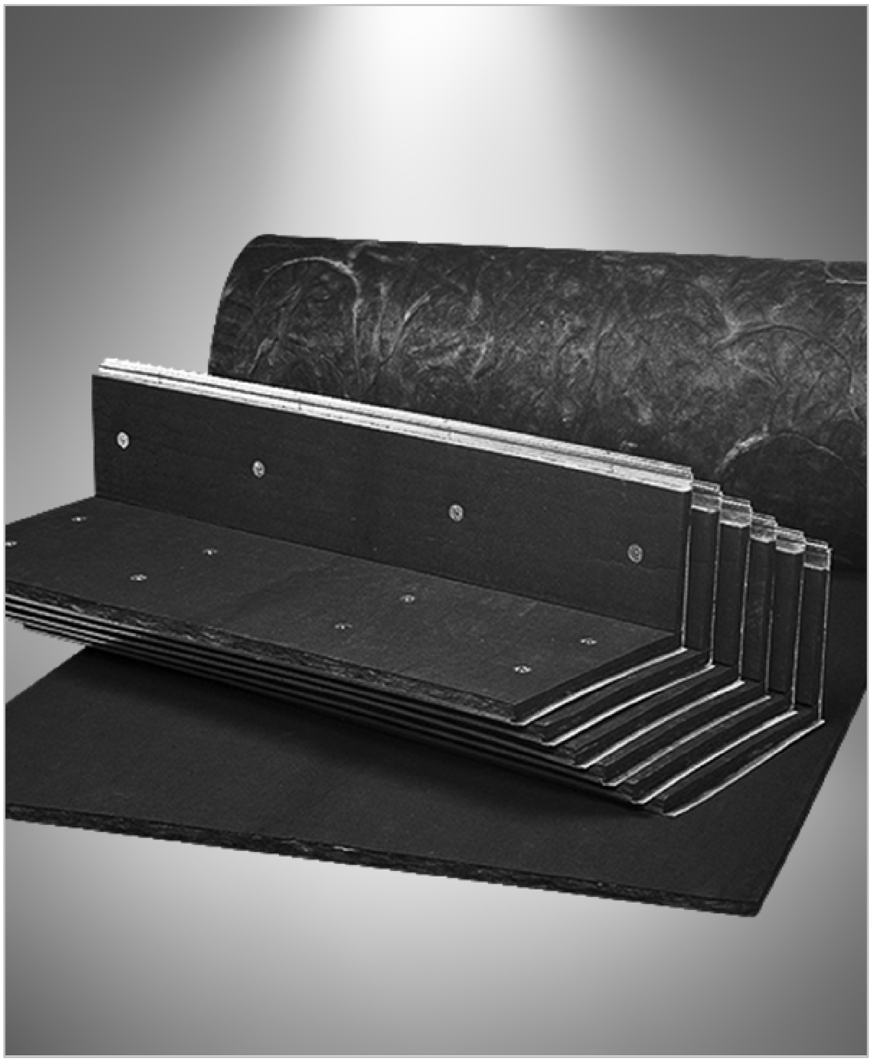
Environmental Product Declaration

Duct Liner

Linacoustic® RC • Linacoustic® RC-IG • Permacote® Linacoustic® RC-HP • Duct Liner PM



Think JM.

Linacoustic® RC/RC-IG/RC-HP is a fiber glass duct liner used to improve thermal and acoustical performance in metal ducts. Above: Fabricated Linacoustic RC/RC-IG/RC-HP and Linacoustic RC/RC-IG/RC-HP roll, manufactured in Cleburne, Texas

Johns Manville
A Berkshire Hathaway Company

At Johns Manville, product performance and corporate accountability are top priorities. We ensure that each of our HVAC insulation products not only performs but also contributes to the health, safety, and sustainability of the environments where they are used.

We strive to ensure that our products meet the rigorous demands of their applications while focusing on finding new ways to reduce our environmental footprint. We want to provide you with reliable materials that will allow you to do the same.

As a company, we are committed to evolving to help create a sustainable world for our future. When it comes to making decisions about your environmental impact, don't think just insulation, think JM.

PEOPLE • PASSION • PERFORM • PROTECT

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

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LINACOUSTIC® RC • LINACOUSTIC® RC-IG • PERMACOTE® LINACOUSTIC® • DUCT LINER PM
DUCT LINER – MECHANICAL INSULATION

According to ISO 14025, EN 15804 and ISO21930:2017

EPD PROGRAM AND PROGRAM OPERATOR NAME, ADDRESS, LOGO, AND WEBSITE	UL Environment 333 Pfingsten Road Northbrook, IL 60611 WWW.UL.COM www.spot.ul.com
GENERAL PROGRAM INSTRUCTIONS AND VERSION NUMBER	Program Operator Rules v2.7 2022
MANUFACTURER NAME AND ADDRESS	Johns Manville 717 17th Street, Denver, CO 80202
DECLARATION NUMBER	4790545973.107.1
DECLARED PRODUCT & FUNCTIONAL UNIT OR DECLARED UNIT	Duct liner insulation, 1 m^2
REFERENCE PCR AND VERSION NUMBER	Part A: Product Category Rules for Building-Related Products and Services, UL 10010, v3.2 Part B: Mechanical, Specialty, Thermal, and Acoustic Insulation Product EPD Requirements
DESCRIPTION OF PRODUCT APPLICATION/USE	Mechanical insulation
PRODUCT RSL DESCRIPTION (IF APPL.)	N/A
MARKETS OF APPLICABILITY	North America
DATE OF ISSUE	September 28, 2022
PERIOD OF VALIDITY	5 Years
EPD TYPE	Company-specific
RANGE OF DATASET VARIABILITY	n/a
EPD SCOPE	Cradle to gate with options (A4, A5, C1-C4)
YEAR(S) OF REPORTED PRIMARY DATA	July 2020 to June 2021
LCA SOFTWARE & VERSION NUMBER	GaBi 10.5
LCI DATABASE(S) & VERSION NUMBER	GaBi 2021 (CUP 2021.2)
LCIA METHODOLOGY & VERSION NUMBER	TRACI 2.1 and CML v4.2

The PCR review was conducted by:	UL Environment PCR Review Panel epd@ul.com
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ INTERNAL ☒ EXTERNAL	Cooper McCollum, UL Environment
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	Sphera Solutions
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	James Mellentine, Thrive ESG

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.

Product Definition and Information

Description of Organization

For more than 160 years, Johns Manville (JM) has been dedicated to providing products that improve energy efficiency, and contribute to the health and comfort of building occupants.

Johns Manville manufactures premium-quality building and mechanical insulation, commercial roofing, glass fibers and nonwoven materials for commercial, industrial and residential applications. JM products are used in a wide variety of industries including building products, aerospace, automotive and transportation, filtration, commercial interiors, waterproofing and wind energy.

JM employs 7,000 people globally and provides products to more than 85 countries. We operate 44 manufacturing facilities in North America, Europe, and China. Since 1988, JM's global headquarters has been located in downtown Denver, Colorado.

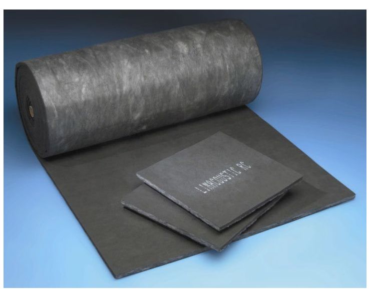
Product Description

Product Identification

The following Johns Manville duct liner products are covered by this environmental product declaration:

- Linacoustic® RC
- Linacoustic® RC-IG
- Permacote® Linacoustic® RC-HP
- Duct Liner PM

Product Specification



Linacoustic® RC

Linacoustic® RC insulation is a flexible duct liner made from resilient glass fibers bonded with a thermosetting resin. The airstream surface is protected with JM's exclusive Reinforced Coating system, which combines our state-of-the-art Permacote® acrylic coating with a flexible glass mat reinforcement to provide a smooth airstream surface. In order to protect the coating system from damage caused by mold and mildew, the coating is treated with anantimicrobial agent.

Linacoustic RC duct liner has many advantages:

- **Improved Indoor Building Environment.** Linacoustic RC duct liner improves indoor environmental quality by helping to control both temperature and sound.
- **Resistant to Dust and Dirt.** The tough, acrylic polymer coating, Permacote, helps guard against the incursion of dust or dirt into the substrate.
- **Improved fiber shedding.** Permacote was designed to prevent fiber shedding.
- **Will Not Support Microbial Growth.** Permacote is formulated with an immobilized, EPA-registered anti-microbial agent in order to protect the coating from damage caused by potential fungi or bacterial growth.
- **Highly Resistant to Water.** Linacoustic RC's reinforced surface-coating provides superior resistance to incidental water penetration into the fiber glass core.

- **Cleanability.** If HVAC system cleaning is required, the airstream surface may be cleaned with industry-recognized dry methods. See the North American Insulation Manufacturers Association (NAIMA) "Cleaning Fibrous Glass Insulated Air Duct Systems."

Linacoustic® RC-IG duct liner offers the same benefits as Linacoustic RC, with one additional advantage:

- **Exclusive propietary InsuGrip adhesive layer** Linacoustic® RC-IG has a preapplied non-toxic, water reactivated adhesive layer for easier, cleaner, and quicker installtion on sheet metal.

Linacoustic® RC-HP

Linacoustic® RC-HP is a flexible glass duct liner with a glass mat facing and an EPA-registerd antimicrobial top and edge coating to protect the product from damage caused by mold or mildew growth. It is designed for lining sheet metal ducts in air conditioning, heating and ventilating systems.

Linacoustic® RC-HP duct liner offers the same benefits as Linacoustic RC, with two additional advantages:

- **Improved Acoustical Value.** Linacoustic® RC-HP has a higher density than Linacoustic RC. This creates a higher noise reduction coefficient (NRC), improving the acoustical performance of Linacoustic RC-HP in building enviroments.
- **Improved Thermal Value.** The increased density of Linacoustic® RC-HP creates a slightly improved R-value which accounts for the better thermal performance of Linacoustic® RC-HP.

Duct Liner PM

Duct Liner PM is a flexible duct liner insulation made from resilient glass fibers bonded with a thermosetting resin. The airstream glass mat surface includes an EPA registered antimicrobial agent to protect it from damage that could be caused by mold and mildew. Duct Liner PM is the basic liner product offered by Johns Manville. Duct Liner PM meets the requirements of the NAIMA Fibrous Glass Duct Liner Standards as well as the SMACNA HVAC Duct Construction Standards.

Flow Diagram

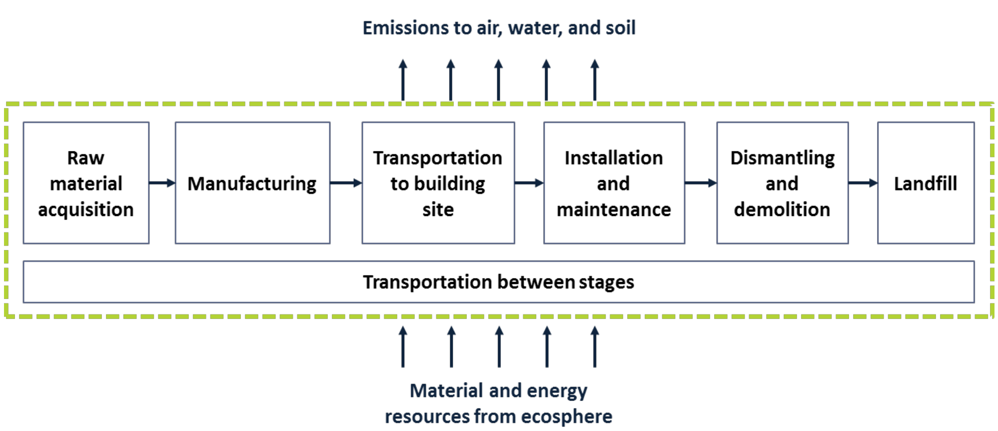


Figure 1: Flow diagram for duct liner manufacturing

Product Average

This EPD is intended to represent company-specific duct liner products. The results for the final products are calculated for the Johns Manville production site located in Cleburne, Texas, US. Use of this EPD is limited to Johns Manville.

Application

Linacoustic RC/RC-IG/RC-HP and Duct Liner PM are specifically designed for lining sheet metal ducts in air conditioning, heating and ventilating systems. These duct liners are engineered to provide superior acoustical performance and thermal control in applications that operate at 250°F (121°C) or below.

Declaration of Methodological Framework

This EPD is declared under a “cradle-to-installation with end-of-life” system boundary. As such, it includes life cycle stages A1-A5 and C1-C4. It should be noted here that, C1 and C3 are to be reported as zero as they are assumed to fall below the cut-off criteria defined by ISO 21930. C2 is assumed as 20 km by truck.

Per the PCR (UL Environment, 2018), the assessment was conducted using a building service life of 75 years.

Technical Requirements

The technical specifications apply to products considered in this EPD:

- ASTM C1071 – Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
- ICC Compliant
- California Title 24
- MEA# 353-93-M
- ASHRAE 62
- SMACNA Application Standards for Duct Liners
- NAIMA Fibrous Glass Duct Liner Installation Standard
- Additionally, the the following fire-related standards and test methods apply:
- ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials
- UL 723 – Standard for Test for Surface Burning Characteristic of Building Materials test
- NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials
- NFPA 90A and 90B - Standard for the Installation of Air-Conditioning and Ventilating Systems, and NFPA 90B is the Standard for the Installation of Warm Air Heating and Air-Conditioning Systems
- NFPA 259 CAN/ULC S102 - Standard Test Method for Potential Heat of Building Materials

Properties of Declared Product as Delivered

Duct liner is delivered to the site of installation as packaged.

Material Composition

Table 1: Duct liner material composition (per % weight)

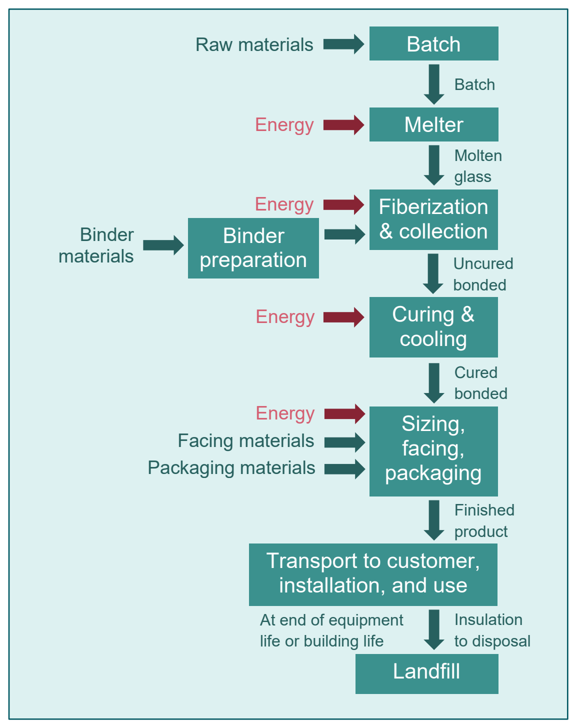
COMPONENTS	VALUE (% WEIGHT)
Sand	46.4%
Nepheline syenite	5%
Soda ash	15.5%
Borax	10.5%
Burnt dolomitic lime	5.7%
Fluorspar	0.2%
Barytes	0.2%
Binder	16.5%

Manufacturing

This Environmental Product Declaration (EPD) represents the production of Johns Manville duct liner at Cleburne, Texas (United States).

The life cycle of the product under study begins with the extraction and processing of the raw materials that constitute the batch. Together, these materials (sand, borax, soda ash, recycled glass, and minerals) are melted. The molten glass is formed into fibers and a thermosetting binder is applied. The bonded product is then formed into insulation of the required configuration and specifications. After curing with hot air through convection and cooling, the product is cut into the desired width, faced with an acrylic latex coating (if applicable), and sent to the packaging line.

Figure 2: Production and life cycle stages



Packaging

Packaging of the finished product for shipment comprises shrink film and polyester bags.

Transportation

Reported transportation distances via truck and rail are included for the inbound transport of raw materials to the production facility. Distribution of the finished product to the construction site is estimated at 250 miles via heavy-duty truck and assumed to be volume-limited rather than mass-limited, with a utilization rate of 28% of mass capacity.

Product Installation

Johns Manville duct liner installation must be performed in accordance with the requirements of the NAIMA Fibrous Glass Duct Liner Standards or SMACNA HVAC Duct Construction Standard (NAIMA, 2021). All transverse edges, or any edges exposed to airflow, must be coated with an approved duct liner coating material, such as Johns Manville SuperSeal products.

Linacoustic RC/RC-IG/RC-HP and Duct Liner PM are highly usable, resilient duct liner insulations. This facilitates efficient fabrication and installation, and reduces inventory loss during transportation and construction.

- **Minimizes Pre-installation Damage.** The durable, glass-mat facing is resistant to damage that can occur during in-shop handling, fabrication, jobsite shipping and installation.
- **Easy to Fabricate.** Linacoustic RC/RC-IG/RC-HP and Duct Liner PM are lightweight and easy to handle. The fiber glass is consistent throughout the core, making it easier to cut clean, even edges with regular shop tools.

Use

Duct insulation is assumed to have a reference service life of 75 years, equal to that of the building. Once installed, insulation does not directly consume energy, but instead, contributes to a reduction in the amount of energy required to heat and cool the building. The insulation requires no maintenance, and there are no parts to repair or refurbish. Any reduction in building operational energy consumption associated with insulation use needs to be considered on the level of the individual building and is considered outside the scope of this LCA. Fiberglass insulations on average save in the first month or two all the energy used to make them.

Reference Service Life and Estimated Building Service Life

The use phase is considered to be burden-free for insulation products as they require no maintenance and have a 75-year reference service life equal to that of the entire building.

Reuse, Recycling, and Energy Recovery

When the building is demolished, the insulation is assumed to be sent to landfill. While insulation can theoretically be reused or recycled, doing so is not common practice in the industry.

Disposal

At end-of-life, insulation is removed from the deconstructed building. Wastes are then disposed in a landfill. Therefore, the analysis assumes that after removal, the insulation is transported to the disposal site and landfilled.

Life Cycle Assessment Background Information

Declared Unit

Per the PCR, the declared unit for this analysis is *1 m² of insulation material as delivered, with a building service life* (RSL) *of 75 years*.

Table 2 shows the declared unit along with its specific thickness and mass reference flow.

Table 2: declared unit and subsequent product attributes

	AREA [M^2]	R_{SI} [M^2K/W]	R_{US} [BTU/(H °F FT^2)]	RSL [YEARS]	THICKNESS [IN]	MASS [KG]
Functional Unit	1	1	5.68	75	1.35	0.942

Duct liner insulation is produced with a Permacote acrylic coated glass mat facing area that is added during manufacturing. The declared unit of the duct liner facing is 1 m^2 as seen in table 3 below.

Table 3: Declared unit of glass mat facing for duct liner

	AREA (M^2)	RSL [YEARS]	DENSITY [KG/M^2]	MASS [KG]
Declared Unit	1	75	0.056	0.056

System Boundary

Table 4 represents the system boundary and scope.

Table 4: 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	X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	X	X	X	X	MND

This study covers the life cycle of the products from cradle to gate (installation) with end-of-life options. Within these boundaries, the following stages were included as per Figure 3 below:

- **Raw materials acquisition:** Raw material supply (including virgin and recycled materials), inbound transport
- **Manufacturing:** Production of insulation, product packaging, manufacturing waste, releases to environment
- **Transportation:** Distribution of the insulation product from the manufacturer to a distributor (if applicable) and from there, to the building site
- **Installation and Maintenance:** Installation process, installation wastes and releases to the environment, maintenance under normal conditions
- **End-of-Life:** Dismantling/demolition, transport to final disposal site, final disposition

Building operational energy and water use are considered outside of this study's scope: any beneficial impact that the use of insulation may have on a building's energy consumption is not calculated or incorporated into the analysis.

Figure 3: Life cycle stages included in the system boundary

Estimates and Assumptions

The analysis uses the following assumptions:

- Insulation is assumed to have a 75-year reference service life, equal to that of the building.
- Installation is done by hand and assumed to have a negligible scrap rate (0%).

Since primary data were not available to describe end-of-life treatment, the default values specified by the PCR Part A (UL Environment, 2018) were applied (Table 5).

Table 5. Default end-of-life assumptions from the PCR

COMPONENT	RECYCLED	LANDFILLED	INCINERATED
Product	0%	100%	0%
Paper packaging	75%	20%	5%
Plastic packaging	15%	68%	17%

Cut-off Criteria

Cut-off criteria were applied to capital equipment production and maintenance under the assumption that the impacts associated with these aspects were sufficiently small enough to fall below cut-off when scaled down to the functional unit. All energy and material flow data available were included in the model. In addition, biogenic carbon has also been excluded as the overall difference in GWP result is less than 2%.

Data Sources

The LCA model was created using the GaBi 10.5. Software system for life cycle engineering, developed by Sphera Inc. (Sphera, 2021). Background life cycle inventory data for raw materials and processes were obtained from the GaBi CUP 2021.2 database. Primary manufacturing data were provided by Johns Manville.

Data Quality

A variety of tests and checks were performed throughout the project to ensure high quality of the completed LCA. Checks included a review of project specific LCA models as well as the background data used.

Geographical Coverage
In order to satisfy cut-off criteria, proxy datasets were used as needed for raw material inputs to address lack of data for a specific material or for a specific geographical region. These proxy datasets were chosen for their representativeness of the actual product. Additionally, European data or global data were used when North American data (for raw materials sourced in the US) were not available.

Temporal Coverage
Foreground data for each manufacturer represent a continuous 12-months from July 2020 – June 2021. The majority of background datasets are based on data from the last 10 years (since 2017).

Technological Coverage

The primary data represent production of the products under evaluation. Secondary data were chosen to be specific to the technologies in question (or appropriate proxy data used where necessary).

Completeness

Foreground processes were checked for mass balance and completeness of the emissions inventory. No data were knowingly omitted.

Period under Review

Primary data were collected on insulation production in July 2020 – June 2021.

Allocation

No multi-output (i.e., co-product) allocation was performed in the foreground system of this study. No known flows are deliberately excluded from this EPD.

Allocation of background data (energy and materials) taken from the GaBi 2021 databases is documented online at https://sphera.com/wp-content/uploads/2020/04/Modeling-Principles-GaBi-Databases-2021.pdf.

Allocation of manufacturing material and energy inputs was done on a mass basis. Allocation of transportation was based on mass while considering the utilization rate.

For recycled content and disposal at end-of-life, system boundaries were drawn consistent with the cut-off allocation approach. Likewise, the system boundary was drawn to include landfilling of fiberglass at end-of-life (following the polluter-pays principle) but exclude any avoided burdens from material or energy recovery.

Data collection was performed by Johns Manville reaching out directly to plant facility managers. Specific data were collected for raw material use; however, energy use posed a considerable challenge to attribute to the products. The only exception was natural gas, where process-level boiler and furnace energy use was available. For electricity and other facility fuel use, only site-level and multi-process data were available. These data were normalized by the mass of product manufactured at the facility over the temporal scope. Air emissions were also unavailable at the process-level; therefore, a facility air emission report was leveraged to attribute the emissions to per declared unit of product.

Comparability

No comparisons or benchmarking is included in this EPD.

Life Cycle Assessment Scenarios

Duct liner insulation requires no maintenance, and there are no parts to repair or refurbish. The reference service life for the duct liner insulation product is 75 years. Installation is done by hand with only packaging waste generated during that step.

Table 6. Transport to the building site (A4) (based on material properties described in Table 2)

NAME	VALUE	UNIT
Fuel type	Diesel	
Liters of fuel	0.0011	L/100 km
Vehicle type	Heavy Duty Truck	
Transport distance	402	km
Capacity utilization (including empty runs, mass based	67	%
Gross density of products transported	27.5	kg/m^3

Table 7. Installation (A5) and RSL information

INSTALLATION INTO THE BUILDING (A5)	DUCT LINER	FACING	UNIT
Ancillary materials (plastic packaging)	0.0033	-	kg
REFERENCE SERVICE LIFE	**DUCT LINER**	**FACING**	**UNIT**
RSL	75	75	years

Table 8. End of life (C1-C4)

NAME		DUCT LINER	FACING	UNIT
Assumptions for scenario development (description of deconstruction, collection, recovery, disposal method and transportation)		landfill	landfill	100%
Collection process (specified by type)	Collected separately	-	-	kg
	Collected with mixed construction waste	0.942	0.056	kg
Recovery (specified by type)	Reuse	-	-	kg
	Recycling	-	-	kg
	Landfill	0.942	0.056	kg
	Incineration	-	-	kg
	Incineration with energy recovery	-	-	kg
	Energy conversion efficiency rate	-	-	
Disposal (specified by type)	Product or material for final deposition	0.942	0.056	kg
Removals of biogenic carbon (excluding packaging)		-	-	kg CO_2

Life Cycle Assessment Results

The following results are based on a declared unit of 1 m^2 of duct liner insulation and 1 m^2 of facing. The following results exclude biogenic carbon as there are no relevant biogenic carbon removals or emissions in the life cycle. There is no calcination, carbonation and combustion of waste from non-renewable sources.

Impact assessment and other results are shown for a cradle-to-installation with end-of-life options (C1-C4). Modules C1 and C3 are not associated with any impact and are therefore declared as zero.

Life Cycle Impact Assessment Results

Table 9. North American impact assessment (TRACI) results for duct liner (1 m^2, unfaced)

TRACI v2.1	Units	A1- A3 Product Stage	A4 Product delivery	A5 Construction Stage	C2 Transport to End of Life	C4 Disposal at End of Life
Global warming potential	kg CO_2 eq.	2.74E+00	6.66E-02	1.58E-03	2.46E-03	4.15E-02
Depletion potential of the stratospheric ozone	kg CFC11 eq.	4.48E-15	1.30E-17	4.45E-19	4.83E-19	1.38E-16
Acidification potential	kg SO_2 eq.	9.33E-03	3.52E-04	8.93E-07	6.90E-06	1.77E-04
Eutrophication potential	kg N eq.	8.77E-04	3.21E-05	6.48E-07	7.95E-07	9.83E-06
Smog formation potential	kg O_3 eq.	9.80E-02	8.15E-03	1.12E-05	1.57E-04	3.14E-03
Abiotic depletion potential for fossil resources	MJ, surplus	1.00E+01	1.22E-01	2.82E-04	4.54E-03	8.07E-02

Table 10. North American impact assessment (TRACI) results for duct liner (1 m^2, Facing)

TRACI v2.1	Units	A1- A3 Product Stage	A4 Product delivery	A5 Construction Stage	C2 Transport to End of Life	C4 Disposal at End of Life
Global warming potential	kg CO_2 eq.	1.17E-01	-	-	1.61E-07	2.72E-06
Depletion potential of the stratospheric ozone	kg CFC11 eq.	2.10E-15	-	-	3.17E-23	9.07E-21
Acidification potential	kg SO_2 eq.	6.24E-04	-	-	4.52E-10	1.16E-08
Eutrophication potential	kg N eq.	3.15E-05	-	-	5.21E-11	6.44E-10
Smog formation potential	kg O_3 eq.	5.00E-03	-	-	1.03E-08	2.06E-07
Abiotic depletion potential for fossil resources	MJ, Surplus	2.30E-01	-	-	2.97E-07	5.29E-06

Table 11. EU impact assessment (CML) results for duct liner (1 m^2, Unfaced)

CML v4.2	Units	A1- A3 Product Stage	A4 Product delivery	A5 Construction Stage	C2 Transport to End of Life	C4 Disposal at End of Life
Global warming potential	kg CO_2 eq.	2.63E+00	6.58E-02	1.58E-03	2.44E-03	4.07E-02
Depletion potential of the stratospheric ozone	kg R 11 eq.	4.48E-15	1.30E-17	4.45E-19	4.83E-19	1.38E-16
Acidification potential	kg SO_2 eq.	7.30E-03	2.55E-04	7.84E-07	5.08E-06	1.63E-04
Eutrophication potential	kg P eq.	1.55E-03	7.37E-05	6.81E-07	1.58E-06	2.18E-05
Photochemical oxidant creation potential	kg C_2H_2 eq.	7.08E-04	-9.54E-05	1.64E-08	-1.71E-06	1.55E-06
Abiotic depletion potential, fossil resources	MJ	7.24E+01	9.16E-01	2.30E-03	3.40E-02	6.20E-01
Abiotic depletion potential, non-fossil resources	kg Sb eq.	8.25E-05	2.05E-08	6.46E-11	7.61E-10	1.79E-08

Table 12. EU impact assessment (CML) results for duct liner (1 m², Facing)

CML v4.2	Units	A1- A3 Product Stage	A4 Product delivery	A5 Construction Stage	C2 Transport to End of Life	C4 Disposal at End of Life
Global warming potential	kg CO_2 eq.	1.15E-01	-	-	1.60E-07	2.67E-06
Depletion potential of the stratospheric ozone	kg R 11 eq.	2.10E-15	-	-	3.17E-23	9.07E-21
Acidification potential	kg SO_2 eq.	6.34E-04	-	-	3.33E-10	1.06E-08
Eutrophication potential	kg P eq.	4.61E-05	-	-	1.04E-10	1.43E-09
Photochemical oxidant creation potential	kg C_2H_2 eq.	4.49E-05	-	-	-1.12E-10	1.01E-10
Abiotic depletion potential, fossil resources	MJ	1.87E+00	-	-	2.23E-06	4.07E-05
Abiotic depletion potential, non-fossil resources	kg Sb eq.	4.44E-06	-	-	4.99E-14	1.17E-12

Life Cycle Inventory Results

Table 13. Resource use for duct liner (1 m², Unfaced)

	Units	A1- A3 Product Stage	A4 Product delivery	A5 Construction Stage	C2 Transport to End of Life	C4 Disposal at End of Life
Renewable primary energy as energy carrier	MJ	2.67E+00	3.80E-02	1.69E-04	1.41E-03	5.27E-02
Renewable primary energy as material utilization	MJ	-	-	-	-	-
Total use of renewable primary energy resources	MJ	2.67E+00	3.80E-02	1.69E-04	1.41E-03	5.27E-02
Non-renewable primary energy as energy carrier	MJ	7.28E+01	9.22E-01	2.36E-03	3.43E-02	6.34E-01
Non-renewable primary energy as material utilization	MJ	1.07E+00	-	-	-	-
Total use of non-renewable primary energy resources	MJ	7.39E+01	9.22E-01	2.36E-03	3.43E-02	6.34E-01
Use of secondary material	kg	-	-	-	-	-
Use of renewable secondary fuels	MJ	-	-	-	-	-
Use of non-renewable secondary fuels	MJ	-	-	-	-	-
Use of recovered energy	MJ	-	-	-	-	-
Use of net fresh water	m^3	4.56E-03	1.62E-04	2.89E-06	6.03E-06	8.71E-05

Table 14. Resource use for duct liner (1 m², Facing)

	Units	A1- A3 Product Stage	A4 Product delivery	A5 Construction Stage	C2 Transport to End of Life	C4 Disposal at End of Life
Renewable primary energy as energy carrier	MJ	3.86E-01	-	-	9.25E-08	3.45E-06
Renewable primary energy as material utilization	MJ	-	-	-	-	-
Total use of renewable primary energy resources	MJ	3.86E-01	-	-	9.25E-08	3.45E-06
Non-renewable primary energy as energy carrier	MJ	1.99E+00	-	-	2.24E-06	4.15E-05
Non-renewable primary energy as material utilization	MJ	-	-	-	-	-
Total use of non-renewable primary energy resources	MJ	1.99E+00	-	-	2.24E-06	4.15E-05
Use of secondary material	kg	-	-	-	-	-
Use of renewable secondary fuels	MJ	-	-	-	-	-
Use of non-renewable secondary fuels	MJ	-	-	-	-	-

Use of recovered energy	MJ	-	-	-	-	-
Use of net fresh water	m³	4.24E-04	-	-	3.95E-10	5.71E-09

Table 15. Output Flows and Waste Categories for duct liner (1 m^2, Unfaced)

	UNITS	A1- A3 PRODUCT STAGE	A4 PRODUCT DELIVERY	A5 CONSTRUCTION STAGE	C2 TRANSPORT TO END OF LIFE	C4 DISPOSAL AT END OF LIFE
Hazardous waste disposed	kg	7.94E-09	7.71E-11	2.08E-13	2.86E-12	5.99E-11
Non-hazardous waste disposed	kg	1.68E-01	8.48E-05	2.53E-03	3.15E-06	9.44E-01
High-level radioactive waste	kg	7.06E-07	3.11E-09	3.06E-11	1.15E-10	6.11E-09
Intermediate and low-level radioactive waste	kg	1.95E-05	8.55E-08	8.29E-10	3.17E-09	1.63E-07
Components for re-use	kg	-	-	-	-	-
Materials for recycling	kg	-	-	5.28E-04	-	-
Materials for energy recovery	kg	-	-	-	-	-
Recovered energy exported from the product system	kg	-	-	-	-	-

Table 16. Output flows and waste categories for duct liner (1 m^2, Facing)

	UNITS	A1- A3 PRODUCT STAGE	A4 PRODUCT DELIVERY	A5 CONSTRUCTION STAGE	C2 TRANSPORT TO END OF LIFE	C4 DISPOSAL AT END OF LIFE
Hazardous waste disposed	kg	5.37E-10	-	-	1.88E-16	3.93E-15
Non-hazardous waste disposed	kg	1.52E-02	-	-	2.06E-10	6.19E-05
High-level radioactive waste	kg	5.34E-08	-	-	7.56E-15	4.01E-13
Intermediate and low-level radioactive waste	kg	1.41E-06	-	-	2.08E-13	1.07E-11
Components for re-use	kg	-	-	-	-	-
Materials for recycling	kg	-	-	-	-	-
Materials for energy recovery	kg	-	-	-	-	-
Recovered energy exported from the product system	kg	-	-	-	-	-

Table 17. Carbon emissions and removals

	DUCT LINER INSULATION	UNIT
CCE (calcination carbon emissions)	7.06E-02	kg CO_2

Scaling to Other R-values

Environmental performance results are presented per functional unit, defined as 1 m^2 of insulation. In the US, insulation is typically purchased based on R-value stated in units of ft^2·°F·hr/Btu. Environmental impacts per square meter of these alternative R-values can be calculated by multiplying the above results by scaling factors presented in Table 18.

Table 18. Scaling Factors to Other R-values

Customary US R-value	Thickness [in]	Scaling factor per 1 m^2 of R_{SI} = 1
R-11	3.2	2.20
R-13	3.8	2.64
R-19	5.6	3.52
R-22	6.5	4.40
R-30	8.8	5.72
R-38	11.2	7.48
R-49	14.4	9.68

$$\text{Duct liner impact per } m^2 \text{ (R-xx)} = \text{Impact scaling factor (R-xx)} \times \text{Duct liner impact per } m^2 \ (R_{SI} = 1)$$

LCA Interpretation

Manufacturing drives all TRACI impact categories (presented in Figure 4 below). Electricity generation and natural gas combustion dominate global warming and ozone depletion, respectively. For acidification, eutrophication and smog formation potentials, the reported facility NO_x air emissions is the dominant contributor. There is significant contribution to all impact categories from upstream production of raw materials, largely attributed to acrylic latex coating, soda ash, phenol formaldehyde, burnt dolomite, and borax; however, the relative contributions vary depending on the impact categories.

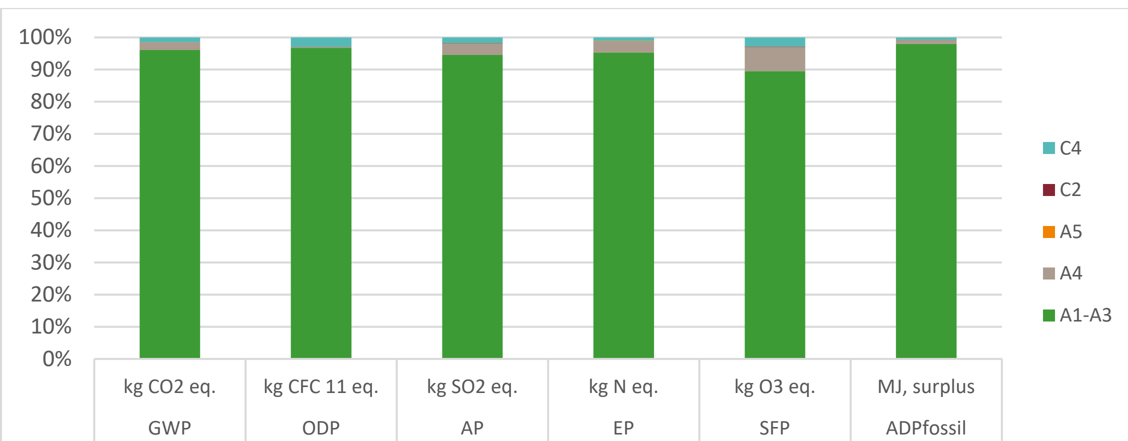


Figure 4: Results per life cycle stages

There are exceptions, such as soybean-oil derived dedusting oil contributing to eutrophication and tailpipe emissions from transportation contributing to smog formation potential.

Transportation to the installation site represents a minor driver of impacts overall. Installation accounts for a negligable impact fraction given that minimal resources are required to install the mechanical insulation. There is no impact associated with the use stage. While insulation can influence building energy performance, this aspect is outside the scope of this study. Additionally, it is assumed that insulation does not require any maintenance to achieve its reference service life, which is modeled as being equal to that of the building (i.e., 75 years). No replacements are necessary.

At end-of-life (EoL), insulation is removed from the building and landfilled. Non-hazardous waste was dominated by the EoL disposal of the entire functional unit of product. Non-hazardous waste also accounts for waste generated during manufacturing and installation. Hazardous waste is driven by waste from raw material production and manufacturing; however, the amount of hazardous waste generated is a small fraction of the total waste produced.

Additional Environmental Information

Environment and Health During Manufacturing

Johns Manville mechanical insulation products are designed, manufactured and tested in our own facilities, which are certified and registered to the stringent ISO 9001 (ANSI/ASQC 90) and ISO 14001 quality and environmental standards. These certifications, along with regular, independent third-party auditing for compliance, is your assurance that Johns Manville products deliver consistent high quality.

Environment and Health During Installation

The Linacoustic® RC/RC-IG/RC-HP and Duct Liner PM are fiber glass duct liner products that are labeled as non-hazardous according to 29 CFR 1910.1200 when used as intended. The glass fibers are non-biopersistant (biosoluble) and are not designated as carcinogenic by either the International Agency for the Research on Cancer, a branch of the World Health Organization, or the National Toxicology Program, a component of the US Department of Health and Human Service.

As with most fiber glass products, direct exposure to fibers or dust during handling may lead to mild, superficial irritation (itching) of the skin, eyes, or respiratory tract. This temporary mechanical irritation can be avoided by using the appropriate personal protective equipment (PPE). As such, Johns Manville recommends the following PPE precautions when handling Linacoustic duct liner:

- **Respiratory**: Under typical handling and installation conditions, respiratory protection is unnecessary.
  - The North America Insulation Manufacturers Association (NAIMA) recommends the use of NIOSH N95 respirator/dust mask when occupational exposures to glass fibers exceed 1 fiber per cc (1 f/cc) for a time weighted average. Although data from the NAIMA exposure database confirm that manufacturing, fabrication, and installation activities related to this product will not result in fiber concentrations over 1 f/cc, workers may choose to use such a respirator/dust mask for comfort.
- **Hand protection**: For prolonged or repeated contact when handling Linacoustic products, discomfort or irritation can be avoided by using protective gloves.
- **Eye protection**: Safety glasses are recommended during fabrication and installation.
- Skin and body protection: Long-sleeved shirt and long pants are recommended to avoid skin irritation on unprotected areas.
- **Hygiene measures**: In any industrial setting, good hygiene practices can facilitate safer and healthier working environments. We recommend practicing appropriate hygiene under any manufacturing, fabrication, or installation setting.

- **Ingestion:** Avoid ingesting or swallowing Linacoustic duct liner; however, should ingestion occur, rinse your mouth thoroughly with water to remove dust or fibers, and drink plenty of water to help reduce irritation. Should symptoms persist call a physician

The NAIMA safety recommendations may be found at: https://insulationinstitute.org/about-naima/health-and-safety/

Johns Manville's Linacoustic Safety Data Sheets may be located at:
https://www.jm.com/content/dam/jm/global/en/MSDS/200000005089_US_EN.pdf

NAIMA Fibrous Glass Duct Liner Standards or SMACNA HVAC Duct Construction Standard (NAIMA 2002) may be found at: *http://www.SMACNA.org*

NAIMA Fibrous Glass Duct Liner Standard: *http://insulationinstitute.org/wp-content/uploads/2015/11/AH124.pdf*

Environmental Activities and Certifications

GreenGuard Certified Document #1020-410

GreenGuard Gold Certified Document #1020-420

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