ENVIRONMENTAL PRODUCT DECLARATION

AP ARMAFLEX TUBE INSULATION

ARMAFLEX INSULATION FOR INDUSTRIAL AND BUILDING INSTALLATION

armacell®

Environmental protection is one of the main pillars of Armacell's corporate philosophy. It is an integral part of the business strategy and ranks equally with other company objectives.

Armacell practices active environmental protection throughout the company. To efficiently utilize resources, we are constantly searching for ways to reduce raw material use, energy consumption and waste.

The environmental policy obliges all Armacell employees worldwide to aim to protect the environment and conserve natural resources.

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ENVIRONMENTAL PRODUCT DECLARATION

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AP ArmaFlex Tube Insulation

According to ISO 14025, EN 15804, and ISO 21930:2017

EPD PROGRAM AND PROGRAM OPERATOR NAME, ADDRESS, LOGO, AND WEBSITE	UL Environment 333 Pfingsten Road Northbrook, IL 60611 https://www.ul.com/ https://spot.ul.com
GENERAL PROGRAM INSTRUCTIONS AND VERSION NUMBER	General Program Instructions v.2.4 July 2018
MANUFACTURER NAME AND ADDRESS	Armacell LLC 7600 Oakwood Street Extension,Mebane, NC 27302
DECLARATION NUMBER	4789527027.102.1
DECLARED PRODUCT & FUNCTIONAL UNIT OR DECLARED UNIT	AP ArmaFlex Tube Insulation 1m2 for Non-piping applications with service time of 75 years with packaging included.
REFERENCE PCR AND VERSION NUMBER	Product Category Rules for Building-Related Products and Services Part A: Life Cycle Assessment Calculation Rules and Report Requirements, *Standard 10010, Version 3.2* Part B: Mechanical, Specialty, Thermal, and Acoustic Insulation Product EPD Requirements, UL 10010–03,*version 1.0*
DESCRIPTION OF PRODUCT APPLICATION/USE	The original, fiber-free, flexible elastomeric pipe insulation for reliable protection against condensation and energy loss.
PRODUCT RSL DESCRIPTION (IF APPL.)	75 years
MARKETS OF APPLICABILITY	North America
DATE OF ISSUE	October 1, 2020
PERIOD OF VALIDITY	5 Years
EPD TYPE	Product-Specific
RANGE OF DATASET VARIABILITY	N/A
EPD SCOPE	Cradle-to-installation with end of life
YEAR(S) OF REPORTED PRIMARY DATA	January 2019 —December 2019
LCA SOFTWARE & VERSION NUMBER	SimaPro 9
LCI DATABASE(S) & VERSION NUMBER	Ecoinvent 3, Ecoinvent 3- CN, USLCI, ELCD
LCIA METHODOLOGY & VERSION NUMBER	TRACI 2.1(version 1.05)

This PCR review was conducted by:	UL Environment PCR Review Panel epd@ulenvironment.com
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ 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

LIMITATIONS

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; the level of accuracy in estimation of effect differs for any particular product line and reported impact.

Comparability: EPDs from different programs may not be comparable. Full conformance with a PCR allows EPD comparability only when all stages of a life cycle have been considered. However, variations and deviations are possible". Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared.

1. Product Definition and Information

1.1. Description of Company/Organization

Armacell is a world leader in flexible insulation foams for the equipment insulation market and also a leading provider of engineered foams.

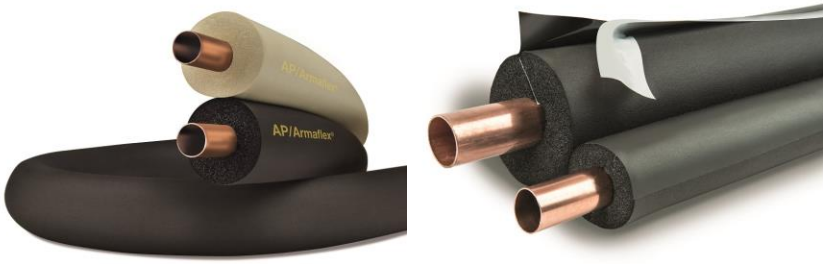
Armacell is a truly global company managed from its corporate headquarters in Luxembourg and regional head offices in Germany, the USA and Singapore.With its 24 manufacturing plants in 16 countries on four continents, Armacell follows a strategy of internationalization. The company operates within two main businesses: the Advanced Insulation business develops flexible insulation foam products for the insulation of mechanical equipment. The Engineered Foams business develops and markets light foams for use in a broad range of end-markets.

The high-tech insulation products of Armacell increase the global energy efficiency and are used in many high-end facilities, including the Empire State Building and the International Space Station. They are an integral part of everyday life: beyond thermal insulation, Armacell products are used as acoustic insulation, as gaskets and seals in a variety of modern car models or as central components of wind turbine blades.

1.2. Product Description

1.2.1 Product Identification

ArmaFlex is a professional, closed-cell flexible elastomeric foam (FEF) insulation material used for continuous energy-saving and condensation control purposes. The combination of very low thermal conductivity and extremely high resistance to water vapor transmission prevents long-term energy losses and water vapor ingress and reduces the risk of corrosion under insulation. ArmaFlex insulation is dust- and fiber-free, CFC- and HCFC-free with an ODP of zero.



AP ArmaFlex Tube is part of the Armaflex series, which is fiber-free .It is black flexible closed-cell elastomeric thermal insulation in tube form. Its detailed features are as follows:

- Fiber-free, formaldehyde-free, low VOC and non-particulating formulation protects indoor air quality
- Closed-cell structure provides excellent condensation control
- Built-in vapor retarder eliminates need for additional vapor retarder
- Microban® antimicrobial product protection inhibits the growth of mold and mildew in the insulation
- 25/50 rated for use in air plenums up to 2" wall

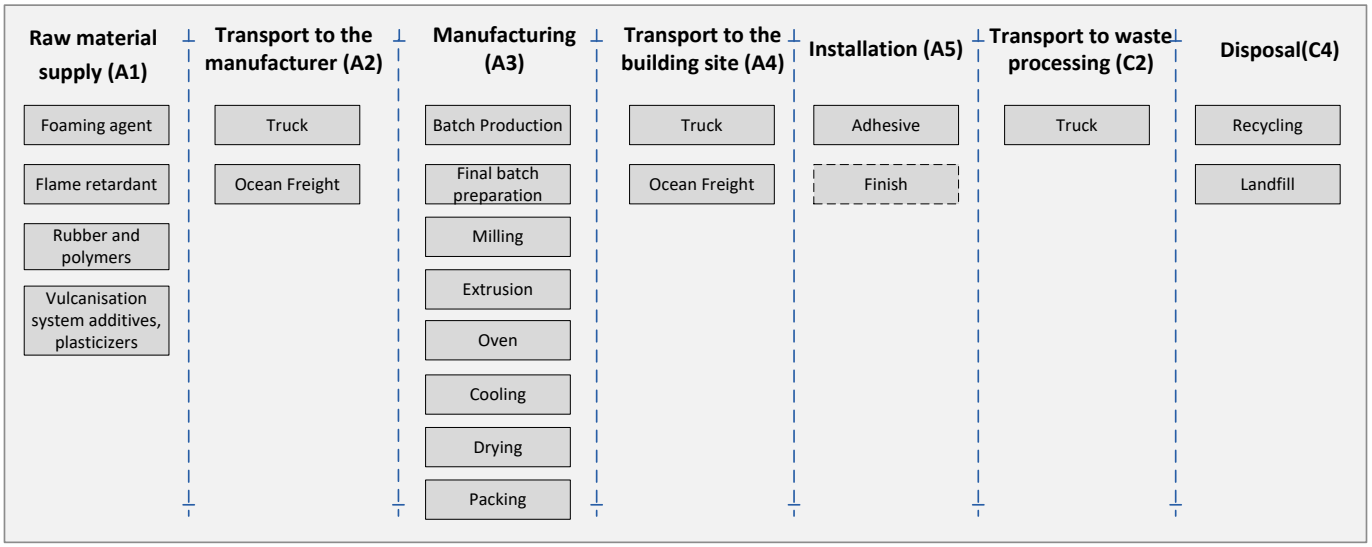
1.2.2 Product Specification

Table 1. Technical datas of AP ArmaFlex Tube insulation products

TECHNICAL DATA: AP ARMAFLEX TUBE INSULATION						
Description:						
Black or white flexible closed-cell elastomeric thermal insulation in a tubular form						
Specifications Compliance(ASTM/ANSI):						
ASTM C 534, Type I — Grade 1 ASTM D 1056, 2C1 ASTM E 84, UL723	ASTM G21/C1338					
Typical Properties						
Specifications:	Values				Test Method:	
	Through 1" Wall		1-1/2" & 2" Walls			
Thermal Conductivity: Btu • in./h • ft2 • °F (W/mK)						
75°F Mean Temperature (24°C) 90°F Mean Temperature (32°C)	0.245 (0.0353) 0.254 (0.0366)		0.28 (0.036) 0.286 (0.037)		ASTM C 177 or C 518	
Water Vapor Permeability: Perm-in. [Kg/(s • m • Pa)]	0.05 (0.725 x 10^{-13})		0.08 (1.16 x 10^{-13})		ASTM E 96, Procedure A	
Flame Spread and Smoke Developed Index:	25/50 rated		25/50 rated		ASTM E 84	
Water Absorption, % by Volume:	0.2%		0.2%		ASTM C 209	
Mold Growth: Fungi Resistance:	Passed		Passed		ASTM G21/C1338	
Upper Use Limit:	220°F (105°C)		300°F (149°C)		ASTM C534	
Lower Use Limit:	-297°F (-183°C)		-297°F (-183°C)		ASTM C534	
Ozone Resistance:	GOOD		GOOD		Ozone Chamber Test	
R-value:	R-1.6	R-2.1	R-3.1	R-4.2	R-6	R-8
	3/8"	1/2"	3/4"	1"	1-1/2"	2"
Sizes:						
Wall Thickness (nominal)	3/8", 1/2", 3/4", 1", 1-1/2", 2" (10, 13, 19, 25, 38, 50 mm)					
Inside Diameter, Tubular	3/8" ID to 10"ID (10 mm ID to 250 mm ID)					
Length of Sections, Feet, Tubular	6' (1.8 m) (Some larger sizes may be shipped in two 3' sections)					
Outdoor Use	Painting with WB Finish or other protective jacketing is required to prevent damage to the insulation in exterior applications and to comply with the insulation protection sections of the International Energy Conservation Code (IECC) and ASHRAE 90.1.					

1.2.3 Flow Diagram

Figure 1. Technical datas of AP ArmaFlex Tube Insulation product flow diagram



1.2.4 Product-Specific EPD

This declaration covers one type of Armacell Insulation product: AP ArmaFlex Tube Insulation. The allocation of energy and material usage within the production site, was carried out based on the average annual mass ratio.

1.3. Application

AP ArmaFlex Tube Insulation materials are used for piping associated with HVAC, VRV and VRF systems, chillers, hot and cold water, and refrigeration.The functions of AP ArmaFlex insulation materials are as follows:

- Energy conservation, noise- and condensation-control in refrigeration and air conditioning equipment and process plants.

- Energy conservation according to local energy-saving laws, reduction of heat loss and noise in heating and plumbing systems.

- Condensation control and noise reduction in service-water and waste-water systems.

- Condensation control, energy-conservation and noise control in refrigeration and air conditioning equipment in the ship-building sector.

1.4. Declaration of Methodological Framework

In this project, a full LCA approach was considered with some simplification on data modeling using generic data for most background systems. The EPD analysis uses cradle-to-installation with end of life system boundary. No known flows are deliberately excluded from this EPD.

To calculate the LCA results for the product maintenance stage, a 75-year reference service life (RSL) was assumed for the declared products.

Additional details on assumptions, cut-offs and allocation procedures can be found in section 2.11, 2.6, and 2.5 respectively.

1.5. Technical Requirements

The chart below lists all standards required for AP ArmaFlex Tube Insulation products.

Table 2. Standards required for AP ArmaFlex Tube Insulation products

STANDARDS	RESULTS
ASTM C 534	Type I — Grade 1
ASTM D 1056	2C1
ASTM E84/UL723/NFPA255	25/50 rated
ASTM G21/C1338	Passes
CAN/ULC S102①	Meets requrements
MEA 107-89M	Passes
MIL-P-15280J①/ FORM T①	Meets requrements
NFPA	90A ,90B
UL 181	Passes
UL 94	5V-A, V-0, File E55798

① AP Armaflex meets CAN/ULC S102 /MIL-P-15280J/ FORM S /Grade SBE 3 through 1" wall

1.6. Properties of Declared Product as Delivered

According to Armacell, AP ArmaFlex Tube Insulation products are consumed in the USA, Canada, Mexico, Costa Rica, Guatemala, Honduras, Panama, San Salvador,Trinidad Tobago, and Venezula.

Table 3. The delivered quantities and market ratio of AP ArmaFlex Tube Insulation

MARKET LOCATION	QUANTITIES/KG	QUANTITIES/LB	RATION
US	2745887	6101971.11	90.5%
Canada	179013.6	397808	5.9%
Mexico	75853.22	168562.71	2.5%
The rest markets	30341.29	67425.09	1.0%

***Note: The rest markets include Costa Rica, Guatemala, Honduras, Panama, etc.**

1.7. Material Composition

This EPD report declares one type of ArmaFlex, namely AP ArmaFlex Tube Insulation. This insulation product consists mainly of the raw material synthetic rubber and other 19 basic components. The following table displays the composition split into five functional groups.

Table 4. Composition/formulation of AP ArmaFlex Tube Insulation

COPOSITION	QUANTITIES/KG	QUANTITIES/LB	RATION
Blowing agent	0.036	0.08	11.61%
Fillers and pigments	0.067	0.149	21.73%
Flame retardant	0.12	0.267	38.32%
Rubber and polymers	0.075	0.167	24.16%
Vulcanisation system additives, plasticizers	0.013	0.08	4.18%

2. Methodological Framework

2.1. Declared Unit

The declared unit for AP ArmaFlex Tube Insulation is defined as 1m for piping applications with service time of 75 years with packaging included. Additional declared unit parameters are shown on Table 5 and Table 6.

Table 5. Additional declared unit parameters of AP ArmaFlex Tube Insulation

NAME	VALUE	UNIT	VALUE	UNIT
Mass	0.390	kg	0.867	lb
Density	61.67	kg/m^3	3.85	lb/ft^3
Thickness (and outside diameter for piping applications)	Thickness: 2.54 Diameter: 5.4	cm	Thickness: 1 Diameter:2.13	in

Table 6. Scaling factor to one meter of AP ArmaFlex Tube Insulation products

COPPER PIPE SIZE (IN)	STEEL PIPE, DN	ID INSULATION (MM)	WALL THICKNESS (MM)	WALL THICKNESS (MM)	WALL THICKNESS (MM)	WALL THICKNESS (MM)	WALL THICKNESS (MM)	WALL THICKNESS (MM)	WALL THICKNESS (MM)	WALL THICKNESS (MM)
			6	9	13	19	25	32	40	50
1/8		3	0.0105	0.0209	0.0403	0.0810	0.1356	0.2170	0.3332	0.5134
1/4		6	0.0139	0.0262	0.0479	0.0920	0.1502	0.2356	0.3565	0.5425
3/8	10.2	10	0.0186	0.0331	0.0579	0.1068	0.1695	0.2604	0.3875	0.5812
1/2		12	0.0209	0.0366	0.0630	0.1141	0.1792	0.2728	0.4030	0.6006

5/8	13.7	15	0.0244	0.0418	0.0705	0.1252	0.1937	0.2914	0.4262	0.6297
3/4		20	0.0302	0.0506	0.0831	0.1436	0.2180	0.3224	0.4650	0.6781
7/8	21.3	22	0.0325	0.0541	0.0882	0.1509	0.2276	0.3348	0.4805	0.6975
1		25	0.0360	0.0593	0.0957	0.1620	0.2422	0.3534	0.5037	0.7265
1 1/8	26.7	28	0.0395	0.0645	0.1033	0.1730	0.2567	0.3720	0.5270	0.7556
1 1/4		32	0.0442	0.0715	0.1133	0.1877	0.2761	0.3968	0.5580	0.7943
1 3/8	33.4	35	0.0477	0.0767	0.1209	0.1988	0.2906	0.4154	0.5812	0.8234
1 1/2		38	0.0511	0.0820	0.1285	0.2098	0.3051	0.4340	0.6045	0.8525
1 5/8	42.2	42	0.0558	0.0889	0.1385	0.2245	0.3245	0.4588	0.6355	0.8912
1 7/8	48.3	48	0.0628	0.0994	0.1536	0.2466	0.3536	0.4960	0.6820	0.9493
2 1/8		54	0.0697	0.1099	0.1687	0.2687	0.3826	0.5332	0.7285	1.0075
2 3/8	60.3	60	0.0767	0.1203	0.1839	0.2908	0.4117	0.5704	0.7750	1.0656
2 5/8		67	0.0849	0.1325	0.2015	0.3166	0.4456	0.6138	0.8292	1.1334
3	76.1	76	0.0953	0.1482	0.2242	0.3497	0.4892	0.6696	0.8990	1.2206
3 1/8		80	0.1000	0.1552	0.2342	0.3644	0.5086	0.6944	0.9300	1.2593
3 1/2	88.9	89	0.1104	0.1709	0.2569	0.3976	0.5522	0.7502	0.9997	1.3465
	101.6	102	0.1255	0.1935	0.2896	0.4454	0.6151	0.8308	1.1005	1.4724
4 1/4		108	0.1325	0.2040	0.3048	0.4675	0.6442	0.8680	1.1470	1.5306
	114.3	114	0.1395	0.2145	0.3199	0.4896	0.6733	0.9052	1.1935	1.5887
	141.3	140	0.1697	0.2598	0.3854	0.5853	0.7992	1.0664	1.3949	1.8405
	168.3	168	0.2023	0.3086	0.4559	0.6884	0.9348	1.2399	1.6119	2.1118

2.2. System Boundary

This study of AP ArmaFlex Tube Insulation includes life cycle information from cradle-to-installation (A1 to A5) with end of life optional stage (C1-C4). The production stage includes production of raw materials, transportation to the factory, manufacturing processes. The construction process stage includes transportation of the insulation product to the building site from the factory and the installation phase. And the end-of-life stage includes transportation of waste products to final disposal site and disposal. Over the life cycle stages of the product, consumption of energy and materials, as well as emissions to soil, water and air were accounted for in the calculations of the environmental impacts. Building's operational energy and water use were excluded from this study's scope: any impact it may have on a building's energy consumption by the use of insulation was not calculated or incorporated into the analysis.

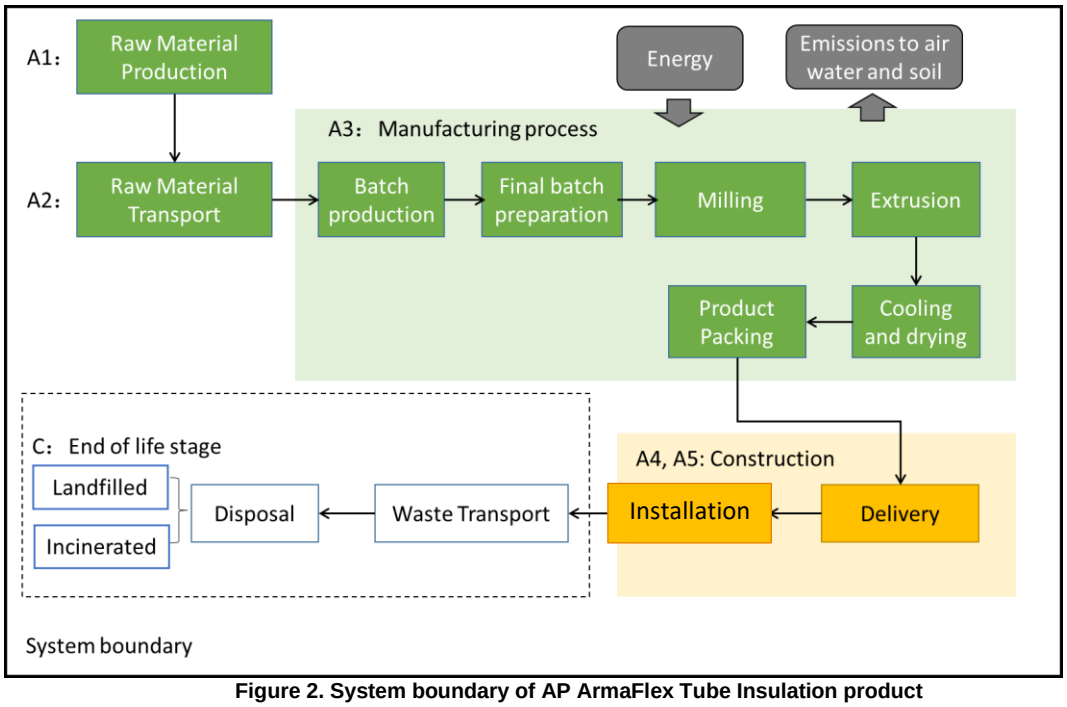


Figure 2. System boundary of AP ArmaFlex Tube Insulation product

2.3. Product Specific Calculations for Use Phase

The product used for following example is AP ArmaFlex Tube. Table 7 shows five sets of working temperature and the corresponding insulation thickness as recommended by ASHRAE 90.1 to calculate the recovery time. The assumptions for this calculation are ambient temperature of 32°C, indoors and insulation without facing. For simplification the thermal conductivity was set to be 0.035W/(m.K) for calculation.

Table 7. Time needed to recover Primary Energy Demand (PED) of AP ArmaFlex for tube application

Fluid Operating Temp. (oC)	Steel Pipe, DN	ASHRAE Recommended Thickness (mm)	Selected Thickness (mm)	PED for one m, (MJ)	Heat loss Bare Pipe (W/m)	Heat loss insulated Pipe (W/m)	Energy saved by one m (W/m)	Converted to PED saved (W/m)	Hours in-situ needed to recover the PED	Days in-situ needed to recover the PED

-10	50	25	25	54.35	82.78	13.23	69.55	79.98	188.8	7.9
7	50	25	25	54.35	46.76	8.06	38.7	44.51	339.2	14.1
60	50	38	40	102.31	59.42	7.78	51.64	59.39	478.6	19.9
80	50	51	55	161.78	114.30	11.17	103.13	118.60	378.9	15.8
100	50	76	80	286.47	177.00	14.09	162.91	187.35	424.8	17.7

2.4. Reference Service life and Estimated Building Service Life

The reference service life of AP ArmaFlex Tube Insulation product is 75 years.

2.5. Allocation

Allocation refers to partitioning of input or output flows of a process or a product system between the product systems under study and one or more other product systems.

Multi-input processes

For data sets in this study, the allocation of the inputs among the processes is generally carried out via the mass. The consumption of raw materials is allocated by mass ratio. The transportation of raw materials is allocated by mass. For masterbatch production, the total consumption of energy and water during manufacturing is equally allocated to per unit mass of masterbatch. The energy consumption among various production stages was calculated using the formula “energy consumption=power consumption rate x operation time of each production stage” for each product type, as no other recorded data of allocation of energy consumption for each type of product is available.

Multi-output processes

In this study, there is no other by products produced from the production line, hence, there is quite little occasion that required allocation for multi-output processes. One allocation occurs on the environmental emissions allocation, especially in the area of waste treatment. The environmental emissions of masterbatch and forming product are both allocated by mass to each unit product. In the end of life stage, the allocation within the disposal scenario follows mass allocation, which applies to waste treatment process inventory adopted from Ecoinvent data.

2.6. Cut-off Rules

The following procedure was followed for the exclusion of inputs and outputs:

• All inputs and outputs to a (unit) process will be included in the calculation for which data is available. Data gaps may be filled by conservative assumptions with average or generic data. Any assumptions for such choices will be documented;

• In case of insufficient input data or data gaps for a unit process, according to the PCR requirement, the cut-off criteria chosen is 1% of renewable and non-renewable primary energy usage and 1% of the total mass of that unit process. The total neglected input flows of the cradle-to-installation with end of life, e.g. per module A1-A3, A4-A5, C2, C4shall be a maximum of 5% of energy usage and mass, in this study, the neglected flow is demonstrated in Table 8.

Table 8. Cut off flows of AP ArmaFlex Tube Insulation

FLOW NAME	PROCESS STAGE	MASS%	TOTAL MASS%
Zinc_pyrithione	production	0%-0.1%	0%-0.1%
Styrenated phenol	production	0%-0.3%	0%-0.4%
Poly(dicyclopentadiene-co-p-cresol)	production	0%-0.3%	0%-0.7%
Nickel dibutyldithiocarbamate	production	0%-0.2%	0%-0.9%
Zinc benzenesulfinate dihydrate	production	0.3%-0.6%	0.3%-1.5%

2.7. Data Sources

The study used generic data from various sources, including scientific literature, public sources, and databases such as Ecoinvent, ELCD, Chinese LCI, USLCI, and others.

In the study, the key parameters for producer-specific foreground data were based on one year (January 2019 — December 2019) of averaged data from Armacell. The life-cycle inventory includes data collected from a variety of publicly available sources, taking into consideration the degree to which it was technologically, temporally and geographically representative. The study utilized the North America-regionalized LCI database to the greatest extent possible. In the event data was missing from or not available in the LCI database, the study referred to Ecoinvent and regional databases such as USLCI, ELCD and other relevant databases. The study then conducted sensitivity analyses to validate the data and outputs using realistic parameters.

2.8. Data Quality

The data quality requirements for this study were as follows:

• Existing LCI data were, at most, 10 years old. Newly collected LCI data were current or up to 3 years old.

• The LCI data related to the geographical locations in which the processes occurred, e.g. electricity and transportation data from USA.

• The technology represented the average technologies at the time of data collection.

In the study the key parameters for producer-specific foreground data are based on yearly production amounts and extrapolations of measurements on specific machines and plants. The production data refer to an average of the year 2019, and the input data of raw material transportation refer to an average of production scenario. Most of the necessary life cycle inventories for the basic materials are available in the Simapro database. The last update of the database was 2018. Further LCIs for materials of the supply chain of the basic materials are approximated with LCIs of similar materials or estimated by the combination of available LCIs.

2.9. Period under Review

The study used primary data collected from January 2019—December 2019.

2.10. Comparability and Benchmarking

No comparisons or benchmarking are included in this EPD. LCA results across EPDs can be calculated with different background databases, modeling assumptions, geographic scope and time periods, all of which are valid and acceptable according to the Product Category Rules (PCR) and ISO standards. The user of the EPD should take care when comparing EPDs from different companies. Assumptions, data sources, and assessment tools may all impact the uncertainty of the final results and make comparisons misleading.

2.11. Estimates and Assumptions

The main assumptions of this LCA study are as follows：

• The transportation distance of packaging and auxiliary materials, like lubricating oil and engine oil is assumed to be 30 km as more accurate data is unavailable, a sensitivity analysis was conducted.

• Material flow of trace scrap which is evaporated during product was included in the system boundary.

• Transport assumptions were made where it was not possible to obtain the specific data, e.g. distance of land transportation in USA, and oceanic transportation for other market. When this occurred, it was clearly stated in the report and a sensitivity analysis was conducted.

• Consumption of adhesive used for product installation is based on assumption of types and quantity, and a sensitivity analysis was conducted.

• Deconstruction of product during the disposal stage was considered through manual operation, and the removal of product was omitted from modelling.

• Waste to energy was not considered in this modeling and the distance from construction site to incineration site was assumed 100 km.

• Installation will generate 1% scrap and scrap applies the same end-of-life disposal scenario as the dismantled product at end-of-life.

2.12. Units

SI units are used for all LCA results of AP ArmaFlex Tube Insulation products .

3. Technical Information and Scenarios

3.1. Manufacturing

AP ArmaFlex Tube Insulation products, which are manufactured at the Mebane, North Carolina plant in the USA, are manufactured in a pressure-less, continuous and discontinuous production process. In the first step, a homogenous compound is produced with rubber, additives, ancillary materials, blowing and vulcanization agents. This is done on the rolling mill or in the internal mixer flowed by the rolling mill. Rubber extruders are used to process the compounds to produce raw profiles with defined dimensions. Here exact compliance with the dimensions for the raw profile is crucial for the dimensional accuracy of the foamed product.

In the case of discontinuous, pressure-less production process, the raw profiles are cut to length and then foamed in a hot-air oven. In the case of the continuous, pressure-less process, the extruded profile is fed directly onto a vulcanization line whose energy source may be hot air, for example. In foam production, vulcanization and blowing

process run alongside each other. Both reactions are regulated by temperature control. Recipe and temperature control determine the properties of the foam.

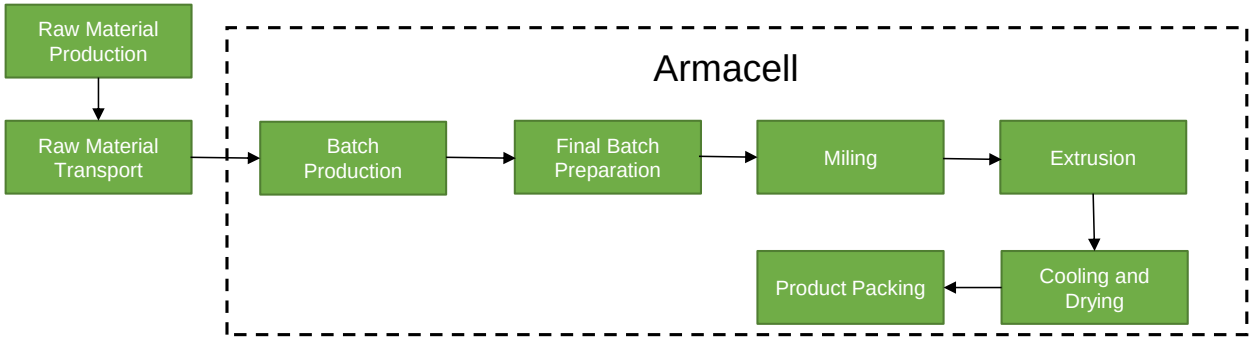


Figure 3. Manufacturing process for AP ArmaFlex Tube Insulation

3.2. Packaging

Recyclable LDPE shrink wrap,recycled cardboard,recycled pallets and recycled foam are the main packaging materials for AP ArmaFlex Tube Insulation. According to Armacell, the target market of products including the USA, Canada, Mexico and other regions. The disposal of packaging materials will adopt a rough country and region weighted average disposal mode following literature review. For packaging disposal in Mexico and the rest market, the waste disposal scenario from the US is adopted as default, as the waste disposal scenarios of Mexico and the rest market is unavailable. And a sensitivity analysis on packaging disposal scenarios was conducted.

3.3. Transportation

According to Armacell, most of insulation products are consumed in North America. Road and oceanic transportation distance for product delivery is estimated with reference from external resources.

Table 9. Transport to the building site (A4)

NAME	VALUE		UNIT
	ROAD	OCEAN	
Fuel type	Diesel	Heavy Oil	
Liters of fuel	31.11 l/100km	12.483 t/100km	l/100km
Vehicle type	Truck (32t)	Transoceanic Ship (50000 dwt)	
Transport distance	2134.7	30	km
Capacity utilization (including empty runs, mass based	50	100	%
Gross density of products transported	61.67	61.67	kg/m^3
Capacity utilization volume factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaging products)	0.4	0.4	-

3.4. Product Installation

Installation of AP ArmaFlex Tube Insulation products is a task requiring only a few tools, including one consumable product-adhesive specific for foam insulation. The adhesive is used to bind insulation together. Tools like cutting instruments (knife, box-cutter), measuring devices, painting brushes and angle tools are necessary for installation of insulation. As tools are reusable, the consumption of tools is omitted in this study. The amount of adhesive used is 10gram per kilogram product, estimated by Armacell. A sensitivity analysis is conducted to simulate the impact of different assumptions on the result.

Table 10. Installation into the building (A5)

NAME	VALUE	UNIT
Ancillary materials	0.01	kg
Net freshwater consumption specified by water source and fate (amount evaporated, amount disposed to sewer)	-	m^3
Other resources	-	kg
Electricity consumption	-	kWh
Other energy carriers	-	MJ
Product loss per functional uni4t	0.01	R
RR	0.01	kg/kg
Output materials resulting from on-site waste processing (specified by route; e.g. for recycling, energy recovery and/or disposal)	-	kg
Mass of packaging waste specified by type	Pulp: 0.262 Plastics: 0.150	kg/kg
Biogenic carbon contained in packaging	0.338	kg CO_2
Direct emissions to ambient air, soil and water	-	kg
VOC content	N/A	µg/m^3

3.5. Disposal

According to Armacell, the products are consumed mainly in the USA, Canada, Mexico and other regions. The disposal of the used products will adopt a country and region average disposal mode following literature review. End of life disposal treatment process (C4) from ecoinvent and USLCI will be used in this LCA study. For the waste scenario, 100km of road transportation (C2) from construction site to MSW treatment site was assumed. Deconstruction of product during the disposal stage was considered through manual operation, hence input and output is omitted in deconstruction (C1) , and waste processing (C3) stage of the tile life cycle.

Table 11. End of life (C1-C4)

NAME		VALUE	UNIT
Assumptions for scenario development (description of deconstruction, collection, recovery, disposal method and transportation)		See description and table above	

Collection process (specified by type)	**Collected separately**	-	kg
	Collected with mixed construction waste	0.390	kg
Recovery (specified by type)	**Reuse**	-	kg
	Recycling	1.07E-03	kg
	Landfill	2.57E-01	kg
	Incineration	0	kg
	Incineration with energy recovery	-	kg
	Energy conversion efficiency rate	-	
Disposal (specified by type)	**Product or material for final deposition**	0	kg
Removals of biogenic carbon (excluding packaging)		7.96E-05	kg CO_2

4. Environmental Indicators Derived from LCA

Table 12. Description of the system boundary modules

	PRODUCT STAGE			CONSTRUCT-ION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
	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
EPD Type cradle-to-installation with EOF	X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	X	MND	X	MND

***Note: "X"means the module included in the LCA model,and "MND" means the module not declared in the LCA model.**

4.1. Life Cycle Impact Assessment Results

LCIA provides indicators and basis for analyzing the potential contributions of the resource extractions, usage of material and wastes disposal/emissions in an inventory to a number of potential impacts. According to ISO 14040, Life Cycle Impact Assessment (LCIA) is essentially meant to improve the understanding of the results of the inventory phase. This LCA follows the UL PCR guideline and use the recommended impact method for the analysis. As the AP ArmaFlex Tube Installation products are consumed in North America, the TRACI method was used in this report.

Table 13. North American Impact Assessment Results for AP ArmaFlex Tube Insulation

TRACI v2.1	Unit	Production	Transport of Product	Installation	Transport of Waste	Disposal
		A1-A3	A4	A5	C2	C4
Ozone depletion	kg CFC-11 eq	1.75E-07	1.85E-11	5.03E-10	8.04E-09	1.10E-09
Global warming	kg CO2 eq	2.02E+00	8.70E-05	9.53E-03	3.31E-02	1.30E-01
Smog	kg O3 eq	3.05E+00	2.78E-05	2.78E-04	5.30E-03	6.93E-04
Acidification	kg SO2 eq	9.06E-02	1.86E-06	1.69E-05	1.92E-04	4.67E-05
Eutrophication	kg N eq	1.45E-02	1.63E-07	3.19E-05	2.69E-05	1.74E-03
Carcinogenics	CTUh	1.28E-07	2.41E-12	2.26E-10	3.21E-10	5.88E-09
Non carcinogenics	CTUh	8.93E-07	7.15E-12	2.27E-09	2.62E-09	3.87E-07
Respiratory effects	kg PM2.5 eq	1.80E-03	1.34E-07	2.77E-06	2.37E-05	7.30E-06
Ecotoxicity	CTUe	1.19E+01	1.83E-04	1.02E-01	3.40E-02	2.88E+01
Fossil fuel depletion	MJ surplus	3.16E+00	1.65E-04	2.29E-02	7.13E-02	1.10E-02

4.2. Life Cycle Inventory Results

Table 14. Resource Use

Parameter	Unit	AP ArmaFlex Tube Insulation
$NRPR_M$	[MJ]	0.00E+00
$NRPR_E$	[MJ]	2.43E+01
RPR_M	[MJ]	0.00E+00
RPR_E	[MJ]	5.13E+00
SM	[kg]	0.00E+00
RSF	[MJ]	0.00E+00
NRSF	[MJ]	0.00E+00
FW	[m^3]	1.22E+00

Table 15. Output Flows and Waste Categories

Parameter	Unit	AP ArmaFlex Tube Insulation
HWD	[kg]	2.67E-05
NHWD	[kg]	4.65E-05
RWD	[kg]	1.39E-12
HLRW	[kg]	0.00E+00
ILLRW	[kg]	0.00E+00
CRU	[kg]	0.00E+00
MR	[kg]	0.00E+00
MER	[kg]	0.00E+00
EE	[MJ]	0.00E+00

Table 15. Carbon Emissions and Removals

PARAMETER	UNIT	AP ARMAFLEX TUBE INSULATION
BCRP	[kg CO_2]	7.96E-05
BCEP	[kg CO_2]	7.92E-05
BCRK	[kg CO_2]	2.76E-02
BCEK	[kg CO_2]	9.11E-03
BCEW	[kg CO_2]	N/A
CCE	[kg CO_2]	N/A
CCR	[kg CO_2]	N/A
CWNR	[kg CO_2]	N/A

5. LCA Interpretation

The stage contribution analysis of AP ArmaFlex Tube Insulation products on various impact categories reveals that production and the treatment of waste products are the main contributions to environment impact categories.

The process contribution analysis reveals that raw material supply and landfill process for waste treatment contributes to most of the environmental impacts.

Sensitivity analysis shows that the changes in assumptions such as substituted raw materials and transportation distance and installation inputs can lead to certain fluctuation of the final LCA results, hence it is recommended to continuously update the model to get up-to-date results, in case the assumption or process parameters will be changed in the future, or better data would be provided.

The LCA study has been carried out based on available data, information, regional and global knowledge and experience to achieve best possible accuracy, completeness and representative of the results.

6. Additional Environmental Information

6.1. Environment and Health During Manufacturing

Production at Armacell adheres to the according national guidelines and regulations during all manufacturing steps, and in all facilities.

6.2. Environment and Health During Installation

When handling and installing insulation material, one should practice reasonable care as a normal safety precaution. When applying adhesives, the information given in the relevant safety data sheets is to be heeded.

- Toxicological information: After contact with skin or eyes, no special measures are required. No hazards in terms of normal handling and skin contact.

- Ecological information: Environmentally harmless

- Insoluble in water: no contamination

6.3. Extraordinary Effects

Fire

ASTM E 84:25/50 rated through 1" wall;1-1/2"&2" walls.

AP Armaflex meets CAN/ULC S102 through 1" wall.

Water

Water Absorption, % by Volume:0.2%

Mechanical Destruction

Painting with WB Finish or other protective jacketing is required to prevent damage to the insulation in exterior applications and to comply with the insulation protection sections of the International Energy Conservation Code (IECC) and ASHRAE 90.1.

6.4. Environmental Activities and Certifications

The certifications of AP ArmaFlex Tube Insulation products are as follow：

• 3rd party certified by Factory Mutual through 1" wall thickness

• GREENGUARD® Children & Schools Indoor Air Quality certified.

• Manufactured without CFCs, HFCs, HCFCs, PBDEs, or Formaldehyde.

• Made with EPA registered Microban® antimicrobial product protection. • All Armacell facilities in North America are ISO 9001 certified.

6.5. Further Information

The additional information of AP ArmaFlex Tube Insulation can be found on the website: http://www.armacell.us

7. Project Report and Supporting Documentation

Since the amount of input and output has a linear relationship with the total output of production, i.e. the more the product manufactured, the more raw material, energy, water and natural gas will be consumed. To simplify, in this analysis, the annual total input and output flow are distributed among the different product specifications using a production weight-ratio based distribution model, due to lack of monitoring record results for different brands of product, the distribution of flow among the various specifications is based on calculations.

As the insulation products are produced in USA, all the energy used for the manufacturing of insulation products, local energy data are used to the best extent to reflect the accuracy and representativeness of results.

According to Armacell, the production process of the insulation product of various Armacell's insulation material series are quite similar, and will not be subjected to significant influence by variation of production location.

8. References

I1) ISO14025:2006 - Environmental labels and declarations - Type III environmental declarations - Principles and procedures

2) ISO 14040:2006 - Environmental management - Life cycle assessment - Principles and framework

3) ISO 14044:2006- Environmental management - Life cycle assessment – Requirements and guidelines

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

5) EN 15804:2012+A1:2013 - Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products

6) SimaPro - LCA Computer Software - http://www.pre-sustainability.com/

7) LCA Report for Insulation Materials, NH/Armaflex, AP/Armaflex sheet and Roll, AP/Armaflex tube, and AP/Coilflex, by Fangyan Xu & Bill Kung, Ecovane Environmental Co., Ltd, July 8, 2020

8) UL General Program Operator Rules v.2.4 2018

9) UL Environment PCR Part A: Life Cycle Assessement Calculation Rules and Report Requirements, December 2018

10) UL Environment PCR Part B: Mechanical, Specialty, Thermal, and Acoustic Insulation Products v.1.0 September 2019