ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804

Owner of the Declaration	**Carlisle SynTec Systems**
Program operator	UL Environment
Publisher	Institut Bauen und Umwelt e.V. (IBU)
Declaration number	4787408569.103.1
Registration number	MR-ULE-EPD-CAR-20180003-EN
Issue date	28.09.2018
Valid to	14.02.2022

NON-REINFORCED EPDM MEMBRANE

Carlisle SynTec Systems

Registered under the scope of mutual recognition between Institut Bauen und Umwelt e.V. (IBU) and UL Environment

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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	Carlisle SynTec Systems
DECLARATION NUMBER	4787408569.103.1
DECLARED PRODUCT	EPDM Non-Reinforced Single Ply Roofing Membrane (Fully Adhered)
REFERENCE PCR	PCR for Single Ply Roofing Membranes. ASTM International.
DATE OF ISSUE	September 28, 2018
DATE OF EXPIRATION	February 14, 2022
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:	PCR Review Panel
	Peer review report available upon request
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This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	Grant R. Martin
	Grant R. Martin, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas P. Gloria
	Thomas P. Gloria, Industrial Ecology Consultants

This EPD conforms with ISO 21930:2007 & EN 15804

Product Definition

Description of Product

The product system evaluated in this report is an installed single ply non-reinforced ethylene propylene diene monomer (EPDM) roofing membrane at the finished nominal thicknesses produced by Carlisle and listed in Table 1.

Table 1: Membrane specification and standard

Roof System	Roof System Component	Declared Thicknesses and Weights	Standard
Non-reinforced ethylene propylene diene monomer (EPDM)	Membrane	1.2 mm: 1.42 kg/m^2 1.5 mm: 1.90 kg/m^2 2.3 mm: 2.88 kg/m^2	ASTM D4637

Application and Uses

Non-reinforced EPDM membranes are utilized in fully adhered and ballasted commercial roofing systems and are known to provide excellent long term weatherability, hail resistance, and repairability. The thicker 1.5 mm and 2.3 mm membranes provide added weathering material and added puncture resistance making them the natural choice for longer term performance. Non-reinforced EPDM membrane is sold with factory applied splice tape creating a very reliable and productive means to adjoin the sheets on the roof. They are also available in either black or white colors to fit different geographic climates. Darker colored black EPDM is typically preferred in heating dominated central and northern climates whereas white EPDM is typically preferred in southern cooling dominated climates.

Health Safety & Environmental Aspects During Installation

There are no known toxicity issues related to human health or the environment.

Exercise caution when walking on a wet membrane as membranes are slippery when wet.

For white membranes the following precautions apply:

- Sunglasses that filter out ultraviolet light are strongly recommended as the white surface intensifies sunlight through reflection.
- White surfaces reflect heat and may become slippery due to frost and ice build-up. Exercise extreme caution during cold conditions to prevent falls.
- Use caution when working close to a roof edge when surrounding area is snow covered as the roof edge may not be clearly visible.

When working with solvent-based bonding adhesives or primers the following precautions apply:

- Adhesives and primers are FLAMMABLE. They contain solvents that are fire hazards when exposed to heat, flame or sparks. Do not smoke while applying. Do not use in a confined or unventilated area. Vapors are

heavier than air and may travel along the ground or may be moved by ventilation and ignited by pilot lights, other flames, sparks, heaters, smoking, electrical motors, static discharge, or other ignition sources at locations distant from the material handling point and flashback. All containers should be grounded when material is transferred from one container to another. A red caution label is required when shipping. A fire extinguisher should be available. In case of fire, use water spray, foam, dry chemical, or carbon dioxide. Do not use a solid stream of water, because it can scatter and spread the fire.

- Avoid breathing vapors. Keep container closed when not in use. Use with adequate ventilation. If inhaled, remove to fresh air. If not breathing, perform artificial respiration. If breathing is difficult, give oxygen. Call a physician immediately. During application, efforts must be made to prevent fumes from entering the building via air ventilation ducts. Do not place open containers or mix adhesive near fresh air intake units. When possible, shut down or seal off the closest units.
- If swallowed, DO NOT INDUCE VOMITING. Call a physician immediately.
- Avoid contact with eyes. Safety glasses or goggles are recommended. If splashed in eyes, immediately flush eyes with plenty of clean water for at least 15 minutes. Contact a physician immediately.
- Avoid contact with skin. Wash hands thoroughly after handling. In case of contact with skin, thoroughly wash affected area with soap and water. Contact a physician if irritation persists.

Product Life Cycle Description

Material Content

Table 2 shows the input material for non-reinforced EPDM roofing membranes and their material percentages for the three membrane thicknesses.

Table 2: Composition of non-reinforced EPDM roofing membrane

Material	1.2 mm [%]	1.5 mm [%]	2.3 mm [%]
EPDM base resin	33	33	34
Filler	24	24	26
Pigment	22	20	18
Paraffinic oil	18	18	17
Fire retardant	2	2	2
Activator	1	1	1
Curative	<1	1	1
Processing aid	<1	<1	<1

Manufacturing Process

The main material input into the manufacturing process is EPDM rubber in the form of pellets and (uncured) scrap. Additional materials include additives, which aid the manufacturing process (e.g., accelerators) and enhance the membrane's performance (e.g., fire retardants and pigments). The manufacturing process begins with mixing the raw materials together in large batches to create uncured rubber that is slabbed off onto skids for quality control (QC) testing of the physical properties. Once the uncured rubber has passed the QC test it is then calendared or extruded into 1.2, 1.5, or 2.3 mm thick sheets. EPDM membranes can be produced with or without internal reinforcing scrim (see Carlisle's EPD on reinforced EPDM membrane). The extruded sheets are sent through an inspection station and then coated with mica dust to keep the material from sticking to itself though the vulcanization process where the sheeting is cured through heat and pressure. Once vulcanized, the sheeting goes through a de-dusting unit, final inspection and then is packaged into 15.25 and 30.05 meter long rolls. For sheets wider than 3 meters, calendared sheets are sent through an inspection table and into an automated sheet building machine to create sheets up to 15.25 meters wide. The large sheets also go through a mica dust box prior to being sent through the vulcanization process. After vulcanization the sheets are cut to the desired width and packaged onto a cardboard core. Any uncured or cured trimmings are recycled back into the process to minimize waste and reduce cost.

Figure 1 shows the manufacturing process for EPDM.

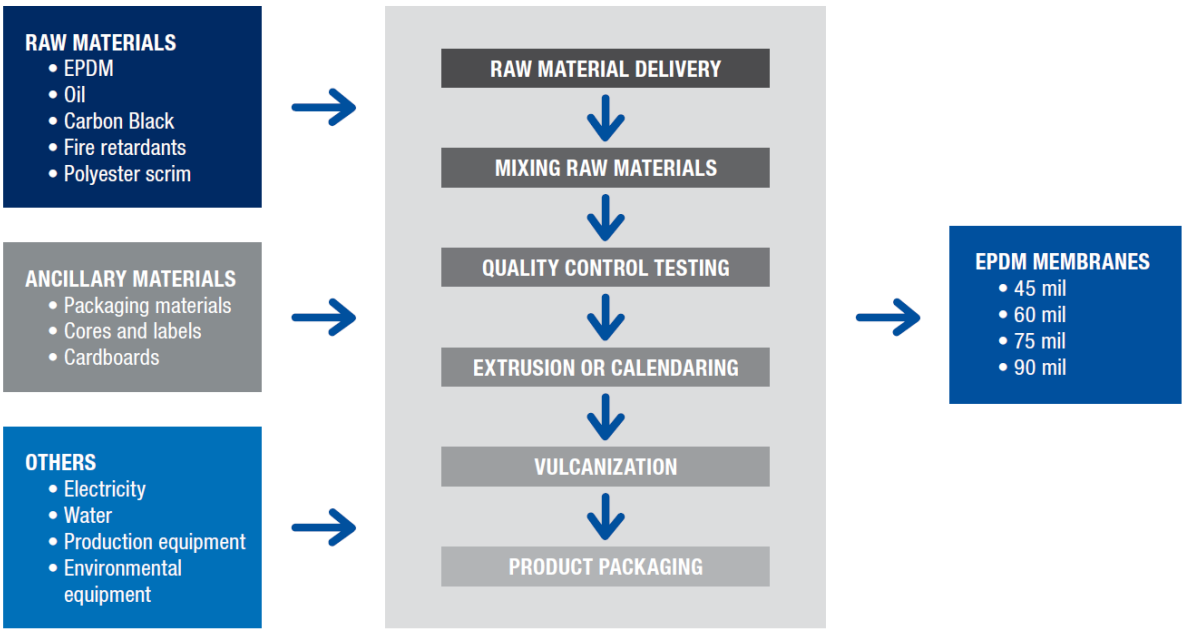

Figure 1: EPDM production process map

Installation

The installation process was modeled following common practice in which non-reinforced EPDM is fully adhered using appropriate adhesives, as approved by Carlisle.

Table 3 shows the material inputs, material outputs, and emissions associated with the installation of 1 m^2 of non-reinforced EPDM membrane. This scenario is identical to the one used for the US industry-average non-reinforced EPDM membrane EPD produced by SPRI, with only the weight of the membrane adjusted according to thickness. It is assumed to be representative for all thicknesses. Packaging materials are disposed of after the membrane is installed at the building site.

Table 3: Installation of non-reinforced EPDM, unit process (per declared unit)

I/O	Material	Value	Unit
Inputs	Non-reinforced EPDM roofing membrane (packaged), incl. 2.5% overlap	1.025	m^2
	Low-VOC adhesive	0.699	kg
Outputs	1 m^2 of installed non-reinforced EPDM roofing membrane	1	m^2
	VOC (toluene) emissions to air	0.161	kg
	Packaging waste (from membrane and adhesive)	*	kg

* varies with membrane thickness

End-of-Life

At the end of the roofing membrane's useful life, it was assumed that the membrane material, as well as any fasteners or adhesive substances, are manually removed from the building and then incinerated. Transport to incineration was approximated with 32 km via large dump truck.

Life Cycle Assessment – Product Systems and Modeling

Declared Unit

The declared unit evaluated is 1 m^2 of single ply roofing membrane for a stated product thickness. As the use stage is excluded from this study, no reference service life is defined.

Life Cycle Stages Assessed

The life cycle assessment (LCA) conducted includes the production, transport to installation site, installation and end-of-life (EoL) stages.

System Boundaries

System boundaries are summarized in Figure 2 for the analysis scope of "cradle-to-building with EoL stage" (i.e., production with installation and EoL stages). Excluded modules are indicated by "MND" or "module not declared". As is typical of works of life cycle assessment, the construction and maintenance of capital equipment, such as production

equipment in the manufacturing stage, are not included in the system, nor are human labor and employee commute. The use stage is also outside the scope of this study.

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END-OF-LIFE STAGE				BEYOND SYSTEM BOUNDARY
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	Reuse, recovery, recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	X	X	X	X	X

Figure 2: Life cycle stages included in system boundary

Assumptions

In cases where no matching life cycle inventories were available to represent a flow, proxy data were applied based on conservative assumptions regarding environmental impacts.

Transportation

Transportation distances and the associated modes of transport are included for the transport of the raw materials, operating materials, and auxiliary materials to production facilities.

Period under Consideration

All primary data were collected for the year 2014. All secondary data come from the GaBi Professional databases and are representative of the years 2010-2013.

Manufacturing Locations

Carlisle manufactures its membranes in the United States. Specifically, non-reinforced EPDM membranes are manufactured in Carlisle, PA and Greenville, IL. As such, the geographical coverage for this study is based on US system boundaries for production. Whenever US background data were not readily available, European data or global data were used as proxies. Installation and end-of-life treatment are intended to be representative of European practice.

Background Data

The LCA model was created using the GaBi ts software system for life cycle engineering, developed by thinkstep AG. The GaBi Professional LCI database provides the life cycle inventory data for several of the raw and process materials

obtained from the background system.

Cut- Off Criteria

Per the PCR, the cut-off criteria for flows to be considered within each system boundary are as follows:

- Mass: If a flow is less than 1% of the cumulative mass of the model flows, it may be excluded, provided its environmental relevance is minor, based on a sensitivity analysis.
- Energy: If a flow is less than 1% of the cumulative energy of the system model, it may be excluded, provided its environmental relevance is minor, based on a sensitivity analysis.
- Environmental relevance: If a flow meets the above two criteria, but is determined to contribute 2% or more to the selected impact categories of the products underlying the EPD, based on a sensitivity analysis, it is included within the system boundary.

At least 95% of the mass flows shall be included and the life-cycle impact data shall contain at least 95% of all elementary flows that contribute to each of the declared category indicators. A list of hazardous and toxic materials and substances shall be included in the inventory and the cut-off rules do not apply to such substances.

No cut-off criteria were applied for this study. All available energy and material flow data were included in the model.

Data Quality Requirements

As the majority of the relevant foreground data are measured data or calculated based on primary information sources of the owner of the technology, precision is considered to be high. Seasonal variations were balanced out by using yearly averages. All background data are sourced from GaBi databases with the documented precision. Each foreground process was checked for mass balance and completeness of the emission inventory. No data were knowingly omitted. Completeness of foreground unit process data is considered to be high. All background data are sourced from GaBi databases with the documented completeness.

Allocation

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

Life Cycle Assessment – Results and Analysis

Use of Resources

The resource consumption associated with the non-reinforced roofing membranes is presented below in Table 4 for the production (A1-A3), transport to installation site (A4), installation (A5), transport to EoL (C2), and EoL disposal (C4) stages. The impacts for modules C1 and C3 are zero, therefore they are excluded from the tables. Module D includes only credits for energy recovered from incineration.

Table 4: Use of resources for non-reinforced EPDM, per declared unit

Indicator	A1-A3	A4	A5	C2	C4	D
Non-reinforced EPDM 1.2 mm						
RPRE [MJ, LHV]	4.69E+00	6.04E-02	2.29E+00	4.11E-03	8.10E-02	-3.88E+00
RPRM [MJ, LHV]	2.77E+00	0.00E+00	3.60E-01	0.00E+00	0.00E+00	0.00E+00
RPRT (RPRE + RPRM) [MJ, LHV]	*7.46E+00*	*6.04E-02*	*2.65E+00*	*4.11E-03*	*8.10E-02*	*-3.88E+00*
NRPRE [MJ, LHV]	7.12E+01	5.56E+00	5.52E+01	7.30E-02	8.07E-01	-4.00E+01
NRPRM [MJ, LHV]	4.16E+01	0.00E+00	1.03E+01	0.00E+00	0.00E+00	0.00E+00
NRPRT (NRPRE + NRPRM) [MJ, LHV]	*1.13E+02*	*5.56E+00*	*6.55E+01*	*7.30E-02*	*8.07E-01*	*-4.00E+01*
SM [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF [MJ, LHV]	9.91E-04	0.00E+00	7.43E-05	0.00E+00	0.00E+00	0.00E+00
NRSF [MJ, LHV]	1.43E-02	0.00E+00	1.07E-03	0.00E+00	0.00E+00	0.00E+00
RE [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW [m^3]	2.35E-02	5.49E-04	1.28E-01	7.27E-06	1.04E-02	-7.84E-03
Non-reinforced EPDM 1.5 mm						
RPRE [MJ, LHV]	6.30E+00	7.52E-02	2.37E+00	5.14E-03	1.01E-01	-4.87E+00
RPRM [MJ, LHV]	3.73E+00	0.00E+00	4.32E-01	0.00E+00	0.00E+00	0.00E+00
RPRT (RPRE + RPRM) [MJ, LHV]	*1.00E+01*	*7.52E-02*	*2.80E+00*	*5.14E-03*	*1.01E-01*	*-4.87E+00*
NRPRE [MJ, LHV]	9.57E+01	6.92E+00	5.71E+01	9.13E-02	1.01E+00	-5.03E+01
NRPRM [MJ, LHV]	5.60E+01	0.00E+00	1.14E+01	0.00E+00	0.00E+00	0.00E+00
NRPRT (NRPRE + NRPRM) [MJ, LHV]	*1.52E+02*	*6.92E+00*	*6.85E+01*	*9.13E-02*	*1.01E+00*	*-5.03E+01*
SM [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF [MJ, LHV]	1.33E-03	0.00E+00	9.99E-05	0.00E+00	0.00E+00	0.00E+00
NRSF [MJ, LHV]	1.93E-02	0.00E+00	1.44E-03	0.00E+00	0.00E+00	0.00E+00
RE [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW [m^3]	3.16E-02	6.83E-04	1.29E-01	9.10E-06	1.30E-02	-9.84E-03
Non-reinforced EPDM 2.3 mm						
RPRE [MJ, LHV]	9.53E+00	1.05E-01	2.53E+00	7.21E-03	1.42E-01	-6.86E+00
RPRM [MJ, LHV]	5.64E+00	0.00E+00	5.75E-01	0.00E+00	0.00E+00	0.00E+00
RPRT (RPRE + RPRM) [MJ, LHV]	*1.52E+01*	*1.05E-01*	*3.11E+00*	*7.21E-03*	*1.42E-01*	*-6.86E+00*
NRPRE [MJ, LHV]	1.45E+02	9.63E+00	6.08E+01	1.28E-01	1.42E+00	-7.08E+01

Indicator	A1-A3	A4	A5	C2	C4	D
NRPRM [MJ, LHV]	8.47E+01	0.00E+00	1.35E+01	0.00E+00	0.00E+00	0.00E+00
NRPRT (NRPRE + NRPRM) [MJ, LHV]	*2.30E+02*	*9.63E+00*	*7.43E+01*	*1.28E-01*	*1.42E+00*	*-7.08E+01*
SM [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF [MJ, LHV]	2.02E-03	0.00E+00	1.51E-04	0.00E+00	0.00E+00	0.00E+00
NRSF [MJ, LHV]	2.91E-02	0.00E+00	2.18E-03	0.00E+00	0.00E+00	0.00E+00
RE [MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW [m^3]	4.78E-02	9.51E-04	1.31E-01	1.28E-05	1.83E-02	-1.39E-02

Life Cycle Impact Assessment

The environmental impacts associated with the non-reinforced roofing membrane are presented below in Table 5 for the production (A1-A3), transport to installation site (A4), installation (A5), transport to EoL (C2), and EoL disposal (C4) stages. The impacts for modules C1 and C3 are zero, therefore they are excluded from the tables. Module D includes only credits for energy recovered from incineration.

Table 5: Life cycle impact category results for non-reinforced EPDM, per declared unit

Indicator	A1-A3	A4	A5	C2	C4	D
Non-reinforced EPDM 1.2 mm						
AP	1.22E-02	7.47E-03	6.63E-03	1.39E-05	3.84E-04	-6.05E-03
EP	1.63E-03	8.69E-04	8.88E-04	3.43E-06	7.08E-05	-4.15E-04
GWP100	4.81E+00	4.24E-01	2.86E+00	5.32E-03	5.18E+00	-2.35E+00
ODP	4.94E-10	2.43E-12	1.46E-09	3.61E-14	1.39E-11	-7.69E-10
POCP	1.47E-03	4.69E-04	1.04E-01	-3.72E-06	4.09E-05	-5.06E-04
ADPe	2.29E-05	3.07E-08	1.16E-05	2.45E-10	4.36E-08	-2.30E-07
ADPf	1.08E+02	5.54E+00	6.38E+01	7.26E-02	6.74E-01	-3.31E+01
Non-reinforced EPDM 1.5 mm						
AP	1.64E-02	9.30E-03	6.96E-03	1.74E-05	4.80E-04	-7.60E-03
EP	2.20E-03	1.08E-03	9.33E-04	4.29E-06	8.86E-05	-5.22E-04
GWP100	6.46E+00	5.27E-01	3.05E+00	6.66E-03	6.48E+00	-2.95E+00
ODP	6.64E-10	3.03E-12	1.48E-09	4.52E-14	1.74E-11	-9.66E-10
POCP	1.98E-03	5.83E-04	1.04E-01	-4.66E-06	5.12E-05	-6.36E-04
ADPe	3.09E-05	3.82E-08	1.22E-05	3.06E-10	5.46E-08	-2.89E-07
ADPf	1.45E+02	6.89E+00	6.66E+01	9.08E-02	8.43E-01	-4.16E+01
Non-reinforced EPDM 2.3 mm						
AP	2.48E-02	1.29E-02	7.64E-03	2.44E-05	6.73E-04	-1.07E-02
EP	3.32E-03	1.50E-03	1.02E-03	6.02E-06	1.24E-04	-7.34E-04

Indicator	A1-A3	A4	A5	C2	C4	D
GWP100	9.77E+00	7.34E-01	3.44E+00	9.33E-03	9.09E+00	-4.15E+00
ODP	1.00E-09	4.21E-12	1.50E-09	6.34E-14	2.43E-11	-1.36E-09
POCP	3.00E-03	8.11E-04	1.04E-01	-6.54E-06	7.18E-05	-8.95E-04
ADPe	4.67E-05	5.32E-08	1.34E-05	4.29E-10	7.66E-08	-4.07E-07
ADPf	2.20E+02	9.59E+00	7.23E+01	1.27E-01	1.18E+00	-5.85E+01

Output Material Flows and Waste

The output material flows and waste associated with the non-reinforced roofing membrane is presented below in Table 6 for the production (A1-A3), transport to installation site (A4), installation (A5), transport to EoL (C2), and EoL disposal (C4) stages. The impacts for modules C1 and C3 are zero, therefore they are excluded from the tables. Module D includes only credits for energy recovered from incineration.

Table 6: Output material flows and waste results for non-reinforced EPDM, per declared unit

Indicator	A1-A3	A4	A5	C2	C4	D
Non-reinforced EPDM 1.1 mm						
HWD [kg]	9.54E-06	5.44E-07	1.36E-05	3.47E-08	2.45E-07	-1.11E-05
NHWD [kg]	8.05E-02	1.36E-04	3.29E-02	1.05E-05	3.52E-02	-1.14E-02
RW [kg]	6.07E-05	2.95E-07	2.18E-05	4.46E-09	1.56E-06	-8.04E-05
CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE, electrical [MJ, LHV]	0.00E+00	0.00E+00	6.15E-01	0.00E+00	7.01E+00	0.00E+00
EE, thermal [MJ, LHV]	0.00E+00	0.00E+00	1.41E+00	0.00E+00	1.61E+01	0.00E+00
Non-reinforced EPDM 1.5 mm						
HWD [kg]	1.28E-05	6.77E-07	1.38E-05	4.34E-08	3.07E-07	-1.39E-05
NHWD [kg]	1.08E-01	1.69E-04	3.74E-02	1.31E-05	4.40E-02	-1.43E-02
RW [kg]	8.17E-05	3.67E-07	2.34E-05	5.59E-09	1.95E-06	-1.01E-04
CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE, electrical [MJ, LHV]	0.00E+00	0.00E+00	8.03E-01	0.00E+00	8.77E+00	0.00E+00
EE, thermal [MJ, LHV]	0.00E+00	0.00E+00	1.85E+00	0.00E+00	2.02E+01	0.00E+00
Non-reinforced EPDM 2.3 mm						
HWD [kg]	1.94E-05	9.42E-07	1.43E-05	6.08E-08	4.31E-07	-1.96E-05
NHWD [kg]	1.64E-01	2.35E-04	4.65E-02	1.84E-05	6.17E-02	-2.02E-02
RW [kg]	1.24E-04	5.11E-07	2.67E-05	7.83E-09	2.73E-06	-1.42E-04

CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE, electrical [MJ, LHV]	0.00E+00	0.00E+00	1.18E+00	0.00E+00	1.23E+01	0.00E+00
EE, thermal [MJ, LHV]	0.00E+00	0.00E+00	2.73E+00	0.00E+00	2.83E+01	0.00E+00

Indicator	A1-A3	A4	A5	C2	C4	D
Non-reinforced EPDM 1.1 mm						
HWD [kg]	9.54E-06	5.44E-07	1.36E-05	3.47E-08	2.45E-07	-1.11E-05
NHWD [kg]	8.05E-02	1.36E-04	3.29E-02	1.05E-05	3.52E-02	-1.14E-02
RW [kg]	6.07E-05	2.95E-07	2.18E-05	4.46E-09	1.56E-06	-8.04E-05
CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE, electrical [MJ, LHV]	0.00E+00	0.00E+00	6.15E-01	0.00E+00	7.01E+00	0.00E+00
EE, thermal [MJ, LHV]	0.00E+00	0.00E+00	1.41E+00	0.00E+00	1.61E+01	0.00E+00
Non-reinforced EPDM 1.5 mm						
HWD [kg]	1.28E-05	6.77E-07	1.38E-05	4.34E-08	3.07E-07	-1.39E-05
NHWD [kg]	1.08E-01	1.69E-04	3.74E-02	1.31E-05	4.40E-02	-1.43E-02
RW [kg]	8.17E-05	3.67E-07	2.34E-05	5.59E-09	1.95E-06	-1.01E-04
CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE, electrical [MJ, LHV]	0.00E+00	0.00E+00	8.03E-01	0.00E+00	8.77E+00	0.00E+00
EE, thermal [MJ, LHV]	0.00E+00	0.00E+00	1.85E+00	0.00E+00	2.02E+01	0.00E+00
Non-reinforced EPDM 2.3 mm						
HWD [kg]	1.94E-05	9.42E-07	1.43E-05	6.08E-08	4.31E-07	-1.96E-05
NHWD [kg]	1.64E-01	2.35E-04	4.65E-02	1.84E-05	6.17E-02	-2.02E-02
RW [kg]	1.24E-04	5.11E-07	2.67E-05	7.83E-09	2.73E-06	-1.42E-04
CRU [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE, electrical [MJ, LHV]	0.00E+00	0.00E+00	1.18E+00	0.00E+00	1.23E+01	0.00E+00
EE, thermal [MJ, LHV]	0.00E+00	0.00E+00	2.73E+00	0.00E+00	2.83E+01	0.00E+00

Additional Environmental Information

Product Performance

Proven weatherability – One of the major themes in commercial construction is sustainability or long term service life. Physical property testing of 30 year old EPDM taken from performing roofs showed the tensile strength and tear resistance actually improved with age (ERA, 2012) . It is important to note that the 30 year old membrane was still very pliable, flexible and didn't lose its ability to expand and contract with building movement or large temperature changes. Another important attribute is the membrane is still "repairable" meaning it can still be spliced with primers and pressure-sensitive flashings to further extend the life of the roof.

Safety factor against condensation – In testing completed by Oak Ridge National Labs it was proven that white mechanically fastened roofing systems accumulate twice as much condensate as a black mechanically fastened roofing system (Manfred & Pallin, 2013). This is an important built-in safety factor for black reinforced EPDM in cooler central and northern climates.

UV resistance – EPDM has excellent UV resistance as evidenced in the ASTM G155 Accelerated Xenon Arc Weathering test. Black non-reinforced EPDM has approximately twice the UV resistance of various white roofing membranes (40,000 kJ/m^2 compared to 20,000 kJ/m^2).

Amount of weathering material – EPDM membrane has approximately twice the thickness of weathering material as a thermoplastic (TPO) reinforced membrane. In a 1.5 mm non-reinforced EPDM there are 1.5 mm of weathering material. In a 1.5 mm TPO reinforced membrane there are only 0.5 to 0.6 mm of weathering material over the scrim. The mode of eventual failure on reinforced membranes is typically when the scrim begins showing through the surface of the membrane and begins taking on water.

Puncture resistance – Thicker membranes like 1.5 mm and 2.3 mm non-reinforced provide more puncture resistance than 1.2 mm. Adding internal reinforcement to the membrane increases the puncture resistance compared to a non-reinforced membrane. Adding external fleece reinforcement gives you the highest amount of puncture resistance and provides a full 1.2, 1.5, or 2.3 mm of weathering membrane above the fleece reinforcement.

Resistance to unwanted biological growth – All of Carlisle's EPDM roofing membranes provide excellent resistance to unwanted biological growth on the surface of the membrane. In the ASTM G21 test, conducted by MicroStar Labs, our EPDM roofing membranes achieved a zero or "no growth" rating (#R2014-131).

Resistance to hail damage – EPDM roofing membranes have had a great track record of resisting hail damage and keeping water out of buildings, which can cut down on the owners' financial losses considerably. Non-reinforced EPDM's ability to elongate over 400% is one of the primary reasons EPDM has great hail resistance. EPDM stays flexible throughout its lifecycle providing good hail resistance even at the end of its warranty term. Adhered systems with a minimum 1.5 mm non-reinforced EPDM membrane have been shown to resist up to 3" simulated hail impact without fracture or damage to the membrane regardless of whether the membrane was new, heat aged or field weathered for 15 years. A 2009 report prepared by Jim Koontz and Tom Hutchinson states, "The results of this research clearly indicate that non-reinforced EPDM…offers a high degree of hail resistance…field and heat aged EPDM membrane… retains the bulk of its impact resistance as it ages" (Koontz & Hutchinson, 2009). Ric Vitiello of Benchmark Services, another veteran of roofing industry hail research, has documented his findings in a 15 page report he prepared for the EPDM Roofing Association in 2007. He commented, "Based on field and test data, it is clear that EPDM outperforms other roof systems." Vitiello additionally stated, "EPDM systems are much more hail-resistant even without special treatment" (Vitiello, 2007).

Roof Surface Solar Reflectance

A 2012 study by Stanford University, titled “Effects of Urban Surfaces and White Roofs on Global and Regional Climate” and published in the Journal of Climate, found that the net effect of white roofs may be raising global temperatures (Jacobson & Ten Hoeve, 2012). White roof membranes possess high reflectivity, which causes heat to be reflected upward into the atmosphere. There, the added heat mixes with black and brown soot particles, which are thought to be contributing to global warming.

Another study, from Arizona State University (ASU), indicates widespread adoption of highly reflective cool roofs could negatively impact rainfall patterns across the United States. Matei Georgescu, a geographical sciences and urban planning professor at ASU, notes that his study shows that cool roofs, while they do reduce temperatures in urban areas, also shift rainfall patterns by reducing evapotranspiration, the process by which water evaporates from the ground and enters the atmosphere. In the most extreme expansion in the study, cool roofs led to a 4 percent decline in rainfall. He concludes that certain regions of the nation might be more appropriate for cool roofs than others (Georgescu *et al.*, 2014).

Potential for Energy Saving Improvements

As a leader in the commercial roofing industry and the largest manufacturer of both white and black roofing membranes, Carlisle continues to advocate careful selection of roofing systems based on a building’s design, location, and climatic conditions. ENERGY STAR’s website cautions, “before selecting a roofing product based on expected energy savings, consumers should explore the expected calculated results that can be found on the Department of Energy's ‘Roof Savings Calculator’”. In general, the Roof Savings Calculator highlights that the heating penalty of white reflective membranes exceeds the cooling benefit in heating dominated central and northern climates. In the central and northern climates heating costs are typically 3-5 times greater than cooling costs and in these climates a black EPDM roof is typically the energy efficient choice. In cooling dominated southern climates a white EPDM roof or a ballasted EPDM roof are typically the energy efficient choice.

The use of insulating ½” (13 mm) cover boards that provide an added 2.5 R_{IP}-value (0.44 R_{SI}) is another means to enhance the energy efficiency of roofing systems and they also improve the durability and wind uplift resistance of the roofing assembly.

Specifying the use of multiple layers of insulation with staggered joints in lieu of a single thick layer of insulation is proven to be more thermally efficient.

Utilizing urethane insulation adhesives to bond insulation to the roof deck in lieu of metal fasteners and metal insulation plates eliminates the 3-8% R-value loss from thermal bridging according to the NRCA’s Roofing & Waterproofing Manual.

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LCA Development

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