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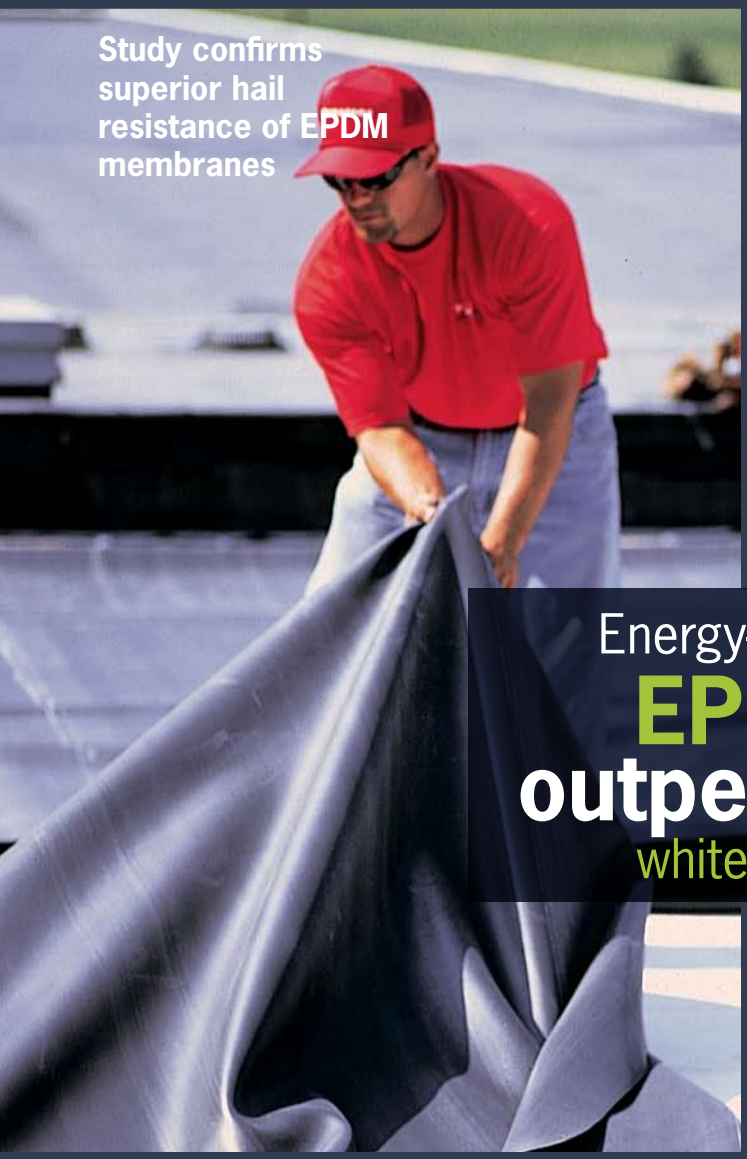
epdm

a sustainable roofing system

Study confirms superior hail resistance of EPDM membranes



Life-cycle study favors cost, performance of EPDM

Energy-saving **EPDM outperforms** white roofs

ERA A NEW ERA IN ROOFING

EPDM ROOFING ASSOCIATION

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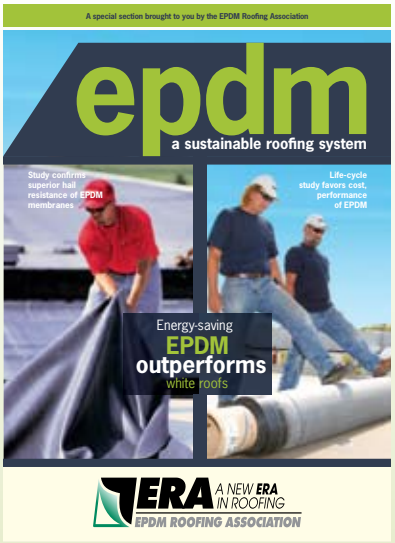

About The Cover: Forty years of empirical experience in field applications has shown EPDM to have the roofing industry's longest average service life. (Photo on left courtesy of Firestone Building Products Co.; photo on right courtesy of Carlisle SynTec Incorporated.)

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By John Geary • Chairman of the Board • EPDM Roofing Association

EPDM: A sustainable roofing option

Welcome to the EPDM Roofing Association's (ERA's) first technical supplement on low-slope roofing technology. We have brought together an impressive group of contributing editors with the goal of educating contractors, architects and property owners on the latest developments in EPDM roofing. However, the topics in this manual cover far more than just EPDM applications.

Over the years, EPDM (ethylene propylene diene terpolymer) single-ply rubber roofing membrane has been the number one roofing choice of architects, roof consultants and contractors for both new construction and replacement roofing projects, according to a variety of surveys conducted by roofing industry publications and trade associations. Today, there are more than 500,000 warranted EPDM roof installations in the U.S., representing 20 billion-plus square feet of existing low-slope roofing.

As environmentalists and code regulators place more emphasis on the sustainable performance of building materials, EPDM continues to be the roofing material that stands the test of time. Characteristics that contribute to EPDM's overall system performance include:

* 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 insurer FM Global's most stringent Class 1 roofing requirements

However, 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. For example, over the last year or so, research studies have found that:

Buildings in certain climate zones in the U.S. can save more energy with a dark colored EPDM roof than a white thermoplastic membrane.

Billions of square feet of existing ballasted EPDM roof membranes have been quietly saving as much energy as white membranes on countless roofing projects nationwide—without designers and property owners even being aware of it until now.

The life cycle costs of EPDM roofing—a critical part of a roof membrane's overall sustainability—has been shown to exceed other popular low-slope roofing systems.

With meteorologists predicting increasingly severe hailstorms in the U.S. over the next several years, an independent research study has again proven that EPDM offers exceptional impact resistance and improved durability in areas where hailstorms are prevalent.

The nation's inventory of school buildings, which are typically unoccupied during the hot summer months, can save considerably more energy with a dark colored roof like EPDM.

While light colored roofing membranes are certainly a benefit in some climactic regions, roofing industry observers are seeing an increasingly disturbing trend toward the promotion of light colored membranes for all low-slope roofing installations. As most experienced roofing contractors and designers already know, no one membrane type can ever be perfect for all roofing applications.

That's why it's so important that roof designers and contractors specify and install the right roofs for the right markets. For example, ASHRAE's current 90.1 recommendations are calling for R-values that are 33% higher than in the past. This means that a properly insulated roof often negates the reflective benefits of a white roofing membrane. In fact, in many of the climate zones defined by ASHRAE, black roofs can provide the same energy saving benefits as reflective membranes. However, in climate zones 1 or 2 in the extreme South, a white roofing membrane would be the best choice.

"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.

RCI past president Tom Hutchinson of The Hutchinson Design Group in Chicago, IL, is one of the industry's most well-respected roof consultants and 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, than it's great,'" Hutchinson laments. "In the real world of roof design, that is definitely not the case."

When it comes to low-slope roofing, saving energy has never been a black-and-white issue. Just as important, the greatest test of any construction material is how it performs under actual field conditions. Forty years of empirical experience in field applications has shown EPDM to have the roofing industry's longest average service life.

The need to provide the construction and roofing communities with current and accurate data documenting the many benefits of EPDM roofing systems led to the formation of ERA and the primary motivation behind the publication of this supplement. We hope you enjoy and learn from it!

EPDM

a sustainable roofing system

Black membranes can outperform white in northern climates

By Michael Russo • Contributing Editor

We all know that specifying and installing sustainable roof systems is the right thing to do. In fact, it's the biggest trend to hit the low-slope roofing industry since the introduction of EPDM membranes and other single plies more than 40 years ago.

Today, sustainability makes sense for environmental, economic and marketing reasons. The real challenge is defining what makes a sustainable roofing system. Most often, that depends on what climate zone the roofing system is being installed.

Black or white–fully adhered, ballasted or mechanically attached–sustainability is about choosing the right roof for the right market and ensuring that it is well-insulated.

How often have roofing contractors come across a mechanically attached reflective roof in a cold climate zone like Chicago, IL, with one layer of polyiso insulation underneath? When it comes to sustainability, these roof designs are lacking and will almost immediately result in higher energy costs for property owners.

A dark-colored EPDM membrane was successfully specified for Pixar Animation Studios, Emeryville, CA. (Photo courtesy of Firestone Building Products Co.)

A much better option is to use two layers of insulation. This allows staggering of the joints and eliminates thermal short circuits.

In addition, on one-layer insulation systems, moisture can move through the insulation joints and condense under the membrane in colder climates. This may lead

to moisture and mold-related problems down the road. A two-layer design--or fully adhering the roofing membrane--eliminates this problem.

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

Pacific Retirement Service's (PRS') Mirabella South Waterfront in Portland, Ore., is a perfect case-in-point. Developer PRS and local de-

Modifying specifications to replace black membranes with white material in climate zones 4 and above could prove to have a less than favorable outcome. In fact, black EPDM roofs account for more than 52% of roofing installations in the northern part of the U.S. Shown here is Staples headquarters in Framingham, MA. (Photo courtesy of Carlise SynTec Incorporated.)

'Cool' roofing revelation

Ballasted systems save as much energy as white roofs

Today, energy savings is one of the primary design criteria when choosing a low-slope roof, and modern fully adhered and mechanically attached reflective roof membranes have been getting all of the attention in the single-ply market. However, a recent study has found that the humble ballasted roof has been saving similar amounts of energy as reflective roofs for tens of thousands of property owners over the last 30 years—long before the first ENERGY STAR® label appeared on a white roofing membrane.

A pleasant surprise

In May of 2008, SPRI—the association representing sheet membrane and component suppliers to the commercial roofing industry—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 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." ORNL conducted side-by-side experiments comparing different weightings of ballasted roofs and a paver system along with black and white membrane controls. The data included continuous monitoring of temperatures, heat flows and weather conditions, as well as periodic verification of the surface properties of solar reflectance and thermal emittance—two values the ENERGY STAR program uses to evaluate a reflective roof. The study found that the heaviest ballast system and the paver assembly have identical area densities but substantially different solar reflectance of 0.22 and 0.55, respectively. Yet, both had similar thermal performance. These observations strongly suggest that the controlling parameter for ballasted systems is mass and not solar reflectance. "After less than two years exposure, the medium and heavy

sign partner Ankrom Moisan Architects are aiming for LEED (Leadership in Energy and Environmental Design) Platinum certification on the project.

"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, LEED and other organizations tend to push the reflective 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."

Energy End-Use Intensities

Building Type	Space Heating % of total	Space Cooling % of total
Education	33%	5%
Health Care	55%	10%
Retail & Service	31%	6%
Office	24%	9%
Public Assembly	54%	6%
Warehouse & Storage	16%	1%
All Buildings	29%	6%

Buildings Energy Data Book: 714 Typical Commercial Buildings September 2007

For educational facilities, the average heating cost is 33% of the total energy used, versus cooling at only 5%. This negates the benefits of a white roofing membrane for these applications.

Black roofs can save more energy

In many climate zones, black roofs can save more energy than reflective membranes. For example, the West Virginia School Building Authority (WVSBA) was recently tasked with creating minimum standards for materials used in school new construction and remodeling projects in West Virginia.

At the request of Ed Smith, manufacturer's representative with North Coast Commercial Roofing Systems in Huntington, WV, energy analyses were performed by Certified Energy Manager Randy Koller, P.E., using the Department of Energy (DOE) Cool Roof Calculator. The analyses were performed for assemblies using black vs. white membrane with different R-values varying from R-15 to R-32. Energy costs and carbon emission comparisons were calculated to determine the most economical and environmentally friendly option.

Koller's simulations showed that black membranes always provided an energy savings versus white material. This is primarily driven by the building location. In West Virginia, for example, Heating Degree Days (HDD) are five times greater than Cooling Degree Days (CDD). The simulations also revealed that energy costs are significantly decreased by increasing the R-value of the roof assembly.

Koller, who has more than 28 years of experience as a certified energy manager, then measured the environmental impact and carbon emission potential of the roof assemblies. Once again,

The recent study conducted by Oak Ridge National Laboratory shows that ballast and paver systems can save as much energy as a reflective or "cool" roof. Shown here is Toyota's Midwest Parts Center in Hebron, KY. (Photo courtesy of Firestone Building Products Co.)

ballast, along with the paver systems, have peak heat flows that are lower than the white membrane roof," says Desjarlais. "This suggests they are as effective as white-membrane roofs in mitigating peak energy demand." The complete report is available for free download from www.spri.org.

Code recognition for ballasted assemblies

By reducing peak roof temperatures and delaying heat flow into a building, the mass of a ballasted roof provides measurable energy saving benefits, according to the study. However, ballasted roofs currently do not meet the official "cool" roof requirements of high solar reflectance used by many federal and code organizations. One of the primary purposes of the study was to get "cool" roofing status for ballasted roofs from the Environmental Protection Agency (EPA), ASHRAE, and other federal and code groups. SPRI's first victory occurred soon after completion of the study, when the California Energy Commission (CEC) included ballasted systems as a prescriptive equivalent to a cool roof in its just-approved 2008 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. "There are two more things we need to accomplish, as we wrap up our work on ballasted systems," says Desjarlais. "Chicago (IL) has been working on a city-wide energy code with similar language to California's Title 24, and we would like to see ballasted systems recognized as an 'energy equal' to cool roofs in the code. Second, EPA is reviewing our request that ballasted system be included in the ENERGY STAR roofing category." However, the results of the SPRI/DOE study are understand-

assemblies with black membranes showed favorable results for potential carbon emissions when compared to those with white membranes. The assemblies with higher R-values yielded the best performance and significantly reduced carbon emissions.

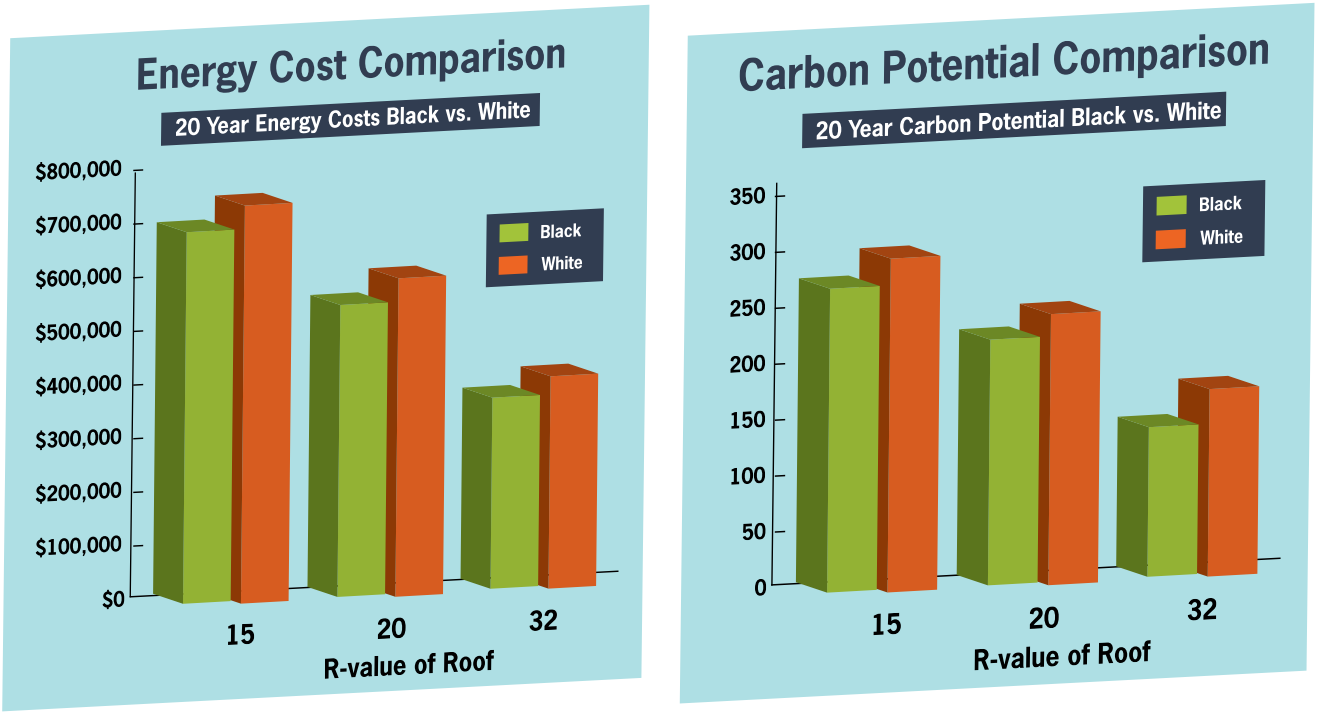
"The West Virginia School Building Authority is not alone in the issue of defining the most sustainable roofing option, especially in a time where regulations, if not responsibly directed, can yield an undesirable outcome," says Samir K. Ibrahim, director of design services for Carlisle SynTec Incorporated.

"White membranes, throughout the northern part of the U.S., may be a tool by which heat island concerns could be addressed, but they do not deliver energy savings, nor do they contribute to lower carbon emissions," continues Ibrahim. "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."

Black roofs have been successfully performing in ASHRAE Zones 4 and above over the past four decades. Black EPDM roofs account for more than 52% of roofing installations in the northern part of the U.S., while white membranes only account for 16% or less. (Photo courtesy of Firestone Building Products Co.)

SPRI and ERA would like to see the City of Chicago's energy code recognize ballasted systems as 'energy equal' to cool roofs in its code. This ballasted roof is on 600 West, in Chicago. (Photo courtesy of Tom Hutchinson, Hutchinson Design Group Ltd., Chicago, IL.)

ably difficult to include in EPA's ENERGY STAR format. In fact, no one, including Desjarlais, expects to see a ballasted roof sporting an ENERGY STAR label anytime soon. However, ERA and SPRI are hoping that EPA will at least recognize and reference the study's findings. "We're just looking for a nod of acknowledgement from EPA, but so far they have been resistant," says Desjarlais. "We understand that getting an ENERGY STAR label on a ballasted roof is out of the question." However, it should not be, based on EPA's mission statement for the ENERGY STAR program. EPA introduced ENERGY STAR in 1992, "as a voluntary labeling program designed to identify and promote energy-efficient products to reduce greenhouse gas emissions." Clearly, SPRI's findings show the energy saving benefits of both reflective and ballasted roofs. "ENERGY STAR's mission is to make consumers aware of products that perform better from an energy saving perspective," says Desjarlais. "But it is difficult for EPA to draw the line on what products get the golden star."



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Thanks to Koller's research, WVSBA changed its roofing specification from a white to a black membrane with increased levels of insulation. For more information on the specifications, see www.wvs.state.wv.us/wvsba/hottopix/quality.pdf.

School's out

Black membranes like EPDM can help schools reduce their energy costs because educational facilities are usually closed during the peak cooling season when reflective membranes perform best.

Table 7.4 of the 2007 Buildings Energy Data Book documents energy use intensity based on the type of building, and heating-versus-cooling as a percentage of the total energy consumed.

The document shows that for educational facilities, the average heating cost is 33% of the total energy used versus cooling at only 5%.

In addition, black membranes have been successfully performing in ASHRAE Zones 4 and above over the past four decades. For example, black EPDM roofs account for more than 52% of roofing installations in the northern part of the U.S. (climate zones 4 and above), while white membranes only account for 16% or less, mainly in areas where heat islands are an issue.

"Modifying specifications to replace black membranes with white material in these locations could prove to have a less than favorable outcome," says Ibrahim, "not only in energy savings but also with construction practices, maintenance and possible mold growth."

Other factors roofing contractors and designers should consider when using a white membrane include:

+ Condensation forming on the surface of a white membrane during winter installations that can inhibit adhesive/primer application, which in turn can result in possible delays or changes in the roofing assembly.

+ Mandating white roofs could influence the type of roof assembly used. In winter roofing installations, contractors will be forced to abandon temperature sensitive adhesive applications and only install mechanically fastened systems to meet project schedules. This, in turn, may impact installation of adhered systems, which have been traditionally favored by school systems in North America. In addition, the use of a mechanically attached membrane and one layer of insulation promotes energy loss through the fasteners, while a fully adhered membrane with two layers of insulation eliminates thermal bridging.

+ Frost and ice build-up can go unnoticed on a white membrane, promoting extremely slippery conditions to which building maintenance personnel are not accustomed. Maintenance schedules would have to be altered and special OSHA training implemented for safety.

+ During cold weather, white roofs will allow snow and ice to remain longer and accumulate, thus increasing dead loads (a phenomenon that typically has not been experienced with black membranes).

+ White roofs, due to their lower surface temperature, will support algae and mold growth during the summer, due to the high humidity and surface temperature (68-86 degrees F). This condition is unlikely to occur when black membranes are used due to their higher surface temperature in the summer.

"When considering the higher energy costs of white membranes plus periodic cleaning costs, the use of black membranes will deliver the best return on investment to the building owner and taxpayers, and will have lesser environmental impact due to the lower carbon emissions," says Ibrahim.

How roof service life impacts sustainability

LEED program may underrate long-term performance

According to a recent study, the current LEED (Leadership in Energy and Environmental Design) program appears to give inadequate value to the long-term performance of roofing materials vs. their apparent environmental benefits. In addition, the study clearly points out the cost effectiveness of EPDM membranes based on their long-term performance.

In his presentation at the Feb. 2008 RCI convention in Phoenix entitled, "Life-cycle assessment and the LEED green building rating system," Jim Hoff, DBA, identified some intriguing findings relating to traditional Life-Cycle Cost (LCC) analyses. For the most part, Hoff's 12-page study focuses on whether Life Cycle Assessment (LCA) is a better method of assessing a roof's long-term economic and environmental value than LCC. However, his work also points to the importance of giving credit to roof system durability, along with its environmental impact.

"LCA could result in a better appreciation of products initially considered as not environmentally friendly as other choices perceived as 'green'," says Hoff, who is research director for the Center for Environmental Innovation in Roofing and president of TEGNOS Research Inc., Carmel, IN. "Discovering truly 'green' products through LCA would ultimately be in the building owner's and general public's best interests."

Premature roof failure represents an environmental disaster, when one considers the additional manufacturing, labor, shipping, tear-off and related energy costs necessary to replace a low-slope roofing system.

Hoff's work also supports the proposition advanced by many roofing consultants that the investment in enhanced system design may provide a real economic return to the building owner. As stated by former Roofing Industry Educational Institute Director Richard Boon (2001) in *Roofing Contractor* Magazine: "…the higher upfront costs of premium roofing systems can be fully justified through long-term savings."

The Equivalent Uniform Annual Cost (EUAC) method of life cycle costing Hoff recommends helps identify the real benefits

Table 1: Roof System Specification and Warranty / Service Life

System Type	System Details	Service Life (SL) Based on Warranty Period (Years)
Ballasted EPDM	45 Mil Unreinforced EPDM over 2" Polysio, Loosely Laid and Ballasted	15
Ballasted EPDM	60 Mil Unreinforced EPDM over 2" Polysio, Loosely Laid and Ballasted	20
Adhered EPDM	45 Mil Unreinforced EPDM over 2" Polysio, Fully Adhered	15
Adhered EPDM	60 Mil Unreinforced EPDM over 2" Polysio, Fully Adhered	20
Adhered EPDM	90 Mil Unreinforced EPDM over 2" Polysio, Fully Adhered	30
Mech. Attached EPDM	45 Mil Unreinforced EPDM over 2" Polysio, Mechanically Attached	15
Mech. Attached EPDM	45 Mil Reinforced EPDM over 2" Polysio, Mechanically Attached	20
Mech. Attached Thermoplastic	45 Mil Reinf. T'Plastic over 2" Polysio, Mechanically Attached	15
Mech. Attached Thermoplastic	60 Mil Reinf. T'Plastic over 2" Polysio, Mechanically Attached	20
Modified Bitumen	Mopped Fiberglass Base/Mopped SBS Cap over Cover Board & 2" Polyiso	15
Modified Bitumen	Mopped SBS Base/Mopped SBS Cap over Cover Board & 2" Polyiso	20
Built-Up Roofing	4-Ply IV w/Gravel over Cover Board & 2" Polyiso	15
Built-Up Roofing	4-Ply IV w/Gravel over Cover Board & 2" Polyiso	20

Table 1: Warranty service lives for a variety of roof systems, including EPDM.

inherent in roof systems than have been enhanced to extend service life.

However, based only on a comparison of the basic LCC of 15 and 20 year roofing systems in the study, the benefits of enhanced specifications might be questioned because the LCC costs were so close.

However, the improved EUAC cost method identifies that 20- and 30-year systems may hold an advantage more than sufficient to justify the additional up-front expense.

As an example, the EUAC calculations indicate that the 20-year roofing systems in the study may offer long-term costs 10% to 15% lower than their 15-year counterparts. In addition, the EUAC of the single 30-year system in the study (a 90 mil EPDM membrane) offers an additional cost savings of 12% beyond a similar 20-year system.

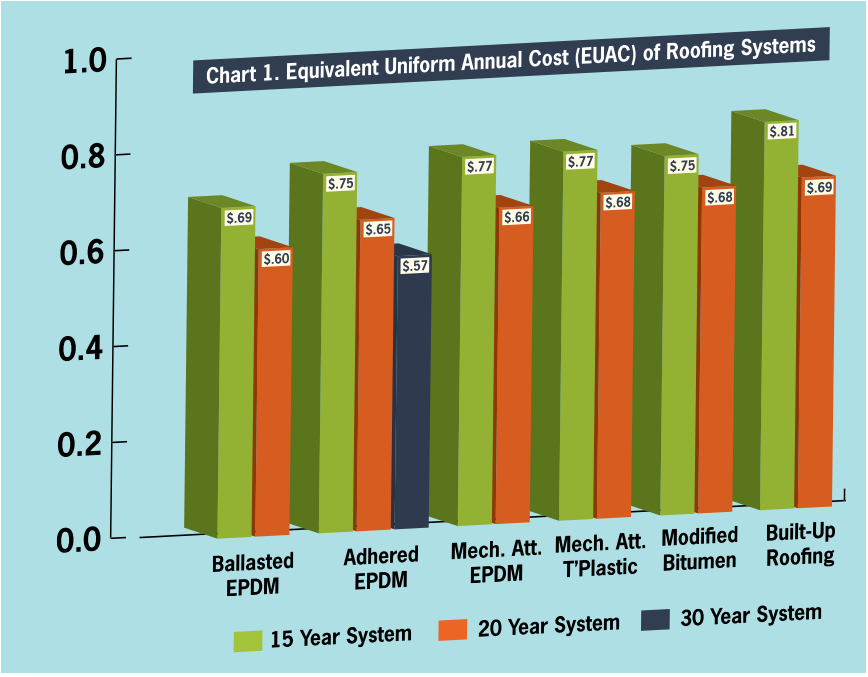


Chart 1: While no single system offers an unassailable economic advantage, 20-year ballasted, adhered and mechanically attached EPDM roof systems may offer some of the lowest EUAC costs for the property owner.

How the roof systems stack up

Table 1 shows warranty service lives for a variety of roof systems, including EPDM. For Hoff's purposes, the nominal warranty period was designated to be the service life period for each roofing system. While the actual service life may exceed the warranted service life, the variation based on warranty length allows for a relative comparison among the systems.

Hoff then presented the initial costs of the various roofing systems using a two-pronged approach:

• establishing initial costs using commonly available industry construction estimating data;

• modifying these initial costs using rank-order data derived from a survey of roofing contractors. Initial costs were established using Means Building Construction Cost Data 2005.

The adjusted costs for each system are summarized in Table 2, below.

Once Hoff established the present values of all initial, maintenance and replacement costs for these roof systems, the calculation of Life Cycle Cost was accomplished by combining these costs into a single amount.

Both a copy of the paper and the slide presentation that accompanied the paper are available at http://www.tegnos.org/LCAResearch.html.

The EUAC method (see Chart 1, above) suggests that the major types of commercial roofing system used in the U.S. today provide a similar economic benefit. While no single system offers an unassailable economic advantage, 20-year ballasted, adhered and mechanically attached EPDM roof systems may offer some of the lowest EUAC costs for the property owner, according to Hoff's research.

In the meantime, the U.S. Green Building Council is responding to long-term performance concerns by incorporating LCA calculations into the LEED program.

Hoff urged the building envelope industry to participate in this process–including environmental product certification programs–to discover which building products are truly sustainable based on service life and long-term performance.

Table 2: Roof System Specification and Initial Cost

System Type	System Details	Service Life (SL) Based on Warranty Period (Years)	Initial Cost ($ /SF)
Ballasted EPDM	45 Mil Unreinforced EPDM over 2" Polysio, Loosely Laid and Ballasted	15	$2.85
Ballasted EPDM	60 Mil Unreinforced EPDM over 2" Polysio, Loosely Laid and Ballasted	20	$3.00
Adhered EPDM	45 Mil Unreinforced EPDM over 2" Polysio, Fully Adhered	15	$3.25
Adhered EPDM	60 Mil Unreinforced EPDM over 2" Polysio, Fully Adhered	20	$3.45
Adhered EPDM	90 Mil Unreinforced EPDM over 2" Polysio, Fully Adhered	30	$4.00
Mech. Attached EPDM	45 Mil Unreinforced EPDM over 2" Polysio, Mechanically Attached	15	$3.35
Mech. Attached EPDM	45 Mil Reinforced EPDM over 2" Polysio, Mechanically Attached	20	$3.55
Mech. Attached Thermoplastic	45 Mil Reinf. T'Plastic over 2" Polysio, Mechanically Attached	15	$3.40
Mech. Attached Thermoplastic	60 Mil Reinf. T'Plastic over 2" Polysio, Mechanically Attached	20	$3.65
Modified Bitumen	Mopped Fiberglass Base/Mopped SBS Cap over Cover Board & 2" Polyiso	15	$3.25
Modified Bitumen	Mopped SBS Base/Mopped SBS Cap over Cover Board & 2" Polyiso	20	$3.70
Built-Up Roofing	4-Ply IV w/Gravel over Cover Board & 2" Polyiso	15	$3.60
Built-Up Roofing	4-Ply IV w/Gravel over Cover Board & 2" Polyiso	20	$3.80

Table 2: Initial costs of the various roof systems, including present values of all initial, maintenance and replacement costs.

EPDM lasts

With a 45-year track record, this single ply is hard to beat

"Mil for mil, EPDM has proven to be one of the most cost effective membranes available today."–Rene Dupuis, president, Structural Research Inc.

Over the last 45 years, EPDM has gained industry-wide acceptance and respect by providing both immediate and long-term roofing solutions. During that time, EPDM has also racked up some impressive numbers in the low-slope roofing market.

As of last year, roofing contractors had installed well over 500,000 warranted EPDM roof systems, representing 20 billion-plus square feet of roofing membrane. No other single-ply system even comes close.

On the new construction side, more than one billion square feet of EPDM are specified annually.

According to the EPDM Roofing Association, black EPDM roofs account for more than 52% of roofing installations in the northern U.S. (ASHRAE Climate Zones 4 and above).

What's more, the National Roofing Contractors Association credits EPDM with holding 25% of the commercial low-slope roofing market, making it the leader for new construction and reroofing applications.

Weatherability is the key reason why more EPDM roofs continue to perform in the existing inventory than any other single-ply membrane. In addition to excellent weathering characteristics, EPDM is a low-maintenance roofing system that offers superior wind, hail and fire resistance.

Ask the experts

Wilbur Kline is an Allentown, PA-based architect ranked in the top 100 specifiers by McGraw-Hill. He is also a firm believer in the long-term performance of EPDM.

In the last 25 years, Dickinson College in Carlisle, PA, has installed more than 400,000 square feet of warranted EPDM roofing. (Photo courtesy of Carlisle SynTec Incorporated, Carlisle, PA.)

"I can't remember any kind of problem with any project in which I used EPDM membrane," says Kline. "I just kept specifying (EPDM) because the performance was consistent."

What makes EPDM such an outstanding roofing system?

Besides its legendary weatherability, EPDM is dimensionally stable, yet expands and contracts with building movement. This allows the membrane to be used successfully in a variety of climates.

EPDM is virtually immune to ozone, UV radiation and cold cracking. The material does not rely on plasticizers for its flexibility, so there's no danger of the membrane becoming brittle from plasticizer loss down the road.

EPDM is available in a wider variety of thicknesses (0.45 to .090 mils) and widths (up to 50' x 100') than thermoplastic membranes. This allows architects to better match EPDM to the performance requirements and budgets of each project, while installers get to use wider sheets that save on labor.

Seam tapes and accessories

There's an old adage in the roofing industry that says a single-ply roof is only as good as its seams. While early EPDM systems were almost bulletproof when it came to weather resistance, the first generation of products relied on liquid adhesives for lap seaming.

Though acceptable at the time, industry professionals knew that a more reli-

able method would be needed in order to make the system a viable, long-term roofing solution.

"From a weatherability standpoint–mil for mil–EPDM has proven to be one of the most cost-effective membranes available today," says Rene Dupuis, president of Structural Research Inc., Madison, WI.

Dupuis has probably studied more EPDM membranes–both in the laboratory and on the roof–than any other independent roofing researcher over the past 30 years. Dupuis is also known for his objectivity and honesty when evaluating roofing systems.

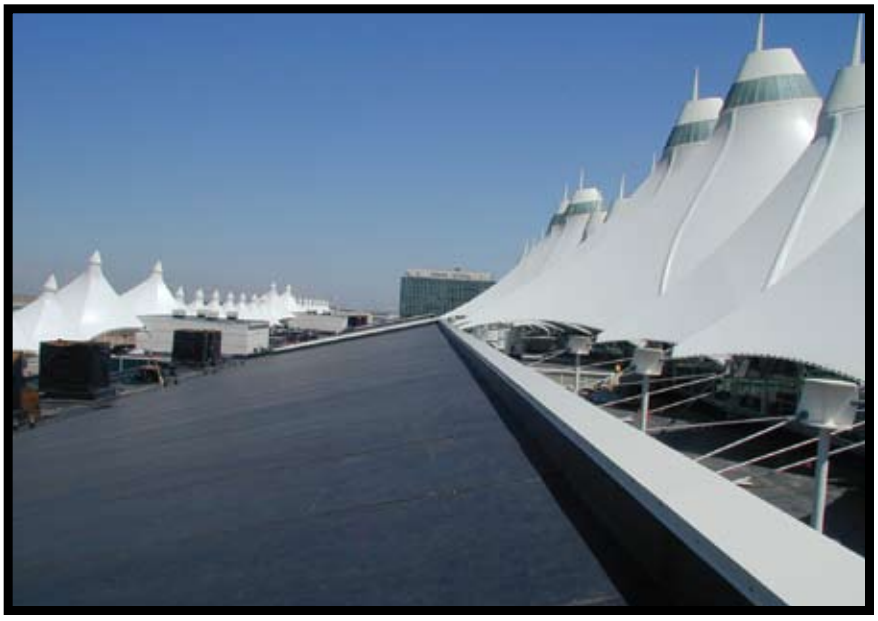
"It's remarkable in hindsight that EPDM started out with one of the more vulnerable lap systems," he says. "However, the industry certainly did not rest until a true high-performance tape system was perfected."

Walt Rossiter, technical director for the Roof Consultants Institute and former research chemist at the National Bureau of Standards (now NIST), agrees.

"EPDM seam performance is really a non-issue–it's simply not discussed anymore," Rossiter says. "The steps the industry has taken in terms of seam tapes and preformed accessories has been fabulous."

With innovations like factory-applied seam tapes and pressure-sensitive accessories, the installation of an EPDM roof has never been easier or more efficient.

"To be able to take a pre-formed boot with a taped flange and slip it over a pipe penetration is amazing for two reasons," says Rossiter. "It saves on labor, but more importantly, it eliminates stretching and bending of the membrane, along with the use of liquid adhesives."



The added "strength" of a 90-mil, EPDM membrane bestows a number of benefits on the roofing system. These include increased hail, traffic, puncture and wind uplift resistance. Shown here is the Denver International Airport, Denver, CO. (Photo courtesy of Firestone Building Products Co.)

Rossiter should know, as he helped author a landmark NIST study on the performance of tape-bonded EPDM seams in 1997 (see http://fire.nist.gov/bfrlpubs).

"We spent well over three years analyzing the performance of taped EPDM seams," recalls Rossiter. "One of the things we discovered was that the strength of a seam made in the laboratory–and in the field–were statistically comparable. That was not the case for the old butyl-based liquid adhesives."

NIST researchers used a long-term creep test to measure the strength of EPDM taped seams. The test was particularly sensitive to key parameters that affect seam performance, including cleaning and application.

"This test and the field samples were very beneficial in helping us understand seam dynamics," says Rossiter, "and the use of EPDM tapes showed a big jump in (seam) performance."

Adding strength to your roofing projects

The added "strength" of a 90-mil, EPDM membrane bestows a number of benefits on the roofing system. These include increased hail, traffic, puncture and wind uplift resistance.

While a 60-mil reinforced EPDM offers excellent long-term performance for most roofing applications, on some projects, roofs must withstand extraordinary loads from construction and maintenance traffic, hail impact, wind uplift loads and snow loads.

Reducing or preventing roof damage from hail impact can save property owners hundreds of thousands of dollars in a single storm.

In areas where hail is not an issue, roof traffic usually is, and most single-ply warranties exclude traffic damage from maintenance crews and other non-roofing trades. However, a typical 30-year warranty on a 90-mil EPDM covers incidental punctures, high winds and hail up to two inches in diameter.

As roof-mounted photo-voltaic (PV) solar systems become more popular, puncture and traffic resistance become even more serious issues. PV systems will require regular maintenance and inspections, which will increase the chances of traffic damage and dropped tools on the roof.

At $40-$50 per square foot, architects and property owners will usually specify extra protection for their roofing investment. They understand that the extra cost of a thicker, 90-mil EPDM pales in comparison to the expense of prematurely replacing the roof membrane below a PV system.

Even for non-PV roofs, studies have shown that a 30-year-warranted, 90 mil EPDM membrane can offer long-term cost savings of 12% beyond a similar 20-year system (see page 10).

Some of these systems are also available with more dependable factory-applied seam tapes, resulting in tighter laps and joints that complement the increased strength of a super-tough 90 mil membrane.

EPDM stands up to Hail

Study confirms superior impact resistance of EPDM membranes

A recent laboratory study conducted by Jim D. Koontz and Associates Inc. (JDK), Hobbs, NM, shows that both new and aged non-reinforced EPDM roof assemblies offer a high degree of hail resistance over a variety of roofing substrates.

The EPDM roof systems tested in the study "provide excellent resistance to large hail," says Koontz, whose company is actively involved in roofing materials research, test standard development, and roof auditing and failure investigation.

Of the 81 60 mil, non-reinforced EPDM "targets" installed over polyiso, wood fiber, plywood and OSB board, 76 EPDM roof assemblies retained their waterproofing integrity when impacted by hail up to 3" in diameter. The field aged samples were collected from six states across the country and ranged in age from five to 20 years.

"Owners of critical facilities, such as hospitals, schools, computer centers, airports and sensitive government buildings have come to realize the importance of installing a hail resistant roof assembly over critical facilities," according to Koontz's report. "The use of non-reinforced EPDM can provide an additional level of long-term protection."

Field experience from the examination of thousands of roofs has shown that hail damage to a roofing system can be the result of several factors. JDK included the following criteria in its study:

- Diameter of the hail
- Type of roofing system
- Age of the roof
- Substrate beneath the primary roof system
- Surface temperature at the point of impact

Historically, the hail resistance of roofing products have been tested by dropping steel balls or darts on to the roofing product. However, within the last few years, greater consideration has been given to impacting targets with ice spheres.

"The use of ice spheres, obviously, comes closer to replicating what occurs during a real hailstorm event," says Koontz, who has spent the past 30 years studying ice sphere impact testing of roofing products with a variety of hail guns.

Koontz used 4' x 4' EPDM targets, which were all fully adhered to their substrates. Each target with substrate was mounted vertically. Hailstones measuring 1.5", 2.0", 2.5" and 3.0" impacted the targets at a 90-degree angle.

According to Koontz, prior research and experience has shown that roof assemblies exhibit different levels of impact resistance depending upon surface temperature. In order to replicate the cold rain that accompanies a hailstorm, the test targets were sprayed with water at 40 degrees F during testing.

"Some geographical areas of the United States are clearly more prone to severe hail events," says Koontz. "Roof assemblies should be capable of resisting impact from reasonably expected hail storms for a given geographical area.

"Just as roofs are required to perform

in various meteorological events," continues Koontz, "such as wind, snow, and rain, a roof should be able to withstand some degree of hail impact over its expected service life."

For mechanically attached systems, the researchers ensured that the EPDM assemblies were impacted both in the field of the roof and directly over the mechanical fasteners and plates. Koontz found that damage did occur over the fasteners and plates with a combination of either 1.5" or 2" ice spheres for both new, heat aged and field aged EPDM.

Koontz defined failure in this test as a "visible split or cut in the surface of the EPDM" membrane. Even though the mechanically attached membranes did not "fail" the test due to impacts on the fasteners and plates, damage did occur to key elements of the roofing system. For this reason, contractors and specifiers looking to maximize hail resistance may want to consider a fully adhered EPDM roof system that eliminates fasteners and plates entirely. Attaching the insulation or cover board with a urethane adhesive instead of mechanical fasteners would also take fastener damage out of the equation.

To obtain a copy of the full report on Koontz's research, please contact ERA at www.epdmroofs.org.

Hailstorms likely to increase

According to a recent Dun & Bradstreet study, building owners paid more for property insurance last year in the wake of a series of catastrophic hailstorms that produced a nation-leading $1.5 billion in claims from one state alone.

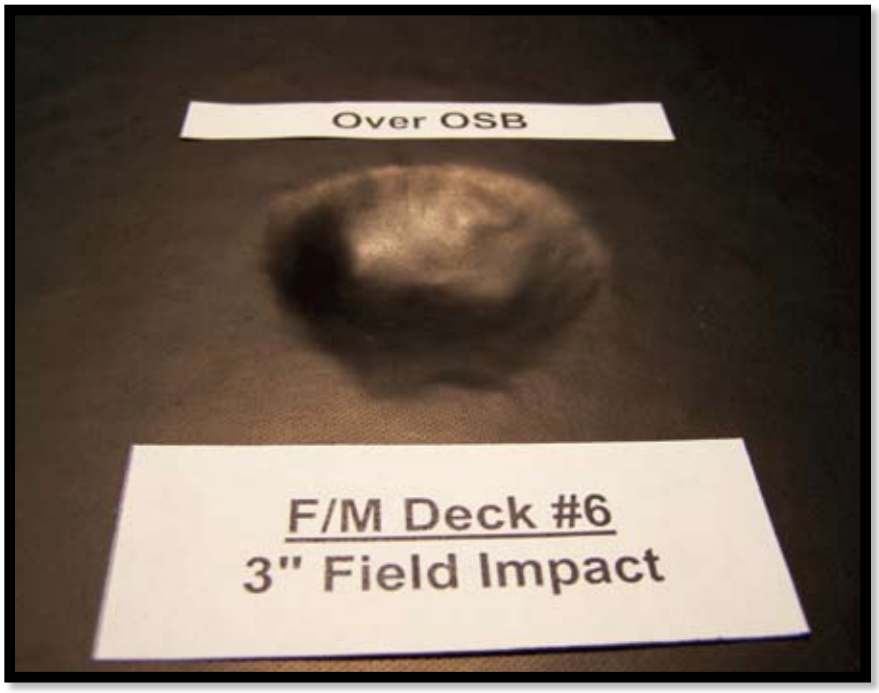
In 2006, Indiana–not Texas or Oklahoma–led the nation in hail-related claims.

"It was a bad year," says Gregg Huey CEO of Indiana Farmers Insurance. "And our state isn't even in the 'hail belt'."

In fact, a Dec. 2007 Purdue University study found that the number of days favorable for severe hailstorms could more than double in some parts of the country by the end of the century.

"This study makes a strong statement that these severe weather events will become much more common than they are today," said Noah Diffenbaugh of Purdue's Climate Change Research Center.

All the more reason why architects and contractors should install the most hail resistant roof systems available. In addition, reducing or preventing roof damage from hail impact can lower insurance costs and save property owners hundreds of thousand of dollars in a single storm.



The impact of a 3" hailstone is clearly shown in this photo of an EPDM membrane tested over OSB. (Photo courtesy of Jim D. Koontz and Associates Inc.)

Strengthening EPDM specs

One of the strategies that contractors and architects can pursue to enhance impact resistance is to add "durability" to the roofing assembly. Durability can be defined as a combination of roof system "strength" and "flexibility," as well as exemplary hail and roof traffic resistance. By specifying a cover board of any type–be it wood fiber, fiberglass or gypsum–the designer adds durability to the roof system.

A cover board is defined as a relatively thin (5/8") semi-rigid board installed between the insulation and the roofing membrane.

There are several commonly used cover boards for contractors and specifiers to choose from:

--Asphaltic board
--Plywood (OSB)
--Mineral fiber board
--Wood fiber board
--Perlite
--Paper-faced gypsum
--Glass-mat gypsum

For years, the National Roofing Contractors Association (NRCA) has recommended the use of cover boards with polyiso insulation to minimize problems with facer-sheet delamination; cavitation at the edge of the board; cupping or bowing of the board; shrinkage; and crushing or powdering.

In areas where hailstorms are common, one major retail chain now specifies gypsum cover board for all of its facilities to keep them in operation and maintain profit flow after a severe hailstorm.

"At one of our Nebraska facilities, golf ball sized hail destroyed the single-ply roof," says the manager of roofing programs for the retailer. "When we rebuilt that roof, we put 1/4" of glass-mat faced gypsum board between the foam insulation and the membrane. In a subsequent storm, 4" diameter hailstones destroyed trees, automobiles and roofs of all types. But our store came out of it with no fractures in the membrane."

Considering all the benefits that a cover board provides, the price of entry is relatively low. According to one Registered Roof Consultant who specifies gypsum on many of his projects, the cover board adds 5% to the cost of the roof, but "gives the roof 25% more life over the long run. It's a return on investment that we're more than willing to make upfront."