# Environmental Product Declaration (EPD)

According to ISO 14025 and ISO 21930:2017

# JOINT COMPOUND

## Drywall Finishing Council (DWFC)

**About Drywall Finishing Council**

Drywall Finishing Council (DWFC) represents companies who manufacture drywall finishing materials, such as interior paints and joint compounds. The DWFC was founded in 1992 as a small group of manufacturers of drywall finishing materials. Founding members were united by concerns over a lack of industry standards related to both specification and application procedures and a shared commitment to address those issues.

Participating Companies:

- Canadian Gypsum Company
- CertainTeed Gypsum
- Freeman Products, Inc.
- Hamilton Drywall Products
- Magnum Products
- National Gypsum Company
- Panel Rey SA
- Southern Wall Products
- United States Gypsum Company
- Westpac Materials

**Sustainable Production**.

The joint compound industry has made significant strides in adopting sustainable practices. Companies are increasingly focusing on environmentally friendly formulations, utilizing recycled materials, and implementing energy-efficient manufacturing processes. These initiatives aim to reduce the environmental impact of production while meeting the growing demand for sustainable construction materials. As the industry continues to evolve, a commitment to sustainability remains integral to its long-term success.

DRYWALL FINISHING COUNCIL

**Issue Date:** 05-10-2024

**Valid Until:** 05-10-2029

**Declaration Number:** ASTM-EPD642



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According to ISO 14025 and ISO 21930:2017

# DECLARATION INFORMATION

| Declaration | |
|---|---|
| **Program Operator:** ASTM International<br>**Company:** Drywall Finishing Council Inc.<br>c/o Walsworth, LLP<br>19900 MacArthur Blvd., Suite 1150<br>Irvine, CA 92612 | **www.astm.org** |

| Product Information | Validity / Applicability |
|---|---|
| **Product Name:** Joint Compound | **Period of Validity:** This declaration is valid for a period of 5 years from the date of publication. |
| **Product Definition:** Joint compound, as defined by ASTM C474 and C475 | |
| **Declaration Type:** Business-to-business (B2B) | **Geographic Scope:** North America |
| **PCR Reference:**<br>• ISO 21930 (ISO, 2017)<br>• PCR for Building-Related Products and Services – Part A: LCA Calculation Rules and Report Requirements, UL 10010, UL v.4.0. (UL Environment, 2022)<br>• PCR Guidance for Building-Related Products and Services—Part B: Joint Compound (NA). (UL Environment, 2016) | **PCR Review was conducted by:**<br>• James Mellentine, Ramboll Environ<br>• Philip S. Moser, P.E., Simpson Gumpertz & Heger<br>• Robert A. Wessel, Ph.D., Gypsum Association |

**Product Application and/or Characteristics**

Joint compounds are used to conceal and prevent cracking of joints between wallboard panels in interior construction and to prepare the wallboard surface for painting. They are also used to conceal fastener heads and other imperfections in the wallboard surface and to repair minor cracking and damage to interior walls.

| Technical Drawing or Product Visual | Content of the Declaration |
|---|---|
|  | • Product definition and physical building-related data<br>• Details of raw materials and material origin<br>• Description of how the product is manufactured<br>• Life Cycle Assessment results<br>• Additional environmental information |

**Verification**

| | |
|---|---|
| Independent verification of the declaration and data, according to ISO 21930:2017 and ISO 14025:2006 by:<br>Tim Brooke, ASTM International | ☐ internal ☒external |

This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:
Lindita Bushi, PhD., Athena Sustainable Materials Institute

*Limitations*
*The environmental impact results of steel products in this document are based on a functional unit and therefore do not provide sufficient information to establish comparisons. The results shall not be used for comparisons without knowledge of how the physical properties of the steel product impact the precise function at the construction level. The environmental impact results shall be converted to a functional unit basis before any comparison is attempted. See Section 3.10 For additional EPD comparability guidelines. Environmental declarations from different programs (ISO 14025) may not be comparable.*

# EPD SUMMARY

This document is a Type III environmental product declaration by the Drywall Finishing Council (DWFC) that is certified by ASTM International (ASTM) as conforming to the requirements of ISO 21930 and ISO 14025. ASTM has assessed that the Life Cycle Assessment (LCA) information fulfills the requirements of ISO 14040 in accordance with the instructions listed in the referenced product category rules. This EPD is intended for business-to-business (B2B) and business-to-consumer (B2C) communication and to further the development of environmentally compatible and sustainable construction methods by providing comprehensive environmental information related to potential impacts in accordance with international standards.

No comparison or benchmarking is included in this EPD. Environmental declarations from different programs based upon differing PCRs may not be comparable. When comparing EPDs created using this PCR, variations and deviations are possible. Example of variations: Different LCA software and background LCI datasets may lead to different results for upstream or downstream of the life cycle stages declared.

No carbon dioxide certificates are used in this EPD.

*Table 1: Summary of life cycle impact assessment results for the different joint compound products*

| Products | Functional Unit (kg/100 $m^2$) | GWP100 (kg $CO_2$ eq.) | AP (kg SO2 eq.) | EP (kg N eq.) | ODP (kg CFC 11 eq.) | SFP (kg O3 eq.) | $ADP_f$ (MJ) |
|---|---|---|---|---|---|---|---|
| Ready-mix, conventional, 3.5-gal carton | 91.2 | 1.51E+01 | 5.48E-02 | 1.22E-02 | 7.00E-12 | 9.74E-01 | 2.23E+02 |
| Ready-mix, conventional, 4.5-gal carton | 91.2 | 2.21E+01 | 7.77E-02 | 1.61E-02 | 1.60E-12 | 1.23E+00 | 3.47E+02 |
| Ready-mix, conventional, 3.5-gal pail | 91.2 | 2.29E+01 | 6.24E-02 | 1.04E-02 | 3.65E-12 | 1.22E+00 | 4.95E+02 |
| Ready-mix, conventional, 4.5-gal pail | 91.2 | 2.08E+01 | 5.92E-02 | 1.24E-02 | 3.14E-12 | 1.17E+00 | 4.68E+02 |
| Ready-mix, lightweight, 3.5-gal carton | 58.7 | 1.24E+01 | 4.28E-02 | 8.38E-03 | 1.03E-09 | 7.12E-01 | 1.90E+02 |
| Ready-mix, lightweight, 4.5-gal carton | 58.7 | 1.62E+01 | 5.13E-02 | 1.03E-02 | 5.50E-09 | 8.33E-01 | 2.77E+02 |
| Ready-mix, lightweight, 3.5-gal pail | 58.7 | 2.08E+01 | 5.42E-02 | 7.75E-03 | 2.64E-12 | 1.10E+00 | 4.28E+02 |
| Ready-mix, lightweight, 4.5-gal pail | 58.7 | 1.86E+01 | 4.57E-02 | 8.44E-03 | 5.02E-09 | 9.27E-01 | 4.08E+02 |
| Dry powder, conventional, bags | 32.6* | 2.60E+01 | 5.95E-02 | 7.88E-03 | 9.46E-10 | 1.24E+00 | 1.87E+02 |
| Dry powder, lightweight, bags | 41.8** | 1.48E+01 | 3.61E-02 | 5.26E-03 | 9.93E-11 | 7.54E-01 | 1.39E+02 |

*72.3 including water during installation
**54.0 including water during installation

## SCOPE AND BOUNDARIES OF THE LIFE CYCLE ASSESSMENT

The Life Cycle Assessment (LCA) was performed according to ISO 14040 (ISO, 2020a) and ISO 14044 (ISO, 2020b) following the requirements of the ASTM EPD Program Instructions and the referenced PCR. This LCA study followed an attributional approach.

**System Boundary:** Cradle-to-grave

**Allocation Method:** No allocation on foreground system

**Functional Unit:** The functional unit is defined as "100 m2 of covered substrate considering an installation scenario as defined by a GA-214 Level 4 finish with the quantity adjusted for the measured shrinkage (testing per ASTM C474) for a service life of 75 years." The following equation is used to calculate the functional unit (note that the formula calculates per 1000 ft2 but the functional unit is 100 m2, all values are presented per functional unit):

$$\textit{Functional Unit (gal/msf)} = \textit{10.1 gal/msf} \div [(1 - \textit{shrinkage rate}) \times (1 - \textit{installation waste})]$$

The functional unit for each joint compound product has been provided in Table 1.

According to ISO 14025 and ISO 21930:2017

# GENERAL INFORMATION

## DESCRIPTION OF COMPANY/ORGANIZATION

**Drywall Finishing Council Inc.**
c/o Walsworth, LLP
19900 MacArthur Blvd., Suite 1150
Irvine, CA 92612

Drywall Finishing Council Inc. is an organization dedicated to improving the quality and standards of the drywall finishing industry, speaking with a unified public voice on behalf of its members, and providing a forum in which to address the issues and concerns of finishing materials manufacturers.

## PRODUCT DESCRIPTION

Joint compound is used along with joint tape to join sheets of drywall by creating a seamless finish. Joint compound is comprised of a blend of minerals. Ready mixed compound is a pre-made form of joint compound that may be used for immediate application without any additional preparation, whereas dry powder compound requires the addition of water prior to installation. All joint compounds are available in lightweight (<12 lb/gal) and conventional weight (>12 lb/gal) options.

**Product Specification**

The different joint compound products covered in this EPD include the following:

- Conventional dry powder, packaged in bags
- Lightweight dry powder, packaged in bags
- Conventional ready-mix, packaged in 3.5-gal cartons
- Conventional ready-mix, packaged in 4.5-gal cartons
- Conventional ready-mix, packaged in 3.5-gal pails
- Conventional ready-mix, packaged in 4.5-gal pails
- Lightweight ready-mix, packaged in 3.5-gal cartons
- Lightweight ready-mix, packaged in 4.5-gal cartons
- Lightweight ready-mix, packaged in 3.5-gal pails
- Lightweight ready-mix, packaged in 4.5-gal pails

Joint compound products are defined by the standards ASTM C474 and C475. Other standards that are applicable for the joint comound (declared in this EPD) are C840 and D3273

**Flow Diagram:**

Figure 1 provides a flow diagram for joint compound. The different modules covered in this EPD include A1(raw materials), A2(transport), A3 (manufacturing), A4 (distribution), A5 (installation), B1-B7 (use phase), C1-C4 (end-of-life phase. Environmental impacts associated with the use of the product are assumed to be zero. Therefore, B1-B7 is zero.

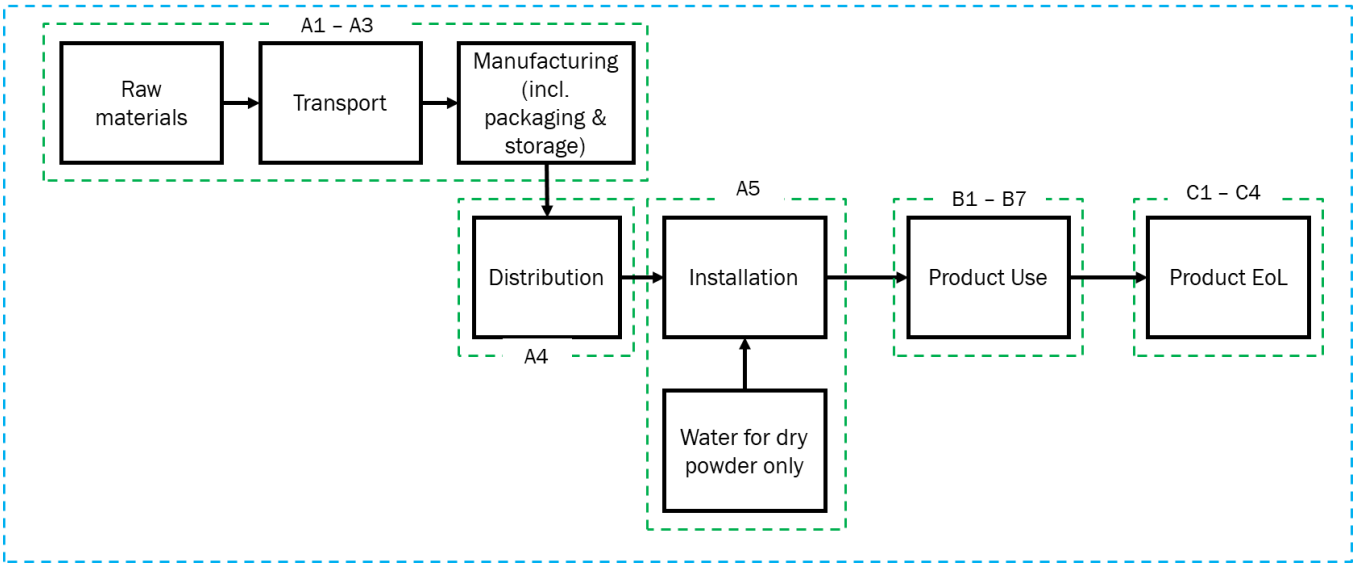


*Figure 1. Product flow diagram*

## PRODUCT AVERAGE

The production data used in this EPD covers of production of joint compound during the 2022 calendar year. The production data is an average of a total of 15 production facilities, manufacturing one or more of the different varieties of joint compound, covered in this EPD. The production facilities belonged to the following member companies of the DWFC:

- Canadian Gypsum Company
- CertainTeed Gypsum
- Freeman Products, Inc.
- Hamilton Drywall Products
- Magnum Products
- National Gypsum Company
- Panel Rey SA
- Southern Wall Products
- United States Gypsum Company
- Westpac Materials

## Application

Joint compound is used to finish gypsum panel joints filled with paper or fiber joint tape, corner bead, trim and fasteners, and to skim coat. It is also convenient for patching holes, bumps, tears, and other minor damage to existing walls.

## Technical Requirements

Technical data for the studied product can be found in Table 2 below.

*Table 2: Technical parameters for the different joint compound products*

| Parameter | Unit | Ready-mix, lightweight | Ready-mix, conventional | Dry powder, lightweight | Dry powder, conventional |
|---|---|---|---|---|---|
| **Functional unit** | kg/100m$^2$ | 58.7 | 91.2 | 54.0 (32.6 excl. water) | 72.3 (41.8 excl. water) |
| **Volume** | L (gal) | 50.6 (13.4) | 55.6 (14.7) | 42.9 (11.2) | 42.5 (11.2) |
| **Average Density (wet, calculated per ASTM C474)** | kg/L (lb/gal)* | 1.16 (9.68) | 1.64 (13.7) | 1.26 (10.6) | 1.70 (14.2) |
| **Average Shrinkage rate (calculated per ASTM C474)** | % | 15.9 | 23.5 | n/a | n/a |
| **Edge and Check Crack Resistance (ASTM C474)** | - | Meets requirements | | | |
| **Microbial resistance (putrefaction) (ASTM C474)** | Days | At minimum, no putrefaction in less than four days | | | |
| *Conversion factor : 8.345 lbs/gallon to kg/liter | | | | | |

## Material Composition

The production of joint compound exclusively uses virgin materials. The average formulation is detailed in Table 3

*Table 3: Base and ancillary materials in joint compound*

| Material | Mass Percentage (%) | | | |
|---|---|---|---|---|
| | **Ready-mix, conventional** | **Ready-mix, lightweight** | **Dry powder, conventional** | **Dry powder, lightweight** |
| **Accelerator** | - | - | 0.38 | 0.33 |
| **Additives** | 0.03 | 0.07 | 0.00 | 0.00 |
| **Anticide** | - | - | 0.00 | - |
| **Biocide** | 0.15 | 0.18 | 0.01 | 0.04 |
| **Bentonite** | - | - | 0.00 | - |
| **Cellulose** | 0.37 | 0.42 | 0.16 | 0.35 |



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| | | | | |
|---|---|---|---|---|
| **Clay** | 1.75 | 1.86 | 1.51 | 2.15 |
| **Defoamer** | - | - | 0.03 | 0.04 |
| **Dispersant** | - | - | - | 0.01 |
| **Glycol** | 0.01 | 0.07 | - | - |
| **Gypsum** | - | - | 20.39 | 22.61 |
| **Guar** | 0.00 | 0.00 | - | - |
| **Humectant** | 0.00 | 0.00 | - | - |
| **Kaolin** | 0.01 | 0.65 | 0.03 | - |
| **Limestone** | 59.19 | 43.00 | 25.17 | 31.34 |
| **Latex** | 1.08 | 1.14 | 0.01 | 0.05 |
| **Mica** | 1.06 | 0.70 | 1.09 | - |
| **Plaster** | - | - | 0.05 | 6.46 |
| **Perlite** | 0.93 | 5.20 | 0.33 | 6.18 |
| **PVA** | 0.61 | 0.84 | 0.10 | 1.06 |
| **Pyrophyllite** | 2.41 | 1.36 | 0.19 | 2.80 |
| **Resin** | - | 0.61 | 0.24 | - |
| **Retarder** | - | - | 0.03 | 0.19 |
| **Surfactant** | 0.00 | 0.00 | - | - |
| **Starch** | 0.24 | 0.12 | 0.92 | 0.79 |
| **Stucco** | - | - | 49.27 | 25.59 |
| **Talc** | 0.01 | 0.02 | 0.00 | - |
| **Thickeners** | - | 0.03 | 0.07 | - |
| **TiO2** | - | - | 0.01 | - |
| **Water** | 32.16 | 43.74 | - | - |

## MANUFACTURING

Raw materials, including limestone, perlite, plasticizers, and other modifiers are unloaded and temporarily stored. When needed for production, materials are retrieved from storage, placed into specific batches based on

formulation in a dry receiver or hopper, and dry-mixed. In the case of ready mixed formulations, liquid ingredients are added to a wet mixer and mixed with dry products and homogenized until a smooth paste is formed. Following the wet mix cycle the material is checked for quality control and, if necessary, the batch is adjusted to meet finished product specifications. The wet mix is then discharged from mixer to the package filling station, packaged, palletized, and stored. Ready mixed products are packaged either in lined cardboard containers or plastic pails, whereas dry powder products are packaged in paper bags. After being subjected to quality assurance inspections, the packaged product is placed into warehouse storage, and finally shipped to the customer warehouse or job site. A process flow diagram for joint compound is shown in Figure 2.

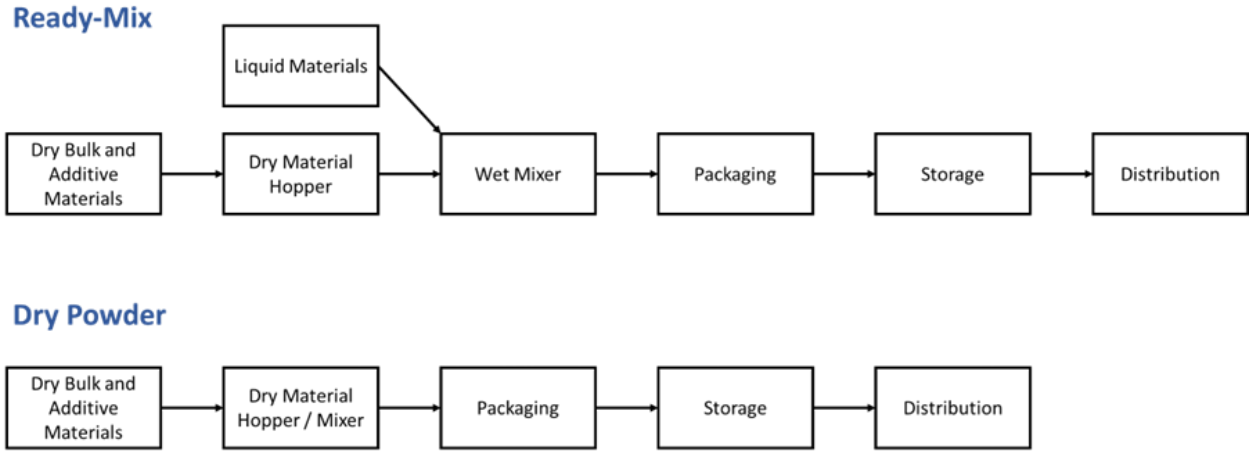


*Figure 2: Joint compound manufacturing process flow diagram*

## TRANSPORTATION

Transportation of products to and within the 15 manufacturing facilities is included in the scope of this EPD. Transportation in downstream life cycle stages is also included in the scope of this EPD. The jobsite distance is assumed to be 60 km whereas the outbound distance from the facility is assumed as 250 km. The transportation of raw materials to the facility was provided by each manufacturing site.

## PRODUCT INSTALLATION

The functional unit specifies the joint compound be applied to a GA-214 Level 4 finish. A Level 4 finish is defined as: "All joints and interior angles shall have tape embedded in joint compound and shall be immediately wiped with a joint knife leaving a thin coating of joint compound over all joints and interior angles. Two (2) separate coats of joint compound shall be applied over all flat joints and one (1) separate coat of joint compound shall be applied over interior angles. Fastener heads and accessories shall be covered with three (3) separate coats of joint compound. The surface shall be smooth and free of tool marks and ridges." (Gypsum Association, 2015).

The installation stage (module A5) includes transportation to the site, production of materials required for joint

compound installation, waste processing, production, transportation and disposal of lost products (3%) and disposal of packaging materials. Average outbound distances of products leaving facilities were provided by DWFC member companies. It was assumed the destination of these shipments are distributions centers, followed by additional 60 km of transportation to the desired job site. Participating companies also provided data for the amount of water to be added to dry powder joint compound prior to installation. During installation, approximately 3% of the joint compound material is lost as waste which is accounted for within the LCA model. Though some of this waste could be recycled, it is modeled as being disposed of in a landfill. All packaging is similarly disposed of in a landfill.

### Use

The building reference service life (RSL) is taken to be the PCR default of 75 years. Joint compound is both expected to last as long as the building itself; therefore, the product will also have an RSL of 75 years. Once installed, joint compound does not have any maintenance requirements, nor does it require any water or electricity for operation, eliminating any use phase impacts. Impacts associated with modules B1-B7 are zero.

All gypsum board surfaces shall be sound, and remain dry. All construction debris, sanding dust or other surface contaminants shall be removed prior to application of interior finishing materials. The interior space shall be maintained at a minimum temperature of 50°F (10°C) for at least 48 hours prior to the application of interior finishing materials. The interior space shall be environmentally controlled at a minimum temperature of 50°F (10°C) during and after the application(s) of interior finishing materials, and ideally, jobsite controlled under occupancy environmental conditions throughout the finishing process until occupancy" (DWFC, 2011).

### Packaging

The finished joint compounds are typically packaged in plastic pails, plastic-lined cardboard boxes, or paper bags, and are then palletized and shipped to the customer. It is assumed 60% of the wooden pallets get reused while the remainder go to landfill.

### Reuse, Recycling, and Energy Recovery

Joint compound is removed from the building at end-of-life and is assumed to not be reused or recycled at this point.

### Disposal

Once the joint compound is removed from the building at end-of-life, the waste is assumed to be transported 20 miles to a landfill. Cured joint compound is inert and not considered as hazardous waste; therefore no adverse environmental or human health impacts are anticipated from the disposal of joint compound, nor does the Resource Conservation and Recovery Act apply.

## Methodological Framework

## FUNCTIONAL UNIT

The functional unit is defined as "100 m2 of covered substrate considering an installation scenario as defined by a GA-214 Level 4 finish with the quantity adjusted for the measured shrinkage (testing per ASTM C474) for a service life of 75 years." The following equation is used to calculate the functional unit (note that the formula calculates per 1000 ft2 but the functional unit is 100 m2, all values are presented per functional unit):

*Functional Unit (gal/msf) = 10.1 gal/msf ÷ [(1 - shrinkage rate) x (1 – installation waste)]*

## SYSTEM BOUNDARY

This cradle-to-grave analysis provides information on the Product Stage (A1-A3), Construction Stage (A4-A5), Use Stage (B1-B7) and End-of-Life Stage (C1-C4) of the joint compound product life cycle.

| PRODUCT STAGE | | | CONSTRUCT-ION PROCESS STAGE | | USE STAGE | | | | | | | END OF LIFE STAGE | | | | BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| **A1** | **A2** | **A3** | **A4** | **A5** | **B1** | **B2** | **B3** | **B4** | **B5** | **B6** | **B7** | **C1** | **C2** | **C3** | **C4** | **D** |
| X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | MND |

## CUT-OFF RULES

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

- ✓ Mass – 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.
- ✓ Energy – 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.
- ✓ 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.

## DATA SOURCES

The LCA model was created using the LCA for Experts (LCAFE, previously GaBi) 10 software system for life cycle engineering, developed by Sphera Solutions, Inc. The Managed LCA Content (MLC) (CUP 2023.2) LCI database

provides the life cycle inventory data for several of the raw and process materials obtained from the background system. Primary manufacturing data were provided by DWFC.

## 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 included 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.

Data included first-hand industry data as well and data from literature review in combination with consistent background life cycle inventory information from the MLC 2023.2 databases. The data are representative of member companies' joint compound production data for the year 2022.

## Geographical Coverage

Joint compound products, covered in this EPD, are manufactured in 15 production facilities, across North America (Canada, Mexico and the United States of America)

## Period under Review

Primary data collected from DWFC represent production data during the 2022 calendar year. Background datasets for upstream data were obtained from the MLC 2023.2 database and are representative of the years 2022 – 2025.

## Allocation

Where manufacturing inputs, such as electricity use, were not sub-metered, they were allocated by mass to the respective products produced at each facility. No other co-product allocation occurs in the product foreground system.

Allocation of background data (energy and materials) taken from the MLC 2023.2 database is documented online at http://www.gabi-software.com/america/support/gabi/ .

## Estimates and Assumptions

Sphera worked with different joint compound manufacturers (totaling 15 production sites) that are members of DWFC. Each manufacturer identified one or more manufacturing sites to be representative of its manufacturing inputs and outputs. Manufacturers also reported total joint compound production at each of their production facilities. 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, energy consumption, and waste data for additional locations may alter the results of this study.

When possible, energy consumption data on joint compound production were collected via sub-metering. However, when not feasible, energy consumption was allocated to the joint compound productions by mass.
Material inbound transport distances, product outbound distances, packaging details, and installation details, are

calculated based on estimations from participating DWFC companies.

# LIFE CYCLE ASSESSMENT RESULTS

North American life cycle impact assessment (LCIA) results are declared using TRACI 2.1 methodology, with the exception of GWP which uses the IPCC AR6 methodology. To comply with IS0 21930, GWP results based on IPCC AR5 methodology are also presented in this EPD. Note that the interpretation of this LCA study regarding GWP results are based on IPCC AR6. LCIA results are relative expressions and do not predict actual impacts, the exceding of thresholds, safety margins or risks. GWP excludes biogenic carbon as there are no relevant biogenic carbon removals or emissions in the life cycle. There is no calcination, carbonation and combustion of waste from non-renewable sources. These six impact categories 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 EPD users shall not use additional measures for comparative purposes.

The LCA results, resource use and waste flows are presented in Table 5 to Table 14. Note that no substances required to be reported as hazardous are associated with the production of this product.

The relevant result parameters have been described in Table 4. The statistical metrics for the LCIA results for all the joint compound products have been tabulated in Table 15 to Table 18.

*Table 4: Description of life cycle impact assessment categories, resource use indicators, waste flows & outputs and carbon emission & removals.*

| Abbreviation | Parameter | Unit | LCIA Method |
|---|---|---|---|
| **Life Cycle Impact Assessment** | | | |
| **GWP 100 AR6** | Global warming potential (IPCC AR6) | [kg $CO_2$-Eq.] | IPCC AR6 |
| **GWP 100 AR5** | Global warming potential (IPCC AR5) | [kg $CO_2$-Eq.] | IPCC AR5 |
| **AP** | Acidification potential of land and water | [kg $SO_2$-Eq.] | TRACI 2.1 |
| **EP** | Eutrophication potential | [kg N-Eq.] | TRACI 2.1 |
| **ODP** | Depletion potential of the stratospheric ozone layer | [kg CFC11-Eq.] | TRACI 2.1 |
| **SFP** | Formation potential of tropospheric ozone photochemical oxidants | [kg $O_3$ -Eq.] | TRACI 2.1 |
| **$ADP_{fossil}$** | Abiotic depletion potential for fossil resources | [MJ][1] | TRACI 2.1 |
| **Resource Use Indicators** | | | |
| **$RPR_E$** | Renewable primary resources used as energy carrier | [MJ LHVs] | Sphera MLC |
| **$RPR_M$** | Renewable primary resources with energy content used as material | [MJ LHVs] | Sphera MLC |
| **$NRPR_E$** | Non-renewable primary resources used as energy carrier | [MJ LHVs] | Sphera MLC |

[1] Surplus energy per extracted MJ, kg or $m^3$ fossil fuel, as a result of lower quality resources

| | | | |
|---|---|---|---|
| **$NRPR_M$** | Non-renewable primary resources with energy content used as material | [MJ LHVs] | Sphera MLC |
| **SM** | Secondary materials | [kg] | Sphera MLC |
| **RSF** | Renewable secondary fuels | [MJ LHVs] | Sphera MLC |
| **NRSF** | Non-renewable secondary fuels | [MJ LHVs] | Sphera MLC |
| **RE** | Recovered energy | [MJ LHVs] | Sphera MLC |
| **FW** | Use of fresh water | [m3] | Sphera MLC |
| **Waste & Output Flows** | | | |
| **HWD** | Hazardous waste disposed | [kg] | Sphera MLC |
| **NHWD** | Non-hazardous waste disposed | [kg] | Sphera MLC |
| **HLRW** | High-level radioactive waste disposed | [kg] | Sphera MLC |
| **ILLRW** | Intermediate- and low-level radioactive waste disposed | [kg] | Sphera MLC |
| **CRU** | Components for reuse | [kg] | Sphera MLC |
| **MFR** | Components for recycling | [kg] | Sphera MLC |
| **MER** | Components for energy recovery | [kg] | Sphera MLC |
| **EE** | Exported energy | [MJ] | Sphera MLC |
| **Carbon Emissions & Removals** | | | |
| **BCRP** | Biogenic carbon removal from product | [kg] | Sphera MLC |
| **BCEP** | Biogenic carbon emission from product | [kg] | Sphera MLC |
| **BCRK** | Biogenic carbon removal from packaging | [kg] | Sphera MLC |
| **BCEK** | Biogenic carbon emission from packaging | [kg] | Sphera MLC |

*Table 5: Life cycle results for Ready-mix, conventional, 3.5-gal carton*

| Indicator | Unit | A1-A3 | A4 | A5 | C2 | C4 |
|---|---|---|---|---|---|---|
| **Life Cycle Impact Assessment** | | | | | | |
| **GWP 100 AR6** | **kg $CO_2$ eq.** | 1.01E+01 | 9.80E-01 | 2.05E+00 | 5.94E-01 | 1.35E+00 |
| **GWP 100 AR5** | **kg $CO_2$ eq.** | 1.03E+01 | 9.88E-01 | 2.37E+00 | 5.99E-01 | 1.37E+00 |
| **AP** | **kg $SO_2$ eq.** | 3.36E-02 | 3.18E-03 | 7.72E-03 | 1.93E-03 | 8.36E-03 |
| **EP** | **kg N eq.** | 8.59E-03 | 3.14E-04 | 2.74E-03 | 1.90E-04 | 3.69E-04 |
| **ODP** | **kg CFC 11 eq.** | 6.71E-12 | 2.53E-15 | 2.19E-13 | 1.53E-15 | 7.34E-14 |
| **SFP** | **kg $O_3$ eq.** | 6.20E-01 | 7.36E-02 | 7.68E-02 | 4.46E-02 | 1.59E-01 |
| **$ADP_{fossil}$** | **MJ, surplus energy** | 1.70E+02 | 1.37E+01 | 1.33E+01 | 8.29E+00 | 1.77E+01 |
| **Life Cycle Indicators** | | | | | | |
| **$RPR_E$** | **MJ, LHV** | 5.92E+01 | 5.49E-01 | 2.38E+00 | 3.33E-01 | 2.97E+00 |
| **$RPR_M$** | **MJ, LHV** | 4.58E+01 | 0.00E+00 | 1.42E+00 | 0.00E+00 | 0.00E+00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **$NRPR_E$** | **MJ, LHV** | 1.46E+02 | 1.38E+01 | 1.26E+01 | 8.35E+00 | 1.83E+01 |
| **$NRPR_M$** | **MJ, LHV** | 3.71E+01 | 0.00E+00 | 1.15E+00 | 0.00E+00 | 0.00E+00 |
| **SM** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **RSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **NRSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **RE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **FW** | **$m^3$** | 2.22E-01 | 1.88E-03 | 7.84E-03 | 1.14E-03 | 4.61E-03 |
| **Waste & Output Flows** | | | | | | |
| **HWD** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NHWD** | **kg** | 0.00E+00 | 0.00E+00 | 1.94E+00 | 0.00E+00 | 9.12E+01 |
| **HLRW** | **kg** | 4.69E-06 | 4.69E-08 | 1.21E-07 | 2.84E-08 | 2.12E-07 |
| **ILLRW** | **kg** | 4.73E-03 | 3.95E-05 | 1.30E-04 | 2.39E-05 | 2.08E-04 |
| **CRU** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MFR** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MER** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **EE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **Carbon Emissions and Removals** | | | | | | |
| **BCRP** | **kg** | 9.65E-01 | 0.00E+00 | 2.99E-02 | 0.00E+00 | 0.00E+00 |
| **BCEP** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **BCRK** | **kg** | 2.81E+00 | 0.00E+00 | 8.69E-02 | 0.00E+00 | 0.00E+00 |
| **BCEK** | **kg** | 0.00E+00 | 0.00E+00 | 5.75E+00 | 0.00E+00 | 0.00E+00 |

*Table 6: Life cycle results for Ready-mix, conventional, 4.5-gal carton*

| Indicator | Unit | A1-A3 | A4 | A5 | C2 | C4 |
|---|---|---|---|---|---|---|
| **Life Cycle Impact Assessment** | | | | | | |
| **GWP 100 AR6** | **kg $CO_2$ eq.** | 1.47E+01 | 1.01E+00 | 4.50E+00 | 5.94E-01 | 1.35E+00 |
| **GWP 100 AR5** | **kg $CO_2$ eq.** | 1.50E+01 | 1.02E+00 | 5.25E+00 | 5.99E-01 | 1.37E+00 |
| **AP** | **kg $SO_2$ eq.** | 4.72E-02 | 3.27E-03 | 1.70E-02 | 1.93E-03 | 8.36E-03 |
| **EP** | **kg N eq.** | 9.14E-03 | 3.23E-04 | 6.09E-03 | 1.90E-04 | 3.69E-04 |
| **ODP** | **kg CFC 11 eq.** | 1.45E-12 | 2.60E-15 | 7.11E-14 | 1.53E-15 | 7.34E-14 |
| **SFP** | **kg $O_3$ eq.** | 7.90E-01 | 7.56E-02 | 1.57E-01 | 4.46E-02 | 1.59E-01 |
| **$ADP_{fossil}$** | **MJ, surplus energy** | 2.80E+02 | 1.41E+01 | 2.71E+01 | 8.29E+00 | 1.77E+01 |
| **Life Cycle Indicators** | | | | | | |
| **$RPR_E$** | **MJ, LHV** | 5.10E+01 | 5.65E-01 | 2.85E+00 | 3.33E-01 | 2.97E+00 |
| **$RPR_M$** | **MJ, LHV** | 7.19E+01 | 0.00E+00 | 2.22E+00 | 0.00E+00 | 0.00E+00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **$NRPR_E$** | **MJ, LHV** | 2.04E+02 | 1.42E+01 | 2.47E+01 | 8.35E+00 | 1.83E+01 |
| **$NRPR_M$** | **MJ, LHV** | 8.89E+01 | 0.00E+00 | 2.75E+00 | 0.00E+00 | 0.00E+00 |
| **SM** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **RSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **NRSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **RE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **FW** | **$m^3$** | 1.51E-01 | 1.94E-03 | 6.92E-03 | 1.14E-03 | 4.61E-03 |
| **Waste & Output Flows** | | | | | | |
| **HWD** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NHWD** | **kg** | 0.00E+00 | 0.00E+00 | 4.52E+00 | 0.00E+00 | 9.12E+01 |
| **HLRW** | **kg** | 5.70E-06 | 4.82E-08 | 1.18E-07 | 2.84E-08 | 2.12E-07 |
| **ILLRW** | **kg** | 4.83E-03 | 4.06E-05 | 1.09E-04 | 2.39E-05 | 2.08E-04 |
| **CRU** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MFR** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MER** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **EE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **Carbon Emissions and Removals** | | | | | | |
| **BCRP** | **kg** | 8.80E-01 | 0.00E+00 | 2.72E-02 | 0.00E+00 | 0.00E+00 |
| **BCEP** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **BCRK** | **kg** | 5.01E+00 | 0.00E+00 | 1.55E-01 | 0.00E+00 | 0.00E+00 |
| **BCEK** | **kg** | 0.00E+00 | 0.00E+00 | 1.35E+01 | 0.00E+00 | 0.00E+00 |

*Table 7: Life cycle results for Ready-mix, conventional, 3.5-gal pail*

| Indicator | Unit | A1-A3 | A4 | A5 | C2 | C4 |
|---|---|---|---|---|---|---|
| **Life Cycle Impact Assessment** | | | | | | |
| **GWP 100 AR6** | **kg $CO_2$ eq.** | 1.57E+01 | 1.00E+00 | 4.19E+00 | 5.94E-01 | 1.35E+00 |
| **GWP 100 AR5** | **kg $CO_2$ eq.** | 1.61E+01 | 1.01E+00 | 4.89E+00 | 5.99E-01 | 1.37E+00 |
| **AP** | **kg $SO_2$ eq.** | 3.35E-02 | 3.26E-03 | 1.53E-02 | 1.93E-03 | 8.36E-03 |
| **EP** | **kg N eq.** | 4.12E-03 | 3.22E-04 | 5.45E-03 | 1.90E-04 | 3.69E-04 |
| **ODP** | **kg CFC 11 eq.** | 3.45E-12 | 2.59E-15 | 1.31E-13 | 1.53E-15 | 7.34E-14 |
| **SFP** | **kg $O_3$ eq.** | 7.93E-01 | 7.53E-02 | 1.46E-01 | 4.46E-02 | 1.59E-01 |
| **$ADP_{fossil}$** | **MJ, surplus energy** | 4.25E+02 | 1.40E+01 | 3.01E+01 | 8.29E+00 | 1.77E+01 |
| **Life Cycle Indicators** | | | | | | |
| **$RPR_E$** | **MJ, LHV** | 4.18E+01 | 5.62E-01 | 2.46E+00 | 3.33E-01 | 2.97E+00 |
| **$RPR_M$** | **MJ, LHV** | 7.84E+00 | 0.00E+00 | 2.42E-01 | 0.00E+00 | 0.00E+00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **$NRPR_E$** | **MJ, LHV** | 2.55E+02 | 1.41E+01 | 2.47E+01 | 8.35E+00 | 1.83E+01 |
| **$NRPR_M$** | **MJ, LHV** | 1.90E+02 | 0.00E+00 | 5.86E+00 | 0.00E+00 | 0.00E+00 |
| **SM** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **RSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **NRSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **RE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **FW** | **$m^3$** | 1.72E-01 | 1.93E-03 | 7.37E-03 | 1.14E-03 | 4.61E-03 |
| **Waste & Output Flows** | | | | | | |
| **HWD** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NHWD** | **kg** | 0.00E+00 | 0.00E+00 | 4.15E+00 | 0.00E+00 | 9.12E+01 |
| **HLRW** | **kg** | 6.73E-06 | 4.80E-08 | 1.55E-07 | 2.84E-08 | 2.12E-07 |
| **ILLRW** | **kg** | 7.05E-03 | 4.04E-05 | 1.81E-04 | 2.39E-05 | 2.08E-04 |
| **CRU** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MFR** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MER** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **EE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **Carbon Emissions and Removals** | | | | | | |
| **BCRP** | **kg** | 6.27E-01 | 0.00E+00 | 1.94E-02 | 0.00E+00 | 0.00E+00 |
| **BCEP** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **BCRK** | **kg** | 3.34E-02 | 0.00E+00 | 1.03E-03 | 0.00E+00 | 0.00E+00 |
| **BCEK** | **kg** | 0.00E+00 | 0.00E+00 | 1.24E+01 | 0.00E+00 | 0.00E+00 |

*Table 8: Life cycle results for Ready-mix, conventional, 4.5-gal pail*

| Indicator | Unit | A1-A3 | A4 | A5 | C2 | C4 |
|---|---|---|---|---|---|---|
| **Life Cycle Impact Assessment** | | | | | | |
| **GWP 100 AR6** | **kg $CO_2$ eq.** | 1.37E+01 | 1.00E+00 | 4.21E+00 | 5.94E-01 | 1.35E+00 |
| **GWP 100 AR5** | **kg $CO_2$ eq.** | 1.41E+01 | 1.01E+00 | 4.92E+00 | 5.99E-01 | 1.37E+00 |
| **AP** | **kg $SO_2$ eq.** | 3.02E-02 | 3.26E-03 | 1.55E-02 | 1.93E-03 | 8.36E-03 |
| **EP** | **kg N eq.** | 5.86E-03 | 3.22E-04 | 5.62E-03 | 1.90E-04 | 3.69E-04 |
| **ODP** | **kg CFC 11 eq.** | 2.95E-12 | 2.59E-15 | 1.16E-13 | 1.53E-15 | 7.34E-14 |
| **SFP** | **kg $O_3$ eq.** | 7.40E-01 | 7.54E-02 | 1.47E-01 | 4.46E-02 | 1.59E-01 |
| **$ADP_{fossil}$** | **MJ, surplus energy** | 3.98E+02 | 1.40E+01 | 2.96E+01 | 8.29E+00 | 1.77E+01 |
| **Life Cycle Indicators** | | | | | | |
| **$RPR_E$** | **MJ, LHV** | 4.37E+01 | 5.63E-01 | 2.55E+00 | 3.33E-01 | 2.97E+00 |
| **$RPR_M$** | **MJ, LHV** | 1.19E+01 | 0.00E+00 | 3.67E-01 | 0.00E+00 | 0.00E+00 |
| **$NRPR_E$** | **MJ, LHV** | 2.24E+02 | 1.41E+01 | 2.41E+01 | 8.35E+00 | 1.83E+01 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **$NRPR_M$** | **MJ, LHV** | 1.92E+02 | 0.00E+00 | 5.94E+00 | 0.00E+00 | 0.00E+00 |
| **SM** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **RSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **NRSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **RE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **FW** | **$m^3$** | 2.30E-01 | 1.93E-03 | 9.21E-03 | 1.14E-03 | 4.61E-03 |
| **Waste & Output Flows** | | | | | | |
| **HWD** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NHWD** | **kg** | 0.00E+00 | 0.00E+00 | 4.23E+00 | 0.00E+00 | 9.12E+01 |
| **HLRW** | **kg** | 5.83E-06 | 4.81E-08 | 1.26E-07 | 2.84E-08 | 2.12E-07 |
| **ILLRW** | **kg** | 6.28E-03 | 4.05E-05 | 1.57E-04 | 2.39E-05 | 2.08E-04 |
| **CRU** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MFR** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MER** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **EE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **Carbon Emissions and Removals** | | | | | | |
| **BCRP** | **kg** | 9.67E-01 | 0.00E+00 | 2.99E-02 | 0.00E+00 | 0.00E+00 |
| **BCEP** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **BCRK** | **kg** | 2.86E-02 | 0.00E+00 | 8.86E-04 | 0.00E+00 | 0.00E+00 |
| **BCEK** | **kg** | 0.00E+00 | 0.00E+00 | 1.26E+01 | 0.00E+00 | 0.00E+00 |

*Table 9: Life cycle results for Ready-mix, lightweight, 3.5-gal carton*

| Indicator | Unit | A1-A3 | A4 | A5 | C2 | C4 |
|---|---|---|---|---|---|---|
| **Life Cycle Impact Assessment** | | | | | | |
| **GWP 100 AR6** | **kg $CO_2$ eq.** | 8.60E+00 | 6.37E-01 | 1.93E+00 | 3.82E-01 | 8.72E-01 |
| **GWP 100 AR5** | **kg $CO_2$ eq.** | 8.76E+00 | 6.42E-01 | 2.24E+00 | 3.85E-01 | 8.80E-01 |
| **AP** | **kg $SO_2$ eq.** | 2.69E-02 | 2.07E-03 | 7.24E-03 | 1.24E-03 | 5.38E-03 |
| **EP** | **kg N eq.** | 5.27E-03 | 2.04E-04 | 2.55E-03 | 1.22E-04 | 2.38E-04 |
| **ODP** | **kg CFC 11 eq.** | 1.00E-09 | 1.64E-15 | 3.10E-11 | 9.86E-16 | 4.72E-14 |
| **SFP** | **kg $O_3$ eq.** | 4.64E-01 | 4.78E-02 | 6.93E-02 | 2.87E-02 | 1.02E-01 |
| **$ADP_{fossil}$** | **MJ, surplus energy** | 1.52E+02 | 8.89E+00 | 1.24E+01 | 5.33E+00 | 1.14E+01 |
| **Life Cycle Indicators** | | | | | | |
| **$RPR_E$** | **MJ, LHV** | 3.91E+01 | 3.57E-01 | 1.74E+00 | 2.14E-01 | 1.91E+00 |
| **$RPR_M$** | **MJ, LHV** | 3.78E+01 | 0.00E+00 | 1.17E+00 | 0.00E+00 | 0.00E+00 |
| **$NRPR_E$** | **MJ, LHV** | 1.28E+02 | 8.96E+00 | 1.16E+01 | 5.38E+00 | 1.18E+01 |
| **$NRPR_M$** | **MJ, LHV** | 3.43E+01 | 0.00E+00 | 1.06E+00 | 0.00E+00 | 0.00E+00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **SM** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **RSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **NRSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **RE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **FW** | **$m^3$** | 1.28E-01 | 1.22E-03 | 4.90E-03 | 7.34E-04 | 2.97E-03 |
| **Waste & Output Flows** | | | | | | |
| **HWD** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NHWD** | **kg** | 1.44E-05 | 0.00E+00 | 1.87E+00 | 0.00E+00 | 5.87E+01 |
| **HLRW** | **kg** | 3.62E-06 | 3.05E-08 | 8.84E-08 | 1.83E-08 | 1.37E-07 |
| **ILLRW** | **kg** | 3.82E-03 | 2.57E-05 | 1.02E-04 | 1.54E-05 | 1.34E-04 |
| **CRU** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MFR** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MER** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **EE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **Carbon Emissions and Removals** | | | | | | |
| **BCRP** | **kg** | 5.39E-01 | 0.00E+00 | 1.67E-02 | 0.00E+00 | 0.00E+00 |
| **BCEP** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **BCRK** | **kg** | 2.57E+00 | 0.00E+00 | 7.94E-02 | 0.00E+00 | 0.00E+00 |
| **BCEK** | **kg** | 0.00E+00 | 0.00E+00 | 5.55E+00 | 0.00E+00 | 0.00E+00 |

*Table 10: Life cycle results for Ready-mix, lightweight, 4.5-gal carton*

| Indicator | Unit | A1-A3 | A4 | A5 | C2 | C4 |
|---|---|---|---|---|---|---|
| **Life Cycle Impact Assessment** | | | | | | |
| **GWP 100 AR6** | **kg $CO_2$ eq.** | 1.14E+01 | 6.46E-01 | 2.87E+00 | 3.81E-01 | 8.70E-01 |
| **GWP 100 AR5** | **kg $CO_2$ eq.** | 1.17E+01 | 6.51E-01 | 3.35E+00 | 3.84E-01 | 8.77E-01 |
| **AP** | **kg $SO_2$ eq.** | 3.20E-02 | 2.10E-03 | 1.07E-02 | 1.24E-03 | 5.37E-03 |
| **EP** | **kg N eq.** | 5.98E-03 | 2.07E-04 | 3.80E-03 | 1.22E-04 | 2.37E-04 |
| **ODP** | **kg CFC 11 eq.** | 5.33E-09 | 1.67E-15 | 1.65E-10 | 9.84E-16 | 4.71E-14 |
| **SFP** | **kg $O_3$ eq.** | 5.54E-01 | 4.85E-02 | 9.97E-02 | 2.86E-02 | 1.02E-01 |
| **$ADP_{fossil}$** | **MJ, surplus energy** | 2.33E+02 | 9.01E+00 | 1.87E+01 | 5.32E+00 | 1.13E+01 |
| **Life Cycle Indicators** | | | | | | |
| **$RPR_E$** | **MJ, LHV** | 4.00E+01 | 3.62E-01 | 2.03E+00 | 2.14E-01 | 1.91E+00 |
| **$RPR_M$** | **MJ, LHV** | 4.97E+01 | 0.00E+00 | 1.54E+00 | 0.00E+00 | 0.00E+00 |
| **$NRPR_E$** | **MJ, LHV** | 1.73E+02 | 9.08E+00 | 1.68E+01 | 5.36E+00 | 1.17E+01 |
| **$NRPR_M$** | **MJ, LHV** | 7.31E+01 | 0.00E+00 | 2.26E+00 | 0.00E+00 | 0.00E+00 |
| **SM** | **kg** | 0.00E+00 | -- | -- | -- | -- |

| | | | | | | |
|---|---|---|---|---|---|---|
| **RSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **NRSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **RE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **FW** | **$m^3$** | 1.24E-01 | 1.24E-03 | 5.24E-03 | 7.33E-04 | 2.96E-03 |
| **Waste & Output Flows** | | | | | | |
| **HWD** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NHWD** | **kg** | 0.00E+00 | 0.00E+00 | 2.83E+00 | 0.00E+00 | 5.86E+01 |
| **HLRW** | **kg** | 5.46E-06 | 3.09E-08 | 1.32E-07 | 1.82E-08 | 1.36E-07 |
| **ILLRW** | **kg** | 4.83E-03 | 2.60E-05 | 1.24E-04 | 1.54E-05 | 1.34E-04 |
| **CRU** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MFR** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MER** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **EE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **Carbon Emissions and Removals** | | | | | | |
| **BCRP** | **kg** | 5.48E-01 | 0.00E+00 | 1.70E-02 | 0.00E+00 | 0.00E+00 |
| **BCEP** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **BCRK** | **kg** | 3.52E+00 | 0.00E+00 | 1.09E-01 | 0.00E+00 | 0.00E+00 |
| **BCEK** | **kg** | 0.00E+00 | 0.00E+00 | 8.42E+00 | 0.00E+00 | 0.00E+00 |

*Table 11: Life cycle results for Ready-mix, lightweight, 3.5-gal pail*

| Indicator | Unit | A1-A3 | A4 | A5 | C2 | C4 |
|---|---|---|---|---|---|---|
| **Life Cycle Impact Assessment** | | | | | | |
| **GWP 100 AR6** | **kg $CO_2$ eq.** | 1.55E+01 | 6.51E-01 | 3.33E+00 | 3.82E-01 | 8.72E-01 |
| **GWP 100 AR5** | **kg $CO_2$ eq.** | 1.59E+01 | 6.56E-01 | 3.86E+00 | 3.85E-01 | 8.80E-01 |
| **AP** | **kg $SO_2$ eq.** | 3.35E-02 | 2.11E-03 | 1.20E-02 | 1.24E-03 | 5.38E-03 |
| **EP** | **kg N eq.** | 3.00E-03 | 2.09E-04 | 4.18E-03 | 1.22E-04 | 2.38E-04 |
| **ODP** | **kg CFC 11 eq.** | 2.49E-12 | 1.68E-15 | 9.56E-14 | 9.86E-16 | 4.72E-14 |
| **SFP** | **kg $O_3$ eq.** | 8.02E-01 | 4.89E-02 | 1.18E-01 | 2.87E-02 | 1.02E-01 |
| **$ADP_{fossil}$** | **MJ, surplus energy** | 3.77E+02 | 9.09E+00 | 2.46E+01 | 5.33E+00 | 1.14E+01 |
| **Life Cycle Indicators** | | | | | | |
| **$RPR_E$** | **MJ, LHV** | 2.86E+01 | 3.65E-01 | 1.78E+00 | 2.14E-01 | 1.91E+00 |
| **$RPR_M$** | **MJ, LHV** | 4.73E+00 | 0.00E+00 | 1.46E-01 | 0.00E+00 | 0.00E+00 |
| **$NRPR_E$** | **MJ, LHV** | 2.43E+02 | 9.16E+00 | 2.04E+01 | 5.38E+00 | 1.18E+01 |
| **$NRPR_M$** | **MJ, LHV** | 1.46E+02 | 0.00E+00 | 4.50E+00 | 0.00E+00 | 0.00E+00 |
| **SM** | **kg** | 0.00E+00 | -- | -- | -- | -- |

| | | | | | | |
|---|---|---|---|---|---|---|
| **RSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **NRSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **RE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **FW** | **$m^3$** | 1.19E-01 | 1.25E-03 | 5.26E-03 | 7.34E-04 | 2.97E-03 |
| **Waste & Output Flows** | | | | | | |
| **HWD** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NHWD** | **kg** | 0.00E+00 | 0.00E+00 | 3.19E+00 | 0.00E+00 | 5.87E+01 |
| **HLRW** | **kg** | 4.03E-06 | 3.12E-08 | 8.34E-08 | 1.83E-08 | 1.37E-07 |
| **ILLRW** | **kg** | 3.98E-03 | 2.62E-05 | 9.48E-05 | 1.54E-05 | 1.34E-04 |
| **CRU** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MFR** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MER** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **EE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **Carbon Emissions and Removals** | | | | | | |
| **BCRP** | **kg** | 3.73E-01 | 0.00E+00 | 1.15E-02 | 0.00E+00 | 0.00E+00 |
| **BCEP** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **BCRK** | **kg** | 2.53E-02 | 0.00E+00 | 7.84E-04 | 0.00E+00 | 0.00E+00 |
| **BCEK** | **kg** | 0.00E+00 | 0.00E+00 | 9.51E+00 | 0.00E+00 | 0.00E+00 |

*Table 12: Life cycle results for Ready-mix, lightweight, 4.5-gal pail*

| Indicator | Unit | A1-A3 | A4 | A5 | C2 | C4 |
|---|---|---|---|---|---|---|
| **Life Cycle Impact Assessment** | | | | | | |
| **GWP 100 AR6** | **kg $CO_2$ eq.** | 1.36E+01 | 6.47E-01 | 3.06E+00 | 3.81E-01 | 8.70E-01 |
| **GWP 100 AR5** | **kg $CO_2$ eq.** | 1.40E+01 | 6.52E-01 | 3.56E+00 | 3.84E-01 | 8.77E-01 |
| **AP** | **kg $SO_2$ eq.** | 2.61E-02 | 2.10E-03 | 1.10E-02 | 1.24E-03 | 5.37E-03 |
| **EP** | **kg N eq.** | 3.96E-03 | 2.07E-04 | 3.91E-03 | 1.22E-04 | 2.37E-04 |
| **ODP** | **kg CFC 11 eq.** | 4.87E-09 | 1.67E-15 | 1.51E-10 | 9.84E-16 | 4.71E-14 |
| **SFP** | **kg $O_3$ eq.** | 6.42E-01 | 4.86E-02 | 1.06E-01 | 2.86E-02 | 1.02E-01 |
| **$ADP_{fossil}$** | **MJ, surplus energy** | 3.59E+02 | 9.03E+00 | 2.31E+01 | 5.32E+00 | 1.13E+01 |
| **Life Cycle Indicators** | | | | | | |
| **$RPR_E$** | **MJ, LHV** | 2.78E+01 | 3.63E-01 | 1.69E+00 | 2.14E-01 | 1.91E+00 |
| **$RPR_M$** | **MJ, LHV** | 6.27E+00 | 0.00E+00 | 1.94E-01 | 0.00E+00 | 0.00E+00 |
| **$NRPR_E$** | **MJ, LHV** | 2.20E+02 | 9.10E+00 | 1.88E+01 | 5.36E+00 | 1.17E+01 |
| **$NRPR_M$** | **MJ, LHV** | 1.52E+02 | 0.00E+00 | 4.69E+00 | 0.00E+00 | 0.00E+00 |
| **SM** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **RSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |

| | | | | | | |
|---|---|---|---|---|---|---|
| **NRSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **RE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **FW** | **$m^3$** | 1.45E-01 | 1.24E-03 | 5.93E-03 | 7.33E-04 | 2.96E-03 |
| **Waste & Output Flows** | | | | | | |
| **HWD** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NHWD** | **kg** | 4.06E-05 | 0.00E+00 | 2.96E+00 | 0.00E+00 | 5.86E+01 |
| **HLRW** | **kg** | 4.39E-06 | 3.10E-08 | 9.75E-08 | 1.82E-08 | 1.36E-07 |
| **ILLRW** | **kg** | 4.35E-03 | 2.61E-05 | 1.09E-04 | 1.54E-05 | 1.34E-04 |
| **CRU** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MFR** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MER** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **EE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **Carbon Emissions and Removals** | | | | | | |
| **BCRP** | **kg** | 5.17E-01 | 0.00E+00 | 1.60E-02 | 0.00E+00 | 0.00E+00 |
| **BCEP** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **BCRK** | **kg** | 7.83E-03 | 0.00E+00 | 2.42E-04 | 0.00E+00 | 0.00E+00 |
| **BCEK** | **kg** | 0.00E+00 | 0.00E+00 | 8.82E+00 | 0.00E+00 | 0.00E+00 |

*Table 13: Life cycle results for Dry powder, conventional, bags*

| Indicator | Unit | A1-A3 | A4 | A5 | C2 | C4 |
|---|---|---|---|---|---|---|
| **Life Cycle Impact Assessment** | | | | | | |
| **GWP 100 AR6** | **kg $CO_2$ eq.** | 2.33E+01 | 4.41E-01 | 7.94E-01 | 4.71E-01 | 1.07E+00 |
| **GWP 100 AR5** | **kg $CO_2$ eq.** | 2.35E+01 | 4.45E-01 | 8.05E-01 | 4.75E-01 | 1.08E+00 |
| **AP** | **kg $SO_2$ eq.** | 4.82E-02 | 1.43E-03 | 1.69E-03 | 1.53E-03 | 6.63E-03 |
| **EP** | **kg N eq.** | 7.02E-03 | 1.41E-04 | 2.83E-04 | 1.51E-04 | 2.93E-04 |
| **ODP** | **kg CFC 11 eq.** | 9.17E-10 | 1.14E-15 | 2.84E-11 | 1.22E-15 | 5.82E-14 |
| **SFP** | **kg $O_3$ eq.** | 1.01E+00 | 3.31E-02 | 3.42E-02 | 3.53E-02 | 1.26E-01 |
| **$ADP_{fossil}$** | **MJ, surplus energy** | 1.55E+02 | 6.15E+00 | 5.60E+00 | 6.57E+00 | 1.40E+01 |
| **Resource Use Indicators** | | | | | | |
| **$RPR_E$** | **MJ, LHV** | 3.20E+01 | 2.47E-01 | 1.11E+00 | 2.64E-01 | 2.36E+00 |
| **$RPR_M$** | **MJ, LHV** | 8.86E+00 | 0.00E+00 | 2.74E-01 | 0.00E+00 | 0.00E+00 |
| **$NRPR_E$** | **MJ, LHV** | 1.61E+02 | 6.20E+00 | 5.91E+00 | 6.62E+00 | 1.45E+01 |
| **$NRPR_M$** | **MJ, LHV** | 4.59E+00 | 0.00E+00 | 1.42E-01 | 0.00E+00 | 0.00E+00 |
| **SM** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **RSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **NRSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |

| | | | | | | |
|---|---|---|---|---|---|---|
| **RE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **FW** | **$m^3$** | 1.44E-01 | 8.48E-04 | 3.51E-02 | 9.05E-04 | 3.66E-03 |
| **Waste & Output Flows** | | | | | | |
| **HWD** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NHWD** | **kg** | 2.81E-06 | 0.00E+00 | 5.53E-02 | 0.00E+00 | 7.23E+01 |
| **HLRW** | **kg** | 4.15E-06 | 2.11E-08 | 1.80E-07 | 2.25E-08 | 1.68E-07 |
| **ILLRW** | **kg** | 3.84E-03 | 1.78E-05 | 1.62E-04 | 1.90E-05 | 1.65E-04 |
| **CRU** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MFR** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MER** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **EE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **Carbon Emissions and Removals** | | | | | | |
| **BCRP** | **kg** | 7.07E-01 | 0.00E+00 | 2.19E-02 | 0.00E+00 | 0.00E+00 |
| **BCEP** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **BCRK** | **kg** | 3.38E-02 | 0.00E+00 | 1.04E-03 | 0.00E+00 | 0.00E+00 |
| **BCEK** | **kg** | 0.00E+00 | 0.00E+00 | 7.62E-02 | 0.00E+00 | 0.00E+00 |

*Table 14: Life cycle results for Dry powder, lightweight, bags*

| Indicator | Unit | A1-A3 | A4 | A5 | C2 | C4 |
|---|---|---|---|---|---|---|
| **Life Cycle Impact Assessment** | | | | | | |
| **GWP 100 AR6** | **kg $CO_2$ eq.** | 1.28E+01 | 3.44E-01 | 4.67E-01 | 3.52E-01 | 8.02E-01 |
| **GWP 100 AR5** | **kg $CO_2$ eq.** | 1.29E+01 | 3.47E-01 | 4.78E-01 | 3.54E-01 | 8.09E-01 |
| **AP** | **kg $SO_2$ eq.** | 2.78E-02 | 1.12E-03 | 1.08E-03 | 1.14E-03 | 4.95E-03 |
| **EP** | **kg N eq.** | 4.60E-03 | 1.10E-04 | 2.15E-04 | 1.13E-04 | 2.19E-04 |
| **ODP** | **kg CFC 11 eq.** | 9.63E-11 | 8.87E-16 | 2.98E-12 | 9.07E-16 | 4.34E-14 |
| **SFP** | **kg $O_3$ eq.** | 5.87E-01 | 2.58E-02 | 2.08E-02 | 2.64E-02 | 9.40E-02 |
| **$ADP_{fossil}$** | **MJ, surplus energy** | 1.14E+02 | 4.80E+00 | 4.21E+00 | 4.90E+00 | 1.05E+01 |
| **Life Cycle Indicators** | | | | | | |
| **$RPR_E$** | **MJ, LHV** | 2.86E+01 | 1.93E-01 | 9.77E-01 | 1.97E-01 | 1.76E+00 |
| **$RPR_M$** | **MJ, LHV** | 7.65E+00 | 0.00E+00 | 2.37E-01 | 0.00E+00 | 0.00E+00 |
| **$NRPR_E$** | **MJ, LHV** | 1.15E+02 | 4.84E+00 | 4.30E+00 | 4.94E+00 | 1.08E+01 |
| **$NRPR_M$** | **MJ, LHV** | 7.86E+00 | 0.00E+00 | 2.43E-01 | 0.00E+00 | 0.00E+00 |
| **SM** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **RSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **NRSF** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **RE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |

| | | | | | | |
|---|---|---|---|---|---|---|
| **FW** | **$m^3$** | 1.04E-01 | 6.61E-04 | 2.48E-02 | 6.75E-04 | 2.73E-03 |
| **Waste & Output Flows** | | | | | | |
| **HWD** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **NHWD** | **kg** | 0.00E+00 | 0.00E+00 | 6.84E-02 | 0.00E+00 | 5.40E+01 |
| **HLRW** | **kg** | 3.25E-06 | 1.65E-08 | 1.36E-07 | 1.68E-08 | 1.26E-07 |
| **ILLRW** | **kg** | 2.84E-03 | 1.38E-05 | 1.18E-04 | 1.42E-05 | 1.23E-04 |
| **CRU** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MFR** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **MER** | **kg** | 0.00E+00 | -- | -- | -- | -- |
| **EE** | **MJ, LHV** | 0.00E+00 | -- | -- | -- | -- |
| **Carbon Emissions and Removals** | | | | | | |
| **BCRP** | **kg** | 5.81E-01 | 0.00E+00 | 1.80E-02 | 0.00E+00 | 0.00E+00 |
| **BCEP** | **kg** | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| **BCRK** | **kg** | 5.82E-02 | 0.00E+00 | 1.80E-03 | 0.00E+00 | 0.00E+00 |
| **BCEK** | **kg** | 0.00E+00 | 0.00E+00 | 1.15E-01 | 0.00E+00 | 0.00E+00 |

*Table 15: Statistical metrics of LCIA results for conventional ready-mix powder*

| **Ready-mix, conventional, 3.5-gal carton** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Impact categories** | **Unit** | **Min (A1-A3)** | **Max (A1-A3)** | **Max/Min Ration (A1-A3)** | **Mean (A1-A3)** | **Median (A1-A3)** | **Standard Deviation (A1-A3)** |
| **GWP 100 AR6** | [kg $CO_2$ - Eq.] | 5.02E+00 | 1.66E+01 | 3.31E+00 | 1.10E+01 | 1.02E+01 | 4.04E+00 |
| **AP** | [kg $SO_2$-Eq.] | 1.20E-02 | 7.01E-02 | 5.85E+00 | 3.62E-02 | 3.60E-02 | 1.50E-02 |
| **EP** | [kg N-Eq.] | 4.07E-03 | 1.15E-02 | 2.82E+00 | 7.04E-03 | 7.08E-03 | 2.21E-03 |
| **ODP** | [kg CFC 11 - Eq.] | 7.37E-13 | 7.45E-12 | 1.01E+01 | 4.18E-12 | 4.28E-12 | 2.13E-12 |
| **SFP** | [kg $O_3$-Eq.] | 2.29E-01 | 1.68E+00 | 7.35E+00 | 7.32E-01 | 7.29E-01 | 3.87E-01 |
| **$ADP_{fossil}$** | [MJ] | 9.91E+01 | 2.91E+02 | 2.94E+00 | 1.84E+02 | 1.73E+02 | 6.23E+01 |
| **Ready-mix, conventional, 4.5-gal carton** | | | | | | | |
| **Impact categories** | **Unit** | **Min (A1-A3)** | **Max (A1-A3)** | **Max/Min Ration (A1-A3)** | **Mean (A1-A3)** | **Median (A1-A3)** | **Standard Deviation (A1-A3)** |
| **GWP 100 AR6** | [kg $CO_2$ - Eq.] | 1.27E+01 | 5.37E+01 | 4.22E+00 | 2.36E+01 | 1.41E+01 | 2.34E+01 |
| **AP** | [kg $SO_2$-Eq.] | 4.17E-02 | 1.46E-01 | 3.50E+00 | 6.95E-02 | 4.51E-02 | 5.99E-02 |
| **EP** | [kg N-Eq.] | 9.14E-03 | 1.44E-02 | 1.57E+00 | 1.15E-02 | 1.12E-02 | 2.77E-03 |
| **ODP** | [kg CFC 11 - Eq.] | 1.33E-12 | 1.50E-12 | 1.13E+00 | 1.43E-12 | 1.45E-12 | 8.62E-14 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SFP** | [kg $O_3$-Eq.] | 6.47E-01 | 3.45E+00 | 5.33E+00 | 1.39E+00 | 7.32E-01 | 1.61E+00 |
| **$ADP_{fossil}$** | [MJ] | 2.60E+02 | 8.28E+02 | 3.18E+00 | 4.10E+02 | 2.76E+02 | 3.25E+02 |
| **Ready-mix, conventional, 3.5-gal pail** | | | | | | | |
| **Impact categories** | **Unit** | **Min (A1-A3)** | **Max (A1-A3)** | **Max/Min Ration (A1-A3)** | **Mean (A1-A3)** | **Median (A1-A3)** | **Standard Deviation (A1-A3)** |
| **GWP 100 AR6** | [kg $CO_2$ - Eq.] | 1.53E+01 | 1.90E+01 | 1.24E+00 | 1.67E+01 | 1.57E+01 | 2.57E+00 |
| **AP** | [kg $SO_2$-Eq.] | 3.17E-02 | 4.21E-02 | 1.33E+00 | 3.58E-02 | 3.35E-02 | 7.32E-03 |
| **EP** | [kg N-Eq.] | 3.66E-03 | 5.12E-03 | 1.40E+00 | 4.30E-03 | 4.12E-03 | 1.03E-03 |
| **ODP** | [kg CFC 11 - Eq.] | 3.45E-12 | 3.98E-12 | 1.16E+00 | 3.67E-12 | 3.57E-12 | 2.88E-13 |
| **SFP** | [kg $O_3$-Eq.] | 7.59E-01 | 9.90E-01 | 1.30E+00 | 8.47E-01 | 7.93E-01 | 1.63E-01 |
| **$ADP_{fossil}$** | [MJ] | 4.25E+02 | 5.03E+02 | 1.18E+00 | 4.52E+02 | 4.27E+02 | 5.37E+01 |
| **Ready-mix, conventional, 4.5-gal pail** | | | | | | | |
| **Impact categories** | **Unit** | **Min (A1-A3)** | **Max (A1-A3)** | **Max/Min Ration (A1-A3)** | **Mean (A1-A3)** | **Median (A1-A3)** | **Standard Deviation (A1-A3)** |
| **GWP 100 AR6** | [kg $CO_2$ - Eq.] | 5.02E+00 | 5.65E+01 | 1.13E+01 | 1.79E+01 | 1.50E+01 | 1.31E+01 |
| **AP** | [kg $SO_2$-Eq.] | 1.20E-02 | 1.48E-01 | 1.24E+01 | 4.31E-02 | 3.07E-02 | 3.65E-02 |
| **EP** | [kg N-Eq.] | 1.81E-03 | 1.27E-02 | 7.03E+00 | 5.87E-03 | 5.54E-03 | 3.13E-03 |
| **ODP** | [kg CFC 11 - Eq.] | 6.50E-13 | 5.40E-12 | 8.30E+00 | 2.36E-12 | 2.94E-12 | 1.52E-12 |
| **SFP** | [kg $O_3$-Eq.] | 2.29E-01 | 3.58E+00 | 1.56E+01 | 1.05E+00 | 7.40E-01 | 9.00E-01 |
| **$ADP_{fossil}$** | [MJ] | 1.04E+02 | 9.54E+02 | 9.16E+00 | 4.15E+02 | 4.08E+02 | 2.14E+02 |

*Table 16: Statistical metrics of LCIA results for lightweight ready-mix powder*

| **Ready-mix, lightweight, 3.5-gal carton** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Impact categories** | **Unit** | **Min (A1-A3)** | **Max (A1-A3)** | **Max/Min Ration (A1-A3)** | **Mean (A1-A3)** | **Median (A1-A3)** | **Standard Deviation (A1-A3)** |
| **GWP 100 AR6** | [kg $CO_2$ - Eq.] | 4.15E+00 | 1.51E+01 | 3.63E+00 | 1.01E+01 | 8.94E+00 | 3.44E+00 |
| **AP** | [kg $SO_2$-Eq.] | 1.13E-02 | 3.80E-02 | 3.38E+00 | 2.87E-02 | 2.94E-02 | 7.62E-03 |
| **EP** | [kg N-Eq.] | 1.36E-03 | 8.52E-03 | 6.26E+00 | 5.43E-03 | 5.33E-03 | 2.02E-03 |
| **ODP** | [kg CFC 11 - Eq.] | 7.04E-13 | 8.97E-09 | 1.27E+04 | 1.85E-09 | 3.55E-12 | 3.56E-09 |
| **SFP** | [kg $O_3$-Eq.] | 2.11E-01 | 7.73E-01 | 3.67E+00 | 5.32E-01 | 5.72E-01 | 1.65E-01 |
| **$ADP_{fossil}$** | [MJ] | 8.18E+01 | 3.37E+02 | 4.12E+00 | 1.86E+02 | 1.52E+02 | 8.27E+01 |

| Ready-mix, lightweight, 4.5-gal carton | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Impact categories** | **Unit** | **Min (A1-A3)** | **Max (A1-A3)** | **Max/Min Ration (A1-A3)** | **Mean (A1-A3)** | **Median (A1-A3)** | **Standard Deviation (A1-A3)** |
| **GWP 100 AR6** | [kg $CO_2$ - Eq.] | 8.78E+00 | 1.41E+01 | 1.60E+00 | 1.12E+01 | 1.12E+01 | 2.15E+00 |
| **AP** | [kg $SO_2$-Eq.] | 2.86E-02 | 3.51E-02 | 1.23E+00 | 3.21E-02 | 3.27E-02 | 2.82E-03 |
| **EP** | [kg N-Eq.] | 4.93E-03 | 7.69E-03 | 1.56E+00 | 5.86E-03 | 5.65E-03 | 1.12E-03 |
| **ODP** | [kg CFC 11 - Eq.] | 2.16E-12 | 8.97E-09 | 4.16E+03 | 3.80E-09 | 2.67E-09 | 4.78E-09 |
| **SFP** | [kg $O_3$-Eq.] | 5.39E-01 | 6.73E-01 | 1.25E+00 | 5.84E-01 | 5.71E-01 | 5.55E-02 |
| **$ADP_{fossil}$** | [MJ] | 1.48E+02 | 3.11E+02 | 2.09E+00 | 2.19E+02 | 2.05E+02 | 7.70E+01 |
| **Ready-mix, lightweight, 3.5-gal pail** | | | | | | | |
| **Impact categories** | **Unit** | **Min (A1-A3)** | **Max (A1-A3)** | **Max/Min Ration (A1-A3)** | **Mean (A1-A3)** | **Median (A1-A3)** | **Standard Deviation (A1-A3)** |
| **GWP 100 AR6** | [kg $CO_2$ - Eq.] | 1.29E+01 | 3.03E+01 | 2.36E+00 | 1.82E+01 | 1.49E+01 | 9.71E+00 |
| **AP** | [kg $SO_2$-Eq.] | 2.39E-02 | 8.48E-02 | 3.55E+00 | 4.28E-02 | 3.12E-02 | 3.38E-02 |
| **EP** | [kg N-Eq.] | 2.02E-03 | 7.15E-03 | 3.54E+00 | 3.97E-03 | 3.35E-03 | 2.62E-03 |
| **ODP** | [kg CFC 11 - Eq.] | 7.76E-13 | 3.27E-12 | 4.22E+00 | 2.36E-12 | 2.69E-12 | 1.34E-12 |
| **SFP** | [kg $O_3$-Eq.] | 5.89E-01 | 2.11E+00 | 3.58E+00 | 1.05E+00 | 7.48E-01 | 8.49E-01 |
| **$ADP_{fossil}$** | [MJ] | 3.61E+02 | 4.81E+02 | 1.33E+00 | 4.04E+02 | 3.87E+02 | 6.12E+01 |
| **Ready-mix, lightweight, 4.5-gal pail** | | | | | | | |
| **Impact categories** | **Unit** | **Min (A1-A3)** | **Max (A1-A3)** | **Max/Min Ration (A1-A3)** | **Mean (A1-A3)** | **Median (A1-A3)** | **Standard Deviation (A1-A3)** |
| **GWP 100 AR6** | [kg $CO_2$ - Eq.] | 1.95E+00 | 1.89E+01 | 9.67E+00 | 1.13E+01 | 1.35E+01 | 6.22E+00 |
| **AP** | [kg $SO_2$-Eq.] | 5.29E-03 | 4.23E-02 | 8.00E+00 | 2.32E-02 | 2.59E-02 | 1.36E-02 |
| **EP** | [kg N-Eq.] | 6.39E-04 | 5.50E-03 | 8.60E+00 | 2.78E-03 | 2.72E-03 | 1.80E-03 |
| **ODP** | [kg CFC 11 - Eq.] | 3.31E-13 | 8.97E-09 | 2.71E+04 | 2.41E-09 | 2.45E-12 | 3.59E-09 |
| **SFP** | [kg $O_3$-Eq.] | 9.89E-02 | 9.83E-01 | 9.94E+00 | 5.65E-01 | 6.42E-01 | 3.28E-01 |
| **$ADP_{fossil}$** | [MJ] | 3.84E+01 | 4.66E+02 | 1.21E+01 | 2.87E+02 | 3.10E+02 | 1.56E+02 |

*Table 17: Statistical metrics of LCIA results for conventional dry powder*

| Conventional dry powder | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Impact categories** | **Unit** | **Min (A1-A3)** | **Max (A1-A3)** | **Max/Min Ration (A1-A3)** | **Mean (A1-A3)** | **Median (A1-A3)** | **Standard Deviation (A1-A3)** |
| **GWP 100 AR6** | [kg $CO_2$ - Eq.] | 3.25E+00 | 4.50E+01 | 1.38E+01 | 1.91E+01 | 1.67E+01 | 1.46E+01 |
| **AP** | [kg $SO_2$-Eq.] | 9.61E-03 | 1.32E-01 | 1.37E+01 | 4.55E-02 | 3.80E-02 | 3.85E-02 |
| **EP** | [kg N-Eq.] | 8.75E-04 | 7.29E-02 | 8.33E+01 | 1.09E-02 | 5.08E-03 | 2.07E-02 |
| **ODP** | [kg CFC 11 - Eq.] | 3.37E-13 | 4.54E-09 | 1.35E+04 | 5.95E-10 | 1.44E-10 | 1.33E-09 |
| **SFP** | [kg $O_3$-Eq.] | 1.62E-01 | 3.08E+00 | 1.89E+01 | 9.97E-01 | 8.46E-01 | 8.93E-01 |
| **$ADP_{fossil}$** | [MJ] | 4.80E+01 | 7.70E+02 | 1.60E+01 | 1.93E+02 | 1.40E+02 | 2.09E+02 |

*Table 18: Statistical metrics of LCIA results for lightweight dry powder*

| Lightweight dry powder | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Impact categories** | **Unit** | **Min (A1-A3)** | **Max (A1-A3)** | **Max/Min Ration (A1-A3)** | **Mean (A1-A3)** | **Median (A1-A3)** | **Standard Deviation (A1-A3)** |
| **GWP 100 AR6** | [kg $CO_2$ - Eq.] | 3.72E+00 | 3.04E+01 | 8.17E+00 | 1.95E+01 | 2.25E+01 | 8.86E+00 |
| **AP** | [kg $SO_2$-Eq.] | 8.17E-03 | 6.66E-02 | 8.15E+00 | 4.29E-02 | 4.92E-02 | 1.93E-02 |
| **EP** | [kg N-Eq.] | 2.17E-03 | 1.11E-02 | 5.10E+00 | 6.02E-03 | 6.40E-03 | 2.78E-03 |
| **ODP** | [kg CFC 11 - Eq.] | 4.32E-12 | 1.71E-10 | 3.97E+01 | 7.40E-11 | 6.48E-11 | 5.88E-11 |
| **SFP** | [kg $O_3$-Eq.] | 1.48E-01 | 1.48E+00 | 1.00E+01 | 9.34E-01 | 1.06E+00 | 4.27E-01 |
| **$ADP_{fossil}$** | [MJ] | 6.08E+01 | 3.07E+02 | 5.06E+00 | 1.70E+02 | 1.74E+02 | 7.03E+01 |

# LCA INTERPRETATION

Figure 3 to Figure 12 below show the relative impacts of the declared modules for all the joint compound products. Note that the GWP results shown in the figure is based on IPCC AR6 methodology. The majority of burdens for all impact categories fall within modules A1-A3, due to the impacts associated with raw material supply and manufacturing, with the exception of EP for some of the products. Installation (A5) is the primary contributor for the EP in ready-mix products, when packaged in pails. However, when packaged in cartons, the primary contributor for EP is again A1-A3.

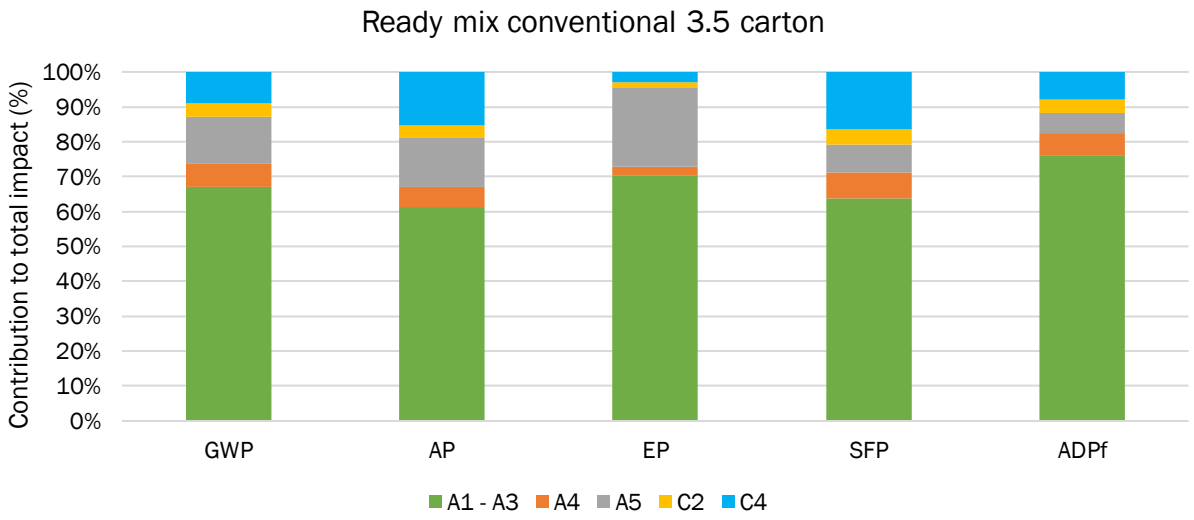


*Figure 3: Breakdown of life cycle impact assessment results for ready mix, conventional, 3.5-gal cartons*

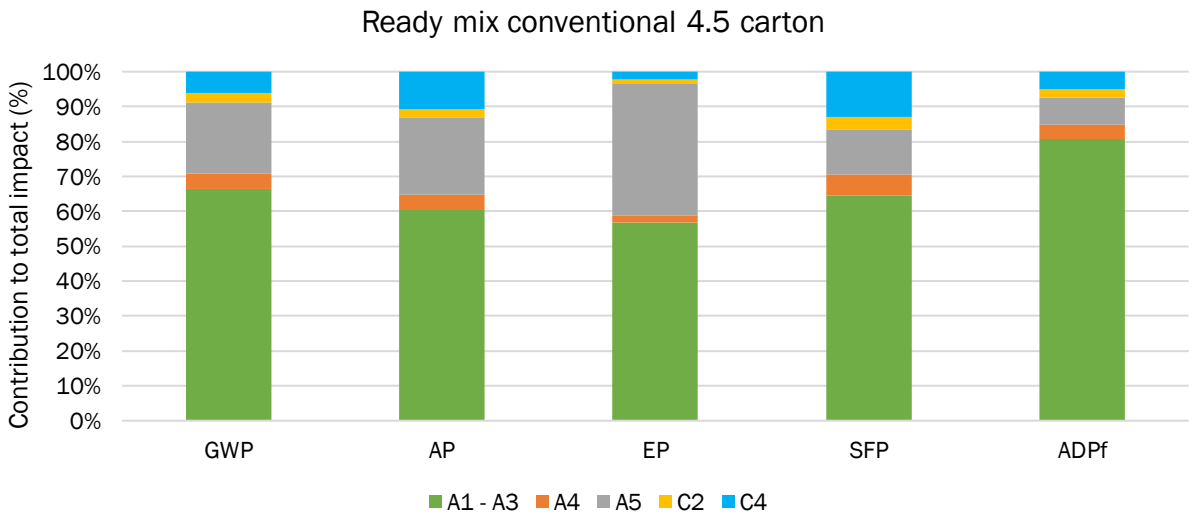


*Figure 4: Breakdown of life cycle impact assessment results for ready mix, conventional, 4.5-gal cartons*

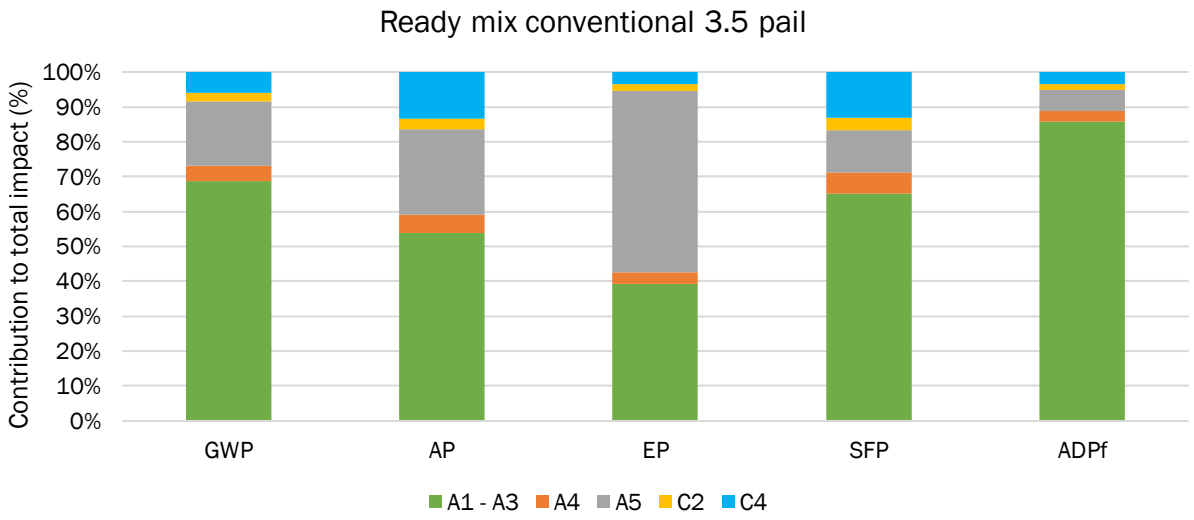


*Figure 5: Breakdown of life cycle impact assessment results for ready mix, conventional, 3.5-gal pails*

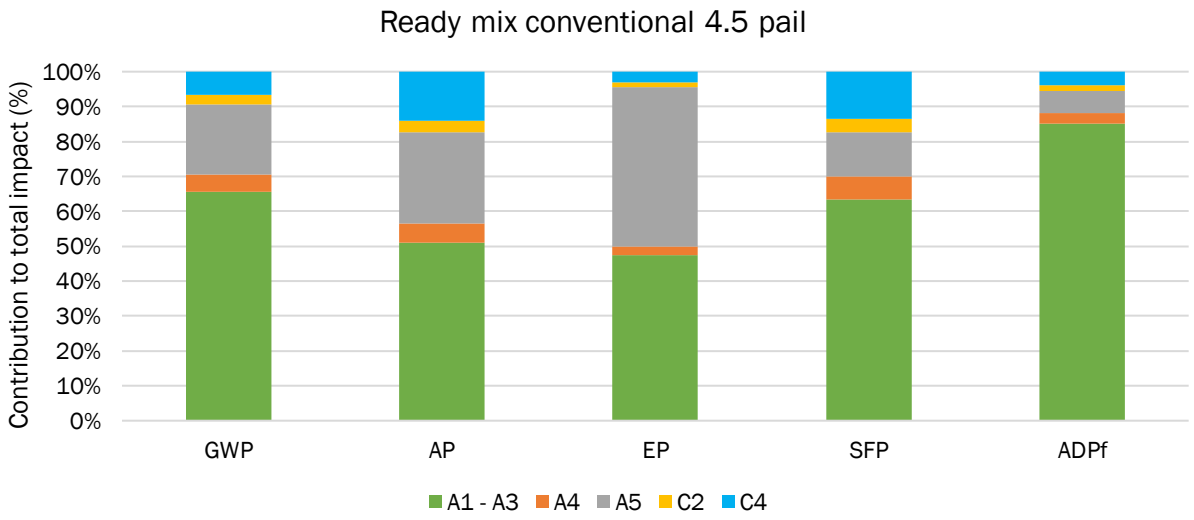


*Figure 6: Breakdown of life cycle impact assessment results for ready mix, conventional, 4.5-gal pails*

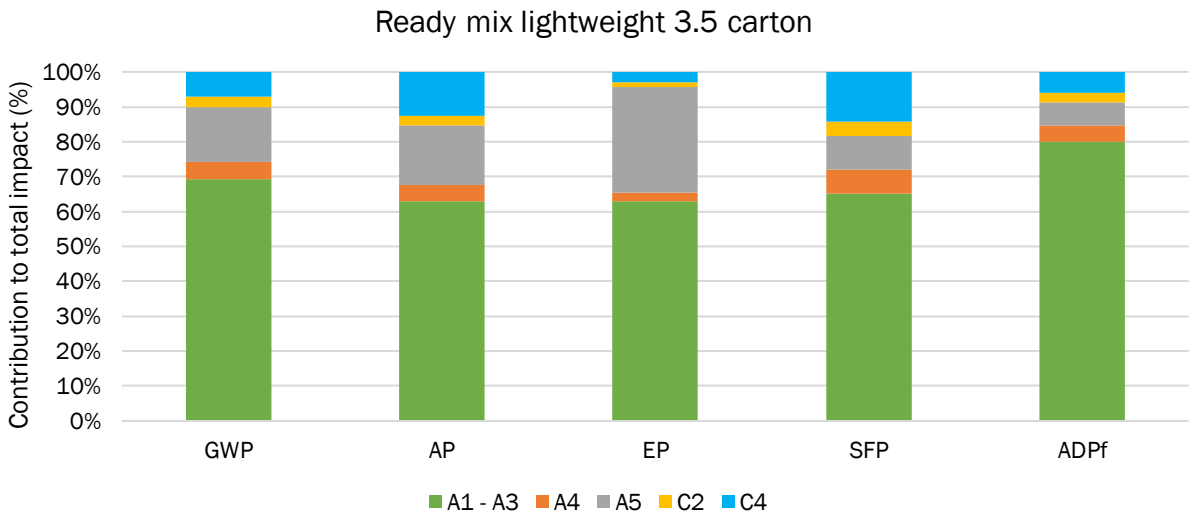


*Figure 7: Breakdown of life cycle impact assessment results for ready mix, lightweight, 3.5-gal cartons*

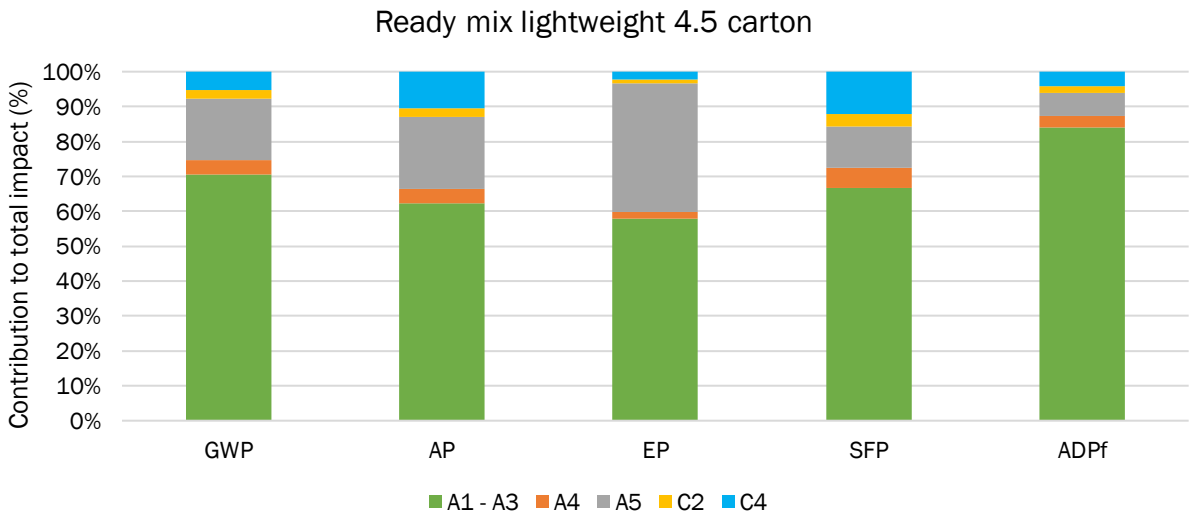


*Figure 8: Breakdown of life cycle impact assessment results for ready mix, lightweight, 4.5-gal cartons*

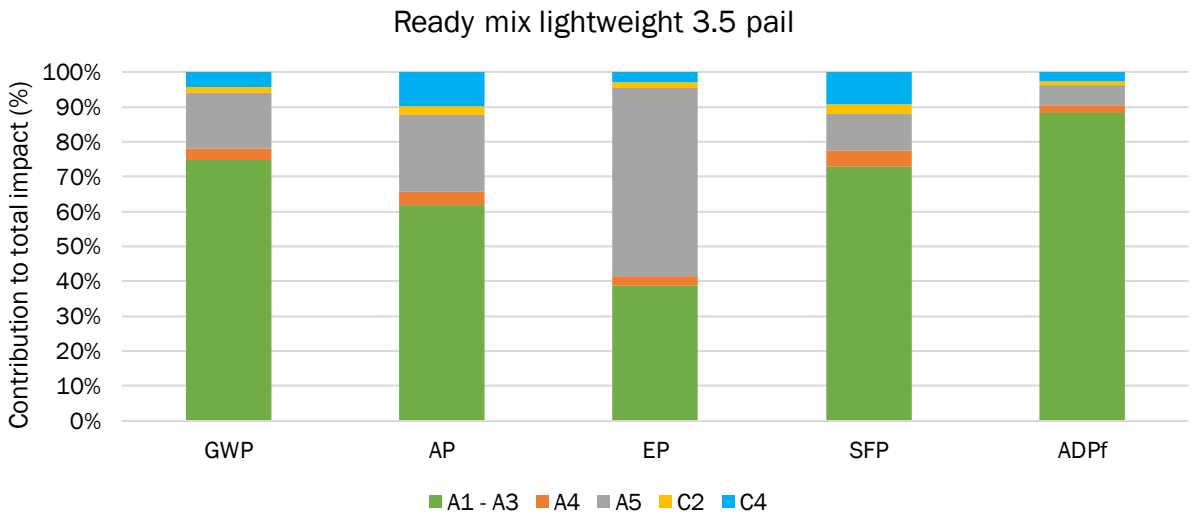


*Figure 9: Breakdown of life cycle impact assessment results for ready mix, lightweight, 3.5-gal pails*

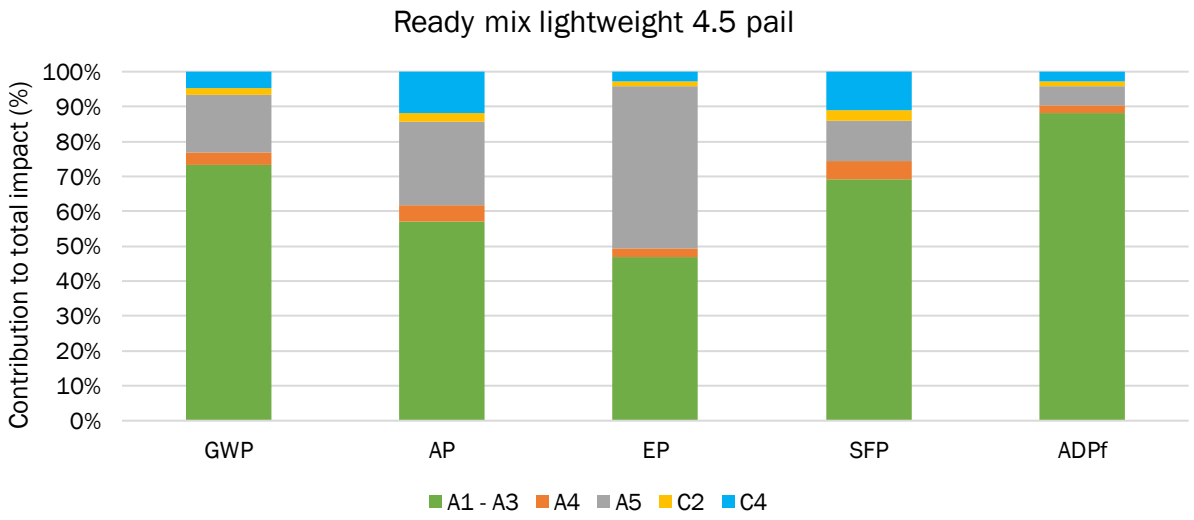


*Figure 10: Breakdown of life cycle impact assessment results for ready mix, lightweight, 4.5-gal pails*

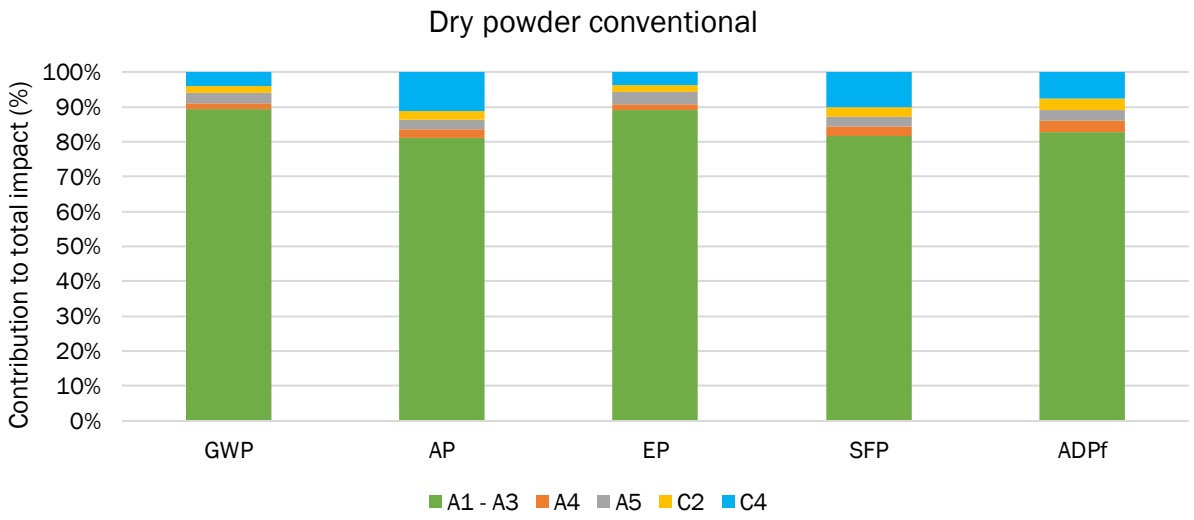


*Figure 11: Breakdown of life cycle impact assessment results for dry powder, conventional, bags*

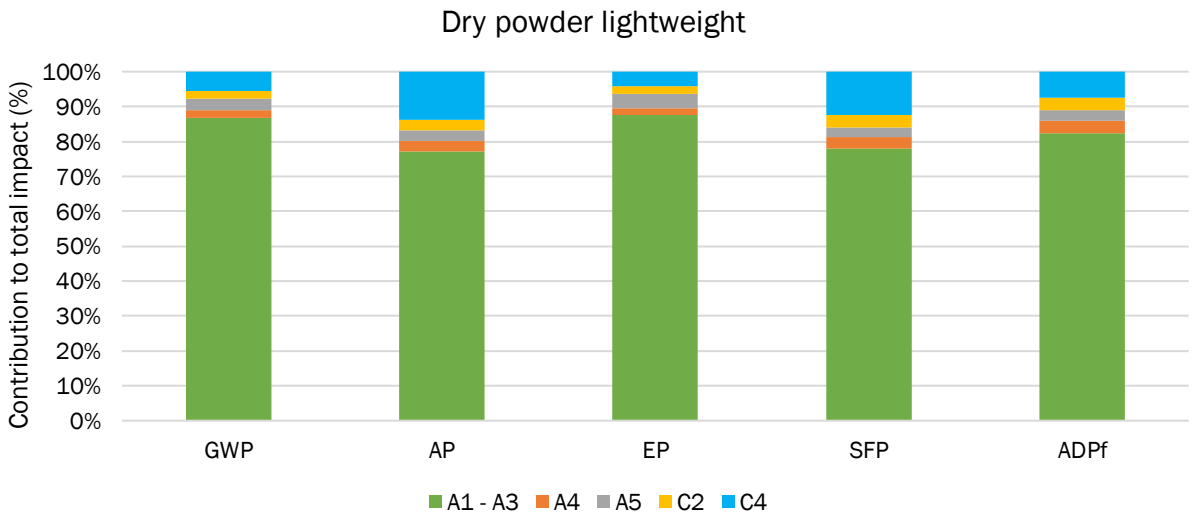


*Figure 12: Breakdown of life cycle impact assessment results for dry powder, lightweight, bags*

# ADDITIONAL ENVIRONMENTAL INFORMATION

## ENVIRONMENT AND HEALTH DURING MANUFACTURING

Where there is potential for airborne exposure in excess of applicable limits determined via Industrial Hygiene

testing/monitoring, wear NIOSH (National Institute for Occupational Safety and Health) approved respiratory protection.

## Environment and Health During Installation

Dust emissions from both joint compound and non-joint compound sources are present during drywall finishing activities and can vary significantly. While the silica content of a particular joint compound product is dictated by the raw materials used by the manufacturer, an employee's potential exposure to dust at the jobsite is ultimately dependent on the jobsite conditions and the other construction activities in progress at the time the workforce is operating. It is recommended that the user review the specific product Safety Data Sheet (SDS) from the manufacturer to determine product-specific silica levels. Additionally, workers should protect themselves by wearing the recommended Personal Protection Equipment (PPE). This requires the employer to implement a respiratory protection program that is specific to the current work site. See OSHA 1910.134 and ANSI Z88.2 for details on respiratory protection requirements (OSHA, 2006) (ANSI/ASSE, 2015). Specific to joint compound, on-site finishing methods can influence the amount of airborne dust directly attributed to a joint compound product.

"The silica exposures of drywall finishing employees are typically well below allowable limits, primarily due to the low silica content of joint compounds. Nonetheless, drywall joint compounds may contain varying amounts of silica and drywall finishing employees can be overexposed in certain circumstances" (OSHA, 2009).

Manufacturers can test their products under "controlled conditions" but the specifics of the tests used will vary depending on the third party testing facility, and there is no requirement to do so given their lack of control over installation methods. Ultimately the burden of protection falls on the installation employer. More information on sampling methods for manufacturers or employers can be found in Appendix A of OHSA's Occupational Exposure to Respirable Crystalline Silica rule (OSHA, 2017a).

It should be noted that OSHA's updated crystalline silica rule does not include drywall finishing as a task in Table 1 for which specified exposure control methods have to be implemented (OSHA, 2017b).

## Environmental Activities and Certifications

For more information, please visit: https://dwfc.org/

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