LIFE CYCLE ASSESSMENT (LCA) OF ISOLATEK INTERNATIONAL PASSIVE FIRE PROTECTION PRODUCTS

Status Draft

Client Isolatek International

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Contents

1 INTRODUCTION

1.1 Opportunity

Isolatek International is the world’s leading single source manufacturer of passive fireproofing materials for the construction industry. Isolatek has been working towards low energy and sustainably built products and solutions that will be important for the construction sector of the market place. In fulfilling their commitment to sustainability, it is important for Isolatek to conduct Life Cycle Assessments. These Life Cycle Assessments will evaluate the environmental impacts of products for the life cycle stages from raw materials to manufacturing of the products or cradle to gate. The goal of conducting the Life Cycle Assessment is to understand the scope of environmental impacts from the products and to recognize ways to improve the process and reduce overall impacts. Isolatek International intends to provide information that the market needs to be able to accurately assess the environmental impacts of their products and solutions.

Isolatek International has chosen the cradle-to-gate approach for the Life Cycle Assessment for their products. By conducting a cradle-to-gate Life Cycle Assessment, Isolatek will be informed on how to reduce the environmental impacts for each of their products from raw material acquisition to manufacturing.

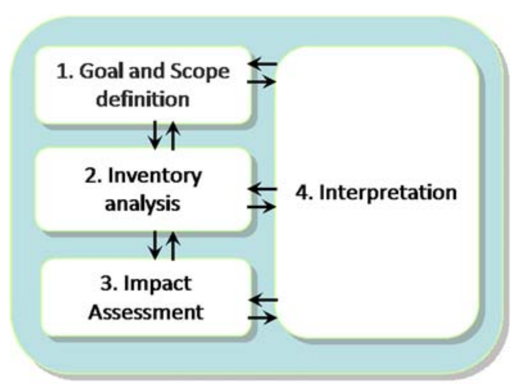
Isolatek International is interested in having a Life Cycle Assessment (LCA) conducted on their most most widely distributed products, so that they can have the data available to the public within a Sustainable Minds Transparency Report™. A Sustainable Minds Transparency Report™ is a Type III Environmental Declaration that can be used for communication with and amongst other companies, architects, and consumer communication, and that can also be utilized in whole building LCA tools in conjunction with the LCA background report and LCI.

Isolatek International commissioned Sustainable Minds to develop LCAs for their passive fireproofing technologies. Isolatek International is seeking guidance for future product development and improvement that can be supplied from the LCA results.

1.2 Life Cycle Assessment

This life cycle assessment (LCA) follows the ASTM PCR for Spray-Applied Fire-Resistive Materials (SFRM), which conforms to ISO 21930:2017 and ISO 14025:2006 [1]. This report includes the following phases:

- Goal and Scope
- Inventory Analysis
- Impact Assessment
- Interpretation



Source: ISO 14040

An ISO 14040-44 third-party review and a third-party report verification for Transparency Reports are required in order to use Transparency Reports as Type III Environmental Declarations. The third-party review and third-party Transparency Report verification will both be completed in this project.

1.3 Status

All information in this report reflects the best possible inventory by Isolatek International at the time it was collected, and best practices were conducted by Sustainable Minds and Isolatek International employees to transform this information into this LCA report. The data covers annual manufacturing data for 1/1/2017-12/31/2017 from four of Isolatek International’s manufacturing locations: Stanhope, NJ; Houston, TX; San Bernardino, CA; and Huntington, IN. Where data was missing, assumptions were made from manufacturing data for the four facilities based upon expertise from Isolatek International employees. Eight months of electricity data was used for the Houston, TX facility because electricity carriers were changed for the Houston plant, and the prior data was not available. For the other three facilities, twelve months of electricity data was used [5].

This study includes primary data from the processes at the four manufacturing facilities. Suppliers provided incoming raw material data to Isolatek's purchasing department. Phil provided SM with the raw material data applicable to the products studied.

Isolatek International has chosen to have the LCA report undergo third-party review and the Transparency Reports undergo third-party verification. This review and verification will be performed by NSF to assess conformance to ISO 14040/14044 and the ASTM PCR.

1.4 Team

This report is based on the work of the following LCA project team members on behalf of Isolatek International:

- Phil Mancuso, Senior Technical Services Manager | Standards & Certifications, Isolatek International. Phil has been assisted by numerous Isolatek International employees during the data collection, reporting, and interpretation phases.

From Sustainable Minds:

- Kelli Young, LCA Practitioner
- Kim Lewis, LCA Internal Reviewer

1.5 Structure

This report follows the following structure:

- Chapter 2: Goal and scope
- Chapter 3: Inventory analysis
- Chapter 4: Impact assessment
- Chapter 5: Interpretation
- Chapter 6: Sources

This report includes LCA terminology. To assist the reader, special attention has been given to list definitions of important terms used at the end of this report.

2 GOAL AND SCOPE

This chapter explains the starting points for the LCA. The aim of the goal and scope is to define the products under study and the depth and width of the analysis.

2.1 Intended application and audience

This report intends to define the specific application of the LCA methodology from raw material acquisition and transport to manufacturing, cradle-to-gate, of Isolatek International products. It is intended for both internal and external purposes. The intended audience includes the program operator (Sustainable Minds) and reviewers who will be assessing the LCA for conformance to the PCRs, as well as Isolatek International stakeholders involved in marketing and communications, operations, and design. Results presented in this document are not intended to support comparative assertions within this study. However, the results will be disclosed to the public in Sustainable Minds Transparency Reports (Type III Environmental Declarations per ISO 14025) which are focused on products that are available in the US market. These Transparency Reports will undergo critical review for conformance to the PCR.

2.2 Applied fireproofing products

Isolatek International is recognized as the world's leading single source manufacturer with a range of applied fireproofing materials for steel construction. For more than 60 years, Isolatek International has been known for the outstanding thermal performance, durability, and ease of application of its products. The products are supported by the industry's most knowledgeable team of Technical and Field professionals [2]. As a manufacturer of applied fireproofing materials, Isolatek International is interested in demonstrating its sustainability leadership and leveraging business value associated with transparent reporting of its products' cradle-to-gate environmental impacts. For more information on Isolatek International products, go to http://isolatek.com/.

The data given by Isolatek combined the CAFCO® BLAZE-SHIELD® II and CAFCO® BLAZE-SHIELD® II HS products. Therefore, in this study, these two products are treated as one. In the CAFCO® BLAZE-SHIELD® Series Products, BLAZE-SHIELD® II and HS as well as CAFCO® BLAZE-SHIELD® HP are averaged together for an overall result.

The declaration names with products represented, manufacturing locations, and type of declaration are listed in Table 2.2a. Other product information for each product is listed in Tables 2.2b.

Table 2.2a Declaration names with products represented, manufacturing locations, and type of declaration

Transparency Report name	Product name(s)	Manufacturing location(s)	Type of declaration
CAFCO® 300 Series Products	CAFCO® 300, CAFCO® 300 AC, CAFCO® 300 HS, CAFCO® 3000	Stanhope, NJ; Houston, TX; San Bernardino, CA	Four specific products as an average from several of the manufacturer's plants
CAFCO® 400 Series Products	CAFCO® 400, CAFCO® 400 AC	Stanhope, NJ; Houston, TX; San Bernardino, CA	Two specific products as an average from several of the manufacturer's plants
CAFCO® FENDOLITE® Series Products	CAFCO® FENDOLITE® M-II, CAFCO® FENDOLITE® M-II/P	Stanhope, NJ; Houston, TX; San Bernardino, CA	Two specific products as an average from several of the manufacturer's plants
CAFCO® BLAZE-SHIELD® Series Products	CAFCO® BLAZE-SHIELD® II, CAFCO® BLAZE-SHIELD® II HS, CAFCO® BLAZE-SHIELD® HP	Huntington, IN	Three specific products from a manufacturer's plant

Table 2.2b Other product information

Transparency Report name	CSI MasterFormat® classification	Application	Product Specification
CAFCO® 300 Series Products	07 81 00	CAFCO 300 Series products are durable, gypsum based, wet mix, commercial density Spray-Applied Fire Resistive Materials (SFRMs) designed to provide fire protection to concealed floor and roof assemblies, steel beams, columns, and joists in building construction projects.	• MasterSpec®, Section 078100 - APPLIED FIREPROOFING (AIA) (C300, C300AC, C300HS, C3000) • MasterFormat® 2014, Section 07 81 00 Applied Fireproofing (CSC, CSI) (C300, C300AC, C300HS, C3000) • United Facilities Guide Specification, UFGS 07 81 00 Spray-Applied Fireproofing (USACE, NAVFAC, AFCEC, NASA) (C300, C300AC, C300HS, C3000) • Master Construction Specifications, Number 07 81 00 Applied Fireproofing (VA) (C300, C300AC, C300HS, C3000) • Code of Federal Regulations, Title 40: Protection of the Environment (EPA) (C300, C300AC, C300HS, C3000) • PBS-P100 Facilities Standards for the Public Buildings Services (GSA) • Factory Mutual Approved (C300, C300HS)
CAFCO® 400 Series Products	07 81 00	CAFCO 400 Series products are Portland cement based, wet mix, medium density Spray-Applied Fire Resistive Materials (SFRMs) designed	• MasterSpec®, Section 078100 APPLIED FIREPROOFING (AIA) (C400, C400AC) • MasterFormat® 2014, Section 07 81 00 Applied Fireproofing (CSC, CSI) (C400, C400AC) • Unified Facilities Guide Specification, UFGS 07 81

		to provide fire protection for structural steel in commercial and high rise construction. The durable surface and Portland cement based formulation make it well suited for applications in either unconditioned or conditioned areas	00 Spray-Applied Fireproofing (USACE, NAVFAC, AFCEC, NASA) (C400, C400AC) • Master Construction Specifications, Number 07 81 00 Applied Fireproofing (VA) (C400, C400AC) • Code of Federal Regulations, Title 40 Protection of the Environment (EPA) (C400, C400AC) • PBS-P100, Facilities Standards for the Public Buildings Services (GSA) (C400, C400AC) • Factory Mutual Approved(C400)
CAFCO® FENDOLITE® Series Products	07 81 00	CAFCO® FENDOLITE® Series products for commercial use are vermiculite and Portland cement based, wet mix, high density Spray-Applied Fire Resistive Materials (SFRMs) designed to provide fire protection to structural columns and beams in exterior environments and interior situations where the highest levels of abrasion resistance and hardness are necessary.	• MasterSpec®, Section 078100 - APPLIED FIREPROOFING (AIA) • MasterFormat® 2014, Section 07 81 00 Applied Fireproofing (CSC, CSI) • Unified Facilities Guide Specification, UFGS-07 81 00 Spray-Applied Fireproofing (USACE, NAVFAC, AFCEC, NASA) • Master Construction Specifications, Number 07 81 00 Applied Fireproofing (VA) • Code of Federal Regulations, Title 40: Protection of the Environment (EPA) • PBS-P100 Facilities Standards for the Public Buildings Services (GSA)
CAFCO® BLAZE-SHIELD® Series Products	07 81 00	CAFCO® BLAZE-SHIELD® Series products are Portland cement and mineral wool based applied fireproofing materials available in commercial and medium densities, as well as with high bonding capabilities to satisfy the International Building Code (IBC) bond strength requirement for buildings up to 420 ft in height.	• MasterSpec®, Section 078100 APPLIED FIREPROOFING (AIA) • MasterFormat® 2014, Section 07 81 00 Applied Fireproofing (CSC, CSI) • Unified Facilities Guide Specification, UFGS 07 81 00 • Spray-Applied Fireproofing (USACE, NAVFAC, AFCEC, NASA) • Master Construction Specifications, Number 07 80 10 • Applied Fireproofing (VA) • Code of Federal Regulations, Title 40 Protection of the Environment (EPA) • PBS-P100 Facilities Standards for the Public Buildings Services (GSA)

2.3 Declared unit

Since the PCR for spray-applied fire resistive materials (SFRMs) only covers the cradle-to-gate stages, a declared unit 1,000 kg of product is used [1]. The results of the LCA in this report are expressed in terms of the declared unit.

2.4 System boundaries

This section describes the system boundaries for the products being modeled in this LCA. The system boundaries define which life cycle stages are included and which are excluded.

This LCA's system boundaries include the following life cycle stages:
- Raw materials acquisition
- Transportation
- Manufacturing

These boundaries apply to the modeled products and can be referred to as "cradle-to-gate" which means that it includes the raw material acquisition, transportation, and manufacturing (A1-A3) life cycle stages and modules as identified in the PCR since the PCR also applies a cradle-to-gate approach [1].

The system boundaries for Isolatek International products are detailed below. Figure 2.4a represents the life cycle stages for the cradle-to-gate cycle of these products. Table 2.4a lists specific inclusions and exclusions for the system boundaries.

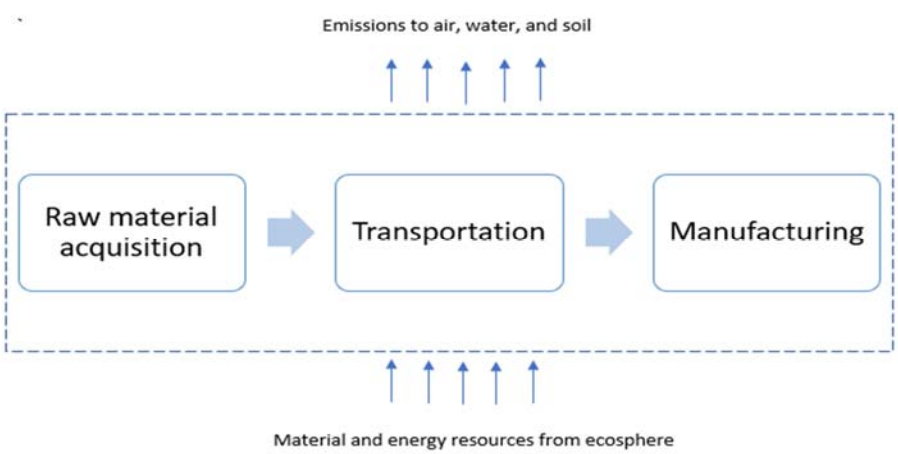


Figure 2.4a Applied system boundaries for the modeled insulation products

Table 2.4a System boundaries

Included	Excluded
• Extraction and processing of raw materials • Average or specific transportation of RMs from source to manufacturing site • Manufacturing, including all energy and materials required, and all emissions and wastes produced • Packaging of final products • Recycling/reuse/recovery of pre-consumer wastes and byproducts from production	• Construction of major capital equipment • Maintenance and operation of support equipment • Human labor and employee transport • Manufacture and transport of packaging materials not associated with final product • Energy and water use related to company management and sales activities

2.4.1. Raw materials acquisition (A1)

The raw materials acquisition, where relevant, the following processes:

- Extraction and processing of raw materials
- Processing of recycled materials

2.4.2. Transportation (A2)

The transportation stage includes the following:

- Transport of raw materials from extraction/production to manufacturer
- Transport of recycled/used materials to manufacturer

2.4.3. Manufacturing (A3)

The manufacturing stage includes the following:

- Manufacturing of building envelope thermal insulation products
- Packaging
- Landfill of manufacturing waste
- Emissions to air from the manufacturing process

3 INVENTORY ANALYSIS

This chapter includes an overview of the obtained data and data quality that has been used in this study. For the complete life cycle inventory which catalogues the flows crossing the system boundary and provides the starting point for life cycle impact assessment, see the attached spreadsheets [3].

3.1 Data collection

Data used for this project represents a mix of primary data collected from Isolatek on the production of the applied fireproofing products (gate-to-gate) and background data from EcoInvent 3. Overall, the quality of the data used in this study is considered to be high and representative of the described systems. All appropriate means were employed to guarantee the data quality and representativeness as described below.

- **Gate-to-gate**: Data on processing materials and manufacturing the applied fireproofing products were collected in a consistent manner and level of detail to ensure high quality data. All submitted data were checked for quality multiple times on the plausibility of inputs and outputs. All questions regarding data were answered by Isolatek. Data were collected for all four facilities. Data for CAFCO® 300 Series products, CAFCO® 400 Series products, and CAFCO® FENDOLITE® Series products were collected at three facilities (Stanhope, NJ; Houston, TX; and San Bernardino, CA) to provide an accurate representation of their production; for these products, the aggregated results represent a weighted average of the same products from the three different plants. Data for CAFCO® BLAZE-SHIELD® Series products were collected from only the Huntington, IN facility because that is the only place they are produced.

- **Background data**: All data from SimaPro were created with consistent system boundaries and upstream data. Expert judgment and advice was used in selecting appropriate datasets to model the materials and energy for this study and has been noted in the preceding sections. Detailed database documentation for EcoInvent can be accessed at: https://www.ecoinvent.org/database/ecoinvent-33/new-data-in-ecoinvent-33/pdf-documentation.html.

All primary data were provided by Isolatek. Upon receipt, data were cross-checked for completeness and plausibility using mass balance, stoichiometry, and benchmarking. If gaps, outliers, or other inconsistencies occurred, Sustainable Minds engaged with Isolatek to resolve any open issues.

3.2 Primary data

Applied fireproofing materials generally have a simple manufacturing process. The spray-applied fire resistive materials are made in the four manufacturing facilities and are divided into two different groups: cement- or plaster-based dry mix and wet mix products, depending on the type of bulk density carrier and type of application. The CAFCO® BLAZE-SHIELD® Series products are dry mixes, and they use a mineral fiber as a bulking agent. That fiber is manufactured locally in Huntington, IN and utilizes up to 75% post-industrial (pre-consumer) waste as raw material (blast furnace slag). CAFCO® 300 Series, CAFCO® 400 Series, and CAFCO® FENDOLITE® Series products are wet mixes. Wet mixes use a mined mineral - vermiculite, which is then exfoliated to achieve desired finished product density at each of the other 3 US locations: Stanhope, NJ; Houston, TX; and San Bernardino, CA. Both product types are manufactured by blending the specified bulking agent with a number of product-specific binders to achieve prescribed fire rating performance in the field. Finished goods are packaged in individual bags, stacked on pallets, and stretch wrapped before distribution into warehouses and delivery to job sites.

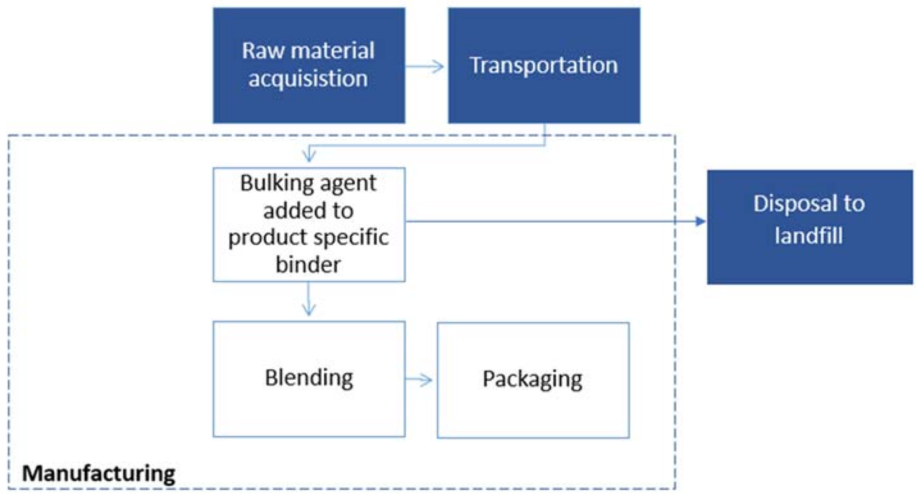


Figure 3.2a Life cycle flow chart of passive fire protection products production

3.2.1. Raw Materials acquisition (A1)

Raw materials acquisition represents the first stage of the spray applied fireproofing products life cycle. Portland cement, calcium sulfate, vermiculite, calcium carbonate, mica, cellulose, bentonite clay, are raw materials and paper bags are packaging materials that are transported to the facilities: Stanhope, NJ; Houston, TX; and San Bernardino, CA. Feldspar, levy slag, Portland cement, plaster of Paris, and are raw materials and bags are packaging materials transported to the Huntington, IN facility. Isolatek uses recycled levy slag in the production of the CAFCO® BLAZE-SHIELD® Series products. CAFCO BLAZE-SHIELD II & CAFCO BLAZE-SHIELD II HScontains 61.5% (combined average of BLAZE-SHIELD II & HS) recycled levy slag. CAFCO BLAZE-SHIELD HP contains 56% recycled levy slag .

3.2.2. Transportation (A2)

All raw materials are transported to Isolatek facilities. Raw materials are transported to the facilities using both rail and truck. Transport data was collected for each raw material and calculated for each product.

3.2.3. Manufacturing (A3)

All raw materials are transported to Isolatek facilities. Products are manufactured in the facilities by blending the bulking agent with several product specific binders.

Finished goods are then packaged, stacked, and stretch wrapped before being distributed to warehouses and delivered to job sites.

Waste and emissions

Vermiculite is used in the following product series: CAFCO® 300, CAFCO® 400, and CAFCO® FENDOLITE®. About 10% of vermiculite does not expand in the exfoliation process. The vermiculite that does not expand is sent to landfill. Emissions associated with the production of electricity and combustion of natural gas used to manufacture the products are accounted for in the SimaPro background processes. Stack emissions were provided from federal reporting regulations and are not exact emissions from the facilities. This provides a conservative assessment.

3.3 Data selection and quality

The data used to create the inventory model is as precise, complete, consistent, and representative as possible with regard to the goal and scope of the study under given time and budget constraints.

- Measured primary data is considered to be of the highest precision, followed by calculated and estimated data.
- Completeness is judged based on the completeness of the inputs and outputs per unit process and the completeness of the unit processes themselves. Wherever data were available on material and energy flows, these were included in the model.
- Consistency refers to modeling choices and data sources. The goal is to ensure that differences in results occur due to actual differences between product systems, and not due to inconsistencies in modeling choices, data sources, emission factors, or other.
- Representativeness expresses the degree to which the data matches the geographical, temporal, and technological requirements defined in the study's goal and scope.

An evaluation of the data quality with regard to these requirements is provided in the interpretation chapter of this report.

Time coverage. Primary data were collected on fire protection product production for January 2017 to December 2017. These dates were chosen in order to capture a representative picture of content use at Isolatek. Background data for upstream and downstream processes (i.e. raw materials, energy resources, transportation, and ancillary materials) were obtained from the EcoInvent databases.

Technology coverage. Data were collected for spray applied fire protection production at Isolatek's facilities in the US.

Geographical coverage. Isolatek's facilities are located in Stanhope, NJ; Houston, TX; San Bernardino, CA; and Huntington, IN. As such, the geographical coverage for this study is based on United States system boundaries for all processes and products. Whenever US background data were not readily available, European data or global data were used as proxies. Where multiple locations are used to produce the same product, results are presented as mass-weighted averages of production at each of the locations.

3.4 Background data

This section details background datasets used in modeling spray applied fire protection product environmental performance. Each table lists dataset purpose, name, source, reference year, and location.

3.4.1. Fuels and energy

National and regional averages for fuel inputs and electricity grid mixes were obtained from SimaPro. The grid mixes used for electricity are from the North American Regional Reliability Councils and Interconnections (NERC). For Stanhope, NJ and Huntington, IN, the RFC electric grid is used. For Houston, TX, the TRE electric grid is used. For San Bernardino, CA, the WECC electric grid is used [6]. Table 3.4.1 shows the most relevant LCI datasets used in modeling the product systems.

Table 3.4.1 Key energy datasets used in inventory analysis

Energy	Dataset name	Primary source	Reference year	Data Category	Geography
Electricity	Electricity- TRE	NERC	2014	Estimated; only eight months of data was given so calculations were made based on that data	US TRE
Electricity	Electricity- WECC	NERC	2014	Direct; supplied by purchasing department	US WECC
Electricity	Electricity- RFC	NERC	2014	Direct; supplied by purchasing department	US RFC
Technical heat	Heat, natural gas	EI v3	2014	Direct; supplied by purchasing department	Global
Coke	Hard coal	EI 2.2	2014	Direct; supplied by purchasing department	US

3.4.2. Ancillary materials

Data for ancillary materials was obtained from the EcoInvent 3 database. Table 3.4.2 shows the most relevant LCI datasets used in modeling the ancillary materials.

Table 3.4.2 Key ancillary material datasets used in inventory analysis

Ancillary Material	Dataset name	Primary source	Reference year	Data Category	Geography
Waste oil	Lubricating oil	EI3	2013	Direct; supplied by purchasing department	Global
Grease tube	Lubricating oil	EI3	2013	Direct; supplied by purchasing department	Global
Aerosol can	Lubricating oil	EI3	2013	Direct; supplied by purchasing department	Global
Parts solvent	Light fuel oil	EI3	2014	Direct; supplied by purchasing department	Europe
Hydraulic oil	Lubricating oil	EI3	2013	Direct; supplied by purchasing department	Global

3.4.3. Raw materials production

Data for up- and down-stream raw materials were obtained from the EcoInvent database. Table 3.4.3 shows the most relevant LCI datasets used in modeling the raw materials.

Table 3.4.3 Key material datasets used in inventory analysis

Raw Material	Dataset name	Primary source	Reference year	Data Category	Geography
Product	Gypsum, mineral	EI3	2014	Direct; supplied by purchasing department	Global
Product	Vermiculite	EI3	2014	Direct; supplied by purchasing department	Global
Product	Limestone, crushed, washed	EI3	2014	Direct; supplied by purchasing department	Global
Product	Chemical, organic	EI3	2014	Direct; supplied by purchasing department	Global
Product	Bentonite	EI3	2014	Direct; supplied by purchasing department	Global
Product	Cement, portland	EI3	2014	Direct; supplied by purchasing department	US
Product	Vermiculite	EI3	2014	Direct;	Global

				supplied by purchasing department	
Product	Feldspar	EI3	2014	Direct; supplied by purchasing department	Global
Product	Ground granulated blast furnace slag	EI3	2014	Direct; supplied by purchasing department	Global
Product	Gypsum, mineral	EI3	2014	Direct; supplied by purchasing department	Global
Packaging	Kraft paper, unbleached	EI3	2014	Direct; supplied by purchasing department	Global
Packaging	Packaging film, low density polyethylene	EI3	2014	Direct; supplied by purchasing department	Global
Transportation	Polyethylene, high density, granulate	EI3	2014	Direct; supplied by purchasing department	Global

3.4.4. Transportation

Average transportation distances and modes of transport are included for the transport of the raw materials to production facilities. Typical vehicles used include trailers and rail cars.

The EcoInvent datasets for transportation vehicles and fuels was used to model transportation. Truck transportation within the United States was modeled using the EcoInvent US truck transportation datasets. The vehicle types, fuel usage, and emissions for these transportation processes were developed based on the US Census Bureau Vehicle Inventory and Use Survey (2002) and US EPA emissions standards for heavy trucks.

Table 3.4.4 Key transportation datasets used in inventory analysis

Transportation	Dataset name	Primary source	Reference year	Data Category	Geography
Bulk tanker	Transport, lorry, 16-32 metric ton	EI v3	2014	Indirect; this value was a calculation	Global
40' Container	Transport, lorry, 16-32 metric ton	EI v3	2014	Indirect; this value was a calculation	Global
53’ Dry Van	Transport, lorry, 16-32 metric ton	EI v3	2014	Indirect; this value was a calculation	Global
48’ Rail	Transport, freight train	EI3	2014	Indirect;	US

Container	{US}| market for | Alloc Def, U			this value was a calculation	

3.4.5. Disposal

Disposal processes were obtained from the EcoInvent database. These processes were chosen to correspond to the material being disposed, which is vermiculite. Since these materials do not decompose in a landfill, there are no energy recovery credits from landfill gas capture and combustion. The 'Glass/inert on landfill' data set was used for vermiculite. Table 3.4.5 reviews the relevant disposal dataset used in the model.

Table 3.4.5 Key disposal dataset used in inventory analysis

Material disposed	Dataset name	Primary source	Reference year	Data Category	Geography
Vermiculite	Inert waste, for final disposal {GLO}| market for | Alloc Def, U	EI3	2014	Estimate; approximately 10% of vermiculite is sent to landfill when it does not "pop"	Global

3.4.6. Emissions to air, water, and soil

All cradle-to-gate emissions reported by Isolatek for the manufacturing stage are taken into account in the study

3.5 Limitations

Proxy data used in the LCA model were limited to background data for raw material production. US background data were used whenever possible, with European or global data substituted as proxies as necessary.

A proxy dataset was used for the cellulose and mica product ingredients. For cellulose, the 'chemical, organic' EcoInvent data set was used. This dataset is the most relevant for the raw material. For mica, the vermiculite EcoInvent dataset was used because it was the most relevant dataset for this material. The VOC dataset proxy was used for the combined hazardous air pollutants emission.

The emission data that was provided from Isolatek are the maximum emissions allowed at each facility [5]. They are not the actual or estimated emissions for each facility. Therefore, the emission impacts are very conservative for this model.

Only eight months of electricity data was used for the Houston, TX facility. This is because the electricity carriers were switched at the plant, and the prior data was not available. For the other three facilities, twelve months of electricity data was used [5].

3.6 Criteria for the exclusion of inputs and outputs

All energy and material flow data were included in the model and comply with the ASTM PCR cut-off criteria. None of the data that was provided needed to be excluded by the cut-off rules [1].

The cut-off criteria on a unit process level can be summarized as follows:

- A flow can be excluded if a flow is less than 1% of the cumulative mass of the unit processes if its environmental relevance is minor.
- A flow can be excluded if it is less than 1% of the cumulative energy of the system model as long as its environmental relevance is minor
- Any material and energy flows that are expected or known to have the potential to cause environmentally relevant emissions into air, water, or soil that are related to the environmental indicators of this PCR should be included unless justification for exclusion is documented.
- At least 95% of the energy usage and mass flow should be included. The life-cycle impact data should contain at least 95% of all elementary flows that contribute to each of the declared category indicators.
- All hazardous and toxic materials and substances should be included in the inventory and the cutoff rules should not apply to such substances

In this report, no known flows are deliberately excluded; therefore, these criteria have been met. The completeness of the bill of materials defined in this report satisfies the above defined cut-off criteria.

3.7 Allocation

Whenever a system boundary is crossed, environmental inputs and outputs have to be assigned to the different products. Where multi-inputs or multi-outputs are considered, the same applies. The PCR prescribes to report where and how allocation occurs in the modeling of the LCA.

The model used in this report ensures that the sum of the allocated inputs and outputs of a unit process are equal to the inputs and outputs of the unit process before allocation. This means that no double counting or omissions of inputs or outputs through allocation is occurring.

The Isolatek manufacturing facilities included in this report all produce multiple products. Since only facility level data were available, allocation among a facility's co-products was necessary to determine the input and output flows associated with each product. Allocation of materials and energy was done on a mass basis for all products. Allocation of transportation was based on the weight of the outputs for the products from each facility. Emissions were allocated for each product from facilities based on output weight per product as well. Electricity for Houston was averaged by eight months and then multiplied by twelve to get an approximation of electricity used for the facility in a year.

3.8 Software and database

The LCA model was created using SimaPro Analyst 8.5.2.0 for life cycle engineering. The EcoInvent 3.1 LCI datasets provide the life cycle inventory data of most of the raw materials and processes for modeling the products.

3.9 Critical review

This is a supporting LCA report for passive fire protection products Transparency Reports and will be evaluated for conformance to the PCR according to ISO 14025 [7] and the ISO 14040/14044 standards [8].

4 IMPACT ASSESSMENT METHODS

4.1 Impact assessment

The environmental indicators as required by the PCR are included as well as other indicators required to use the SM2013 Methodology [9] (see Table 4.1). The impact indicators are derived using the 100-year time horizon[1] factors, where relevant, as defined by TRACI 2.1 classification and characterization [10]. Long-term emissions (> 100 years) are not taken into consideration in the impact estimate. This follows the approach from the PCR.

Table 4.1 Selected impact categories and units

Impact category	Unit
Acidification	kg SO_2 eq (sulphur dioxide)
Ecotoxicity	CTUe
Eutrophication	kg N eq (nitrogen)
Global warming	kg CO_2 eq (carbon dioxide)
Ozone depletion	kg CFC-11 eq
Carcinogenics	CTUh
Non-carcinogenics	CTUh
Respiratory effects	kg PM2.5 eq (fine particulates)
Smog	kg O_3 eq (ozone)
Fossil fuel depletion	MJ surplus

With respect to global warming potential, biogenic carbon is included in impact category calculations.

It shall be noted that the above impact categories represent impact potentials. They are approximations of environmental impacts that could occur if the emitted molecules would follow the underlying impact pathway and meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen declared unit (relative approach).

The results from the impact assessment indicate potential environmental effects and do not predict actual impacts on category endpoints, the exceedance of thresholds, or safety margins or risks.

4.2 Normalization and weighting

To arrive to a single score indicator, normalization [11] and weighting [12] conforming to the SM2013 Methodology were applied.

[1] The 100-year period relates to the period in which the environmental impacts are modeled. This is different from the time period of the declared unit. The two periods are related as follows: all environmental impacts that are created in the period of the declared unit are modeled through life cycle impact assessment using a 100-year time horizon to understand the impacts that take place.

Table 4.2 Normalization and Weighting factors

Impact category	Normalization	Weighting (%)
Acidification	90.9	3.6
Ecotoxicity	11000	8.4
Eutrophication	21.6	7.2
Global warming	24200	34.9
Ozone depletion	0.161	2.4
Carcinogenics	5.07E-05	9.6
Non carcinogenics	1.05E-03	6.0
Respiratory effects	24.3	10.8
Smog	1390	4.8
Fossil fuel depletion	17300	12.1

5 ASSESSMENT AND INTERPRETATION

This chapter includes the results from the LCA for the products studied. It details the results per product per declared unit and concludes with recommendations. LCI and LCIA data can be seen in the LCA results spreadsheets [3]. The results are presented per declared unit, for an average of similar products as outlined in Table 2.2c.

5.1 Resource use and waste flows

Use of resources and generation of waste are presented in this section. The methods in SimaPro used to calculate the life cycle inventory were Cumulative Energy Demand version 1.09 and SM 2013 TRACI 2.1 Version 1.0.

Resource use indicators represent the amount of materials consumed to produce not only the SFRM product itself, but the raw materials, electricity, natural gas, etc. that go into the product's life cycle. Secondary materials used in the production of SFRMs include recycled levy slag.

Primary energy is an energy form found in nature that has not been subjected to any conversion or transformation process and is expressed in energy. Energy consumption is reported in Higher Heating Values (HHV) mega joules. Recycled and recovered materials with fuel content and used as fuels are considered alternative energy.

Recovered or recycled materials are neither nonrenewable nor renewable resources.

Fresh water is naturally occurring water on the earth's surface and underground as groundwater in aquifers and underground streams. The term specifically excludes seawater and brackish water, but does include fresh water that has been treated to make it potable. Energy use and other impacts associated with fresh water treatment are not included. Consumption of net fresh water includes fresh water entering the system being studied that is not returned to the same drainage basin that it originated from.

Non-hazardous waste is calculated based on the amount of waste generated during manufacturing. There is no hazardous or radioactive waste associated with the life cycle. Additionally, all materials are assumed to be landfilled rather than incinerated or reused/recycled, so no materials are available for energy recovery or reuse/recycling.

Tables 5.1a-d show resource use and waste flows for all products per declared unit.

Table 5.1a Resource use and waste flows for CAFCO® 300 Series products per declared unit [3]

	Unit	A1	A2	A3	Total
Total primary energy consumption indicators					
Nonrenewable fossil	MJ, HHV	4.56E+03	4.53E+03	1.18E+03	1.03E+04
Nonrenewable nuclear	MJ, HHV	2.27E+02	7.18E+01	1.29E+02	4.28E+02
Renewable (solar, wind, hydroelectric, and geothermal)	MJ, HHV	8.85E+00	4.39E+00	1.79E+01	3.11E+01
Renewable (biomass)	MJ, HHV	6.41E+02	2.67E+01	9.79E+00	6.77E+02
Material resources consumption indicators					
Renewable material resources	kg	3.65E+01	9.02E-01	4.84E-01	3.79E+01
Nonrenewable material resources	kg	1.16E+03	3.58E+02	2.28E+01	1.54E+03
Net fresh water	L	1.32E+04	3.24E+03	2.53E+03	1.90E+04
Waste flows					
Non-hazardous waste generated	kg	0	0	2.96E+01	2.96E+01
Hazardous waste generated	kg	0	0	0	0

Numbers shown in **purple** have a variation of 10 to 20%
Numbers shown in **red** have a variation greater than 20%

Table 5.1b Resource use and waste flows for CAFCO® 400 Series products per declared unit [3]

	Unit	A1	A2	A3	Total
Total primary energy consumption indicators					
Nonrenewable fossil	MJ, HHV	5.87E+03	3.66E+03	1.19E+03	1.07E+04
Nonrenewable nuclear	MJ, HHV	3.27E+02	5.83E+01	1.47E+02	5.32E+02
Renewable (solar, wind, hydroelectric, and geothermal)	MJ, HHV	1.72E+01	3.57E+00	1.42E+01	3.50E+01
Renewable (biomass)	MJ, HHV	4.00E+02	2.17E+01	1.01E+01	4.32E+02
Renewable material resources	kg	2.25E+01	1.06E+00	4.97E-01	2.41E+01
Nonrenewable material resources	kg	1.44E+03	2.90E+02	2.37E+01	1.75E+03
Net fresh water	L	1.62E+04	2.63E+03	2.62E+03	2.14E+04
Waste flows					
Non-hazardous waste generated	kg	0	0	1.14E+05	1.14E+05
Hazardous waste generated	kg	0	0	0	0

Numbers shown in **purple** have a variation of 10 to 20%
Numbers shown in **red** have a variation greater than 20%

Table 5.1c Resource use and waste flows for CAFCO® FENDOLITE® Series procucts per declared unit [3]

	Unit	A1	A2	A3	Total
Total primary energy consumption indicators					
Nonrenewable fossil	MJ, HHV	3.68E+03	2.59E+03	1.16E+03	7.43E+03
Nonrenewable nuclear	MJ, HHV	2.89E+02	4.02E+01	1.04E+02	4.34E+02
Renewable (solar, wind, hydroelectric, and geothermal)	MJ, HHV	2.18E+01	2.45E+00	1.84E+01	4.26E+01
Renewable (biomass)	MJ, HHV	7.59E+02	1.50E+01	8.24E+00	7.82E+02
Renewable material resources	kg	4.34E+01	7.29E-01	4.06E-01	4.45E+01
Nonrenewable material resources	kg	1.61E+03	2.03E+02	2.10E+01	1.83E+03
Net fresh water	L	1.14E+04	1.82E+03	7.01E+03	2.02E+04
Waste flows					
Non-hazardous waste generated	kg	0	0	6.05E+04	6.05E+04
Hazardous waste generated	kg	0	0	0	0

Numbers shown in **purple** have a variation of 10 to 20%

Numbers shown in **red** have a variation greater than 20%

Table 5.1d Resource use and waste flows for CAFCO® BLAZE-SHIELD® Series products per declared unit [3]

	Unit	A1	A2	A3	Total
Total primary energy consumption indicators					
Nonrenewable fossil	MJ, HHV	2.54E+03	7.54E+02	6.19E+03	9.49E+03
Nonrenewable nuclear	MJ, HHV	1.48E+02	1.17E+01	7.44E+02	9.04E+02
Renewable (solar, wind, hydroelectric, and geothermal)	MJ, HHV	8.85E+00	7.13E-01	8.39E+00	1.80E+01
Renewable (biomass)	MJ, HHV	3.26E+01	4.36E+00	8.12E+01	1.18E+02
Renewable material resources	kg	1.53E+00	2.12E-01	3.85E+00	5.59E+00
Nonrenewable material resources	kg	8.88E+02	5.89E+01	3.18E+02	1.26E+03
Net fresh water	L	5.29E+03	5.28E+02	1.11E+04	1.69E+04
Waste flows					
Non-hazardous waste generated	kg	0	0	0	0
Hazardous waste generated	kg	0	0	0	0

Numbers shown in **purple** have a variation of 10 to 20%

Numbers shown in **red** have a variation greater than 20%

5.2 Life cycle impact assessment (LCIA)

It shall be reiterated at this point that the reported impact categories represent impact potentials; they are approximations of environmental impacts that could occur if the emitted molecules would follow the underlying impact pathway and meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen declared unit (relative approach). LCIA results are therefore relative expressions only and do not predict actual impacts on category endpoints, the exceeding of thresholds, safety margins, or risks.

Life cycle impact assessment (LCIA) results are shown for Isolatek's passive fire protection products. Unlike life cycle inventories, which only report sums for individual inventory flows, the LCIA includes a classification of individual emissions with regard to the impacts they are associated with and subsequently a characterization of the emissions by a factor expressing their respective contribution to the impact category indicator. The end result is a single metric for quantifying each potential impact, such as "Global Warming Potential".

The impact assessment results are calculated using characterization factors published by the United States Environmental Protection Agency. The TRACI 2.1 (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts 2.1) methodology is the most widely applied impact assessment method for U.S. LCA studies. The SM2013 Methodology is also applied to come up with single score results.

The five impact categories required by the PCR are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined and LCA should continue making advances in their development; however, the Type III environmental declaration users shall not use additional measures for comparative purposes. Impact categories which were not required by the PCR are included in part to allow for the calculation of millipoints using the SM2013 Methodology, but it should be noted that there are known limitations related to these impact categories due to their high degree of uncertainty.

5.2.1. CAFCO® 300 Series Products

Table 5.2.1a shows the contributions of each stage of the life cycle for the weighted average of the four options for CAFCO® 300 Series products: CAFCO® 300, CAFCO® 300 HS, CAFCO® 300 AC, and CAFCO® 3000.

The raw material acquisition stage dominates the results for all impact categories except for ecotoxicity, carcinogenics, and smog where the transportation stage dominates. Following these two stages, the next highest impacts come from manufacturing. The lowest impacts come from the manufacturing waste and emissions. The impact of the raw material acquisition stage is mostly due to the calcium sulfate and vermiculite. This is because of the high material weights used in manufacturing. Approximately 10% of vermiculite is sent to landfill. The landfilling of the discarded product contributes to the manufacturing waste. Vermiculite is a bulkingbulking agent, and approximately 10% of vermiculite is sent to landfill when it does not "pop" in the manufacturing process. The highest contributers to the transportation stage are vermiculite and bentonite clay. These two raw materials are transported the furthest distance which is why they have the highest impacts.

Table 5.2.1a CAFCO® 300 Series products impact potential results per declared unit [3]

Impact category	Unit	A1	A2	A3	Total
Acidification	kg SO_2 eq	1.80E+00	1.12E+00	3.19E-01	3.24E+00
Eutrophication	kg N eq	1.56E-01	1.56E-01	2.24E-02	3.34E-01
Global warming	kg CO_2 eq	1.99E+02	2.88E+02	8.02E+01	5.67E+02
Ozone depletion	kg CFC-11 eq	2.54E-05	6.92E-05	1.00E-05	1.05E-04
Carcinogenics	CTUh	1.98E-06	2.22E-06	2.26E-07	4.43E-06
Non-carcinogenics	CTUh	3.38E-05	6.09E-05	1.68E-06	9.64E-05
Respiratory effects	kg PM2.5 eq	2.67E-01	1.96E-01	3.22E-02	4.95E-01
Smog	kg O_3 eq	2.53E+01	2.34E+01	3.27E+00	5.19E+01
Ecotoxicity	CTUe	1.50E+02	1.13E+03	1.23E+01	1.30E+03
Fossil fuel depletion	MJ, LHV	5.55E+02	5.83E+02	1.23E+02	1.26E+03

Numbers shown in **purple** have a variation of 10 to 20%
Numbers shown in **red** have a variation greater than 20%

Variations

Variations are due to different raw material weights required for each product in the series.

Single score results

The SM millipoint score by life cycle phase for this product is presented below (Table 5.2.1b). They conincide with the trends in the results using the impact assessment results before normalization and weighting. The use of normalization and weighting to create SM mPt results produced the same conclusions and recommendations as the TRACI results.

Table 5.2.1b SM millipoint scores for CAFCO® 300 Series productsby life cycle stage per declared unit [3]

Impact category	Unit	A1 (how do I format this like the other single score tables?)	A2	A3	Total
SM single figure score	mPts	1.69E-02	2.72E-02	3.09E-03	4.72E-02

Numbers shown in **purple** have a variation of 10 to 20%
Numbers shown in **red** have a variation greater than 20%

5.2.2. CAFCO® 400 Series Products

Table 5.2.2a shows the contributions of each stage of the life cycle for the weighted average of the two options for the CAFCO® 400 Series products: CAFCO® 400, CAFCO® 400 AC.

The raw material acquisition stage dominates the results for all impact categories except for ecotoxicity, where the transportation stage dominates. Following these two stages, the next highest impacts come from manufacturing. The lowest impacts come from the manufacturing waste and emissions. The impact of the raw material acquisition stage is mostly due to the calcium sulfate, vermiculite, and portland cement. This is because of the high material weights used in manufacturing. Approximately 10% of vermiculite is sent to landfill. The landfilling of the discarded product contributes to the manufacturing waste. Vermiculite is an aggregate, and approximately 10% of vermiculite is sent to landfill when it does not “pop” in the manufacturing process. The highest contributers to the transportation stage are vermiculite and bentonite clay. These two raw materials are transported the furthest distance which is why they have the highest impacts.

Table 5.2.2a CAFCO® 400 Series products impact potential results per declared unit [3]

Impact category	Unit	A1	A2	A3	Total
Acidification	kg SO_2 eq	2.45E+00	9.19E-01	3.67E-01	3.74E+00
Eutrophication	kg N eq	2.06E-01	1.27E-01	2.37E-02	3.57E-01
Global warming	kg CO_2 eq	5.00E+02	2.33E+02	8.27E+01	8.16E+02
Ozone depletion	kg CFC-11 eq	3.78E-05	5.59E-05	1.02E-05	1.04E-04
Carcinogenics	CTUh	2.27E-06	1.82E-06	2.29E-07	4.33E-06
Non-carcinogenics	CTUh	3.55E-05	4.89E-05	1.76E-06	8.62E-05
Respiratory effects	kg PM2.5 eq	2.59E-01	1.58E-01	4.56E-02	4.63E-01
Smog	kg O_3 eq	3.70E+01	1.93E+01	3.58E+00	5.98E+01
Ecotoxicity	CTUe	1.64E+02	9.10E+02	1.18E+01	1.09E+03
Fossil fuel depletion	MJ, LHV	6.67E+02	4.70E+02	1.23E+02	1.26E+03

Numbers shown in **purple** have a variation of 10 to 20%
Numbers shown in **red** have a variation greater than 20%

Variations
Variations are due to different raw materials required for each product as well as different raw material weights for each product in the series.

Single score results
The SM millipoint score by life cycle phase for this product is presented below (Table 5.2.2b). They conincide with the trends in the results using the impact assessment results before normalization and weighting. The use of normalization and weighting to create SM mPt results produced the same conclusions and recommendations as the TRACI results.

Table 5.2.2b SM millipoint scores for CAFCO® 400 Series products by life cycle stage per declared unit [3]

Impact category	Unit	A1	A2	A3	Total
		Raw material acquisition	Transportation	Production	
SM single figure score	mPts	2.36E-02	2.20E-02	3.23E-03	4.88E-02

Numbers shown in **purple** have a variation of 10 to 20%
Numbers shown in **red** have a variation greater than 20%

5.2.3. CAFCO® FENDOLITE® Series Products

Table 5.2.3a shows the contributions of each stage of the life cycle for the weighted average of the two options for the CAFCO® FENDOLITE® Series products: CAFCO® FENDOLITE® M-II, CAFCO® FENDOLITE® M-II/P.

The raw material acquisition stage dominates the results for all impact categories except for ecotoxicity, where the transportation stage dominates. Following these two stages, the next highest impacts come from manufacturing. The lowest impacts come from the manufacturing waste and emissions. The impact of the raw material acquisition stage is mostly due to the portland cement and vermiculite. This is because of the high material weights used in manufacturing. Approximately 10% of vermiculite is sent to landfill. The landfilling of the discarded product contributes to the manufacturing waste. Vermiculite is a bulking agent, and approximately 10% of vermiculite is sent to landfill when it does not "pop" in the manufacturing process. The highest contributers to the transportation stage are vermiculite and mica. These two raw materials are transported the furthest distance which is why they have the highest impacts.

Table 5.2.3a CAFCO® FENDOLITE® Series products impact potential results per declared unit [3]

Impact category	Unit	A1	A2	A3	Total
Acidification	kg SO_2 eq	2.75E+00	6.14E-01	2.93E-01	3.66E+00
Eutrophication	kg N eq	2.10E-01	8.74E-02	2.12E-02	3.19E-01
Global warming	kg CO_2 eq	6.13E+02	1.64E+02	7.69E+01	8.54E+02
Ozone depletion	kg CFC-11 eq	4.10E-05	3.97E-05	9.92E-06	9.06E-05
Carcinogenics	CTUh	1.81E-06	1.20E-06	2.19E-07	3.23E-06
Non-carcinogenics	CTUh	5.34E-05	3.53E-05	1.57E-06	9.02E-05
Respiratory effects	kg PM2.5 eq	2.29E-01	1.11E-01	3.04E-02	3.71E-01
Smog	kg O_3 eq	4.49E+01	1.25E+01	3.38E+00	6.08E+01
Ecotoxicity	CTUe	1.29E+02	6.62E+02	1.29E+01	8.04E+02
Fossil fuel depletion	MJ, LHV	3.55E+02	3.34E+02	1.25E+02	8.14E+02

Numbers shown in **purple** have a variation of 10 to 20%
Numbers shown in **red** have a variation greater than 20%

Variations

Variations are due to different raw material weights for each product in the series.

Single score results

The SM millipoint score by life cycle phase for this product is presented below (Table 5.2.3b). They coincide with the trends in the results using the impact assessment results before normalization and weighting. The use of normalization and weighting to create SM mPt results produced the same conclusions and recommendations as the TRACI results.

Table 5.2.3b CAFCO® FENDOLITE® Series products by life cycle stage per declared unit [3]

Impact category	Unit	A1	A2	A3	Total
		Raw material acquisition	Transportation	Production	
SM single figure score	mPts	2.31E-02	1.55E-02	3.03E-03	4.17E-02

Numbers shown in **purple** have a variation of 10 to 20%

Numbers shown in **red** have a variation greater than 20%

5.2.4. CAFCO® BLAZE-SHIELD® Series Products

Table 5.2.4a shows the contributions of each stage of the life cycle for the weighted average of the two options for the CAFCO® BLAZE-SHIELD® Series products: CAFCO® BLAZE-SHIELD® II and HS, CAFCO® BLAZE-SHIELD® HP.

Overall, the raw material aquisition stage dominates the results for impact categories. Followed closely behind by the manufacturing stage. There is a higher energy input in the Huntington, IN facility which is why the manufacturing stage is higher for this series. Following the raw material acquisition and manufacturing stages, the next highest impacts come from the transportation stage. The overall lowest impacts come from the manufacturing waste and emissionsstage. The impact of the raw material acquisition stage is mostly due to the levy slag and portland cement. This is because of the high material weights used in manufacturing. Mineral fiber and not vermiculite is used as a bulking agent for this product series, so there is no vermiculite waste to landfill.r BLAZE-SHIELD® II and BLAZE-SHIELD II HS contain 61.5% recycled levy slag. BLAZE-SHIELD® HP contains 56% recycled levy slag. The high values from end of life stage are due to the emissions from the Huntington, IN facility which are contributed through the manufacturing stage. The highest emissions from this plant are carbon monoxide, particulate matter, and sulfure dioxide. BLAZE-SHIELD® II and HS are the major contributing products to the high impacts. This is due to the larger amount of output for these products compared to BLAZE-SHIELD® HP.

Table 5.2.4a CAFCO® BLAZE-SHIELD® Series products impact potential results per declared unit [3]

Impact category	Unit	A1	A2	A3	Total
Acidification	kg SO_2 eq	1.13E+00	1.79E-01	1.68E+01	1.81E+01
Eutrophication	kg N eq	1.07E-01	2.55E-02	3.24E-01	4.56E-01
Global warming	kg CO_2 eq	3.87E+02	4.78E+01	2.27E+02	6.61E+02
Ozone depletion	kg CFC-11 eq	1.76E-05	1.16E-05	1.52E-05	4.44E-05
Carcinogenics	CTUh	9.35E-07	3.49E-07	7.16E-07	2.00E-06
Non-carcinogenics	CTUh	1.94E-05	1.03E-05	6.49E-06	3.62E-05
Respiratory effects	kg PM2.5 eq	2.62E-01	3.24E-02	4.38E+00	4.67E+00
Smog	kg O_3 eq	1.67E+01	3.63E+00	6.64E+01	8.68E+01
Ecotoxicity	CTUe	6.84E+01	1.93E+02	3.07E+01	2.92E+02
Fossil fuel depletion	MJ, LHV	1.81E+02	9.72E+01	1.24E+02	4.02E+02

Numbers shown in **purple** have a variation of 10 to 20%
Numbers shown in **red** have a variation greater than 20%

Variations
There are no notable variations.

Single score results
The SM millipoint score by life cycle phase for this product is presented below (Table 5.2.4b). They coincide with the trends in the results using the impact assessment results before normalization and weighting. This is in part due to the emissions from the Huntington, IN plant. The use of normalization and weighting to create SM mPt results produced the same conclusions and recommendations as the TRACI results.

Table 5.2.4b SM millipoint scores for CAFCO® BLAZE-SHIELD® Series products by life cycle stage per declared unit [3]

Impact category	Unit	A1	A2	A3	Total
		Raw material acquisition	Transportation	Production	
SM single figure score	mPts	1.27E-02	4.52E-03	3.56E-02	5.28E-02

5.3 Sensitivity analysis

A sensitivity analysis was performed for raw material percentages, TRACI results, and SM single figure scores using the highest and lowest values for the most important choices and assumptions to check the robustness of the results of the LCA (disregarding outliers is appropriate). The choices or assumptions which influence the results in any environmental parameter by more than 20% are reported in the Variations section of the LCIA results. The previous section includes the variations within the product groups which are dominated by the product composition, raw material weights, and the transportation phase.

5.4 Overview of relevant findings

This study assessed a multitude of inventory and environmental indicators. The overall results are consistent with expectations for passive fire protection products' life cycles. The primary finding, across the environmental indicators and for the products considered, was that raw material acquisition dominates the impacts. The raw material acquisition stage consists of the raw materials and their amounts required to make the final product. The main raw material contributers are calcium sulfate, portland cement, and vermiculite due to their high weights. In the case of the CAFCO® BLAZE-SHIELD® Series, levy slag and portland cement dominate the raw material acquisition impacts.

For the CAFCO® 400 Series and the CAFCO® FENDOLITE® Series products, ecotoxicity is the only impact category for inbound transportation that accounts for a sizeable impact. For the CAFCO® 300 Series products, ecotoxicity, carcinogenics, and smog impact categories for inbound transport accounts for a sizable impact. For other impact categories, inbound transport is not as big of a contributor as raw material acquisition. The impact associated with inbound transport is due to the far transportation distances.

Manufacturing accounts for a small fraction of overall life cycle impact except in the case of CAFCO® BLAZE-SHIELD® Series products. These high impacts are associated with the greater amount of electricity used in the creation of this product series.

In A3, only 10% of vermiculite is landfilled. This waste is a very low contributer overall. No hazardous waste is created by the product system.

5.5 Discussion on data quality

Inventory data quality is judged by its precision (measured, calculated or estimated), completeness (e.g., federal reporting regulations emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological).

To cover these requirements and to ensure reliable results, first-hand industry data in combination with consistent background LCA information from SimaPro Analyst 8.5.2.0. The EcoInvent LCI and NERC datasets were used.

Precision and completeness

- Precision: As the relevant foreground data is primary data or modeled based on primary information sources of the owner of the technology, precision is considered to be high. Seasonal variations were balanced out by collecting 12 months of data. Most background data are from EcoInvent databases with the documented precision.
- Completeness: Each unit process was checked for mass balance and completeness of the emission inventory. Capital equipment was excluded under cut-off criteria. Otherwise, no data were knowingly omitted.

Consistency and reproducibility

- Consistency: To ensure consistency, all primary data were collected with the same level of detail, while most background data were sourced from the EcoInvent databases. Allocation and other methodological choices were made consistently throughout the model.
- Reproducibility: Reproducibility is warranted as much as possible through the disclosure of input-output data, dataset choices, and modeling approaches in this report. Based on this information, any third party should be able to approximate the results of this study using the same data and modeling approaches.

Representativeness

- Temporal: All primary data were collected for January 2017 through December 2017 in order to ensure representativeness of post-consumer content. Most secondary data were obtained from the EcoInvent databases and are typically representative of the years 2008 – 2014.
- Geographical: Primary data are representative of Isolatek's production in the US. Data were collected from Stanhope, NJ; Houston, TX; San Bernardino, CA; and Huntington, IN. Differences in electric grid mix are taken into account with appropriate secondary data. In general, secondary data were collected specific to the region of the country under study. Geographical representativeness is considered to be high.
- Technological: All primary and secondary data were modeled to be specific to the technologies under study. Technological representativeness is considered to be high.

5.6 Completeness, sensitivity, and consistency

Completeness

All relevant process steps for each product system were considered and modeled to represent each specific situation. The process chain is considered sufficiently complete with regard to the goal and scope of this study.

Sensitivity

Sensitivity analyses were performed to test the robustness of the results towards uncertainty, as described earlier in this report.

Consistency

All assumption, methods, and data were found to be consistent with the study's goal and scope. Differences in background data quality were minimized by using LCI data from the EcoInvent databases. System boundaries, allocation rules, and impact assessment methods have been applied consistently throughout the study.

5.7 Conclusions, limitations, and recommendations

The goal of this study was to conduct a cradle-to gate LCA on several insulation products so as to develop SM Transparency Reports. The creation of these Transparency Reports will allow consumers in the building and construction industry to make better informed decisions about the environmental impacts associated with the products they choose. Raw material acquisition and transportation drive environmental performance. Additionally, manufacturing also accounts for a notable contribution to impact.

The results show that the largest area for reduction of each product's environmental impact is in the raw material acquisition and transportation phases. These are important areas for Isolatek to focus its efforts and ones which it can influence.

6 SOURCES

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ACRONYMS

EI	EcoInvent
ISO	International Standardization Organization
LCA	life cycle assessment
LCI	life cycle inventory
LCIA	life cycle impact analysis
PCR	Product Category Rule document
PE	PE International (now thinkstep)
TR	Transparency Report™
ts	Thinkstep
ULE	UL Environment

GLOSSARY

For the purposes of this report, the terms and definitions given in ISO 14020, ISO 14025, the ISO 14040 series, and ISO 21930 apply. The most important ones are included here:

allocation	Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems
close loop & open loop	A closed-loop allocation procedure applies to closed-loop product systems. It also applies to open-loop product systems where no changes occur in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials. An open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.
cradle to grave	Addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of life
cradle to gate	Addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of the production process ("gate of the factory"). It may also include transportation until use phase
declared unit	quantity of a product for use as a reference unit in an EPD based on one or more information modules
functional unit	quantified performance of a product system for use as a reference unit
life cycle	consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal
life cycle assessment - LCA	compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle
life cycle impact assessment - LCIA	phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product

life cycle inventory - LCI	phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle
life cycle interpretation	Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations

APPENDIX A. USED DATASHEETS

To model the LCA different data sources have been used. This appendix includes a list of all datasheets that have been used:

- Isolatek_results_LCI energy
- Isolatek_results_LCI material resources
- Isolatek_results_LCIA
- Isolatek_calculated primary data