Environmental Product Declaration

According to ISO 14025 and ISO 21930:2017

FleeceBACK® TPO MEMBRANE

Carlisle SynTec Systems

Carlisle SynTec Systems has been the leader in the commercial single-ply roofing industry for more than 60 years. It continues to lead the roofing industry today by providing its customers with superior roofing systems and services through a select network of manufacturer's representatives, distributors, and applicators.

Today, Carlisle's diverse product offering includes EPDM, TPO, PVC, and FleeceBACK® roofing membranes, as well as a full line of labor-saving flashing accessories. Backed by industry-leading warranties, Carlisle's products have been installed on a wide range of buildings around the world, including schools, hospitals, warehouses, and cold storage facilities.

To date, Carlisle has manufactured and sold more than 20 billion square feet of roof membranes and remains committed to developing and manufacturing the highest-quality, most sustainable commercial roofing materials on the market.

Issue Date: 05-10-2024

Valid Until: 05-10-2029

Declaration Number: ASTM-EPD667

DECLARATION INFORMATION

Declaration	
Program Operator: ASTM International **Company:** Carlisle SynTec Systems, a division of Carlisle Construction Materials 1285 Ritner Hwy Carlisle, PA 17013 www.carlislesyntec.com	**www.astm.org**
Product Information	**Validity / Applicability**
Product Name: FleeceBACK® TPO Single-Ply Roofing Membrane	**Period of Validity:** This declaration is valid for a period of 5 years from the date of publication.
Product Definition: Fleece-backed Thermoplastic Polyolefin (TPO) Single-Ply Roofing Membrane	
Declaration Type: Business-to-business (B2B)	**Geographic Scope:** North America
PCR Reference: • Core PCR: ISO 21930:2017 (ISO 21930, 2017) • Sub-category PCR: Product Category Rules for Single-Ply Roofing Membranes (NSF International, 2019)	**PCR Review was conducted by:** • Thomas P. Gloria, Ph.D., Industrial Ecology Consultants • Bill Stough, Sustainable Research Group • Jack Geibig, EcoForm
Product Application and/or Characteristics	
Single-ply, fleece-backed TPO roofing membrane representative of 100, 115, and 135 mil thicknesses are used as a roofing protective layer for building applications.	
Content of the Declaration	
• Product definition and physical building-related data • Details of raw materials and material origin • Description of how the product is manufactured • Life Cycle Assessment results • Additional environmental information	
Verification	
This declaration was independently verified in accordance with ISO 21930:2017, ISO 14025:2006 and the reference PCR by Tim Brooke, ASTM International.	☐ Internal ☒External
This life cycle assessment was independently verified in accordance with ISO 21930:2017 and ISO 14044:2006 and the reference PCR by Lindita Bushi, Ph.D., Athena Sustainable Materials Institute.	
Limitations *The environmental impact results of TPO products in this document are based on a declared unit and therefore do not provide sufficient information to establish comparisons. The results shall not be used for comparisons without knowledge of how the physical properties of the TPO product impact the precise function at the construction level. The environmental impact results shall be converted to a functional unit basis before any comparison is attempted. See Section 3.10 for additional EPD comparability guidelines. Environmental declarations from different programs (ISO 14025) may not be comparable.*	

EPD Summary

This document is a Type III environmental product declaration by Carlisle SynTec Systems that is certified by ASTM International (ASTM) as conforming to the requirements of ISO 21930 and ISO 14025. ASTM has assessed that the Life Cycle Assessment (LCA) information fulfills the requirements of ISO 14040 in accordance with the instructions listed in the referenced product category rules. The intent of this document is to further the development of environmentally compatible and sustainable construction methods by providing comprehensive environmental information related to potential impacts in accordance with international standards.

No comparisons or benchmarking are included in this EPD. Environmental declarations from different programs based upon differing PCRs may not be comparable. In general, EPDs may not be used for comparability purposes when not considered in a construction works context. Given that the PCR ensures products meet the same functional requirements, comparability is permissible provided the information given for such comparison is transparent and the limitations of comparability explained. Only EPDs prepared from cradle-to-grave life cycle results, and based on the same function, quantified by the same functional unit, and taking account of replacement based on the product reference service life (RSL) relative to an assumed building service life, can be used to assist purchasers and users in making informed comparisons between products. When comparing EPDs created using this PCR, variations and deviations are possible. Example of variations: Different LCA software and background LCI datasets may lead to different results for upstream or downstream of the life cycle stages declared.

Scope and Boundaries of the Life Cycle Assessment

The Life Cycle Assessment (LCA) was performed according to ISO 14040 (ISO 14040, 2020a) and ISO 14044 (ISO 14044, 2020b) following the requirements of the ASTM EPD Program instructions and the referenced PCR.

System Boundary: Cradle-to-gate

Declared Unit: 1 m^2 of single-ply roofing membrane for a stated product thickness. Environmental performance results therefore represent Carlisle's average production of TPO, normalized to 1 m^2.

General Information

Description of Company/Organization

Carlisle SynTec Systems, the flagship division of Carlisle Construction Materials, is the largest supplier of commercial roofing products in the world. Carlisle produces high-performance EPDM, TPO, PVC, and FleeceBACK® single-ply roofing membranes, a full line of polyiso and expanded polystyrene insulation, and a wide variety of solvent-based and low-VOC adhesives. With decades of manufacturing experience and billions of square feet of roofing materials sold, Carlisle continues to lead the industry by providing the best products, services, and warranty options available today.

Product Description

Carlisle's FleeceBACK® TPO is reinforced and enhanced with fleece, creating a very tough, durable and versatile sheet that is ideal for re-roofing or new construction projects. All FleeceBACK® TPO membranes utilize Octaguard XT™ weathering package technology to withstand extreme durability testing intended to simulate exposure to severe climates. TPO FleeceBACK® membranes are installed using Flexible FAST Adhesive for a VOC-free, quite, low-odor, non-penetrating application and a roof system that offers superior wind uplift.

The product system evaluated in this report is a single-ply fleece-backed TPO roofing membrane at the finished nominal thicknesses produced by Carlisle. See Table 1 for membrane specification and standard.

Table 1: Membrane specification and standard

Roof System	Roof System Component	Declared Thicknesses and Weights per declared unit	Standard
Fleece-backed Thermoplastic Polyolefin (TPO)	Membrane	100 mils: 1.32 kg/m^2 115 mils: 1.61 kg/m^2 135 mils: 2.25 kg/m^2	ASTM D6878

Product Average

The 2019 production data used in this EPD considers FleeceBACK® TPO roofing membranes produced by Carlisle in two (2) sites in North America during the year. The participating facilities are:

- Senatobia, MS
- Tooele, UT

Results are weighted according to production amounts at participating facilities.

Application

Carlisle FleeceBACK® TPO systems are preferred for new construction and re-roofing projects, and are particularly well-suited for critical facilities that require superior protection against severe weather, as well as Roof Garden and solar applications.

Material Composition

Table 2 shows the input material for FleeceBACK® TPO roofing membranes and their material percentages for the three membrane thicknesses. The composition of the 115 mil FleeceBACK® TPO produced in Tooele and Senatobia were averaged between the two locations.

Table 2: Composition of TPO roofing membrane

Material	**100 mil % Composition**	**115 mil % Composition**	**135 mil % Composition**
Base resin (TPO)	41.9	45.3	45.0
Fire retardant	27.3	26.2	29.3
Fleece	15.4	11.9	9.0
Stabilizers	8.9	9.3	9.6
Polyester scrim	5.4	5.9	5.8
Pigments	1.2	1.3	1.3

Manufacturing

The main material inputs into the TPO manufacturing process are the base resin in the form of pellets and processed scrap and polyester reinforcing scrim. Additional materials include those which aid the manufacturing process (e.g., accelerators) and those which enhance the membrane's performance (e.g., fire retardants, weathering package ingredients, and pigments). The mix is heated and either extruded simultaneously onto both sides of the reinforcing polyester scrim, or extruded at approx. half of the specified thickness with reinforcing polyester scrim pressed in between the top and bottom layers, forming the final TPO membrane sheet. Non-reinforced edges are trimmed and this material is ground and recycled directly back into the extrusion process. The product is cooled as it runs through a series of rollers, after which it is transferred onto large cardboard roll cores and wrapped in plastic film to be shipped to building sites for installation.

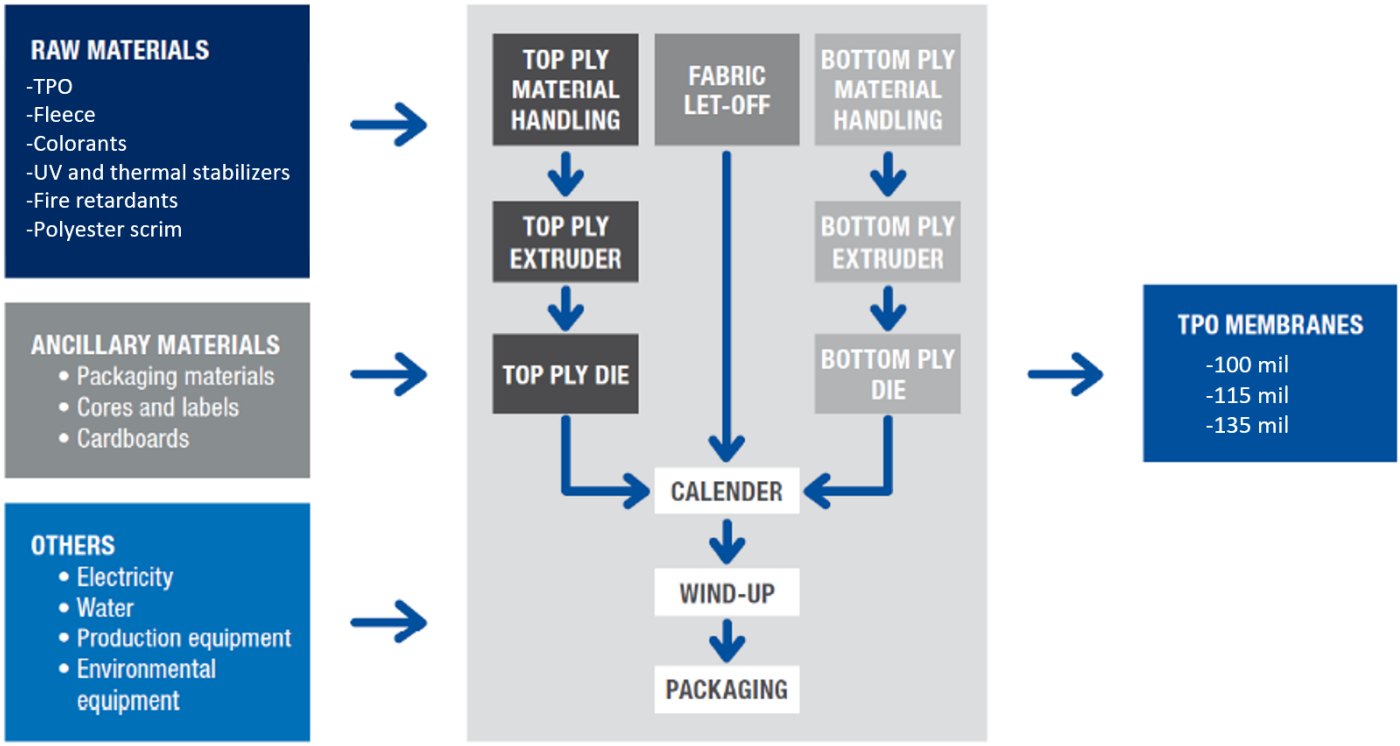

Figure 1: FleeceBACK® TPO production process map

Transportation

Primary data on inbound transportation of raw materials and packaging material were collected. These materials included base resin (TPO), scrim, fire retardants, weathering concentrates, etc. Transportation to the customer or construction site is outside the scope of this EPD.

Product Installation

Installation is outside the scope of this EPD.

Use

Product use is outside the scope of this EPD.

Reuse, Recycling, and Energy Recovery

Product reuse, recycling, and energy recovery are outside the scope of this EPD.

Disposal

Product disposal is outside the scope of this EPD.

METHODOLOGICAL FRAMEWORK

DECLARED UNIT

The declared unit for this study is :

1 m² of single-ply roofing membrane for a stated product thickness

Environmental performance results therefore represent Carlisle's average production of TPO, normalized to 1 m². The reference service life is not specified. Since the use stage is not included in the system boundary, no reference service life needs to be defined for the analysis.

SYSTEM BOUNDARY

System boundaries are summarized in Figure 2 for the analysis scope of "cradle-to-gate". 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			CONSTRUCT-ION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY
Raw material supply	Transport	Manufacturing	Transport from gate to site	Assembly/Install	Use	Maintenance	Repair	Replacement	Refurbishment	Building Operational Energy Use During Product Use	Building Operational Water Use During Product Use	Deconstruction	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	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

Figure 2: Life cycle stages included in system boundary

CUT-OFF RULES

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

DATA SOURCES

The LCA model was created using the LCA FE software system for life cycle engineering, version 2023.2, developed by Sphera (Sphera, 2023). Background life cycle inventory data for raw materials and processes were obtained from the MLC 2023.2 database. Primary manufacturing data were provided by the participating companies.

Data Quality

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 that were then weighted according to each manufacturer's production volume. All background data are sourced from MLC 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 MLC databases with the documented completeness.

Geographical Coverage

This study represents production at Carlisle facilities in North America. As such, the geographical coverage for this study is based on North American system boundaries for all processes and products.

Regionally specific datasets, where available, were used to represent each manufacturing location's energy consumption. Proxy datasets were used as needed for raw material inputs to address lack of data for a specific material or for a specific geographical region. These proxy datasets were chosen for their technological representativeness of the actual materials.

Period under Review

Primary data collected represent production during the 2019 calendar year. This analysis is intended to represent production in 2019. All secondary data come from the MLC Professional databases and are representative of the years 2017-2022.

Allocation

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

Allocation of background data (energy and materials) taken from the MLC 2023 databases is documented online at https://sphera.com/product-sustainability-gabi-data-search/.

Estimates and 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.

Life Cycle Assessment Results

The environmental impacts associated with the FleeceBACK® TPO roofing membrane is presented below in Table 3 for the production stage (A1-A3).

Table 3: Environmental impact indicators for 1m² of FleeceBACK® TPO Single-Ply Roofing Membrane

Indicator	A1	A2	A3	Total
Global Warming Potential [kg CO_2 eq.] – IPCC AR6				
TPO 100 mil	3.28E+00	5.62E-02	2.36E-01	3.57E+00
TPO 115 mil	4.09E+00	1.22E-01	2.85E-01	4.50E+00
TPO 135 mil	5.42E+00	9.04E-02	4.02E-01	5.91E+00
Global Warming Potential [kg CO_2 eq.] – IPCC AR5				
TPO 100 mil	3.37E+00	5.67E-02	2.41E-01	3.66E+00
TPO 115 mil	4.20E+00	1.23E-01	2.90E-01	4.61E+00
TPO 135 mil	5.57E+00	9.11E-02	4.09E-01	6.07E+00
Ozone Depletion Potential [kg CFC-11 eq.]				
TPO 100 mil	2.07E-13	1.45E-16	1.19E-09	1.19E-09
TPO 115 mil	2.41E-13	3.02E-16	8.35E-10	8.35E-10
TPO 135 mil	2.99E-13	2.31E-16	2.03E-09	2.03E-09
Acidification Potential [kg SO2 eq.]				
TPO 100 mil	6.42E-03	2.95E-04	5.17E-04	7.23E-03
TPO 115 mil	8.20E-03	9.28E-04	5.30E-04	9.65E-03
TPO 135 mil	1.11E-02	4.99E-04	8.81E-04	1.25E-02
Eutrophication Potential [kg N eq.]				
TPO 100 mil	1.69E-03	2.54E-05	7.61E-05	1.79E-03
TPO 115 mil	2.19E-03	6.49E-05	7.59E-05	2.33E-03
TPO 135 mil	3.02E-03	4.24E-05	1.29E-04	3.19E-03
Smog Formation Potential [kg O_3 eq.][1]				
TPO 100 mil	1.28E-01	8.85E-03	7.44E-03	1.45E-01
TPO 115 mil	1.63E-01	2.61E-02	7.83E-03	1.97E-01
TPO 135 mil	2.20E-01	1.53E-02	1.27E-02	2.48E-01

The resource use associated with the FleeceBACK® TPO roofing membrane is presented below in Table 4 for the production stage (A1-A3). Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories (NSF International, 2019).

[1] Per ISO 21930, TRACI Smog Formation Potential (SFP) is reported instead of Photochemical Oxidant Creation Potential (POCP)

Table 4: Resource use indicators for 1m² of FleeceBACK® TPO Single Ply Roofing Membrane

Indicator	A1	A2	A3	Total
Renewable Primary Energy Resources as Energy (RPRE) [MJ]				
TPO 100 mil	6.50E+00	3.26E-02	7.10E-01	7.24E+00
TPO 115 mil	7.86E+00	6.61E-02	1.05E+00	8.97E+00
TPO 135 mil	1.01E+01	5.24E-02	1.21E+00	1.13E+01
Renewable Primary Resources as Material (RPRM) [MJ]				
TPO 100 mil	0.00E+00	0.00E+00	3.03E-01	3.03E-01
TPO 115 mil	0.00E+00	0.00E+00	2.52E-01	2.52E-01
TPO 135 mil	0.00E+00	0.00E+00	5.16E-01	5.16E-01
Non-Renewable Primary Resources as Energy (fuel) (NRPRE) [MJ]				
TPO 100 mil	5.97E+01	8.26E-01	3.91E+00	6.45E+01
TPO 115 mil	7.51E+01	1.77E+00	4.80E+00	8.17E+01
TPO 135 mil	1.02E+02	1.33E+00	6.65E+00	1.10E+02
Non-Renewable Primary Resources as Material (NRPRM) [MJ]				
TPO 100 mil	3.85E+01	0.00E+00	1.18E-01	3.86E+01
TPO 115 mil	4.85E+01	0.00E+00	1.12E-01	4.86E+01
TPO 135 mil	6.29E+01	0.00E+00	2.01E-01	6.31E+01
Secondary Materials (SM) [kg]				
TPO 100 mil	0.00E+00	0.00E+00	9.43E-02	9.43E-02
TPO 115 mil	0.00E+00	0.00E+00	9.23E-02	9.23E-02
TPO 135 mil	0.00E+00	0.00E+00	1.60E-01	1.60E-01
Renewable Secondary Fuels (RSF) [MJ]				
TPO 100 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 115 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 135 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-Renewable Secondary Fuels (NRSF) [MJ]				
TPO 100 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 115 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 135 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered Energy (RE) [MJ LHV]*				
TPO 100 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 115 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 135 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Abiotic Depletion Potential for Fossil Resources (ADP_{fossil}) [MJ]*				

TPO 100 mil	9.54E+01	8.19E-01	3.23E+00	9.94E+01
TPO 115 mil	1.20E+02	1.75E+00	3.82E+00	1.26E+02
TPO 135 mil	1.61E+02	1.32E+00	5.50E+00	1.67E+02
Use of Net Freshwater Resources (FW) [m³]*				
TPO 100 mil	1.08E-01	1.12E-04	2.07E-03	1.10E-01
TPO 115 mil	1.41E-01	2.27E-04	3.16E-03	1.45E-01
TPO 135 mil	1.96E-01	1.80E-04	3.52E-03	2.00E-01

*Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in this category.

The waste generation associated with the FleeceBACK® TPO roofing membrane is presented below in Table 5 for the production stage (A1-A3). Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories (NSF International, 2019).

Table 5: Output flows & waste categories for 1m² of FleeceBACK® TPO Single-Ply Roofing Membrane

Indicator	A1	A2	A3	Total
Hazardous Waste Disposed (HWD) [kg]				
TPO 100 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 115 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 135 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-Hazardous Waste Disposed (NHWD) [kg]				
TPO 100 mil	0.00E+00	0.00E+00	2.25E-01	2.25E-01
TPO 115 mil	0.00E+00	0.00E+00	1.62E-01	1.62E-01
TPO 135 mil	0.00E+00	0.00E+00	3.95E-01	3.95E-01
High-Level Radioactive Waste, Conditioned, to Final Repository (HLRW) [kg]*				
TPO 100 mil	1.10E-06	2.68E-09	3.38E-07	1.44E-06
TPO 115 mil	1.37E-06	5.60E-09	4.63E-07	1.84E-06
TPO 135 mil	1.81E-06	4.27E-09	5.75E-07	2.39E-06
Intermediate- and Low-Level Radioactive Waste, Conditioned, to Final Repository (ILLRW) [kg]*				
TPO 100 mil	1.02E-03	2.26E-06	2.84E-04	1.31E-03
TPO 115 mil	1.28E-03	4.71E-06	3.87E-04	1.67E-03
TPO 135 mil	1.69E-03	3.60E-06	4.82E-04	2.17E-03
Components for Re-Use (CRU) [kg]*				
TPO 100 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 115 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 135 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Materials for Recycling (MR) [kg]*				
TPO 100 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 115 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 135 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for Energy Recovery (MER) [kg]*				
TPO 100 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 115 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 135 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Recovered Energy Exported from the Product System (EE) [MJ LHV]*				
TPO 100 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 115 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TPO 135 mil	0.00E+00	0.00E+00	0.00E+00	0.00E+00

*Emerging LCA impact categories and inventory items are still under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in this category.

LCA Interpretation

The major contributor for almost every impact is raw materials (A1) followed by manufacturing (A3) and inbound transportation (A2). There is an exception with ODP, where manufacturing (A3) takes the lead due to the production of bio-based packaging materials, such as corrugated and cardboard, which contribute significantly (79-99%) to ODP. The raw TPO materials contributed the most to AR6 GWP (35-39%) and SFP (36-41%) impacts. The weathering ingredients contributed the most to EP (75-81%). Raw TPO materials and weathering ingredients also play a major role in AP.

The EPDs are comparable only if they comply with the document ISO 21930, use the same sub-category PCR where applicable, include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works.

Additional Environmental Information

UV resistance – TPO has excellent UV resistance as evidenced by in the ASTM G155 Accelerated Xenon Arc Weathering test. White reinforced TPO FleeceBACK has a UV resistance range of 17,000 kJ/m^2 to 28,000 kJ/m^2 based on thickness.

Puncture resistance – TPO is internally reinforced using polyester scrim creating excellent puncture resistance when compared to non-reinforced membranes. Adding external fleece gives you the highest amount of puncture resistance.

Resistance to unwanted biological growth – All Carlisle's TPO FleeceBACK roofing membranes provide excellent resistance to unwanted biological growth on the surface of the membrane. Using ASTM D3274, Carlisle's TPO FleeceBACK membranes exhibit zero or "no growth" rating.

Resistance to hail damage – TPO FleeceBACK roofing membranes have had a great track record of resisting hail damage and keeping water out of buildings, which can cut down on owners' financial losses considerably. Adhered systems utilizing

TPO FleeceBACK over a cover board set in adhesive, are a practical way to eliminate potential hail damage due to a direct hail strike over a fastener or plate that is required in a mechanically fastened system. This creates a more resilient roofing system that performs well during severe weather events reducing the need for replacement.

Pollution abatement equipment – The Carlisle plant employs pollution abatement equipment, including scrubbers, filter boxes, and dust collectors, whereas no such equipment is present in the Senatobia and Tooele plants.

Clarification regarding hazardous substances in the final product – Per TPO Safety Data Sheet (SDS), the finished product declared in this EPD is considered "Articles" as defined in OSHA Hazardous Communication Standard. This finished product is not hazardous and does not contain any regulated substances of very high concern. No components in the product are listed under the SDS Section 15 Regulatory Requirements, specifically U.S. Federal Regulations, SARA Section 311/312, California Prop 65, or the Canadian WHMIS IDL. Information on ingredients and regulatory information can be found in the SDS.

Clarification regarding release of dangerous substances from the final product – The finished product declared in the EPD is classified as an article with no release of dangerous substances.

Clarification regarding hazardous waste generated during production – No hazardous waste is generated during the production of the product declared in this EPD.

REFERENCES

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