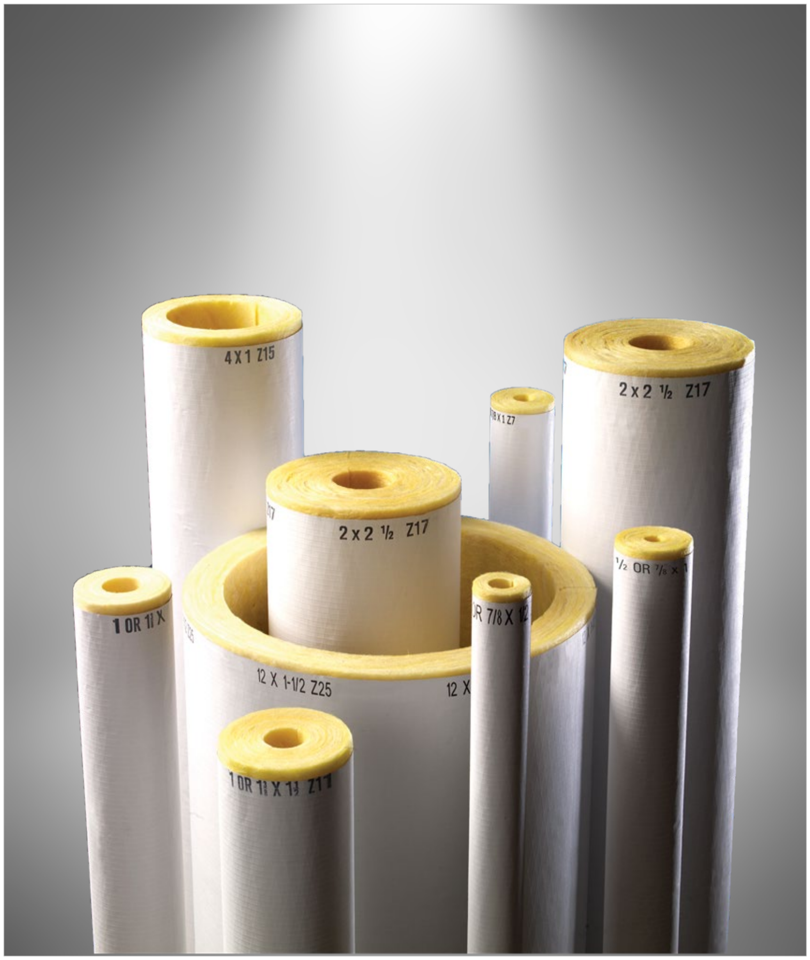
ENVIRONMENTAL PRODUCT DECLARATION

PIPE INSULATION

Micro-Lok® HP is a high-performance fiber glass pipe insulation

MICRO-LOK® *HP*, MICRO-LOK® *HP* ULTRA, MICRO-LOK® *HP* PLAIN



Think JM.

***Micro-Lok® HP is a high-performance fiber glass pipe insulation* that can be used in both above-ambient and below-ambient applications. It is available both jacketed and unjacketed. Above: Micro-Lok HP, manufactured in Defiance, OH**

Johns Manville
A Berkshire Hathaway Company

Johns Manville (JM) is a global manufacturer of premium-quality building products for insulation, roofing, fibers and nonwovens for commercial, industrial and residential applications.

We ensure that each of our 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, and we want to provide you with reliable materials that will allow you to do the same.

The use of JM's products improves energy efficiency in homes and buildings as the quickest and most cost-effective way to reduce energy use and lower greenhouse gas emissions.

People ● Passion ● Perform ● Protect

CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION
UL.COM/EPD

Environmental Product Declaration

Johns Manville
A Berkshire Hathaway Company

MICRO-LOK® HP, MICRO-LOK® HP ULTRA, MICRO-LOK® HP PLAIN
MECHANICAL INSULATION PRODUCT

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 St, Denver, CO 80202
Declaration Number	4790545973.109.1
Declared Product & Functional Unit or Declared Unit	Pipe Insulation with a length of 1 meter
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	Piping insulation made with heavy density fiberglass and resin tailored to fit pipe applications
Product RSL Description (if Appl.)	75 years
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	2020
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 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 create stronger buildings, improve energy efficiency, and contribute to the health and comfort of building occupants.

JM 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

Micro-Lok® *HP*

Micro-Lok *HP* fiber glass pipe insulation is a high-performance pipe insulation for use in both above-ambient and below-ambient applications. It comes with a factory-applied all-service jacket (ASJ) with a self-sealing longitudinal closure lap.

The tape can be installed at ambient temperatures down to 20°F (-7°C), and, once installed, it will not soften or separate from the jacket when exposed to high temperature and humidity. The jacket itself is sealed to the insulation using a unique adhesive that is specially formulated to ensure the jacket stays secured to the insulation.

Micro-Lok® *HP* Plain

Micro-Lok *HP* Plain is the un-jacketed version of Micro-Lok *HP*.

Micro-Lok® *HP* Ultra

Micro-Lok HP Ultra offers the same fiber glass and insulating performance as Micro-Lok HP, however, its facing is an ASJ jacket with an additional layer of water-resistant polypropylene film poly-coating. This makes it usable in applications where the insulation may be exposed to intermittent, transient weather during construction or installation.

Product Average

This EPD is intended to represent company-specific pipe insulation produced by JM in the Defiance site, in Ohio, United States. Use of this EPD is limited to Johns Manville.

Flow Diagram

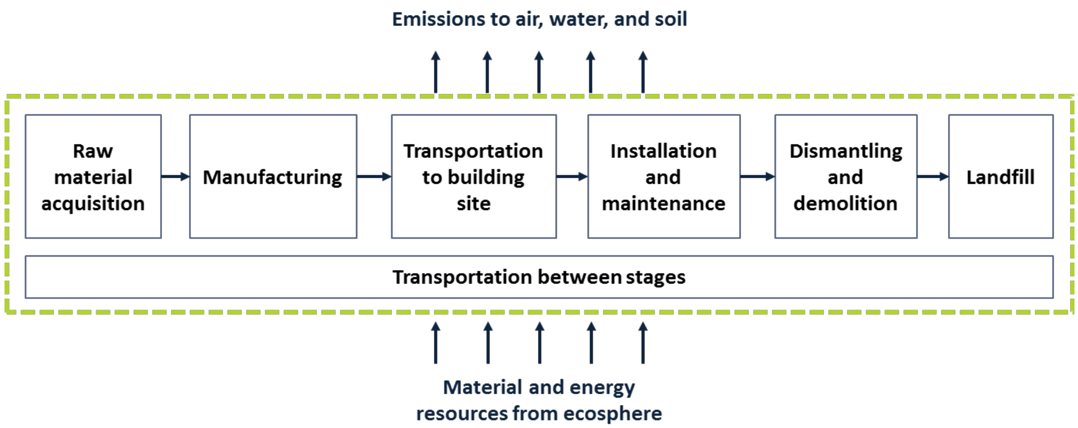


Figure 1: Flow diagram for manufacturing of pipe insulation

Application

Micro-Lok *HP* pipe insulation is used to insulate standard iron pipe, copper tubing and other pipes of similar sizes. The product line is designed to be used in hot, cold, concealed, and exposed applications. It can be used on systems that operate at temperatures ranging from below ambient to 850°F (454°C). If the application is outdoors, a weather-protective jacketing is required to ensure product integrity. When being used in applications with below ambient temperatures, all joints in the insulation system must be sealed with the factory-applied, self-seal lap and butt strips.

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 and fire-related standards and test methods apply to products considered in this EPD:

- ASTM C547 – Standard Specification for Mineral Fiber Pipe Insulation
- ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials

Properties of Declared Product as Delivered

Pipe insulation is delivered to the site of installation in either cartons or polypackaging. In the case of compression packaged material, the product will recover to the size and thickness to deliver the advertised R-value.

Material Composition

Manufacturers of pipe insulation use a mechanized process to spin a molten composition of sand, soda ash, and recycled glass cullet along with the materials mentioned in Table 1, bonded by a thermosetting resin into a temperature-resistant thermal and acoustical pipe insulation. Table 1 provides the average material content of pipe insulation.

Table 1: Pipe insulation material composition

COMPONENT	PIPE INSULATION [WT. %]
Sand	34.8%
Borax	12.9%
Burnt Dolomite Lime	3.4%
Nepheline Syenite	4.1%
Fluorspar	0.03%
Salt Cake	0.02%
Soda Ash	11.9%
Bottle Cullet	32.9%

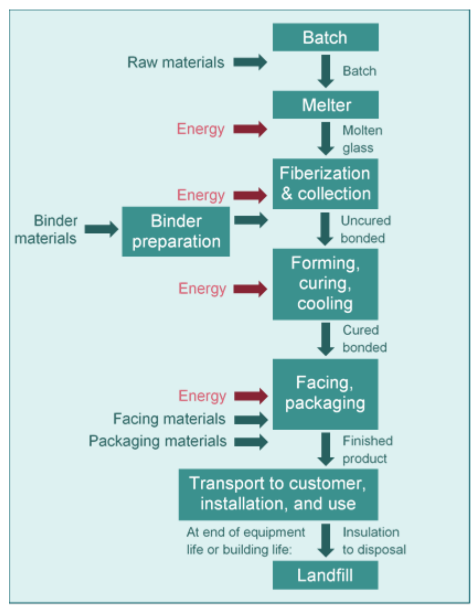
Manufacturing

This Environmental Product Declaration represents the production of Johns Manville pipe insulation at Defiance, OH. The life cycle of the product under study begins with the extraction and processing of the raw materials that constitute the glass batch. Together, these materials (sand, borax, soda ash, recycled glass, and minerals) are melted, the molten glass is spun into fibers, bonded with a thermosetting resin, and then formed into pipe insulation of the required configuration and specifications. After curing with hot air through convection and cooling, Micro-Lok HP insulation is faced with All-Service-Jacket (ASJ), facing comprised of white paper, latex adhesive, glass fiber scrim and aluminum foil, while Micro-Lok HP Ultra's facing has an additional layer of polyethylene film. The product is cut into the desired length and sent to the packaging line. The finished product is packaged in cartons with the appropriate butt strips.

Transport to the job site is estimated with 250 miles via truck. The insulation product is assumed to be tailored to customer specifications, leading to negligable material loss during installation. Only the packaging materials are sent to landfill. 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. When the building is demolished, the insulation is assumed to be sent to landfill.

Figure 2 illustrates the production and subsequent life cycle stages.

Figure 2: Production and life cycle stages



Packaging

Typically, faced pipe insulation is shipped to the job site in cartons. In the case of unjacketed pipe insulation shipped in a compression package, the product utilizes a recyclable plastic wrap. However, for the EPD, packaging materials are not assumed to be reused. Since no primary data are available, the disposal assumptions provided in Part A (UL Environment, 2018) are used.

Transportation

Average transportation distances via truck and rail are included for the transport of the raw materials to production facilities. Transport of the finished product via truck to the construction site is also accounted for, along with the transport of construction wastes and the deconstructed product at end-of-life to disposal facilities (20 miles via truck). Additional information is provided in Table 5.

Product Installation

There are different standards for installing the Micro-Lok *HP* product line in hot and cold applications. It should be installed in accordance with the Johns Manville "*InsulSpec: 3-Part Specification" for preformed fiber glass pipe insulation installation in above and below ambient conditions.:*
https://www.jm.com/content/dam/jm/global/en/mechanical-insulation/pipe/micro-lok-hp/Microlok-insulspec.pdf

Chilled water system installations may also use the NAIMA *Guide to Insulating Chilled Water Piping Systems with Mineral Fiber Pipe Insulation* (NAIMA 2015) as an installation guide. In above ambient applications, the insulation must be thick enough to ensure that the maximum surface temperature of the insulation is below 140°F (60°C). If operating temperatures exceed 500°F (260°C), the insulation thickness must range between 2" (51mm) minimum to 6" (152mm) maximum.

If the air temperature is below 20°F (-7°C) or above 130°F (54°C) do not apply the jacketed Micro-Lok HP products. The extreme temperatures will affect the tape performance of the self-seal lap and butt strips during application. If possible, allow the insulation cartons to stand within the recommended temperature range for 24 hours prior to the installation. If the application falls outside this temperature range, stapling the product helps ensure a secure closure. While not recommended, if the insulation is secured with staples and used in a below ambient system, a low perm rated mastic or other vapor retarded must be used over the staples to minimize moisture penetration.

If the product is being used in applications above 350°F (177°C), an acrid odor and some smoke may be given off during the initial heat-up to operating temperatures. This is caused by the decomposition of the phenolic binders used in the fiber glass pipe insulation. If this occurs, ensure that the area is well ventilated.

For full application instructions, please review the Micro-Lok CSI 3-Part Insulspec (Literature # MECH-261 – see above for the URL).

Use

Once installed, insulation does not directly consume energy and it requires no maintenance. 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.

Reference Service Life and Estimated Building Service Life

Pipe insulation is assumed to have a reference service life of 75 years, equal to that of the building.

Reuse, Recycling, and Energy Recovery

Pipe insulation is typically not reused or recycled following its removal from a building. Although recycling is feasible, there are minimal recycling programs and infrastructure; therefore, current practice is to send the waste to a landfill.

Disposal

At the end-of-life, insulation is removed from the deconstructed building. The waste is then transported 20 miles by trailer/truck and disposed in a landfill per PCR requirements. Landfill and incineration emissions from paper, plastic, and wood packaging are allocated to installation (module A5).

Life Cycle Assessment Background Information

Declared Unit

Per the product category rules, the declared unit for this analysis is 1 m of insulation material, as delivered to the job site, with a building service life of 75 years.

Table 2: Declared unit properties of pipe insulation

	Length (m)	R_{SI} [m²K/W]	R_{US} [BTU/(h °F ft^2)]	RSL [years]	Thickness [in]	Mass [kg]
Declared Unit	1.00	1	5.68	75	1.31	0.44

For the declared unit, the amount of pipe insulation material with ASJ and poly-coating is the same as that of unjacketed pipe insulation. However, for the production of pipe insulation with ASJ and poly-coating, an area of facing is added during manufacturing. The declared unit of the pipe insulation facing is 1 m^2.

Table 3: Declared unit of ASJ/poly-coating

	Area (m^2)	RSL [years]	Density [kg/m^2]	Mass [kg]
Declared Unit	1	75	0.152	0.152

System Boundary

Table 4 represents the system boundary and scope.

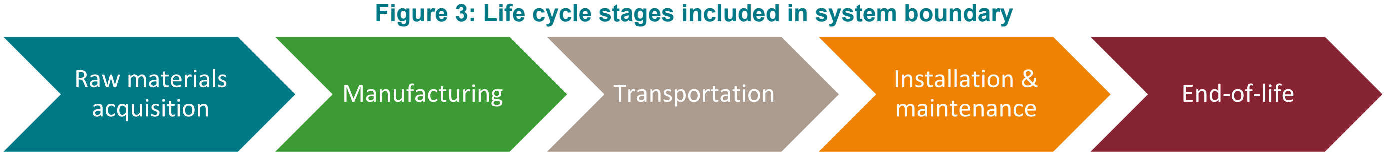
Table 4: Description of the system boundary modules

	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

Figure 3: Life cycle stages included in system boundary



Each module includes provision of all relevant materials, products and energy. Impacts and aspects related to wastage (i.e. production, transport and waste processing and end-of-life stage of lost waste products and materials) are considered in the module in which the wastage occurs. Building operational energy and water use are considered outside of this study's scope: any impact the use of insulation may have on a building's energy consumption is not calculated or incorporated into the analysis.

The end-of-life stage modules C1 and C3 are declared as having zero impact as deconstruction is done manually and the insulation is not recycled. Consequently, there are no direct emissions associated with these modules.

Per the PCR, capital goods and infrastructure flows are assumed to not significantly affect LCA results or conclusions and thus excluded from the analysis.

Estimates and Assumptions

The analysis uses the following assumptions:

- If inbound transportation distances were not provided for materials used in manufacturing, a default assumption of 250 miles (402 km) transport via truck was applied in the model.
- Pipe insulation is cut and installed by hand and installation is assumed to have a negligible scrap rate.
- 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).
- Pipe insulation is assumed to last the lifespan of the building and is only removed upon building demolition. Since the PCR states that the building has a 75-year reference service life, the insulation is assumed to have the same reference service life.

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

For the processes within the system boundary, all available energy and material flow data have been included in the model. Cut-off criteria, however, were applied to exclude capital goods and infrastructure as these are assumed to not significantly affect LCA results nor conclusions. 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 between July 2020 to 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 collected represent a continuous 12-months from July 1, 2020 - June 30, 2021.

Allocation

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.

Comparability

No comparisons or benchmarking is included in this EPD.

Life Cycle Assessment Scenarios

Table 6. Transport to the building site (A4)

NAME	PIPE INSULATION	UNIT
Fuel type	Diesel	
Liters of fuel	0.0011	L/100km
Vehicle type	Truck	-
Transport distance	402	km
Gross density of products transported	52.9	kg/m^3
Weight of products transported (if gross density not reported)	N/A	kg
Volume of products transported (if gross density not reported)	N/A	m^3
Capacity utilization volume factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaging products)	> 1	-

Table 7. Installation (A5) and Reference Service Life

INSTALLATION INTO THE BUILDING (A5)	PIPE INSULATION	ASJ/POLY-COATING	UNIT
Ancillary materials (packaging)	0.106	-	kg
REFERENCE SERVICE LIFE			
RSL	75	75	years

Table 8. End of life (C1-C4)

NAME		PIPE INSULATION	ASJ/POLY-COATING	UNIT
Collection process (specified by type)	Collected separately	0	0	kg
	Collected with mixed construction waste	0.44	0.152	kg
Recovery (specified by type)	Reuse	0	0	kg
	Recycling	0	0	kg
	Landfill	0.44	0.152	kg
	Incineration	0	0	kg
	Incineration with energy recovery	0	0	kg
	Energy conversion efficiency rate	N/A	N/A	
Disposal (specified by type)	Product or material for final deposition	0.44	0.152	kg
Removals of biogenic carbon (excluding packaging)		0	0	kg CO2

Life Cycle Assessment Results

Pipe insulation requires no maintenance, and there are no parts to repair or refurbish. The reference service life for the pipe insulation product is 75 years. Installation is done by hand with only packaging waste being generated. Impact assessment and other results are shown for a cradle-to-installation with end-of-life system boundary. Modules C1 and C3 are not associated with any impact and are therefore declared as zero.

Biogenic carbon is not reported as the only relevant emissions are from paper packaging and are very small compared to the overall life cycle. As such, carbon emissions and removals are not declared.

Life Cycle Impact Assessment Results

Table 9. North American impact assessment (TRACI) results for pipe insulation (1 m, 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.	3.32E+00	3.95E-02	1.62E-02	1.15E-03	1.94E-02
Depletion potential of the stratospheric ozone	kg CFC11 eq.	1.86E-12	7.72E-18	3.73E-18	2.26E-19	6.47E-17
Acidification potential	kg SO_2 eq.	6.43E-03	2.09E-04	5.70E-05	3.22E-06	8.25E-05
Eutrophication potential	kg N eq.	6.03E-04	1.90E-05	1.16E-05	3.71E-07	4.59E-06
Smog formation potential	kg O_3 eq.	1.02E-01	4.84E-03	2.58E-04	7.34E-05	1.46E-03
Abiotic depletion potential for fossil resources	MJ, surplus	5.38E+00	7.25E-02	2.16E-03	2.12E-03	3.77E-02

Table 10. North American impact assessment (TRACI) results for ASJ/poly facing (1 m^2)

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.	3.06E-01	-	-	1.87E-04	5.40E-02
Depletion potential of the stratospheric ozone	kg CFC11 eq.	1.04E-12	-	-	3.67E-20	1.05E-17
Acidification potential	kg SO_2 eq.	1.02E-03	-	-	5.24E-07	1.85E-04
Eutrophication potential	kg N eq.	7.90E-05	-	-	6.04E-08	3.86E-05
Smog formation potential	kg O_3 eq.	1.43E-02	-	-	1.19E-05	7.04E-04
Abiotic depletion potential for fossil resources	MJ, surplus	7.32E-01	-	-	3.45E-04	6.13E-03

Table 11. EU impact assessment (CML) results for pipe insulation (1 m, 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.	3.26E+00	3.90E-02	1.23E-02	1.14E-03	1.90E-02
Depletion potential of the stratospheric ozone	kg R 11 eq.	1.86E-12	7.72E-18	3.73E-18	2.26E-19	6.47E-17
Acidification potential	kg SO_2 eq.	5.52E-03	1.51E-04	3.51E-05	2.37E-06	7.59E-05
Eutrophication potential	kg P eq.	9.57E-04	4.37E-05	1.52E-05	7.38E-07	1.02E-05
Photochemical oxidant creation potential	kg C_2H_2 eq.	7.35E-04	-5.66E-05	9.01E-06	-8.00E-07	7.23E-07
Abiotic depletion potential for fossil resources	MJ	4.83E+01	5.43E-01	1.68E-02	1.59E-02	2.90E-01
Abiotic depletion potential for non-fossil resources	kg Sb eq.	5.85E-05	1.22E-08	5.20E-10	3.56E-10	8.36E-09

Table 12. EU impact assessment (CML) results ASJ/poly facing (1 m^2)

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.	2.99E-01	-	-	1.85E-04	4.09E-02
Depletion potential of the stratospheric ozone	kg R 11 eq.	1.04E-12	-	-	3.67E-20	1.05E-17
Acidification potential	kg SO_2 eq.	9.51E-04	-	-	3.86E-07	1.13E-04
Eutrophication potential	kg P eq.	1.15E-04	-	-	1.20E-07	5.01E-05
Photochemical oxidant creation potential	kg C_2H_2 eq.	6.37E-05	-	-	-1.30E-07	3.01E-05
Abiotic depletion potential for fossil resources	MJ	5.74E+00	-	-	2.58E-03	4.71E-02
Abiotic depletion potential for non-fossil resources	kg Sb eq.	1.74E-06	-	-	5.78E-11	1.36E-09

Life Cycle Inventory Results

Table 13. Resource use for pipe insulation (1 m, unfaced)

	Units	A1- A3 Product Stage	A4 Product Delivery	A5 Construction Stage	C2 Transport End of Life	C4 Disposal at End of Life
Renewable primary energy as energy carrier	MJ	4.67E+00	2.25E-02	1.41E-03	6.59E-04	2.46E-02
Renewable primary energy as material utilization	MJ	-	-	-	-	-
Total use of renewable energy resources	MJ	4.67E+00	2.25E-02	1.41E-03	6.59E-04	2.46E-02
Non-renewable primary energy as energy carrier	MJ	5.40E+01	5.47E-01	1.74E-02	1.60E-02	2.96E-01
Non-renewable primary energy as material utilization	MJ	1.58E+00	-	-	-	-
Total use of non-renewable primary energy	MJ	5.56E+01	5.47E-01	1.74E-02	1.60E-02	2.96E-01
Use of secondary materials	kg	2.13E-01	-	-	-	-
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	8.51E-03	9.63E-05	1.96E-05	2.82E-06	4.07E-05

Table 14. Resource use for ASJ/poly facing (1 m^2)

	Units	A1- A3 Product Stage	A4 Product Delivery	A5 Construction Stage	C2 Transport End of Life	C4 Disposal at End of Life
Renewable primary energy as energy carrier	MJ	2.40E+00	-	-	1.07E-04	4.00E-03
Renewable primary energy as material utilization	MJ	-	-	-	-	-
Total use of renewable energy resources	MJ	2.40E+00	-	-	1.07E-04	4.00E-03
Non-renewable primary energy as energy carrier	MJ	6.03E+00	-	-	2.60E-03	4.81E-02
Non-renewable primary energy as material utilization	MJ	-	-	-	-	-
Total use of non-renewable primary energy	MJ	6.03E+00	-	-	2.60E-03	4.81E-02
Use of secondary materials	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	2.13E-03	-	-	4.58E-07	1.29E-05

Table 15. Output flows and waste categories for pipe insulation (1 m, unfaced)

	Units	A1- A3 Product Stage	A4 Product delivery	A5 Construction Stage	C2 Transport End of Life	C4 Disposal at End of Life
Hazardous waste disposed	kg	3.48E-08	4.57E-11	1.62E-12	1.34E-12	2.80E-11
Non-hazardous waste disposed	kg	2.26E-01	5.03E-05	1.67E-02	1.47E-06	4.41E-01
High-level radioactive waste	kg	3.37E-06	1.84E-09	2.51E-10	5.39E-11	2.86E-09
Intermediate and low-level radioactive waste	kg	9.33E-05	5.07E-08	6.79E-09	1.48E-09	7.59E-08
Components for re-use	kg	-	-	-	-	-
Materials for recycling	kg	-	-	7.93E-02	-	-
Materials for energy recovery	kg	-	-	-	-	-
Recovered energy exported from the product system	kg	-	-	-	-	-

Table 16. Output flows and waste categories for ASJ/poly facing (1 m^2)

	Units	A1- A3 Product Stage	A4 Product delivery	A5 Construction Stage	C2 Transport End of Life	C4 Disposal at End of Life
Hazardous waste disposed	kg	2.19E-08	-	-	2.17E-13	4.55E-12
Non-hazardous waste disposed	kg	3.01E-02	-	-	2.39E-07	5.52E-02
High-level radioactive waste	kg	1.28E-07	-	-	8.76E-12	4.64E-10
Intermediate and low-level radioactive waste	kg	3.58E-06	-	-	2.41E-10	1.23E-08
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

	Pipe insulation	Unit
CCE (calcination carbon emissions)	1.10E-02	kg CO_2

Scaling to Other R-values

Environmental performance results are presented per functional unit, defined as 1 m of R_{SI} = 1 m K/W insulation. In the US, insulation is typically purchased based on R-value stated in units of $ft^2 \cdot °F \cdot hr/Btu$.

Environmental impacts per meter of these alternative R-values can be calculated by multiplying the results by scaling factors presented in Table 18.

Table 18. Scaling Factors to Other R-values

CUSTOMARY US R-VALUE	PIPE INSULATION [IN]	SCALING FACTOR PER 1 M 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

$$\text{Pipe insulation impact per m (R-xx)} = \text{Impact scaling factor (R-xx)} \times \text{Pipe insulation impact per m } (R_{SI} = 1)$$

LCA Interpretation

The manufacturing stage dominates the majority of impact categories due to the energy required by the melter and finishing stages. Outbound transport accounts for relevant contributions to the eutrophication potential and smog formation potential impact categories. For other impact categories, outbound transport is a minor contributor.

For the ASJ/poly facing used for the pipe insulation material, the manufacturing stage also represents the majority of the impact in all categories, with minor contributions associated with end-of-life and transportation.

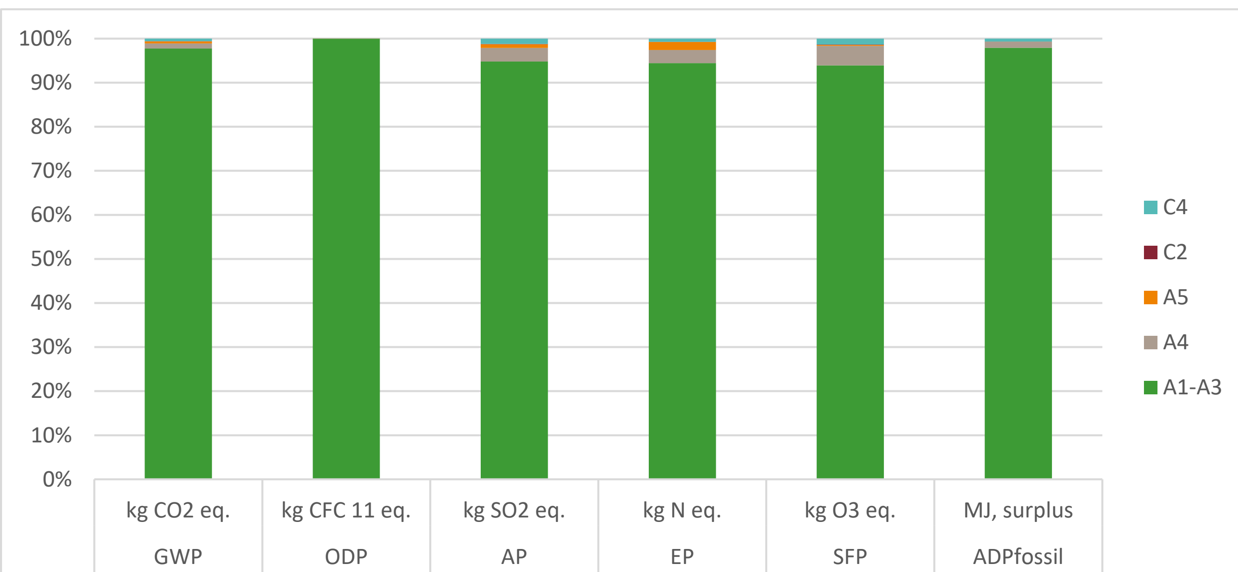


Figure 4: Results per life cycle stages

Installation accounts for a small fraction of overall life cycle impact given that minimal resources are required to install piping 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; therefore, results represent the production of one (1) meter of insulation at a thickness defined by the PCR functional unit.

The use of JM's products improve energy efficiency in homes and buildings as the quickest and most cost-effective way to reduce energy use and lower greenhouse gas emissions.

At end-of-life, insulation is removed from the building and landfilled. Waste was dominated by the end-of-life disposal of the product. Non-hazardous waste also accounts for waste generated during manufacturing and installation.

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.

Building Use Stage Benefits

Sustainable insulation requires no additional energy or maintenance in order to perform during the life of service. Fiberglass insulation is effective in helping reduce heat flow, reduce unwanted noise, and control moisture.

Environment and Health During Installation

Micro-Lok *HP*/Ultra/Plain fiber glass pipe insulation is 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 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 irritation can be avoided by using the appropriate personal protective equipment (PPE). As such, Johns Manville recommends the following PPE precautions when handling Micro-Lok *HP*/Ultra/Plain pipe insulation:

- **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 fiber glass products, discomfort or irritation can be avoided by using protective gloves.
- **Eye protection:** Safety glasses are recommended during fabrication and installation.
- **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 Micro-Lok pipe insulation; 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 Micro-Lok *HP* Safety Data Sheets may be located at:
https://msds.jm.com/irj/go/km/docs/documents/Public/MSDS/200000002134_US_EN.pdf

Extraordinary Effects

Fire

The performance of building materials in a fire is a key factor in protecting the occupants of the building and allowing them to escape safely. Fiberglass insulation is naturally non-combustible and remains this way for the life of the product without the addition of harsh and potentially dangerous chemical fire retardants. The insulation can resist temperatures up to 850°F. Because these products have a high melting temperature, they can be used in a wide variety of applications that call for these unique properties.

These products should meet NFPA 255 and NFPA 90A & 90B standards and test methods and are Class A product tested per ASTM E84.

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