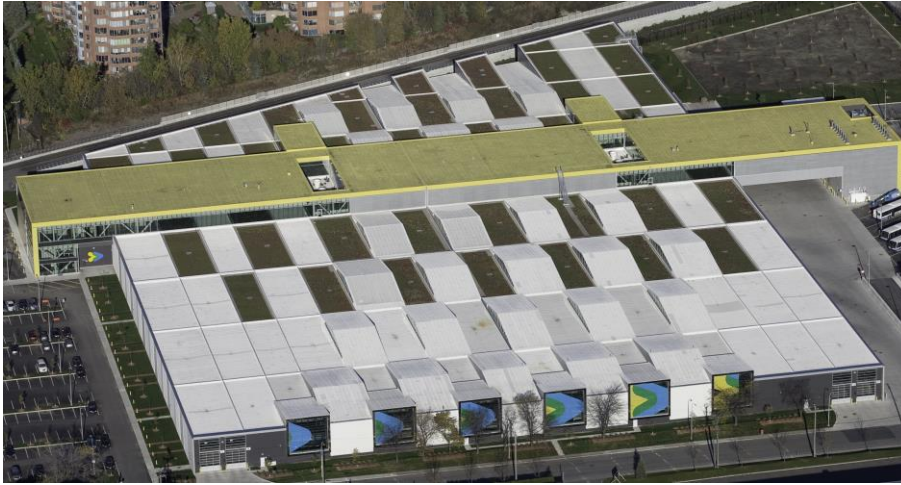


## ENVIRONMENTAL PRODUCT DECLARATION

# SBS-MODIFIED BITUMEN ROOFING MEMBRANE

INSTALLATION: TORCH APPLIED



Low-slope roofing membrane consisting of a SBS-modified bitumen cap sheet installed by torching and base sheet installed using one of several methods.



SOPREMA is an international manufacturer specializing in innovative products for waterproofing, insulation, soundproofing and vegetated solutions for the roofing, building envelope, and civil engineering sectors.

SOPREMA was founded in 1908 in Strasbourg (France) by Charles Geisen who developed a fully waterproof, flexible and easy to install fabric, by soaking jute in hot bitumen. The result gave a lightweight but strong screed - MAMMOUTH®. SOPREMA now operates 50 manufacturing plants across the globe and 7 state of the art R&D laboratories.

SOPREMA's sustainability efforts are not new. In January 1998, SOPREMA was the first modified bitumen manufacturer to earn an ISO 14001 certification. At the heart of its values lies an environmental focus, particularly as it relates to manufacturing and R&D.



# ENVIRONMENTAL PRODUCT DECLARATION





**SBS-MODIFIED BITUMEN ROOFING MEMBRANE**  
 INSTALLATION: TORCH APPLIED

According to ISO 14025

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	Soprema	
DECLARATION NUMBER	4787703772.102.1	
DECLARED PRODUCT	SBS-Modified Bitumen Roofing Membrane (Installation: Torch Applied)	
REFERENCE PCR	ASTM PCR for asphalt shingles, built-up asphalt membrane roofing and modified bituminous membrand roofing	
DATE OF ISSUE	September 29, 2017	
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:	Review Panel	
	François Charron-Doucet, Quantis Canada (Chair)	
	cert@astm.org	
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 Gloria, Industrial Ecology Consultants	
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:		

# ENVIRONMENTAL PRODUCT DECLARATION



SBS-MODIFIED BITUMEN ROOFING MEMBRANE  
INSTALLATION: TORCH APPLIED

According to ISO 14025

## 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
<b>SBS Cap Sheet (T)</b>	ASTM D6162, D6163, D6164, CSA A123.23	- Polyester and/or fiberglass mat coated with polymer-modified asphalt and colored mineral granule surfacing
<b>SBS Base Sheet (T, F, and M)</b>	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
<b>SBS Base Sheet (S)</b>	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. - The bottom surface is covered by an opaque release film intended to be removed upon installation

A number of Soprema products fall into each of the above component categories. They were all considered in the life cycle assessment that served as the basis for this EPD. For cap sheets, all colors were considered, as well as regular and FR-rated versions. These products are:

#### SBS Cap Sheet (T: torch-applied)

COLVENT FLAM GR (all versions)  
COLVENT TRAFFIC CAP GR (all versions)  
ELASTOPHENE FLAM GR (all versions)  
SOPRAPHIX CAP GR (all versions)  
SOPRAPHIX TRAFFIC CAP GR (all versions)  
SOPRALENE FLAM 180 GR (all versions)  
SOPRALENE FLAM 250 GR (all versions)  
SOPRALENE FLAM 350 GR (all versions)  
SOPRALENE MAMMOUTH GR (all versions)  
SOPRAPLY CAP GR (all versions)  
SOPRAPLY TRAFFIC CAP GR (all versions)  
SOPRASTAR FLAM GR (all versions)  
STARTER FLAM GR (all versions)

#### SBS Base Sheet (M: hot-mopped)

ELASTOPHENE 180 PS (all versions)  
ELASTOPHENE 180 SANDED (all versions)  
ELASTOPHENE HS (all versions)  
ELASTOPHENE PS (all versions)  
ELASTOPHENE SANDED (all versions)  
SOPRALENE 180 PS (all versions)  
SOPRALENE 180 SANDED (all versions)  
SOPRALENE 250 SANDED (all versions)

#### SBS Base Sheet (T: torch-applied)

COLVENT TG (all versions)  
ELASTOPHENE 180 SANDED (all versions)  
ELASTOPHENE 180 SP (all versions)  
ELASTOPHENE FLAM (all versions)  
ELASTOPHENE SP (all versions)  
SOPRALENE 180 SP (all versions)  
SOPRALENE 250 SP (all versions)  
SOPRALENE FLAM 180 (all versions)  
SOPRALENE FLAM 250 (all versions)  
SOPRAPLY BASE (all versions)  
SOPRALAP (all versions)

#### SBS Base Sheet (F: fastened)

All SOPRAPHIX base sheets

#### SBS Base Sheet (S: self-adhered)

COLVENT (all versions except TG)  
ELASTOPHENE FLAM STICK (all versions)  
ELASTOPHENE STICK (all versions)  
SOPRAFLASH FLAM STICK (all versions)  
SOPRAFLASH STICK (all versions)  
SOPRALENE FLAM STICK (all versions)  
SOPRALENE STICK (all versions)



# ENVIRONMENTAL PRODUCT DECLARATION



**SBS-MODIFIED BITUMEN ROOFING MEMBRANE**  
 INSTALLATION: TORCH APPLIED

According to ISO 14025

## Manufacturing Locations

The components of the low-slope SBS-modified bitumen roofing membrane covered by this EPD are manufactured by Soprema in Chilliwack (British Columbia), Drummondville (Québec), Gulfport (Mississippi), and Wadsworth (Ohio).

## Application 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.

While numerous SBS-modified bituminous product and system innovations have been introduced over the years, one thing that has not changed in decades is their toughness and redundant waterproof protection. SBS-modified bitumen sheets can be applied using a variety of methods allowing the flexibility to complete the job within project parameters in virtually any climate. They can withstand heat and low temperatures in installations all over the world and are available in a wide range of thicknesses and mechanical properties to cover any design need.

Installation of modified bitumen roof systems with the heat of a torch provides an instant and intimate bond upon cooling. All the systems addressed in this EPD utilize a torch-applied cap sheet. The various base sheet types used can be installed with a torch as well (base sheet T), or alternatively, by mechanical attachment (base sheet F), by using hot asphalt (base sheet M), or by self-adhesion (base sheet S).

## System Description

### Material content

Table 1 shows the composition of the cap sheet and base sheets, weighted by the production totals (by mass) of the four manufacturing sites.

**Table 1: Material inputs for SBS-modified bitumen base sheets**

Material Inputs	Production Weighted Composition [%]				
	Base Sheet T	Base Sheet F	Base Sheet S	Base Sheet M	Cap Sheet T
<b>Mats</b>					
Fiberglass mat	0.71	-	3.0	1.06	0.1
Polyester mat	3.31	3.36	0.52	4.07	3.7
Polyester + fiberglass combination mat	0.44	2.28	1.2	0.36	0.9
<b>Reinforcement saturant</b>					
Asphalt (oxidized) (where applicable)	7.69	7.47	13.6	10.46	12.9
<b>Asphaltic compound ingredients</b>	85.3	76.7	77.8	65.7	55.2
Asphalt (non-oxidized)	Composition of asphaltic compound not disclosed. Confidential information.	Composition of asphaltic compound not disclosed. Confidential information.	Composition of asphaltic compound not disclosed. Confidential information.	Composition of asphaltic compound not disclosed. Confidential information.	Composition of asphaltic compound not disclosed. Confidential information.
Plasticizing oil (CAS #64742-52-5)					
Limestone filler					
SBS					
Tackifying resin (CAS #64742-16-1)					
Fire retardant					



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Surfacing materials (top/bottom)					
Granules	-	-	-	-	26.9
Sand	2.16	9.35	2.46	17.93	0.003
Fire retardant	-	-	-	-	0.2
Clear PP film	0.29	0.18	0.14	0.08	0.1
Clear HDPE film	-	-	0.01	0.08	-
Silicone-coated release film	-	0.28	0.94	0.09	-
Quartz powder (for lay lines)	0.14	0.17	0.11	0.14	-
Silicone-coated paper	-	0.21	0.27	-	-
Aluminum foil	-	-	-	-	0.02

Table 2 shows the shares of cap and base sheets by mass percent for the four systems covered by this EPD.

**Table 2: Composition of the roofing systems by mass percent**

System	Cap	Base			
		T	F	S	M
<b>Torch-applied, T/T</b>	57%	43%	-	-	-
<b>Fastened/Torch-applied, F/T</b>	60%	-	40%	-	-
<b>Self-adhered/Torch-applied, S/T</b>	62%	-	-	38%	-
<b>Hot mopped/Torch-applied, M/T</b>	64%	-	-	-	36%

## Manufacturing Process

### SBS Cap Sheets

Manufacture of SBS polymer-modified bitumen cap sheets involves the saturation of a reinforcing mat, composed of fiberglass, non-woven polyester, or combination of both, and coating the mat with a polymer-modified asphalt. The polymer-modified asphalt is produced by mixing appropriate proportions of asphalt, polymer, and limestone or other suitable mineral stabilizer. An appropriate surfacing material is applied. SBS cap sheets typically use a colored mineral granule top surfacing. Thin polyolefin film is applied as a parting agent to the bottom surface of the cap sheet. The product is cooled, wound into rolls, and packaged for shipment.

### SBS Base Sheets

Manufacture of SBS polymer-modified bitumen base sheets involves the saturation of a reinforcing mat, composed of fiberglass, non-woven polyester, or combination of both, and coating the mat with a polymer-modified asphalt. The polymer-modified asphalt is produced by mixing appropriate proportions of asphalt, polymer, and limestone or another suitable mineral stabilizer. Thin polyolefin film is applied as a parting agent to the top surface of the base sheet. Its bottom surface may either be covered with fine mineral matter (such as sand), thin polyolefin film, or an opaque release film depending on the installation method. The product is cooled, wound into rolls, and packaged for shipment.

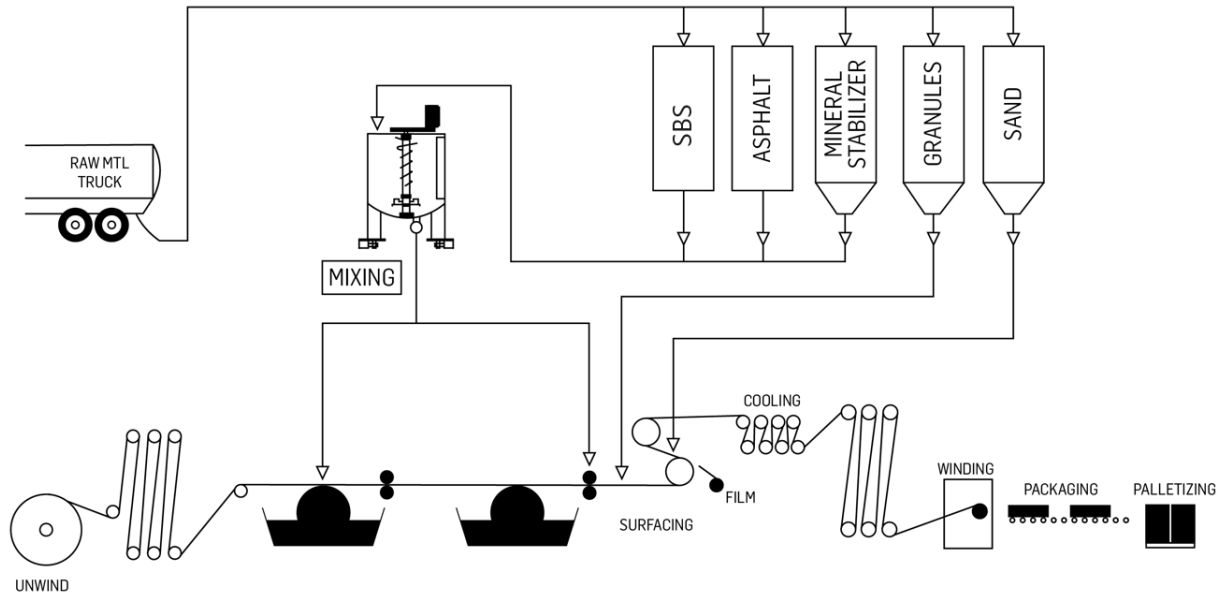


# ENVIRONMENTAL PRODUCT DECLARATION



**SBS-MODIFIED BITUMEN ROOFING MEMBRANE**  
 INSTALLATION: TORCH APPLIED

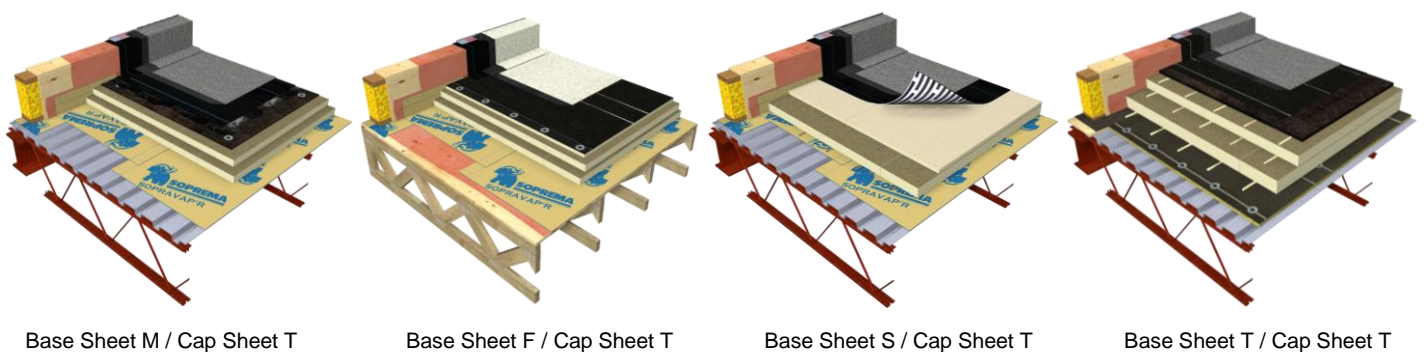
According to ISO 14025



**Figure 1: Modified bitumen sheet process diagram**

## Installation

For this EPD, a torch-applied SBS-modified bitumen roofing membrane consists of one base sheet and one cap sheet. Torch-applied SBS installation requires the SBS-modified bitumen base sheet to be unrolled directly to the roof surface and secured to it using hot asphalt, in-seam mechanical attachment, self-adhesion or torch welding. Regardless of the base sheet installation method, the SBS-modified bitumen cap sheet is torched directly on top of the base sheet. Mineral granules are applied to the asphalt bleed-out (the portion 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 examples with torched cap sheet**

The following tables present the components of typical SBS torch-applied systems, which are the same as those





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presented in the Asphalt Roofing Manufacturers Association (ARMA) study (thinkstep, Inc. , 2015). The effective coverage includes the required overlap of sheets while the scrap rate accounts for material wasted during installation.

**Table 3: Torch Applied, T/T installation details**

	Weight of Material [kg / m <sup>2</sup> ]	Effective Coverage [m <sup>2</sup> of Material / 1 m <sup>2</sup> of Roof]	Scrap Rate	Required Quantity of Material [kg / 1 m <sup>2</sup> ]
<b>Inputs</b>				
Cap sheet T	4.64	1.10	5%	5.27
Base sheet T	3.46	1.10	5%	3.93
Flashing	0.095	N/A	10%	0.11
Granules (at seams)	0.08	N/A	-	0.08
Thermal energy from propane	2.4 (MJ)	N/A	-	2.4 (MJ)
<b>Outputs<sup>1</sup></b>				
Installed system				8.93
Waste				0.45
NMVOCs (from torching)	0.01	N/A	-	0.01

<sup>1</sup> Excludes combustion emissions from propane use

**Table 4: Fastened/Torch Applied, F/T installation details**

	Weight of Material [kg / m <sup>2</sup> ]	Effective Coverage [m <sup>2</sup> of Material / 1 m <sup>2</sup> of Roof]	Scrap Rate	Required Quantity of Material [kg / 1 m <sup>2</sup> ]
<b>Inputs</b>				
Cap sheet T	4.64	1.10	5%	5.27
Base sheet F	3.11	1.1	5%	3.53
Fasteners	0.128	N/A	-	0.13
Flashing	0.095	N/A	10%	0.10
Granules (at seams)	0.08	N/A	-	0.08
Thermal energy from propane	1.1 (MJ)	N/A	-	1.1 (MJ)
<b>Outputs<sup>1</sup></b>				
Installed system				8.66
Waste				0.44
NMVOCs (from torching)	0.005	N/A	-	0.005

<sup>1</sup> Excludes combustion emissions from propane use

**Table 5: Self-adhered/Torch-applied, S/T installation details**

	Weight of Material [kg / m <sup>2</sup> ]	Effective Coverage [m <sup>2</sup> of Material / 1 m <sup>2</sup> of Roof]	Scrap Rate	Required Quantity of Material [kg / 1 m <sup>2</sup> ]
<b>Inputs</b>				
Cap sheet T	4.64	1.10	5%	5.27
Base sheet S	2.91	1.1	5%	3.30
Primer	0.128	N/A	-	0.18
Flashing	0.095	N/A	10%	0.10



# ENVIRONMENTAL PRODUCT DECLARATION



SBS-MODIFIED BITUMEN ROOFING MEMBRANE  
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	Weight of Material [kg / m <sup>2</sup> ]	Effective Coverage [m <sup>2</sup> of Material / 1 m <sup>2</sup> of Roof]	Scrap Rate	Required Quantity of Material [kg / 1 m <sup>2</sup> ]
<b>Granules (at seams)</b>	0.08	N/A	-	0.08
<b>Thermal energy from propane</b>	1.1 (MJ)	N/A	-	1.1 (MJ)
<b>Outputs<sup>1</sup></b>				
<b>Installed system</b>				8.39
<b>Waste (includes silicone-coated paper)</b>				0.46
<b>Acetone emission (from primer)</b>	0.034	N/A	-	0.034
<b>Naphtha emission (from primer)</b>	0.057	N/A	-	0.057
<b>NMVOCs (from torching)</b>	0.005	N/A	-	0.005

<sup>1</sup> Excludes combustion emissions from propane use

**Table 6: Hot-mopped/Torch-applied, M/T installation details**

	Weight of Material [kg / m <sup>2</sup> ]	Effective Coverage [m <sup>2</sup> of Material / 1 m <sup>2</sup> of Roof]	Scrap Rate	Required Quantity of Material [kg / 1 m <sup>2</sup> ]
<b>Inputs</b>				
<b>Cap sheet T</b>	4.64	1.10	5%	5.27
<b>Base sheet M</b>	2.62	1.1	5%	3.00
<b>Mopping asphalt<sup>1</sup></b>	1.22	N/A	5%	0.18
<b>Flashing</b>	0.095	N/A	10%	0.10
<b>Granules (at seams)</b>	0.08	N/A	-	0.08
<b>Thermal energy from propane (torching)</b>	1.1 (MJ)	N/A	-	1.1 (MJ)
<b>Thermal energy from propane (kettles)</b>	1.3 (MJ)	N/A	-	1.3 (MJ)
<b>Diesel (pump to roof<sup>2</sup>)</b>	2.5x10 <sup>-4</sup> (MJ)	N/A		2.5x10 <sup>-4</sup> (MJ)
<b>Outputs<sup>3</sup></b>				
<b>Installed system</b>				9.24
<b>Waste</b>				0.47
<b>NMVOCs (from torching)</b>	0.005	N/A	-	0.005
<b>NMVOCs (from asphalt kettle)<sup>4</sup></b>	0.004	N/A	-	0.004

<sup>1</sup> 1.22 kg / 1 m<sup>2</sup> per layer

<sup>2</sup> Assumes 4-story building<sup>1</sup> and 3.95 m story height<sup>2</sup>

<sup>3</sup> Excludes combustion emissions from propane and diesel use

<sup>4</sup> 3.1 kg NMVOCs (non-methane volatile organic compounds) / 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.

<sup>1</sup> <https://www.eia.gov/consumption/commercial/data/2012/bc/cfm/b6.php>

<sup>2</sup> [http://www.pnl.gov/main/publications/external/technical\\_reports/PNNL-20380.pdf](http://www.pnl.gov/main/publications/external/technical_reports/PNNL-20380.pdf)





# ENVIRONMENTAL PRODUCT DECLARATION



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INSTALLATION: TORCH APPLIED

According to ISO 14025

## Life Cycle Assessment – Product Systems and Modeling

### Declared Unit

The declared unit of this study is 1 m<sup>2</sup> (10.8 ft<sup>2</sup>) of the installed roofing membrane. The associated reference flow (the quantity of material required to fulfill the declared unit for each system is shown below.

Table 7: Roofing system reference flows

System	Weight of installed systems (incl. overlap, loss, and other ancillary materials) [kg / 1 m <sup>2</sup> ]
Torch-applied, T/T	8.93
Fastened/Torch-applied, F/T	8.66
Self-adhered/Torch-applied, S/T	8.39
Hot mopped/Torch-applied, M/T	9.24

### Life Cycle System Boundaries

The study encompasses the following life cycle stages: production, installation, transport, and end-of-life (EoL). **Error! Reference source not found.** depicts the modules included in the study, in accordance with EN 15804 and the referenced PCR (ASTM, 2014). As the use stage is excluded, a reference service life is not specified for the systems under study.

Table 8: System boundary modules

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)															
PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE			
Raw material supply	Transport	Manufacturing	Transport	Construction-installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	X	X	X	X

### 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



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pigment used for white products, titanium dioxide, generally has a higher impact than other pigments; therefore, using white is a conservative assumption.

- 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

Average transportation distances and modes of transport are included for the transport of the raw materials, operating materials, and auxiliary materials to production facilities and installation sites.

For distribution, the different transport distances from the four facilities to their respective distribution centers plus the average distance from the distribution centers to the construction sites are considered.

**Table 9: Weighted distance from the four facilities to distribution center**

Weighted transport distances	Truck km (miles)
Cap sheet T	629 (391)
Base sheet T	755 (469)
Base sheet F	687 (427)
Base sheet S	608 (378)
Base sheet M	739 (459)

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 32.2 km (20 miles).

## Temporal, Technological, and Geographical Coverage

**Temporal:** All primary data were collected for a 12-month period during the years 2014 to 2015. All secondary data come from the GaBi 2016 databases and are representative of the years 2007-2016, with the exception of asphalt oxidation information for which the only available source was from 1977. As the study intended to represent the product systems for the reference year 2015, temporal representativeness is considered to be high.

**Technological:** All primary and secondary data were modeled to be specific to the technologies or technology mixes under study. Where technology-specific data were unavailable, proxy data were used. Technological representativeness is considered to be high.

**Geographical:** The geographic coverage represented by this study is the United States and Canada. Whenever US background data were not readily available, European data or global data were used as proxies, depending on appropriateness and availability. Geographical representativeness is considered to be high.

## Background Data

The LCA model was created using the GaBi ts Software system for life cycle engineering, developed by thinkstep AG. The GaBi 2016 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



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(asphalt oxidation information) and 2016.

## 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. All primary data were collected with the same level of detail, while all background data were sourced from the GaBi 2016 databases, with the exception of granule production and asphalt oxidation. Allocation and other methodological choices were made consistently throughout the model.

## Allocation

As several products are often manufactured at the same plant, participating sites 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.

## 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.

The environmental impacts, primary energy consumption, materials resource consumption, and waste generation associated with the installed roofing membrane are presented below for the production, installation, and EoL stages of all systems covered in this EPD. Primary energy consumption results are given as higher heating value (HHV), per the PCR. Renewable energy is negative for installation due to the credit given for reusing pallets.

**Table 10: Results for Torch Applied, T/T system, per 1 m<sup>2</sup> of installed roof**

Indicator	Unit	Production (A1-A3)	Transport (A4)	Installation (A5)	EOL (C1-C4)
<b>TRACI 2.1 Impact Categories</b>					
<b>Global warming potential</b>	kg CO <sub>2</sub> -eq	6.75	0.512	0.739	0.416
<b>Acidification potential</b>	kg SO <sub>2</sub> -eq	0.0226	0.00245	0.00157	0.00197
<b>Eutrophication potential</b>	kg N-eq	0.00180	2.28x10 <sup>-4</sup>	1.06x10 <sup>-4</sup>	1.14x10 <sup>-4</sup>
<b>Smog formation potential</b>	kg O <sub>3</sub> -eq	0.382	0.0780	0.0512	0.0396
<b>Ozone depletion potential</b>	kg CFC-11-	7.56x10 <sup>-10</sup>	3.47x10 <sup>-12</sup>	3.71x10 <sup>-9</sup>	8.29x10 <sup>-12</sup>
<b>Total Primary Energy Consumption</b>					
<b>Nonrenewable fossil</b>	MJ (HHV)	334	7.62	6.69	6.88
<b>Nonrenewable nuclear</b>	MJ (HHV)	6.69	0.0302	0.129	0.161
<b>Renewable (solar, wind, hydro, geo)</b>	MJ (HHV)	6.41	0.115	0.104	0.398



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Indicator	Unit	Production (A1-A3)	Transport (A4)	Installation (A5)	EOL (C1-C4)
Renewable (biomass)	MJ (HHV)	0.162	-	-0.0975	-
<b>Material Resources Consumption</b>					
Nonrenewable material resources	kg	11.7	0.0280	1.07	2.13
Renewable material resources	kg	4140	21.8	25.1	205
Water consumption (Net fresh water)	L	26.6	1.44	0.141	1.02
Non-hazardous waste generated	kg	0.559	2.40x10 <sup>-4</sup>	0.549	8.96
Hazardous waste generated	kg	5.08x10 <sup>-5</sup>	9.09x10 <sup>-9</sup>	2.74x10 <sup>-6</sup>	1.23x10 <sup>-8</sup>

Table 11: Results for Fastened/Torch Applied, F/T system, per 1 m<sup>2</sup> of installed roof

Indicator	Unit	Production (A1-A3)	Transport (A4)	Installation (A5)	EOL (C1-C4)
<b>TRACI 2.1 Impact Categories</b>					
Global warming potential	kg CO <sub>2</sub> -eq	6.44	0.469	0.913	0.404
Acidification potential	kg SO <sub>2</sub> -eq	0.0208	0.00224	0.00217	0.00191
Eutrophication potential	kg N-eq	0.00173	2.09x10 <sup>-4</sup>	1.36x10 <sup>-4</sup>	1.10x10 <sup>-4</sup>
Smog formation potential	kg O <sub>3</sub> -eq	0.367	0.0715	0.0393	0.0384
Ozone depletion potential	kg CFC-11-eq	7.40x10 <sup>-10</sup>	3.18x10 <sup>-12</sup>	5.14x10 <sup>-9</sup>	8.04x10 <sup>-12</sup>
<b>Total Primary Energy Consumption</b>					
Nonrenewable fossil	MJ (HHV)	315	6.98	8.03	6.67
Nonrenewable nuclear	MJ (HHV)	6.58	0.0277	0.175	0.156
Renewable (solar, wind, hydro, geo)	MJ (HHV)	6.79	0.105	0.341	0.386
Renewable (biomass)	MJ (HHV)	0.156	-	-0.0936	-
<b>Material Resources Consumption</b>					
Nonrenewable material resources	kg	11.6	0.0256	1.75	2.07
Renewable material resources	kg	4,390	20.0	24.9	199
Water consumption (Net fresh water)	L	26.9	1.32	0.780	0.987
Non-hazardous waste generated	kg	0.568	2.20x10 <sup>-4</sup>	0.544	8.69
Hazardous waste generated	kg	5.08x10 <sup>-5</sup>	8.33x10 <sup>-9</sup>	2.74x10 <sup>-6</sup>	1.19x10 <sup>-8</sup>

Table 12: Results for Self-adhered/Torch-applied, S/T system, per 1 m<sup>2</sup> of installed roof

Indicator	Unit	Production (A1-A3)	Transport (A4)	Installation (A5)	EOL (C1-C4)
<b>TRACI 2.1 Impact Categories</b>					
Global warming potential	kg CO <sub>2</sub> -eq	6.26	0.436	0.992	0.391
Acidification potential	kg SO <sub>2</sub> -eq	0.0215	0.00209	0.00259	0.00185
Eutrophication potential	kg N-eq	0.0016	1.94x10 <sup>-4</sup>	1.90x10 <sup>-4</sup>	1.07x10 <sup>-4</sup>
Smog formation potential	kg O <sub>3</sub> -eq	0.373	0.0665	0.064	0.0372
Ozone depletion potential	kg CFC-11-eq	6.64x10 <sup>-10</sup>	2.96x10 <sup>-12</sup>	5.89x10 <sup>-9</sup>	7.79x10 <sup>-12</sup>
<b>Total Primary Energy Consumption</b>					
Nonrenewable fossil	MJ (HHV)	324	6.49	17.9	6.46
Nonrenewable nuclear	MJ (HHV)	6.00	0.0258	0.366	0.151
Renewable (solar, wind, hydro, geo)	MJ (HHV)	6.87	0.0977	0.82	0.374



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Indicator	Unit	Production (A1-A3)	Transport (A4)	Installation (A5)	EOL (C1-C4)
Renewable (biomass)	MJ (HHV)	0.158	0	-0.0907	0
<b>Material Resources Consumption</b>					
Nonrenewable material resources	kg	11.0	0.0238	1.35	2.00
Renewable material resources	kg	4420	18.6	250	193
Water consumption (Net fresh water)	L	25.9	1.23	1.17	0.956
Non-hazardous waste generated	kg	0.607	2.05x10 <sup>-4</sup>	0.568	8.41
Hazardous waste generated	kg	5.08x10 <sup>-5</sup>	7.75x10 <sup>-9</sup>	2.75x10 <sup>-6</sup>	1.15x10 <sup>-8</sup>

Table 13: Results for Hot-mopped/Torch-applied, M/T system, per 1 m<sup>2</sup> of installed roof

Indicator	Unit	Production (A1-A3)	Transport (A4)	Installation (A5)	EOL (C1-C4)
<b>TRACI 2.1 Impact Categories</b>					
Global warming potential	kg CO <sub>2</sub> -eq	6.27	0.455	1.17	0.431
Acidification potential	kg SO <sub>2</sub> -eq	0.02053	0.00217	0.00383	0.00204
Eutrophication potential	kg N-eq	0.00165	2.03x10 <sup>-4</sup>	2.08x10 <sup>-4</sup>	1.17x10 <sup>-4</sup>
Smog formation potential	kg O <sub>3</sub> -eq	0.340	0.069	0.087	0.041
Ozone depletion potential	kg CFC-11-eq	7.08x10 <sup>-10</sup>	3.08x10 <sup>-12</sup>	3.69x10 <sup>-9</sup>	8.58x10 <sup>-12</sup>
<b>Total Primary Energy Consumption</b>					
Nonrenewable fossil	MJ (HHV)	269	6.29	66.7	6.57
Nonrenewable nuclear	MJ (HHV)	6.24	0.0269	0.327	0.167
Renewable (solar, wind, hydro, geo)	MJ (HHV)	5.82	0.102	0.261	0.412
Renewable (biomass)	MJ (HHV)	0.137	-	-0.0820	-
<b>Material Resources Consumption</b>					
Nonrenewable material resources	kg	11.3	0.025	1.07	2.21
Renewable material resources	kg	3,708	0.204	123	212
Water consumption (Net fresh water)	L	24.5	1.28	0.76	1.05
Non-hazardous waste generated	kg	5.13x10 <sup>-5</sup>	8.07x10 <sup>-9</sup>	7.42x10 <sup>-8</sup>	1.27x10 <sup>-8</sup>
Hazardous waste generated	kg	0.608	2.13x10 <sup>-4</sup>	0.553	9.27

## Additional Environmental Information

### Sustainable Roofing

Some have promoted sustainable roofing by focusing on green roofs and reflective roofs only. Roof design for sustainability entails more than membrane selection and detailing. It means to incorporate materials and details that extend the service life of the roof system beyond its currently accepted service life expectancy and provide future rehabilitation options to minimize consumption of new resources and delay demolition. Design for sustainable recovery from premature failure must be part of the original concept. It has to be realistically expected that a portion of a roof will eventually fail at some point for some reason. Sustainable recovery minimizes damage impact, reduces material waste and consumption of new materials. It also facilitates repair and renews roof performance.

Modified-bitumen membranes allow for recovering or resurfacing at the end of their service life. Once the waterproof integrity of the membrane in place has been verified, or minor repairs have been performed to it if needed, the addition



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of a SBS-modified cap sheet to the system can be done easily.

That is not to say that “cool roof” principles should be overlooked. Mitigation of urban heat islands should guide the design and specification of roof assemblies, just as energy conservation, durability, resiliency, raw materials consumption and waste reduction.

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. Modified bitumen membranes provide options for varying levels of reflectivity and have proven to retain high reflectivity levels over their service life (per the Cool Roof Rating Council, [www.coolroofs.org](http://www.coolroofs.org)).

## 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 14: Production stage (A1-A3) impact results for each system component, per 1 m<sup>2</sup> of individual component**

Impact Category	Units	Base (T)	Base (F)	Base (S)	Base (M)	Cap (T)
<b>TRACI 2.1 Impact Categories</b>						
<b>Global warming potential</b>	kg CO <sub>2</sub> -eq	2.65	2.37	2.22	2.02	3.31
<b>Acidification potential</b>	kg SO <sub>2</sub> -eq	0.00908	0.00749	0.00814	0.00707	0.0108
<b>Eutrophication potential</b>	kg N-eq	6.90x10 <sup>-4</sup>	6.23x10 <sup>-4</sup>	5.12x10 <sup>-4</sup>	5.43x10 <sup>-4</sup>	8.98x10 <sup>-4</sup>
<b>Smog formation potential</b>	kg O <sub>3</sub> -eq	0.147	0.134	0.140	0.107	0.189
<b>Ozone depletion potential</b>	kg CFC-11-eq	2.81x10 <sup>-10</sup>	2.66x10 <sup>-10</sup>	2.00x10 <sup>-10</sup>	2.32x10 <sup>-10</sup>	3.86x10 <sup>-10</sup>
<b>Total Primary Energy Consumption</b>						
<b>Nonrenewable fossil</b>	MJ (HHV)	137	120	128	95.7	158
<b>Nonrenewable nuclear</b>	MJ (HHV)	2.49	2.39	1.88	2.04	3.41
<b>Renewable (solar, wind, hydro, geo)</b>	MJ (HHV)	2.28	2.62	2.69	1.71	3.37
<b>Renewable (biomass)</b>	MJ (HHV)	0.0618	0.0561	0.0577	0.0479	0.0815
<b>Material Resources Consumption</b>						
<b>Nonrenewable material resources</b>	kg	3.62	3.52	2.96	3.18	6.71
<b>Renewable material resources</b>	kg	1,380	1,600	1,630	961	2,270
<b>Water consumption (Net fresh water)</b>	kg	9.44	9.69	8.78	7.31	14.0
<b>Non-hazardous waste generated</b>	L	0.124	0.132	0.166	0.161	0.369
<b>Hazardous waste generated</b>	kg	1.35x10 <sup>-7</sup>	1.19x10 <sup>-7</sup>	1.30x10 <sup>-7</sup>	9.43x10 <sup>-8</sup>	4.47x10 <sup>-5</sup>

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## LCA Development



thinkstep

The EPD and background LCA were prepared by thinkstep, Inc.

**thinkstep, Inc.**

170 Milk Street, 3rd Floor

Boston, MA 02109

[info@thinkstep.com](mailto:info@thinkstep.com); [www.thinkstep.com](http://www.thinkstep.com)

## Contact Information



**SOPREMA**

310 Quadral Dr.

Wadsworth, OH 44281

Telephone; (330) 334-0066

[www.soprema.us](http://www.soprema.us)

**SOPREMA**

1688 J.-B. Michaud

Drummondville QC J2C 8E9

Telephone; 1-877-MAMMOUTH

[www.soprema.ca](http://www.soprema.ca)

