ENVIRONMENTAL PRODUCT DECLARATION

BUILT-UP ASPHALT ROOFING MEMBRANE

INSTALLATION: HOT ASPHALT

Low-slope roofing membrane installed using hot asphalt and consisting of a built-up roof (BUR) cap sheet and ply felt components.

ASPHALT ROOFING MANUFACTURERS ASSOCIATION

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.

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

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	4787168709.103.1	
DECLARED PRODUCT	Built-Up Asphalt Roofing Membrane (Installation: Hot Asphalt)	
REFERENCE PCR	ASTM: Asphalt shingles, built-up and modified bituminous membrane roofing. 2014	
DATE OF ISSUE	October 28, 2016	
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 Chair: Francois Charron-Doucet cert@astm.org
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL		Wade Stout, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:		Thomas P. Gloria, Industrial Ecology Consultants

Participating Members

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

CertainTeed
www.certainteed.com

GAF
www.gaf.com

Johns Manville
www.jm.com

Malarkey Roofing
www.malarkeyroofing.com

Product Definition

Product Description

The low-slope roofing membrane included in this study consists of built-up roof (BUR) cap sheet and ply felt components.

Component	Specification	Description
BUR Cap Sheet	ASTM D3909; CSA A123.2	- Mineral-surfaced BUR cap sheets consist of asphalt-impregnated and coated glass felt roll roofing surfaced on the weather side with colored mineral granules
BUR Ply Felt	ASTM D2178; CSA A123.17	- Ply felts consist of glass felts impregnated with oxidized asphalt - A fine mineral matter parting agent is typically applied to facilitate use during installation

Manufacturing Locations

The components of the low-slope BUR 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.

One significant benefit of BUR systems is the protection provided by the multiple water-resistant layers. These systems are durable and can stand up to weather conditions, temperature extremes, impacts, and foot traffic. BUR roofing systems can be installed in a variety of ways to meet many building design requirements.

System Description

Material Content

Table 1 shows the input materials for the BUR mineral-surfaced cap sheet and ply felt 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: Material inputs, average, for BUR cap and ply felt manufacturing

Material Inputs*	Weight Percentage in Individual Component
BUR Mineral Cap Sheet (37% of representative roofing system)	
Mineral granules	43%
Mineral stabilizers	25%
Asphalt	21%
Sand	7%
Fiberglass mat	3%
BUR Ply Felt (11% of representative roofing system)	
Asphalt	71%
Fiberglass mat	27%
Sand	1%
Release agent (soaps, sodium cocoate)	1%

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

Manufacturing Process

BUR Mineral-surfaced Cap Sheet

Manufacture of mineral-surfaced cap sheets involves impregnating and coating a fiberglass mat with a filled asphalt coating. The filled coating mixture is produced in a separate process that involves mixing oxidized asphalt and limestone (or other suitable mineral stabilizer) in appropriate proportions. Colored mineral granules are added as surfacing. Fine mineral matter may be used as a parting agent. The product is cooled, wound into rolls, and packaged for shipment.

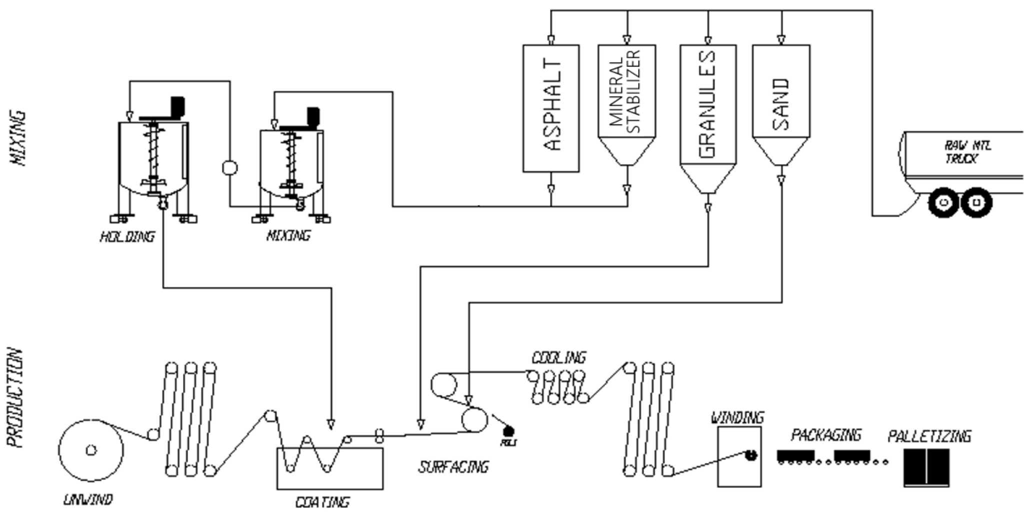

Figure 1: Mineral-surfaced cap sheet process diagram

BUR Ply Felt

Manufacture of ply felts involves impregnating a fiberglass mat with oxidized asphalt. A fine mineral matter parting agent is typically applied to facilitate installation. The product is cooled, wound into rolls, and packaged for shipment.

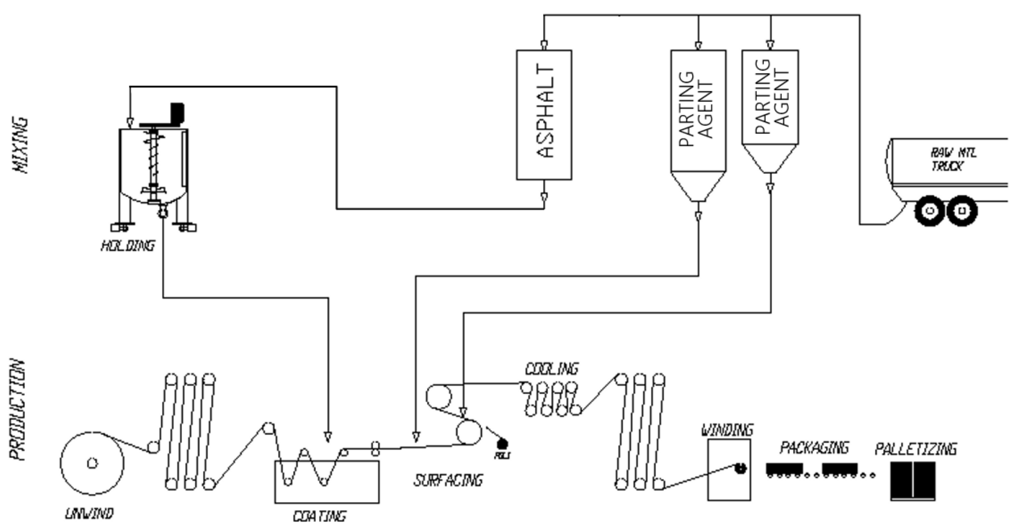

Figure 2: Ply felt process diagram

Installation

For this EPD, a BUR membrane consists of three ply felts and a mineral-surfaced cap sheet. Hot-mopped BUR installation requires hot asphalt to be mopped onto the roof surface and the ply felts unrolled directly into the asphalt and broomed into place. Asphalt kegs are heated in a propane-fueled kettle to the required temperature and viscosity for their application. This process is repeated until three layers of ply felts have been installed. The same process is used to install the mineral-surfaced cap sheet on top of the three-ply layer of felts. 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.

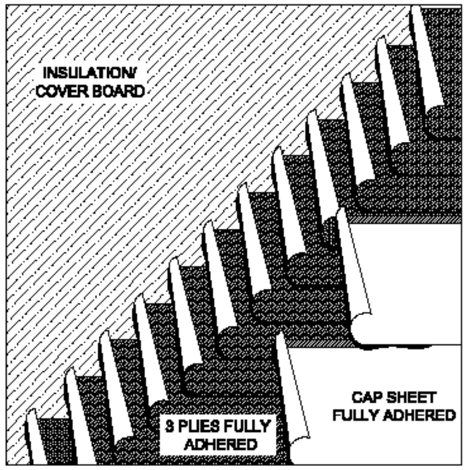

Figure 3: Built-Up roofing system installation detail

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 from the asphalt kettle are calculated using the US Environmental Protection Agency (EPA) Area Source Category Method.

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

	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	3.44	1.06	5%	3.83
Ply felt	0.33	3.14	5%	1.08
Flashing	0.10	N/A	10%	0.11
Asphalt[1]	4.89	N/A	5%	5.13
Mineral granules (at seams)	0.08	N/A	-	0.08
Propane	5.0 (MJ)	N/A	-	5.0 (MJ)
Diesel (pump to roof)[2]	0.001 (MJ)	N/A	-	0.001 (MJ)
VOCs from asphalt kettle[3]	0.02	N/A	-	0.02
Outputs				
Installed System				9.74
Waste				0.49

[1] 1.22 kg / 1 m^2 per layer
[2] Assumes 4-story building[1] and 3.95 m story height[2]
[3] 3.1 kg VOCs/metric tonne of asphalt

[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

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 m^2 (10.8 ft^2) of the installed roofing membrane. The associated reference flow (the quantity of material required to fulfill the declared unit) is 9.74 kg/m^2.

Life Cycle System Boundaries

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

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.

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 m^2

Impact Category	Units	Production (A1-A3)	Construction (A4-A5)	EoL (C1-C4)	Total
Renewable materials	kg	21.7	3.3	1.2	**26.1**
Nonrenewable materials	kg	8.9	1.9	2.3	**13.1**
Water consumption	L	0.01	0.002	-0.02	**-0.004**

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 m^2

Primary Energy	Units	Production (A1-A3)	Construction (A4-A5)	EoL (C1-C4)	Total
Nonrenewable fossil	MJ (HHV)	129	273	7.7	**411**
Nonrenewable nuclear	MJ (HHV)	3.6	1.0	0.2	**4.8**
Renewable (solar, wind, hydro, geo)	MJ (HHV)	4.3	-0.2	0.3	**4.4**
Renewable (biomass)	MJ (HHV)	2×10^{-11}	1×10^{-5}	5×10^{-12}	**1×10^{-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	3.9	3.0	0.5	**7.3**
Smog creation potential	kg O_3-eq	0.2	0.3	0.04	**0.6**
Acidification potential	kg SO_2-eq	0.02	0.02	0.002	**0.04**
Eutrophication potential	kg N-eq	0.001	6×10^{-4}	3×10^{-4}	**0.002**
Ozone depletion potential	kg CFC-11 eq	4×10^{-10}	3×10^{-9}	1×10^{-11}	**4×10^{-9}**

Waste Generation

The waste generation associated with the installed roofing membrane is presented below for the production, 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	0.5	0.5	9.8	**10.8**
Hazardous waste generated	kg	0.002	2×10^{-4}	2×10^{-4}	**0.002**

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.

BUR membranes provide options for varying levels of reflectivity. The reflectivity is related to color of the cap sheet 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 m^2 of individual component

Impact Category	Units	Ply Felt	Mineral Cap sheet
Renewable materials	kg	3.3	9.3
Nonrenewable materials	kg	0.6	6.2
Water consumption	L	1.6	8.6
Nonrenewable fossil	MJ (HHV)	17.4	56.9
Nonrenewable nuclear	MJ (HHV)	0.5	1.7
Renewable (solar, wind, hydro, geo)	MJ (HHV)	0.5	2.3
Renewable (biomass)	MJ (HHV)	2×10^{-12}	9×10^{-12}
Global warming potential	kg CO^2-eq	0.6	1.8
Smog creation potential	kg O^3-eq	0.04	0.1
Acidification potential	kg SO^2-eq	0.003	0.008
Eutrophication potential	kg N-eq	2×10^{-4}	6×10^{-4}
Ozone depletion potential	kg CFC-11 eq	6×10^{-11}	2×10^{-10}
Non hazardous waste generated	kg	0.04	0.3
Hazardous waste generated	kg	1×10^{-4}	0.001

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_Asphalt_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).

thinkstep, Inc.
170 Milk Street, 3rd Floor
Boston, MA 02109
info@thinkstep.com
www.thinkstep.com

Contact Information

Asphalt Roofing Manufacturers Association
529 14th Street, NW
Suite 750
Washington, DC 20045
Tel: (202) 591-2450