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Duro-Tuff® | Single-Ply PVC Roof Membrane

Company Name	Duro-Last, Inc.
Product Type	Single-ply PVC roofing
Product Name	Duro-Tuff® 50-mil, 60-mil, 80-mil
Manufacturing Site	525 Morley Drive Saginaw, MI 48601
EPD Scope	Cradle-to-gate
Declared Unit	1 m^2
Product Colors	white, gray, charcoal, tan, patina, blue, copper, and green

Company Information

Duro-Last, Inc. began in 1978 with the simple need to find a roofing system that worked. Existing roofing systems presented a common problem — they required ongoing maintenance and continual expense, with no long-term solution in sight. Our Founder, John R. Burt, used his experience in fabricating pool liners to develop a remarkable new roofing membrane. Investigation of the roofing industry proved that the majority of roofing system failures then were not due to the roofing system assembly itself but to workmanship on-site. To solve this problem, we brought our roofing system "in-house," developing custom prefabrication methods and specialized equipment that allows us to complete nearly all of the difficult roof details and up to 85% of field seams. The result is lower on-site labor costs and better installation quality.

Product Description

The Duro-Tuff® PVC roof membrane is a proprietary thermoplastic formulation that provides a highly reflective, durable, and superior quality product. An 18 x 9 weft-inserted anti-wicking knit scrim that is laminated between two layers of PVC film gives the membrane its strength and durability. This EPD applies to the Duro-Tuff® single-ply membrane in white, light gray, charcoal, light tan, patina, copper, blue, and green, 50-mil, 60-mil, and 80-mil nominal thicknesses. The Duro-Tuff® membrane was engineered to be used with the complete line of Duro-Last's proven, precision-fabricated flashings for curbs, stacks, and parapets. Duro-Tuff® can be applied by a Duro-Last certified contractor utilizing a variety of methods, including mechanically fastened, Duro-Bond® induction welding, or fully adhered. All commercial warranted installations are inspected by Duro-Last's certified Quality Assurance Technical Representatives

EPD Program Operator
NSF International
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Ann Arbor MI 48105 USA
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NSF® Certified Environmental Product Declaration www.nsf.org

Date of Issue: 01/04/2022
Valid Until: 01/04/2027
Declaration#: EPD10675

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ENVIRONMENTAL PRODUCT DECLARATION VERIFICATION

EPD Information			
Program Operator		NSF International	
Declaration Holder		Duro-Last, Inc.	
Product Duro-Tuff® 50-mil, 60-mil, 80-mil	Date of Issue 01/04/2022	Valid Until 01/04/2027	Declaration Number EPD10675
This EPD was independently verified by NSF International in accordance with ISO 14025 and ISO 21930: ☐ Internal ☒ External		[signature] Tony Favilla afavilla@nsf.org	
This life cycle assessment was independently verified by in accordance with ISO 14044 and the reference PCR:		[signature] Jack Geibig jgeibig@ecoform.com	
LCA Information			
EPD Project report		A Cradle-to-Gate Life Cycle Assessment of Duro-Last Inc's Single-ply PVC Roofing Membranes, December 2021	
LCA Preparer Athena Sustainable Materials Institute		Lindita Bushi Ph.D., Mr. Jamie Meil and Mr. Grant Finlayson Athena Sustainable Materials Institute 280 Albert Street, Suite 404 Ottawa, Ontario, Canada K1P 5G8 info@athenasmi.org www.athenasmi.org	
This EPD project report was critically reviewed in accordance with ISO 14025, ISO 14040/44, and the reference PCR by:		Jack Geibig EcoForm jgeibig@ecoform.com	
PCR Information			
Program Operator		NSF International	
Reference PCR		NSF International, Product Category Rules for Preparing an Environmental Product Declaration for Single Ply Roofing Membranes	
Date of Issue		October 2019	
PCR review was conducted by:		Thomas P. Gloria, PhD (Chair), Industrial Ecology Consultants Mr. Jack Geibig, EcoForm Mr. Bill Stough, Sustainable Research Group	

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Product Specifications

Physical Property	Test Method	ASTM 4434 Requirement for Type III Sheet	50-mil Result	60-mil Result	80-mil Result
Overall Thickness	ASTM D751	≥ 0.045 in.	PASS	PASS	PASS
Thickness Over Scrim	ASTM D7635	≥ 0.016 in.	PASS	PASS	PASS
Breaking Strength	ASTM D751 Grab Method	≥ 200 lbf./in.	PASS	PASS	PASS
Elongation	ASTM D751 Grab Method	≥ 15%	PASS	PASS	PASS
Seam Strength	ASTM D751 Grab Method	≥ 317 lbf. (75% of Breaking Strength)	PASS	PASS	PASS
Tear Strength	ASTM D751 Procedure B	≥ 45 lbf.	PASS	PASS	PASS
Low Temp. Bend	ASTM D2136	Must pass at -40° F.	PASS	PASS	PASS
Heat Aging	ASTM D3045	Conditioned for 56 days in oven maintained at 176° F.	PASS	PASS	PASS
Accelerated Weathering	ASTM G155	10,000 hours total test time. Irradiance level of 0.35 W/m2-340nm. Cycle: 102 minutes light, 18 minutes light + H20 spray, 63±2.5° C black panel, 30±5% RH	PASS	PASS	PASS
Dimensional Stability	ASTM D1204	Conditioned for 6 hours in oven maintained at 176° F. Allowable change: ≤ 0.5%	PASS	PASS	PASS
Water Absorption	ASTM D570	Immersed in water at 158° F for 168 hours. Allowable change: ≤ 3%	PASS	PASS	PASS
Static Puncture	ASTM D5602	≥ 33 lbf.	PASS	PASS	PASS
Dynamic Puncture	ASTM 5635	≥ 14.7 ft.-lbf. (20 J)	PASS	PASS	PASS

Additional Testing Requirements

Duro-Tuff has met or exceeded all major fire and wind code requirements, and regional approvals as necessary throughout the country. Duro-Tuff has been approved by Factory Mutual as a 1-60, 1-90, 1-165, and 1-915 roofing system. Duro-Last is also listed by Underwriters Laboratories as a Class A, B, & C approved material. Evaluation services ICBO and NES have merged to form ICC-ES. The Duro-Tuff roofing system has been approved by the IBC and code agency MIAMI-DADE for use in their respective jurisdictions.
Further testing information and results can be found in the Specs & Technical Info section of the Duro-Last website at duro-last.com.

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Life Cycle Stages

Figure 1 shows the life-cycle stages and information modules that are included within the cradle-to-gate LCA system boundary of this EPD. The boundary is "cradle-to-gate", including the Production stage (A1 to A3 modules). Construction, Use, and End-of-Life stages - are excluded from the system boundary. The Production stage system boundary is shown in Figure 3. Per ISO 21930, 7.1.7.2.1 [3], the system boundary with nature (natural environment) includes those technical processes that provide the material and energy inputs into the system and the subsequent manufacturing and transport processes up to the factory gate, as well as the processing of any waste arising from those processes.

Figure 1: Life cycle stages and modules

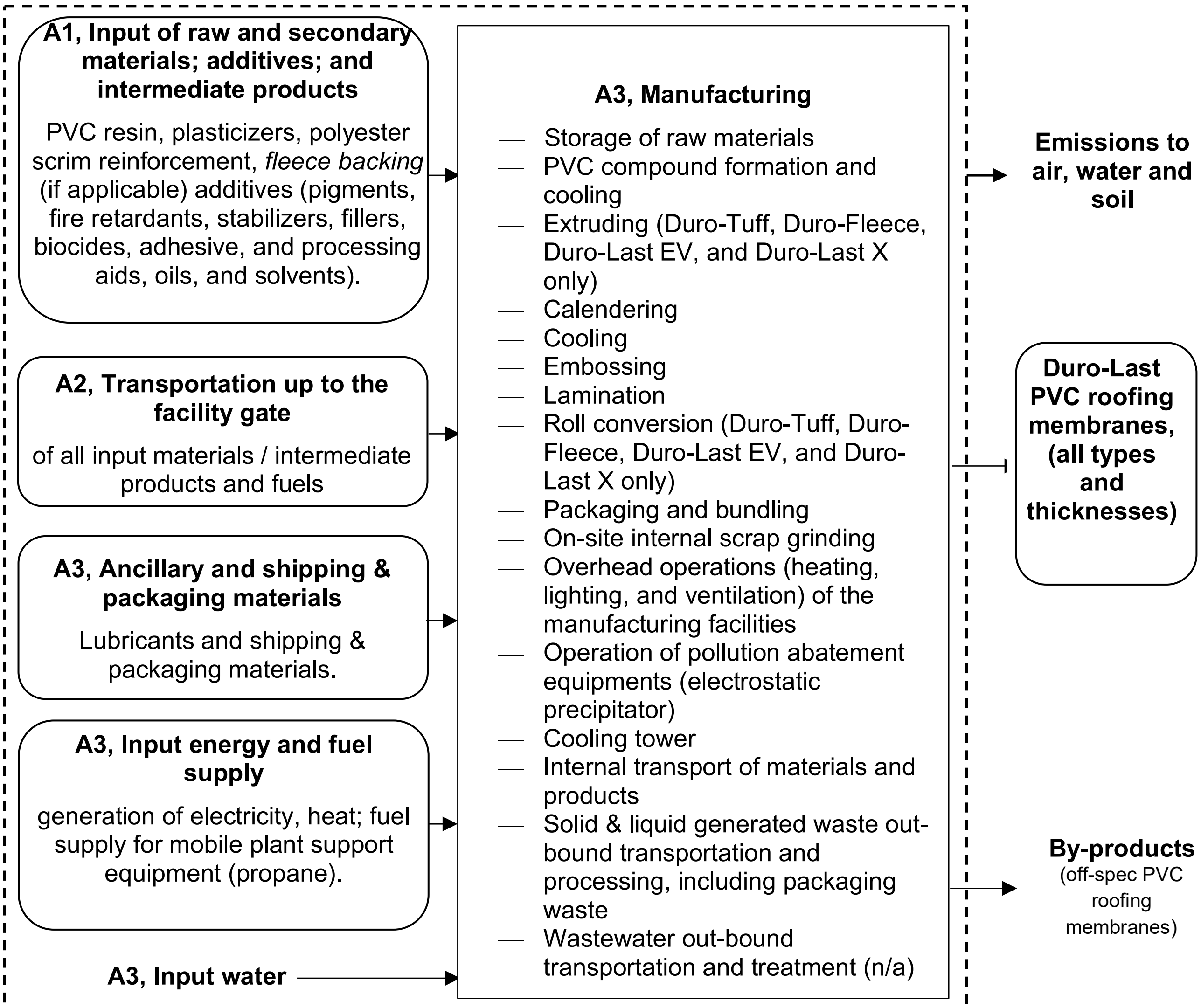
Production stage			Construction stage		Use stage							End-of-life stage			
Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy Use	Operational Water Use	De-Construction/ Demolition	Transport to waste processing or disposal	Waste processing	Disposal of waste
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4
X			MND												
X- module is included in system boundary; MND- module is not declared (excluded from system boundary)															

System Boundary

The PVC single-ply membrane is manufactured through an extruding process. Two layers of PVC sheet are laminated together with knit scrim reinforcement between. The polyester scrim is knit onsite at the manufacturing plant. The extruder manufactures master rolls of material which are then cut to length into smaller rolls. Internal off-spec scraps and edge trim cut from rolls during manufacturing are ground and compounded back into other processes; no external scrap is used in the membrane. Any off-spec or surplus scrap is sent to the Duro-Last sister company, Oscoda Plastics®, where it is recycled into resilient flooring and concrete expansion joints.

The purchased electricity used at the facility is primarily used by process equipment like the calender, laminator, extruder, and roll converters. The laminator uses an electrostatic precipitator, a particulate collection device that removes aerosol plasticizers released during manufacturing. There is also a 1,110,000 BTU capacity 2.2.2 induced draft crossflow cooling tower. Natural gas supplied to the plant is used by IR heaters on the extruder and laminators and space conditioning, while propane is used by fork trucks to internally transport products and materials. The calender equipment uses a small amount of water as non-contact cooling water. The water does not come into contact with any chemicals; therefore, there is little to no risk of contamination. VOC emissions from the manufacturing process are calculated based on the amount of product manufactured and stack testing that took place when the equipment was installed. Minimal VOCs are produced during manufacturing which exempts the extruder from requiring any pollution abatement equipment. Figure 2 represents the inputs, outputs, and processes within the system boundary.

Figure 2: Product stage system boundary



Cut-off Rules

The cut-off criteria as per NSF PCR, Section 7.1.6 [6] and ISO 21930, 7.1.8 [3], were followed. All input/output data reported by the Saginaw, MI manufacturing plant were included in the LCI modelling. None of the reported flow data were excluded based on the cut-off criteria. No substances with hazardous and toxic properties that pose a concern for human health and/or the environment were identified in the framework of this EPD. Any plant-specific data gaps for the reference year (e.g., input hydraulic fluids, lubricants, greases, or heated oil) were filled with generic plant data from 2018. Duro-Last confidentially provided Safety Data Sheet (SDSs) for each additive, e.g., plasticizer, fire retardant, stabilizer, fleece backing, etc. As appropriate, any data gaps in the SDS are filled in with proxy and conservative generic LCI datasets.

This EPD excludes the following processes:

- Capital goods and infrastructure flows; and
- Personnel related activity (travel, furniture, office operations and supplies).

Data Quality

The LCA project report provides a detailed description of collected data and the data quality assessment regarding the NSF PCR requirements and ISO 14044. Data quality is assessed based on its representativeness (technology coverage, geographic coverage, time coverage), completeness, consistency, reproducibility, transparency, and uncertainty (Table 1).

Table 1. Data Quality Requirements and Assessments

Data Quality Requirements	Description
Technology Coverage	Data represents the prevailing technology at the Saginaw, MI facility. Whenever available, North American typical or average industry LCI datasets were utilized for all upstream and core material and processes. *Technological representativeness is characterized as "high".*
Geographic Coverage	The geographic region considered is the U.S. *Geographical representativeness is characterized as "high".*
Time Coverage	Activity data are representative. - Roofing membrane manufacturing process - primary data collected for the reference year 2020 (12 months) - In-bound/ out-bound transportation data- primary data collected for reference year 2020 (12 months) - Polyester scrim reinforcement production- U.S. industry data for the reference year 2010 (12 months) - Fleece backing data- SDS and confidential data provided by Duro-Last (2021) - Generic data: the most appropriate LCI datasets were used as found in the US LCI Database, ecoinvent v.3.5 database for the US and Global, 2018. *Temporal representativeness is characterized as "medium" to "high".*
Completeness	All relevant, specific processes, including inputs (raw materials, energy, and ancillary materials) and outputs (emissions and production volume), were considered and modelled. The relevant background materials and processes were taken from the US LCI Database (adjusted for known data placeholders), ecoinvent v 3.5 LCI database for the US, and modelled in SimaPro software v.9.2, 2021. The completeness of the cradle-to-gate process chain in terms of process steps is rigorously assessed for all membranes and documented in the project report.

Data Quality Requirements	Description
Consistency	To ensure consistency, the input/output LCI modelling of the PVC single-ply roofing membranes used the same LCI modelling structure, which consisted of input raw, secondary (if applicable), ancillary, and packaging materials, intermediate products, energy flows, water resource inputs, product outputs, co-products, by-products, emissions to air, water and soil, and solid and liquid waste disposal. Crosschecks concerning the plausibility of mass and energy flows were continuously conducted. The LCA team conducted mass and energy balances at the facility level and selected process levels to maintain a high level of consistency.
Reproducibility	Internal reproducibility is possible since the data and the models are stored and available in the *Athena Duro-Last LCI database* developed in SimaPro, 2021. A high level of transparency is provided throughout the report as the LCI profile is presented for each of the declared products and primary upstream inputs. The supporting LCA project report summarizes key primary (manufacturer specific) and secondary (generic) LCI data sources.
Transparency	Activity and LCI datasets are transparently disclosed in the project report, including data sources.
Uncertainty	A *sensitivity check* was conducted to assess the reliability of the EPD results and conclusions by determining how they are affected by uncertainties in the data or assumptions on the calculation of LCIA and energy indicator results. The sensitivity check includes the results of *sensitivity analysis* and *Monte Carlo uncertainty analysis of background data sets.*

Allocation

Per NSF PCR, Section 7.2 [6], allocation, if required, shall follow the requirements and guidance of ISO 14044:2006, Section 4.3.4 and ISO 21930, Section 7.2.5.

The Saginaw, MI manufacturing facility produces other co-products besides selected membranes, and as such and as per the PCR, allocation based on the mass of membrane products was necessary. “Mass” based, plant-specific formulation for 1m^2 of PVC roofing membranes were used to calculate the input raw the ancillary materials consumed. “Mass” was used as the physical parameter for allocating flows between the products of interest and other co-products to calculate the input energy flows (electricity, natural gas, propane, etc.), shipping and packaging materials, lubricants, hydraulic fluid, greases, and heating oil, total water consumption, process emissions to air and waste flows. No burden is allocated to the by-product of the declared product system, such as off-spec PVC roofing membranes. In addition, allocation related to transport is based on the mass of transported inputs and outputs.

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Product Material Content & Packaging

Tables 2 and 3 represent the formulation for the three declared products, consisting of polyester scrim reinforcement between a top and bottom layer of PVC film and the packaging materials. The membrane is rolled onto cardboard cores and stored on wood pallets with Styrofoam roll guards. Each pallet typically holds four rolls and is secured with plastic banding.

Table 2: Formulation for 1 m^2 of 50-mil, 60-mil, and 80-mil Duro-Tuff membrane

Raw Material Input	50-mil	60-mil	80-mil
	% weight of the product		
PVC resin	44%	45%	47%
PVC resin, regrind	9%	9%	9%
Plasticizer	25%	25%	26%
Polyester scrim reinforcement	11%	9%	6%
Pigment	3%	3%	3%
Flame retardant	<1%	<1%	<1%
Others – stabilizer, filler, processing aids, biocide	8%	7%	8%
Total	**100%**	**100%**	**100%**
Note: Total may not add to 100 due to rounding.			

Table 3: Packaging materials for 1m^2 of 50-mil, 60-mil, and 80-mil Duro-Tuff membrane

Packaging Material	Quantity (kg)
Wooden pallet	0.10
Cardboard core	0.04
Total	**0.14**

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Life Cycle Assessment Results

Table 4 presents the "cradle-to-gate" LCA results for 1 m2 of Duro-Tuff® PVC membrane for each nominal thickness.

As per the NSF PCR, the US EPA Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI), version 2.1, 2012 impact categories are used as they provide a North American context for the mandatory category indicators to be included in this EPD. *These are relative expressions only and do not predict category impact endpoints, the exceeding of thresholds, safety margins or risks [4], [5]*. Additional mandatory resource use, waste categories and output flows are also reported per the PCR. *It is also noted that a number of LCA impact categories and inventory items are still emerging and/or under development and can have high levels of uncertainty that preclude international acceptance pending further development. Use caution when interpreting data in these categories: RPRE, RPRM, NRPRE, NRPRM, SM, RSF, NRSF, RE, HWD, NHWD, HLRW, ILLRW, CRU, MR, MER, EE" [6].*

Table 4: LCA results for 1 m^2 of 40-mil, 50-mil, and 60-mil PVC membrane- Product Stage (A1-A3)

Impact category and inventory indicators	Unit	Duro-Tuff® PVC membrane Production stage (A1 to A3)		
		50 mils	**60 mils**	**80 mils**
Global warming potential, GWP 100 1)	kg CO_2 eq	**3.9**	**4.9**	**7.4**
Ozone depletion potential, ODP 1)	kg CFC-11 eq	**5.1E-07**	**6.8E-07**	**1.1E-06**
Smog formation potential, SFP 1)	kg O_3 eq	**0.20**	**0.25**	**0.37**
Acidification potential, AP 1)	kg SO_2 eq	**0.018**	**0.023**	**0.035**
Eutrophication potential, EP 1)	kg N eq	**0.028**	**0.039**	**0.060**
Fossil fuel depletion, FFD 1)	MJ surplus	**7.7**	**9.8**	**14.8**
Abiotic depletion potential, fossil ADPf 2)	MJ LHV	**59.3**	**74.8**	**111.7**
Renewable primary resources used as an energy carrier (fuel), RPR_E	MJ LHV	**4.7**	**6.2**	**9.8**
Renewable primary resources with energy content used as material, RPR_M 3)	MJ LHV	- 5)	-	-
Non-renewable primary resources used as an energy carrier (fuel), $NRPR_E$	MJ LHV	**41.9**	**51.7**	**74.7**
Non-renewable primary resources with energy content used as material, $NRPR_M$ 3)	MJ LHV	**26.1**	**34.0**	**53.2**
Secondary materials, SM 3)	kg	**0**	**0**	**0**
Renewable secondary fuels, RSF 3)	MJ LHV	-	-	-
Non-renewable secondary fuels, NRSF 3)	MJ LHV	-	-	-
Recovered energy, RE 3)	MJ LHV	-	-	-
Consumption of freshwater, FW 3)	m^3	**1.1E-03**	**1.5E-03**	**2.3E-03**
Hazardous waste disposed, HWD 3)	kg	**4.2E-03**	**5.4E-03**	**8.5E-03**
Non-hazardous waste disposed, NHWD 3)	kg	**1.2E-02**	**1.5E-02**	**2.4E-02**

Impact category and inventory indicators	Unit	Duro-Tuff® PVC membrane Production stage (A1 to A3)		
		50 mils	60 mils	80 mils
High-level radioactive waste, conditioned, to the final repository, HLRW3) 4)	m^3	**4.1E-09**	**5.1E-09**	**7.4E-09**
Intermediate- and low-level radioactive waste, conditioned, to the final repository, ILLRW3) 4)	m^3	**6.3E-08**	**7.9E-08**	**1.2E-07**
Components for re-use, CRU3)	kg	-	-	-
Materials for recycling, MR3)	kg	**0.019**	**0.037**	**0.060**
Materials for energy recovery, MER3)	kg	-	-	-
Recovered energy exported from the product system, EE3)	MJ LHV	-	-	-

Notes:
1) Calculated as per U.S EPA TRACI 2.1, v1.05, SimaPro v 9.2 [10]. GWP 100, excludes biogenic CO_2 removals and emissions associated with biobased products, including bio-based packaging. There is no biogenic content in the declared products. CO_2 emissions from calcination and carbonation are not applicable to the declared products; 100-year time horizon GWP factors are provided by the IPCC 2013 Fifth Assessment Report (AR5), TRACI 2.1, v1.05 [10]. FFD is required in LEED V4.1 MR Credit: Building Product Disclosure and Optimization – Environmental Product Declarations [12].
2) Calculated as per CML-IA Baseline V3.05, SimaPro v 9.2. ADP_f is also required in LEED V4.1 MR Credit: Building Product Disclosure and Optimization – Environmental Product Declarations [12].
3) Calculated as per ACLCA ISO 21930 Guidance [11], respective sections 6.2 to 10.8.
4) It should be noted that the foreground system (Duro-Last roofing membrane manufacturing process) does not generate any HLRW or ILLRW. High, intermediate or low-level radioactive waste is generated by electricity production (spent fuel from reactors, routine facility maintenance and operations)" (ISO 21930:2017, clause 7.2.14).
5) "-"N/A for this product system. "*Not all LCA datasets for upstream materials include these impact categories, and thus results may be incomplete. Use caution when interpreting data in these categories"* [6].

Interpretation

The above represents a cradle-to-gate life cycle assessment for 1 m^2 of Duro-Tuff single-ply scrim reinforcement PVC roofing membrane in the nominal thicknesses of 50-mil, 60-mil, and 80-mil. Across all the declared membranes, Module A1 *Extraction and upstream material input production* contributes the largest share of the LCIA category and energy indicator results – accounting for between 69% (smog) and 94% (eutrophication) of the potential environmental burdens. Module A2 *Transportation* contributed around 22% of the smog-related emissions, but was otherwise, a minor contributor (<10%) to the overall impact of membrane manufacture. Module A3 *Manufacturing* contributed around 25% to non-renewable primary energy and is the second-largest contributor (<16%) to the overall potential environmental impacts of the membrane manufacture. Primary energy consumption is predominately fossil fuels at 94%. The industry standard scrim reinforcement is 9 x 9 threads per square inch, whereas Duro-Last reinforces its membrane with a high-strength weft-inserted polyester scrim with an 18 x 9 pattern. The high-density yarn helps improve the membrane's durability, strength, and longevity but may also increase the carbon footprint.

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Additional Environmental Information

- The Duro-Tuff membrane is NSF 347 Sustainability Assessment for Single-Ply Roofing Silver certified.
- The white Duro-Tuff membrane complies with efficiency programs requiring the use of a highly reflective roof like California Title 24, U.S. Green Building Council's (USBGC) Leadership in Energy and Environmental Design (LEED) rating system, the International Green Construction Code (IgCC), IECC, and Green Building Institute's Green Globes. It is also an ENERGY STAR® qualified product.
- Duro-Tuff membrane contains a maximum amount of around 10% secondary material.
- The membrane is up to 100% recyclable. Post-industrial scrap from the manufacturing process is recycled into the new membrane, walk-way pads, concrete expansion joints and resilient flooring.
- Duro-Tuff white reflective roofs, when designed and installed properly, can help increase energy efficiency, especially the building's peak energy demand.
- Cool Roof Rating Council Product ID: 0610-0008.
    - Solar Reflective Index (initial value): 108.

Declaration Type

This "Cradle-to-gate" EPD applies to the Duro-Tuff PVC roofing membrane (all colours) 50, 60, and 80 mils nominal thicknesses. Production activities covered include the *extraction and upstream production, transport to factory, manufacturing* (modules A1 to A3). The declaration is intended for Business-to-Business (B-to-B) communication.

The three declared thicknesses (50, 60 and 80 mils), Duro-Tuff PVC roofing membrane falls under the description:

- *A product-specific EPD from a manufacturer's plant.*

EPD Comparability Limitation Statement

- *Only EPDs prepared from cradle-to-grave life cycle results and based on the same function, RSL, quantified by the same functional unit, and meeting all the conditions for comparability listed in ISO 14025:2006 and ISO 21930:2017 can be used to make comparison between products.*
- *Declarations based on the NSF Product category rules are not comparative assertions; that is, no claim of environmental superiority may be inferred or implied.*

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References

1. ASTM D4434/ D4434M – 15 Standard Specification for Poly(Vinyl Chloride) Sheet Roofing.

2. ANSI NSF 347 Sustainability Assessment for Single Ply Roofing Membranes.

3. ISO 21930:2017 Sustainability in buildings and civil engineering works - Core rules for environmental product declarations of construction products and services.

4. ISO 14040:2006/Amd 1:2020 Environmental management - Life cycle assessment - Principles and framework.

5. ISO 14044:2006/Amd1:2017/Amd2:2020 Environmental management - Life cycle assessment - Requirements and guidelines.

6. NSF International, Product Category Rule Environmental Product Declarations, PCR for Single Ply Roofing Membrane, October 2019. https://www.spri.org/wpfb-file/pcr-single-ply-roofing-membrane-2019-pdf/, accessed 10-2021.

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8. ISO 14025:2006 Environmental labeling and declarations - Type III environmental declarations - Principles and procedures.

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10. PRé 2019.SimaPro LCA Software v9.2, 2021. https://simapro.com/, accessed 10-2021.

11. ACLCA 2019, Guidance to Calculating Non-LCIA Inventory Metrics in Accordance with ISO 21930:2017. The American Centre for Life Cycle Assessment. May 2019. https://aclca.org/aclca-iso-21930-guidance/, accessed 10-2021.

12. LEED v4.1 July 2019, Building Design and Construction Guide (BD+C), Getting started guide for beta participant, MR Credit: Building Product Disclosure and Optimization – Environmental Product Declarations, Option 2 Multi-attribute optimization (1 point), pg.170. https://leeduser.buildinggreen.com/credit/NC-v4.1/MRc2#tab-credit-language, accessed 10-2021.

13. Athena Sustainable Materials Institute, *A Cradle-to-Gate Life Cycle Assessment of Duro-Last's Single-Ply PVC Roofing Membranes*, December 2021.