ENVIRONMENTAL PRODUCT DECLARATION

SPRAY POLYURETHANE FOAM INSULATION

CLOSED CELL USING HYDROFLUOROCARBONS (CCSPF, HFC)

SPF products are commonly used in residential, light commercial, commercial, institutional, and certain industrial applications. Closed cell SPF (ccSPF) is applied to the interior or exterior side of the building envelope.

SPRAY POLYURETHANE FOAM ALLIANCE

Founded in 1987, originally as the Polyurethane Foam Contractors Division, the Spray Polyurethane Foam Alliance (SPFA) is the collective voice, along with the educational and technical resource, for the spray polyurethane foam industry. Our experienced staff and member-comprised committees provide a wide variety of services to the industry.

SPFA develops tools designed to educate and influence the construction industry with the positive benefits of spray polyurethane foam roofing, insulation, coatings, and specialty installations.

ASTM INTERNATIONAL Standards Worldwide

Environmental Product Declaration

Spray Polyurethane Foam Alliance
Spray Polyurethane Foam (ccSPF, HFC)

**According to ISO 14025,
ISO 21930:2017**

EPD Program and Program Operator Name, Address, Logo, and Website	ASTM International 100 Barr Harbour Dr, West Conshohocken, PA 19428, USA www.astm.org
General Program Instructions and Version Number	ASTM Program Operator for Product Category Rules (PCR) and Environmental Product Declarations (EPDs), General Program Instructions, Version: 8.0, Revised 04/29/20
Association Name and Address	Spray Polyurethane Foam Association | 11 Hope Rd, Suite 111 #308, Stafford, VA 22554
Declaration Number	EPD 806
Declared Product & Functional Unit or Declared Unit	Spray polyurethane foam insulation (ccSPF, HFC), 1 m² of installed insulation material with a thickness that gives an average thermal resistance of RSI = 1m²·K/W
Reference PCR and Version Number	PCR Part A: UL Environment Building Related Products and Services. (UL Environment, 2022) and PCR Part B: UL Environment. Building-Related Products and Services. Building Envelope Thermal Insulation EPD Requirements (UL Environment, 2024)
Description of Product Application/Use	Closed cell, HFC spray polyurethane foam (ccSPF, HFC) used in building and construction
Markets of Applicability	North America
Date of Issue	11/11/2024
Period of Validity	5 Years
EPD Type	Industry-average
Range of Dataset Variability	N/A
EPD Scope	Cradle-to-grave
Year(s) of Reported Primary Data	2022-2023
LCA Software & Version Number	LCA FE 10.9 (formerly GaBi Software)
LCI Database(s) & Version Number	Managed LCA Content 2024.2 (formerly GaBi Database, CUP 2024.2)
LCIA Methodology & Version Number	IPCC AR6 + CML 2001 Aug 2016 + TRACI 2.1

The PCR review was conducted by:	ASTM International
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ INTERNAL ☒ EXTERNAL	Timothy S Brooke, ASTM International tbrooke@astm.org
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	Sphera Solutions, Inc.
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas P. Gloria, Ph.D, Industrial Ecology Consultants t.gloria@industrial-ecology.com

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.

1. Product Definition and Information

1.1. Description of Company/Organization

Founded in 1987,originally as the Polyurethane Foam Contractors Division, the Spray Polyurethane Foam Alliance (SPFA) is the collective voice, along with the educational and technical resource, for the spray polyurethane foam industry. Our experienced staff and member-comprised committees provide a wide variety of services to the industry.

SPFA develops tools designed to educate and influence the construction industry with the positive benefits of spray polyurethane foam roofing, insulation, coatings, and specialty installations.

This project was funded by contributions from thirteen SPFA supplier member companies in the spray polyurethane foam (SPF) industry. Seven of these sponsors produce or formulate closed cell, HFC spray foam (ccSPF, HFC) systems throughout the U.S. and Canada. SPF producers that contributed to this declaration are featured below. In addition, there are two other sponsors who produce chemical components used in the formulation of SPF products or equipment used to mix and install SPF on the jobsite.

SPF Formulator Sponsors:

BASF We create chemistry

Johns Manville

CREATIVE POLYMER SOLUTIONS

NATURAL POLYMERS

ELASTOCHEM

NCFI POLYURETHANES

GENERAL COATINGS MANUFACTURING CORP.

SOPREMA

HOLCIM

SWD

HUNTSMAN BUILDING SOLUTIONS

SPF Chemical and Equipment Supplier Sponsors:

Chemours™ Honeywell

1.2. Product Description

Product Identification

SPF is made on the jobsite by combining polymeric methylene-diphenyl diisocyanate (pMDI/MDI or side-A) with an equal volume of a polyol blend (side-B). Sides A and B react and expand at the point of application in the building envelope to form polyurethane foam. The formed-in-place SPF provides both thermal insulation and air sealing to the building.

There are various classes of SPF, one of them being closed cell or medium density foam (ccSPF) using hydrofluorocarbons (HFC) as the blowing agent. Please note that this declaration only covers HFC formulations for ccSPF products.

Table 1. Typical properties of ccSPF, HFC spray polyurethane foam

NAME	CCSPF, HFC
Density [lb / ft^3]	1.5 to 2.4
Thermal resistivity [R / in]	6.2 to 7.0
Air impermeable material	✓
Integral vapor retarder	✓
Water resistant	✓
Cavity insulation	✓
Continuous insulation	✓
Structural improvement	✓

Product Specification

All SPF products must meet numerous performance requirements to comply with building codes. The details of these requirements are described in specific tests listed in consensus standards for material performance and code compliance. ccSPF products must follow the following standards:

ASTM Standards:

- C1029-15 Type I and II, Standard Specification for Spray-Applied Rigid Cellular Polyurethane Thermal Insulation

UL Canada Standards:

- S705.1 Standard for Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density

International Code Council Standards:

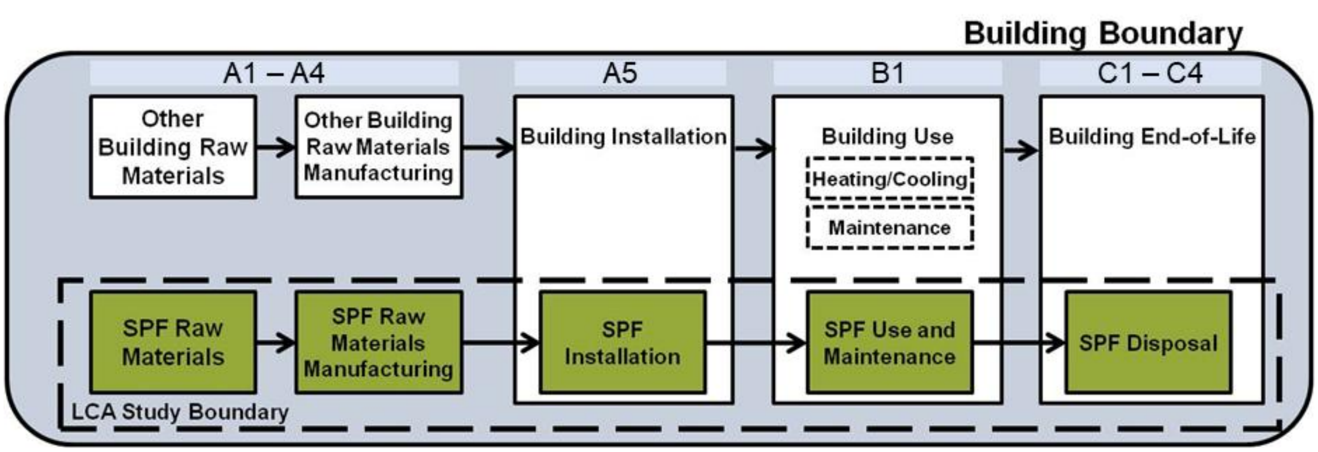
- ICC-ES AC-377 Acceptance Criteria for Spray-Applied Foam Plastic Insulation
- ICC-1100-20xx Standard for Spray-applied Polyurethane Foam Plastic Insulation

Typical material performance requirements per ICC-1100 are provided in Table 2 below.

Table 2. Summary of typical material performance requirements for ccSPF, HFC in Construction

STANDARD TYPE		ccSPF, HFC
Thermal Performance (R-value)	ASTM C518, C177 or C1363	As reported (typ R_{IP}6.0-7.0/inch / 4.2-4.8/100 mm)
Surface Burning Characteristics	ASTM E84 or UL723	Flame spread index ≤ 75 Smoke developed ≤ 450
Core Density	ASTM D1622	As reported (typ 1.5-2.5 pcf / 24-40 kg/m^3)
Closed-Cell Content	ASTM D2856 or ASTM D6226	>90%
Tensile Strength	ASTM D1623	15 psi min (103 kPa)
Compressive Strength	ASTM D1623	15 psi min (103 kPa)
Dimensional Stability	ASTM D2126	15% max change
Water Vapor Permeance	ASTM E96 (dry cup)	As reported (typ 1 US perm @ 2" thk / 0.66 SI perm @ 51 mm)
Air Permeance	ASTM D E283 or D2178	As reported (typ imperm @ 1.5" thk / 38 mm)
Water Absorption	ASTM D2842	<5% max

Flow Diagram



Product Average

This EPD is intended to represent an industry average for ccSPF, HFC. The average is calculated based on a weighted-average formulation for side-B, combined with production data collected from each member's facility. The data were weighted according to the mass produced by each member (i.e. vertical averaging). The formulators participating in this study represent a significant majority of the U.S. SPF production.

1.3. Application

SPF products are commonly used in residential, light commercial, commercial, institutional, and certain industrial applications. CcSPF, HFC are commonly applied to the interior side of the building envelope as an insulation and air-sealing material.

1.4. Declaration of Methodological Framework

This EPD is "cradle-to-grave" in scope with all modules declared except for module D.

1.5. Technical requirements

Spray foam insulation products must be installed in compliance with building codes. Nearly all jurisdictions have adopted a version of the following building codes:

a) International Code Council (ICC) - International Residential Code (IRC) – For 1 and 2 family dwellings

b) International Code Council (ICC) - International Building Code (IBC) – For multifamily dwellings, as well as commercial, institutional and industrial buildings.

c) International Code Council (ICC) - International Energy Conservation Code (IECC) – Providing envelope energy efficiency requirements for all buildings.

d) American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1- Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings

e) American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.2- Energy-Efficient Design of Low-Rise Residential Buildings

To meet code requirements, SPF product must meet minimum performance requirements, demonstrated by laboratory testing using approved test methods. These tests are performed by third-party laboratories and test data typically submitted to a certification agency for evaluation of the results and the creation of an independent code compliance report for the product. Certification agencies also perform regular quality control testing from random samples taken from the manufacturer's facilities.

There are two guides that are followed by these certification bodies to collect and evaluate data to generate code compliance reports:

- ICC 1100 Standard for Spray-applied Polyurethane Foam Plastic Insulation (2021)
- IAPMO/ANSI ES1000 Building Code Compliance Spray-Applied Polyurethane Foam (2020)

Table 3. Testing Requirements per ICC 1100 and IAPMO ES1000 Standards

Testing Requirements per ICC 1100 and IAPMO ES1000 Standards			
Property	**Measurement**	**Test Method**	**Requirement**
Thermal Resistance	R-value at thickness or thermal resistance	ASTM C177-19 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus, ASTM C518-21 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus, OR ASTM C1363-24 Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus	Report
Air Permeance	Thickness where foam is air impermeable	ASTM E283/E283M-19 Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen OR ASTM E2178-21a Standard Test Method for Determining Air Leakage Rate and Calculation of Air Permeance of Building Materials	Report minimum thickness where air impermeable
Water Vapor Permeance	Thickness where foam meets Class I, II or III vapor retarder performance	ASTM E96/E96M-24 Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials (Method A)	Report thickness at vapor retarder class I, II or III.
Density	Mass density of foam	ASTM D1622-20 Standard Test Method for Apparent Density of Rigid Cellular Plastics	Report
Surface Burning Characteristics	Flame Spread Index	ASTM E84-24 Standard Test Method for Surface Burning Characteristics of Building Materials	75 or less
	Smoke Developed Index	ASTM E84-24 Standard Test Method for Surface Burning Characteristics of Building Materials	450 or less for insulation, unlimited for roofing
Thermal Barrier Testing	Pass fire test with prescriptive thermal barrier for thickness over 4"	NFPA 286, FM 4880, UL 1040 or UL1715	Pass 15 minute criteria
Alternate Thermal Barrier Assembly	Pass fire test with specific covering or coating	NFPA 286, FM 4880, UL 1040 or UL1715	Pass 15 minute criteria
Ignition Barrier Testing	Pass fire test with or without covering or coating	Various special test methods	See standard for details

In addition to these standards, there are also two ASTM material standards for SPF materials.

- ASTM C1029 Standard Specification for Spray-Applied Rigid Cellular Polyurethane Thermal Insulation – Including closed-cell insulation and roofing foams,
- ASTM D7425 Standard Specification for Spray Polyurethane Foam Used for Roofing Applications.

Table 4. Testing Requirements per ASTM C1029 and D7425 Material Standards

Testing Requirements per ASTM C1029 and D7425 Material Standards				
Property	Measurement	Test Method	ASTM C1029 Requirement	ASTM D7425 Requirement
Thermal Resistance	R-value at thickness or thermal resistance	ASTM C177-19 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus, ASTM C518-21 Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus, OR ASTM C1363-24 Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus	R6.2/inch minimum	R5.6/inch minimum
Water Vapor Permeability	perm-inches	ASTM E96/E96M-24 Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials (Method A)	3.0 perm-inches	3.0 perm-inches
Density	Apparent density of foam	ASTM D1622-20 Standard Test Method for Apparent Density of Rigid Cellular Plastics	Report	2.5 lb/ft^3 minimum
Surface Burning Characteristics	Flame Spread Index	ASTM E84-24 Standard Test Method for Surface Burning Characteristics of Building Materials	Report (75 limit in building codes)	Not required
	Smoke Developed Index	ASTM E84-24 Standard Test Method for Surface Burning Characteristics of Building Materials	Report (no limit in building codes)	Not required
Closed-cell Content	Percentage of closed cells	ASTM D6226-21 Standard Test Method for Open Cell Content of Rigid Cellular Plastics	90% or greater	90% or greater
Compressive Strength	psi	ASTM D1621-16(2023) Standard Test Method for Compressive Properties of Rigid Cellular Plastics	Minimum determined by Type per ASTM C1029: Type I - 15 psi Type II - 25 psi Type III - 40 psi Type IV - 60 psi	40 psi minimum
Tensile Strength	psi	ASTM D1623-17(2023) Standard Test Method for Tensile and Tensile Adhesion Properties of Rigid Cellular Plastics	Minimum determined by Type per ASTM C1029: Type I - 20 psi Type II - 32 psi Type III - 42 psi Type IV - 56 psi	40 psi minimum

Testing Requirements per ASTM C1029 and D7425 Material Standards				
Property	Measurement	Test Method	ASTM C1029 Requirement	ASTM D7425 Requirement
Response to Thermal/Humid Aging	dimensional stability percent	ASTM D2126-20 Standard Test Method for Response of Rigid Cellular Plastics to Thermal and Humid Aging	Maximum determined by Type per ASTM C1029: Type I - 12% Type II - 9% Type III - 6% Type IV - 5&	6% maximum
Water Absorption	Percentage by volume	ASTM D2842-19 Standard Test Method for Water Absorption of Rigid Cellular Plastics	5% maximum	5% maximum

1.6. Properties of Declared Product as Delivered

The two chemicals required to produce SPF (side-A and side-B) are delivered as a set to the job site in separate containers. On the job site, these chemicals are mixed in equal volume proportions to create SPF. A total mass of 0.68kg (or 1.50 lb) of ccSPF, HFC product is delivered.

1.7. Material Composition

The side-A of SPF is made from a blend of polymeric methylene diphenyl diisocyanate (MDI). The side-B is a mixture of polyester and polyether polyols, flame retardants, blowing agents, catalysts, and other additives that, when mixed with side-A, creates foam that can be applied for insulation. As the precise formulation of the side-B will vary with each company producing SPF chemicals, this study uses a weighted average formulation shown in Table 5.

While some of the ingredients may be classified as hazardous, per the Resource Conservation and Recovery Act (RCRA), Subtitle C, the product as installed and ultimately disposed of is not classified as a hazardous substance, as hazardous ingredients are rendered chemically inert after installation.

There are no toxic materials or hazardous wastes directly associated with either the manufacturing of these components or the installation of the spray foam systems.

Table 5. ccSPF, HFC side-B formulations

Chemical (% Composition)		ccSPF, HFC
Polyol	Polyester	45
	Polyether	13
	Mannich	12
	Compatibilizer	1
Fire Retardant	TCPP	10
	TDCP	2
Blowing Agent	HFC-245fa	9
	Reactive (H_2O)	3

CHEMICAL (% COMPOSITION)		CCSPF, HFC
Catalyst	Catalyst, amine	4
Surfactant	Silicone	1

1.8. Manufacturing

A significant majority the side-A of SPF is manufactured by U.S. based chemical manufacturing companies with processing facilities located in Texas and Louisiana. The side-B formulation is made by several formulators or systems houses located throughout the U.S. and Canada. Most of the primary chemicals used in the side-B formulation are processed in facilities in Texas, Louisiana, and Virginia.

During the side-B production process, materials are blended together in closed tanks and packaged. The side-B blending process utilizes internal scrap from a manufacturer's own operations. Additionally, many facilities utilize technology to minimize the release of gaseous material inputs, such as blowing agents, during material transfer and processing. Waste materials are typically reintegrated into the formulation without additional collection, transport, or processing.

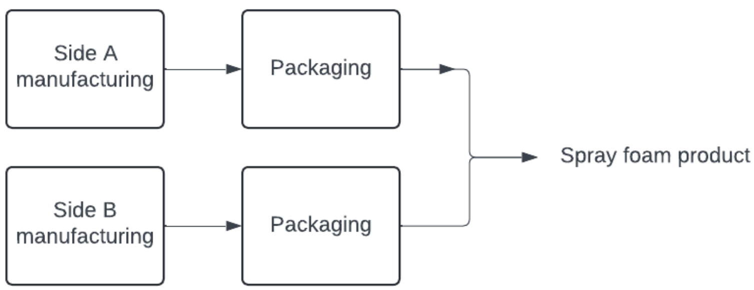


Figure 1. Manufacturing process

1.9. Packaging

CcSPF, HFC are high-pressure SPF chemicals that are packaged in unpressurized containers of varying types, most commonly in 55-gallon (208 L) steel or plastic drums and in some cases, plastic totes. Since each member company utilizes different package types and sizes, packaging data were aggregated by type (i.e. steel or plastic) and function (i.e. side-A or side-B). Finished packaged products are loaded onto pallets, where additional shipping materials, such as strapping, cardboard, and plastic wrap, are applied. In this study, it is assumed that the empty chemical containers are properly cleaned and taken to a drum recycler.

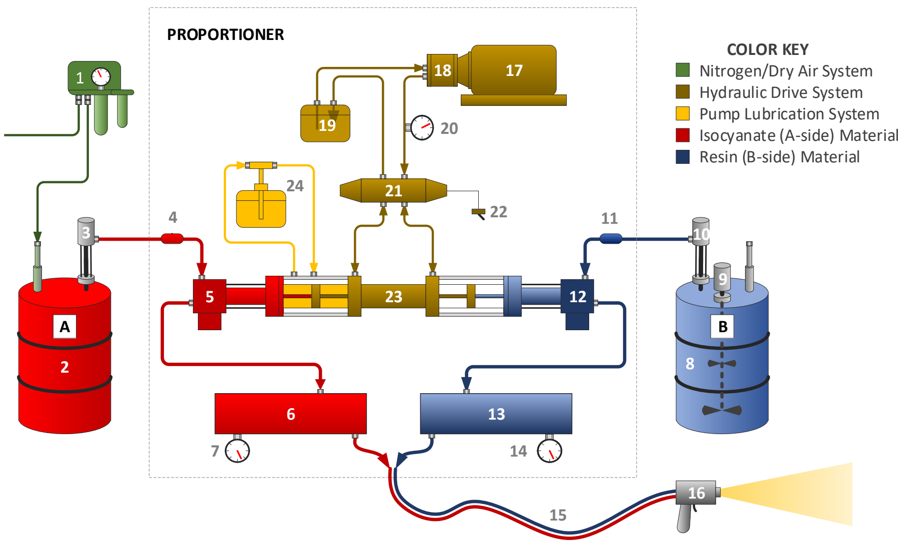
Disposal of packaging materials is modeled in accordance with the assumptions outlined in Part A of the PCR (UL Environment, 2022). Plastic based packaging is disposed in landfill (68%), incineration (17%), and recycled (15%). Metal based packaging is disposed in landfill (34%), incineration (9%), and recycled (57%). Paper based packaging is disposed in landfill (20%), incineration (5%), and recycled (75%).

1.10. Transportation

Final products are distributed via container truck and refrigerated truck, which are fueled by diesel. These final products are either directly to customers, or first to warehouse, prior to being sent to customers. Table 7 details distribution assumptions for finished SPF products.

1.11. Product Installation

High-pressure SPF such as ccSPF, HFC, are installed by professional applicators by on-site mixing of the side-A and side-B chemicals.



1. Nitrogen/Dry Air System
2. Isocyanate Drum/Tote
3. Isocyanate Transfer Pump
4. Isocyanate Filter
5. Isocyanate Proportioning Pump
6. Isocyanate Primary Heater
7. Isocyanate Output Pressure Gauge
8. Resin Drum/Tote
9. Resin Drum Mixer
10. Resin Transfer Pump
11. Resin Filter
12. Resin Proportioning Pump
13. Resin Primary Heater
14. Resin Output Pressure Gauge
15. Dual Heated Hose
16. Spray Gun
17. Electric Motor
18. Hydraulic Pump
19. Hydraulic Fluid Reservoir
20. Hydraulic Pressure Gauge
21. Hydraulic Directional Valve
22. hydraulic Directional Switch
23. Hydraulic Cylinder
24. Pump Lube System

Figure 2. Schematic of a High-Pressure SPF system

Installation includes insulation of the walls, floors and ceilings of entire buildings, or application as an insulated low-slope roofing system. These chemicals are delivered to the jobsite in unpressurized containers (usually 55-gallon / 208 L drums) and heated to approximately 120-130 °F (49-54 °C) and pressurized to about 1000 psi (6,895 kPa) by specialized equipment. The chemicals are transferred by a heated hose and aerosolized by a spray gun and combined by impingement mixing at the point of application. Personal protective equipment such as goggles, protective suits, and respirator cartridges is required to protect applicators from chemical exposure during installation. Also needed are disposable materials such as masking tape and drop cloths. The schematic in Figure 2 shows the typical equipment components used to produce high-pressure SPF foam, including unpressurized side-A and side-B liquid drums with transfer pumps, which are connected to the proportioner system for heating and pressurizing the chemicals, and then through a heated hose connected to a spray gun for application.

After the foam cures and expands, any excess that may prevent installation of the interior cladding is cut off and discarded. For SPF with physical blowing agents, this study assumes 10% of the installed blowing agent is released to surrounding air during the installation phase. Discarded foam from installation also experiences blowing agent release while in landfill. Disposal of packaging materials is modeled in accordance to the assumptions outlined in Part A of the PCR (UL Environment, 2022). All ancillary installation materials are assumed to be sent to landfill.

Although foam will assist with noise reduction in building assemblies, there are no specific requirements for noise reduction for insulation in the building codes. Some manufacturers have measured and published noise reduction in terms of Sound Transmission Class (STC) rating per ASTM E90, and Noise Reduction Coefficient (NRC) for sound absorption per ASTM C423. These measurements are highly dependent on the assembly in which the foam is applied, and the sound frequencies used for testing.

1.12. Use

As this study only looks at the life cycle of spray foam insulation, and not the building, the use phase only contains the emissions of any chemicals off-gassed from the foam. This study assumes 24% of the original chemical blowing agent is off-gassed over a 75-year lifetime (Honeywell International).

1.13. Reference Service Life and Estimated Building Service Life

The reference service life (RSL) and estimated building service life (ESL) for SPF is the life of the building of 75 years.

1.14. Reuse, Recycling, and Energy Recovery

SPF is typically not reused or recycled following its removal from a building. Thus, reuse, recycling, and energy recovery are not applicable for this product.

1.15. Disposal

When the building is decommissioned, it is assumed that only manual labor is involved to remove the foam. Waste is assumed to be transported 30 miles (48 km) to the disposal site. The spray foam is assumed to be landfilled at end-of-life, as is typical for construction and demolition waste in the US. This study assumes 16% of the original physical blowing agent is emitted at this stage in the life cycle. It is further assumed the spray foam is inert in the landfill and 50% of the blowing agent remains in the product after disposal (Kjeldsen & Jensen, 2001).

2. Life Cycle Assessment Background Information

2.1. Functional or Declared Unit

The product's function is to provide thermal insulation to buildings. Accordingly, the functional unit for the study is 1 m² of installed insulation material with a thickness that gives an average thermal resistance of R_{SI}=1m^2·K/W (R = 5.68 hr·ft²·°F/Btu) with a building service life of 75 years (packaging included).

Table 6. Functional unit properties

NAME	VALUE	UNITS
Functional Unit	1 m² of installed insulation material with a thickness that gives an average thermal resistance of RSI=1m²·K/W	
Mass	1.50	lb
	0.68	kg
Thickness to achieve functional unit	0.84	in
	0.02	m

2.2. System Boundary

The study uses a cradle-to-grave system boundary. As such, it includes upstream processing and production of raw materials (A1), auxiliary material and energy resources needed for the production of SPF (A3), transport of materials (all chemical inputs for production and packaging) to SPF formulation sites (A2), transport of the components to the installation site (A4), installation of insulation (A5), removal and transport of insulation to disposal site (A5), use phase (B1), transportation to end-of-life (C2), and end-of-life-disposal (C4). Building energy savings from the use of insulation are excluded from this analysis. Module D has been excluded from this analysis.

2.3. Estimates and Assumptions

The formulations of side-B mixtures for each company are proprietary. However, the main ingredients do not vary significantly, so a weighted average formulation is used to represent the side-B products evaluated in this study.

The material and energy inputs and outputs were modeled according to data provided by the representative site, while the electricity grid and natural gas mix were chosen based on the locations of each manufacturer's production facilities. Further granularity of raw material and waste data for additional locations may alter the results of this study.

When possible, energy consumption data on side-B production were collected via sub-metering. However, when not feasible, energy consumption was allocated to the spray polyurethane foam production by mass.

Lastly, this study assumes 50% of blowing agent consumed in the production of the formulation is eventually emitted, with 10% released during installation, 24% released during lifetime in building, and 16% released during end-of-life. The remaining 50% remains in the product (Honeywell International) (Kjeldsen & Jensen, 2001).

2.4. Cut-off rules

The cut-off criteria for including or excluding materials, energy and emissions data of the study are as follows:

- **Mass** – According to ISO guidelines, if a flow is less than 1% of the cumulative mass of the model it may be excluded, providing its environmental relevance is not a concern. For the purpose of this LCA, all known mass flows are reported, and no known flows were deliberately excluded.
- **Energy** – According to ISO guidelines, if a flow is less than 1% of the cumulative energy of the model it may be excluded, providing its environmental relevance is not a concern. For the purpose of this LCA, all known energy flows are reported, and no known flows were deliberately excluded.
- **Environmental relevance** – If a flow meets the above criteria for exclusion, yet is thought to potentially have a significant environmental impact, it was included. Material flows which leave the system (emissions) and whose environmental impact is greater than 1% of the whole impact of an impact category that has been considered in the assessment must be covered. This judgment was made based on experience and documented as necessary.

Packaging of incoming raw materials (e.g. pallets, totes, super-sacks) are excluded as they represent less than 1% of the product mass and are not environmentally relevant. Capital goods and infrastructure required to produce and install SPF (e.g. batch mixers, spraying equipment) are presumed to produce millions of units over the course of their life, so impact of a single functional unit attributed to these equipment is negligible; therefore, capital goods and infrastructure were excluded from this study. No known flows are deliberately excluded from this EPD.

Capital goods and infrastructure flows were excluded from this analysis due to the minimal extent that it affects the LCIA results. For the manufacturing of SPF products, capital goods and infrastructure last for 20 to 40 years with periodic re-placement of valves and repair of control systems, with an annual production of around 9.5 million lbs of side-B product that are included in this study. During the final stage of manufacturing (Installation) performed by SPF contractors, the life of the most expensive piece of equipment, the proportioner, is around 20 to 25 years. Diesel generators, compressors and spray guns may be around 15 to 20 years.

2.5. Data Sources

The LCA model was created using the LCA for Experts (LCA FE) software system for life cycle engineering, developed by Sphera (Sphera, 2024). Background life cycle inventory data for raw materials and processes were obtained from the Sphera MLC 2024.2 database (CUP 2024.2). Primary manufacturing data were provided by participating companies.

2.6. Data Quality

A variety of tests and checks were performed by the LCA practitioner throughout the project to ensure high quality of the completed LCA. Checks in cluded an extensive internal review of the project-specific LCA models developed as well as the background data used. A full data quality assessment is documented in the background report.

Temporal coverage

The data are intended to represent spray polyurethane foam production during the 2022 calendar year. As such, each participating SPFA member company provided primary data for 12 consecutive months during the 2022 calendar year. These data were then used to calculate average production values for each company.

Geographical coverage

This background LCA represents SPFA members' products produced in the United States and Canada. Primary data are representative of these countries. Regionally specific datasets were used to represent each manufacturing location's energy consumption. Proxy datasets were used as needed for raw material inputs to address lack of data for a specific material or for a specific geographical region. These proxy datasets were chosen for their technological representativeness of the actual materials.

Technological coverage

Data on material composition were developed using industry formulation for the ccSPFA, HFC. Manufacturing data were collected directly from SPFA members. Waste, emissions, and energy use are calculated from reported annual production during the reference year from SPFA member companies.

2.7. Period under Review

Primary data collected represent production during the 2022 calendar year. This analysis is intended to represent production in 2022.

2.8. Allocation

Multi-output allocation follows the requirements of ISO 14044, section 4.3.4.2 (ISO, 2006a; ISO, 2006b). When allocation becomes necessary during the data collection phase, the allocation rule most suitable for the respective process step was applied. Energy outputs were allocated based on engineering knowledge that certain products require more energy to produce. Comparative consumption data between different products were obtained from participating companies producing multiple products and used appropriately for allocating electricity and fuel outputs. Waste outputs were allocated by mass.

The background MDI dataset used in the LCA study, which was developed by the European diisocyanates and polyols producers' association known as ISOPA is based on a combination of mass and elemental allocation approach (European Diisocyanate and Polyol Producers Association (ISOPA), 2021). This also aligns with the 2022 LCA study conducted by the American Chemistry Council. (American Chemistry Council, 2022)

The cut-off allocation approach is adopted in the case of any post-consumer and post-industrial recycled content, which is assumed to enter the system burden-free. Only environmental impacts from the point of recovery and forward (e.g., inbound transports, grinding, processing, etc.) are considered.

3. Life Cycle Assessment Scenarios

Transport to the building site uses a weighted average of the various vehicle types used by member companies. Table 7 is a summary of the different vehicle types and total transport distance. Liters of fuel and capacity utilization will vary depending on the vehicle type.

Results reported are per functional unit.

Table 7. Transport to the building site (A4)

Name	Value			Unit
Fuel type	Diesel			
Liters of fuel	0.0148	0.0001	0.0017	l/100km
Vehicle type	Truck, TL/Dry van	Truck, heavy/bulk	Truck, refrigerated	
Transport distance	100	1210	188	km
Capacity utilization (including empty runs, mass based	100	100	100	%
Gross density of products transported	42	42	42	kg/m^3

Table 8. Installation into the building (A5)

Name	Value	Unit
Ancillary materials	0.021	kg
Net freshwater consumption specified by water source and fate (amount evaporated, amount disposed to sewer)	0	m^3
Other resources	N/A	kg
Electricity consumption	0.041	kWh
Other energy carriers	2.69	MJ
Product loss per functional unit	0.025	kg
Waste materials at the construction site before waste processing, generated by product installation	0.0032	kg
Output materials resulting from on-site waste processing (specified by route; e.g. for recycling, energy recovery and/or disposal)	0	kg
Biogenic carbon contained in packaging	0.0011	kg CO_2
Direct emissions to ambient air, soil and water	0.0032	kg
VOC content	0	µg/m^3

Table 9. Reference service life

Name	Value	Unit
Direct emissions to ambient air, soil and water	0.0076	kg

Table 10. End of life (C1-C4)

Name		Value	Unit
Assumptions for scenario development (description of deconstruction, collection, recovery, disposal method and transportation)		Landfill	
Collection process (specified by type)	Collected with mixed construction waste	0.68	kg
Recovery (specified by type)	Landfill	0.68	kg
Disposal (specified by type)	Product or material for final deposition	0.68	kg
Removals of biogenic carbon (excluding packaging)		0	kg CO_2

4. Life Cycle Assessment Results

Table 11. Description of the system boundary modules

	PRODUCT STAGE			CONSTRUCT-ION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
	Raw material supply	Transport	Manufacturing	Transport from gate to site	Assembly/Install	Use	Maintenance	Repair	Replacement	Refurbishment	Building Operational Energy Use During Product Use	Building Operational Water Use During Product Use	Deconstruction	Transport	Waste processing	Disposal	Reuse, Recovery, Recycling Potential
EPD Type	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	MND

MND = module not declared

4.1. Life Cycle Impact Assessment Results

North American life cycle impact assessment (LCIA) results are declared using TRACI 2.1 (Bare, 2012; EPA, 2012) methodology, with the exception of GWP and ADP fossil. GWP is reported using the IPCC AR6 (IPCC, 2023) methodology, excluding biogenic carbon. ADP fossil is reported using CML 2001, Version 4.8, Aug 2016 (CML, 2001). Primary energy from non-renewable resources (NRPRe) and renewable resources (RPRe) represent the lower heating value (LHV) a.k.a. net calorific value (NCV).

The GWP indicators reported in this study exclude land use change impacts since manufacturing, use, and disposal of SPF products do not have a significant impact on land use, as it does not consume any agricultural products or chemicals that have a direct impact on land use.

Results reported are per functional unit.

Table 12. North American Impact Assessment Results

TRACI v2.1	A1	A2	A3	A4	A5	B1	C2	C4
GWP 100 [kg CO_2 eq]	2.10E+00	5.01E-02	1.76E-01	6.15E-02	3.61E+00	7.28E+00	1.09E-03	4.87E+00
ODP [kg CFC-11 eq]	5.32E-14	1.26E-16	4.47E-13	1.57E-16	4.14E-12	0.00E+00	2.78E-18	7.04E-16
AP [kg SO_2 eq]	3.24E-03	4.19E-04	4.34E-04	2.69E-04	1.24E-03	0.00E+00	4.65E-06	7.61E-05
EP [kg N eq]	3.37E-04	2.46E-05	2.64E-05	2.43E-05	1.08E-04	0.00E+00	4.24E-07	3.28E-06
POCP [kg O_3 eq]	5.99E-02	8.76E-03	7.10E-03	6.18E-03	4.12E-02	5.69E-06	1.07E-04	1.36E-03
ADP_{fossil} [MJ, LHV]	4.94E+01	6.48E-01	2.00E+00	8.07E-01	4.35E+00	0.00E+00	1.43E-02	2.16E-01

4.2. Life Cycle Inventory Results

Table 13. Resource Use

PARAMETER	A1	A2	A3	A4	A5	B1	C2	C4
RPR_E [MJ, LHV]	2.59E+00	2.50E-02	1.32E-01	3.52E-02	2.67E-01	0.00E+00	6.25E-04	2.76E-02
RPR_M [MJ, LHV]	0.00E+00	0.00E+00	1.42E-02	0.00E+00	2.87E-03	0.00E+00	0.00E+00	0.00E+00
RPR_T [MJ, LHV]	2.59E+00	2.50E-02	1.47E-01	3.52E-02	2.70E-01	0.00E+00	6.25E-04	2.76E-02
$NRPR_E$ [MJ, LHV]	3.46E+01	6.52E-01	2.05E+00	8.13E-01	3.97E+00	0.00E+00	1.44E-02	2.23E-01
$NRPR_M$ [MJ, LHV]	1.69E+01	0.00E+00	1.37E-02	0.00E+00	5.38E-01	0.00E+00	0.00E+00	0.00E+00
$NRPR_T$ [MJ, LHV]	5.15E+01	6.52E-01	2.06E+00	8.13E-01	4.51E+00	0.00E+00	1.44E-02	2.23E-01
SM [kg]	-	-	-	-	-	-	-	-
RSF [MJ, LHV]	-	-	-	-	-	-	-	-
NRSF [MJ, LHV]	-	-	-	-	-	-	-	-
RE [MJ, LHV]	-	-	-	-	-	-	-	-
FW [m^3]	1.19E-02	8.29E-05	9.76E-03	1.19E-04	8.58E-04	0.00E+00	2.11E-06	2.88E-05

Table 14. Output Flows and Waste Categories

PARAMETER	A1	A2	A3	A4	A5	B1	C2	C4
HWD [kg]	-	-	-	-	-	-	-	-
NHWD [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.84E-02	0.00E+00	0.00E+00	6.80E-01
HLRW [kg] or [m^3]	8.52E-07	2.03E-09	1.67E-08	2.50E-09	6.88E-08	0.00E+00	4.43E-11	2.65E-09
ILLRW [kg] or [m^3]	7.76E-04	1.71E-06	1.40E-05	2.11E-06	5.76E-05	0.00E+00	3.73E-08	2.36E-06
CRU [kg]	-	-	-	-	-	-	-	-
MR [kg]	-	-	-	-	-	-	-	-
MER [kg]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.17E-03	0.00E+00	0.00E+00	0.00E+00
EE [MJ, LHV]	-	-	-	-	-	-	-	-

Table 15. Carbon Emissions and Removals

PARAMETER	A1	A2	A3	A4	A5	B1	C2	C4
BCRP [kg CO_2]	-	-	-	-	-	-	-	-
BCEP [kg CO_2]	-	-	-	-	-	-	-	-
BCRK [kg CO_2]	0.00E+00	0.00E+00	9.73E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCEK [kg CO_2]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.87E-04	0.00E+00	0.00E+00	0.00E+00

5. LCA Interpretation

GWP100 is driven dominantly by installation phase (A5), use (B1), and end-of-life (C4) due to the HFC blowing agent emissions. In the other impact categories, ccSPF, HFC environmental performance is driven primarily by raw materials (A1), in particular MDI (side-A), polyols and TCPP due to their high mass contribution to the product. Installation tends to be the second highest driver of impact due to the use of on-site diesel generator, as well as waste foam disposal.

Though some raw materials are transported thousands of miles, the inbound transportation module (A2) has a modest contribution to overall impact. Other transportation modules representing transport to site (A4) and transport to end-of-life (C2), have negligible contribution to life cycle results

It is also important to note the assumptions and limitations to this study. These have been identified as:

- Datasets selected to represent the various inputs are based on regional or global averages rather than primary data collected directly from member company supply chains. When selecting these datasets, a conservative approach is applied in that datasets with higher impacts were used when there are multiple options.
- Proxy datasets were used where no exact dataset match was found. Similarly, a conservative approach was applied when selected these datasets.
- This study reports 50% of its blowing agents are released over its lifetime (Honeywell International). However, actual emissions may vary, which will affect impact categories such as global warming potential.

Results presented in this document do no constitute comparative assertions. Comparison of the environmental performance 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.

6. Additional Environmental Information

6.1. Environment and Health During Manufacturing

Manufacturing of SPF formulations and upstream chemicals are performed in an industrial manufacturing facilities. Like many manufacturing processes, hazardous chemicals and manufacturing procedures may be employed. These manufacturers follow all local, state and federal regulations regarding safe use and disposal of all chemicals (United States EPA, 2024) (United States EPA, 2024), as well as safety requirements required of the generally manufacturing operation of equipment and processes (U.S. and State OSHA) (Occupational Safety and Health Standards) (Safety and Health Regulations for Construction) (US Department of Labour, 2024) (US Department of Labour, 2024) and safe transport of all materials (US DOT)Environment and Health During Installation (US Code of Federal Regulations, November)

6.2. Energy Savings during Use

The use of any insulation in a building will provide substantial energy savings. Based on a third-party use phase analysis performed in 2018, the energy savings from SPF will offset the embodied energy of SPF within a few years, depending on climate zone and amount of insulation installed (Sustainable Solutions Corporation, 2020).

6.3. Environment and Health During Installation

Installation of SPF involves potential exposure to certain hazardous chemicals that requires risk mitigation through the use of personal protective equipment and on-site actions including ventilation and restricted access. Of greatest concern is the potential exposure to airborne and liquid isocyanates during and immediately after installation of SPF. Isocyanates are known chemical sensitizers and exposure can occur through contact with the skin, eyes and respiratory system. Ventilation of the work zone, coupled with use of proper personal protective equipment is required during and immediately after installation SPF. For more information on health and safety during and immediately after SPF installation, please visit www.spraypolyurethane.org.

6.4. Extraordinary Effects

Fire

Spray polyurethane foam, like all foam plastics and many construction materials – including wood - is a combustible material and will emit toxic gases including carbon monoxide during a fire. When used in buildings and other construction applications, foam plastics employ flame retardants to control ignition and spread of fire and development of smoke. In addition, foam plastics may need to be protected with fire-resistant coverings or coatings when used in certain construction applications, as dictated by the building codes. All foam plastic materials and assemblies should meet the fire test requirements of the applicable building codes.

Water

Closed-cell and roofing SPF products meet the FEMA Class 5 requirements[1] for flood-damage resistant insulation materials for floors and walls.

Mechanical Destruction

Should the assembly the SPF is installed in, i.e. the wall or roof, have to be replaced then the SPF will have to be replaced as well.

6.5. Environmental Activities and Certifications

Several SPF manufacturers have certified or tested their insulation products to various VOC standards to measure emissions of volatile or semi-volatile compounds, and thus do not emit significant VOCs. These standards include:

- UL Environment GREENGUARD® Certification – The GREENGUARD® Certification Program specifies strict certification criteria for VOC's and indoor air quality. This voluntary program helps consumers identify products that have low chemical emissions for improved indoor air quality.
- California Department of Health Services – Also known as Section 01350, this small-chamber emissions test standard is detailed under: Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers (CA/DHS/EHLB/Standard Method v1.1-2010).
- Canadian ULC – Required for SPF insulation products, this standard provides a similar VOC emissions test protocol specifically for SPF: CAN/ULC S774-09 Standard Laboratory Guide for the Determination of Volatile

[1] "Flood Damage-Resistant Materials Requirements", FEMA Technical Bulletin 2, 2008, Table 2.

Organic Compound Emissions from Polyurethane Foam

- Currently, an ASTM workgroup is developing a small-chamber emissions test protocol for chemical compounds specific to SPF that include MDI, blowing agents, flame retardants and catalysts.

6.6. Natural Oil Polyols

Natural Oil Polyols, or NOPs, are being used in some spray foam formulations, as some manufacturers are using renewable materials in their formulation to help differentiate their products from conventional petroleum-based materials. NOPs may include vegetable oils such as soy, castor, glycerin and rapeseed. This LCA was based on conventional petroleum-based polyols, as these are the most widely used in the industry and more representative of most current spray foam formulations.

6.7. Low-GWP blowing agents for SPF

This EPD is based on an LCA of SPF products that use HFC-134a and HFC-245fa as blowing agents. Because of the high global warming potential factor of HFC-134a and HFC-245fa (1,430 and 1,030 kg CO_2-eq./kg, respectively, over a 100 year time horizon) the emissions of these blowing agents account for approximately 85% of the global warming potential life cycle results for HFC containing foams.

A concurrent EPD study was also conducted for SPF products with low GWP blowing agents – hydrofluoroolefins (HFOs) (SPFA, 2018). Despite being released at the same rate over the course of the life of the product as HFCs, HFOs have a substantially lower contribution to GWP due to their GWP characterization factor being less than 1 CO_2-eq, over a 100 year time horizon (IPCC, 2023).

6.8. Further Information

Additional information can be found here: https://www.sprayfoam.org/sustainable

7. References

American Chemistry Council. (2022). *Cradle-to-gate Life Cycle Analysis of Methylene Diphenyl Diisocyanate (MDI).*

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.

CML. (2001). *CML's Impact Assessment Methods and Characterisation Factors.* Leiden University, Institute of Environmental Science.

EPA. (2012). *Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI) - User's Manual.* Washington, D.C.: US EPA.

European Diisocyanate and Polyol Producers Association (ISOPA). (2021). *Eco-profile of toluene diisocyanate (TDI) and methylene diphenyl diisocyanate (MDI).*

Honeywell International. (n.d.). *Predictive Model for Polyurethane Blowing Agent Emissions into a House.* Buffalo.

IPCC. (2023). *Climate Change 2023: Synthesis Report.* Geneva, Switzerland: IPCC.

ISO. (2006a). *ISO 14040: Environmental management – Life cycle assessment – Principles and framework.* Geneva: International Organization for Standardization.

ISO. (2006b). *ISO 14044: Environmental management – Life cycle assessment – Requirements and guidelines.* Geneva: International Organization for Standardization.

ISO. (2017). *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.

Kjeldsen, P., & Jensen, M. (2001). Release of CFC-11 from Disposal of Polyurethane Foam Waste. *ENVIRONMENTAL SCIENCE & TECHNOLOGY*, 3055-3063.

Occupational Safety and Health Standards. (n.d.). *US Code of Federal Regulations, Title 29, Subtitle B, Chapter XVII, Part 1910.* Retrieved from https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1910

Safety and Health Regulations for Construction. (n.d.). *US Code of Federal Regulations, Title 29, Subtitle B, Chapter XVII, Part 1926.* Retrieved from https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1926

SPFA. (2018). *Environmental Product Declaration: Spray Polyurethane Foam Insulation.* ASTM.

Sphera. (2024). *Sphera LCA Database Documentation*. Retrieved from Sphera Solutions, Inc.: https://sphera.com/product-sustainability-gabi-data-search/

Sustainable Solutions Corporation. (2020). *SPF Residential Energy Modeling Analysis .*

UL Environment. (2022). *Product Category Rules for Building-Related Products and Services - Part A: Life Cycle*

Assessment Calculation Rules and Report Requirements, UL 10010 (v4.0).

UL Environment. (2024). *PCR Part B: Building Envelope Thermal Insulation EPD Requirements UL 10010-1 (v.3.0).*

United States EPA. (2024, November). *US Code of Federal Regulations, Title 40.* Retrieved from https://www.ecfr.gov/current/title-40

United States EPA. (2024, November). *Waste, Chemical, and Cleanup Enforcement*. Retrieved from https://www.epa.gov/enforcement/waste-chemical-and-cleanup-enforcement

US Code of Federal Regulations. (November , 2024). *Federal Motor Carrier Safety Regulations.* Retrieved from Title 49, Subtitle B, Chapter III, Part 397 : https://www.ecfr.gov/current/title-49/subtitle-B/chapter-III/subchapter-B/part-397

US Department of Labour. (2024, November). *Law and Regulations*. Retrieved from https://www.osha.gov/laws-regs

US Department of Labour. (2024, November). *State Plans*. Retrieved from https://www.osha.gov/stateplans