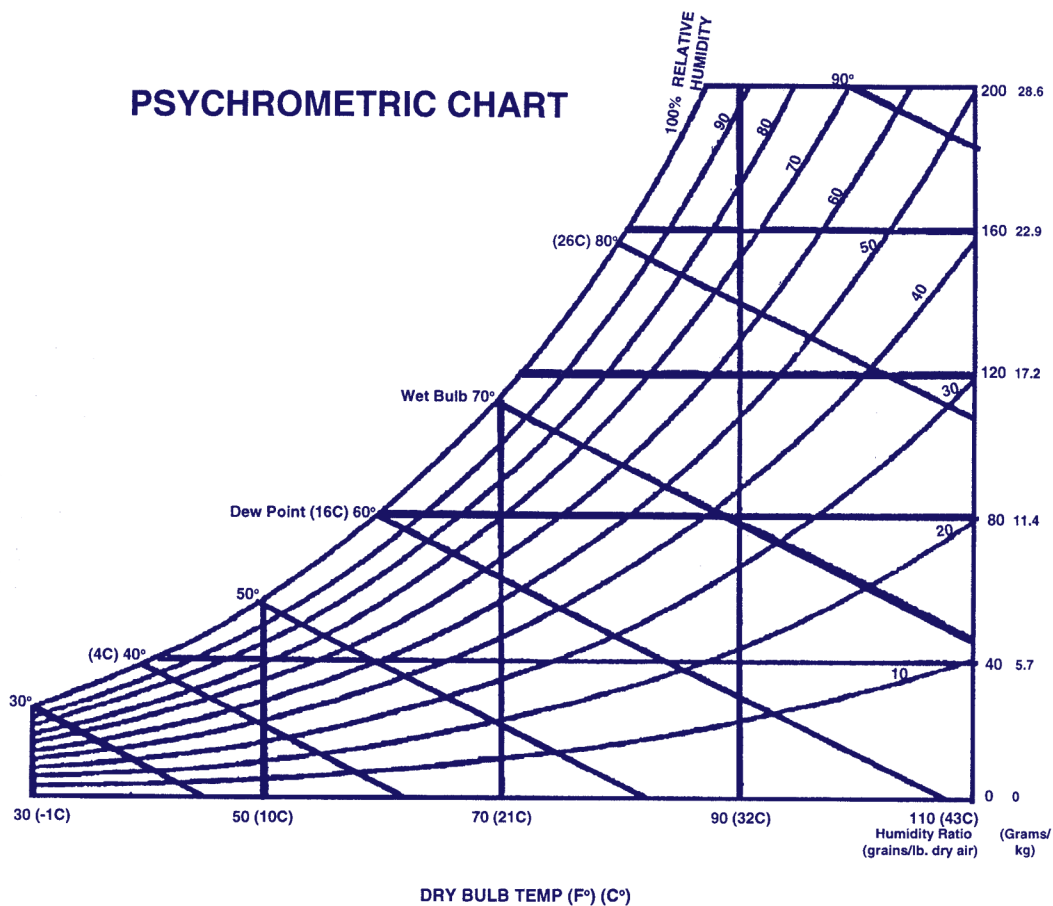


Figure 6: Psychrometric chart, courtesy of RIEL.

YEAR OF INTRO:	TECHNOLOGY IMPROVEMENTS
1985 - 1986	Butyl-based splice adhesive replaces water- and heat-sensitive Neoprene-based adhesives.
1985 - 1986	EPDM-based wall flashings replace heat- and ozone-sensitive Neoprene-based flashings.
1987 - 1988	Tape laminates replace adhesive seams at roof edges and battens.
1988 - 1989	Metal battens and screw fasteners replace treated wood nailers and nails at base tie-ins.
1991 - 1992	Reinforced perimeter fastening strips introduced as an alternative to metal battens for base tie-ins.
1992 - 1993	Seam tape with high solids primer replaces seam adhesive.

Table 2

diffusion. Thickness of a material also affects the permeability or rate of diffusion. In most building situations, warm air tends to have a higher absolute humidity than cooler air. This gives rise to the adage, "water vapor goes from hot to cold." This is not necessarily true for buildings with unusually high or low interior humidity or buildings with wet or moisture-laden components. Water vapor migration is usually not a concern until the gaseous molecules reach the dewpoint temperature and condense into liquid water.¹⁰

Foam insulation products can become wet by vapor diffusion followed by condensation. Water accumulates in the foam when vapor drive acts in concert with thermal gradients and the vapor is restricted on the cold side of the building envelope. Moisture accumulation is reversible, which means foam insulation can eventually dry out, if allowed to, by vapor diffusion.

On the airport project, evidence shows that the permeability of the EPDM membrane was not sufficient to allow adequate amounts of water vapor to escape to the atmosphere. The polyisocyanurate rigid insulation and facer at the DIA project experienced numerous cycles of wetting and drying as a result of the residual moisture trapped between the deck and black EPDM membrane. The black membrane reached temperatures of 180°F in the summer, which increased the thermal gradient, vapor pressure, and therefore, the vapor diffusion rate, thereby accelerating the degradation of the foam insulation and facer on the top side of the boards. This, however,

would not explain the brown discoloration of the top surface of the insulation board (refer to Figure 5), which is usually indicative of photochemical oxidation. The solvents in the bonding adhesive, in concert with moisture and heat, may have reacted with the polymer matrix of the insulation board. Further study is needed. This demonstrates the need for a vapor retarder over freshly-poured (moisture-laden) concrete decks.

Elastomeric EPDM Single-ply Membranes

EPDM is an elastomeric thermoset polymer synthesized from ethylene propylene and a small proportion of a diene monomer with rubber-like or elastic properties. The black membrane, which has carbon black as a UV inhibitor, has excellent weathering characteristics. EPDM is not resistant to petroleum oils and gasoline.³ The membrane will swell and soften when exposed to these chemicals. Other than silicone, EPDM has the best service temperature range of any elastomeric membrane on the market (-65 to 300°F). A non-reinforced membrane has a tensile strength of 1400 lbf/in² and an ultimate elongation of 300%. EPDM also performs very well under heat and exposure to ozone. EPDM membranes have a proven track record. Due to improved product technology and superior details, problems with shrinkage and failed seams have greatly diminished since the product was first introduced to the roofing market more than 25 years ago.¹²

It was decided that a black, 90-mil, non-reinforced EPDM membrane would be

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ROOF REPLACEMENT OPTIONS	PROS AND CONS
Built-up roof	Rejected because of asphalt fumes, loose rock, and potential for melting existing polystyrene.
SBS modified, hot- or cold-applied	Rejected because of asphalt or solvent fumes and potential for melting existing polystyrene.
APP modified, torch or cold-applied	Rejected because of risk of open flames and the negative effect of solvent fumes on polystyrene.
PVC	Rejected because of past experience at airport.
TPO	Rejected because of limited performance history.
EPDM ballasted	Rejected because of loose rock or pavers.
EPDM mechanically attached	Rejected because of dynamic forces on membrane and fasteners and noise from the extensive use of fasteners.
EPDM fully-adhered	Accepted because of durability, low life cycle cost, excellent resistance to wind and hail, and minimal intrusion on facility operations.

Table 3

installed over a layer of 5/8" glass-faced gypsum board, which was mechanically fastened over the existing salvaged polystyrene rigid insulation. The only drawback perceived with the EPDM roof on the airport was its black color, which gets hot during the summer months from solar radiation. The temperatures would get hot enough to cause deformation of the existing polystyrene insulation board.

White EPDM, which has a titanium dioxide UV inhibitor, was rejected because the product does not have the same weathering properties as black EPDM, which uses carbon black. It was decided to coat the roof with approximately 15 mils of a high albedo white acrylic elastomeric roof coating, after washing and priming the membrane. Prior to coating, seams of the EPDM sheets were mated with 3"-wide butyl seam tape and a high-solids, butyl-based primer. The seams were then covered with a 5"-wide, butyl-backed, self-curing EPDM flashing tape. This seaming method provided redundancy and ensured that any small pinholes – particularly at tee joints – were sealed watertight for the serviceable life of the roof membrane.

The hail and puncture resistance are excellent with EPDM when installed over a

hard board. The fully-adhered EPDM over 5/8" glass-faced gypsum board has passed the most severe hail tests and has received the highest ratings from United Laboratories (UL), the National Institute of Standards and Technology (NIST), and Factory Mutual (FM) for hail resistance. A 2" hail warranty was issued by the roofing manufacturer.

The membrane installation was rather innocuous, but some precautions were needed to avoid adhesive fumes from being drawn into the building through the fresh air intakes of the mechanical air handling system. Plywood chutes eight feet high were built around the fresh air intakes and were very effective.

High Albedo White Roof Coating

A white roof coating was specified and installed to lower the surface temperature of the roof in order to prevent the polystyrene rigid insulation from heat degradation. The coating also provides the following benefits:

- Encapsulates all seams and edges of the membrane and flashing materials, thereby providing additional redundancy in the waterproofing system.
- Protects the membrane and flash-

ings from heat and UV exposure, extending service life.

- Greatly reduces the temperature gradient of the roof, which lowers the relative humidity and vapor drive within the roof system components.
- Provides an aesthetic appearance to the roof.

It is anticipated that the coating will weather at the rate of 1 mil per year. This gradual chalking process is what keeps the roof white and highly reflective for the life of the coating. It is anticipated that the roof may need to be recoated at least once during its useful life. The cost of the coating is offset by the savings achieved from the extension of the useful life and reduced energy consumption during the summer to condition the air in the building.

The peel strength and adhesion of water-based acrylic roof coatings have improved greatly since primers or "pre-washes" were introduced. Practically all manufacturers of roof coatings and EPDM membranes offer white coating specification and warranties. The prewash was lightly sprayed on the surface of the finished EPDM roof and then rinsed off with water. After the membrane dried, the water-based coating was applied with rollers. To avoid overspray, a spray apparatus was not used.

Water-based acrylic coatings perform best on roofs with adequate slope and drainage. Ponding water will cause the coating to swell and peel away from the membrane. When exposed to standing water for prolonged periods, moisture will be absorbed into the coating, causing dimensional changes. This induces shear stress at the adhesive bond. If the water absorbed into the coating freezes, the coating will break down and eventually delaminate from the substrate.

ROOF SYSTEM SELECTION PROCESS

Owner's Concerns

As one can imagine, the facility management and engineering staff had several concerns and expectations with regard to the new roof systems. With the exception of one roof area (System No. 7), the original roofs did not perform as anticipated and had to be replaced prematurely due to hail damage and degradation of the physical properties of the polyisocyanurate rigid insulation and PVC roof membranes. The manufacturer's roof guarantee did not cover hail damage, and the manufacturer would not participate

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in replacing the roof because of the change in the membrane's physical properties and likelihood of further hail damage. Because of the premature degradation of the PVC membrane, foot traffic on the roofs had to be limited to times when the outdoor ambient temperature was 40°F or above. The design team had to come up with a roof that would address the following issues:

- **Heat Aging:** The high R-values (super insulated roof at apex of tapered insulation system) and the reflective glass on the clerestory windows places the membrane in an environment with abnormally high heat and solar radiation. The new membrane must have good heat aging properties.
- **Sustainable:** The new roof system must be compatible with the existing polystyrene insulation boards. A large investment had already been made with the thermal insulation and tapered system.
- **Low Meltpoint of XEPS:** The temperature of the membrane must remain well below the melt point of the polystyrene insulation board.
- **Hail Resistance:** The new membrane must be proven to withstand hail.
- **Facility Operations:** The roof replacement process must be as non-intrusive as possible, and the finished roof must not utilize loose-laid components that could become missiles in the event of a tornado or high winds. Removing the polystyrene rigid insulation also posed a high risk for the tarmac operations, particularly on windy days.
- **Maintenance:** The roof system should be easy to repair and require little maintenance.
- **Temperature Limitations:** The adhesives and products must be workable during all four seasons of the year, due to the long duration of the project.

Options Presented to Owner

Several roof replacement options were presented to the airport staff. The pros and cons were discussed for each roof type.

PROJECT CHALLENGES

The first and foremost challenge was selecting a roof system that would be as unintrusive and risk free as possible for the facility operations and customers of the airport. The transfer of materials on and off of the roof had to be minimized and the roofing products had to be rather innocuous. By salvaging the majority of the existing insulation board, the owner enjoyed cost savings as well as reducing the risk of debris blowing onto the tarmac.

Security issues were paramount, especially after the September 11, 2001, terrorist attack on the U.S. The contractor had to provide a sufficient number of laborers who could pass the stringent screening methods imposed by the government. Even moving tools onto the jobsite was cumbersome. Personnel on the roof had to be badged and escorted by qualified persons.

Staging was limited and difficult. The airport officials required that staging plans be submitted and approved weeks in advance. Most of the material and debris handling was done at night. Underground tunnels and buildings precluded crane setups to specific areas. Special cranes with long booms were utilized to move materials on and off of the ten-story Airport Operations Building.

Debris, flammable goods, and loose materials could not be stockpiled on the roof. Products and materials that were not properly bundled together had to be removed from the jobsite at the end of each day.

Some parapet wall sections were curved. New sections of coping had to be custom fabricated and pre-finished. Each curved section had to be measured with a template and shipped to the metal supplier for fabrication. Over 100 different coping sections had to be custom made.

The roof had to be installed during dry and warm weather because of the water-based roof coating, which is subject to damage from freezing prior to curing. The established schedule was from April to Novem-

ber. Over 4,000,000 square feet of roofing had to be installed in six months.

Return air intakes were located near the roof level, which presented a potential problem with offensive solvent fumes being drawn into the air handling units and dispersing them into the occupied building. Plywood chutes were constructed around the intakes and anchored with tie-backs to resist wind pressures. This precaution was deemed effective, and no complaints were received with regard to the solvent fumes (refer to *Figure 7*).

CONCLUSIONS

Weathered reinforced PVCs are subject to hail damage. In hail zone areas, designers should consider a hard coverboard that offers more resistance to impact deformation and lowers the strain energy imparted to the membrane.

Polystyrene rigid insulation is subject to heat degradation, even when a light-colored membrane and slip sheet are provided, particularly when exposed to extraordinary solar radiation that occurs with reflective clerestory windows.



Figure 7: Return air chutes.

Fiberglass slip sheets are subject to damage on mechanically-fastened, single-ply roof systems due to fluttering of the membrane on windy days. Slip sheet displacement will result in premature plasticizer migration of PVC over polystyrene.

High thermal R-values and solar reflection from windows accelerate weathering of a PVC roof membrane, resulting in premature plasticizer loss and degradation.

Manufacturing processes, compounds, and environmental exposure can have a major affect on long-term flexibility and serviceability of PVCs.

Generally, polyisocyanurate rigid insulation products perform very well under extreme heat or temperatures often experienced in a roof assembly, even when installed below dark or black membranes which can achieve surface temperatures of 180°F. When moisture is introduced and becomes trapped in the insulation from membrane leaks, vapor diffusion, or residual water in cementitious roof decks, the weathering and degradation of polyisocyanurate rigid insulation are intensified. In such instances, the physical properties and dimensional stability of polyisocyanurate rigid insulation are eventually compromised, and the sustainability of the product is negated.

Concrete decks on new construction are apt to contain large amounts of residual moisture that can have a deleterious effect on some plastic foam insulation products, organic facers, and adhesive seams of elastomeric membranes. Designers and installers should consider vapor retarders over moisture-laden concrete decks to pre-

vent moisture migration and condensation within an insulated roof assembly.

Construction traffic can cause scarring of the roof membrane that will cause latent problems post construction.

The product quality and long-term serviceability of roof membranes differ greatly among manufacturers. In the selection process of a roof system, there is no substitute for time-proven performance.

To be successful, difficult projects require extraordinary planning, synergies from all parties, cooperation, and constant open lines of communication. ©

REFERENCES and FURTHER READING

1. Dr. H.O. Laaly, *The Science and Technology of Traditional and Modern Roof Systems, Volume 1*. Los Angeles: Laaly Scientific Publishing, 1992.
2. Ralph Paroli, Brian Whelan, and Thomas Smith, "Shattering of Unreinforced PVC Roof Membranes: Problem Phenomenon, Causes and Preventions," *Proceedings of NRCA/NIST Tenth Conference on Roofing Technology*, April 22-23, 1993, pp. 93-107, NRCA, Rosemont, IL.



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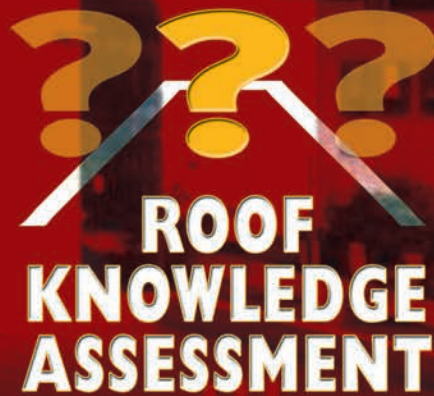
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ROOF KNOWLEDGE ASSESSMENT

Test your knowledge of roofing with the following questions, developed by Donald E. Bush Sr., RRC, FRCI, chairman of the RRC Examination Development Subcommittee. These humidity-related questions are based on information contained in Heinz R. Trechsel's "Moisture Analysis and Condensation Control in Building Envelopes," ASTM Stock Number MNL 40, Chapter I – Moisture Primer.

1. **What four primary factors are required to cause electrochemical corrosion on metals?**
2. **What are the three basic kinds of corrosion?**
3. **How does temperature affect the rate of corrosion?**
4. **One of the basic premises of chemistry is that it is exact and repetitive. All reactions occur from a high level to a low level, be it high concentration to low concentration, high pressure to low pressure, high temperature to low temperature. A term denoting exactness in chemistry is stoichiometric. What is the meaning of this term?**
5. **pH is a numerical mechanism that measures the relative acidity of products in solution by the number of hydrogen ions that are available. What is the mathematical range of pH?**

Answers on page 30



ROOF KNOWLEDGE ASSESSMENT

Answers from page 29:

1. a. an anode
b. a cathode
c. an electrolyte
d. an electrical circuit
2. a. Chemical
b. Electrochemical
c. Physical

These differ according to the degree of involvement of the ions, electrons, and atoms.
3. Increasing the temperature of a corrosive system will normally have the effect of increasing corrosion rates.
4. It means there is an exact quantity of material that will react with an exact quantity of another material.
5. Mathematically it is quantified in a range between 1 and 14; 1 being acidic, 14 being basic, 7 being neutral. Consider concentrated hydrochloric acid at 1, distilled water at 7, and sodium hydroxide at 14.

Reference: Professional Roof Consulting Seminar, Section 8, Roof Consultants Institute.

3. Walter Rossiter Jr. and Robert Math-ey, National Bureau of Standards, "Elastomeric Roofing," *Roofing/Siding/Insulation*, Harcourt Brace Jovanovich, Inc., September 1979.
4. American Society for Testing and Materials, "Standard Definitions of Terms Relating to Rubber, ASTM Designation D-1566-77a," 1977 *Annual Book of ASTM Standards*, Part 37, Philadelphia, Pennsylvania, 1977.
5. American Society for Testing and Materials, ASTM C-755; "Standard Recommended Practice for Selection of Vapor Barriers for Thermal Insulations," ASTM C-755, Philadelphia.
6. N.V. Schwartz, M. Bomberg, and M.K. Kumaran, "Water Vapor Transmission and Moisture Accumulations in Polyurethane and Polyisocyanurate Foams," *Water Vapor Transmission Through Building Materials and Systems; Mechanisms and Measurements*, ASTM, Philadelphia, 1989.
7. American Society for Testing and Materials, Standard Specification for Poly(Vinyl Chloride) Sheet Roofing, ASTM D-4434, Philadelphia.
8. R.R. Zarr and T. Nguyen, "Effects of Humidity and Elevated Temperature on Density and Thermal Conductivity of a Rigid Polyisocyanurate Foam," *Proceedings of the SPI 34th Annual Polyurethane Technical/Marketing Conference*, October 1992.
9. "Moisture Vapor Transmission," The Society of the Plastics Industry, Inc., Polyurethane Foam Contractors Division, Washington, DC 1994.
10. ASTM E-96, "Standard Test Method for Water Vapor Transmission of Materials," ASTM, Philadelphia.
11. Warren R. French, "Post Installation Field Evaluation of a Pressure-Equalized Single-ply Roofing System to Determine Drying Effects on a Moist Cementitious Roof Deck," *Interface*, Roof Consultants Institute, August 1999.
12. James L. Hoff, "EPDM Roof System Performance: An update of Historical Warranty Service Costs," *Interface*, Roof Consultants Institute, September 2003.
13. Jim D. Koontz and Vickie Crenshaw, "Simulated Hail Damage and Impact Resistance Test Procedures for Roof Coverings and Membranes," *Interface*, Roof Consultants Institute, May 2001.

This article, originally entitled, "Reroof Project Case Study: Denver International Airport Terminal Flat Roofs," was presented as a part of the 19th RCI International Convention & Trade Show in April 2004 in Reno, Nevada.

Nick A. Lovato

Nick Lovato is president of CyberCon Engineering Inc., a roofing and waterproofing consulting firm founded in 1991. He graduated from the University of New Mexico with a B.S. in civil engineering and has 25 years of professional experience in roofing, including technical sales support, roof consulting, and construction management. Mr. Lovato has been a member of the Roof Consultants Institute since 1992 and is a past director of Region V. Nick resides in Littleton, Colorado with his wife Candace.



— WOE IS WEDNESDAY —

A new study of data from the U.S. Labor Dept. showed that Fridays and Mondays are NOT the most dangerous days of the week for workers. Conventional wisdom had it that those days were dangerous because people are either tired or looking forward to the weekend. Of 707 fatalities studied in 2003 in construction, Friday actually had the fewest number of weekday deaths (96), while Monday and Wednesday had the most - 148 and 146. The two-hour periods before and after noon contained the most fatal accidents, while the noon hour had the fewest.

— ENR

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Are Ballasted Roof Systems

Cool?

By Dick Gillenwater, Tom Petrie, Bill Miller, and André Desjarlais

This paper was originally prepared in February 2005 for SPRI (Sheet Membrane & Component Suppliers to the Commercial Roofing Industry) and presented at the "Cool Roofing... Cutting Through the Glare" symposium sponsored by the Roof Consultants Institute Foundation (RCIF), Oak Ridge National Laboratory (ORNL), and the National Research Council Canada's Institute for Research in Construction (NRC/IRC).

EXECUTIVE SUMMARY

A combined experimental and analytical study was initiated to quantify the energy savings of ballasted roofing systems and to compare their thermal performance to that of cool roof membranes. The experimental design was structured to evaluate how a mass of three different stone ballast weights and one paver ballast affected heat flux into the building and the build-up of the membrane surface temperature in comparison to the controls (in this case, both a black and a white single-ply membrane).

Experimental work included the initial and subsequent occasional measure of reflectance and initial estimate of the emittance of the test samples, weekly organization of the temperature and heat flux data, and the comparison of the ballast with the white and black membrane thermal performance. This work builds on the earlier work completed and published in "The Field Performance of High-reflectance Single-ply Membranes Exposed to Three Years of Weathering in Various U.S. Climates," which was also prepared by Oak Ridge National Laboratory for SPRI. This study investigated the reflectivity and thermal performance of single-ply membranes when exposed to the outdoor environment.

Modeling the stone for its thermal performance is one of the deliverables of the experimental work. The paver ballast with weight equal to that of the heavy stone sample was included to aid in developing the model. This model will allow the stone to be entered as a roof component into the Department of Energy's (DOE's) Cool Roof Calculator, permitting the annual heating

and cooling loads to be calculated for specific ballast configurations on roofs containing various insulation levels located in different regions of the country.

Stone Reflectivity Versus Stone Mass and the Impact on Heat Flow

After eight months of exposure in east Tennessee's climate, the white single-ply membrane control degraded in reflectivity by 15%, a similar rate as seen in the earlier study referenced above that showed the exposed single-ply membranes degraded 30 to 50% after three years of outdoor exposure. On the other hand, the paver ballast increased in reflectivity by 7%, while the stone ballast reflectivity was assumed to remain unchanged based on results from the earlier study.

The study evaluated the effects of mass on thermal performance by including three stone ballast weights of #4 stone at 10, 16.75, and 23.5 pounds per square foot; the 10-pound weight being the minimum allowed for ballasted systems. The paver weight was 23.5 pounds per square foot, matching the heaviest stone weight. The membrane temperature and insulation heat flux data taken early in the study indicated

that the 10-pound ballast weight produced thermal values about 30% higher than the white control. This is substantially better than what would be expected from the stone's reflectivity value of 0.21, which is 73% lower reflectivity than the white membrane (0.78) and closer to the black reflectivity of 0.06. As the mass of the stone was increased with no change in stone reflectivity, the thermal performance values proportionally reduced, moving closer to the exposed white membrane system performance with the 24-pound ballast (stone or paver) having only 5% more heat transfer. Although the paver has a reflectivity of 0.51 compared to the stone value of 0.21, the paver and 24-pound stone samples had very similar thermal profiles with nearly equal high and low values indicating mass has a greater effect on thermal performance than reflectivity.

Thermal Performance of Ballast Versus Reflective Membranes

The white membrane, with a reflectivity of 0.78, again proved to be an effective tool for deflecting the sun's energy from the building. However, some of this ability deteriorates over time, as the high reflectivity is

	White	Stone	Paver	Black
Initial	0.78	0.21	0.52	0.06
8 Month	0.67	0.21	0.55	0.09
% Change	(15)	0	7	50

Chart 1: Reflectivity readings.

lost due to air-borne fallout, biological growth, and the weathering process. The study also showed that the ballast samples were successful in shielding the building from the sun's energy even though the ballast reflectivity was only 0.21. As the ballast mass increased, the thermal performance continued to improve. As stated above, the 10-pound ballast was within 30% of the thermal performance of the new white membrane, while the 24-pound ballast was within 5%. The mass also delayed the time at which the maximum membrane surface temperature and heat flux were reached versus the white and black controls, a two- to three-hour delay, dependent on the amount of the mass. This delay moves more of the cooling load into the off-peak hours of the day.

At the eight-month point in the study, the maximum temperature and heat flux values for the ballast had moved closer to the white thermal profile with the 24-pound ballast closely mimicking the white control. This is related to the loss of reflectivity of the white membrane, which is now 0.67, just above the 0.65 minimum reflectivity value required for a new product to be listed as an EnergyStar™ roofing product.

When the data are analyzed for only the daylight hours where cooling of a building is the major concern, the results at the start of the study showed the 24-pound stone providing the same level of performance as the white membrane, while the paver provided slightly less savings. If one factors in the time delay in reaching the maximum temperature/heat flux (which moves more of the cooling load into the off-peak hours), the ballast offers an effective alternative to white membranes.

However, in the process of acting as a shield against the exterior conditions, the ballast mass absorbs some of this energy. With its mass far greater than that of a single-ply membrane, the ballasted roof takes longer to dissipate this energy even though it has emissivity values equal to those of the single-ply membranes. This, in turn, keeps its average temperature and heat flux above those of the white membrane over a 24-hour period. In the heat of the summer, this is a disadvantage to the ballast system. However, as the outside temperature moderates both in the spring and fall, this slower reaction to both high and low temperatures dampens the heat flow through the roof and stabilizes the heating and cooling loads in the building under a ballasted system.

Will Ballast Qualify as an EnergyStar™ Roofing Product?

A roofing product that has a “new” minimum reflective value of 0.65 and a three-year aged value of 0.50 or greater (after washing) qualifies to be listed as an EnergyStar™ product for use on low-sloped roofs. The ballast used in the study does not meet the current EnergyStar™ criteria. The study indicates that a ballasted system with a reflective value of only 0.21 does perform at the same level of thermal performance as the rated EnergyStar™ products. There is also an indication that the damping effect of the ballast may actually offer equal or better performance over a full day, month, or year of operation. More information will be developed to try to determine whether or not ballast performs as well as currently listed EnergyStar™ roofing products.

Essential to this effort is the ability to model the thermal performance of the bal-

	White	10#	17#	24#	Paver	Black
Initial Temp.	85	104	95	90	90	145
Initial Heat Flux	3	8.5	7	5	5	16.5
8-Month Temp.	100	110	105	95	95	145
8-Month Heat Flux	7	10	8	6	5	17

Chart 2: Sunny day maximum temperature (°F) and heat flux [BTU/(h•ft²)] values.

	White	10#	17#	24#	Paver	Black
Initial Temp.	81	87	86	86	85	98
Initial Heat Flux	1.9	3.9	3.8	3.2	3.2	5.6
8-Month Temp.	66	73	71	72	70	81
8-Month Heat Flux	-1.1	.7	.4	.3	-.4	2.1

Chart 3: Sunny day average temperature (°F) and heat flux [BTU/(h•ft²)] values.



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lasted systems with available tools. Specifically, thermal properties are needed for use in the transient heat conduction equation. Preliminary work has been done with a program that does the inverse: it uses the transient heat conduction equation to predict thermal properties to fit the measurements of heat flux and temperature. The program had difficulty converging with the data for the 10-pound and 16.75-pound ballasts during the summer months when convection effects in thin layers of stone could be expected. Early on in the project and again after nine months, analysis with the program is showing some hope of predicting thermal properties consistently from week to week.

Best estimates, so far, put the thermal conductivity of the stone at 0.3 to 0.4 BTU/(h•ft•°F) and volumetric heat capacity (product of density and specific heat) at 19 to 21 BTU/(ft³•°F). The corresponding estimates for the paver are 1.45 to 1.65 BTI/(h•ft•°F) and 23 to 25 BTU/(ft³•°F). With the measured thicknesses of the stone and paver, these thermal conductivities yield R-values of 0.3 to 0.4 h•ft²•°F/BTU for the 10-pound stone, 0.5 to 0.6 for the 16.75-pound stone, 0.6 to 0.8 for the 23.5-pound stone, and 0.10 to 0.11 for the 23.5-pound paver. The ballasts form low R-value, high thermal mass systems.

Until a consistent picture emerges of the thermal properties, work cannot be started with the modeling of the thermal performance of the systems. Modeling will use the thermal properties to predict the heat flux through the fiberboard insulation in each test section. Comparison to the measured heat flux will validate the model; or, if agreement is affected consistently by convection effects in the thin stones, the comparison will calibrate the model. A validated or calibrated model permits prediction of thermal performance in different locations with roofs having typical insulation R-value. The test roofs had minimal insulation R-value in order to maximize the sensitivity of the measurements to differences in the ballast properties.

INTRODUCTION

In warm desert climates, structures were often made of thick, sand-colored adobe walls before modern construction materials were available. These walls had substantial thermal mass, which helped to isolate the inside of the building from the outside environment. In many parts of the United States, older structures were made

with thick stone walls also providing some protection from the heat of a summer day by absorbing the sun's energy in the wall mass. On the other hand, light colored materials protect the building by reflecting the sun's energy, reducing the energy load on a building. Temperature measurements made at the Buildings Technology Center (BTC) show that, on a sunny day, a highly reflective roof surface can be as little as 3°C (5°F) warmer than ambient air temperature, while a dark, absorptive roof surface can be upwards of 40°C (72°F) warmer. This knowledge has accelerated the use of roofing products that offer smooth, highly reflective surfaces to reduce the energy needs for cooling the building.

Where do ballasted systems with irregular earth tone-colored stone surfaces fall in comparison to new "high-tech" exposed membrane systems? Some information on ballasted system thermal performance was obtained in the original study, "The Field Performance of High-reflectance Single-ply Membranes Exposed to Three Years of Weathering in Various U.S. Climates," but was of secondary interest since the primary focus was on the exposed membranes. The ballast weight was not measured accurately, so the data could not be quantified. Trends indicated that the ballast was shielding the building from the sun's heat, to some extent helping to justify the initiation of the current study.

Brief History of Ballasted Roofing Systems

Ballasted systems entered the roofing market in the early 1970s. The stone used with these systems is different from the traditional quarter-inch chip or smaller stone used with built-up and modified bitumen roofing. With these last two systems, the small stones are partially imbedded into the topcoat of asphalt to protect the asphalt (same applies to coal tar based systems) from the harmful rays of the sun. The stone used as ballast for single-ply systems is large in size, #4 (.75 to 1.5 inch in diameter) and larger stone. Ballast comes in other configurations, such as concrete or rubber pavers. Ballast is applied in loadings from 10 (the minimum) to over 24 pounds per square foot.

So with the loose-laid ballasted roof system, the contractor places all the components of the roof system, including the thermal barrier and insulation, unattached on the roof deck. The membrane is also loose-laid except for attachment around the

perimeter of the building and at roof penetrations. The ballast is then placed on top of the membrane, weighing down all the components to hold them in place. This technique eliminates the use of copious fasteners that are used to hold the roofing components in place, which in turn minimize thermal bridging. This also eliminates the need for adhesives to attach the membrane to the roof deck substrate. Thus, the ballasted method can greatly reduce the installed cost of the roof system as well as the time to install it. In addition, this ballast is basically fireproof, providing Class A (top rating) fire protection for the building that is under the system. EPDM takes great advantage of this construction with its ability to be factory-made in large sheets (up to 10,000 sq. ft.), further reducing the labor and, in turn, the installed cost of the roof system while improving overall quality. These benefits have allowed this system to become a major factor in the roofing marketplace.

Ballast is also used with the inverted -protected roof system where the roof system is built "upside down." A protective course may be placed over the deck. The membrane is then laid down, followed by the insulation, a filter fabric, and the ballast. The ballast often used in this application is pavers because it is often applied where there will be pedestrian traffic. Plaza decks and rooftop terraces are a few examples. The paver offers a trafficable surface with the insulation acting as a thermal protection layer and a shock absorber for the waterproofing system below it. In some applications, the paver is made from rubber, yielding a play exercise surface on the roof. Another form of ballast is mixed soil media and plants to form a roof garden with unique aesthetic appeal and performance characteristics such as stormwater management.

Because of the inherent simplicity of ballast systems, early proponents focused mainly on expansion into the market. During this early period, there was little technical information available on one design consideration: namely, how to design a ballasted roof system to resist the destructive powers of the wind. This led to a number of wind performance issues toward the end of the '70s and into the early '80s. This, in turn, energized the industry to find the answers for designing a ballasted system for specific wind zones.

Extensive wind tunnel work was conducted with thorough verification of the modeling through field observations, all

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leading to the development of the SPRI RP-4 national standard entitled “Wind Design Standard for Ballasted Single-Ply Roofing Systems.” This standard outlines design procedures for ballasted systems for addressing wind loads on various building designs in locations across the country. This standard has proven its merits with these systems surviving major storm events, including the hurricane season of 2004. The development of this standard increased confidence in the ballast system.

In recent years, new “high-tech” roofing membranes offering highly reflective surfaces have become the “new rage” of the industry. These membranes are used in fully-adhered and mechanically-fastened roof systems to take advantage of the reflective property of the membrane. With these systems offering aesthetically pleasing roofs that assist in saving energy for the building owner, ballast systems now seem a little old-fashioned and out of step with the times. Is this truly the case, or are there hidden attributes to the ballasted system that have not been identified?

Georgia Tech Infrared Study

The paper titled “Georgia State University Roof Temperature Study,” written by Marty Waterfill, CSI, and Patrick Downey, RRC, CDT, evaluated techniques to measure roof surface temperatures for buildings on the campus of Georgia State University. They compared results from a hand-held infrared thermometer to a high-resolution multispectral sensor mounted in an aircraft that did flyovers of the buildings. The roof types that were measured were built-up and modified bitumen with different surfacing, as well as ballasted EPDM. The data in the paper were very limited, so items such as surface reflectivity were not supplied, except for the three modified bitumen roofs that had their roof surface color identified. Even so, *Table 1* shows that the ballasted systems had the lowest surface temperature readings of the group of roofs. This information added additional support for the current study on ballast thermal performance.

Membrane Reflectivity Versus Ballast Thermal Mass

The river-washed stone used with the ballasted system, when laid over a substrate, produces a rather irregular surface that scatters any reflected light in many directions. Some light will reflect off one stone only to strike other stones, leading to

Roof Type	Ave. Temp
CTP BUR	113
CTP BUR	115
CTP BUR	146
MB – white granules	138
ASP BUR	112
CTP BUR	136
CTP BUR	146
CTP BUR	137
CTP BUR	151
CTP BUR	123
MB – white granules	150
CTP BUR	132
EPDM Ballasted	117
EPDM Ballasted	111
EPDM Ballasted	124
MB – white granules	141
ASP BUR	118
EPDM black surface	152
ASP BUR	150
Roof Family	Ave. Temp
CTP BUR	133
ASP BUR	126
MB Granules	143
EPDM Ballast	117
EPDM Black Surface	150
Note: CTP = Coal Tar Pitch; ASP = Asphalt; MB = Modified Bitumen multi ply	

Table 1. Roof surface temperatures from the Georgia State University Roof Temperature Study.

multiple absorptions and low reflectivity. Stone comes in many colors, from dark browns and reds to bright white. These stone types will produce reflectivity values from below 0.20 to over 0.40; however, none will qualify as an EnergyStar™ roof for low-slope roof applications.

Pavers have flat surfaces that can be finished to any surface smoothness and color. Hence, there is an opportunity to produce products with reflective values from below 0.2 to well above 0.65, the value at which a roofing product qualifies with EnergyStar™. However, there is a penalty to achieve this higher reflectivity, for it takes additional manufacturing procedures to produce the smooth or glazed surfaces,

greatly increasing the cost of the pavers. The paver that was used in this study had an initial reflectivity of 0.52, which is below the EnergyStar™ threshold.

Ballast mass is a factor independent from either surface color or finish. Ballast with high thermal mass requires considerable energy to raise its temperature, therefore absorbing much of the sun’s energy and shielding the building from it. The unknown is just how effective ballast is in shielding this energy when its mass is in the 10- to 24-pounds-per-square-foot range and comes in different forms, both stone and paver. The stone, with its open structure, has air cavities, while the paver is a dense material. How do they affect thermal performance in comparison to EnergyStar™-listed reflective products?

FIELD TEST FACILITY

Roof Thermal Research Apparatus

The Roof Thermal Research Apparatus (RTRA) at the Oak Ridge National Laboratory located in Oak Ridge, Tennessee, was constructed in the late 1980s for documenting the effects of long-term exposure of small, low-slope roof test sections to the East Tennessee climate. The RTRA has four 4-ft. by 8-ft. openings in its roof to receive different instrumented low-slope roof test sections. Each 4-ft. by 8-ft. test section may be divided into multiple areas.

The original use of the RTRA showed in-service aging effects with CFC and alternative blowing agents for polyisocyanurate foam insulation boards in roofs covered by black and white membranes. Each test section was divided into two 4-ft. by 4-ft. areas, one with a black membrane and the other with a white membrane.

In the late 1990s, the RTRA was used to document the thermal performance of low-slope roofs coated with reflective coatings. Each test section was divided into 2-ft. by 2-ft. areas with as many as eight different surfaces on a test section.

Currently, three of the four test sections are being used for the ballast systems project. Each test section is divided into two 4-ft. by 4-ft. areas. One contains the ballast systems for the 10-pound and 16.75-pound tests. The second contains the 23.5-pound tests, both stone and paver. The third contains the control systems, one with a black membrane and the other with a white membrane. The fourth test section continues to be used to show the in-service aging effects for polyisocyanurate foam insulation



Figure 1: Roof Thermal Research Apparatus (RTRA) with weather station.

boards, now with third generation blowing agents. Figure 1 is a photograph of the RTRA that shows the entire building, including the weather station.

A dedicated data acquisition system is housed inside the RTRA. It acquires the outside temperature and relative humidity, wind speed, and direction ten feet above the roof of the RTRA. The total horizontal solar insolation and the total horizontal infrared radiation are measured at the top of the railing in Figure 1. There are also many dedicated input channels for thermocouples and for millivolt signals, such as those produced by heat flux transducers. Jack panels are conveniently located under the test sections on the inside of the RTRA walls to make for short lead wires from the test sections to the jack panels. Data are acquired under control of a database that is specific to each experiment. The database instructs the data acquisition program as to what data to acquire and how often. Most channels are polled every minute. Data are

stored in a compressed historical record. For ongoing experiments, averages every 15 minutes of all variables are written weekly to a spreadsheet. Special reports can be generated for further detail on time dependency down to the frequency in the historical record.

Ballast Project Test Sections

Figure 2 is a photograph taken on top of the RTRA that shows the three test sections being used for the ballast systems project. The controls are in the foreground and the ballast systems are in the background beyond an uninstrumented area for

unmonitored exposure of materials.

To begin construction of the ballast systems, pavers 2 inches thick and 2 feet square were weighed on a scale to determine their weight per unit area. It was 23.5 pounds per square foot. Three of the four pavers required for a 4-ft.-square test section were sawed in half in order not to have any seams at the center of the paver test section. A whole paver occupies the center, and halves complete it. The required weight of stone in the test area to achieve the same loading as the pavers was determined for the heaviest stone. The lightest stone ballast loading was set at 10 pounds per square foot, which is the minimum allowed for a ballast system, and it did supply 100 percent coverage of the membrane. The third paver was set at the average of the heaviest and lightest. Buckets were used to carry the #4 stone from the scale to the roof of the RTRA, where it was distributed inside frames to confine the ballast to its assigned area. Exactly enough stone was used to achieve the 10-, 16.75-, and 23.5-pound-per-square-foot loadings. Separate determinations were made of the weight of stone to



Figure 2: Test sections configured for the ballast test.



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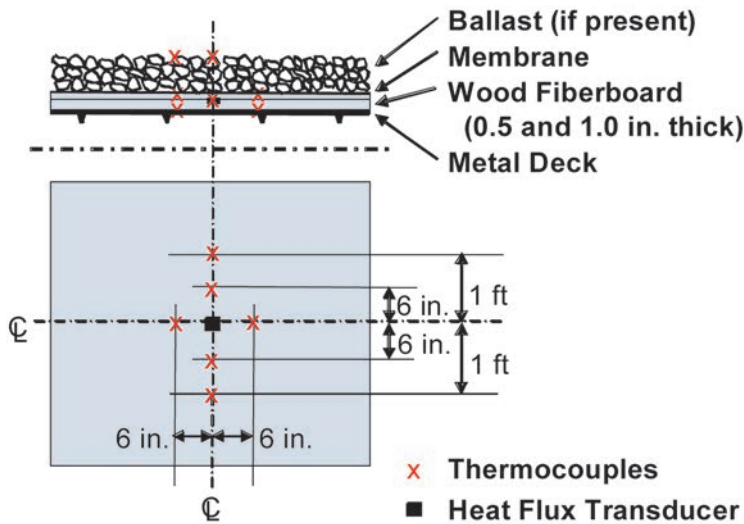


Figure 3: Thermocouple and heat flux transducer placement relative to the center of each 4-ft. by 4-ft. test section.

exactly fill a bucket and the volume of the bucket. This yielded a density of 92.4 lb/ft³ for the stone. Dividing each loading by the density of the stone yielded average thicknesses of 1.30, 2.18, and 3.05 in., respectively, for the three stone ballast systems. Due to the nature of the stone, the thicknesses vary over the area of each stone test section.

Instrumentation of the Test Sections

The instrumentation for each 4-ft. by 4-ft. test section is shown in Figure 3. The metal decks are exposed to the conditions inside the RTRA, which is maintained year round between 70°F and 75°F by an electric resistance heater and a small, through-the-wall air conditioner. The membranes (in the case of the unballasted controls), or the top surfaces of the ballast, for the other test sections, are exposed to climatic conditions. Thermocouples on the decks and at the top of the test sections monitor the direct response to the imposed conditions. Additional thermocouples are at the internal interfaces. Wood fiberboard insulation 1.5 in.-thick is used to maximize sensitivity to differences among the test sections. At the interface between 1 in.-thick and 0.5 in.-thick pieces of insulation, a heat flux transducer (HFT) is embedded in the top of the thicker insulation board. Each HFT is especially calibrated in the same configuration. Thermocouples are deployed at the level of each HFT, 6 in. and 12 in. from its center to monitor any significant heat flow in the horizontal direction. Thermocouples at the other levels are 6 in. from the center

of the test section.

The irregular upper surface of the stone-ballasted test sections presents a special challenge for monitoring surface temperature. Figure 4 shows the scheme that was adopted. Aluminum wire is strung across the middle of the frame from side to side in both directions. Thermocouples are attached to

measured for the surfaces of the test sections with two different techniques. For the smooth-surfaced controls and the relatively smooth-surfaced pavers, a Devices & Services solar spectrum reflectometer was taken onto the RTRA and used according to ASTM C 1549-02, "Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer."

Solar reflectance for the white TPO membrane at five locations on its surface averaged 0.779 for measurements on 3/12/2004 and decreased to 0.666 on 9/27/2004. For the black EPDM membrane, the average solar reflectance at five locations was 0.060 on 3/12/2004 and 0.090 on 9/27/2004. Measurements on the central full-sized paver yielded 0.516 on 3/12/2004 and 0.553 on 9/27/2004. Seven locations were measured in March and five in September on the paver.

For the stone-covered test sections, a Davis Energy Group roof surface albedometer was taken onto the RTRA and used with guidance from ASTM E 1918-97, Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field. The albedometer measures the solar reflectance of a surface as the ratio of the output of a solar spectrum pyrometer when inverted (facing downward toward the surface) and facing upward during an interval of constant solar irradiance. The area of the ballasted test sections is only 4 ft. by 4 ft., not the 4 m. by 4 m. (13

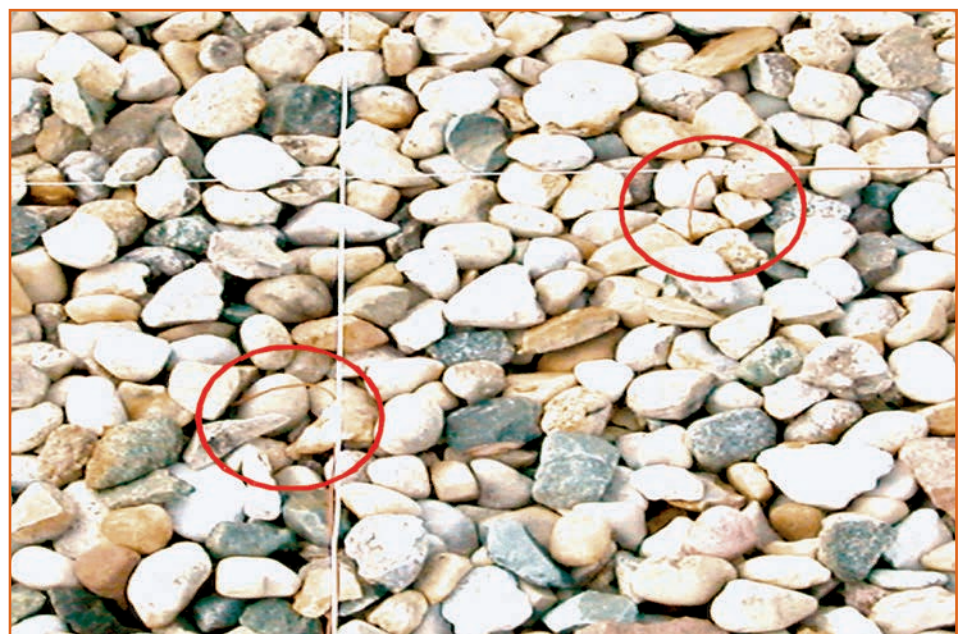
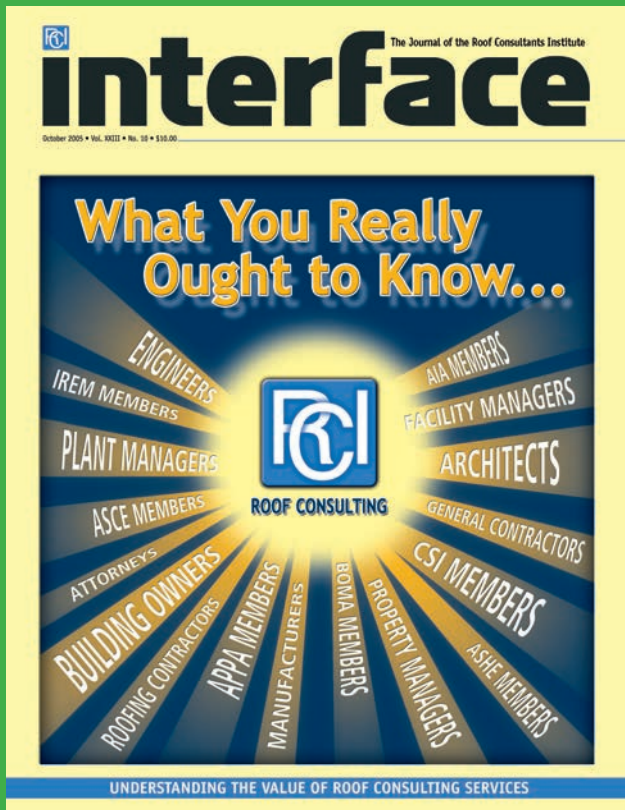


Figure 4: Thermocouple measuring junctions placed against pieces of stone at the top of the stone-ballasted test sections.

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ft. by 13 ft.) recommended in E-1918 for use of the instrument. In order to minimize the effect of shadows from the assembly on the test section during use of the albedometer, a standard 50 cm. (20 in.) height of the sensor above test sections is specified. It is achieved by the support stand that is part of the assembly.

Because of the relatively small size of the ballasted test sections, the standard height was relaxed. A special guide was made to achieve heights of 10 in., 15 in., and 20 in. above the surfaces while manually holding and leveling the pyranometer

and its support arm long enough for a steady response from the millivolt meter that monitors the output of the pyranometer. Apparent solar reflectance was measured at these three heights. Shape factor algebra yielded the fraction of the pyranometer's view taken up by the stone. The remainder is surroundings at some constant but unknown reflectance. The reflectance of the surroundings was varied by trial and error until the reflectance of the stone was constant with the height of the pyranometer above the surface. It was concluded that the solar reflectance for the

stone ballast is 0.21 ± 0.01 . Within the precision, it is the same value obtained during the SPRI study and indicates that the reflectance of the stone is constant. Precision better than ± 0.01 would require an improved apparatus for measuring reflectance at small heights.

A property of secondary interest for modeling thermal performance of roofs is the infrared emittance of the roof surface. It is difficult to measure for thermally massive systems, especially the irregular surfaces of the stone-ballasted systems. In general, non-metallic surfaces have infrared emittance near 0.9. This value is assumed to apply to all the test sections in the ballast system study and has been verified often in the SPRI study for single-ply white and black membranes.

To model the thermal performance of the ballasted systems with available tools, thermal conductivity and volumetric heat capacity (product of density and specific heat) of the ballast are needed for use in the transient heat conduction equation. Preliminary work has been done with a program that does the inverse: it uses the transient heat conduction equation to predict thermal properties to fit the measurements of heat flux and temperature. The program had difficulty converging with the data for the 10-pound and 16.75-pound ballasts during the summer months when convection effects in the stone could be expected. Early on in the project and now again after nine months, analysis with the program is showing some hope of predicting thermal properties consistently from week to week.

Best estimates so far put the thermal conductivity of the stone at 0.3 to 0.4 BTU/(h•ft•°F) and volumetric heat capacity at 19 to 21 BTU/(ft³•°F). The corresponding estimates for the paver are 1.45 to 1.65 BTU/(h•ft•°F) and 23 to 25 BTU/(ft³•°F). With the measured thicknesses of the stone and paver, these thermal conductivities yield R-values of 0.3 to 0.4 h•ft²•°F/BTU for the 10-pound ballast, 0.5 to 0.6 for the 16.75-pound ballast, 0.6 to 0.8 for the 23.5-pound ballast, and 0.10 to 0.11 for the 23.5-pound paver. The ballasts form low R-value, high thermal mass systems.

Until a consistent picture emerges of the thermal properties, no work can be done with modeling the thermal performance of the systems. Modeling will use the thermal properties to predict the heat flux through the fiberboard insulation in each test section. Comparison to the measured heat flux will validate the model or, if agreement is

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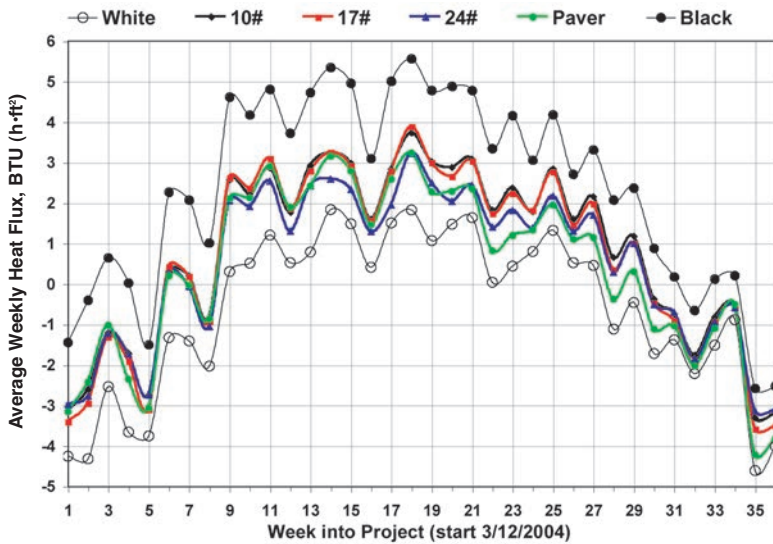
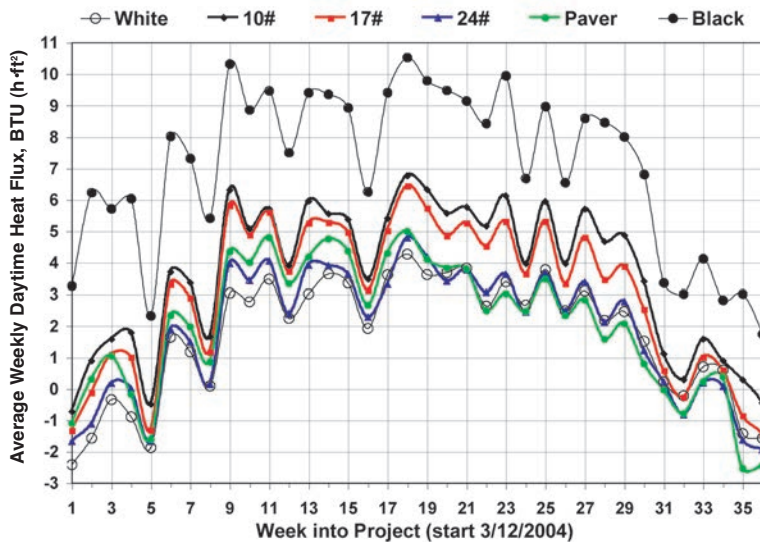


Figure 5: Average weekly heat flux through the insulation under the ballast and the control membranes through week 36 of the project.

Right: Figure 6: Average weekly heat flux (daytime only) through the insulation under the ballast and the control membranes through week 36 of the project.



NOTE: Preliminary results can show the observed differences among the test sections with some preliminary conclusions. In addition to the behavior on sunny days already presented to SPRI by André Desjarlais, which shows peak shaving and peak shifting due to ballast, the weekly behavior of heat flux may be of interest. Figures 5 and 6 show this so far in the project.

affected consistently by convection effects in the thin stones, calibrate the model. A validated or calibrated model permits prediction of thermal performance in different locations with roofs having typical insulation R-value. The test roofs had minimal insulation R-value in order to maximize the sensitivity of the measurements to differences in the ballast properties.

EXPERIMENT RESULTS

The ballast study went live on March 12, 2004 with the start of the data collection that continued through 36 weeks at the point of this writing. Figure 5 shows the week results for the average heat flux either

into the building (positive) or out of the building (negative) for a 24-hour period. The three distinct assemblies: black-surfaced membrane, ballast, and the white-surfaced membrane are visible in the figure. As the study moved into the summer period, the ballasted configurations began to show some separation as the heavier systems provided better shielding of the building from the heat. As the study moved into the fall, the white assembly began to move closer to the ballasted systems because of the deterioration of its reflectivity due to aging; however, its reflective value of 0.67 is still above the EnergyStar™-minimum requirement of 0.65. As the assemblies move into



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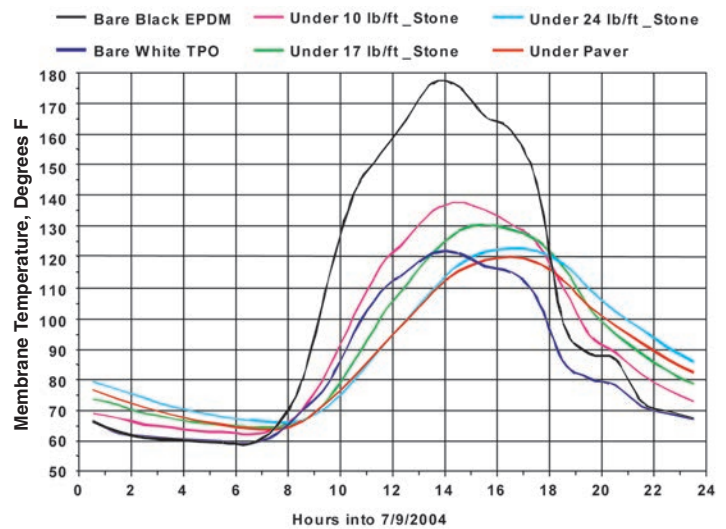
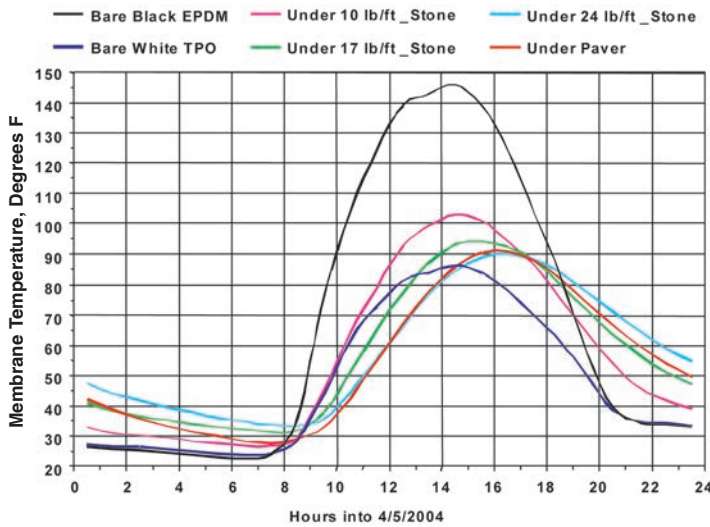


Figure 7: Membrane temperatures for a clear spring day in east Tennessee.

Figure 8: Membrane temperatures for a clear summer day in east Tennessee.

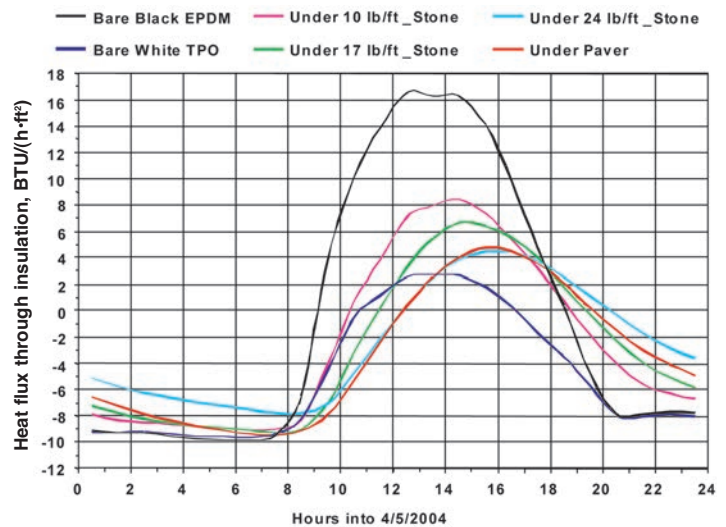
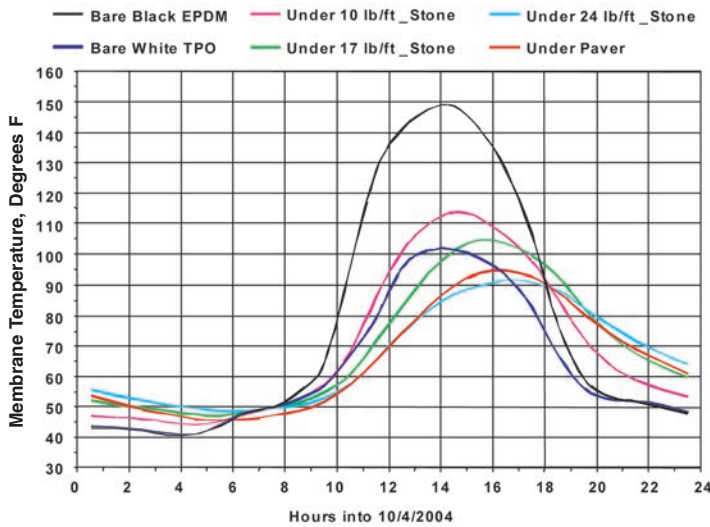


Figure 9: Membrane temperatures for a clear fall day in east Tennessee.

Figure 10: Heat fluxes through the insulation for a clear spring day in east Tennessee.

the first cold weather of the study, the thermal curves all collapse together.

In *Figure 6*, the weekly heat flux averages are shown for just the daylight hours, the period when the white membrane is reflecting the sun's energy, reducing the air conditioning load. As with *Figure 5*, this figure shows the same distinct curves for the assemblies with the black surface having the greatest heat flux, the white the least, and the ballast in the middle. There is greater separation between the four ballast assemblies in this scenario as the mass factor has a great effect as the heat develops in this part of the day. However, as the assemblies move into summer, the 24-pound ballast assemblies begin to match the white membrane for heat flux and by fall has

equaled or bettered the white membrane. As the first of the cold weather hits, the data duplicate *Figure 5* with all but the black membrane collapsing together.

Figures 7 through 12 show the thermal data collected for each assembly for a 24-hour period. There is a set of two charts – one membrane temperature and one for heat flux – for a specific day in the spring, summer, and fall. *Figure 7* and *10* are spring readings taken on April 5 when everything is new. Starting at sunrise, the membrane temperature climbs with the white peaking first (85°F) followed closely by the 24-pound paver and stone assemblies, which peak slightly higher at 90°F. Next to peak is the 17-pound ballast followed by the 10-pound ballast and then, at a consider-

ably higher temperature, the black membrane at 145°F. The chart shows the ballast variables are close to the white membrane in peak temperature reached, but offer one unique property in that as the weight increases, the time the peak temperature is reached is delayed. This delay can be in the range of three hours, pushing more of the cooling load into the off-peak hours of the day, saving both energy and dollars.

Figures 8 and 11 show the readings taken during the summer period where the 24-pound paver and stone are now performing basically equal to the white membrane for peak temperature with the 17 and 10 pound ballast peaking just over it.

The fall readings shown in *Figures 10 and 12* now show the 24-pound assemblies

peaking in temperature first with the white membrane peaking at a higher temperature. The 17-pound assembly is peaking at a temperature that is basically the same as the white. At the fall reading, the white membrane is still above the EnergyStar™ minimum reflective value of 0.65, indicating that the ballast systems do perform as a cool roof.

An additional item to note is the reflectivity for the 24-pound paver is 0.51, while the 24-pound of stone is 0.21, yet the thermal curves fall pretty much on top of each other during the daylight hours. This indicates that after a certain weight, mass becomes the controlling factor instead of reflectivity for shielding the building. Yet at other times of the day, the paver and ballast thermal curves separate, showing they are not the same and making it more difficult to model the ballast for use in the energy model calculators. There is some indication that the ballast

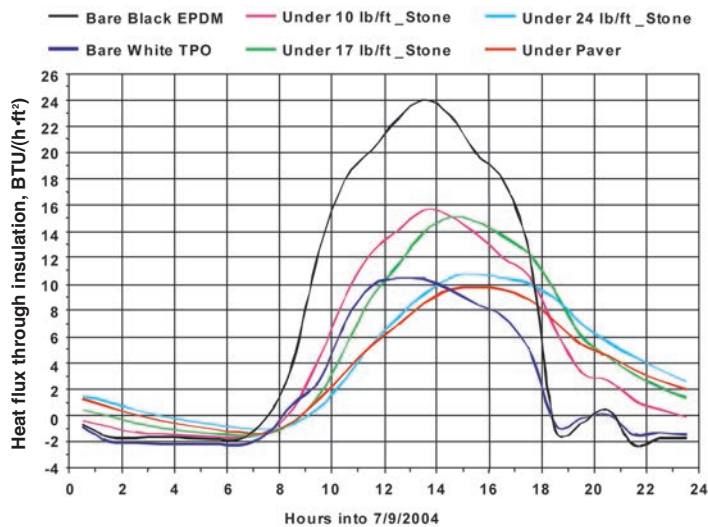


Figure 11: Heat fluxes through the insulation for a clear summer day in east Tennessee.

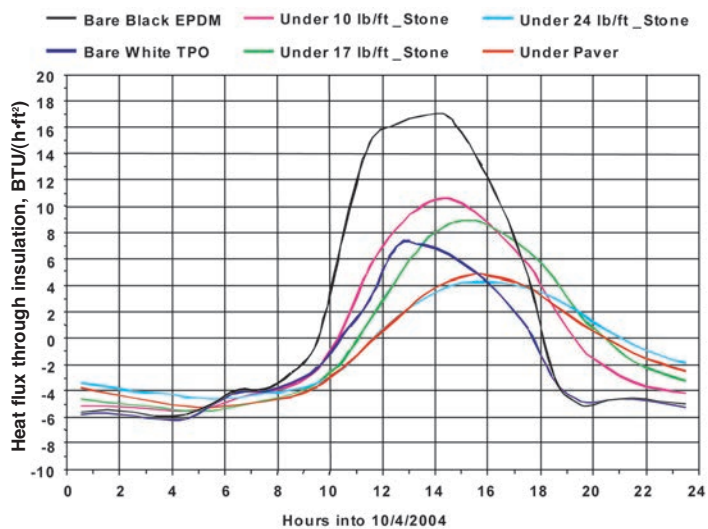


Figure 12: Heat fluxes through the insulation for a clear fall day in east Tennessee.

may have two R-values, depending on whether heat is moving into or out of the building. ☑

Test section	Covering or loading	Thickness (in.)	Solar reflectivity	
			3/12/2004	9/27/2004
Black control	Bare EPDM	0.045	0.06	0.09
White control	Bare TPO	0.050	0.78	0.67
10# stone	10.0 lb/ft_ on EPDM	1.3	0.22	Not done
17# stone	16.75 lb/ft_ on EPDM	2.2	0.22	Not done
24# stone	23.5 lb/ft_ on EPDM	3.1	0.22	Not done
Paver	23.5 lb/ft_ on EPDM	2.0	0.52	0.55

Table 2. Membrane reflectivity changes during the first six months of the project.



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Items to be Completed in the Study

The following items in the study are to be completed:

1. Complete the data collection:
 - a. For one full year.
 - b. Through the second summer.
2. Model the stone characteristics for use in the energy calculators:
 - a. Thermal conductivity.
 - b. Volumetric heat capacity (product of density and specific heat).
3. Quantify the ballast performance against the EnergyStar™ requirements.
4. Determine the value of the ballast time delay for energy cost savings.

REFERENCES

- Childs, P.W., T.W. Petrie, and J.A. Atchley. "Comparison of Techniques for *in situ*, Non-damaging Measurement of Infrared Emittances of Low-slope Roof Membranes." Submitted for review and publication in *Proceedings, Thermal Performance of the Exterior Envelopes of Buildings VIII Conference*, Clearwater Beach, Florida, December 2-6, 2001.
- Incropera, F.P., D.P. DeWitt. *Fundamentals of Heat and Mass Transfer*. 3rd ed. John Wiley & Sons, New York. 1990.
- Miller, W.A., M.D. Chen, A. Pfiffner, and N. Byars. "The Field Performance of High-reflectance Single-ply Membranes Exposed to Three Years of Weathering in Various U.S. Climates." *ORNL/TM-2002*. Oak Ridge, TN, Oak Ridge National Laboratory. The Single-Ply Roofing Institute. 2002.
- Petrie, T.W., A.O. Desjarlais, R.H. Robertson, and D.S. Parker. "Comparison of Techniques for *in-situ*, Non-damaging Measurement of Solar Reflectance of Low-slope Roof Membranes." Presented at the 14th Symposium on Thermophysical Properties and under review for publication in *International Journal of Thermophysics*, Boulder, CO: National Institute of Standards and Technology. 2000.
- Reagab, J.A., D.M. Acklam. "Solar Reflectivity of Common Building Materials and its Influence on the Roof Heat Gain of Typical Southwestern US Residences." *Energy Building*, Vol. 2, 237. 1979.

Taha, H., D. Sailor, H. Akbari. *High Albedo Materials for Reducing Building Cooling Energy Use*, LBL-31721, Lawrence Berkeley National Laboratory, Berkeley, CA, 1992.

Waterfill, M. and P. Downey. "Georgia

State University Roof Temperature Study." *Interface*, March 1999. 10-13.

Wilkes, K.E. *Model for Roof Thermal Performance*. ORNL/CON-274. Oak Ridge, TN, Oak Ridge National Laboratory. 1989.

Dick Gillenwater

Richard Gillenwater, Carlisle SynTec Inc.'s manager of advanced projects, began his career with Carlisle in 1979. Gillenwater has held such positions as manager of technical services, manager of systems engineering, manager of new product development, and most recently, director of research and development. Additionally, Gillenwater is active in the Single Ply Roofing Industry (SPRI), EPDM Roofing Association (ERA), and the Cool Roof Rating Council (CRRC).



Dr. Tom Petrie

Tom Petrie is a research engineer in the Buildings Envelope Program in the Buildings Technology Center (BTC) at the Oak Ridge National Laboratory (ORNL). His special expertise is design, execution, and analysis of short-term experiments in the BTC's Large-Scale Climate Simulator on a variety of residential and commercial roof assemblies. He carries out longer-term experiments on the BTC's outdoor test facilities or by remote data acquisition from field sites. Petrie joined the BTC staff in 1995, after research activities since 1988 with the BTC while on the mechanical engineering faculty at Marquette University. He earned a BSME from Marquette University in 1964, a MSME from the University of Minnesota in 1967, and a Ph.D. from the University of Minnesota in 1969.

Dr. William A. Miller

Dr. William A. Miller has 20 years of experience as a research engineer for Oak Ridge National Laboratory. He has designed and directed the setup of numerous refrigeration systems and served as principal investigator of a contract awarded ORNL by the Gas Research Institute. He earned his doctorate of philosophy in mechanical engineering and is presently using his expertise in finite difference heat conduction to quantify the long-term energy and durability benefits of highly reflective roofing materials in support to the Department of Energy's Roof, Wall, and Foundation program supported by the Office of Building Technology, State and Community Programs.



André Desjarlais

André Desjarlais is the Group Leader of the Building Envelope and Materials Research programs at Oak Ridge National Laboratory. Desjarlais has been involved in materials research for over 30 years – first as a consultant, and for the last 15 years with ORNL. He participates in ASHRAE, ASTM, SPRI, RICOWI, the National Fenestration Rating Council, the Building Environment and Thermal Envelope Committee, and the RCI Foundation Board. His areas of expertise include building envelope and material energy efficiency, moisture control, and durability.

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RCI AND MASTERFORMAT™ 2004

BY FRANCIS M. DE SIMONE, RRC, CCA

As a species, humans are quite successful at adaptation; but as individuals, we are occasionally overwhelmed by change. Before taking time to truly examine the facts, I regarded the impending regime change of CSI's MasterFormat™ 95 Divisions 1 to 16 to MasterFormat™ 2004 Divisions 1 to 50 as overwhelming and doubted very much that such extravagance was warranted. One important reality to face, however, is that the procurement infrastructures of most major organizations, governmental agencies, manufacturers, and vendors will adopt MasterFormat™ 2004.

For those readers whose main domain is in building enclosure design, the new MasterFormat™ 2004 will not pose big challenges. Most roofing and waterproofing projects require a limited selection of MasterFormat™ Divisions. Those Divisions commonly focus on Division 7 (Moisture and Thermal) with the usual support from Division 1 (General Requirements) and often some immediately related structural elements, accessories and finishes that are covered in:

- Division 2 – Site Work
- Division 3 – Concrete
- Division 4 – Masonry
- Division 5 – Steel
- Division 6 – Wood
- Division 8 – Doors and Windows - (including skylights)
- Division 9 – Finishes
- Division 15 – Plumbing (usually drainage or related to rooftop HVAC)
- Division 16 – Electrical (usually to support HVAC involved in reroofing)

Divisions 10 through 14 are typically not included in such projects, since they involve specialized systems within the building.

The subject matter of Divisions 15 and

16 are now spread through 20 to 29, and Division 2 (MF 95) is now expanded through Divisions 30 to 39. Divisions 40 to 50 are devoted to constructing manufacturing facilities and have incorporated many of the heavy items previously in Division 11. This large reorganization undertaken by CSI is intended to sort out the industry and make room for expansion as the future brings us new categories.

The major departures from MasterFormat™ 95 are:

1. Changing the focus of the technical sections from products to what are termed "Work Results." Think of 24 Gage Galvanized Sheet Metal Framing, 2SSS4 Gage Galvanized Sheet Metal Flashing, and 24 Gage Galvanized Sheet Metal Duct as utilizing very similar materials, but towards a very different end and are therefore specified in different divisions. Although this may not seem like much of a revelation, it recognizes that the construction products industry provides for other materials that can be specified alongside if they accomplish similar results. This will make the task of both the designer and contractor simpler in a fundamental way.
2. Sorting the Divisions into two groups:
 - **Division 00** Procurement and Contracting Requirements Group (formerly Bidding and Conditions of the Contract Requirements)
 - **Divisions 01 - 50:** Specifications Group
3. Subdividing the Specifications group into four Subgroups:
 - **Division 01:** General Require-

ments

- **Divisions 02 - 19:** Facility Construction
- **Divisions 20 - 29:** Facility Services
- **Divisions 30 - 39:** Site and Infrastructure
- **Divisions 40 - 49:** Process Equipment

Not only are new Divisions added, old ones are renamed and even some newly created Divisions have been left blank and as yet unnamed - including the newly vacated Divisions 15 and 16, in anticipation of the development of new, undefined work results. Woe be to those who take it upon themselves to privately designate the blank Divisions, or so I have been warned. While this seemed at first to be gratuitous reorganization, further examination of the structure of these subgroups suggests that teasing out some of the sections and creating room for expansion within the subgroups will prove useful as technology shows no let-up in providing new work results and solves more and newer problems.


4. Numbers designating MasterFormat™ 2004 sections will now be six digits grouped in pairs instead of the five digits of MasterFormat™ 95.
 - **Level One** designation will be as it is currently with the first two digits. For example: **03000** will become **03 00 00** Concrete.
 - **Level Two** designation will change from use of the third digit to the third and fourth digit. For example: **03300** to **03 30 00** Cast in Place Concrete.
 - **Level Three** designation will change from the fourth digit to the fifth and sixth. For example: **03310** to **03 30 10** Structural Concrete Cast In Place.

- **Level Four** designation will change from the fifth digit to the utilizing of two additional decimal places. For example: 03315 to 03 30 10.05 Colored Structural Concrete Cast in Place.
- Additional resolution will be formatted and further definition can be achieved through the use of three-letter suffixes. For example: 03 30 30.01.HAR Colored Structural Concrete Cast in Place for a particular client, project type, or whatever enhances the organization (typically in-house or between entities having established relationships).

5. Additionally, there is a standardization of certain number pairs placed in the third and fourth position, such as: 22 XX 00 designating sets of work result.
- 01 - Operation and Maintenance
 - 05 - Common Work Results
 - 06 - Schedules
 - 07 - Insulation
 - 08 - Commissioning

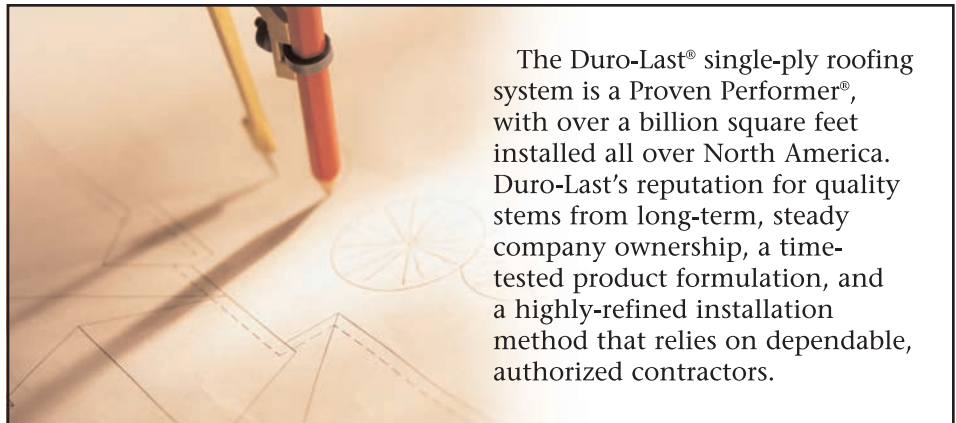
Example: 22 07 00 Plumbing Insulation

6. Room for expansion is built into MasterFormat™ 2004. CSI asks that individuals refrain from assuming usage of any of the unassigned Divisions. You can be sure that CSI is cooking up MasterFormat™ 20XX as we speak, but it is unlikely that it will entail the major level of change in transition between MasterFormat™ 95 and MasterFormat™ 2004.

In conclusion, I am making friends with the new MasterFormat™ 2004 and coming to believe its modifications are justified and that they will enhance my approach to the industry. I am taking this upheaval a bit like moving: hard, annoying, but probably worth the effort. As I sort through my old stuff and repackage it, I will tell myself to enjoy the unique opportunity to review and upgrade.... one item at a time... grumble... grumble. 

Frank M. De Simone, RRC, CCA

Frank De Simone has 32 years of experience focusing on building enclosure construction. A former engineering technician with Simpson, Gumpertz & Heger, he formed his own consultancy in Framingham, Massachusetts in 2000. Frank is a member of ASTM's Nondestructive Testing Committee, CSI, The International Facility Management Association (IFMA), the Boston Society of Architects' Building Enclosure Council, and RCI.



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EMPLOYMENT INCREASES; HOTEL CONSTRUCTION UP

By Ken Simonson

Over the past 12 months, employment increased everywhere except Michigan and South Carolina. Construction employment showed a similarly strong pattern, rising in 45 states plus the District of Columbia, remaining virtually unchanged in New Jersey and North Dakota, and falling only in South Carolina (-3%), Michigan (-0.7%), and Ohio (-0.3%). As usual, the biggest gain was in Nevada (16%), closely followed by Idaho (15%), Arizona (12%), and West Virginia (10%).

The Bureau of Labor Statistics (BLS) reported on the number of workers and median weekly earnings by sex and occupation in the second quarter. Among 7,061,000 full-time wage and salary workers in construction and extraction occupations, 6,873,000 (97%) were men, who earned an average of \$599 per week. The 188,000 women averaged \$406 per week.

The Census Bureau recently listed the 10 counties with the fastest growth in housing units from July 1, 2003 to July 1, 2004. First was Flagler, Florida (14%); followed by Madison, Idaho; Loudoun, Virginia; Henry and Newton, Georgia; Pinal, Arizona; St. Lucie and Sumter, Florida; Paulding and Fannin, Georgia.

In another sign that the market will remain hot for hotel construction, the *Wall Street Journal* reported that “developers have 917 projects in the pipeline that will add about 100,000 new rooms in the U.S. in

2007 alone,” citing the projection of Pat Ford, president of research firm Lodging Econometrics. That compares to 71,000 rooms to be added this year, but is below the peak of 156,000 set in 1998. “Even all those new rooms won’t be enough to add much supply, especially in the top markets. Last year net supply grew just 1% as developers opened a relatively low number of rooms while the condo craze caught fire. Hotel supply actually went down in six of the top 25 markets last year as developers converted hotels into condos and closed obsolete hotels, and that pace has increased. So far this year, supply has fallen in 11 of the top 25 markets. ‘The implications are that 2008 and ‘09 will also be very strong,’ Mr. Ford says. ‘There’s no visible reversal in the lodging industry through decade end.’”

“U.S. architectural firms reported growth in billings in June, but the pace of growth has slowed substantially since the beginning of the year,” American Institute of Architects (AIA) Chief Economist Kermit Baker reported. “In June, almost 23% of firms reported that billings had increased compared to May levels, but 14% of firms reported that they declined over this period. According to analysis conducted by the AIA, the strong growth in billings reported by firms points to an upturn in construction levels later this year, while the recent easing in growth in billings at firms points to slower growth in construction activity during the first half of 2006.”

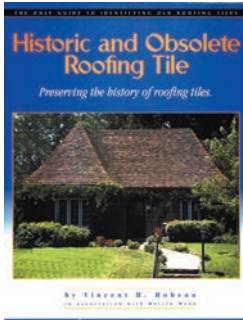


Ken Simonson

This series on the economy and its impact on the construction industry is published monthly in Interface. This month's column was prepared by Kenneth D. Simonson, Chief Economist for the

Associated General Contractors of America (AGC). Before joining AGC, Simonson spent three years as senior economic advisor in the Office of Advocacy of the U.S. Small Business Administration and 13 years as vice president and chief economist of the American Trucking Association. Simonson may be reached at simonsonk@agc.org.

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INDUSTRY NEWS

To submit an industry news item to **Interface** (Note: News must fit journal requirements in order to be published.):

E-MAIL IT TO: kammerman@rci-online.org OR MAIL TO: **RCI, Interface Journal, 1500 Sunday Drive, Suite 204, Raleigh, NC 27607**

HOFF NAMED ERA CHAIRMAN

James Hoff, Firestone Building Products Co., has been named as chairman for the EPDM Roofing Association (ERA). Hoff replaces Nick Shears, Carlisle SynTec. Added to the board of directors were Stan Choiniere, OMG Roofing Products; and John Murphy, Milliken & Co.

CENTENNIAL OF D-08 MARKED

The centennial celebration of the American Society for Testing and Materials Committee D-08 on Roofing and Waterproofing was recently commemorated at the National Automobile Museum in Reno, NV. The committee, formed in 1905, currently has 410 members. Carlisle SynTec sponsored the event.

AMERILUX BECOMES LEXAN DISTRIBUTOR

GE has named AmeriLux International LLC of Appleton, Wisconsin, a distributor of Lexan™ multiwall sheet, roofing panels, and corrugated sheet in order to expand into new markets, including architectural applications for its Lexan polycarbonate (PC) sheet products.

FIRESTONE AND BUILDERS GIVE

Six roofing contractors throughout the country recently worked with Firestone Building Products Co. to give back to their communities through the Firestone Community Service Program. The program rewards participating contractors with a standard material credit for Firestone products installed as part of a donated labor community service project.

INSULFOAM SP INSULATION INTRODUCED

Insulfoam, a division of Premier Industries, Inc., announced the introduction of InsulFoam™ SP roof insulation. InsulFoam™ SP incorporates a superior, closed-cell, lightweight, and resilient expanded polystyrene (EPS) insulation with a durable and stable factory laminated fiberglass facer.

POLYGLASS OPENS PLANT

Polyglass U.S.A., Inc. announces the opening of a new regional warehouse and manufacturing center located in the Winter Haven area of central Florida. This facility is being opened to support the extensive demand for self-adhered modified bitumen roofing products in the southeastern United States.

SHEWSKI INSTALLED AS FRSA PRESIDENT

David Shewski of Shewski Roofing, Inc., Sarasota, FL, was installed as the president of the Florida Roofing, Sheet Metal and Air Conditioning Contractors Association (FRSA) recently in Orlando, FL. Also taking office were Gary Register, president elect; Billy Cone, secretary/treasurer; and Jim Cheshire, immediate past president.

INSULFOAM HIRES ROBERTS

Insulfoam, a division of Premier Industries, Inc., has hired Paul N. "Nate" Roberts as territory manager for its Texas division. Roberts most recently was VP of sales for DK Haney Construction, Inc. in Fort Worth. Insulfoam is the largest manufacturer of block-molded expanded polystyrene (EPS) in the U.S. with 11 manufacturing locations throughout the country.

METAL-ERA PROMOTES SALES MANAGERS

Metal-Era Inc., a leader in metal edge roofing systems, announces the promotions of Eric Godfrey, Duane Trautner, and Ken Wicinski to inside regional sales managers. In addition to technical service responsibilities for Metal-Era and its ten private label membrane manufacturers, they will also supervise Metal-Era's network of independent sales representatives for their respective territories.

SARNAFIL EARNS DOE KUDO

Sarnafil has earned Premier Business Partner honors from Rebuild America, a U.S. Department of Energy (DOE) conservation initiative, for the second consecutive year. This year, Sarnafil joined 23 other partners to receive the award for its strong participation in Rebuild America - sponsored events — most notably a series of technical seminars presented in communities across the U.S.

UK Roofing Market Expands

The United Kingdom's roofing materials market increased by 7% from 2000 to 2004 and will increase by another 7% from 2005 to 2009. This according to MSI Market Research for Industry. The report added that metal roofing represented the largest proportion of the total roofing materials market in the UK, at some 35%, in 2004.

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CALENDAR OF EVENTS

Black print: INDUSTRY EVENTS

Blue print: RCI EVENTS

Calendar subject to change without prior notice. Visit www.rci-online.org for schedule updates. *A completed application must be received by Headquarters 90 days prior to sitting for an exam.

SEPTEMBER 2005

- 3 *Application deadline for 12/3/05 exam*
- 10 *Application deadline for 12/10/05 exam*
- 10-11 Mid-year Board Meeting
Phoenix, AZ
- 13-14 Roof Technology & Science I
Seattle, WA
- 15 St. Louis Chapter Organizational Meeting
Info: 319-393-9100
- 15-16 Roof Technology & Science II
Seattle, WA
- 16 Region III Meeting
St. Louis, MO
- 22 Chicago Chapter Meeting

OCTOBER 2005

- 4-5 Wind & Drainage
San Diego, CA
- 5-7 MRCA Conference
Grapevine, TX
Info: www.mrca.org
- 6 Region IV Meeting
Grapevine, TX
- 6-7 Professional Roof Consulting
San Diego, CA

- 16-20 SMACNA Convention
Palm Desert, CA
Info: www.smacna.org
- 25-26 Advanced Waterproofing
Alexandria, VA
- 27 Advanced Thermal & Moisture
Alexandria, VA
- 28 Roof Asset Management
Alexandria, VA

NOVEMBER 2005

- 3-5 Roofing Issues: Decks to Dockets
Los Cabos, Mexico
Info: NRLRC; 847-299-9070
- 8-9 Roof Technology & Science I
Chicago, IL
- 10 Mid Atlantic Chapter meeting
Maryland
- 10-11 Roof Technology & Science II
Chicago, IL
- 10-11 Symposium on Building Envelope Technology
Chicago, IL
- 12 RWC Exam
Chicago, IL

- 14 Region VI Meeting
Los Angeles, CA
- 17 Chicago Chapter Meeting
- 18 Region III / Ohio Valley Chapter Meeting
Indianapolis, IN

DECEMBER 2005

- 1-2 Rooftop Quality Assurance
Orlando, FL
- 2 Region I Meeting
Harrisburg, PA
- 3 RRO Exam
Orlando, FL
- 3-4 Executive Committee Winter Meeting - TBD
- 4-7 ASTM Committee D-08 on Roofing and Waterproofing
Dallas, TX
Info: 610-832-9740
- 6-7 Wind & Drainage
Atlantic City, NJ
- 8-9 Professional Roof Consulting
Atlantic City, NJ
- 10 RRC Exam
Atlantic City, NJ

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Comten	(800) 552-5546	www.com-ten.com	25
Duro-Last	(800) 248-0280	www.duro-last.com	47
ER Systems	(800) 403-7747	www.ersystems.com	23
Firestone Building Products	(800) 428-4442	www.firestonebpco.com	11
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ON THE ROOF

Reroofing at Taliesin

By Matt Millen

Photo 1: Wright modified the farm wing into domestic quarters, garden court, and work court for his apprentices after 1932.



Photo 2: An addition to the old milk tower in the mid 1930s covered up an older terne-coated steel flat roof. The new ridge line resulted in an improvised surface flashing at a lower windowsill and the need for a saddle behind the tower wall.

Frank Lloyd Wright built and rebuilt his home, Taliesin, in Spring Green, Wisconsin, from 1911 until his death in 1959. Taliesin survived two major fires in 1914 and 1925 and was rebuilt after both. The structure encompasses 37,000 square feet and has 59 rooms. Initially, it included residential, studio, and farm wings. After 1932, the farm wing was converted to domestic and work areas for his apprentices in the Taliesin Fellowship. Wright used the building to test design and construction methods. He directly supervised local tradesmen and his apprentices on what, where, and how to build. The house was subject to continual evolution, representing his changing views on structure and architecture.

The maintenance, stabilization, and now restoration of Taliesin include the ongoing maintenance and replacement of wood shingles on over 100 sections of steep roofs and a mile of often unique hidden flashings. Because the house is an architectural masterpiece and was a living laboratory for design and construction for five decades, the roof restoration work includes special challenges and opportunities. The three major imperatives are to save as much original fabric as possible, strive to provide an authentic picture of Taliesin as it existed at some point during Wright's life, and to provide longevity for the structure.

Hidden physical evidence of structural changes can be recorded where the existing shingles are removed and the roof deck opened up for repairs. The exact locations of additions are revealed at changes in the roof boards and rafters. New rooflines were often built directly over older roof sections. Nailing patterns reveal the number of roofs and earlier shingle exposures and lengths. Older roofing materials and methods of construction are sometimes buried under later work. Post 1959 modifications can be identified and reversed.

Unusual wall flashing details were often required and improvised where Wright raised or added roof lines. Wright preferred to hide roof flashings so that the change from a line of wood shingles to a stucco or native stone wall was uninterrupted and clean. Gutters were not used, so good flashings and drainage patterns converging over multiple levels of roofs were more critical to the performance of the roof assemblies. Saddles, spillways, and small flat roofs were used as solutions where design considerations resulted in difficult roof configurations.

Reroofing is also an opportunity to use better materials and methods of construction outlined within *The Secretary of the Interior's Standards for the Treatment of Historic Properties*. Plywood is sometimes added over old, irregularly-spaced roof boards to both preserve the original building fabric and add the strength of a diaphragm where roof boards were partially deteriorated or the rafters or other structural parts needed to be strengthened. CCA-treated wood shingles are required to extend the service life of the roof system without changing the appearance. Underlayments and ice dam protection membrane are used to improve roof performance and for added protection. Field decisions are coordinated with the Taliesin Preservation staff and the supervising architect, Peter Rott.

Matt Millen is a 5th generation roofer who, with his brother John, runs the 112-year-old family roofing company in Milwaukee, Wisconsin. He worked on the 4th and 5th editions of NRCA's *Steep Slope Roofing Manual* during his five years on NRCA's steep roofing committee and has authored articles and papers on steep roofing. Matt is the immediate past president of the National Slate Association.

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