

ENVIRONMENTAL PRODUCT DECLARATION

SBS-MODIFIED BITUMEN ROOFING MEMBRANE

INSTALLATION: HOT ASPHALT



Low-slope roofing membrane installed using hot asphalt and consisting of a SBS-modified bitumen cap sheet and base sheet.



The Asphalt Roofing Manufacturers Association (ARMA) is a trade association representing North America's asphalt roofing manufacturing companies and their raw material suppliers. The association includes the majority of North American manufacturers of asphalt shingles and asphalt low slope roof membrane systems. Information that ARMA gathers on modern asphalt roofing materials and practices is provided to building and code officials, as well as regulatory agencies and allied trade groups. Committed to advances in the asphalt roofing industry, ARMA is proud of the role it plays in promoting asphalt roofing to those in the building industry and to the public.

ARMA's vision and mission is to be an association committed to the long-term sustainability of the asphalt roofing industry and to advocate and advance the interests of the asphalt roofing industry by leveraging the collective expertise of its members.



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This declaration is an environmental product declaration (EPD) in accordance with ISO 14025. EPDs rely on Life Cycle Assessment (LCA) to provide information on a number of environmental impacts of products over their life cycle. Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc. Accuracy of Results: EPDs regularly rely on estimations of impacts, and the level of accuracy in estimation of effect differs for any particular product line and reported impact. Comparability: EPDs are not comparative assertions and are either not comparable or have limited comparability when they cover different life cycle stages, are based on different product category rules or are missing relevant environmental impacts. EPDs from different programs may not be comparable.



PROGRAM OPERATOR	UL Environment
DECLARATION HOLDER	Asphalt Roofing Manufacturers Association (ARMA)
DECLARATION NUMBER	4787168709.105.1
DECLARED PRODUCT	APP-Modified Bitumen Roofing Membrane (Installation: Torch Applied)
REFERENCE PCR	SBS-Modified Bitumen Roofing Membrane (Installation: Hot Asphalt)
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PERIOD OF VALIDITY	5 Years
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications
The PCR review was conducted by:	ASTM International
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This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories <input type="checkbox"/> INTERNAL <input checked="" type="checkbox"/> EXTERNAL	 Wade Stout, UL Environment
	 Thomas P. Gloria, Industrial Ecology Consultants
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	 Thomas P. Gloria, Industrial Ecology Consultants

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Participating Members

The following ARMA members provided data for the product covered within this document:



CertainTeed
www.certainteed.com



Johns Manville
www.jm.com



Firestone Building Products
www.firestonebpc.com



Malarkey Roofing
www.malarkeyroofing.com



GAF
www.gaf.com



SOPREMA
www.soprema.us
www.soprema.ca

Product Definition

Product Description

The low-slope roofing membrane included in this study consists of a styrene-butadiene-styrene (SBS)-modified bitumen cap sheet and a base sheet.

Component	Specification	Description
SBS Cap Sheet	ASTM D6162, D6163, D6164, CSA A123.23	- Polyester and/or fiberglass mat coated with polymer-modified asphalt and colored mineral granule surfacing
SBS Base Sheet	ASTM D6162, D6163, D6164, CSA A123.23	- Polyester and/or fiberglass mat coated with polymer-modified asphalt - A fine mineral matter may be applied as a surfacing or parting agent to both sides of the base sheets

Manufacturing Locations

The components of the low-slope SBS-modified bitumen roofing membrane are manufactured in the United States and/or Canada.

Applications and Uses

Low-slope roofing systems are installed on roofs with slopes less than 2:12. Low-slope roofing systems are primarily used to protect buildings and structures from the weather.

In addition to providing beauty, affordability and reliability, modified bitumen roof systems are trusted to protect against weather conditions, temperature extremes, impacts, and foot traffic. Multiple layers of roofing materials including engineered reinforcements provide strength and durability. It is a versatile solution, able to adapt to many roof design challenges.





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System Description

Material Content

Table 1 shows the input materials for SBS-modified bitumen cap sheet and base sheet manufacturing, and the weight percentages of the components in the product system. The remainder of the system weight consists primarily of asphalt applied during installation.

Table 1: Average material inputs for SBS-modified bitumen cap and base sheet manufacturing

Material Inputs*	Weight Percentage in Individual Component
SBS-Modified Cap Sheet (47% of representative roofing system)	
Asphalt	35%
Mineral granules	30%
Mineral stabilizers	15%
Sand	6%
Fire retardant (colemanite, alumina trihydrate)	6%
Mat (fiberglass, polyester, fiberglass/polyester)	4%
Styrene butadiene styrene (SBS) polymer	4%
SBS-Modified Base Sheet (28% of representative roofing system)	
Asphalt	41%
Mineral stabilizers	29%
Sand	21%
Mat (fiberglass, polyester, fiberglass/polyester)	4%
Styrene butadiene styrene (SBS) polymer	4%

*Total system also includes weight of ancillary materials used during installation

Manufacturing Process

SBS Cap Sheets

Manufacture of SBS polymer-modified bitumen cap sheets involves impregnating and coating a fiberglass or polyester mat with a polymer-modified asphalt. The polymer-modified asphalt is produced by mixing appropriate proportions of polymer, non-oxidized or lightly oxidized asphalt, and limestone or other suitable mineral stabilizer. An appropriate surfacing material is applied. SBS cap sheets typically use a colored mineral granule surfacing. The product is cooled, wound into rolls, and packaged for shipment.

SBS Base Sheets

Manufacture of SBS polymer-modified bitumen base sheets involves impregnating a fiberglass and/or polyester mat and subsequently coating the mat with polymer-modified asphalt. The polymer-modified asphalt is produced by mixing appropriate proportions of polymer, non-oxidized or lightly oxidized asphalt, and limestone or another suitable mineral stabilizer. Fine mineral matter may be applied as a surfacing agent or as a parting agent to both sides of the base sheets. The product is cooled, wound into rolls, and packaged for shipment.





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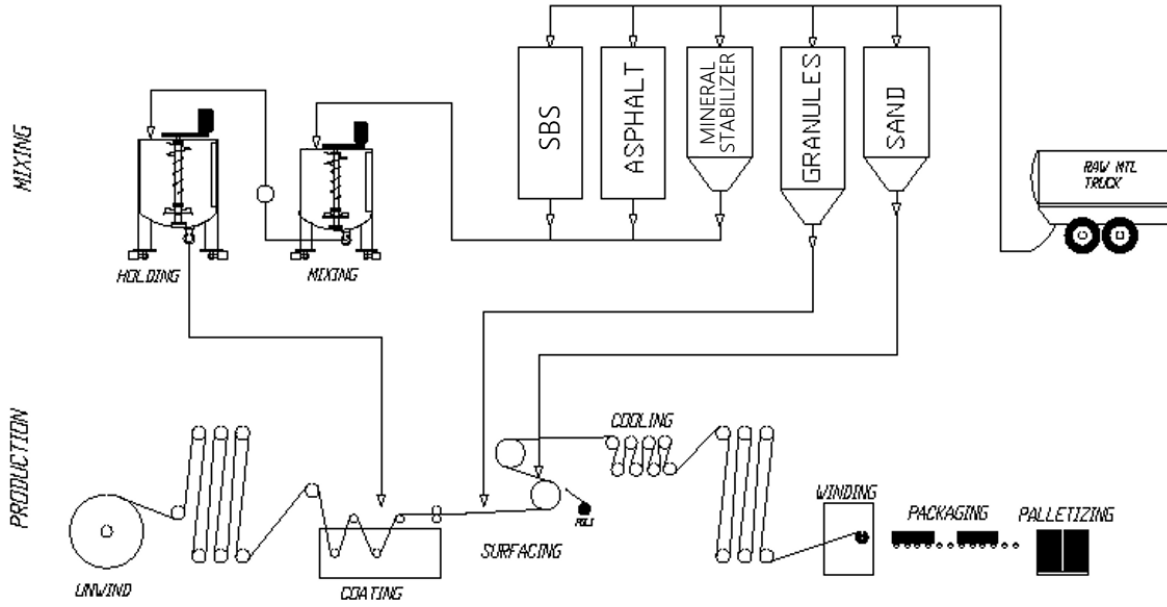


Figure 1: Modified bitumen sheet process diagram

Installation

For this EPD, a hot-mopped SBS-modified bitumen roofing membrane consists of one base sheet and one cap sheet. Hot-mopped SBS installation requires hot asphalt to be first mopped onto the roof surface and the SBS-modified bitumen base sheet to be unrolled directly into the asphalt and pressed into place. This same process is used to install the SBS-modified bitumen cap sheet on top of the base sheet. A weighted roller follows the sheet, securing the seam. Mineral granules are applied to the asphalt that has migrated out of the cap sheet seams to protect it from UV and for aesthetic reasons.

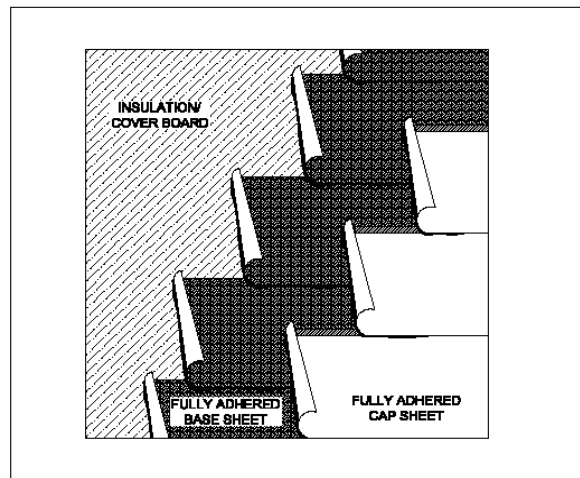


Figure 2: SBS modified bitumen roof membrane system installation details





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The table below presents the installation details for the membrane. The effective coverage includes the required overlap of sheets while the scrap rate accounts for material wasted during installation. The VOC emissions associated with heating the asphalt in a kettle are calculated using the US Environmental Protection Agency (EPA) Area Source Category Method.

Table 2: Roofing system installation inputs and outputs, per 1 m²

	Weight of Material [kg / m ²]	Effective Coverage [m ² of Material / 1 m ² of Roof]	Scrap Rate	Required Quantity of Material [kg / 1 m ²]
Inputs				
Cap sheet	4.5	1.10	5%	5.2
Base sheet	2.7	1.10	5%	3.1
Flashing	0.1	N/A	10%	0.1
Mopping asphalt ¹	2.4	N/A	5%	2.6
Mineral granules (at seams)	0.08	N/A	-	0.08
Propane for kettles	2.6 (MJ)	N/A	-	2.6 (MJ)
Diesel (pump to roof) ²	5.0 x 10 ⁻⁴ (MJ)	N/A	-	5.0 x 10 ⁻⁴ (MJ)
VOCs (asphalt kettle ³)	0.008	N/A	-	0.008
Outputs				
Installed System				10.6
Waste				0.5

¹ 1.22 kg / 1 m² per layer

² Assumes 4-story building¹ and 3.95 m story height²

³ 3.1 kg VOCs / metric tonne of asphalt

End-of-Life

At the end-of-life, the low-slope membrane is removed by manual labor, often with roofing shovels. The debris is collected and transported off-site via truck. The waste is brought to a landfill.

Life Cycle Assessment – Product Systems and Modeling

Declared Unit

The declared unit of this study is 1 m² (10.8 ft²) of the installed roofing membrane. The associated reference flow (the quantity of material required to fulfill the declared unit) is 10.56 kg/m².

Life Cycle System Boundaries

The life cycle study encompasses the cradle-to-gate production, construction, and end-of-life (EoL) stages of a hot-mopped low-slope SBS-modified bitumen roofing membrane including raw material extraction and processing, product manufacturing and installation, plus EoL. Transportation between stages is accounted for, including raw material

¹ http://buildingsdatabook.eren.doe.gov/docs/xls_pdf/3.2.3.pdf

² http://www.pnl.gov/main/publications/external/technical_reports/PNNL-20380.pdf





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transport to the manufacturing facility, finished product transport to the construction site, and transport of the roof system at EoL to the landfill. Use, maintenance, repair, or replacement of the roof system over a building’s service life is not included in this evaluation. In addition, production, manufacture, and construction of manufacturing equipment and infrastructure; repair and maintenance of the production system; energy and water use related to company management and sales; delivery vehicles and laboratory equipment; as well as maintenance and operation of support equipment are all outside of the scope of the study.

Product Stage			Construction Stage		Use Stage					End-of-Life Stage			
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4
Raw materials supply	Transport	Manufacturing	Transport	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	De-construction	Transport	Waste processing	Disposal
X	X	X	X	X	MND	MND	MND	MND	MND	X	X	X	X

MND = module not declared

Assumptions

The analysis uses the following assumptions:

- Mineral granules can be made in a variety of colors, which affects the composition of the required mineral granule coating. White mineral granules were selected as a representative product for this study because the pigment used for white products, titanium dioxide, generally has a higher impact than other pigments; therefore, using white is a conservative assumption.
- Where a manufacturer was unable to calculate an average distance for the distribution of its final product from its facility, it provided a best estimate.
- Due to lack of data availability some proxy background data were used, specifically in the context of the geographical scope of the study.

Cut-off Criteria

No cut-off criteria were applied in this study. All reported data were incorporated and modeled using best available LCI data.

Transportation

Production-weighted averages for the transportation distances and modes of transport associated with each participating company are included for the transport of the raw materials to production facilities and the transport of the finished products to distribution centers. The transport of finished products from distribution center to the construction site and of waste from the construction site to landfill were each assumed to be 20 miles.





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Temporal, Technological, and Geographical Coverage

Temporal: Primary data, collected from the participating ARMA member companies, is representative of the year 2012.

Technological: At least 75% of the production market is estimated to be represented within this study.

Geographical: The geographic coverage represented by this study is the United States and Canada, though some manufacturers source their raw materials from outside this region. Whenever US background data were not readily available, European data or global data were used as proxies, depending on appropriateness and availability. Results are presented as production weighted averages for the US and Canada.

Background Data

The LCA model was created using the GaBi ts Software system for life cycle engineering, developed by thinkstep AG (previously PE INTERNATIONAL). The GaBi 2013 database provides the LCI data for several of the raw and process materials obtained from the background system. Secondary data, information from relevant literature, are from a range of sources between 1977 (asphalt oxidation information) and 2013.

Data Quality

As the relevant foreground data is primary data or modeled based on primary information sources of the owner of the technology, no better precision is reachable within this product. Seasonal variations and variations across different manufacturers were balanced out by using yearly averages and weighted averages. All primary data were collected with the same level of detail, while all background data were sourced from the GaBi 2013 databases. Allocation and other methodological choices were made consistently throughout the model.

Allocation

As several products are often manufactured at the same plant, participating companies used mass allocation to report data since the environmental burden in the industrial process (energy consumption, emissions, etc.) is primarily governed by the mass throughput of each sub-process.

All packaging waste generated during installation, as well as 40% of the wooden pallets used for shipping of products, are assumed to be sent to landfill and the system credited with any avoided production of electricity generated from the combustion of landfill gas.

The impacts due to the use of any recycled materials during manufacturing come only from further processing required during the recycling process. Where in-house recycling is used to create other products, co-product allocation by mass is used and any additional processing steps required for use of the recovered materials are accounted for. It is conservatively assumed that all roofing materials disposed at EoL are sent to landfill. This will vary from job site to job site as some roofers may recycle metal components.

Life Cycle Assessment – Results and Analysis

Environmental Product Declarations (EPDs) created under a different Product Category Rule (PCR) are not comparable. Additionally, EPDs based on a declared unit shall not be used for comparisons between products, regardless of the EPDs using the same PCR.





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Use of Material Resources

The material resource consumption associated with the installed roofing membrane is presented below for the production, construction, and EoL stages. Water consumption values are negative due to waste sent to landfill at EoL. A landfill introduces blue water to the watershed because it collects rainwater during its lifetime that is eventually released back into the ground, therefore more blue water is coming out of the process than going in. Rainwater is not blue water and is therefore not included in the water consumption metric.

Table 3: Resource use results for each life cycle stage, per 1 m²

Impact Category	Units	Production (A1-A3)	Construction (A4-A5)	EoL (C1-C4)	Total
Renewable materials	kg	40.6	1.9	1.3	43.8
Nonrenewable materials	kg	14.6	1.5	2.5	18.6
Water consumption	L	0.06	4.5 x 10 ⁻⁴	-0.02	0.04

Primary Energy by Life Cycle Stage

The primary energy demand associated with the installed roofing membrane is presented below for the production, construction, and EoL stages. Results are given as higher heating value (HHV), per the PCR. Renewable energy is negative for construction due to the credit given for reusing pallets.

Table 4: Primary energy demand results for each life cycle stage, per 1 m²

Primary Energy	Units	Production (A1-A3)	Construction (A4-A5)	EoL (C1-C4)	Total
Nonrenewable fossil	MJ (HHV)	274	146	8.3	428
Nonrenewable nuclear	MJ (HHV)	6.6	0.6	0.2	7.5
Renewable (solar, wind, hydro, geo)	MJ (HHV)	6.8	-0.6	0.4	6.6
Renewable (biomass)	MJ (HHV)	8 x 10 ⁻¹¹	1 x 10 ⁻⁵	6 x 10 ⁻¹²	1 x 10⁻⁵

Life Cycle Impact Assessment

The environmental impacts associated with the installed roofing membrane are presented below for the production, construction, and EoL stages.

Table 5: Life cycle impact category results, per 1 m² (TRACI 2.1)

Impact Category	Units	Production (A1-A3)	Construction (A4-A5)	EoL (C1-C4)	Total
Global warming potential	kg CO ₂ -eq	6.7	2.2	0.5	9.4
Smog creation potential	kg O ₃ -eq	0.4	0.2	0.05	0.6
Acidification potential	kg SO ₂ -eq	0.02	0.01	0.002	0.04
Eutrophication potential	kg N-eq	0.002	6 x 10 ⁻⁴	3 x 10 ⁻⁴	0.003
Ozone depletion potential	kg CFC-11 eq	6 x 10 ⁻¹⁰	3 x 10 ⁻⁹	1 x 10 ⁻¹¹	4 x 10⁻⁹

Waste Generation

The waste generation associated with the installed roofing membrane is presented below for the production,





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construction, and EoL stages.

Table 6: Waste generation results, per 1 m²

Impact Category	Units	Production (A1-A3)	Construction (A4-A5)	EoL (C1-C4)	Total
Non hazardous waste generated	kg	1.0	0.6	10.6	12.2
Hazardous waste generated	kg	0.004	8 x 10 ⁻⁵	2 x 10 ⁻⁴	0.004

Additional Environmental Information

Reflective Roofs

Reflective roofs are defined as roofing products with high solar reflectance. Many in the construction industry define “cool roofs” as roofing products with high solar reflectance and high thermal emittance. Asphalt-based products have the inherent property of having high emittance, regardless of their reflective properties. Asphaltic roof systems typically have thermal emittance values greater than 0.80. Reflectance is a deliberate product characteristic, and varies based on the surfacing used.

There are reflective roof options available for virtually any roof and any building. Because of asphalt roofs’ longevity, asphalt-based products provide excellent value for homeowners and building owners by delivering superior durability and sustainability at reasonable cost.

Modified bitumen membranes provide options for varying levels of reflectivity. The reflectivity is related to the color of the modified bitumen membrane surface, surfacing material, or field applied coating. While reflective roofs are an increasingly popular roof option, they represent one of many approaches to help building owners and consumers reduce building energy use and address contemporary environmental concerns.

Individual Component Results

The material resource consumption, primary energy demand, environmental impacts, and waste generation results associated with each individual component (excluding ancillary materials used during installation) of the roofing system are presented below for the production stage (A1-A3).

Table 7: Production stage (A1-A3) impact results for each system component, per 1 m² of individual component

Impact Category	Units	Base sheet	Cap sheet
Renewable materials	kg	12.6	22.5
Nonrenewable materials	kg	3.6	9.0
Water consumption	L	11.3	41.5
Nonrenewable fossil	MJ (HHV)	85.2	135
Nonrenewable nuclear	MJ (HHV)	1.9	3.9
Renewable (solar, wind, hydro, geo)	MJ (HHV)	1.8	4.0
Renewable (biomass)	MJ (HHV)	2 x 10 ⁻¹¹	5 x 10 ⁻¹¹
Global warming potential	kg CO ² -eq	2.1	3.7
Smog creation potential	kg O ³ -eq	0.1	0.2





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Impact Category	Units	Base sheet	Cap sheet
Acidification potential	kg SO ² -eq	0.008	0.01
Eutrophication potential	kg N-eq	6 x 10 ⁻⁴	0.001
Ozone depletion potential	kg CFC-11 eq	2 x 10 ⁻¹⁰	3 x 10 ⁻¹⁰
Non hazardous waste generated	kg	0.3	0.6
Hazardous waste generated	kg	7 x 10 ⁻⁴	0.002

References

- ASTM (2014). “Product category rules for preparing an environmental product declaration for product group: Asphalt Shingles, Built-up Asphalt Membrane Roofing and Modified Bituminous Membrane Roofing.” (http://www.astm.org/CERTIFICATION/DOCS/152.PCR_ASTM_Aspphalt_Roofing_PCR_073114.pdf)
- LBP, University of Stuttgart and thinkstep GmbH, Leinfelden-Echterdingen (2013). GaBi 6 dataset documentation for the software-system and databases (<http://documentation.gabi-software.com/>)
- thinkstep (formerly PE INTERNATIONAL) (2015). “Life Cycle Assessment of Asphalt Roofing Systems: Cradle-to-grave LCAs of a steep-slope and four low-slope industry-average asphalt roofing systems.”
- US EPA. “Area Source Category Method Abstract – Asphalt Roofing Kettles.” (2000). (<https://www.epa.gov/sites/production/files/2015-08/documents/asphalt.pdf>)

LCA Development



thinkstep

The EPD and background LCA were prepared by thinkstep, Inc. (previously PE INTERNATIONAL).

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