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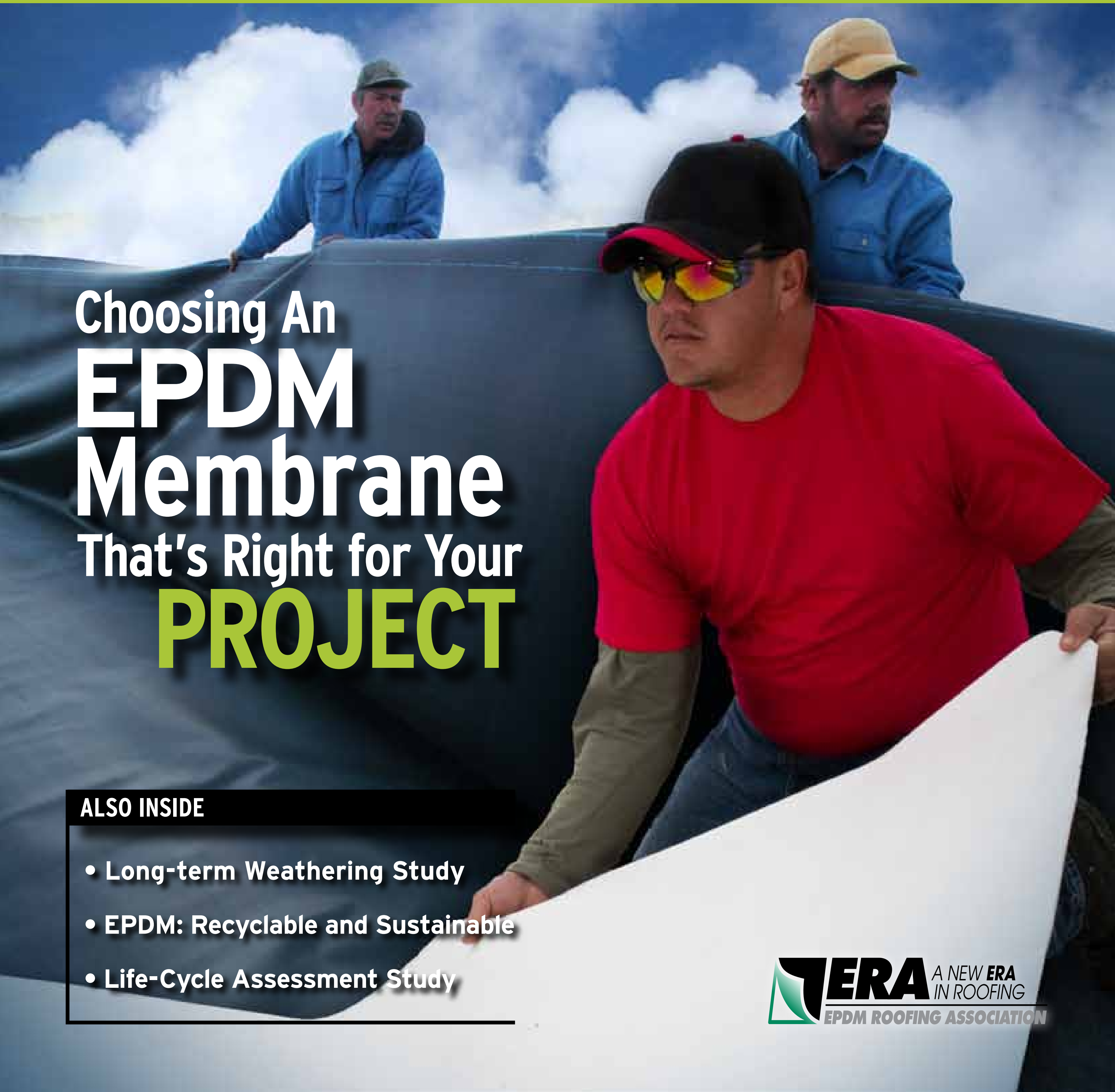
A ROOF SYSTEM FOR EVERY CLIMATE



Choosing An EPDM Membrane That's Right for Your PROJECT

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ERA A NEW ERA IN ROOFING
EPDM ROOFING ASSOCIATION

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ERA A NEW ERA IN ROOFING EPDM ROOFING ASSOCIATION

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AboutThe**COVER**

As environmentalists and code regulators place more emphasis on energy efficiency and the long-term performance of building materials, EPDM has become an increasingly versatile and preferred choice.

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EPDM

A Roof System for Every Climate

Light, dark or ballasted, there's an EPDM membrane that's right for your facility.

Today's construction climate places a heavy emphasis on green, sustainable building practices. For example, a building's roof was once thought of as just a means to keep the building dry, but not anymore. The impact a roof can have on energy consumption is understood now more than ever, but determining which roofing surface is most energy efficient continues to generate spirited debate. Many experts agree that light-colored, reflective surfaces are most appropriate in warm southern climates while dark, heat-absorbing surfaces are best in the north. EPDM (ethylene propylene diene terpolymer) single-ply roofing membrane is the only roofing material that offers solutions for all climates without the need for additional coatings or modifications.

More than 45 years of empirical experience in field applications has shown EPDM to have the roofing industry's longest average service life. As environmentalists and code regulators place more emphasis on the sustainable performance of building materials, EPDM single-ply rubber roofing membrane continues to be the roofing material that stands the test of time.

If you're considering a new or retrofit roof for your facility, now is actually a great time to be searching for a sustainable solution. In terms of dependability, performance and sustainability, the choices in the low-slope roofing market have never been better.

According to a variety of surveys conducted by roofing industry publications and associations, EPDM has been the number one roofing choice of architects, roof consultants, contractors and building owners for both new construction and replacement roofing projects for nearly half a century.

Just as important, the greatest test of any construction material is how it performs under actual field conditions.

Today, there are more than 500,000 warranted EPDM roof installations in the U.S. This figure represents an astounding 20 billion-plus square feet of exist-

The primary function of a roofing membrane like EPDM is waterproofing. As important as sustainability is, proven application techniques and long-term weathering performance can overshadow reflectivity by increasing membrane service life.

ing low-slope roofing on facilities across the country. In fact, EPDM is the only roof membrane that delivers solutions to meet all of today's sustainability and energy efficiency needs.

Recent research shows that EPDM has other desirable performance characteristics that dovetail nicely with the nation's need for more environmentally friendly and durable low-slope roofing systems.

Here's a short list of EPDM's overall system performance benefits:

- Cyclical membrane fatigue resistance
- Proven hail resistance
- High resistance to ozone, weathering and abrasion
- Flexibility in low temperatures
- Thermal shock durability
- Ultraviolet radiation resistance
- The ability to meet FM Global's most stringent Class 1 roofing requirements.

Weatherability is the key reason why more EPDM roofs continue to perform in the existing inventory than any other single-ply membrane.

REFLECTIVE ROOFING IN THE SOUTH

It's no surprise that reflective roofing products remain the fastest growing product in warmer low-slope roofing markets. White roofs can lower energy consumption (in climates where the number of cooling-degree days exceeds the number of heating-degree days) — a key goal of state and federal regulators — as well as meet more stringent cool-roof performance requirements in many building codes.

So there's no question that in ASHRAE Zones 1 to 3, most architects and roof designers today will specify a reflective roof membrane like white EPDM—and rightly so.

However, lowering energy use is not the only result from the use of a reflective roof membrane.

Depending on the geographical location and building configuration, white roof membranes can reduce energy consumption and improve building occupant comfort.

No roof membrane is perfect, of course. Dirt pick-up and mildew growth can be issues with some white roofing membranes. However, a well-designed roof system, regardless of color, should be resistant to dirt pick-up and be reasonably receptive to cleaning. This is best accomplished by initiating a semi-annual maintenance program that includes thorough cleaning, inspection and repairs.

COLOR-NEUTRAL IN ASHRAE ZONES 3 AND 4

There's little question that a white roof is the best choice in Florida. But across the geographic "middle" of North America, there is a neutral or gray area. This region makes up ASHRAE Climate Zones 3 and 4. In these areas, one can make a case that energy efficiency is not impacted by roof membrane color. Using the DOE Cool Roof Calculator, calculations would show little to no difference when comparing white versus black membranes in these zones in overall energy consumption (see figure 1).

In fact, it may surprise you to know that ballasted roofs can save as much energy as white roofs in ASHRAE zones 3 and 4—and in more southerly climates as well.

The development of complementary technologies has allowed EPDM to be beneficial in a wide number of applications, including plaza decks and larger projects using white EPDM membrane. Pictured (above) is a plaza deck paver system installed over a 145-mil EPDM system and (below) a white EPDM roof system.

In May of 2008, SPRI released a final report on a joint study with the Department of Energy (DOE) and the EPDM Roofing Association (ERA) entitled, "Evaluating the Energy Performance of Ballasted Roof Systems." The study shows that ballast and paver systems can save as much energy as a reflective or "cool" roof—even in southern climates.

"The magnitude of the savings was somewhat of a surprise to us," says André Desjarlais, who led the research effort at Oak Ridge National Laboratory (ORNL) for SPRI and DOE.

"To think that these very low-tech ballasted roofs that have been out there for so long were achieving energy savings equal to the newer white roof membranes. The 'adobe' method of construction used 600-700 years ago all makes sense."

In fact, the California Energy Commission now includes certain ballasted systems as a prescriptive equivalent to a cool roof in its Title 24 standard. In addition, ASHRAE may insert the energy saving data on ballasted roofs in its revisions for the next version of Standard 90.1. The EPA is also reviewing SPRI's request that the ballasted system be included in the ENERGY STAR roofing category.

Besides energy efficiency, part of the reason for the continued use of ballasted systems is positive real-world experience: Many older ballasted systems continue to perform well long beyond the warranty period.

Data from the Roofing Industry Committee on Weather Issues (RICOWI) Wind Investigation Program sheds further positive light on the performance of ballasted roofs.

EQUALIZING ENERGY PERFORMANCE UTILIZING ASHRAE 90.1 STANDARDS

With the emphasis on optimizing energy performance, the table below is based on insulation R-values (shown in second column) published in ASHRAE 90.1 Addendum F, which was approved in June 2010. For white and black membranes, the table outlines the necessary adjustments in R-values to maintain a roof assembly's energy performance. For example, with ASHRAE's intent to utilize reflective membranes in Zone 3, to achieve the same energy performance using a black membrane, the assembly must utilize insulation with an R-value of 29. Quite the contrary in colder regions (ASHRAE Zones 4 through 8). For example, while optimum performance can be achieved with a black membrane combined with R-35 in Zones 7, an assembly with a white membrane will require an increase in the insulation levels to R-38 in order for the assembly to deliver the same energy performance.

Traditional ballasted EPDM roof assemblies can deliver superior energy performance to cool roofs in Zones 4 and above. With an increase in coverage, ballasted roofs equal the performance of cool roofs in Zones 3 and below.

INSULATION LEVELS WITH EQUIVALENT LOAD VALUES

		Fully Adhered & Mechanically Fastened		
ASHRA Zone	R-Value	White EPDM	Black EPDM	Ballasted EPDM
1	R-20	R-20	R-33	R-20 *
2	R-25	R-25	R-31	R-25 *
3	R-25	R-25	R-29	R-25 *
4	R-30	R-31	R-30	R-30 **
5	R-30	R-32	R-30	R-30 **
6	R-30	R-32	R-30	R-30 **
7	R-35	R-38	R-35	R-35 **
8	R-35	R-38	R-35	R-35 **

Figure 1. * = 17 #/SF Ballast ** = 10 #/SF Ballast

RICOWI inspected 93 low-slope and 91 steep-slope roofs in Florida in the immediate aftermath of Hurricane Charley in August 2004 and Hurricane Ivan in September 2004. More than 50 experts examined roof shape, materials, edge conditions, installation details and degree of deterioration, if any.

"From the ballasted roofs observed in the Charlie and Ivan investigations, I would conclude that stone ballasted roofs did not contribute to the debris stream from these hurricanes," said Dave Roodvoets, RICOWI's wind event coordinator. "Worst case, after Katrina, we saw a few stones lying around near a building with a ballasted roof. In Ivan and Charlie, there was some movement of stone on the roof, but the stone did not blow off the roof, even when the building height and wind zone requirements did not comply with local codes."

Poor workmanship and improper materials and specifications were the primary causes of roof failures in Florida and on the Gulf Coast, according to the RICOWI report.

SPECIFYING FOR ZONE 4 AND ABOVE

Legislators, architects and property owners are embracing the idea that building design has a large impact on energy consumption and sustainability. They are also recognizing that white roofing has a few drawbacks, depending on where it is specified.

Energy Secretary Dr. Steven Chu's now-famous suggestion for painting all the roofs of all buildings white to reduce carbon dioxide emissions and save energy has increased interest in reflective roofing. It has also evoked widespread debate within the scientific community.

Especially in ASHRAE Zone 4 and above, a dark-colored roof membrane is almost always the best choice.

"You need to step away from Dr. Chu's comment and think about what it will do for you and your home or building," says Dr. Brian Eberly on Legal Planet, The Environmental Law and Policy Blog. "Where I live in California, the winter sun warms my house. If I am required to have a reflective roof, my winter heating bill will be much higher than it is now. Maybe this should be legislated by climate zone in my state. Let's not use a one-building-fits-all approach."

A property owner responding to Dr. Eberly agrees: "Our greatest energy usage (in Wisconsin) is in the winter when the heater runs to keep our pipes (metal and biological) from freezing. I chose a black roof last year to lower my energy costs."

White membranes, throughout the northern part of the U.S., may be a strategy for addressing heat island concerns, but they do not always deliver energy savings, nor do they contribute to lower carbon emissions. The key factor should always be the amount of insulation utilized in the assembly, which has been demonstrated as the most influential component by which sustainability can be achieved.

For the developers, owners and operators of large-scale multifamily properties, sustainable design has become a fiscal necessity.

Pacific Retirement Service's (PRS's) projects are a case-in-point. Developer PRS and local design partner Ankrom Moisan Architects always aim for Leadership in Energy and Environmental Design (LEED) certification on the facilities they develop.

"We don't care what color the roof is, as long as it saves us energy down the road," says Rick

Mazza, vice president of business development and planning for PRS, one of the largest multifamily developers in the U.S. "Admittedly, the U.S. Green Building Council (that administers LEED), and other organizations, tend to push the reflective roofing products, but we're much more concerned about the energy efficiency of the entire building envelope. And, on the roof, that means more insulation, particularly in high heating-degree-day climate zones."

SAVING ENERGY ISN'T A BLACK-AND-WHITE ISSUE

Well-meaning legislators are pushing for "cool" roof requirements in the building codes. In their zeal to address heat islands, many are focusing too closely on roofing color instead of energy performance in northern climates.

Tom Hutchinson of The Hutchinson Design Group in Chicago, Ill., is a well-respected roof consultant who has worked with two international committees tasked with defining roof sustainability.

"It's gotten to the point out there where people think, 'if a roof membrane is white, then it's great,'" Hutchinson says. "In the real world of roof design, that is definitely not the case."

According to Hutchinson, specifying bright-white roofing has become a knee-jerk reaction for some designers who do not take climate zones and building use into consideration.

That's why it's so important that roof designers, contractors and facilities managers consider the right roofs for the right markets.

For example, ASHRAE's current 90.1 recommendations are calling for R-values that are 33 percent higher than in the past. This means that a properly insulated roof often negates the intended reflective benefits of a white roofing membrane in ASHRAE Zones 4 and above.

"We push no particular (roof) system but look at each building, geographic location and owner situation as unique," says Andy Hoover, principal of The Best Consultant Inc. in Suwanee, Ga., and secretary of the Roof Consultants Institute's (RCI's) Georgia chapter.

The fact is that "cool" roofing can be light, dark or anything in between depending on the climate zone where it is specified.

The primary function of a roofing membrane is waterproofing. As important as sustainability is, a major roof leak will help facilities managers forget about reflectivity in a hurry. That's why it's so important to keep the "big picture" in mind when choosing a roof membrane. It's a point that few experts in the roofing industry would dispute.

Unfortunately, there are currently no standards governing sustainability beyond singular characteristics, such as roof reflectivity. This can lead to the deselection of some high-performance roofing solutions and the specification of roofing systems that may actually be less sustainable over the long term. In addition, this is creating confusion in the design and research community.

For example, the efforts to modify specifications and replace black membranes with white material in Northern Climate Zones (ASHRAE zones 4 and above) could prove to have a less than favorable outcome. In fact, there are good reasons why black EPDM roofs account for more than 52 percent of roofing installations in the northern part of the U.S.

Primary among these sustainable strategies is longevity. Black roofs have been successfully performing in all ASHRAE Zones over the past four decades.

> "Maybe this should be legislated by climate zone in my state. Let's not use a **ONE-BUILDING-FITS-ALL** approach."
>
> – Dr. Brian Eberly, Legal Planet

Measuring the environmental impact and carbon emissions potential of low-slope roofs should also play a part in sustainable design. For the past 30 years, Certified Energy Manager Randy Koller, P.E., has been hard at work doing just that.

In 2008, he conducted an energy analysis for the West Virginia School Building Authority using the Department of Energy (DOE) Cool Roof Calculator. He found that black roofs installed on the state's public schools showed favorable results for potential energy costs and carbon emissions when compared to white roofs.

His analyses compared assemblies using dark-colored and white reflective membranes with R-values ranging from R-15 to R-32. Energy cost and carbon emission comparisons were conducted, and black roofs were found to be the most economical and environmentally friendly option.

When considering the higher energy costs of white membranes plus periodic cleaning costs to keep them light and reflective, the use of black membranes can deliver the best return on investment and should have less of an environmental impact due to recycling potential and lower carbon emissions.

A BRIGHT FUTURE FOR EPDM

Since the early 1960s, EPDM has gained wide industry acceptance and respect by providing long-term, economically efficient, dependable roofing solutions for facilities managers and others in the construction industry.

EPDM attributes include long-term warranties, low life-cycle costs, reduced labor costs, minimal maintenance and user-friendly code approvals.

The sustained growth of EPDM roofing systems is attributed to the development of complementary technologies that have made it possible for EPDM roofing systems to be beneficial in a wide number of applications. Architects, property owners and facilities managers have come to depend on this proven track record of performance.

As environmentalists and code regulators place more emphasis on energy efficiency and the long-term performance of building materials, EPDM has become an increasingly versatile and preferred choice.

EPDM: A PROVEN PERFORMER

Long-term weathering study shows 30-year roofs continue to perform well.

A brand-new study of roof systems conducted on behalf of the EPDM Roofing Association (ERA) provides tangible proof of the long-term performance capability of EPDM roof systems. The study concluded that all of the systems examined were still performing as intended after 28 to 32 years of in-field service. The study shows that all of the aged EPDM roof samples taken have physical characteristic properties above or just below the ASTM minimum properties required of newly manufactured 45-mil EPDM membrane.

The testing performed in ERA's latest study examined five critical performance characteristics of the EPDM membrane. The roofs were inspected first-hand to give researchers a good sense of their condition in the field. Then, samples were sent to Momentum Technologies, a testing facility for the roofing industry in Uniontown, Ohio, where the following tests were performed:

- Elongation (%)
- Tensile (psi)
- Thickness XD (Cross Direction) (in)
- Thickness MD (Machine Direction) (in)
- Factory Seam Strength (psi)

The test results of these advanced-aged EPDM membranes confirm the facts generated from earlier studies—EPDM withstands the effects of various climates extremely well.

Not only can properly designed, installed and maintained EPDM membranes successfully withstand extreme weather cycles, the testing also indicates that these roofs and other EPDM systems can approach or exceed 40 years of service life.

"The first field studies of EPDM were done in the late 1980s, and we are finding a pattern," says Thomas W. Hutchinson, AIA, FRCI, RRC and principal, Hutchinson Design Group, Ltd., Barrington, Ill. "The pattern is that these roofs can really last a long time. By using today's advanced design techniques and proper roof maintenance, property owners should actually get more than 30 years out of an EPDM roof."

To help prove that theory, the samples from the latest study are being heat-aged and tested at prorated "life spans" of 40, 50 and 60 years. Updates from this study will be posted on www.epdmroofs.org.

The continued analysis of these roof systems by ERA will help develop a study that will provide details on the design and management processes that would enable such a long service life. It is believed that the information in the study

FIGURE 1. ELONGATION TEST RESULTS

Sample #	Roof Type/Location	Sample Age (yrs.)	ASTM Standard	Manufacturer Minimum	Test Results
1	**Ballasted 45 mil EPDM** N. Michigan University • Jacobetti Ctr. 1401 Presque Isle Ave. Marquette, MI 49855	32	D4637	New 350% Aged 200%	252.71%
2	**Ballasted 45 mil EPDM** N. Michigan University • Jamerich Bldg. 1401 Presque Isle Ave. Marquette, MI 49855	29	D4637	New 350% Aged 200%	494.07%
3	**Ballasted 45 mil EPDM** North Asheboro Middle School 1861 North Asheboro School Rd. Asheboro, NC 27203	28	D4637	New 350% Aged 200%	339.23%
4	**Ballasted 45 mil EPDM** 5296 County Road P West West Bend, WI 53095	29	D4637	New 350% Aged 200%	287.05%
5	**Fully Adhered 45 mil EPDM** Barrington C.C.S.D. 220 310 James Street, Barrington, IL 60010	29	D4637	New 350% Aged 200%	165.51%

will have great relevance to achieving long-term service for a number of roof systems, by encouraging thoroughly planned assessments and interventions via roof inspection and maintenance.

"Based on the data we've seen, we can predict that a 90-mil EPDM membrane that is not physically abused has the potential to last for an extended period of time," says Hutchinson. "We are talking far beyond the building owner's expected service life. It is reasonable to expect greater than 50 years from a 90-mil membrane"

FIGURE 2. TENSILE STRENGTH TEST RESULTS

Sample #	Roof Type/Location	Sample Age (yrs.)	ASTM Standard	Manufacturer Minimum	Test Results (psi)
1	**Ballasted 45 mil EPDM** N. Michigan University • Jacobetti Ctr. Marquette, MI	32	D4637	1305.00	1888.7
2	**Ballasted 45 mil EPDM** N. Michigan University • Jamerich Bldg. Marquette, MI	29	D4637	1305.00	1836.5
3	**Ballasted 45 mil EPDM** Asheboro, NC	28	D4637	1305.00	1828.8
4	**Ballasted 45 mil EPDM** West Bend, WI	29	D4637	1305.00	2200.9
5	**Fully Adhered 45 mil EPDM** Barrington, IL	29	D4637	1305.00	1519.0

The 29-year-old EPDM roof protecting the Jamerich Building at Northern Michigan University in Marquette, Mich., is still performing well.

THE STUDY IN DETAIL

The goals of ERA's long-term service life study were to:

- Verify the long-term performance characteristics of EPDM membrane
- Validate empirical sustainability experiences
- Create a foundation for specifier-to-owner discussions in regard to long-term service life.

To conduct the study, samples from five roof systems, installed between 28 and 32 years ago, were collected for analysis. They were:

1) A ballasted, 45-mil EPDM roof membrane (sample age: 32 years); Northern Michigan University; Jacobetti Center; Marquette, Mich.

2) A ballasted 45-mil EPDM (sample age: 29 years); Northern Michigan University; Jamerich Building; Marquette, Mich.

3) A ballasted 45-mil EPDM (sample age: 28 years); North Asheboro Middle School; Asheboro, N.C.

4) A ballasted 45-mil EPDM (sample age: 29 years); warehouse facility; West Bend, Wisc.

5) A fully adhered 45-mil EPDM (sample age: 29 years); Barrington Combined Community School District 220 Headquarters; Barrington, Ill.

Momentum Technologies conducted the factory seam strength tests using the ASTM Standard D816 - *Standard Test Methods for Rubber Cements.* The other four tests were conducted, using the ASTM Standard D4637 - *Standard Specification for EPDM Sheet Used In Single-Ply Roof Membrane.* In addition, manufacturer minimum physical properties for new EPDM were applied to the results.

Those results showed that all of the samples had physical characteristic properties above or just below the minimum physical characteristics of a newly manufactured 45-mil EPDM membrane.

For example, regarding elongation test results (Figure 1), four of the five roof samples exceeded the minimum characteristics for aged EPDM, and one exceeded the minimum for new EPDM.

For Tensile Strength (Figure 2), all five samples exceeded the minimum standard for newly manufactured membranes. For thickness XD (cross direction) (Figure 3), three samples exceeded the manufacturer minimum, while the other two missed by one one-thousandth of an inch. For thickness MD (machine direction), three achieved or exceeded the minimum, while one missed by one one-thousandth of an inch and another by four one-thousandths of an inch. For factory seam strength (Figure 4), it was only possible to test two of the samples, and both easily surpassed manufacturers' minimums.

ADDITIONAL OBSERVATIONS

ERA representatives are quick to point out that while a qualified roof inspector can make some judgments about the performance of a roof membrane in situ, the group's most current study "takes the process five steps further" by analyzing several different aspects of membrane performance.

One thing readers need to be keenly aware of is the state of EPDM technology at the time that these roofs were installed.

"The 45-mil EPDM roofs we examined are about as cost-effective as you can make them in terms of manufacture and design," says Hutchinson. "In addition, the proven installation methods we use today were still in their infancy when these roofs were installed.

"From this study, as well as our previous experiences in places like Saudi Arabia, we have found that ballasted or 'protected' EPDM membranes will exhibit even better weathering performance than exposed roof membranes."

FIGURE 3. THICKNESS TEST RESULTS

Sample #	Roof Type/Location	Sample Age (yrs.)	ASTM Standard	Manufacturer Minimum (in)	XD Test Results (in)	MD Test Results (in)
1	**Ballasted 45 mil EPDM** N. Michigan University • Jacobetti Ctr. Marquette, MI	32	D4637	0.0405	0.0390	0.0360
2	**Ballasted 45 mil EPDM** N. Michigan University • Jamerich Bldg. Marquette, MI	29	D4637	0.0405	0.0430	0.0390
3	**Ballasted 45 mil EPDM** Asheboro, NC	28	D4637	0.0405	0.0400	0.0400
4	**Ballasted 45 mil EPDM** West Bend, WI	29	D4637	0.0405	0.0390	0.0450
5	**Fully Adhered 45 mil EPDM** Barrington, IL	29	D4637	0.0405	0.0530	0.0530

FIGURE 4. FACTORY SEAM STRENGTH TEST RESULTS

Sample #	Roof Type/Location	Sample Age (yrs.)	ASTM Standard	Manufacturer Minimum (psi)	Test Results (psi)
1	**Ballasted 45 mil EPDM** N. Michigan University • Jacobetti Ctr. Marquette, MI	32	D816	N/A	N/A
2	**Ballasted 45 mil EPDM** N. Michigan University • Jamerich Bldg. Marquette, MI	29	D816	N/A	N/A
3	**Ballasted 45 mil EPDM** Asheboro, NC	28	D816	N/A	N/A
4	**Ballasted 45 mil EPDM** West Bend, WI	29	D816	±100	677.40
5	**Fully Adhered 45 mil EPDM** Barrington, IL	29	D816	±100	734.30

A HISTORY OF PERFORMANCE

It should come as no surprise that a well-designed and installed EPDM roof can attain a service life of 30 years or more.

In fact, EPDM roofing systems have been "under the microscope" of researchers for almost two decades. One of the industry's first key studies was presented in 1991 at the *Third International Symposium on Roofing Technology.* This kind of detailed scrutiny is without precedent in the single-ply roofing industry, and all of it has shed a positive light on the long-term weathering performance of EPDM membranes.

In the 1991 study, 45 membrane samples were cut from roofs in 13 states. The eight- to 10-year-old 45-mil EPDM membranes were tested for tensile strength, elongation, tear resistance, hardness, brittleness temperature, glass transition temperature and appearance.

The physical properties of the samples taken from the roofs showed a general *increase* in tensile strength and tear resistance. The brittleness temperature of these early membranes actually improved upon roof exposure.[1]

"All membranes except the 17-year-old sample were still in their early years of service life," says Brian Gish, co-author of the study. "The 17-year-old membrane had approached middle age in terms of performance, although its tensile strength was still quite high."

In 2003, EPDM roof membranes were again the focus of rigorous testing. ERA conducted a study to update the findings of Gish and Kathleen Lusardi, selecting 33 membranes—aged between 16 and 26 years — from in-service roofs in nine states. The samples included 10 ballasted and 23 fully adhered and mechanically fastened EPDM roofs.

The tensile strength, ultimate elongation, and tear resistance of the ballasted membranes remained relatively unchanged after 23 years of service life.[2] "There was no significant, observable deterioration of EPDM's physical properties," wrote researcher Tim Trial, Ph.D.

While the same general trend was observed in exposed membranes in terms of tensile strengths and tear resistance values, a decrease in the ultimate elongation was observed due to UV exposure. But overall, the study "confirms the excellent field-aging performance of EPDM," Trial reported.

WARRANTY RECORDS AS A MEASURE OF SERVICE LIFE

Prior to Dr. Tim Trial's study, James Hoff, DBA, evaluated the performance of aged EPDM membranes through an examination of manufacturer warranty records.[3] At that time, the repair costs of the first five years of service life for EPDM membranes declined by 84.6 percent. The study was updated in 2003 to include the repair costs over the first 10 years of service life (i.e., 1982 to 1993), demonstrating a repair cost drop of 60 percent between 1987 and 1993, and an astounding 93 percent decrease over the course of the study. Hoff, who is currently research director for the Center for Environmental Innovation in Roofing and president of TEGNOS Research Inc., Carmel, Ind., attributed the decline in warranty repair costs to advances in several important EPDM detailing technologies.

Today, Hutchinson continues to see "a huge preponderance of EPDM roofs in the Midwest that are doing well."

"All of the roofs we investigated were leak-free," reports Hutchinson. "The elongation of these roofs has decreased a bit, as expected, but they are still above the minimum requirements for a new EPDM roof today."

***References**: 1. Gish, B.D. and K.P. Lusardi*, Proceedings of the 3rd International Symposium on Roofing Technology *(1991), p. 159-166.; 2. Trial, T.R. Robinson and B. Gish*, Proceedings of the RCI 19th International Conference *(2004).; 3. Hoff, J.L.*, RCI Interface *(Sept. 2003).*

Sustainability OF EPDM

HIGHLIGHTED BY LIFE-CYCLE ASSESSMENT

New LCA study shows EPDM offers outstanding performance in reducing environmental impact.

A new Life-Cycle Assessment, or LCA, of the long-term environmental impact of EPDM shows that it performs significantly better than comparable roof assemblies. Equally as important, the study—based on the most up-to-date data supplied by industry and public sources—reports that the environmental impact of EPDM is lower than previously thought. LCA is an analysis of the environmental aspects and potential impacts associated with a product, process, or service. It is also a criteria that is growing in importance and for assessment of environmental impact.

The study was conducted on behalf of the EPDM Roofing Association (ERA) by the GreenTeam, Inc., a strategic environmental consulting firm based in Tulsa, Okla., that specializes in building industry issues. The LCA included all inputs associated with the manufacture and installation of various roofing systems, including EPDM, TPO, PVC and SBS modified bitumen. (The sidebar on page 13 shows all the roofing systems assessed in the GreenTeam LCA study.)

Upon completion of the study, the GreenTeam data was submitted to the Athena Institute for adoption into its EcoCalculator, the industry standard for life-cycle analysis data pertaining to construction materials. Specifically, a July 2010 life-cycle assessment of roofing assem-

FIGURE 1. **ROLE OF SERVICE LIFE**

	Membrane	System	Global Warming (Kg. CO^2)	Min. Service Life to Achieve Equivalency[1]
EPDM	60 Mil Black	Ballasted	28.3	**19 Years**
EPDM	60 Mil Black	Adhered	29.6	**19.8 Years**
EPDM	60 Mil Black	Mech. Att.	28.7	**19.2 Years**
EPDM	60 Mil White	Adhered	22.4	**15 Years**
TPO	60 Mil White	Adhered	30.0	**20.7 Years**
TPO	60 Mil White	Mech. Att.	29.8	**20 Years**
PVC	60 Mil White	Adhered	73.1	**49 Years**
PVC	60 Mil White	Mech. Att.	67.8	**45.4 Years**
SBS	140 Mil	Adhered	81.8	**54.8 Years**

[1]Using a comparative service life of 15 years for the lowest GWP system (fully adhered white EPDM)

blies using the Athena EcoCalculator with revised EPDM data generated by the GreenTeam shows that EPDM roofing has a lower environmental impact than PVC, TPO and asphalt based roof systems. For a typical low-slope roof over R-20 insulation and a steel deck, the EcoCalculator found that EPDM offers the lowest Global Warming Potential (GWP):

- **EPDM:** 6.93 kg CO^2 / sq. ft.
- **PVC:** 11.31 kg CO^2 / sq. ft.
- **Modified Bitumen:** 11.80 kg CO^2 / sq. ft.
- **BUR:** 20.74 kg CO^2 / sq. ft.

At only 6.93 kg CO^2 per square foot, EPDM's GWP is nearly half the nearest material. The easy-to-use EcoCalculator is available for free download at the Athena website (http://www.athenasmi.org). The calculator is available in a number of versions based on local climate conditions. The data above was generated using ASHRAE Zone 3, which would include Atlanta, Ga.

WHY IS LCA IMPORTANT?

As a forward-thinking organization that stresses environmental stewardship, ERA is keenly aware that LCA is likely to become an increasingly significant factor within the building industry in the future. The study conducted by the GreenTeam is evidence of this awareness.

At the same time, significant progress has been made to establish the specific criteria for an unbiased playing field to create effective LCA studies.

In regard to LCA and LEED, the U.S. Green Building Council has established Pilot Credit 1 Life Cycle Assessment (LCA) of Building Assemblies and Materials. The credit specifically calls for the use of the Athena Impact Estimator and EcoCalculator in order to calculate the number of LEED points than can be awarded based on a material's life-cycle impact.

As a pilot credit, its use is not mandatory, however many designers are looking into the process because the work involved is relatively simple. Most experts anticipate the pilot credit to be adopted into the next version of LEED. More information about this credit is available at http://www.leeduser.com/credit/Pilot-Credits/PC1#bev-tab

Currently, the International Green Construction Code (IgCC) encourages, but does not require, life-cycle assessment. The code offers an elective credit that may be adopted as either a mandatory requirement or as part of a menu of optional requirements by a local code body.

Moreover, the growing emphasis on environmentally responsible building practices; more sophisticated criteria for financing of construction projects; and, increasing governmental regulation within public construction is also making LCA requirements more likely in the future.

ENSURING ACCURACY OF LCA STUDIES

Because the LCA process involves a final step of interpreting the results, it is often employed as a comparative method to make decisions among alternatives. However, this is particularly challenging in the arena of low-slope roofing systems, which feature widely varying chemical components, installation methods and expected service lives.

In the most recent LCA study conducted by the GreenTeam, all outputs and impacts were calculated using SimaPro LCA software. Impacts were summarized using the categories and unit measures of the U.S. EPA TRACI Model. All materials studied were assumed to provide equal service lives, so the basic impacts were unadjusted for service life, and all impacts were calculated based on one square meter (M^2) of installed membrane.

Energy-related categories such as global warming appear to offer the greatest relevance. GWP as measured by kilograms of CO^2-equivalents varied from a low of 22.4 kg per square foot (fully adhered white non-reinforced EPDM) to a high of 81.8 kg per square foot (140-mil smooth surface SBS).

The relevance of the global warming category is further supported by the degree of differences exhibited by the membranes studied. As an example, the global warming potential of a white PVC or smooth surface SBS membrane is more than twice that of a black EPDM or white TPO roofing membrane for all system types studied.

ROLE OF INSTALLATION

One of the most interesting findings in the study is the minimal role played by attachment method in determining overall environmental impact. As an example, the various attachment methods studied (ballasted, fully adhered, mechanically attached) appear to affect overall GWP by less than 4 percent for EPDM and TPO and less than 7 percent for PVC. This lack of demonstrable difference suggests that the selection of the most suitable application method should be based on other factors such as potential longevity, ease of repair, etc.

For the TPO and PVC membranes, membrane color appears to play little or no role as a differentiating factor. As an example, the GWP for a fully adhered gray 60-mil TPO membrane (30.5 kg/ft^2) is essentially identical to the GWP for a similar white 60-mil TPO membrane (30.9 kg/ft^2). For EPDM membranes, however, the difference between white and black is more pronounced, with a fully adhered white 60-mil EPDM membrane exhibiting the lowest GWP of the study (22.4 kg/ft^2) as compared to a similar black 60-mil EPDM membrane (29.6 kg/ft^2).

THE ROLE OF SERVICE LIFE

At the conclusion of the study, the GreenTeam identified the number of years each roof system would have to perform in order to negate their GWP created during their manufacture and installation. This service life equivalency was calculated using a service life of 15 years for the system with the lowest GWP—fully adhered white EPDM—as a benchmark to compare all other systems. It was found that all four EPDM systems in the study exhibited the lowest service life equivalencies among all tested systems, which means an EPDM system requires less service time to become carbon neutral than its counterparts. Combine the low equivalency ratings with a service life that can often exceed thirty years, and it's easy to see how EPDM can be considered one of the most sustainable and environmentally friendly roof systems available. Figure 1 (see Role of Service Life, page 11) illustrates this comparison among widely used low-slope roofing systems.

The LCA conducted by the GreenTeam was based on a cradle-to-building approach. As a consequence, no impacts were identified or measured for activities that occur during the service life of the roofing system (routine maintenance and periodic repair or renovation) or at the end of service life (removal, disposal and possible recycling).

Although many of the activities not addressed by this study such as routine maintenance and periodic renovation generate relatively small environmental impacts, their value in extending service life may be much more important than their incremental impact contribution.

For a roof system designer, the opportunity to reduce overall environmental impact by extending useful service life implies that material or design features supporting this opportunity should receive considerable attention. Such features may include the ability to accurately predict maintenance and repair requirements, relative ease of repair, and the ability to remove and replace selected roof system components.

ROOFING SYSTEMS ASSESSED BY GREENTEAM STUDY

The LCA included the following low-slope roofing membranes, thicknesses and application methods:

Membrane Types:

- Non-reinforced EPDM (black & white*)
- Reinforced EPDM (black)
- Reinforced TPO (gray & white**)
- Reinforced PVC (gray & white**)
- SBS modified bitumen (smooth surface)

*white top layer over black bottom layer
**white top layer over gray bottom layer

Membrane Thicknesses:

- 45 mil (Non-reinforced EPDM, black only)
- 60 mil (Non-reinforced and Reinforced EPDM, Reinforced TPO and PVC)
- 72 mil (Reinforced TPO)
- 80 mil (Reinforced TPO and PVC)
- 90 mil (Non-reinforced EPDM, black only)
- 140 mil (SBS modified bitumen)

Application Methods:

- Loosely laid and ballasted (EPDM, TPO, PVC)
- Fully adhered (Non-reinforced and reinforced EPDM, reinforced TPO and PVC, SBS modified bitumen)
- Mechanically attached (Reinforced EPDM, TPO and PVC)

In addition to the above membranes and application methods, the following ancillary materials necessary for system installation were also evaluated:

- Metal fasteners and plates (For insulation attachment and membrane securement as required for fully adhered and mechanically attached applications)
- Membrane bonding adhesive (for fully adhered applications)
- Ballast stone (for ballasted applications)

All LCAs were conducted on a "cradle-to-gate" (or cradle-to-building) basis, including all necessary inputs to complete the installation of the roofing membrane. Additional studies will be necessary to extend this research to include in-service and end-of-life impacts.

Input Sources. Sources of input used by the GreenTeam included:

- Previous LCA studies of low-slope roofing systems (Franklin Associates, 2001; Morrison Hershfield Ltd., 2001)
- EPDM membrane composition (TRC Environmental Corporation, 1995)
- EPDM Roofing Association (ERA) supplied information
- EPA AP-42 emission factors
- Existing LCI Databases (US LCI, Ecoinvent / SimaPro, Athena Institute)

LCI data for TPO, PVC and SBS modified bitumen was derived primarily from the Athena Institute and was based on the Franklin Associates and Morrison Hershfield LCA studies.

LCI data for EPDM was derived from Rubber Manufacturers Association (RMA) compounding and manufacturing data provided by TRC Environmental, supplemented by EPA AP-42 and existing LCI database information.

LCI data for metal fasteners and ballast stone were derived from existing LCI database information. LCI data for bonding adhesive was derived from generic adhesive formulation information provided by ERA.

For more information, visit epdmroofs.org.

TAKING THE NEXT STEP

As mentioned above, the LCA data in the GreenTeam study was conducted using a cradle-to-building approach. For this reason, additional studies will be necessary to extend this research to include in-service and end-of-life impacts.

It is also important to reiterate that after an internal review, Athena accepted and incorporated current data from ERA and updated its LCI database. Similar steps will now take place with the U.S. LCI database for use with the BEES tool developed by the National Institute of Science and Technology, as well as other LCA tools.

In the interim, it would be prudent for building design professionals using the Athena EcoCalculator to be aware of the significantly reduced EPDM impact data demonstrated by this study.

Recyclable Sustaina

Recycling programs keep roofing waste out of landfills, give a boost to the bottom line.

EPDM rubber is one of the world's most recyclable low-slope roofing products. Since 2006, almost six million square feet of EPDM have been removed, transported and recycled from buildings all across North America and Canada. This, of course, reduces solid waste and pollution. Beyond that, recycled EPDM can have significant impact on a company's bottom line: more than half of the EPDM recycled nationally has become either cost-neutral or yielded cost savings when compared to traditional landfill disposal. ERA, with the help of its recycling partners Firestone Building Products and Carlisle SynTec, has taken a lead in proving both the practicality and economic viability of recycling for roofing contractors and building owners.

Today, roofing contractors are doing most of the recycling work, with the reroofing market currently driving the low-slope roofing business for installers. This bodes well for EPDM recycling in the near term. Long-term, the new construction market will almost inevitably grow. Today, more and more architects are writing a recycling process into their new roof specifications, and with good reason. Specifiers and facilities managers with foresight see roof recycling as an absolute necessity in the years to come.

A recyclable roofing product specified today should pay big dividends down the road. The average EPDM roofing membrane installed on a facility in 2011 may be up for replacement in 20 to 30 years. By that time, roof recycling will most likely be a necessity, not an option, due to a growing number of codes that incorporate sustainability requirements. And the penalties property owners will pay for disposing of non-recyclable roofing materials three decades from now will likely be heavy indeed.

"We all have to be aware of the recycling potential of roofing materials," says Sanford P. Steinberg, AIA, CGP, principal of Steinberg Design Collaborative LLP in Houston, Texas. "If the initial cost premium is minimal, and there is a future incentive or rebate, yes — we would go with the recyclable materials."

Along with more stringent government penalties, a decline in available landfill space in some parts of the country and rising disposal costs have contributed to the viability of recycling. According to the U.S. Environmental Protection Agency (EPA), 40 percent of total landfill waste comes from construction and demolition debris — one quarter of which is generated by roofing materials. While landfill space is plentiful nationally, areas such as the heavily populated East Coast are facing critical capacity issues and have seen disposal costs escalate.

In the last several years, the EPDM roofing community has made great strides in terms of recycling. The potential to streamline the process even further by the end of this decade is even more exciting.

Nationwide Foam Inc. (NFI) of Framingham, Mass., is one of the nation's largest recyclers of roofing waste and a member of the EPDM Roofing Association's (ERA's) Recycling Council. NFI brings more than 20 years of recycling experience to the roofing industry and is North America's largest EPDM and foam insulation board recycler. The demand for the company's EPDM recycling services has grown 200 percent per year since 2008. This rapid

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growth is primarily attributed to more end markets looking to purchase the products made from the recycled EPDM.

"EPDM is more economical for us to recycle and more functional as an end product than other roof membranes," says Rod Pfannenstiel, vice president of sales for NFI. "Also, from a removal and handling standpoint, EPDM is less expensive and more viable, because the process is simpler."

By the end of 2010, NFI expects to have recycled nearly two million pounds of EPDM, as well as to have kept more than six million pounds of roofing waste out of local landfills. Through its nationwide network, NFI has created an easy-to-use EPDM roof recycling program that has been used in 48 states in the U.S. and several provinces in southern Canada.

The program is available for low-slope ballasted and mechanically attached EPDM membrane tear-offs. NFI offers jobsite collection and transportation directly to a recycling center.

"The EPDM roofing industry has really put itself way out front in the recycling process," observes Pfannenstiel. "ERA has created a huge opportunity to foster the growth of EPDM recycling."

In addition, expectations for green building practices in all aspects of construction are much higher today.

"We are giving our end-market customers the opportunity to become better corporate citizens and reuse EPDM that would have taken up space in their local landfills."

AN UNPRECEDENTED INDUSTRY EFFORT

Certainly, the efforts needed to make EPDM recycling practical from a financial and logistical perspective were unprecedented in the commercial roofing industry.

It all began in 2006, when ERA launched a recycling initiative to determine the possibilities of recycling used, in-place EPDM roof membranes.

Working closely with roofing manufacturers Firestone Building Products and Carlisle SynTec, several pilot projects were executed to help better understand the feasibility and logistical processes involved. By the end of 2007, approximately one million square feet of EPDM had been successfully removed, transported and recycled.

With the additional support of NFI and West Development Group (WDG) — the first two members of ERA's Recycling Council — the program made significant progress in 2009 and 2010 in terms of national scope and cost efficiency.

The EPDM industry task force has already accomplished three of its primary goals:

1. To provide a recycling option for EPDM membranes currently reaching the end of their service lives, as well as for excess EPDM materials from new construction jobsites.

2. To provide roof system designers motivation for specifying EPDM and procuring LEED points.

3. To determine potential for EPDM recycling and reuse.

"With the continued support of industry leaders and broader awareness among roofing professionals for the economical and environmental impact of EPDM recycling, we expect the rate of EPDM recycling to explode over the next two years," said Greg Conigliaro, president of NFI.

RECYCLING SUCCESS STORY

According to WDG, there are three key attributes that must be maintained to ensure EPDM recycling remains sustainable and environmentally responsible:

1. The process must be environmentally beneficial. For example, the recycling process must not create a larger carbon footprint than what is being saved.

2. The recycled roof must be functionally equivalent to an EPDM membrane created from new materials. If the material is "green" but doesn't offer the same waterproofing abilities as a normal roof, the benefits are lost.

3. The recycling process must be economically viable. Customers will pay "a little bit more for a sustainable product," says West, but it must be nearly equivalent in price.

"In many cases, it costs our clients no more—or even saves them money—to ship the old EPDM to our facility instead of paying a dumping fee," says West. "We are even starting to get calls from contractors who are being forced by local regulations to recycle their EPDM waste."

So far, WDG has collected and recycled more than two million square feet of EPDM.

RIGHT: The finest EPDM particles are used to manufacture recycled EPDM polymers for roof coatings and other products. **BELOW:** Since 2006, almost six million square feet of EPDM membrane have been removed, transported and recycled from buildings all across the U.S. and Canada.

"Cost-effectively recycling EPDM and then using it for its original purpose as part of a new roofing membrane is the ultimate in recycling," says West. "You can't do much better than that."