ENVIRONMENTAL PRODUCT DECLARATION

PVC PIPE FITTINGS AND JACKETING

Zeston® 2000 II Zeston® 300 II Zeston® Jacketing series

Think JM

Johns Manville's fitting covers and jacketing are designed to cover insulated pipes in, above, and below ambient applications. They can be used indoors and outdoors (UV-resistant white) and come in 14 different colours.

Above: Zeston® parts – manufactured in Edison, NJ.

Johns Manville

At Johns Manville, product performance and corporate accountability are top priorities. We ensure that our Zeston® PVC fittings and jacketing not only perform but also contribute 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 just think insulation, think JM.

PEOPLE • PASSION • PERFORM • PROTECT

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

Environmental Product Declaration

Johns Manville

CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION UL.COM/EPD

PVC PIPE FITTINGS AND JACKETING

Product Category: Pipe and Equipment Covers

According to ISO 14025 and ISO 21930:2017

EPD Program and Program Operator Name, Address, Logo, and Website	UL Solutions 333 Pfingsten Rd, Northbrook IL, 60062 www.ul.com www.spot.ul.com
General Program Instructions and Version Number	Program Operator Rules v 2.7 2022
Manufacturer Name and Address	Johns Manville
Declaration Number	4791369156.101.1
Declared Product & Functional Unit or Declared Unit	Zeston® PVC Pipe Fittings Covers and Jacketing
Reference PCR and Version Number	Product Category Rule (PCR) 2019:14 for Construction Products created by EPD International AB (Environdec: EPD International AB, 2023) Version 1.3.4
Description of Product Application/Use	Commercial, institutional and industrial applications, mainly being the protection of insulated or bare pipes.
Product RSL Description (if Appl.)	N/A
Markets of Applicability	North America
Date of Issue	September 16, 2024
Period of Validity	5 Years
EPD Type	Product Specific
Range of Dataset Variability	Manufacturer Specific
EPD Scope	Cradle to gate with options (A1-A3, A4-A5, C1-C4)
Year(s) of Reported Primary Data	January 2022 to December 2022
LCA Software & Version Number	LCA for Experts v10
LCI Database(s) & Version Number	Managed LCA Content, CUP 2023.2
LCIA Methodology & Version Number	IPCC AR6, IPCC AR5, CML-IA v4.8, TRACI 2.1

The PCR review was conducted by:	EPD International PCR Review Panel envirodec.com
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ INTERNAL ☒ EXTERNAL	Cooper McCollum, UL Solutions
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	Sphera
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas P. Gloria, Industrial Ecology Consultants

Limitations

Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts of raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools and certifications that are designed to address these impacts and/or set performance thresholds – e.g. Type 1 certifications, health assessments and declarations, environmental impact assessments, etc.

Accuracy of Results: EPDs regularly rely on estimations of impacts; the level of accuracy in estimation of effect differs for any particular product line and reported impact.

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

The EPD owner has the sole ownership, liability, and responsibility for the EPD.

1. Product Definition and Information

1.1. Description of Company/Organization

Johns Manville (JM) is a leading manufacturer and marketer of premium-quality building and mechanical insulation, commercial roofing, glass fibers, and nonwovens for commercial, industrial, and residential applications (Johns Manville , 2024).

For more than 150 years, JM has been dedicated to providing products that improve energy efficiency and contribute to the health and comfort of building occupants. 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.

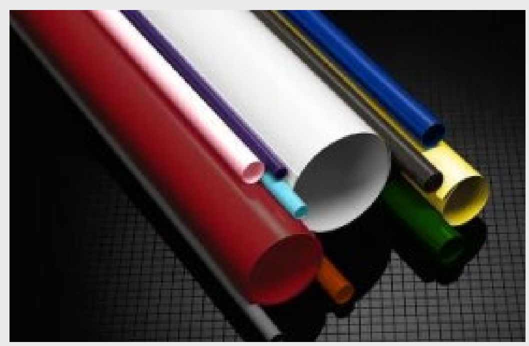
1.2. Product Description

Product Identification

This EPD covers JM's PVC fittings and jacketing for pipe insulation, specifically those branded as Zeston® 2000 fitting covers series, Zeston® 300 fitting covers series and Zeston® jacketing series. All these products are manufactured by JM in both white and colored options. Table 1 gives an overview of the Zeston® products covered under this EPD.

Table 1: JM's Zeston® series product specification.

PRODUCT NAME	DESCRIPTION	FIGURE
Zeston® 2000	Zeston 2000® series white or colored PVC is intended for the protection of insulated or bare pipes. The standard gauge PVC fitting covers are manufactured from high-impact, polyvinyl chloride material designed to provide abuse-resistant protection for insulated piping. The one-piece fittings are available with or without 'Hi-Lo Temp' formaldehyde-free fiber glass inserts (Johns Manville, 2024). Technical specifications (e.g., weight) are available at https://www.jm.com/content/dam/jm/global/en/mechanical-insulation/pvc/zeston-2000-series-white/Zeston-2000-WT-PVC-DS-0415.pdf	

Zeston® 300	Zeston 300® series white or colored PVC heavy-duty fitting covers are specifically designed for industrial and commercial applications. The PVC fitting covers are made from a thick gauge material that provides superior impact resistance and increased durability for high-abuse areas in industrial and commercial applications. This product variation is manufactured from a glossy, high-impact, UV-resistant material. When combined with JM's jacketing and solvent welding adhesive, the product also meets standardized requirements for applications in food, beverage, and pharmaceutical facilities (Johns Manville, 2024). Technical specifications (e.g., weight) are available at https://www.jm.com/content/dam/jm/global/en/mechanical-insulation/pvc/zeston-300-series/CI-67_Zeston%C2%AE%20300.pdf	
Zeston® jacketing	Zeston® jacketing is made from high impact white or colored PVC material designed to provide an inherent vapor retarder and protection to insulated pipes. They are designed to fit seamlessly over the Zeston® fitting covers in industrial and commercial applications (Johns Manville, 2024). Technical specifications (e.g., weight) are available at https://www.jm.com/content/dam/jm/global/en/mechanical-insulation/pvc/zeston-pvc-jacketing/Zeston-PVC-Jacketing-DS-MECH-264-0315-HR.pdf	

Product Average

This EPD represents a manufacturer-specific PVC pipe fittings and jacketing products that are branded under the Zeston® series. JM's manufacturing information and operational data for PVC pipe fittings and jacketing are directly considered in the LCA study.

1.3. Application

JM's PVC pipe fitting covers and jacketing products are designed to cover and protect insulated or bare pipes in above and below ambient applications. The products are used in commercial, industrial and residential buildings.

Zeston® PVC fitting covers and jacketing are ideally suited for indoor use on chilled water, hot water, steam and other piping sustems in commercial, institutional, and infustrial applications. When combined with Zeston® PVC color jacketing and solvent welding adhesive or Z-tape, Zeston® fitting covers form a completely sealed system that may be used for chilled water applications. The Zeston® PVC colour system of fittings and jacketing provides easy identification for different pipe systems. All colored Zeston® fittings and jacketing are not recommended for outdoor use; however, all white PVC from JM is UV-resistant and may be used outdoors in certain applications.

1.4. Declaration of Methodological Framework

As per the PCR, (Environdec: EPD International AB, 2023), this EPD is declared under the "cradle-to-gate (A1-A3) with options (A4-A5, C1-C4)" life cycle assessment system boundaries. This includes:

- Upstream: Raw material supply (including virgin and recyled materials and the generation of electricity from primary energy resources).
- Core: Inbound transportation of raw materials, manufacturing of PVC products, packaging of finished product, manufacturing waste, release to the environment.
- Downstream: Distribution of the product from the production plant to an installation building site, installation process, installation waste and releases to the environment, end-of-life (EoL) transport to final disposal site, final disposition.

Figure 1 provides an overview of the cradle-to-gate (A1-A3) with options (A4-A5, C1-C4) system boundary for the present EPD.

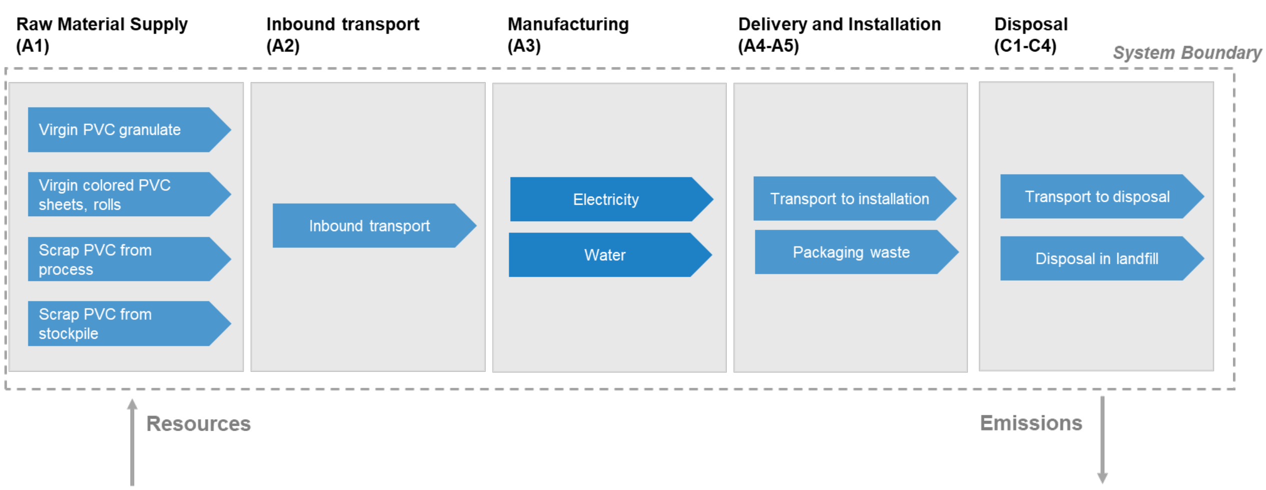


Figure 1: Cradle-to-gate with options for PVC pipe fittings and jacketing.

1.5. Technical Requirements

The technical specifications and fire-related standards and test methods that apply to the products considered in this EPD are:

- ASTM C1917 – Standard Specification for Rigid Polyvinyl Chloride (PVC) Jacketing for Insulation

- ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials

1.6. Delivery Status

JM's Zeston® PVC pipes fittings and jacketing are delivered in bulk to the customer's specfied location or to distribution centers using road transportation.

1.7. Material Composition

JM's PVC pipe fittings and jacketing are produced in its manufacturing plant in Edison, NJ, from processing virgin PVC resin as well as regrind PVC scrap. Finished colored PVC sheets are also used to provide pigmentation to the final products. Together, these materials are extruded into sheets. Table 2 provides the average product composition per kg of PVC pipe cover products based on the primary data collected by JM (January 2022 to December 2022).

Table 2: Average product composition per kg of PVC pipe fitting and jacketing.

MATERIAL	MASS [KG]	MASS [%]	DQI*
Virgin PVC granulate	0.92	66%	Calculated
Virgin colored PVC sheets	0.02	1%	Calculated
Virgin colored PVC rolls	0.03	2%	Calculated
Scrap PVC regrind from same process	0.26	18%	Calculated
Scrap PVC regrind from stockpile	0.17	12%	Calculated

1.8. Manufacturing

Manufacturing of JM's PVC pipe cover products entails extrusion of jacketing and bulk rolls and thermoforming of fitting covers. A fraction of the fitting covers is equipped with fiber glass insulation. Raw materials for the manufacturing process are virgin PVC granulate, scrap PVC regrind, and colored finished PVC parts. In the first part of JM's manufacturing process, virgin and regrind PVC scrap are extruded into sheets. PVC jacketing and bulk rolls are sold as is, while the remaining 'work in progress' PVC material is fed into thermoforming alongside colored PVC sheets and rolls (produced off-site) to produce fitting covers like elbows, reducers, or tees. Utilities required for extrusion and thermoforming are electricity and process water. The final products are bulk packaged using corrugated boxes, shrink wrap and wooden pallets for distribution to customers' installation sites. Figure 2 shows an overview of the PVC pipe covers manufacturing process.

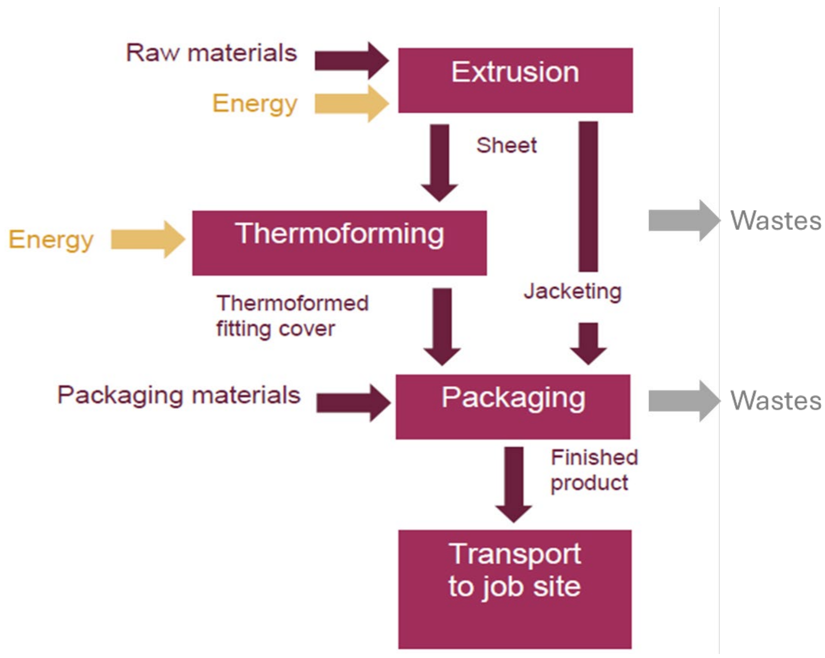


Figure 2: Manufacturing process of PVC pipe fittings and jacketing.

Table 3 discloses the energy source mix assumed in the modeling of the electricity used in manufacturing. The reference year for the grid mix is 2020. The GWP100 of the grid mix is 0.37 kg CO2e/kWh according to the IPCC's Fifth Assessment Report (AR5) (IPCC, 2013) and IPCC's Six Assessment Report (AR6) (IPCC, 2021). The difference between the results from both methodologies is negligible.

Table 3: Source mix for electricity in the RFCE eGRID region, based on 2020.

ELECTRICITY SOURCE FOR RFCE EGRID REGION	% NET PRODUCTION FOR 2020
Natural gas	53.29
Nuclear	32.41
Hard coal	9.02
Hydro	1.49
Waste	1.21
Wind	1.18

Photovoltaics	0.78
Biogas	0.44
Fuel oil	0.08
Biomass (solid)	0.10

1.9. Packaging

Corrugated boxes, cardboard cores, fiberglass inserts, shring wrap, adhesive tape and wood pallets are used as packaging materials of the finished product of PVC pipe fittings and jackating. Biogenic carbon related with the corrugated boxes, cores, and wood pallets are reported in the EPD.

1.10. Transportation

Transportation distances and modes of transport are included for raw material supply to the production facility. Transport of the finished product to the construction site and of the deconstructed product at end-of-life to disposal facilities are also included.

For the installation stage, only the delivery to the construction site and subsequent disposal of discarded bulk packaging is considered. The average transportation to the construction site is considered to be 700 miles, an assumption based on JM's industry knowledge.

For end-of-life transportation, it is assumed that the deconstructed product waste is transported a distance of 20 miles by truck from the building to a landfill site, as per JM's industry knowledge.

1.11. Product Installation

It is assumed that the Zeston® PVC products are tailored to customer specifications, and therefore material loss at installation is negligible. Once installed, these products do not directly consume energy, and require no maintenance. There are no parts to repair or refurbish. Any reduction in building operational energy consumption associated with the use of these products needs to be considered on the level of the individual building and is considered outside the scope of this LCA study.

At this stage, the only wastes accounted for are the disposal of the product's bulk packaging, consisting of cartons, shrink wrap, tape, fiberglass, and wooden pallets.

1.12. Use

The use phase is not included in the system boundary and therefore not included in this study.

1.13. Reuse, Recycling, and Energy Recovery

Following the guidance provided by ISO 21930 (ISO, 2017) for allocation between product systems or across a system boundary, the end-of-life cut-off allocation approach has been considered in this study for waste flows with potential for recyclability. Therefore, any potential credit from wastes considered secondary materials (e.g., scrap PVC, packaging materials sent to recycling) has been cut-off in this assessment.

1.14. Disposal

At end-of-life, PVC pipe covers are removed manually, and, therefore, this stage does not contribute to the lifetime environmental impacts. After removal, the PVC jacketing and fitting covers are transported to a landfill site 20 miles away by truck and disposed of.

Bulk packaging waste discarded at installation (consisting of cartons, cores, shrink wrap, tape, fiberglass, and wooden pallets) is disposed of following the packaging disposal assumptions by region published by ULE in its Part A PCR (UL Environment, 2022), as shown in Table 4.

Table 4: Packaging disposal rate assumptions by ULE Part A PCR (UL Environment, 2022).

PRODUCT	RECYCLED	INCINERATED	LANDFILLED
Paper/wood packaging	68%	5%	20%
Plastic packaging	9%	17%	68%

2. Life Cycle Assessment Background Information

2.1. Declared Unit

The PVC pipe fittings and jacketing are used to connect sections of PVC pipe together, allowing compatibility in a piping systems or structures. Jacketing parts are used as protective cover for pipes from physical damages.

According to the PCR (Environdec: EPD International AB, 2023), the declared unit in this EPD for PVC pipe fittings and jacketing is:

1 kg of packaged Zeston® PVC fittings and jacketing products.

2.2. System Boundary

The system boundary of the EPD follows the modular structure defined by ISO 21930 (ISO, 2017) and EN 15804 (EN 15804+A2/AC 2021, 2021). The system boundary includes the cradle-to-gate stages (A1-A3) with options (A1-A5, C1-C4); more specifically, it encompasses all potential environmental impacts from raw materials extraction, processing, and transport to the manufacturing stage (A1-A3), to the transport to construction site and installation (A4-A5), and the end-of-life treatment of the product (C1-C4). No impacts from the product's use and maintenance (modules B1-B7) are included in this study. The optional module D has also been excluded for reporting benefits and loads beyond the system boundary. A summary of the system boundary stages is detailed in Table 5 below.

Table 5: Modules of the production life cycle included in the present EPD

PRODUCTION			INSTALLATION		USE STAGE							END-OF-LIFE				NEXT PRODUCT SYSTEM
Raw material supply (extraction, processing, recycled material)	Transport to manufacturer	Manufacturing	Transport to building site	Installation into building	Use / application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to EOL	Waste processing	Disposal	Reuse, recovery or recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	MND	MND	MND	MND	MND	MND	MND	X	X	X	X	MND

(X = declared module; MND = module not declared; they are not applicable for the products under study)

It is important to clarify that module C1 is zero because deconstruction/demolition is done manually. Likewise, module C3 is zero as there is no waste processing for reuse, recycle, or recovery involved in the study.

A more detailed description of the specific activities included within the system boundaries, presented by declared modules, is listed below.

Module A1 to A3:

The production stage includes provision of all raw materials, products, and energy, as well as waste processing up to the end-of waste state or disposal of final residues during the product stage.

These modules consider the manufacturing of system components, including the virgin PVC granulate manufacturing and the colored PVC sheets and rolls that serve as coloring agents. These materials are transported to the manufacturing and assembly plant by truck within the USA. The manufacturing energy sources, packaging and auxiliary materials are also included in these modules.

Module A4:

Modules A4-A5 consider the construction stage. Only the delivery to the job site and subsequent disposal of packaging is considered. Specifically, module A4 considers transportation to installation site. An average transportation distance to job site of 700 miles by truck (diesel driven by medium-duty truck) is considered.

Module A5:

This is the installation module. It is assumed that manual installation is representative of this stage. Therefore, in this module only the disposal of packaging materials is accounted for. These include fiberglass inserts, corrugated cartons, plastic shrink wrap, adhesive tape, and wooden pallets. Typical rates of waste processing routes (e.g., landfill, incineration, recycling) are assumed for the main packaging materials being discarded at installation.

Installation losses have not been accounted for since such losses highly depend on the specific building geometry and other site-specific factors. Furthermore, the fittings are assumed to be custom-made for the building with minimal installation losses.

Module C1 to C4:

Modules C1 and C3 are accounted as zero, where there are no potential environmental impacts arising from these activities because demotion and deconstruction of PVC pipe covers is usually done manually. In addition, waste at the end-of-life is not processed for reuse, recycle, or recovery activities, but rather landfilled. Therefore, module C4 accounts for landfill as the final disposal of uninstalled PVC fittings and jacketing.

Module C2 refers to the transportation of the PVC pipe cover products at their end-of-life to final disposal site. A road (truck) transport distance of 20 miles is assumed at this stage, according to JM's industry knowledge.

2.3. Estimates and Assumptions

- A number of key assumptions have been applied throughout the study, more specifically: Electricity is the only energy consumed by the Edison, NJ, manufacturing plant.
- All process water becomes wastewater that is disposed of in the municipal sewage. Hence, no losses via evaporation or other discharges are considered.
- No additional materials or energy sources were used during installation; all installation is assumed to be manual.
- Wood pallets for bulk packaging are assumed to be reused 20 times in their lifetime.
- Unknown transportation distances beyond JM's control (e.g., distance to installation site, distance to landfill) have been assumed considering typical averages informed by JM's industry knowledge.
- Unknown disposal activities beyond JM's control (e.g., discarded bulk packaging at installation, de-molished product at end-of-life) have been assumed following packaging disposal assumptions by region published by ULE in its Part A PCR (UL Environment, 2022) and JM's industry knowledge.

2.4. Cut-off Criteria

No cut-off criteria are defined for this study. As summarized in 2.2, the system boundary was defined based on relevance to the goal of the study. For the processes within the system boundary, all available energy and material flow data have been included in the model. In cases where no matching life cycle inventories are available to represent a flow, proxy data have been applied based on conservative assumptions regarding environmental impacts.

2.5. Data Sources

The LCA model was created using the Life Cycle Assessment for Experts (LCA FE) software system for life cycle engineering, developed by Sphera Solutions, Inc. The Managed LCA Content (MLC) 2023.2 software package provides the life cycle inventory data for several of the raw materials and processes obtained from the background system. The documentation on the dataset and modeling choices are available at https://sphera.com/life-cycle-assessment-lca-database/.

2.6. Data Quality

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

Temporal Coverage

The primary data collected by JM for this study is representative of the production of PVC pipe covers within the time period of January 2022 to December 2022. Background data for upstream and downstream processes (i.e., raw materials, energy sources, transportation, and ancillary materials) were obtained from the Managed LCA Content, 2023.2 (CUP 2023.2) databases. The information is documented online at https://scn.spherasolutions.com/client/login.aspx

Technology Coverage

All primary data were collected specifically for the manufacturing process implemented at JM's Edison plant in New Jersey, USA. This includes typical extrusion and thermoforming processes of PVC resin and subsequent packaging for distribution. Background data are representative of the USA. When US-specific data were unavailable, proxy data were used.

Geographical Coverage

The intended geographical coverage for the study is the United States of America (USA). The manufacturing plant evaluated in this study is in Edison, New Jersey. Manufacturing inputs and packaging materials are sourced from different states within the country. Likewise, it is assumed that the finished PVC product is shipped, installed, and disposed of within the USA.

Completeness

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

2.7. Period under Review

Primary data collected for PVC pipe fittings and jacketing considered in the analysis represents production during the time period of January 2022 to December 2022. and therefore, this analysis is intended to represent production in 2022 and 2023.

2.8. Allocation

No multi-output allocation was required in the foreground system of the study.

Allocation of background data (energy and materials) taken from the Managed LCA Content (MLC) 2023.2 databases is documented online at https://sphera.com/life-cycle-assessment-lca-database/.

3. Life Cycle Assessment Scenarios

Table 6. Transport to the building site (A4)

NAME	VALUE	UNIT
Fuel type	Diesel	-
Fuel consumption	3.18	l/US ton
Vehicle type	Truck TL/dry van (EPA SmartWay)	-
Transport distance	1127 (700)	km (mi)
Payload capacity	22.6	US ton
Gross density of products transported	1.48	kg/m^3
Weight of products transported (if gross density not reported)	-	kg
Volume of products transported (if gross density not reported)	-	m^3
Capacity utilization volume factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaging products)	<1	-

Table 7. Installation into the building (A5)

NAME	VALUE	UNIT
Ancillary materials	-	kg
Net freshwater consumption specified by water source and fate (amount evaporated, amount disposed to sewer)	-	m^3
Other resources	-	kg
Electricity consumption	-	kWh
Other energy carriers	-	MJ
Product loss per functional unit	-	kg
Waste materials at the construction site before waste processing, generated by product installation	0.302	kg
Output materials resulting from on-site waste processing (specified by route, e.g. for recycling, energy recovery and/or disposal)	-	kg
Biogenic carbon contained in packaging	0.338	kg CO_2

Direct emissions to ambient air, soil and water	-	kg
VOC content	-	µg/m^3

Table 8. End of life (C1-C4)

NAME		VALUE	UNIT
Assumptions for scenario development (description of deconstruction, collection, recovery, disposal method and transportation)			
Collection process (specified by type)	Collected separately	-	kg
	Collected with mixed construction waste	-	kg
Recovery (specified by type)	Reuse	-	kg
	Recycling	-	kg
	Landfill	0.673	kg/declared unit
	Incineration	-	kg
	Incineration with energy recovery	-	kg
	Energy conversion efficiency rate	-	
Disposal (specified by type)	Product or material for final deposition	0.673	kg/declared unit
Removals of biogenic carbon (excluding packaging)		-	kg CO_2

4. Life Cycle Assessment Results

4.1. Life Cycle Impact Assessment Results

The potential environmental impacts of JM's PVC pipe fittings and jacketing (manufactured at its Edison plant, NJ) are presented in this section. The estimated impact results are only relative statements, which do not indicate the endpoints of the impact categories, exceeding threshold values, safety margins and/or risks. As the market for this product is North America, results for the North American characterization methods listed in ISO 21930 (ISO, 2017) are declared in this report (see Section 5.4.5 Environmental Performance of PCR (Environdec, 2023)). The IPCC AR6 methodology (IPCC, 2021) has been considered for GWP100 impacts; however, since both ISO 21930 (ISO, 2017) and EN15804 (EN 15804+A2/AC 2021, 2021) make reference to the IPCC's Fifth Assessment Re-port (AR5) (IPCC, 2013) for GWP100 indicators, the latter has been also included in this assessment. The GWP100 category is reported excluding biogenic carbon. It is relevant to note that the difference in results for GWP100 indicators from AR6 and AR5 methodologies is negligible. ISO 21930 (ISO, 2017) requires the abiotic depletion potential for fossil resources (ADP_f) to be reported in this study. CML 2016 (CML, 2016) is the methodology used to report ADP_f. The rest of the impact parameters are based on TRACI 2.1 (Bare, 2012). Resource use, output flows and waste, and carbon emissions and removal have been tabulated as per ISO 21930 (ISO, 2017). Modules A1, A2, A3, A4, A5, C1, C2, C3, and C4 are included in the system boundary of this LCA. The PCR (Environdec: EPD International AB, 2023) requires the aggregated reporting of results for modules A1, A2, and A3 (i.e., A1-A3). The use of results of modules A1-A3 without considering the results of module C is strongly discouraged.

Table 9 presents the results for the LCIA categories in the cradle-to-gate with options for the production of 1 kg of packaged PVC pipe fittings and jacketing. The values of C1 and C3 are zeroes as described in the System Boundary 2.2.

Table 9: LCIA categories for 1 kg of packaged PVC pipe fittings and jacketing.

TRACI v2.1	Units	A1-A3	A4	A5	C1	C2	C3	C4
GWP100 AR6	[kg CO_2 eq]	2.41E+00	7.35E-02	3.59E-02	0.00E+00	1.45E-03	0.00E+00	1.43E-02
GWP100 AR5	[kg CO_2 eq]	2.41E+00	7.35E-02	3.71E-02	0.00E+00	1.45E-03	0.00E+00	1.43E-02
ODP	[kg CFC-11 eq]	8.46E-12	1.63E-16	2.02E-16	0.00E+00	3.22E-18	0.00E+00	6.92E-16
AP	[kg SO_2 eq]	6.62E-03	2.61E-04	1.33E-04	0.00E+00	4.67E-06	0.00E+00	7.47E-05
EP	[kg N eq]	5.37E-04	2.50E-05	1.49E-05	0.00E+00	4.63E-07	0.00E+00	1.20E-04
SFP	[kg O_3 eq]	1.19E-01	6.04E-03	8.12E-04	0.00E+00	1.08E-04	0.00E+00	1.36E-03
ADP_f	[MJ, LHV]	5.07E+01	1.03E+00	6.37E-02	0.00E+00	2.03E-02	0.00E+00	2.18E-01

Figure 3 presents an overview of the contribution analysis of the different life cycle modules to each environmental impact category reported. It is important to note that the 100-year time horizon global warming potential presented in Figure 3 excludes biogenic carbon and is estimated according to the IPCC AR6 methodology (IPCC, 2021). Raw materials supply (A1) contributes the most to GWP100 (57%), while manufacturing (A3) contributes an additional 33%. As expected, a similar trend is ob-served for abiotic depletion potential - fossil resources (ADP_f), where the supply of raw materials (A1) contributes 67% to the total impact, while manufacturing (A3) accounts for an additional 26%. Manufacturing (A3) is also the main contributor to acidification potential (AP, 64%), eutrophication potential (EP, 50%), smog formation potential (SFP, 50%) and ozone depletion potential (ODP, 99.6%). The second largest contributor in these impact categories is raw materials supply (A1). Downstream impacts from installation (A4-A5) contribute at most 5% to the total impact of any category and are driven by the road transportation of the product to the installation site. Product disposal at its end-of-life becomes only relevant for the eutrophication potential metric, where it accounts for 16% of its total impact; may be related to landfill leachate emissions.

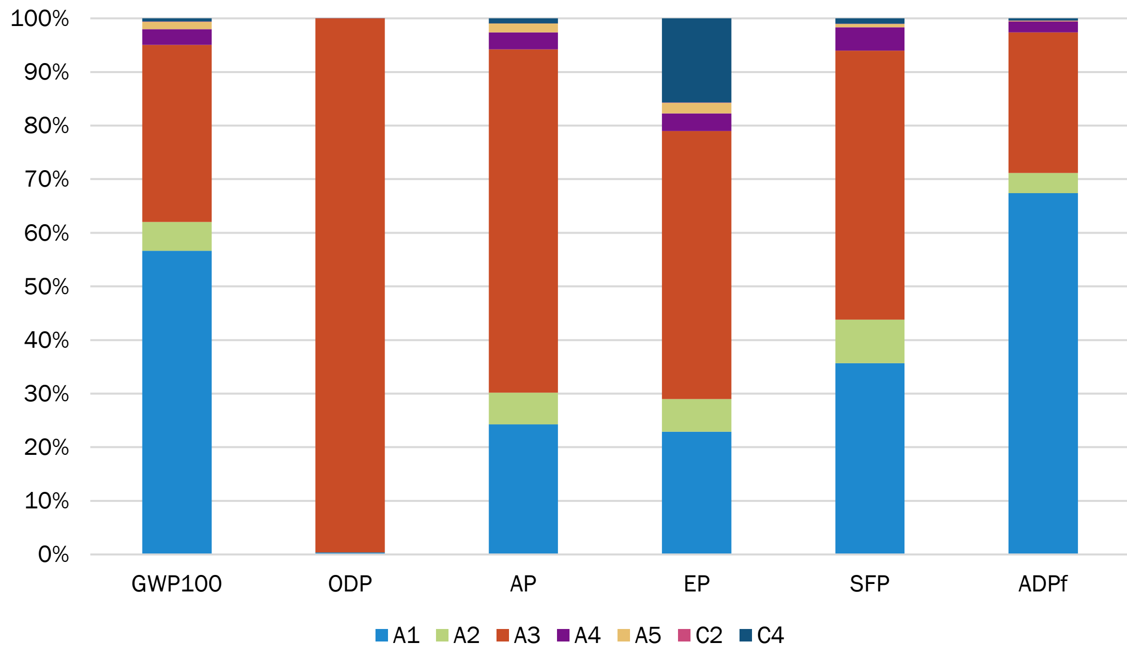


Figure 3: Contributions to environmental impacts for 1 kg of packaged PVC pipe fittings and jacketing.

4.2. Life Cycle Inventory Results

Table 10 to Table 12 present the results for the resource use, output flows and waste categories, and carbon emissions and removals in the cradle-to-gate with options for the production of 1 kg of packaged PVC pipe fittings and jacketing. The values of C1 and C3 are zeroes as described in the System Boundary 2.2

Table 10: Resource use for 1 kg of packaged PVC pipe fittings and jacketing.

PARAMETER	UNITS	A1-A3	A4	A5	C1	C2	C3	C4
RPR_E	[MJ, LHV]	1.46E+01	4.02E-02	7.65E-03	0.00E+00	7.94E-04	0.00E+00	2.64E-02
RPR_M	[MJ, LHV]	2.46E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RPR_T	[MJ, LHV]	1.71E+01	4.02E-02	7.65E-03	0.00E+00	7.94E-04	0.00E+00	2.64E-02
$NRPR_E$	[MJ, LHV]	4.52E+01	1.03E+00	6.62E-02	0.00E+00	2.04E-02	0.00E+00	2.25E-01
$NRPR_M$	[MJ, LHV]	1.20E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$NRPR_T$	[MJ, LHV]	5.72E+01	1.03E+00	6.62E-02	0.00E+00	2.04E-02	0.00E+00	2.25E-01
SM	[kg]	3.17E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	[MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

NRSF	[MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE	[MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	[m^3]	1.22E-02	1.40E-04	4.82E-05	0.00E+00	2.76E-06	0.00E+00	2.79E-05

Table 11: Output flows and waste categories for 1 kg of packaged PVC pipe fittings and jacketing.

PARAMETER	UNITS	A1-A3	A4	A5	C1	C2	C3	C4
HWD	[kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NHWD	[kg]	1.10E-02	0.00E+00	1.80E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
HLRW	[kg]	2.65E-06	3.01E-09	9.88E-10	0.00E+00	5.94E-11	0.00E+00	2.79E-09
ILLRW	[kg]	2.22E-03	2.54E-06	8.71E-07	0.00E+00	5.01E-08	0.00E+00	2.49E-06
CRU	[kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MFR	[kg]	5.88E-02	0.00E+00	1.10E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MER	[kg]	0.00E+00	0.00E+00	1.17E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
EE	[MJ, LHV]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 12: Carbon emissions and removals for 1 kg of packaged PVC pipe fittings and jacketing.

PARAMETER	UNITS	A1-A3	A4	A5	C1	C2	C3	C4
BCRP	[kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEP	[kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCRK	[kg CO_2]	2.51E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEK	[kg CO_2]	2.47E-02	0.00E+00	1.07E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEW	[kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCE	[kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CCR	[kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CWNR	[kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 13 presents the variations in GWP100 impact (according to the IPCC AR6 methodology) for the declared modules between the products from extrusion (i.e., bulk rolls and jacketing) and the products from thermoforming (i.e., fittings). Bulk rolls and jacketing are produced by the same machining process (i.e., extrusion) and therefore have the same GWP100. On the other hand, fittings undergo an extra thermoforming step which increases their GWP100.

Table 13: Variations in GWP100 between the products of extrusion and thermoforming steps.

MODULE	UNITS	PRODUCT COUNT	MINIMUM (BULK ROLLS, JACKETING)	MAXIMUM (FITTINGS)	MAX/ MIN RATIO	MEAN	WEIGHTED AVERAGE	PERCENTAGE VARIATION
GWP100 AR6								
A1-A3	[kg CO_2 eq.]	3	1.68E+00	3.22E+00	1.92E+00	2.45E+00	2.41E+00	48%
A4	[kg CO_2 eq.]	3	7.35E-02	7.35E-02	1.00E+00	7.35E-02	7.35E-02	0%
A5	[kg CO_2 eq.]	3	3.59E-02	3.59E-02	1.00E+00	3.59E-02	3.59E-02	0%
C2	[kg CO_2 eq.]	3	1.45E-03	1.45E-03	1.00E+00	1.45E-03	1.45E-03	0%
C4	[kg CO_2 eq.]	3	1.43E-02	1.43E-02	1.00E+00	1.43E-02	1.43E-02	0%
Total	[kg CO_2 eq.]	3	1.81E+00	3.35E+00	1.85E+00	2.58E+00	2.53E+00	46%

Table 14 displays the variation of each environmental impact indicator result, aggregated over all included modules, between the products of extrusion (i.e., bulk rolls and jacketing) and the products of thermoforming (i.e., fittings).

Table 14: Variations in LCIA impact categories and indicators between the products of extrusion and thermoforming steps.

	UNITS	PRODUCT COUNT	MINIMUM (BULK ROLLS, JACKETING)	MAXIMUM (FITTINGS)	MAX/MIN RATIO	MEAN	WEIGHTED AVERAGE	% VARIATION
LCIA Categories								
GWP100 AR6	[kg CO_2 eq.]	3	1.81E+00	3.35E+00	1.85E+00	2.58E+00	2.53E+00	46%
GWP100 AR5	[kg CO_2 eq.]	3	1.81E+00	3.35E+00	1.85E+00	2.58E+00	2.54E+00	46%
ODP	[kg CFC11 eq.]	3	5.84E-12	1.14E-11	1.95E+00	8.62E-12	8.46E-12	49%
AP	[kg SO_2 eq.]	3	5.25E-03	9.16E-03	1.75E+00	7.21E-03	7.09E-03	43%
EP	[kg P eq.]	3	5.53E-04	8.59E-04	1.55E+00	7.06E-04	6.97E-04	36%
SFP	[kg O_3 eq.]	3	9.69E-02	1.61E-01	1.66E+00	1.29E-01	1.27E-01	40%
ADP_f	[MJ]	3	3.96E+01	6.61E+01	1.67E+00	5.28E+01	5.21E+01	40%

Resource Use								
RPRe	[MJ, LHV]	3	1.01E+01	1.99E+01	1.98E+00	1.50E+01	1.47E+01	49%
RPRm	[MJ, LHV]	3	1.69E+00	3.31E+00	1.95E+00	2.50E+00	2.46E+00	49%
NRPRe	[MJ, LHV]	3	3.24E+01	6.25E+01	1.93E+00	4.75E+01	4.66E+01	48%
NRPRm	[MJ, LHV]	3	1.01E+01	1.41E+01	1.39E+00	1.21E+01	1.20E+01	28%
SM	[kg]	3	2.79E-01	3.59E-01	1.28E+00	3.19E-01	3.17E-01	22%
FW	[m^3]	3	8.87E-03	1.65E-02	1.86E+00	1.27E-02	1.24E-02	46%
Output flows and waste categories								
NHWD	[kg]	3	1.91E-01	1.91E-01	1.00E+00	1.91E-01	1.91E-01	0%
HLRW	[kg]	3	1.16E-06	4.34E-06	3.73E+00	2.75E-06	2.66E-06	73%
ILLRW	[kg]	3	9.71E-04	3.62E-03	3.73E+00	2.30E-03	2.22E-03	73%
MFR	[kg]	3	1.24E-01	2.19E-01	1.77E+00	1.71E-01	1.69E-01	43%
MER	[kg]	3	1.17E-02	1.17E-02	1.00E+00	1.17E-02	1.17E-02	0%
Carbon emissions and removals								
BCRK	[kg CO_2 eq.]	3	1.73E-01	3.38E-01	1.95E+00	2.56E-01	2.51E-01	49%
BCEK	[kg CO_2 eq.]	3	1.31E-01	1.31E-01	1.00E+00	1.31E-01	1.31E-01	0%

5. LCA Interpretation

The present life cycle assessment found that the 100-year time horizon global warming potential (GWP100) excluding biogenic carbon of JM's packaged Zeston® PVC pipe fittings and jacketing is 2.53 kg CO_2e/kg of packaged product. Upstream environmental impacts from the production and supply of raw materials (A1) dominate the GHG intensity of the product (57% contribution to GWP100). More specifically, the manufacturing and supply of virgin PVC resin accounts for more than half (54%) of GWP100. Other key hotspots of the GHG intensity of the product are the supply of packaging materials (19%), and the generation of the electricity consumed during manufacturing (14%).

The manufacturing stage (A3) drives the environmental impacts measured by other categories, as is the case for acidification potential (AP), eutrophication potential (EP), smog formation potential (SFP), and ozone depletion potential (ODP). Downstream impacts from installation (A4-A5) contribute at most 5% to the total impact of any category and are driven by the road transportation of the product to the installation site. End-of-life disposal to landfill (C2, C4) does not contribute significantly to the declared impact categories, as PVC and insulation are all but inert in a landfill environment, except for its contribution to EP.

6. Additional Environmental Information

6.1. Environment and Health During Installation

Zeston® PVC fittings and jacketing are classified as a non-hazardous substance or mixture per GHS classification. They meet the definition of article in the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

Use the appropriate personal protective equiptment (PPE) during installation. Johns Manville recommends the following PPE precautions when handling Zeston PVC fittings and jacketing:

- **Respiratory:** No personal respiratory protective equipment is normally required.
- **Hand protection:** For prolonged or repeated contact when handling Zeston products, use protective gloves.
- **Eye protection:** Safety glasses are recommended during installation.
- **Skin and body protection:** If used as directed, no special protective equipment is necessary.
- **Hygeine measures:** Handle Zeston PVC in accordance with good, industrial hygeine and safety practice. Written instructions for handling must be available at the work place.

JM's Zeston® PVC safety data sheet may be found at:

https://www.jm.com/content/dam/jm/global/en/MSDS/200000000063_US_EN.pdf

7. References

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