ENVIRONMENTAL PRODUCT DECLARATION

HOT-DIP GALVANIZED STEEL AFTER FABRICATION

GALVANIZED HOT-ROLLED SECTIONS, PLATE, AND HOLLOW STRUCTURAL SECTIONS
AMERICAN GALVANIZERS ASSOCIATION

The San Diego Central Library façade and dome utilizes hot-dip galvanized hot-rolled sections, plate, and hollow structural steel sections.

Use of this EPD is limited to North American AGA members. Member names are available at galvanizeit.org/galvanizers/.

AGA Zn American Galvanizers Association™
Protecting Steel for a Sustainable Future

Hot-dip galvanizing is a proven steel corrosion protection system that transcends time with little economic or environmental impact. From artful sculptures and building facades to utilitarian bridges, utility poles, and other infrastructure, hot-dip galvanized steel is an important part of everyday life.

Not only does hot-dip galvanizing provide decades of maintenance-free longevity, its primary components, zinc and steel, are both 100% recyclable, making hot-dip galvanizing an infinitely renewable building material.

Sustainability and corrosion protection are intrinsic whenever hot-dip galvanized steel (HDG) is used. Lower maintenance of installed HDG steel ensures less natural resources are consumed, less emissions are released, and less money is spent over the life of a project.

The American Galvanizers Association (AGA) is a not-for-profit trade association serving the after fabrication (batch) hot-dip galvanizing industry in North America.

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According to ISO 14025 and ISO 21930:2017

EPD PROGRAM AND PROGRAM OPERATOR NAME, ADDRESS, LOGO, AND WEBSITE	UL ENVIRONMENT 333 PFINGSTEN ROAD NORTHBROOK, IL 60611 https://www.ul.com https://spot.ul.com
GENERAL PROGRAM INSTRUCTIONS AND VERSION NUMBER	General Program Instructions v.2.5 March 2020
ASSOCIATION NAME AND ADDRESS	American Galvanizers Association | 6881 South Holly Circle, Suite 108, Centennial, CO 80112
DECLARATION NUMBER	4790062268.101.1
DECLARED PRODUCT & DECLARED UNIT	Galvanized structural steel product, 1 metric ton
REFERENCE PCR AND VERSION NUMBER	Part A: Calculation Rules for the LCA and Requirements Project Report, (IBU/UL Environment, V3.2, 12.12.2018) and Part B: Designated Steel Construction Product EPD Requirements (UL Environment, V2.0, 08.26.2020).
DESCRIPTION OF PRODUCT APPLICATION/USE	Hot-dip galvanized structural steel used in construction
MARKETS OF APPLICABILITY	North America
DATE OF ISSUE	April 1, 2022
PERIOD OF VALIDITY	5 years
EPD TYPE	Industry average
EPD SCOPE	Cradle to gate
YEAR(S) OF REPORTED PRIMARY DATA	2019
LCA SOFTWARE & VERSION NUMBER	GaBi v10
LCI DATABASE(S) & VERSION NUMBER	GaBi 2021 (CUP 2021.2)
LCIA METHODOLOGY & VERSION NUMBER	IPCC AR5 + TRACI 2.1

The sub-category PCR review was conducted by:	UL Environment PCR Review Panel epd@ulenvironment.com
This declaration was independently verified in accordance with ISO 14025: 2006. ☐ INTERNAL ☒EXTERNAL	Cooper McCollum, UL Environment
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Thomas P. Gloria, Industrial Ecology Consultants

LIMITATIONS

Exclusions: EPDs do not indicate that any environmental or social performance benchmarks are met, and there may be impacts that they do not encompass. LCAs do not typically address the site-specific environmental impacts or raw material extraction, nor are they meant to assess human health toxicity. EPDs can complement but cannot replace tools 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 estimation 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 for upstream or downstream of the life cycle stages declared.

General Information

Description of Organization

The American Galvanizers Association (AGA), headquartered in Centennial, CO, is a not-for-profit trade association dedicated to serving the needs of specifiers, architects, engineers, contractors, fabricators, and after-fabrication (batch) hot-dip galvanizers throughout North America. Since 1933, the AGA has provided information on the most innovative applications and state-of-the-art technological developments in hot-dip galvanizing for corrosion control. The AGA serves as the unified voice and representative of the North American hot-dip galvanizing industry and strives to deliver clear, objective messages about the environmental and economic benefits of utilizing hot-dip galvanized (HDG) steel. The AGA maintains a large technical library, provides multimedia educational seminars, offers technical support, and preserves and expands HDG's steel's market position in existing and emerging markets.

Participating Members

This EPD represents hot-rolled structural steel sections, steel plate, and hollow structural steel sections that are hot-dip galvanized after fabrication by the AGA's membership. Galvanizing data were collected from appropriate AGA members to represent the industry average. Member names are available at galvanizeit.org/galvanizers/.

Product Description

Hot-rolled structural sections, plate, and hollow structural sections (HSS) hot-dip galvanized after fabrication are used in myriad of applications where corrosion resistance is necessary, including building, bridge & highway, food & agriculture, industrial, public/private utility, recreational, and transportation applications. Hot-dip galvanizing after fabrication has been specified to combat steel corrosion in the harshest environments throughout various markets for more than 100 years. New process technologies continue to evolve the specification and use of hot-dip galvanized steel as new markets emerge. Once considered only as a means of corrosion protection, hot-dip galvanizing is now specified for an array of reasons including lower initial and life cycle costs, durability, longevity, availability, versatility, sustainability, and aesthetics.

Product Specification

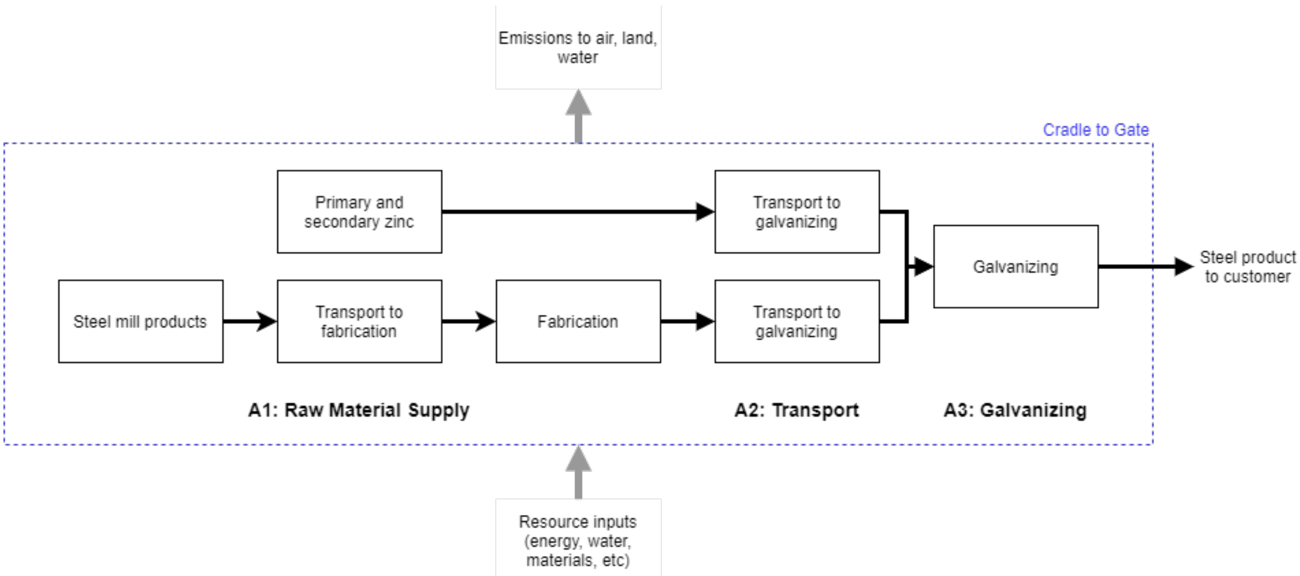
Structural steel consists of the elements of the structural frame that are shown and sized in the structural design documents, essential to support the design loads and described in the *Code of Standard Practice for Structural Steel Buildings and Bridges*, AISC 303-10. Hot-dip galvanized coating for corrosion protection as described in ASTM A123/A123M.

Galvanized steel products are defined by the following standards.

- ANSI/AISC 360-10: Specification for Structural Steel Buildings
- ANSI/AISC 341-10: Seismic Provisions for Structural Steel Buildings
- AISC 303-10: Code of Standard Practice for Structural Steel Buildings
- AASHTO LRFD Bridge Design Specifications, Customary U.S. Units, 7^{th} Edition
- ASTM A123/A123M: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM B6: Standard Specification for Zinc

Additional information can be found on AGA's website at galvanizeit.org.

Flow Diagram



Product Average

The data collected represents hot-dip galvanizing during 2019 by participating AGA member companies located throughout North America. Results are weighted according to production totals at participating facilities.

Application

Hot-dip galvanized structural steel products are typically used in buildings, bridges, and industrial applications.

Material Composition

Hot-dip galvanized products are manufacturered from fabricated structural steel and zinc with a small percentage of alloy elements included.The products do not contain any materials or substances for which there exists a route to exposure that leads to humans or flora/fauna in the environment being exposed to said materials or substances at levels exceeding safe health thresholds. The products do not contain any hazardous substances according to the Resource Conservation and Recovery Act (RCRA), Subtitle 3. Steel and zinc are both infinitely renewable resources that are both natural and abundant. Zinc is essential for human health and all living organisms. More information on zinc and its benefits is available from the International Zinc Association (IZA) publication *Zinc: A Sustainable Material, Essential for Modern Life.*

Methodological Framework

Declared unit

The declared unit for this EPD is one metric ton of hot-dip galvanized structural steel product. Note that comparison of EPD results on a mass basis alone is insufficient and should consider the technical performance of the product.

Table 1. Declared unit

NAME	VALUE	UNIT
Declared unit	1	metric ton
Density (typical)	7,800	kg/m^3

System Boundary

This EPD is "cradle-to-gate" in scope. The life cycle stages included in the assessment represent the product stage (modules A1-A3) and include:

- A1: Extraction and processing of raw materials, reuse of products or materials from a previous product system, processing of secondary materials, and any energy recovery or other recovery processes from secondary fuels;
- A2: Transportation to the factory gate;
- A3: Generation of electricity used in galvanizing from primary energy resources (including upstream processes), extraction, processing, and combustion of natural gas, direct emissions from galvanizing, and production of ancillary materials.

<table>
<tr><th colspan="3">PRODUCT STAGE</th><th colspan="2">CONSTRUCT-ION PROCESS STAGE</th><th colspan="7">USE STAGE</th><th colspan="4">END OF LIFE STAGE</th><th>BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY</th></tr>
<tr><td>Raw material supply</td><td>Transport</td><td>Manufacturing</td><td>Transport from gate to site</td><td>Assembly/Install</td><td>Use</td><td>Maintenance</td><td>Repair</td><td>Replacement</td><td>Refurbishment</td><td>Building Operational Energy Use During Product Use</td><td>Building Operational Water Use During Product Use</td><td>Deconstruction</td><td>Transport</td><td>Waste processing</td><td>Disposal</td><td>Reuse, Recovery, Recycling Potential</td></tr>
<tr><td>A1</td><td>A2</td><td>A3</td><td>A4</td><td>A5</td><td>B1</td><td>B2</td><td>B3</td><td>B4</td><td>B5</td><td>B6</td><td>B7</td><td>C1</td><td>C2</td><td>C3</td><td>C4</td><td>D</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>MND</td><td>MND</td><td>MND</td><td>MND</td><td>MND</td><td>MND</td><td>MND</td><td>MND</td><td>MND</td><td>MND</td><td>MND</td><td>MND</td><td>MND</td><td>MND</td></tr>
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* X = module included, MND = module not declared

Allocation

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

Allocation of background data (energy and materials) taken from the GaBi 2021 databases is documented online at https://sphera.com/wp-content/uploads/2020/04/Modeling-Principles-GaBi-Databases-2021.pdf. The background data for steel plate, steel sections, and hollow structural sections were obtained from industry-average AISC and STI EPDs, which were published based on industry-average steelmaking data from AISI and worldsteel. While background data for steelmaking from AISI and worldsteel use the system expansion allocation method for selected co-products from the steelmaking process, ISO 21930, clause 7.2.4 allows the use of such upstream data as long as these datasets are clearly identified, subjected to a sensitivity analysis, justified in the project report, and in line with ISO 14044 allocation rules.

Background data based on physical allocation are available upon request from AISI. A comparison between physical allocation and system expansion background datasets for steelmaking revealed that the variation in fabrication of steel products was less than 5% across all reported impact categories (with the exception of ODP, which showed a 13% increase). This translates to a maximum variation of around 3% in the environmental impacts of galvanized steel products across all reported impact categories (with the exception of ODP, which showed around 8% increase). For the sake of consistency with the published AISC and STI EPDs, the upstream data using system expansion was therefore used.

Since the EPD does not cover the end-of-life of the products, end-of-life allocation is outside the scope of the study. Metal scrap from manufacturing (module A3) was balanced with the scrap demand of the raw materials module (A1) in order to calculate the net scrap input to module A1.

Under a cradle-to-gate system boundary, scrap inputs to the system are not associated with any upstream burden, and scrap produced during manufacturing is assumed to be at least the same quality as scrap inputs into steelmaking. Remelting of scrap to produce structural steel and other raw materials is accounted for within module A1 using upstream datasets.

Cut-off Rules

No formal cut-off criteria were defined for this study. The system boundary was defined based on relevance to the goal of the study. For the processes within the system boundary, all available energy and material flow data have been included in the model.

Data Sources

The LCA model was created using the GaBi software system for life cycle engineering, version 10, developed by Sphera (Sphera, 2021). Background life cycle inventory data for raw materials and processes were obtained from the GaBi 2021 database (CUP 2021.2). Primary galvanizing data were provided by AGA member companies. Steelmaking was represented using background data from the American Iron and Steel Institute (AISI) (American Iron and Steel Institute, 2020) and fabrication data were taken from the American Institute of Steel Construction (AISC) industry average EPD (AISC, 2021).

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.

Period Under Review

Primary data were collected for galvanizing during the year 2019. Background data for steel production was taken from AISI and represents steel production during 2017 and background data for fabrication was taken from AISC and represents fabrication during 2019. This analysis is intended to represent hot-dip galvanizing in 2019.

Estimates and Assumptions

This study does not differentiate between the hot-dip galvanizing of different types of structural steel products — namely, hot rolled sections, plate, and hollow structural sections. Therefore, it does not evaluate whether some types of structural steel, and the applications in which they're used, require different quantities of zinc per kg or per ton. The ratio of zinc to steel mass will vary depending on the dimensions and surface area of the piece of steel coated and medium structural sections were chosen because they represent the middle-ground for the ratio of zinc relative to steel required for hot-dip galvanizing. To ensure hot-dip galvanizing data represent an average ratio while balancing time and effort spent by galvanizers in data provision, manufacturers who primarily coat medium structural sections were chosen to provide data and assumed to be representative of hot-dip galvanizing by AGA members.

All the raw materials and energy inputs have been modeled using processes and flows that closely follow actual production data on raw materials and processes. All the reported material and energy flows have been accounted for.

Technical Information and Scenarios

Manufacturing

The major input to hot-dip galvanizing is the fabricated steel itself, along with the zinc used to produce the coating. Process materials such as dilute acids, degreasers, and zinc ammonium chloride are used to prepare the steel prior to galvanizing. Once the surface is prepared, the steel is immersed in a bath of molten zinc to form the coating. Energy is needed to prepare and coat the steel as well as to move the materials. Dilute acids and zinc byproducts (skimmings and dross) are reprocessed internally and recycled or reused externally.

Inbound Transportation

Inbound transportation distances and modes for steel, zinc and process materials were collected from each participating galvanizer.

Transportation

Transportation to the customer or construction site is outside the scope of this EPD.

Product Installation

Installation is outside the scope of this EPD.

Use

Product use is outside the scope of this EPD.

Reuse, Recycling, and Energy Recovery

Product reuse, recycling, and incineration for energy recovery is outside the scope of this EPD.

Disposal

Product disposal is outside the scope of this EPD.

Environmental Indicators Derived from LCA

North American life cycle impact assessment (LCIA) results are declared using TRACI 2.1 (Bare, 2012; EPA, 2012) methodology, with the exception of GWP which is reported using the IPCC AR5 (IPCC, 2013) methodology, excluding biogenic carbon dioxide. Primary energy use represents the lower heating value (LHV) a.k.a. net calorific value (NCV).

Table 2. Required declaration of environmental impacts, use of resources, and generation of waste

INDICATOR	UNIT
Life Cycle Impact Assessment Results	
Global warming potential, excluding biogenic carbon, 100-year time frame (GWP 100)	kg CO_2 eq
Ozone depletion potential (ODP)	kg CFC-11 eq
Acidification potential (AP)	kg SO_2 eq
Eutrophication potential (EP)	kg N eq
Smog formation potential (SFP)	kg O_3 eq
Abiotic resource depletion potential of non-renewable (fossil) energy resources (ADP_{fossil})	MJ
Resource Use	
Renewable primary resources used as energy carrier (fuel) (RPR_E)	MJ LHV
Renewable primary resources with energy content used as material (RPR_M)	MJ LHV
Non-renewable primary resources used as an energy carrier (fuel) ($NRPR_E$)	MJ LHV
Non-renewable primary resources with energy content used as material ($NRPR_M$)	MJ LHV
Secondary materials (SM)	kg
Renewable secondary fuels (RSF)	MJ LHV
Non-renewable secondary fuels (NRSF)	MJ LHV
Recovered energy (RE)	MJ LHV
Use of net fresh water resources (FW)	m^3
Output Flows and Waste Categories	
Hazardous waste disposed (HWD)	kg
Non-hazardous waste disposed (NHWD)	kg
High-level radioactive waste, conditioned, to final repository (HLRW)	kg
Intermediate- and low-level radioactive waste, conditioned, to final repository (ILLRW)	kg
Components for re-use (CRU)	kg
Materials for recycling (MFR)	kg
Materials for energy recovery (MER)	kg
Recovered energy exported from the product system (EE)	MJ LHV

LCIA results are relative expressions and do not predict actual impacts, the exceeding of thresholds, safety margins or risks.

Comparability: Comparisons cannot be made between product-specific or industry average EPDs at the design stage of a project, before a building has been specified. Comparisons may be made between product-specific or industry average EPDs at the time of product purchase when product performance and specifications have been established and serve as a functional unit for comparison. Environmental impact results shall be converted to a functional unit basis before any comparison is attempted.

Any comparison of EPDs shall be subject to the requirements of ISO 21930. EPDs are not comparative assertions and are either not comparable or have limited comparability when they have different system boundaries, are based on different product category rules or are missing relevant environmental impacts. Such comparison can be inaccurate, and could lead to erroneous selection of materials or products which are higher-impact, at least in some impact categories.

Per the PCR, "industry average EPDs shall report information on the statistical distribution of results for all TRACI indicators". The min and max results presented in Table 6, Table 10, and Table 14 represent the facilities with the lowest (best) and highest (worst) impacts, respectively. Min and max facilities are calculated for each impact category. The mean and median do not take production volumes across facilities into account (i.e. it is a calculation based on each individual facility as a data point), while the weighted averages presented in Table 3, Table 7, and Table 11 are calculated via weighting production volume reported by each galvanizer.

Hot-Dip Galvanized Structural Steel Sections

Table 3. LCIA results, per 1 metric ton of hot-dip galvanized steel sections

PARAMETER	UNIT	TOTAL	A1	A2	A3
GWP 100	kg CO_2 eq.	**1.71E+03**	1.38E+03	2.83E+01	3.06E+02
ODP	kg CFC 11 eq.	**1.72E-09**	1.72E-09	5.86E-15	3.06E-13
AP	kg SO_2 eq.	**4.67E+00**	3.86E+00	1.40E-01	6.68E-01
EP	kg N eq.	**2.75E-01**	2.11E-01	1.32E-02	5.07E-02
SFP	kg O_3 eq.	**8.84E+01**	6.66E+01	3.23E+00	1.86E+01
ADP_{fossil}	MJ surplus	**2.21E+03**	1.50E+03	5.51E+01	6.54E+02

Table 4. Resource use results, per 1 metric ton of hot-dip galvanized steel sections

PARAMETER	UNIT	TOTAL	A1	A2	A3
RPR_E	MJ LHV	**1.94E+03**	1.76E+03	1.71E+01	1.67E+02
RPR_M	MJ LHV	**-**	-	-	-
$NRPR_E$	MJ LHV	**2.42E+04**	1.89E+04	4.16E+02	4.89E+03
$NRPR_M$	MJ LHV	**1.29E+01**	1.28E+01	0.00E+00	1.07E-01
SM	kg	**2.04E+03**	2.04E+03	0.00E+00	2.17E-01
RSF	MJ LHV	**-**	-	-	-
NRSF	MJ LHV	**-**	-	-	-
RE	MJ LHV	**-**	-	-	-
FW	m^3	**2.97E+01**	2.85E+01	7.32E-02	1.12E+00

Table 5. Output flows and waste categories results, per 1 metric ton of hot-dip galvanized steel sections

Parameter	Unit	Total	A1	A2	A3
HWD	kg	**3.76E-01**	3.37E-01	0.00E+00	3.94E-02
NHWD	kg	**1.05E+01**	9.80E+00	0.00E+00	7.03E-01
HLRW	kg	**1.26E-03**	1.21E-03	1.40E-06	4.55E-05
ILLRW	kg	**1.05E+00**	1.01E+00	1.18E-03	3.85E-02
CRU	kg	**-**	-	-	-
MR	kg	**1.58E+02**	7.82E+01	0.00E+00	7.99E+01
MER	kg	**-**	-	-	-
EE	MJ LHV	**-**	-	-	-

Table 6. Statistical distribution of LCIA results, per 1 metric ton of hot-dip galvanized steel sections

Parameter	Unit	Min (A1-A3)	Max (A1-A3)	Max/Min Ratio (A1-A3)	Mean (A1-A3)	Median (A1-A3)
GWP 100	kg CO_2 eq.	1.43E+03	1.83E+03	1.28E+00	1.73E+03	1.79E+03
ODP	kg CFC 11 eq.	1.58E-09	1.76E-09	1.12E+00	1.73E-09	1.76E-09
AP	kg SO_2 eq.	3.20E+00	4.99E+00	1.56E+00	4.70E+00	4.93E+00
EP	kg N eq.	1.70E-01	3.00E-01	1.76E+00	2.78E-01	2.96E-01
SFP	kg O_3 eq.	5.03E+01	9.65E+01	1.92E+00	8.95E+01	9.57E+01
ADP_{fossil}	MJ surplus	1.76E+03	2.45E+03	1.39E+00	2.27E+03	2.37E+03

Figure 1 represents the relative contribution of each life cycle stage to the overall cradle-to-gate impacts per 1 metric ton of hot-dip galvanized structural steel sections.

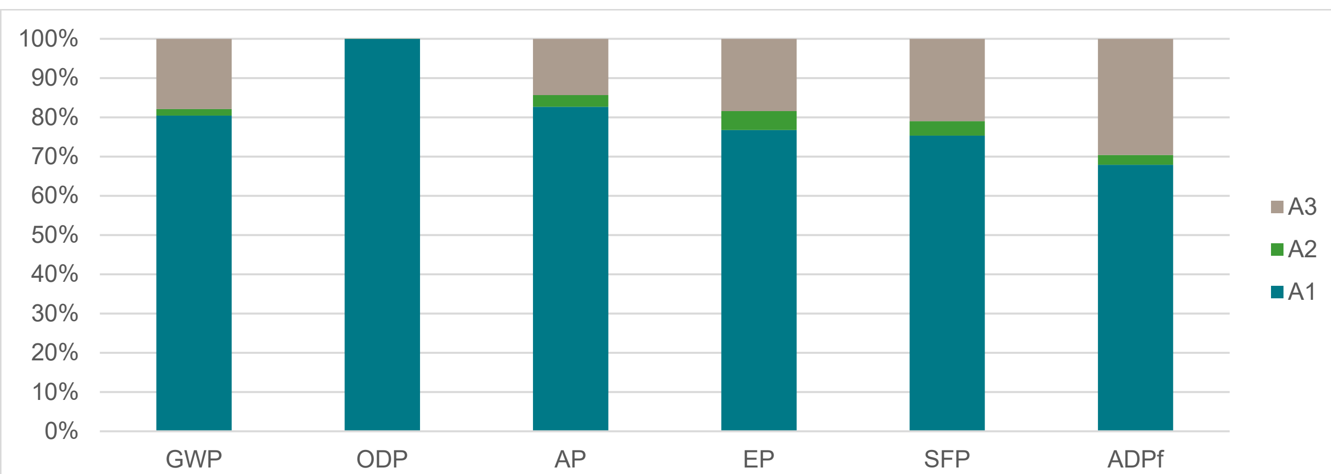

Figure 1: Relative contribution by life cycle stage for 1 metric ton of hot-dip galvanized structural steel sections

Hot-Dip Galvanized Structural Steel Plate

Table 7. LCIA results, per 1 metric ton of hot-dip galvanized steel plate

PARAMETER	UNIT	TOTAL	A1	A2	A3
GWP 100	kg CO_2 eq.	**2.23E+03**	1.89E+03	2.83E+01	3.06E+02
ODP	kg CFC 11 eq.	**1.71E-09**	1.71E-09	5.86E-15	3.06E-13
AP	kg SO_2 eq.	**5.46E+00**	4.65E+00	1.40E-01	6.68E-01
EP	kg N eq.	**3.11E-01**	2.47E-01	1.32E-02	5.07E-02
SFP	kg O_3 eq.	**1.00E+02**	7.85E+01	3.23E+00	1.86E+01
ADP_{fossil}	MJ surplus	**2.29E+03**	1.58E+03	5.51E+01	6.54E+02

Table 8. Resource use results, per 1 metric ton of hot-dip galvanized steel plate

PARAMETER	UNIT	TOTAL	A1	A2	A3
RPR_E	MJ LHV	**2.12E+03**	1.93E+03	1.71E+01	1.67E+02
RPR_M	MJ LHV	-	-	-	-
$NRPR_E$	MJ LHV	**2.84E+04**	2.31E+04	4.16E+02	4.89E+03
$NRPR_M$	MJ LHV	**1.29E+01**	1.28E+01	0.00E+00	1.07E-01
SM	kg	**1.72E+03**	1.72E+03	0.00E+00	2.17E-01
RSF	MJ LHV	-	-	-	-
NRSF	MJ LHV	-	-	-	-
RE	MJ LHV	-	-	-	-
FW	m^3	**4.02E+01**	3.90E+01	7.32E-02	1.12E+00

Table 9. Output flows and waste categories results, per 1 metric ton of hot-dip galvanized steel plate

PARAMETER	UNIT	TOTAL	A1	A2	A3
HWD	kg	**3.76E-01**	3.37E-01	0.00E+00	3.94E-02
NHWD	kg	**1.05E+01**	9.80E+00	0.00E+00	7.03E-01
HLRW	kg	**1.23E-03**	1.18E-03	1.40E-06	4.55E-05
ILLRW	kg	**1.02E+00**	9.84E-01	1.18E-03	3.85E-02
CRU	kg	-	-	-	-
MR	kg	**1.58E+02**	7.82E+01	0.00E+00	7.99E+01
MER	kg	-	-	-	-
EE	MJ LHV	-	-	-	-

Table 10. Statistical distribution of LCIA results, per 1 metric ton of hot-dip galvanized steel plate

PARAMETER	UNIT	MIN (A1-A3)	MAX (A1-A3)	MAX/MIN RATIO (A1-A3)	MEAN (A1-A3)	MEDIAN (A1-A3)
GWP 100	kg CO_2 eq.	1.92E+03	2.36E+03	1.23E+00	2.25E+03	2.31E+03
ODP	kg CFC 11 eq.	1.56E-09	1.75E-09	1.12E+00	1.72E-09	1.75E-09
AP	kg SO_2 eq.	3.95E+00	5.80E+00	1.47E+00	5.49E+00	5.73E+00
EP	kg N eq.	2.04E-01	3.37E-01	1.65E+00	3.15E-01	3.33E-01
SFP	kg O_3 eq.	6.16E+01	1.09E+02	1.76E+00	1.01E+02	1.08E+02
ADP_{fossil}	MJ surplus	1.83E+03	2.53E+03	1.38E+00	2.35E+03	2.45E+03

Figure 2 represents the relative contribution of each life cycle stage to the overall cradle-to-gate impact per 1 metric ton of hot-dip galvanized structural steel plate.

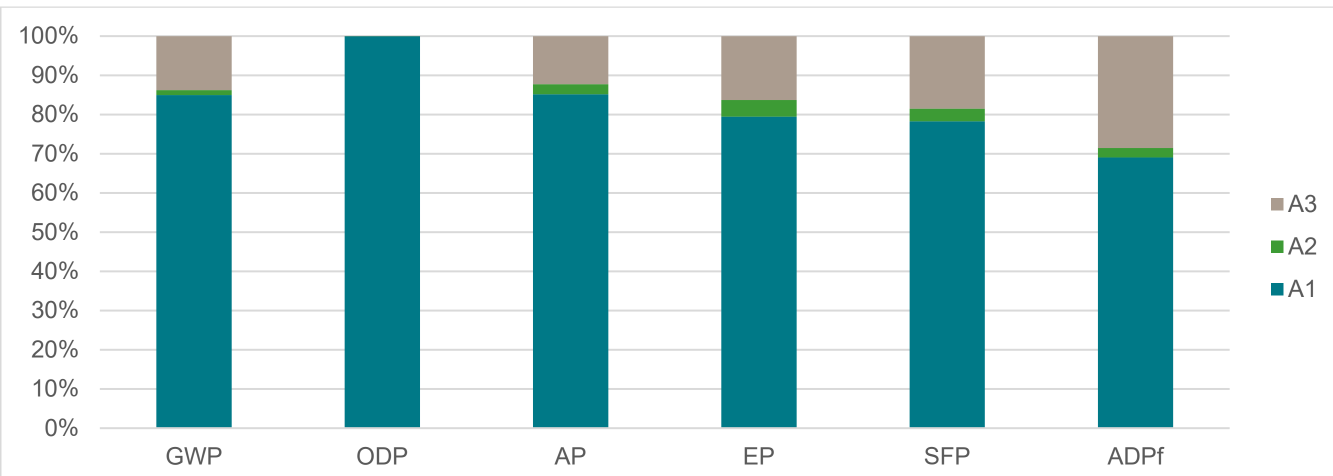

Figure 2: Relative contribution by life cycle stage for 1 metric ton of hot-dip galvanized structural steel plate

Hot-Dip Galvanized Hollow Structural Sections

Table 11. LCIA results, per 1 metric ton of hot-dip galvanized HSS

PARAMETER	UNIT	TOTAL	A1	A2	A3
GWP 100	kg CO_2 eq.	**2.48E+03**	2.14E+03	2.83E+01	3.06E+02
ODP	kg CFC 11 eq.	**1.71E-09**	1.71E-09	5.86E-15	3.06E-13
AP	kg SO_2 eq.	**6.05E+00**	5.24E+00	1.40E-01	6.68E-01
EP	kg N eq.	**3.56E-01**	2.92E-01	1.32E-02	5.07E-02
SFP	kg O_3 eq.	**1.19E+02**	9.69E+01	3.23E+00	1.86E+01
ADP_{fossil}	MJ surplus	**2.56E+03**	1.85E+03	5.51E+01	6.54E+02

Table 12. Resource use results, per 1 metric ton of hot-dip galvanized HSS

PARAMETER	UNIT	TOTAL	A1	A2	A3
RPR_E	MJ LHV	**2.06E+03**	1.87E+03	1.71E+01	1.67E+02
RPR_M	MJ LHV	**-**	-	-	-
$NRPR_E$	MJ LHV	**3.27E+04**	2.73E+04	4.16E+02	4.89E+03
$NRPR_M$	MJ LHV	**1.31E+01**	1.30E+01	0.00E+00	1.07E-01
SM	kg	**9.23E+02**	9.23E+02	0.00E+00	2.17E-01
RSF	MJ LHV	**-**	-	-	-
NRSF	MJ LHV	**-**	-	-	-
RE	MJ LHV	**-**	-	-	-
FW	m^3	**3.47E+01**	3.35E+01	7.32E-02	1.12E+00

Table 13. Output flows and waste categories results, per 1 metric ton of hot-dip galvanized HSS

PARAMETER	UNIT	TOTAL	A1	A2	A3
HWD	kg	**5.45E-01**	5.05E-01	0.00E+00	3.94E-02
NHWD	kg	**1.69E+01**	1.62E+01	0.00E+00	7.03E-01
HLRW	kg	**1.21E-03**	1.16E-03	1.40E-06	4.55E-05
ILLRW	kg	**1.01E+00**	9.67E-01	1.18E-03	3.85E-02
CRU	kg	**-**	-	-	-
MR	kg	**2.35E+02**	1.55E+02	0.00E+00	7.99E+01
MER	kg	**-**	-	-	-
EE	MJ LHV	**-**	-	-	-

Table 14. Statistical distribution of LCIA results, per 1 metric ton of hot-dip galvanized HSS

PARAMETER	UNIT	MIN (A1-A3)	MAX (A1-A3)	MAX/MIN RATIO	MEAN (A1-A3)	MEDIAN (A1-A3)
GWP 100	kg CO_2 eq.	2.16E+03	2.62E+03	1.21E+00	2.50E+03	2.57E+03
ODP*	kg CFC 11 eq.	1.57E-09	1.75E-09	1.12E+00	1.72E-09	1.75E-09
AP	kg SO_2 eq.	4.51E+00	6.40E+00	1.42E+00	6.09E+00	6.34E+00
EP	kg N eq.	2.47E-01	3.82E-01	1.55E+00	3.59E-01	3.78E-01
SFP	kg O_3 eq.	7.91E+01	1.27E+02	1.61E+00	1.20E+02	1.27E+02
ADP_{fossil}	MJ surplus	2.09E+03	2.81E+03	1.35E+00	2.63E+03	2.73E+03

Figure 3 represents the relative contribution of each life cycle stage to the overall cradle-to-gate impact per 1 metric ton of hot-dip galvanized HSS.

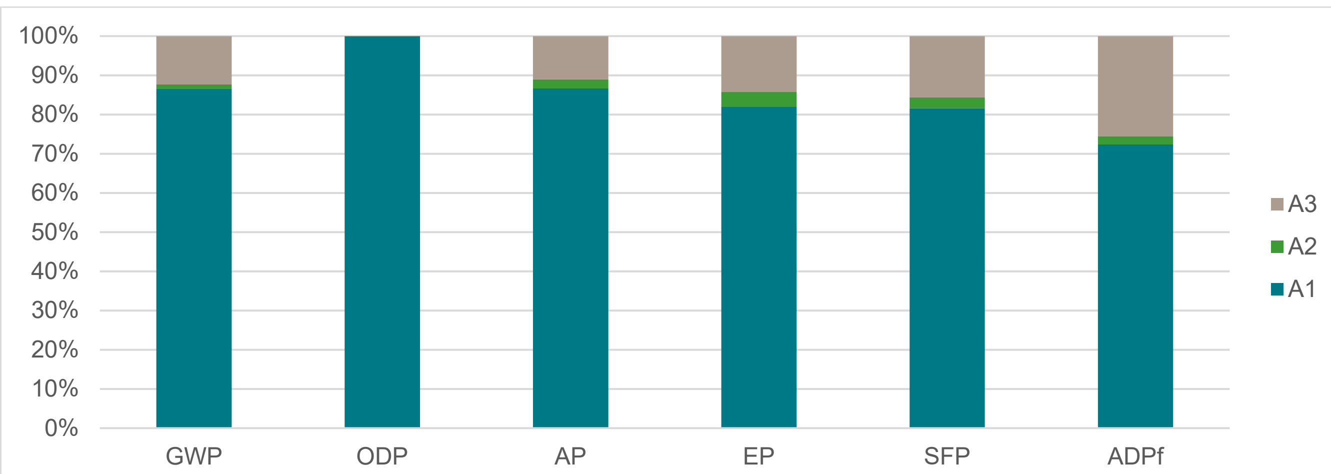

Figure 3: Relative contribution by life cycle stage for 1 metric ton of hot-dip galvanized HSS

Additional Environmental Information

Environment and Health During Manufacturing

Environmental, occupational health and safety practices are in accordance with OSHA and individual state requirements.

Environment and Health During Installation

During installation and use, hot-dip galvanized products do not adversely impact human health or release emissions to indoor air. Hot-dip galvanized products do not contain any hazardous substances according to the Resource Conservation and Recovery Act (RCRA), Subtitle 3. White Papers discussing the environmental impacts of hot-dip galvanizing to water and soil are available.

Hot-Dip Galvanized Steel's Contribution to Zinc Levels in the Water Environment

Hot-Dip Galvanized Steel's Contribution to Zinc Levels in the Soil Environment

Further Information

Additional information regarding the sustainable attributes of hot-dip galvanized after-fabrication can be found at https://galvanizeit.org/sustainability.

Information regarding this EPD is available at https://galvanizeit.org/ epd

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