Declaration Owner

Aeroflex USA
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Sweetwater, TN 37874 United States
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Products

Aeroflex tube insulation products

1. Aerocel® Stay-Seal® with Protape® (SSPT™)
2. Aerocel® REF™
3. Aerocel® Tube Black (Aerocel® AC)
4. Aerocel® Tube White (Aerocel® WG)
5. Aerocel® ULP® (Ultra Low Perm)

Functional Unit

1 m of product installed for use over 75 years

EPD Number and Period of Validity

SCS-EPD-07135
EPD Valid June 15, 2021 through June 14, 2026
Version: June 18, 2021

Product Category Rule

PCR Guidance for Building-Related Products and Services Part A: Life Cycle Assessment Calculation Rules and Report Requirements. Version 3.2. Sept. 2018
PCR Guidance for Building-Related Products and Services Part B: Mechanical, Specialty, Thermal, and Acoustic Insulation Product EPD Requirements. Sept. 2019

Program Operator

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Declaration Owner:	Aeroflex USA
Address:	282 Industrial Park Rd, Sweetwater, TN 37874
Declaration Number:	SCS-EPD-07135
Declaration Validity Period:	June 15, 2020 through June 14, 2026
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Declaration URL Link:	https://www.scsglobalservices.com/certified-green-products-guide
LCA Practitioner:	Gerard Mansell, Ph.D., SCS Global Services
LCA Software and LCI database:	OpenLCA v1.10 software and the Ecoinvent v3.6 database
Product RSL:	25 years
Markets of Applicability:	North America;
EPD Type:	Product-Specific
EPD Scope:	Cradle-to-Grave
LCIA Method and Version:	CML-IA and TRACI 2.1
Independent critical review of the LCA and data, according to ISO 14044 and ISO 14071	☐ internal ☒ external
LCA Reviewer:	Thomas Gloria, Ph.D., Industrial Ecology Consultants
Part A Product Category Rule:	PCR Guidance for Building-Related Products and Services Part A: Life Cycle Assessment Calculation Rules and Report Requirements. Version 3.2. UL Environment. Sept. 2018
Part A PCR Review conducted by:	Lindita Bushi, PhD (Chair); Hugues Imbeault-Tétreault, ing., M.Sc.A.; Jack Geibig
Part B Product Category Rule:	PCR Guidance for Building-Related Products and Services Part B: Mechanical, Specialty, Thermal, and Acoustic Insulation Product EPD Requirements. Sept. 2019
Part B PCR Review conducted by:	Hugues Imbeault-Tétreault, (Chair), ,Group AGECO; Thomas Gloria, Industrial Ecology Consultants; Andre Omer Desjarlais, Oak Ridge National Laboratory
Independent verification of the declaration and data, according to ISO 14025 and the PCR	☐ internal ☒ external
EPD Verifier:	Thomas Gloria, Ph.D., Industrial Ecology Consultants
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Disclaimers: *This EPD conforms to ISO 14025, 14040, 14044, and ISO 21930.*

Scope of Results Reported: *The PCR requirements limit the scope of the LCA metrics such that the results exclude environmental and social performance benchmarks and thresholds, and exclude impacts from the depletion of natural resources, land use ecological impacts, ocean impacts related to greenhouse gas emissions, risks from hazardous wastes and impacts linked to hazardous chemical emissions.*

Accuracy of Results: *Due to PCR constraints, this EPD provides estimations of potential impacts that are inherently limited in terms of accuracy.*

Comparability: *The PCR this EPD was based on was not written to support comparative assertions. EPDs based on different PCRs, or different calculation models, may not be comparable. When attempting to compare EPDs or life cycle impacts of products from different companies, the user should be aware of the uncertainty in the final results, due to and not limited to, the practitioner's assumptions, the source of the data used in the study, and the specifics of the product modeled.*

In accordance with ISO 21930:2017, EPDs are comparable only if they comply with the core PCR, 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.

1. Aeroflex USA

Aeroflex USA manufactures the Aerocel® brand of EPDM (ethylene propylene diene monomer) elastomeric closed cell insulation for HVAC piping, ductwork & equipment, refrigeration and plumbing systems.

We source materials that minimize hazards to the environment and human health. Most of our products are manufactured in the U.S.A. utilizing an energy-efficient production process that yields minimal waste and contributes to favorable energy optimization, indoor environmental quality and building mechanical system life cycle costs.

2. Product

The Aeroflex products included in the EPD scope are summarized below.

Aerocel® Stay-Seal® with Protape® (SSPT™)

Aerocel® Stay-Seal® with Protape® (SSPT) is a "factory-split" EPDM closed cell elastomeric insulation tube with a pressure-sensitive adhesive along the longitudinal seam and Aerocel® Protape® factory-applied to the outside wall offering a secure double-closure system. SSPT is available in the following product lines: Aerocel®, Aerocel® REF™, Aerocel® ULP® and Aerocel® White/Gray. The owner benefits of SSPT are lower installation costs, fewer callbacks, reduced probability of corrosion under insulation, can contribute to LEED® credits and is GREENGUARD Gold Certified for low chemical emissions. Aerocel® Stay-Seal® with Protape® (SSPT) is designed for installation above and below ground, interior/exterior applications and is 25/50 rated through 2" (51 mm) thickness.

Aerocel® REF™

Aerocel® REF pipe insulation effectively retards heat gain or loss and controls condensation formation on refrigeration systems. Aerocel® REF™ is designed for installation above and below ground, interior/exterior applications, is 25/50 rated through 2" (51 mm) thickness, can contribute to LEED® credits, is naturally resistant to microbiological growth and is GREENGUARD Gold Certified for low chemical emissions. Aerocel® REF Sheet & Roll can also insulate large OD pipes.

Aerocel® Tube Black (Aerocel® AC)

Aerocel® pipe insulation effectively retards heat gain or loss and controls condensation formation on cold-water plumbing, chilled water, and refrigeration systems. The material also efficiently reduces heat flow on hot water plumbing, liquid heating and dual-temperature piping systems. Aerocel® is designed for installation above and below ground, interior/exterior applications, is 25/50 rated through 2" (51 mm) thickness, can contribute to LEED® credits, is naturally resistant to microbiological growth and is GREENGUARD Gold Certified for low chemical emissions.

Aerocel® Tube White (Aerocel® WG)

Aerocel® White/Gray insulation effectively retards heat gain or loss and controls condensation formation on cold-water plumbing, chilled water, and refrigeration systems. The material also efficiently reduces heat flow on hot water plumbing, liquid heating and dual-temperature piping systems. Aerocel® is designed for installation above and below ground, interior/exterior applications, is 25/50 rated through 2" (51 mm) thickness, can contribute to LEED® credits, is naturally resistant to microbiological growth and is GREENGUARD Gold Certified for low chemical emissions.

Aerocel® ULP® (Ultra Low Perm)

The unique cell structure and composition of Aerocel® ULP™ (Ultra Low Perm) EPDM insulation effectively retards the flow of water vapor transmission (perms = <0.01 perm-in). Aerocel® ULP™ is a flexible, lightweight alternative to cellular glass. In normal service conditions, Aerocel® ULP™ requires no supplemental vapor retarder protection on plumbing equipment such as pumps chillers, tanks & vessels. When used in extremely low-temperature service such as ammonia refrigeration or cryogenic piping systems, or extremely high humidity conditions, additional vapor barrier materials may be required. The recommended service temperature range for Aerocel® ULP™ is -320°F to +257°F (-196°C to 125°C). Aerocel® ULP™ is designed for installation above and below ground, interior/exterior applications, is 25/50 rated through 2" (51 mm) thickness, can contribute to LEED® credits and is GREENGUARD Gold Certified for low chemical emissions. No UV protective finish is required for exterior applications. Aerocel® ULP™ is available in Sheets & Rolls and Sheet & Roll PSA in thicknesses ranging from 1/8" to 2" (3.175 mm to 51 mm).

2.2 Application

The Aeroflex rubber insulation products provide the primary function of thermal insulation for commercial applications.

2.3 Technical Data

Technical specifications of the products included in the LCA scope, as well as product performance testing results are available on the manufacturer's website (https:// www.aeroflexusa.com/) and summarized in Table 1.

Table 1. *Technical performance specifications for the Aeroflex rubber insulation products.*

Test Method	Test Results
ASTM C518 Steady-State Thermal Transmission Properties	Thermal conductivity = .245 @ 75°F [24°C]
ASTM C411 Hot Surface Performance of High Temperature Thermal Insulation	Service Temperature (Continuous) = -297°F [-183°C] - +257°F [+125°C]
ASTM C209 Cellulosic Fiber Insulating Board	Water Absorption (Volume %) = .2%
ASTM C534 Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet & Tubular Form	Flexibility = Pass
ASTM C692, DIN 1988 Influence of Thermal Insulations on External Stress Corrosion Cracking Tendency of Austenitic Stainless Steel	Non-corrosive
ASTM D635 Rate of Burning and/or Extent and Time of Burning Plastics in a Horizontal Position	Self-extinguishing
ASTM C1338 / G21 / UL 181 Determining Fungi Resistance of Insulation Materials and Facings	No growth
ASTM D1056 Flexible Cellular Materials - Sponge or Expanded Rubber	Closed Cell
ASTM D1171 Rubber Deterioration - Surface Ozone Cracking Outdoors	No cracking
ASTM E84 Surface Burning Characteristics of Building Materials	Pass 25/50 through 2" [50 mm] thickness
ASTM E96 Water Vapor Permeability of Materials	Water Vapor Permeability = .03 perm-inch (ULP = .01 perm-inch)
ASTM G7 Atmospheric Environmental Exposure Testing of Nonmetallic Materials	Minimal Cracking
NFPA 90A / 90B	Meets requirements
UL 94 Flammability of Plastic Materials for Parts in Devices and Appliances	UL-94 V-O
U.S. FDA CPG No. 7117.11 BESN 12868	Nitrosamine Content = None detected

2.4 Base Materials

The products assessed include sheet and rolls, tubing and insulation accessory products manufactured primarily from EPDM rubber. Packaging materials consist of corrugated board and plastic wrap.

Table 2. *Material component summary for the Aeroflex pipe insulation products by mass and as a percentage of total mass.*

Product	Units	Material				Packaging	
		Rubber	Plastics	Other	Total Product	Paperboard	Total Packaging
Aerocel® Stay-Seal® with Protape® (SSPT™)	kg/m	1.14	0.00	8.14×10^{-3}	**1.15**	0.202	**0.202**
	%	99%	0%	0.71%	**100%**	100%	**100%**
Aerocel® REF™	kg/m	0.119	0.00	9.48×10^{-4}	**0.120**	4.45×10^{-2}	**4.45×10^{-2}**
	%	99%	0%	0.79%	**100%**	37%	**37%**
Aerocel® Tube Black (Aerocel® AC)	kg/m	6.85×10^{-2}	0.00	5.45×10^{-4}	**6.90×10^{-2}**	2.59×10^{-2}	**2.59×10^{-2}**
	%	99%	0%	0.79%	**100%**	100%	**100%**
Aerocel® Tube White (Aerocel® WG)	kg/m	0.732	0.00	7.99×10^{-3}	**0.740**	0.620	**0.620**
	%	99%	0%	1.1%	**100%**	100%	**100%**
Aerocel® ULP® (Ultra Low Perm)	kg/m	0.221	0.00	1.47×10^{-3}	**0.222**	0.206	**0.206**
	%	99%	0%	0.66%	**100%**	100%	**100%**

2.5 Manufacture

The Aeroflex insulation products are manufactured at the company's production facilities in the United States and Thailand. Resource use at the production facilities is allocated to the products based on mass.

2.6 Environment and Health during Manufacture

No environmental or health impacts are expected during the manufacture of the product.

2.7 Product Processing/Installation

Typical installation is accomplished using hand tools.

2.8 Packaging

The products are packaged for shipment using corrugated board and plastic wrap.

2.9 Condition of Use

No special conditions of use are noted.

2.10 Environment and Health during use

No environmental or health impacts are expected due to normal use of the roof boards.

2.11 Reference Service Life

The Reference Service Life (RSL) of the products is based on the manufacturer's estimated lifetime of 25 years. The building Estimated Service Life (ESL) is 75 years, consistent with the PCR.

2.12 Extraordinary Effects

No environmental or health impacts are expected due to extraordinary effects including fire and/or water damage and unforeseeable mechanical destruction.

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2.13 Further Information

Further information on the product can be found on the manufacturers' website at https:// www.aeroflexusa.com/).

3. LCA: Calculation Rules

3.1 Functional Unit

The functional units used for each product in the study is 1 m^2 of product installed for use over 75 years. corresponding reference flow and number of product replacements required over the 75 year Estimated Service Life for each product system is presented below in Table 3.

Table 3. *Reference Service Life (RSL) and reference flows for Aeroflex's rubber insulation and accessory products.*

Product Name	Reference Flow	Units	Reference Service Life – RSL (years)	Replacement Cycle (ESL/RSL-1)
Aerocel® Stay-Seal® with Protape® (SSPT™)	1.15	kg/m	25	2
Aerocel® REF™	0.120	kg/m	25	2
Aerocel® Tube White (Aerocel® WG)	6.90×10^{-2}	kg/m	25	2
Aerocel® Tube Black (Aerocel® AC)	0.740	kg/m	25	2
Aerocel® ULP® (Ultra Low Perm)	0.220	kg/m	25	2

3.2 System Boundary

The scope of the EPD is cradle-to-grave, including raw material extraction and processing, transportation, product manufacture, product delivery, installation and use, and product disposal. The life cycle phases included in the EPD scope are described in Table 4 and illustrated in Figure 1.

Table 4. *The modules and unit processes included in the scope for the Aeroflex products.*

Module	Module Description	Unit Processes Included in Scope
A1	Extraction and processing of raw materials; any reuse of products or materials from previous product systems; processing of secondary materials; generation of electricity from primary energy resources; energy, or other, recovery processes from secondary fuels	Extraction and processing of raw materials for the rubber insulation product components.
A2	Transport (to the manufacturer)	Transport of component materials to the manufacturing facilities
A3	Manufacturing, including ancillary material production	Manufacturing of products and packaging (incl. upstream unit processes)
A4	Transport (to the building site)	Transport of product (including packaging) to the building site
A5	Construction-installation process	Impacts from the installation of product are assumed negligible. Only impacts from packaging disposal are included in this phase
B1	Product use	Use of the products in a commercial building setting. There are no associated emissions or impacts from the use of the product
B2	Product maintenance	No routine maintenance of the products is required once installed.
B3	Product repair	The products are not expected to require repair over their lifetime
B4	Product replacement	The materials and energy required for replacement of the product over the 75-year ESL of the assessment are included in this phase
B5	Product refurbishment	The products are not expected to require refurbishment over their lifetime
B6	Operational energy use by technical building systems	There is no operational energy use associated with the use of the product
B7	Operational water uses by technical building systems	There is no operational water use associated with the use of the product
C1	Deconstruction, demolition	Demolition of the product is accomplished using hand tools with no associated emissions and negligible impacts
C2	Transport (to waste processing)	Transport of insulation products to waste treatment at end-of-life
C3	Waste processing for reuse, recovery and/or recycling	The products are disposed of by recycling, landfilling or incineration which require no waste processing
C4	Disposal	Disposal of product
D	Reuse-recovery-recycling potential	Module Not Declared

Figure 1. *Flow diagram representing the major unit operations in the life cycle of the Aeroflex products.*

3.3 Estimates and Assumptions

- Energy resource use and emissions at the Aeroflex manufacturing facilities were reported separately for electricity and fuel consumption (natural gas, propane). Resource use and emissions were allocated to the insulation products based on the product mass as a fraction of the total facility production.
- Electricity use at the manufacturing facilities is modeled using Ecoinvent inventory datasets modified to reflect the eGRID energy mix for the relevant NERC sub-region to estimate resource use and emissions. Ecoinvent datasets for the regional electricity grids are used to model resource use at the manufacturing facilities in Thailand and Germany.
- The Reference Service Life (RSL) of the products was modeled based on information provided by the manufacturer assuming their products are installed as recommended and used for the specific application noted.
- Lacking detailed supplier information, much of the upstream raw materials extraction and processing could not be modeled with actual process information. Representative data from the Ecoinvent LCI databases were utilized as appropriate.
- Downstream transport was modeled based on information provided by the manufacturer representing product distribution in North America.
- Specific data to estimate the recycling rates of product materials and packaging data were unavailable. Recycling rates for the product and packaging materials were based on the PCR requirements.
- Disposal of product and packaging is modeled based on regional statistics regarding municipal solid waste generation and disposal in the United States. The data include end-of-life recycling rates of product and packaging materials.
- For final disposal of the product and packaging material at end-of-life, all materials are assumed to transported 20 miles (~32 km) by diesel truck to either a landfill, incineration facility, or material reclamation facility (for recycling). Datasets representing disposal in a landfill and waste incineration are from Ecoinvent.

It should also be noted that LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

The PCR allows for the results for several inventory flows related to construction products to be reported as “other parameters”. These are aggregated inventory flows, and do not characterize any potential impact; results should be interpreted considering this limitation.

3.4 Cut-off criteria

According to the PCR, processes contributing greater than 1% of the total environmental impact indicator for each impact are included in the inventory. No data gaps were allowed which were expected to significantly affect the outcome of the indicator results. No known flows are deliberately excluded from this EPD.

3.5 Background Data

Primary data were provided by Aeroflex USA for their manufacturing facilities. The sources of secondary LCI data are the Ecoinvent database.

Table 5. *Data sources for the Aeroflex product system.*

Component	Dataset	Data Source	Publication data
PRODUCT			
Rubber			
EPDM Compound	market for synthetic rubber | synthetic rubber | Cutoff/GLO	EI v3.6	2019
Masterbatch			
EPDM	market for synthetic rubber | synthetic rubber | Cutoff/GLO	EI v3.6	2019
Flame retardant and Filler	Confidential	EI v3.6	2019
Flame retardant and Filler	Confidential	EI v3.6	2019
Plasticizer and additive	Confidential	EI v3.6	2019
Curative and Accelerator	Confidential	EI v3.6	2019
Curative and Accelerator	Confidential	EI v3.6	2019
Flame retardant and Filler	Confidential	EI v3.6	2019
Flame retardant and Filler	Confidential	EI v3.6	2019
Blowing Agent	Confidential	EI v3.6	2019
Curative and Accelerator	Confidential	EI v3.6	2019
Curative and Accelerator	Confidential	EI v3.6	2019
Curative and Accelerator	Confidential	EI v3.6	2019
Curative and Accelerator	Confidential	EI v3.6	2019
Flame retardant and Filler	Confidential	EI v3.6	2019
Acrylic adhesive	market for acrylic binder, without water, in 34% solution state | acrylic binder, without water, in 34% solution state | Cutoff/RoW	EI v3.6	2019
Paper liner, Silicone-coated	market for kraft paper, unbleached | kraft paper, unbleached | Cutoff/GLO	EI v3.6	2019
PACKAGING			
Paperboard carton	market for corrugated board box | corrugated board box | Cutoff/RoW	EI v3.6	2019
Polypropylene can	market for polypropylene, granulate | polypropylene, granulate | Cutoff/GLO	EI v3.6	2019
Plastic wrap	market for packaging film, low density polyethylene | packaging film, low density polyethylene | Cutoff/GLO	EI v3.6	2019
TRANSPORT			
Diesel truck	market for transport, freight, lorry 16-32 metric ton, EURO4 | transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff/RoW	EI v3.6	2019
Ocean freighter	transport, freight, sea, container ship | transport, freight, sea, container ship | Cutoff, S/GLO	EI v3.6	2019
RESOURCES			
Grid electricity	Electricity, medium voltage, per kWh - SRTV/SRTV	EI v3.6; eGRID	2019; 2018
	Electricity, medium voltage, per kWh - RFCE/RFCE	EI v3.6; eGRID	2019; 2018
	market for electricity, medium voltage | electricity, medium voltage | Cutoff/TH	EI v3.6	2019
	market for electricity, medium voltage | electricity, medium voltage | Cutoff/DE	EI v3.6	2019
Heat - natural gas	market group for heat, district or industrial, natural gas | heat, district or industrial, natural gas | Cutoff/GLO	EI v3.6	2019
Heat - propane	heat production, propane, at industrial furnace >100kW | heat, district or industrial, other than natural gas | Cutoff/RoW	EI v3.6	2019

3.6 Data Quality

The data quality assessment addressed the following parameters: time-related coverage, geographical coverage, technological coverage, precision, completeness, representativeness, consistency, reproducibility, sources of data, and uncertainty.

Table 6. *Data quality assessment for the Aeroflex product system.*

Data Quality Parameter	Data Quality Discussion
Time-Related Coverage: Age of data and the minimum length of time over which data is collected	The most recent available data are used, based on other considerations such as data quality and similarity to the actual operations. Typically, these data are less than 5 years old (typically 2016). All of the data used represented an average of at least one year's worth of data collection, and up to three years in some cases. Manufacturer-supplied data (primary data) are based on production data for 2019 and 2020
Geographical Coverage: Geographical area from which data for unit processes is collected to satisfy the goal of the study	The data used in the analysis provide the best possible representation available with current data. Electricity use for product manufacture is modeled using representative data for the US, Thailand and Germany, as appropriate. Surrogate data used in the assessment are representative of global or European operations. Data representative of European operations are considered sufficiently similar to actual processes. Data representing product disposal are based on US statistics.
Technology Coverage: Specific technology or technology mix	For the most part, data are representative of the actual technologies used for processing, transportation, and manufacturing operations. Representative fabrication datasets, specific to the type of material, are used to represent the actual processes, as appropriate.
Precision: Measure of the variability of the data values for each data expressed	Precision of results are not quantified due to a lack of data. Data collected for operations were typically averaged for one or more years and over multiple operations, which is expected to reduce the variability of results.
Completeness: Percentage of flow that is measured or estimated	The LCA model included all known mass and energy flows for production of the insulation products. In some instances, surrogate data used to represent upstream and downstream operations may be missing some data which is propagated in the model. No known processes or activities contributing to more than 1% of the total environmental impact for each indicator are excluded.
Representativeness: Qualitative assessment of the degree to which the data set reflects the true population of interest	Data used in the assessment represent typical or average processes as currently reported from multiple data sources and are therefore generally representative of the range of actual processes and technologies for production of these materials. Considerable deviation may exist among actual processes on a site-specific basis; however, such a determination would require detailed data collection throughout the supply chain back to resource extraction.
Consistency: Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis	The consistency of the assessment is considered to be high. Data sources of similar quality and age are used; with a bias towards Ecoinvent v3.6 data where available. Different portions of the product life cycle are equally considered; however, it must be noted that final disposition of the product is based on assumptions of current average practices in the United States.
Reproducibility: Qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the study	Based on the description of data and assumptions used, this assessment would be reproducible by other practitioners. All assumptions, models, and data sources are documented.
Sources of the Data: Description of all primary and secondary data sources	Data representing energy use at Aeroflex's manufacturing facilities represent an annual average and are considered of high quality due to the length of time over which these data are collected, as compared to a snapshot that may not accurately reflect fluctuations in production. For secondary LCI data, Ecoinvent v3.6 LCI data are used.
Uncertainty of the Information: Uncertainty related to data, models, and assumptions	Uncertainty related to materials in the insulation products and packaging is low. Actual supplier data for upstream operations was not available for all suppliers and the study relied upon the use of existing representative datasets. These datasets contained relatively recent data (<10 years) but lacked geographical representativeness. Uncertainty related to the impact assessment methods used in the study are high. The impact assessment method required by the PCR includes impact potentials, which lack characterization of providing and receiving environments or tipping points.

3.7 Period under review

The period of review represents production data for 2019 and 2020

3.8 Allocation

Manufacturing resource use was allocated to the products based on mass. Impacts from transportation were allocated based on the mass of material and distance transported.

3.9 Comparability

The PCR this EPD was based on was not written to support comparative assertions. EPDs based on different PCRs, or different calculation models, may not be comparable. When attempting to compare EPDs or life cycle impacts of products from different companies, the user should be aware of the uncertainty in the final results, due to and not limited to, the practitioner's assumptions, the source of the data used in the study, and the specifics of the product modeled.

4. LCA: Scenarios and Additional Technical Information

Delivery and Installation stage (A4 - A5)

Distribution of the insulation products to the point of installation is included in the assessment. Transportation parameters for modeling product distribution are summarized in Table 7. Average distances by transport mode were used to represent distribution to the North American consumer market.

Table 7. Distribution modeling parameters by product and transport mode per declared unit.

Transport Mode	Fuel utilization	Capacity utilization (%)
Diesel truck	42 L/100 km	76%
Product	**Gross mass transported[1] (kg)**	**Transport Distance (km)**
Aerocel® Stay-Seal® with Protape® (SSPT™)	1.35	1,954
Aerocel® REF™	0.165	1,954
Aerocel® Tube White (Aerocel® WG)	9.49×10^{-2}	1,954
Aerocel® Tube Black (Aerocel® AC)	1.36	1,954
Aerocel® ULP® (Ultra Low Perm)	0.428	1,954

[1] Including packaging

The impacts associated with the product installation are assumed negligible. The impacts associated with packaging disposal are included with the installation phase as per PCR requirements.

Table 8. Installation parameters for the Aeroflex products, per declared unit.

Parameter	Value		
Ancillary materials (kg)	negligible		
Net freshwater consumption (m^3)	-		
Electricity consumption (kWh)	-		
Product loss per functional unit (kg)	negligible		
Waste materials generated by product installation (kg)	negligible		
Output materials resulting from on-site waste processing (kg)	na		
Direct emissions (kg)	-		
Product	**Mass of packaging waste (kg)**		**Biogenic carbon contained in packaging (kg CO_2)**
	Corrugated	**Plastic**	
Aerocel® Stay-Seal® with Protape® (SSPT™)	0.202	0.00	0.356
Aerocel® REF™	4.45×10^{-2}	0.00	7.83×10^{-2}
Aerocel® Tube White (Aerocel® WG)	2.59×10^{-2}	0.00	4.55×10^{-2}
Aerocel® Tube Black (Aerocel® AC)	0.620	0.00	1.09
Aerocel® ULP® (Ultra Low Perm)	0.206	0.00	0.363

Use stage (B1)

There are no direct impacts from the use of the products.

Maintenance stage (B2)

The products require no maintenance once installed and impacts for this life cycle stage are reported as zero.

Repair/Refurbishment stage (B3; B5)

Product repair and refurbishment are not relevant during the lifetime of the product.

Replacement stage (B4)

The materials and energy required for replacement of the product over the 75-year ESL of the assessment are included in this stage.

Building operation stage (B6 – B7)

There is no operational energy or water use associated with the use of the product.

Disposal stage (C1 - C4)

The disposal stage includes removal of the products (C1); transport of the products to waste treatment facilities (C2); waste processing (C3); and associated emissions as the product degrades in a landfill or is burned in an incinerator (C4). For the movable wall system products, no emissions are generated during demolition (C1) while no waste processing (C3) is required for incineration or landfill disposal.

Transportation of waste materials at end-of-life (C2) assumes a 20 mile (~32 km) average distance to disposal, consistent with assumptions used in the US EPA WARM model. The recycling rates used for the product packaging are based on regional statistics regarding municipal solid waste generation and disposal in the United States for 2015, from the US Environmental Protection Agency. The relevant disposal statistics used for the product and packaging are summarized in Table 9 and Table 10. For material not recycled, 80% are assumed landfilled and 20% incinerated.

Table 9. *Recycling rates for packaging materials at end-of-life.*

Material	Recycling Rate (%)	
	Product	Packaging
Recycling Rates		
Rubber	20.5%	n/a
Plastics	6.6%	15%
Paper & Pulp	n/a	75%
Disposal of Non-recyclables		
Landfill	80%	80%
Incineration	20%	20%

Table 10. *End-of-life disposal scenario parameters for the Aeroflex insulation products.*

Product	Scenario assumptions	Collection process		Recovery	Disposal			Removals of biogenic carbon
		Collected separately	Collected with mixed waste		Recycling	Landfill	Incineration	
Aerocel® Stay-Seal® with Protape® (SSPT™)	EPA 2015	-	1.15	n/a	0.234	0.733	0.183	n/a
Aerocel® REF™	EPA 2015	-	0.120	n/a	2.44×10^{-2}	7.65×10^{-2}	1.91×10^{-2}	n/a
Aerocel® Tube White (Aerocel® WG)	EPA 2015	-	6.90×10^{-2}	n/a	1.40×10^{-2}	4.40×10^{-2}	1.10×10^{-2}	n/a
Aerocel® Tube Black (Aerocel® AC)	EPA 2015	-	0.740	n/a	0.150	0.472	0.118	n/a
Aerocel® ULP® (Ultra Low Perm)	EPA 2015	-	0.222	n/a	4.52×10^{-2}	0.141	3.54×10^{-2}	n/a

5. LCA: Results

Results of the Life Cycle Assessment are presented below. It is noted that LCA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

Table 11. *Life cycle phases included in the product system boundary.*

Product			Construction Process		Use							End-of-life				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 extraction and processing	Transport to manufacturer	Manufacturing	Transport	Construction - installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction demolition	Transport	Waste processing	Disposal	Reuse, recovery and/or recycling potential
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	MND

X = Included in system boundary | MND = Module not declared

The following impact indicators, specified by the PCR, are reported below:

CML-IA Impact Category	Unit	TRACI 2.1 Impact Category	Unit
Global Warming Potential (GWP)	kg CO_2 eq	Global Warming Potential (GWP)	kg CO_2 eq
Depletion potential of the stratospheric ozone layer (ODP)	kg CFC 11 eq	Ozone Depletion Potential (ODP)	kg CFC 11 eq
Acidification Potential of soil and water (AP)	kg SO_2 eq	Acidification Potential (AP)	kg SO_2 eq
Eutrophication Potential (EP)	kg PO_4^{3-} eq	Eutrophication Potential (EP)	kg N eq
Photochemical Oxidant Creation Potential (POCP)	kg C_2H_4 eq	Smog Formation Potential (SFP)	kg O_3 eq
Abiotic depletion potential (ADP-elements) for non-fossil resources	kg Sb eq	Fossil Fuel Depletion Potential (ADP_{fossil})	MJ Surplus, LHV
Abiotic depletion potential (ADP-fossil fuels) for fossil resources	MJ, LHV	-	-

The following inventory parameters, specified by the PCR, are also reported.

Resources	Unit	Waste and Outflows	Unit
RPR_E: Renewable primary resources used as energy carrier (fuel)	MJ, LHV	HWD: Hazardous waste disposed	kg
RPR_M: Renewable primary resources with energy content used as material	MJ, LHV	NHWD: Non-hazardous waste disposed	kg
$NRPR_E$: Non-renewable primary resources used as an energy carrier (fuel)	MJ, LHV	HLRW: High-level radioactive waste, conditioned, to final repository	kg
$NRPR_M$: Non-renewable primary resources with energy content used as material	MJ, LHV	ILLRW: Intermediate- and low-level radioactive waste, conditioned, to final repository	kg
SM: Secondary materials	MJ, LHV	CRU: Components for re-use	kg
RSF: Renewable secondary fuels	MJ, LHV	MR: Materials for recycling	kg
NRSF: Non-renewable secondary fuels	MJ, LHV	MER: Materials for energy recovery	kg
RE: Recovered energy	MJ, LHV	EE: Recovered energy exported from the product system	MJ, LHV
FW: Use of net freshwater resources	m^3	-	-

Modules B1, B2, B3, B5, B6 and B7 are not associated with any impact and are therefore declared as zero. In addition, module C1 and C3 are likewise not associated with any impact as the products are expected to be manually deconstructed. Additionally, as the products do not contain bio-based materials, biogenic carbon emissions and removals are not declared. Module D is not declared. In the interest of space and table readability, these modules are not included in the results presented below.

Table 12. *Life Cycle Impact Assessment (LCIA) results for the Aerocel® ULP® Stay-Seal® with Protape® (SSPT™) products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.*

Impact Category	A1	A2	A3	A4	A5	B4	C2	C4
CML-IA								
GWP (kg CO_2 eq)	2.80	0.345	1.60	0.451	7.07×10^{-2}	12.7	4.69×10^{-2}	1.04
	15%	1.8%	8.4%	2.4%	0.37%	67%	0.25%	5.4%
ODP (kg CFC-11 eq)	4.35×10^{-7}	5.80×10^{-8}	1.29×10^{-7}	7.92×10^{-8}	1.59×10^{-9}	1.43×10^{-6}	8.17×10^{-9}	3.19×10^{-9}
	20%	2.7%	6%	3.7%	0.074%	67%	0.38%	0.15%
AP (kg SO_2 eq)	1.54×10^{-2}	5.16×10^{-3}	8.41×10^{-3}	1.77×10^{-3}	4.93×10^{-5}	6.24×10^{-2}	2.19×10^{-4}	1.68×10^{-4}
	16%	5.5%	9%	1.9%	0.053%	67%	0.23%	0.18%
EP (kg $(PO_4)^{3-}$ eq)	4.63×10^{-3}	6.63×10^{-4}	2.74×10^{-3}	4.21×10^{-4}	1.19×10^{-4}	2.11×10^{-2}	4.73×10^{-5}	1.93×10^{-3}
	15%	2.1%	8.7%	1.3%	0.38%	67%	0.15%	6.1%
POCP (kg C_2H_4 eq)	9.65×10^{-4}	1.40×10^{-4}	3.44×10^{-4}	6.16×10^{-5}	1.48×10^{-5}	3.27×10^{-3}	7.26×10^{-6}	1.01×10^{-4}
	20%	2.9%	7%	1.3%	0.3%	67%	0.15%	2.1%
ADPE (kg Sb eq)	2.28×10^{-8}	2.41×10^{-10}	2.28×10^{-8}	4.64×10^{-10}	5.64×10^{-12}	9.27×10^{-8}	1.28×10^{-11}	5.76×10^{-11}
	16%	0.17%	16%	0.33%	0.0041%	67%	0.0092%	0.041%
ADPF (MJ eq)	63.5	4.76	19.5	6.66	0.129	191	0.642	0.304
	22%	1.7%	6.8%	2.3%	0.045%	67%	0.22%	0.11%
TRACI 2.1								
GWP (kg CO_2 eq)	2.76	0.344	1.59	0.450	6.41×10^{-2}	12.5	4.69×10^{-2}	0.987
	15%	1.8%	8.5%	2.4%	0.34%	67%	0.25%	5.3%
ODP (kg CFC-11 eq)	5.62×10^{-7}	7.71×10^{-8}	1.52×10^{-7}	1.05×10^{-7}	2.11×10^{-9}	1.83×10^{-6}	1.09×10^{-8}	4.04×10^{-9}
	20%	2.8%	5.6%	3.8%	0.077%	67%	0.4%	0.15%
AP (kg SO_2 eq)	1.58×10^{-2}	5.54×10^{-3}	8.36×10^{-3}	2.08×10^{-3}	7.05×10^{-5}	6.48×10^{-2}	2.71×10^{-4}	3.13×10^{-4}
	16%	5.7%	8.6%	2.1%	0.073%	67%	0.28%	0.32%
EP (kg N eq)	9.31×10^{-3}	4.64×10^{-4}	5.65×10^{-3}	5.27×10^{-4}	2.99×10^{-4}	4.28×10^{-2}	3.56×10^{-5}	5.10×10^{-3}
	15%	0.72%	8.8%	0.82%	0.47%	67%	0.056%	7.9%
SFP (kg O_3 eq)	0.191	0.106	8.98×10^{-2}	4.94×10^{-2}	1.57×10^{-3}	0.900	7.67×10^{-3}	4.26×10^{-3}
	14%	7.9%	6.7%	3.7%	0.12%	67%	0.57%	0.32%
FFD (MJ eq)	7.90	0.650	1.83	0.895	1.78×10^{-2}	22.8	9.09×10^{-2}	3.54×10^{-2}
	23%	1.9%	5.4%	2.6%	0.052%	67%	0.27%	0.1%

Table 13. *Resource use and waste flows for the Aerocel® ULP® Stay-Seal® with Protape® (SSPT™) products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.*

Parameter	A1	A2	A3	A4	A5	B4	C2	C4
Resources								
RPR_E (MJ)	2.73	4.30×10^{-2}	2.33	7.39×10^{-2}	1.27×10^{-3}	10.4	2.37×10^{-3}	1.42×10^{-2}
	18%	0.28%	15%	0.47%	0.0081%	67%	0.015%	0.091%
RPR_M (MJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$NRPR_E$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
$NRPR_M$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
SM (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF/NRSF (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
RE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
FW (m^3)	0.153	2.71×10^{-3}	0.140	4.84×10^{-3}	1.03×10^{-4}	0.605	2.11×10^{-4}	1.68×10^{-3}
	17%	0.3%	15%	0.53%	0.011%	67%	0.023%	0.19%
Wastes								
HWD (kg)	3.65×10^{-5}	8.89×10^{-6}	1.67×10^{-5}	1.78×10^{-5}	3.30×10^{-7}	1.67×10^{-4}	1.75×10^{-6}	1.30×10^{-6}
	15%	3.6%	6.7%	7.1%	0.13%	67%	0.7%	0.52%
NHWD (kg)	0.730	0.128	0.139	0.319	4.14×10^{-2}	4.22	3.04×10^{-3}	0.749
	12%	2%	2.2%	5%	0.65%	67%	0.048%	12%
HLRW (kg)	8.97×10^{-6}	1.96×10^{-7}	2.52×10^{-5}	3.63×10^{-7}	6.66×10^{-9}	6.97×10^{-5}	1.08×10^{-8}	7.62×10^{-8}
	8.6%	0.19%	24%	0.35%	0.0064%	67%	0.01%	0.073%
ILLRW (kg)	2.17×10^{-4}	3.22×10^{-5}	1.35×10^{-4}	4.40×10^{-5}	8.80×10^{-7}	8.71×10^{-4}	4.56×10^{-6}	1.45×10^{-6}
	17%	2.5%	10%	3.4%	0.067%	67%	0.35%	0.11%
CRU (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR (kg)	0.00	0.00	0.00	0.00	0.152	0.772	0.00	0.234
	0%	0%	0%	0%	13%	67%	0%	20%
MER (kg)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
EE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

INA = Indicator not assessed | Neg. = Negligible

Table 14. *Life Cycle Impact Assessment (LCIA) results for the Aerocel® REF™ products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.*

Impact Category	A1	A2	A3	A4	A5	B4	C2	C4
CML-IA								
GWP (kg CO_2 eq)	0.291	3.60×10^{-2}	0.183	5.49×10^{-2}	1.55×10^{-2}	1.39	4.90×10^{-3}	0.108
	14%	1.7%	8.8%	2.6%	0.75%	67%	0.24%	5.2%
ODP (kg CFC-11 eq)	4.50×10^{-8}	6.05×10^{-9}	1.47×10^{-8}	9.64×10^{-9}	3.49×10^{-10}	1.54×10^{-7}	8.53×10^{-10}	3.33×10^{-10}
	19%	2.6%	6.4%	4.2%	0.15%	67%	0.37%	0.14%
AP (kg SO_2 eq)	1.60×10^{-3}	5.38×10^{-4}	9.40×10^{-4}	2.16×10^{-4}	1.08×10^{-5}	6.68×10^{-3}	2.29×10^{-5}	1.76×10^{-5}
	16%	5.4%	9.4%	2.1%	0.11%	67%	0.23%	0.18%
EP (kg $(PO_4)^{3-}$ eq)	4.81×10^{-4}	6.92×10^{-5}	3.23×10^{-4}	5.12×10^{-5}	2.61×10^{-5}	2.31×10^{-3}	4.94×10^{-6}	2.01×10^{-4}
	14%	2%	9.3%	1.5%	0.75%	67%	0.14%	5.8%
POCP (kg C_2H_4 eq)	1.01×10^{-4}	1.46×10^{-5}	3.94×10^{-5}	7.49×10^{-6}	3.26×10^{-6}	3.54×10^{-4}	7.57×10^{-7}	1.05×10^{-5}
	19%	2.8%	7.4%	1.4%	0.61%	67%	0.14%	2%
ADPE (kg Sb eq)	2.44×10^{-9}	2.51×10^{-11}	2.40×10^{-9}	5.64×10^{-11}	1.24×10^{-12}	9.87×10^{-9}	1.34×10^{-12}	6.01×10^{-12}
	16%	0.17%	16%	0.38%	0.0084%	67%	0.009%	0.041%
ADPF (MJ eq)	6.63	0.497	2.22	0.811	2.84×10^{-2}	20.6	6.70×10^{-2}	3.17×10^{-2}
	21%	1.6%	7.2%	2.6%	0.092%	67%	0.22%	0.1%
TRACI 2.1								
GWP (kg CO_2 eq)	0.287	3.59×10^{-2}	0.181	5.47×10^{-2}	1.41×10^{-2}	1.36	4.89×10^{-3}	0.103
	14%	1.8%	8.9%	2.7%	0.69%	67%	0.24%	5%
ODP (kg CFC-11 eq)	5.80×10^{-8}	8.05×10^{-9}	1.76×10^{-8}	1.28×10^{-8}	4.64×10^{-10}	1.97×10^{-7}	1.14×10^{-9}	4.22×10^{-10}
	20%	2.7%	5.9%	4.3%	0.16%	67%	0.38%	0.14%
AP (kg SO_2 eq)	1.63×10^{-3}	5.79×10^{-4}	9.43×10^{-4}	2.52×10^{-4}	1.55×10^{-5}	6.96×10^{-3}	2.83×10^{-5}	3.27×10^{-5}
	16%	5.5%	9%	2.4%	0.15%	67%	0.27%	0.31%
EP (kg N eq)	9.67×10^{-4}	4.84×10^{-5}	6.63×10^{-4}	6.41×10^{-5}	6.59×10^{-5}	4.69×10^{-3}	3.72×10^{-6}	5.32×10^{-4}
	14%	0.69%	9.4%	0.91%	0.94%	67%	0.053%	7.6%
SFP (kg O_3 eq)	1.97×10^{-2}	1.11×10^{-2}	1.06×10^{-2}	6.01×10^{-3}	3.46×10^{-4}	9.79×10^{-2}	8.00×10^{-4}	4.45×10^{-4}
	13%	7.6%	7.2%	4.1%	0.24%	67%	0.54%	0.3%
FFD (MJ eq)	0.824	6.79×10^{-2}	0.213	0.109	3.92×10^{-3}	2.46	9.49×10^{-3}	3.69×10^{-3}
	22%	1.8%	5.8%	2.9%	0.11%	67%	0.26%	0.1%

Table 15. *Resource use and waste flows for the Aerocel® REF™ products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.*

Parameter	A1	A2	A3	A4	A5	B4	C2	C4
Resources								
RPR_E (MJ)	0.283	$4.49x10^{-3}$	0.377	$8.99x10^{-3}$	$2.79x10^{-4}$	1.35	$2.47x10^{-4}$	$1.49x10^{-3}$
	14%	0.22%	19%	0.44%	0.014%	67%	0.012%	0.073%
RPR_M (MJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$NRPR_E$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
$NRPR_M$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
SM (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF/NRSF (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
RE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
FW (m^3)	$1.62x10^{-2}$	$2.82x10^{-4}$	$1.55x10^{-2}$	$5.88x10^{-4}$	$2.26x10^{-5}$	$6.55x10^{-2}$	$2.20x10^{-5}$	$1.75x10^{-4}$
	16%	0.29%	16%	0.6%	0.023%	67%	0.022%	0.18%
Wastes								
HWD (kg)	$3.86x10^{-6}$	$9.28x10^{-7}$	$2.03x10^{-6}$	$2.17x10^{-6}$	$7.25x10^{-8}$	$1.87x10^{-5}$	$1.82x10^{-7}$	$1.35x10^{-7}$
	14%	3.3%	7.2%	7.7%	0.26%	67%	0.65%	0.48%
NHWD (kg)	$7.31x10^{-2}$	$1.34x10^{-2}$	$1.81x10^{-2}$	$3.88x10^{-2}$	$9.10x10^{-3}$	0.462	$3.17x10^{-4}$	$7.81x10^{-2}$
	11%	1.9%	2.6%	5.6%	1.3%	67%	0.046%	11%
HLRW (kg)	$9.43x10^{-7}$	$2.04x10^{-8}$	$2.67x10^{-6}$	$4.42x10^{-8}$	$1.46x10^{-9}$	$7.38x10^{-6}$	$1.13x10^{-9}$	$7.95x10^{-9}$
	8.5%	0.18%	24%	0.4%	0.013%	67%	0.01%	0.072%
ILLRW (kg)	$2.24x10^{-5}$	$3.37x10^{-6}$	$1.45x10^{-5}$	$5.36x10^{-6}$	$1.94x10^{-7}$	$9.29x10^{-5}$	$4.76x10^{-7}$	$1.51x10^{-7}$
	16%	2.4%	10%	3.8%	0.14%	67%	0.34%	0.11%
CRU (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR (kg)	0.00	0.00	0.00	0.00	$3.34x10^{-2}$	0.116	0.00	$2.44x10^{-2}$
	0%	0%	0%	0%	19%	67%	0%	14%
MER (kg)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
EE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

INA = Indicator not assessed | Neg. = Negligible

Table 16. *Life Cycle Impact Assessment (LCIA) results for the Aerocel® Tube Black (Aerocel® AC) products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.*

Impact Category	A1	A2	A3	A4	A5	B4	C2	C4
CML-IA								
GWP (kg CO_2 eq)	0.167	2.07×10^{-2}	0.105	3.16×10^{-2}	9.03×10^{-3}	0.798	2.82×10^{-3}	6.21×10^{-2}
	14%	1.7%	8.8%	2.6%	0.75%	67%	0.24%	5.2%
ODP (kg CFC-11 eq)	2.58×10^{-8}	3.48×10^{-9}	8.48×10^{-9}	5.56×10^{-9}	2.03×10^{-10}	8.85×10^{-8}	4.90×10^{-10}	1.91×10^{-10}
	19%	2.6%	6.4%	4.2%	0.15%	67%	0.37%	0.14%
AP (kg SO_2 eq)	9.19×10^{-4}	3.09×10^{-4}	5.41×10^{-4}	1.24×10^{-4}	6.30×10^{-6}	3.85×10^{-3}	1.32×10^{-5}	1.01×10^{-5}
	16%	5.4%	9.4%	2.2%	0.11%	67%	0.23%	0.18%
EP (kg $(PO_4)^{3-}$ eq)	2.77×10^{-4}	3.98×10^{-5}	1.86×10^{-4}	2.95×10^{-5}	1.52×10^{-5}	1.33×10^{-3}	2.84×10^{-6}	1.16×10^{-4}
	14%	2%	9.3%	1.5%	0.76%	67%	0.14%	5.8%
POCP (kg C_2H_4 eq)	5.79×10^{-5}	8.42×10^{-6}	2.27×10^{-5}	4.32×10^{-6}	1.89×10^{-6}	2.04×10^{-4}	4.36×10^{-7}	6.04×10^{-6}
	19%	2.8%	7.4%	1.4%	0.62%	67%	0.14%	2%
ADPE (kg Sb eq)	1.40×10^{-9}	1.45×10^{-11}	1.38×10^{-9}	3.25×10^{-11}	7.21×10^{-13}	5.68×10^{-9}	7.69×10^{-13}	3.46×10^{-12}
	16%	0.17%	16%	0.38%	0.0085%	67%	0.009%	0.041%
ADPF (MJ eq)	3.81	0.285	1.28	0.467	1.65×10^{-2}	11.8	3.85×10^{-2}	1.82×10^{-2}
	21%	1.6%	7.2%	2.6%	0.093%	67%	0.22%	0.1%
TRACI 2.1								
GWP (kg CO_2 eq)	0.165	2.07×10^{-2}	0.104	3.16×10^{-2}	8.19×10^{-3}	0.783	2.81×10^{-3}	5.92×10^{-2}
	14%	1.8%	8.9%	2.7%	0.7%	67%	0.24%	5%
ODP (kg CFC-11 eq)	3.34×10^{-8}	4.63×10^{-9}	1.01×10^{-8}	7.39×10^{-9}	2.70×10^{-10}	1.13×10^{-7}	6.53×10^{-10}	2.43×10^{-10}
	20%	2.7%	5.9%	4.3%	0.16%	67%	0.38%	0.14%
AP (kg SO_2 eq)	9.38×10^{-4}	3.33×10^{-4}	5.43×10^{-4}	1.46×10^{-4}	9.01×10^{-6}	4.01×10^{-3}	1.63×10^{-5}	1.88×10^{-5}
	16%	5.5%	9%	2.4%	0.15%	67%	0.27%	0.31%
EP (kg N eq)	5.56×10^{-4}	2.79×10^{-5}	3.82×10^{-4}	3.70×10^{-5}	3.83×10^{-5}	2.70×10^{-3}	2.14×10^{-6}	3.06×10^{-4}
	14%	0.69%	9.4%	0.91%	0.95%	67%	0.053%	7.6%
SFP (kg O_3 eq)	1.13×10^{-2}	6.39×10^{-3}	6.09×10^{-3}	3.46×10^{-3}	2.01×10^{-4}	5.64×10^{-2}	4.60×10^{-4}	2.56×10^{-4}
	13%	7.6%	7.2%	4.1%	0.24%	67%	0.54%	0.3%
FFD (MJ eq)	0.474	3.90×10^{-2}	0.123	6.28×10^{-2}	2.28×10^{-3}	1.42	5.46×10^{-3}	2.12×10^{-3}
	22%	1.8%	5.8%	3%	0.11%	67%	0.26%	0.1%

Table 17. *Resource use and waste flows for the Aerocel® Tube Black (Aerocel® AC) products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.*

Parameter	A1	A2	A3	A4	A5	B4	C2	C4
Resources								
RPR_E (MJ)	0.163	$2.58x10^{-3}$	0.218	$5.19x10^{-3}$	$1.62x10^{-4}$	0.780	$1.42x10^{-4}$	$8.54x10^{-4}$
	14%	0.22%	19%	0.44%	0.014%	67%	0.012%	0.073%
RPR_M (MJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$NRPR_E$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
$NRPR_M$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
SM (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF/NRSF (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
RE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
FW (m^3)	$9.29x10^{-3}$	$1.62x10^{-4}$	$8.91x10^{-3}$	$3.39x10^{-4}$	$1.31x10^{-5}$	$3.77x10^{-2}$	$1.27x10^{-5}$	$1.01x10^{-4}$
	16%	0.29%	16%	0.6%	0.023%	67%	0.022%	0.18%
Wastes								
HWD (kg)	$2.22x10^{-6}$	$5.34x10^{-7}$	$1.17x10^{-6}$	$1.25x10^{-6}$	$4.21x10^{-8}$	$1.08x10^{-5}$	$1.05x10^{-7}$	$7.77x10^{-8}$
	14%	3.3%	7.2%	7.7%	0.26%	67%	0.65%	0.48%
NHWD (kg)	$4.21x10^{-2}$	$7.71x10^{-3}$	$1.05x10^{-2}$	$2.24x10^{-2}$	$5.28x10^{-3}$	0.266	$1.82x10^{-4}$	$4.49x10^{-2}$
	11%	1.9%	2.6%	5.6%	1.3%	67%	0.046%	11%
HLRW (kg)	$5.42x10^{-7}$	$1.17x10^{-8}$	$1.54x10^{-6}$	$2.55x10^{-8}$	$8.51x10^{-10}$	$4.24x10^{-6}$	$6.50x10^{-10}$	$4.57x10^{-9}$
	8.5%	0.18%	24%	0.4%	0.013%	67%	0.01%	0.072%
ILLRW (kg)	$1.29x10^{-5}$	$1.94x10^{-6}$	$8.37x10^{-6}$	$3.09x10^{-6}$	$1.12x10^{-7}$	$5.34x10^{-5}$	$2.74x10^{-7}$	$8.70x10^{-8}$
	16%	2.4%	10%	3.9%	0.14%	67%	0.34%	0.11%
CRU (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR (kg)	0.00	0.00	0.00	0.00	$1.94x10^{-2}$	$6.68x10^{-2}$	0.00	$1.40x10^{-2}$
	0%	0%	0%	0%	19%	67%	0%	14%
MER (kg)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
EE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

INA = Indicator not assessed | Neg. = Negligible

Table 18. *Life Cycle Impact Assessment (LCIA) results for the Aerocel® Tube White (Aerocel® WG) products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.*

Impact Category	A1	A2	A3	A4	A5	B4	C2	C4
CML-IA								
GWP (kg CO_2 eq)	1.88	0.227	1.35	0.454	0.217	9.65	3.02×10^{-2}	0.665
	13%	1.6%	9.3%	3.1%	1.5%	67%	0.21%	4.6%
ODP (kg CFC-11 eq)	2.23×10^{-7}	3.81×10^{-8}	1.10×10^{-7}	7.97×10^{-8}	4.87×10^{-9}	9.25×10^{-7}	5.26×10^{-9}	2.05×10^{-9}
	16%	2.7%	7.9%	5.7%	0.35%	67%	0.38%	0.15%
AP (kg SO_2 eq)	1.05×10^{-2}	3.39×10^{-3}	6.72×10^{-3}	1.78×10^{-3}	1.51×10^{-4}	4.55×10^{-2}	1.41×10^{-4}	1.08×10^{-4}
	15%	5%	9.8%	2.6%	0.22%	67%	0.21%	0.16%
EP (kg $(PO_4)^{3-}$ eq)	3.35×10^{-3}	4.36×10^{-4}	2.55×10^{-3}	4.23×10^{-4}	3.64×10^{-4}	1.68×10^{-2}	3.04×10^{-5}	1.24×10^{-3}
	13%	1.7%	10%	1.7%	1.4%	67%	0.12%	4.9%
POCP (kg C_2H_4 eq)	7.42×10^{-4}	9.23×10^{-5}	2.96×10^{-4}	6.19×10^{-5}	4.54×10^{-5}	2.61×10^{-3}	4.67×10^{-6}	6.48×10^{-5}
	19%	2.4%	7.5%	1.6%	1.2%	67%	0.12%	1.7%
ADPE (kg Sb eq)	1.31×10^{-8}	1.58×10^{-10}	1.52×10^{-8}	4.66×10^{-10}	1.73×10^{-11}	5.80×10^{-8}	8.25×10^{-12}	3.71×10^{-11}
	15%	0.18%	18%	0.54%	0.02%	67%	0.0095%	0.043%
ADPF (MJ eq)	36.9	3.13	16.5	6.70	0.396	128	0.413	0.196
	19%	1.6%	8.6%	3.5%	0.21%	67%	0.21%	0.1%
TRACI 2.1								
GWP (kg CO_2 eq)	1.86	0.227	1.34	0.452	0.196	9.47	3.02×10^{-2}	0.634
	13%	1.6%	9.4%	3.2%	1.4%	67%	0.21%	4.5%
ODP (kg CFC-11 eq)	2.83×10^{-7}	5.07×10^{-8}	1.33×10^{-7}	1.06×10^{-7}	6.47×10^{-9}	1.18×10^{-6}	7.01×10^{-9}	2.60×10^{-9}
	16%	2.9%	7.5%	6%	0.37%	67%	0.4%	0.15%
AP (kg SO_2 eq)	1.07×10^{-2}	3.65×10^{-3}	6.87×10^{-3}	2.09×10^{-3}	2.16×10^{-4}	4.78×10^{-2}	1.74×10^{-4}	2.02×10^{-4}
	15%	5.1%	9.6%	2.9%	0.3%	67%	0.24%	0.28%
EP (kg N eq)	6.79×10^{-3}	3.05×10^{-4}	5.17×10^{-3}	5.30×10^{-4}	9.18×10^{-4}	3.40×10^{-2}	2.29×10^{-5}	3.28×10^{-3}
	13%	0.6%	10%	1%	1.8%	67%	0.045%	6.4%
SFP (kg O_3 eq)	0.126	7.01×10^{-2}	8.28×10^{-2}	4.97×10^{-2}	4.82×10^{-3}	0.682	4.93×10^{-3}	2.74×10^{-3}
	12%	6.9%	8.1%	4.9%	0.47%	67%	0.48%	0.27%
FFD (MJ eq)	4.45	0.428	1.63	0.901	5.47×10^{-2}	15.1	5.85×10^{-2}	2.28×10^{-2}
	20%	1.9%	7.2%	4%	0.24%	67%	0.26%	0.1%

Table 19. *Resource use and waste flows for the Aerocel® Tube White (Aerocel® WG) products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.*

Parameter	A1	A2	A3	A4	A5	B4	C2	C4
Resources								
RPR_E (MJ)	2.34	$2.83x10^{-2}$	4.29	$7.44x10^{-2}$	$3.89x10^{-3}$	13.5	$1.52x10^{-3}$	$9.16x10^{-3}$
	12%	0.14%	21%	0.37%	0.019%	67%	0.0075%	0.045%
RPR_M (MJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$NRPR_E$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
$NRPR_M$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
SM (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF/NRSF (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
RE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
FW (m^3)	0.102	$1.78x10^{-3}$	0.108	$4.86x10^{-3}$	$3.15x10^{-4}$	0.436	$1.36x10^{-4}$	$1.08x10^{-3}$
	16%	0.27%	16%	0.74%	0.048%	67%	0.021%	0.16%
Wastes								
HWD (kg)	$2.35x10^{-5}$	$5.85x10^{-6}$	$1.68x10^{-5}$	$1.79x10^{-5}$	$1.01x10^{-6}$	$1.34x10^{-4}$	$1.12x10^{-6}$	$8.34x10^{-7}$
	12%	2.9%	8.3%	8.9%	0.5%	67%	0.56%	0.41%
NHWD (kg)	0.543	$8.44x10^{-2}$	0.165	0.321	0.127	3.45	$1.96x10^{-3}$	0.482
	10%	1.6%	3.2%	6.2%	2.5%	67%	0.038%	9.3%
HLRW (kg)	$5.30x10^{-6}$	$1.29x10^{-7}$	$1.70x10^{-5}$	$3.65x10^{-7}$	$2.04x10^{-8}$	$4.58x10^{-5}$	$6.97x10^{-9}$	$4.91x10^{-8}$
	7.7%	0.19%	25%	0.53%	0.03%	67%	0.01%	0.071%
ILLRW (kg)	$1.02x10^{-4}$	$2.12x10^{-5}$	$9.62x10^{-5}$	$4.43x10^{-5}$	$2.70x10^{-6}$	$5.41x10^{-4}$	$2.94x10^{-6}$	$9.34x10^{-7}$
	13%	2.6%	12%	5.5%	0.33%	67%	0.36%	0.12%
CRU (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR (kg)	0.00	0.00	0.00	0.00	0.465	1.23	0.00	0.150
	0%	0%	0%	0%	25%	67%	0%	8.1%
MER (kg)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
EE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

INA = Indicator not assessed | Neg. = Negligible

Table 20. *Life Cycle Impact Assessment (LCIA) results for the Aerocel® ULP® (Ultra Low Perm) products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.*

Impact Category	A1	A2	A3	A4	A5	B4	C2	C4
CML-IA								
GWP (kg CO_2 eq)	0.542	6.67×10^{-2}	0.417	0.143	7.21×10^{-2}	2.90	9.06×10^{-3}	0.200
	12%	1.5%	9.6%	3.3%	1.7%	67%	0.21%	4.6%
ODP (kg CFC-11 eq)	8.45×10^{-8}	1.12×10^{-8}	3.39×10^{-8}	2.51×10^{-8}	1.62×10^{-9}	3.17×10^{-7}	1.58×10^{-9}	6.15×10^{-10}
	18%	2.4%	7.1%	5.3%	0.34%	67%	0.33%	0.13%
AP (kg SO_2 eq)	3.00×10^{-3}	9.96×10^{-4}	2.06×10^{-3}	5.61×10^{-4}	5.03×10^{-5}	1.35×10^{-2}	4.24×10^{-5}	3.25×10^{-5}
	15%	4.9%	10%	2.8%	0.25%	67%	0.21%	0.16%
EP (kg $(PO_4)^{3-}$ eq)	8.97×10^{-4}	1.28×10^{-4}	7.93×10^{-4}	1.33×10^{-4}	1.21×10^{-4}	4.91×10^{-3}	9.13×10^{-6}	3.72×10^{-4}
	12%	1.7%	11%	1.8%	1.6%	67%	0.12%	5%
POCP (kg C_2H_4 eq)	1.86×10^{-4}	2.71×10^{-5}	9.13×10^{-5}	1.95×10^{-5}	1.51×10^{-5}	7.21×10^{-4}	1.40×10^{-6}	1.94×10^{-5}
	17%	2.5%	8.5%	1.8%	1.4%	67%	0.13%	1.8%
ADPE (kg Sb eq)	4.34×10^{-9}	4.65×10^{-11}	4.55×10^{-9}	1.47×10^{-10}	5.75×10^{-12}	1.82×10^{-8}	2.48×10^{-12}	1.11×10^{-11}
	16%	0.17%	17%	0.54%	0.021%	67%	0.0091%	0.041%
ADPF (MJ eq)	12.3	0.919	5.07	2.11	0.132	41.4	0.124	5.86×10^{-2}
	20%	1.5%	8.2%	3.4%	0.21%	67%	0.2%	0.094%
TRACI 2.1								
GWP (kg CO_2 eq)	0.534	6.65×10^{-2}	0.413	0.142	6.54×10^{-2}	2.84	9.05×10^{-3}	0.190
	13%	1.6%	9.7%	3.3%	1.5%	67%	0.21%	4.5%
ODP (kg CFC-11 eq)	1.09×10^{-7}	1.49×10^{-8}	4.10×10^{-8}	3.34×10^{-8}	2.15×10^{-9}	4.07×10^{-7}	2.10×10^{-9}	7.80×10^{-10}
	18%	2.4%	6.7%	5.5%	0.35%	67%	0.34%	0.13%
AP (kg SO_2 eq)	3.06×10^{-3}	1.07×10^{-3}	2.11×10^{-3}	6.57×10^{-4}	7.19×10^{-5}	1.42×10^{-2}	5.23×10^{-5}	6.05×10^{-5}
	14%	5%	9.9%	3.1%	0.34%	67%	0.25%	0.28%
EP (kg N eq)	1.80×10^{-3}	8.97×10^{-5}	1.61×10^{-3}	1.67×10^{-4}	3.05×10^{-4}	9.92×10^{-3}	6.88×10^{-6}	9.84×10^{-4}
	12%	0.6%	11%	1.1%	2.1%	67%	0.046%	6.6%
SFP (kg O_3 eq)	3.70×10^{-2}	2.06×10^{-2}	2.57×10^{-2}	1.56×10^{-2}	1.60×10^{-3}	0.206	1.48×10^{-3}	8.23×10^{-4}
	12%	6.7%	8.3%	5.1%	0.52%	67%	0.48%	0.27%
FFD (MJ eq)	1.53	0.126	0.506	0.284	1.82×10^{-2}	4.97	1.76×10^{-2}	6.83×10^{-3}
	20%	1.7%	6.8%	3.8%	0.24%	67%	0.24%	0.092%

Table 21. *Resource use and waste flows for the Aerocel® ULP® (Ultra Low Perm) products over a 75-yr time horizon. Results reported in MJ are calculated using lower heating values. All values are rounded to three significant digits.*

Parameter	A1	A2	A3	A4	A5	B4	C2	C4
Resources								
RPR_E (MJ)	0.530	$8.30x10^{-3}$	1.40	$2.34x10^{-2}$	$1.30x10^{-3}$	3.94	$4.57x10^{-4}$	$2.75x10^{-3}$
	9%	0.14%	24%	0.4%	0.022%	67%	0.0077%	0.047%
RPR_M (MJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$NRPR_E$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
$NRPR_M$ (MJ)	INA	INA	INA	INA	INA	INA	INA	INA
SM (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF/NRSF (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
RE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
FW (m^3)	$2.93x10^{-2}$	$5.23x10^{-4}$	$3.28x10^{-2}$	$1.53x10^{-3}$	$1.05x10^{-4}$	0.129	$4.08x10^{-5}$	$3.24x10^{-4}$
	15%	0.27%	17%	0.79%	0.054%	67%	0.021%	0.17%
Wastes								
HWD (kg)	$7.01x10^{-6}$	$1.72x10^{-6}$	$5.26x10^{-6}$	$5.64x10^{-6}$	$3.36x10^{-7}$	$4.11x10^{-5}$	$3.37x10^{-7}$	$2.50x10^{-7}$
	11%	2.8%	8.5%	9.2%	0.55%	67%	0.55%	0.41%
NHWD (kg)	0.144	$2.48x10^{-2}$	$5.26x10^{-2}$	0.101	$4.22x10^{-2}$	1.02	$5.87x10^{-4}$	0.144
	9.4%	1.6%	3.4%	6.6%	2.8%	67%	0.038%	9.4%
HLRW (kg)	$1.72x10^{-6}$	$3.78x10^{-8}$	$5.10x10^{-6}$	$1.15x10^{-7}$	$6.79x10^{-9}$	$1.40x10^{-5}$	$2.09x10^{-9}$	$1.47x10^{-8}$
	8.2%	0.18%	24%	0.55%	0.032%	67%	0.01%	0.07%
ILLRW (kg)	$4.23x10^{-5}$	$6.23x10^{-6}$	$2.90x10^{-5}$	$1.40x10^{-5}$	$8.97x10^{-7}$	$1.87x10^{-4}$	$8.81x10^{-7}$	$2.80x10^{-7}$
	15%	2.2%	10%	5%	0.32%	67%	0.31%	0.1%
CRU (kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR (kg)	0.00	0.00	0.00	0.00	0.155	0.400	0.00	$4.52x10^{-2}$
	0%	0%	0%	0%	26%	67%	0%	7.5%
MER (kg)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
EE (MJ)	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.

INA = Indicator not assessed | Neg. = Negligible

6. LCA: Interpretation

The interpretation phase conforms to ISO 14044 with further guidance from the ILCD General Guide for Life Cycle Assessment. The interpretation included the use of evaluation and sensitivity checks to steer the iterative process during the assessment, and a final evaluation including completeness, sensitivity, and consistency checks, at the end of the study.

The contributions to total impact indicator results are dominated by the product replacement phase (B4) of the assessment which account for approximately 67% of total impacts. Of the remaining life cycle phases, the raw material extraction and processing phase is generally the largest contributor to the overall impacts, followed by product manufacturing (A3), product distribution (A4) and upstream material transport (A2). Other life cycle phase contributions are minimal.

Figure 3. *Contribution analysis for the Aerocel® ULP® insulation products – TRACI 2.1. (Excluding product replacements)*

Figure 4. *Contribution analysis for the Aerocel® REF™ insulation products – TRACI 2.1. (Excluding product replacements)*

Figure 5. *Contribution analysis for the Aerocel® Tube Black (Aerocel® AC) insulation products – TRACI 2.1. (Excluding product replacements)*

Figure 6. *Contribution analysis for the Aerocel® Tube White (Aerocel® WG) insulation products – TRACI 2.1. (Excluding product replacements)*

Figure 7. *Contribution analysis for the Aerocel® SSPT™ Tube black (Aerocel® SSPT™ AC) insulation products – TRACI 2.1. (Excluding product replacements)*

7. Additional Environmental Information

Aeroflex USA does not use CFCs, HFCs, or HCFCs in its manufacturing process.

8. References

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