Environmental Product Declaration

According to ISO 14025

Laminated Glass Products

CARDINAL GLASS INDUSTRIES

Cardinal Glass Industries is considered one of the world's leading providers of superior quality glass products. From the melting of sand to produce clear float glass to the vacuum sputtering of silver to produce low-emissivity coatings.

With this EPD Cardinal intends to support architects and designers with the information they need about the life-cycle environmental impact of Cardinal glass products.

CARDINAL® Glass Industries

Issue Date: 12-04-2020

Valid Until: 12-04-2025

Declaration Number: ASTM-EPD162

DECLARATION INFORMATION

DECLARATION

Program Operator: ASTM International

Company: Cardinal Glass Industries

www.astm.org

www.cardinalcorp.com

PRODUCT INFORMATION

Product Name: Laminated Glass

Product Definition: Two or more lites of glass permanently bonded together with an interlayer material

Declaration Type: Business-to-business (B2B)

PCR Reference:

- Part A: Calculation Rules for the LCA and Requirements Project Report, (IBU/UL E, V1.3, 06.19.2014)
- Part B: Processed Glass EPD Requirements (UL Environment, v1.0, 8.17.2016)

VALIDITY / APPLICABILITY

Period of Validity: This declaration is valid for a period of 5 years from the date of publication

Geographic Scope: United Sates

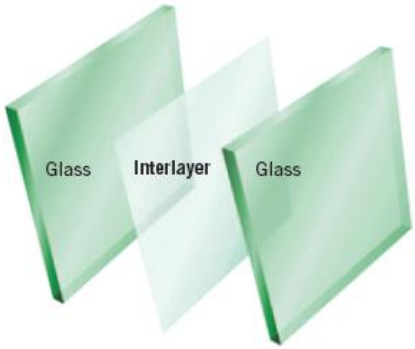
PCR Review was conducted by:

- Thomas P. Gloria, Ph.D., Industrial Ecology Consultants
- Mr. Jack Geibig, Ecoform
- Mr. Bill Stough, Sustainable Research Group

PRODUCT APPLICATION AND / OR CHARACTERISTICS

The primary application is windows and doors.

Technical Drawing or Product Visual



Content of the Declaration

- Product definition and physical building-related data
- Details of raw materials and material origin
- Description of how the product is manufactured
- Data on usage condition, other effects and end-of-life phase
- Life Cycle Assessment results

Verification

Independent verification of the declaration and data, according to ISO 21930:2007 and ISO 14025:2006 ☐ internal x external

This declaration and the rules on which this EPD is based have been examined by an independent verifier in accordance with ISO 14025.

Name: Timothy S. Brooke ASTM International 100 Barr Harbor Dr. West Conshohocken, PA 19428 cert@astm.org	**Date:** 12-04-2020	**Name:** Thomas Gloria, Ph.D. Industrial Ecology Consultants info@industrial-ecology.com	**Date:** 12-04-2020

EPD Summary

This document is a Type III environmental product declaration by Cardinal Glass Industries (Cardinal) that is certified by ASTM International (ASTM) as conforming to the requirements of ISO 21930 and ISO 14025. ASTM has assessed that the Life Cycle Assessment (LCA) information fulfills the requirements of ISO 14040 in accordance with the instructions listed in the referenced product category rules. The intent of this document is to further the development of environmentally compatible and sustainable construction methods by providing comprehensive environmental information related to potential impacts in accordance with international standards.

No comparisons or benchmarking is included in this EPD. Environmental declarations from different programs based upon differing PCRs may not be comparable. Comparison of the environmental performance of construction works and construction products using EPD information shall be based on the product's use and impacts at the construction works level. In general, EPDs may not be used for comparability purposes when not considered in a construction works context. Given this PCR ensures products meet the same functional requirements, comparability is permissible provided the information given for such comparison is transparent and the limitations of comparability explained. When comparing EPDs created using this PCR, variations and deviations are possible. Example of variations: Different LCA software and background LCI datasets may lead to different results for upstream or downstream of the life cycle stages declared.

The table below presents LCIA results for 1 m^2 (17.1 kg) of Cardinal's laminated glass product.

Method	Impact Category	Unit	Laminated Glass Total (A1-A3)
TRACI 2.1	Global Warming Potential	kg CO_2 eq.	49
TRACI 2.1	Ozone Depletion Potential	kg CFC-11 eq.	0
TRACI 2.1	Acidification Potential	kg SO_2 eq.	0.129
TRACI 2.1	Eutrophication Potential	kg N eq.	0.00943
TRACI 2.1	Photochemical Ozone Creation Potential	kg O_3 eq.	3.07
ReCiPe 1.08	Mineral resource depletion potential	kg Fe eq.	0.45
TRACI 2.1	Resources, fossil fuels	MJ	91.3

Note that ODP values are originally in the order of magnitude between negative 10^{-10}-10^{-13}. The negative values are a result of credits given in the background systems of various GaBi datasets. Since the magnitude of these ODP results is extremely low, the values are read and interpreted as zero.

Scope and Boundaries of the Life Cycle Assessment

The Life Cycle Assessment (LCA) was performed according to ISO 14040 (ISO, 2006) and ISO 14044 (ISO, 2006) following the requirements of the ASTM EPD Program Instructions and referenced PCR.

System Boundary: Cradle-to-gate

Allocation Method: Area and mass of glass produced

Declared Unit: 1 m^2 (17.1 kg) of laminated glass

1 Organization, Product, and Product Category Descriptions

Description of Company/Organization

Cardinal Glass Industries is a management-owned S-Corporation leading the industry in the development of residential glass for windows and doors. We have grown to more than 7,000 employees located at 43 manufacturing locations around the United States.

Cardinal operates (5) divisions:

- Cardinal FG (float glass)
- Cardinal CT (custom tempered glass)
- Cardinal LG (laminated glass)
- Cardinal CG (coated glass)
- Cardinal IG (insulating glass)

Description and Definition of Products

Cardinal's laminated glass products are used to improve safety, security, and sound control of windows and doors. Tempered or heat-strengthened glass can be incorporated to enhance load resistance and meet certain building codes. Low-E coated glass can be used to enhance the glazing performance.

Product Use and Application

After fabrication into laminated glass units, the final product is shipped to a customer for installation into an insulating glass unit or window system.

Technical Requirements

Primary use is governed by building codes. These codes will layout safety glazing requirements, structural sufficiency needs, and building energy compliance.

Material Content

The composition of processed glass products produced by Cardinal is given below in Table 1-1.

Table 1-1: Material composition of insulating glass

Material inputs	Mass %
Uncoated glass	43%
Coated glass	9.6%
Tempered glass	28%
Coated & tempered glass	9.0%
Polyvinyl butaral (PVB)	8.1%
Ionomer	1.8%
Galvanized steel	< 1%

2 Life Cycle Stages

Production

Cardinal laminated glass products are produced at three facilities in the United States. The glass and interlayer are cut to size and sandwiched, then de-aired and temporarily bonded in a heated nip rolling process. The pre-laminated glass is then heated under pressure in an autoclave to dissolve any remaining air and permanently bond the glass to the interlayer. The glass is produced in a made-to-order process, allowing for near infinite different combinations of glass, interlayers, and options. At multiple points in the production process, the units are monitored for quality and integrity. They are shipped sequenced, in our customer's production order, and in a just-in-time manner for our customers to assemble into an insulating glass unit or install into their window and door assemblies. Figure 2-1 illustrates the laminating process.

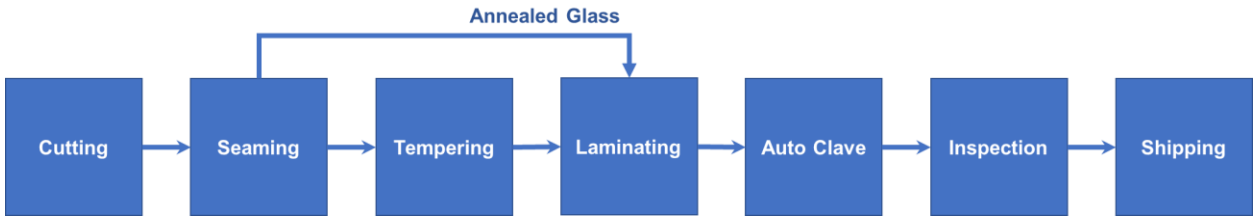


Figure 2-1: Laminating process diagram

The following life cycle stages are evaluated:

- **Material Extraction and Pre-Processing -** Raw material extraction, pre-processing, and upstream transport for raw material manufacturing, but excludes the inbound transport of materials to the manufacturing facility
- **Transport -** Inbound transport of raw materials from the supplier to the manufacturing facility
- **Manufacturing -** Includes the energy and inputs to manufacturing processed glass products

Packaging

The laminated glass product is packaged in cardboard and secured using plastic and steel banding, plastic wrap, and wood.

3 Life Cycle Assessment Background Information

Functional unit

The declared unit for processed glass is 1 m^2 of glass. 1 m^2 of laminated glass weighs 17.1 kg. The laminated glass product is 7.5 mm thick, including two panes of glass and the interlayer.

System Boundary

The system boundary of the study is cradle-to-gate.

Estimates and Assumptions

The "average" glass pane modeled in the study is a calculated average pane thickness and does not necessarily represent a specific product manufactured by Cardinal.

Cut-off Criteria

No cut-off criteria had to be applied within this study. The system boundary was defned 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 LCI are available to represent a flow, proxy data have been applied based on conservative assumptions regarding environmental impacts.

Background Data

The LCA model was created using the GaBi software system, version 9.2 for life cycle engineering, developed by Sphera. The GaBi 2019 LCI database provides the life cycle inventory data for several of the raw and process materials obtained from the background system. Database documentation can be found at http://www.gabi-software.com/support/gabi/gabi-database-2019-lci-documentation/.

Data Quality

A variety of tests and checks were performed throughout the project to ensure the high quality of the completed LCA. Data included first-hand company manufacturing data in combination with consistent background LCI information from the GaBi 2019 databases.

Primary data represent the production of laminated glass at Cardinal facilities located in the United States. As such, the geographical coverage for this study is based on the respective system boundaries for all processes and products produced at each facility. Whenever geographically-relevant background data are not readily available, European or global data have been used as proxies.

Period under Review

The primary data collected from Cardinal are intended to represent production within the 2019 calendar year.

Allocation

For facilities that produce two types of glass products, such as tempered glass and laminated glass, allocation was applied to materials, utilities, packaging, and waste to reflect the production of laminated glass only. Incoming glass and utilities were allocated to laminated glass based on the total mass of glass produced at the facility. Process materials, packaging and waste were allocated to laminated glass based on the total area of glass produced at the facility.

Comparability

A comparison or evaluation of EPD data is only possible if all data sets to be compared are 1) created according to EN 15804 and 2) are considered in a whole building context or utilize identical defined use stage scenarios. Give this PCR is cradle to gate in scope, comparisons of EPD data from one product to another are not allowed. Refer to section 5.3 of EN 15804 for further information.

4 Life Cycle Assessment Results

Life cycle assessment results for laminated glass products are presented per m^2 of glass product. The cradle-to-gate impacts have been broken out into production of glass input and processing. Processing includes inbound transportation of all materials, energy and water use, process and packaging materials, and production waste processing and disposal.

Note that ODP values are originally in the order of magnitude between negative 10^{-10}-10^{-13}. The negative values are a result of credits given in the background systems of various GaBi datasets. Since the magnitude of these ODP results is extremely low, the values are read and interpreted as zero.

Table 4-1: LCIA results for laminated glass, per declared unit (1 m^2, 17.1 kg)

Method	Impact Category	Unit	Float Glass Only (A1)	Processing (A1-A3)	Total (A1-A3)
TRACI 2.1	Global Warming Potential	kg CO_2 eq.	23.4	25.7	49
TRACI 2.1	Ozone Depletion Potential	kg CFC-11 eq.	0	0	0
TRACI 2.1	Acidification Potential	kg SO_2 eq.	0.0815	0.0472	0.129
TRACI 2.1	Eutrophication Potential	kg N eq.	0.00491	0.00452	0.00943
TRACI 2.1	Photochemical Ozone Creation Potential	kg O_3 eq.	2.21	0.864	3.07
ReCiPe 1.08	Mineral Resource Depletion Potential	kg Fe eq.	0.153	0.297	0.45
TRACI 2.1	Resources, Fossil Fuels	MJ	42.5	48.8	91.3

Table 4-2: Resource use LCI results for laminated glass, per declared unit (1 m^2, 17.1 kg)

Flow	Unit	Float Glass Only (A1)	Processing (A1-A3)	Total (A1-A3)
Renewable primary energy as energy carrier	MJ	11.3	27.7	39
Renewable energy resources as material utilization	MJ	-	-	-
Renewable total primary energy demand	MJ	11.3	27.7	39
Non-renewable primary energy as energy carrier	MJ	332	454	786
Non-renewable energy resources as material utilization	MJ	-	-	-
Non-renewable total primary energy demand	MJ	332	454	786
Use of secondary material	kg	0.015	0.00215	0.0171
Renewable secondary fuels	MJ	-	-	-
Non-renewable secondary fuels	MJ	-	-	-
Use of net fresh water resources	m^3	0.0463	0.0965	0.143

Table 4-3: Wastes and outputs LCI results for laminated glass, per declared unit (1 m^2, 17.1 kg)

Flow	Unit	Float Glass Only (A1)	Processing (A1-A3)	Total (A1-A3)
Hazardous waste disposed	kg	2.81E-07	3.22E-07	6.03E-07
Non-hazardous waste disposed	kg	1.01	1.8	2.82
Radioactive waste	kg	-	-	-
Components for re-use	kg	-	-	-
Materials for recycling	kg	0.0039	1.01	1.02
Materials for energy recovery	kg	-	-	-
Exported electrical energy	MJ	-	-	-
Exported thermal energy	MJ	-	-	-

5 LCA Interpretation

The analysis results represent the cradle-to-gate environmental performance of laminated glass products. Detailed results are presented for all impact impact categories, broken down by process component. Note that the float glass category represents all incoming glass that is not processed onsite.

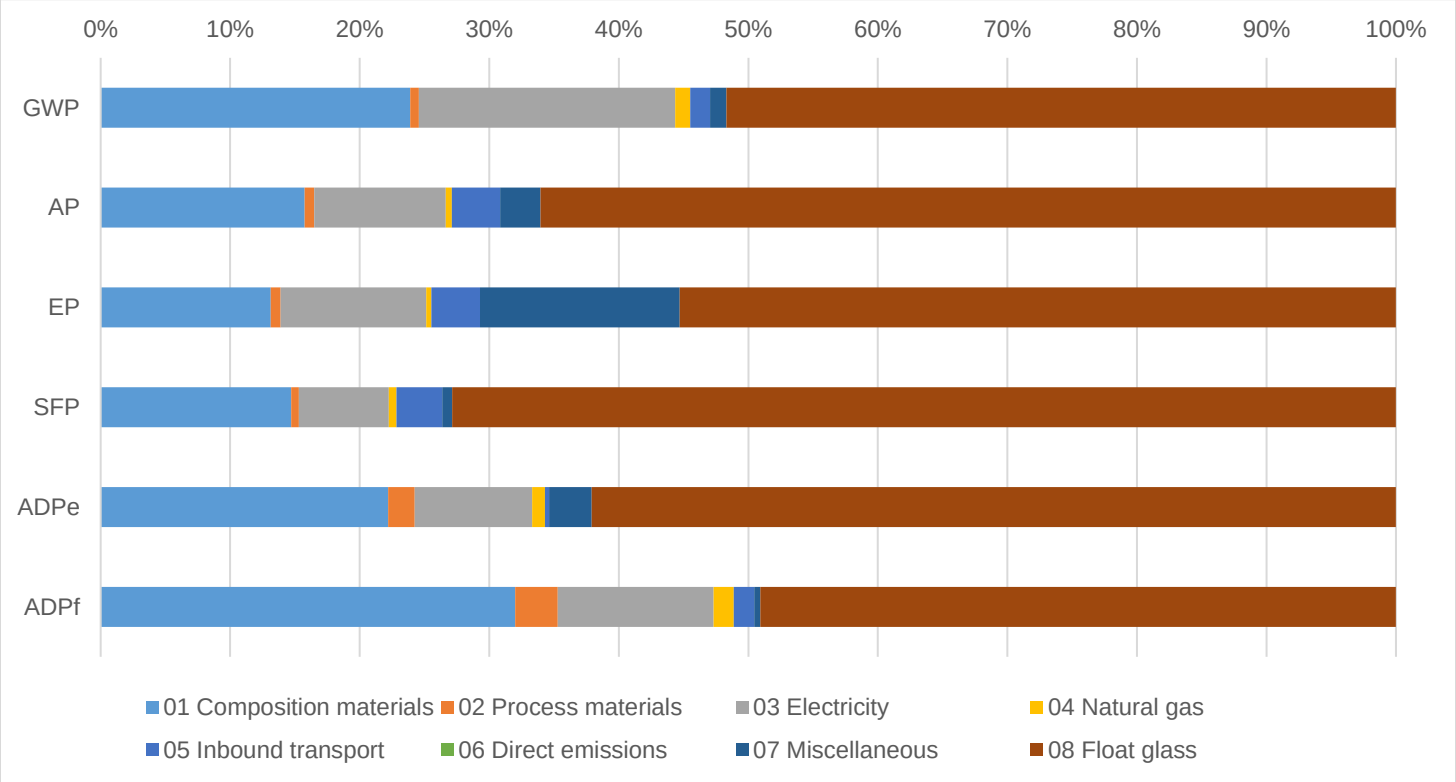


Figure 5-1: Relative contributions of laminating process components (TRACI 2.1)

Figure 5-1 presents relative results for Cardinal's laminated glass. Composition materials represent interlayer materials. Incoming glass and interlayer materials are the primary driver of results. Electricity use during the lamination process is also a major contributor to environmental impacts.

6 Additional Environmental Information

Environment and Health During Manufacturing

Please refer to the Article Data Sheet for laminated glass products, which can be found at www.cardinalcorp.com.

Environment and Health During USE

Please refer to the Article Data Sheet for laminated glass products, which can be found at www.cardinalcorp.com.

Extraordinary Effects

Please refer to the Article Data Sheet for laminated glass products, which can be found at www.cardinalcorp.com.

Environmental Activities and Certifications

Please refer to the Article Data Sheet for laminated glass products, which can be found at www.cardinalcorp.com.

7 References

Bare, J. (2012). *Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI) - Software Name and Version Number: TRACI version 2.1 - User's Manual.* Washington, D.C.: U.S. EPA.

IBU/UL Environment. (2014). *PCR for Building-Related Products and Services - Part A: Calculation Rules for the LCA and Requirements Project Report (V1.3, 06.19.2014).*

ISO. (2006). *ISO 14025: Environmental labels and declarations - Type III environmental declarations - Principles and procedures.* Geneva: International Organization for Standardization.

ISO. (2006). *ISO 14040: Environmental management - Life cycle assessment - Requirements and guidelines.* Geneva: International Organization for Standardization.

ISO. (2006). *ISO 14044: Environmental management - Life cycle assessment - Principles and framework.* Geneva: International Organization for Standardization.

ISO. (2007). *ISO 21930: Sustainability in buildings and civil engineering works -- Core rules for environmental product declarations of construction products and services.* Geneva: International Organization for Standardization.

Sphera. (2019). *GaBi LCA Database Documentation*. Retrieved from Sphera: http://www.gabi-software.com/support/gabi/gabi-database-2019-lci-documentation/

UL Environment. (2016). *PCR Guidance for Building-Related Products and Services - Part B: Processed Glass EPD Requirements.* US.

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