ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804

Owner of the Declaration	bauforumstahl e.V.
Programme holder	Institut Bauen und Umwelt e.V. (IBU)
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Structural Steel: Sections and Plates

bauforumstahl e.V.

Institut Bauen und Umwelt e.V.

www.bau-umwelt.com / https://epd-online.com

1. General Information

bauforumstahl e.V.

Programme holder
IBU - Institut Bauen und Umwelt e.V.
Panoramastr. 1
10178 Berlin
Germany

Declaration number
EPD-BFS-20130094-IBG1-EN

This Declaration is based on the Product Category Rules:
Structural steels, 07-2012
(PCR tested and approved by the independent expert committee)

Issue date
25.10.2013

Valid to
24.10.2018

Prof. Dr.-Ing. Horst J. Bossenmayer
(President of Institut Bauen und Umwelt e.V.)

Dr. Burkhart Lehmann
(Managing Director IBU)

Structural Steel: Sections and Plates

Owner of the Declaration
bauforumstahl e.V.
Sohnstraße 65
D-40237 Düsseldorf

Declared product / Declared unit
The declared unit is 1 t of structural steel (sections and plates)

Scope:
This environmental product declaration covers steel products rolled out to structural sections, merchant bars and heavy plates, intended for bolted, welded or otherwise connected constructions of buildings, bridges and other structures.

This environmental product declaration is valid for the following products:

Plates produced by Dillinger Hütte and GTS Industries, Tata Steel on the Site Scunthorpe and Ilsenburger Grobblech GmbH.

Sections produced by ArcelorMittal with the sites in Ostrava, Differdange, Dabrowa, Esch-Belval, Bergara, Hunedoara, Madrid, Olaberria, Zaragoza, Warszawa and Rodange, Tata Steel with the sites in Scunthorpe and Lackenby as well as Peiner Träger GmbH and Stahlwerk Thüringen GmbH.The owner of the declaration shall be liable for the underlying information and evidence; the IBU shall not be liable with respect to manufacturer information, life cycle assessment data and evidences.

Verification

The CEN Norm EN 15804 serves as the core PCR
Independent verification of the declaration and data according to ISO 14025
☐ internally ☒ externally

Dr. Frank Werner
(Independent tester appointed by SVA)

2. Product

2.1 Product description
This EPD applies to 1 t of structural steel (sections and plates). It covers steel products of the grades S235 to S960 rolled out to structural sections, merchant bars and heavy plates.

2.2 Application
Structural steels are intended for bolted, welded or otherwise connected constructions of buildings, bridges and other structures, or in composite steel and concrete structures.
Examples:
- single storey buildings (industrial and storage halls, etc.)
- multistorey buildings (offices, residential buildings, shops, car parks, high rise, etc.)
- bridges (railway bridge, road bridge, pedestrian bridge, etc.)
- other structures (power plants, stadiums, convention centers, airports, stations, etc.)

2.3 Technical Data
This EPD is valid for plates and sections of varied grades and different forms of delivery. Specific information on dimension tolerances, constructional data as well as mechanical and chemical properties can be found in the relevant literature and/or the standards /EN 1993/.

Constructional data

Name	Value	Unit
Density	7850	kg/m^3
Modulus of elasticity	210000	N/mm^2
Coefficient of thermal expansion	12	$10^{-6}K^{-1}$
Thermal conductivity at 20°C λ	48	W/(mK)
Melting point depending on the alloy proportions up to	1536	°C

Shear modulus	81000	N/mm^2

2.4 Placing on the market / Application rules

For the placing on the market in the European Union the Regulation (EU) No 305/2011 applies. Products need a Declaration of Performance taking into consideration the harmonized product standard /EN 10025/.
Further product standards: /ASTM A36/, /A572/, /A992/, /A913/, /A283/, /A514/, /A573/, /A588/, /A633/, /A709/ and /ASTM 1066/

For the application and use national provisions apply.

Fabrication standards: /EN 1090/, /AISC/, /AWS/

Application standards: /EN 1993 Eurocode 3/, /EN 1994 Eurocode 4/, /AISC/.
Quality control: /ISO 9001/ Monitoring according to the product standards, e.g. /EN 10025, Part 1/.

2.5 Delivery status

The dimensions of the declared products may vary according to the intended application.

2.6 Base materials / Ancillary materials

Structural steels are non-or low-alloy steel products whose carbon content is between 0 and 0.6%. Iron is the main component of steel sections and plates. The content of other elements is significantly less. The exact chemical composition varies depending on the steel grade and is characterized in the product standards listed in 2.4.
Auxiliary materials:
A. For the production route “blast furnace with basic oxygen furnace”: coking coal, coal, lime
B. For the production route “electric arc furnace”: lime
For both production routes:
aluminum, ferro alloys (ferro silocon, ferro manganese, ferro-nickel, ferro niobium, ferro vanadium, ferro titanium)
The rates of these additives are depending on the steel grade.

2.7 Manufacture

In the integrated steel production route iron ore, (typical mix based on ferro-oxides Fe2O3) coke breeze, circulating components and other additives are mixed and sintered in preparation for being fed into the blast furnace together with coking coke, the reducing agent. Also pellets and / or lump may be used.
The pig iron produced in the blast furnace is transferred into the basic oxygen furnace. In this vessel, the iron is converted into steel by lowering the carbon content of the iron by blowing oxygen into the melt (exothermic reaction). For temperature control, scrap (up to 35%) is added to the melt.
In the electric steel production route scrap is molten in an electric arc furnace to obtain liquid steel.
Refining (lowering of sulphur, phosphorous and other tramp elements) and alloying (e.g. about 1% Mn, 0.2% Si) and / or micro-alloying (e.g. about 0.01% V) is applied to give the requested characteristics to the steel.
At the end of the steelmaking process, the liquid steel is transformed into a semi finished product in a continuous casting machine, or in special cases, poured into ingot molds to form blocks.
The semi-product (slab, beam-blank, bloom or billet) is hot-rolled into the final product dimensions (heavy plate, wide flats, H-shape, I-shape, U-shape, L- shape and other merchant bars).
Quality control: /ISO 9001/ Monitoring according to the product standards, e.g. /EN 10025, Part 1/.

2.8 Environment and health during manufacturing

No measures relating to safety, health and environment protecting during the manufacturing process extending beyond national guidelines are required.

2.9 Product processing/Installation

Processing recommendations:
Planning, processing, implementation and intended use of section and plate constructions have to be carried out depending on the respective applications according to the generally recognized rules of engineering and manufacturer’s recommendations.
The standards of /EN 1993/ and /EN 1994/ (EUROCODE EC3 and EC4) apply to the design of steel structures and composite steel and concrete structures. They include the requirements regarding serviceability, bearing capacity, durability and fire resistance of steel structures (EC3) and composite steel and concrete structures (EC4).
The Standard Parts 1+2 of EN 1090 apply to the execution of steel structures and include the requirements for factory production control.
In addition, the European Standards will work in connection with national amendments, national instructions, guidelines and publications, as well as legal provisions.
Regarding transport and storage of sections and plates, the generally accepted requirements for securing loads have to be observed.
Instruction details of the manufacturer based on verified standards and guidelines regarding welding, galvanizing as well as hot and cold forming are to be observed in every case.
Occupational safety / Environmental protection:
When processing/using steel sections and plates pursuant to the generally recognized rules of engineering there are no measures to be taken which are going beyond the public occupational health and safety.
The processing/using of steel sections and plates pursuant to the generally recognized rules of engineering does not release substantial environmental pollutants. Particular measures to protect the environment are not required.
Residual material:
During processing residual pieces as well as turnings are to be separately collected. This scrap steel is entirely recycled by melting and producing new steel products.

2.10 Packaging

Structural steels are delivered unpacked.

2.11 Condition of use

Structural steels are non- /low-alloyed steel products generated by alloying iron with other metals and non-metals (esp. carbon). Iron is the main component of steel sections and plates. The components are listed under chapter 2.6 “Base materials”. During usage no changes in material composition shall occur.

2.12 Environment and health during use

The intended use of sections and plates does not hazard health or environment in any known way.

2.13 Reference service life

A reference service life for structural steel as sections and plates is not declared. As construction products with many different applications, the purpose, possible corrosion protection and adequate maintenance are decisive for service life.

2.14 Extraordinary effects

Fire
The material is class A1, i.e. not flammable per EN 13501.
The material doesn't emit fumes or fire-gases.
The critical temperature for the integrity of the structure is substantially depending on component loading and restraining conditions.
Fire safety

Name	Value
Building material class acc. DIN EN 13501-1	A1

Water
Steel is stable to water, insoluble and does not emit substances in water. In case of flooding no impacts are to be expected.
Steel can corrode in the presence of oxygen in the water (= slow oxidation).

Mechanical destruction
Thanks to the ductility of steel, steel-structures react resilient in the event of unforeseeable mechanical destruction: In case of tensile load necking will occur before cracking. In case of lasting high compression load, components of steel may buckle or bulge. No splintering or breaking edges shall result.

2.15 Re-use phase

General:
Sections and plates of steel are recyclable by 100%. Thanks to the magnetic properties of steel, 99% of the used steel is regained after dismantling /European Commission Technical Steel Research/.
Reuse:
Sections and plates can be reused. Currently, around 11% of the products are re-used after dismantling.
Recycling:
Sections and plates can be recycled without any problems after dismantling. Currently, around 88% of the products are used for closed-loop recycling.
Data from industry estimates based on the following (internal) source: /European Commission Technical Steel Research/.

2.16 Disposal

Due to its high value as a resource, steel scrap is not disposed of, but instead in a well established cycle fed to reuse or recycling. However, in case of dumping due to collection loss no environmental impacts are expected.
Waste code according to European Waste Catalogue (EWC):
17 04 05 - iron and steel

2.17 Further information

Additional information on structural steel and constructing with steel can be obtained from bauforumstahl e.V. (www.bauforumstahl.de).

3. LCA: Calculation rules

3.1 Declared Unit

The declaration refers to the functional unit of 1 t of Structural Steel: Sections and plates as specified in Part B requirements on the EPD for Structural Steel. The LCA is calculated based on averaged volume production data of the contributing plants.

Declared unit

Name	Value	Unit
Declared unit	1	t
Density	7850	kg/m^3
Conversion factor to 1 kg	0.001	-

3.2 System boundary

Type of the EPD: cradle to gate - with Options
The following processes were considered in the product stages **Modules A1-A3** of the structural steel production:

- The provision of resources, additives and energy
- Transport of resources and additives to the production site
- Production process on site including energy, production of additives, disposal of production residues, consideration of related emissions, and recycling of production scrap.

Steel scrap is assumed to reach end of waste following a sorting and shredding process that takes place at demolition sites or waste processing facilities.
Module D Reuse and recycling of structural steel at End-of-Life.

3.3 Estimates and assumptions

For all Input- and Output materials the actual transport distances were applied or assumptions were taken.

3.4 Cut-off criteria

All information from the data collection process has been considered, covering all used and registered materials, thermal energy, electrical energy and diesel consumption. Measurement of on-site emissions took place and those emissions were considered. The specific emissions that are linked to the provision of thermal and electrical energy are considered in the specific processes.
Data for different sites were cross-checked with one another to identify potential data gaps. No processes, materials or emissions that are known to make a significant contribution to the environmental impact of the products studied have been omitted. On this basis, there is no evidence to suggest that input or outputs contributing more than 1% to the overall mass or energy of the system or that are environmentally significant have been omitted.
It can be assumed, that all excluded flows contribute less than 5% to the impact assessment categories.
The manufacturing of required machinery and other infrastructure is not considered in the LCA.

3.5 Background data

As a general rule, specific data derived from specific production processes or average data derived from specific production processes shall be the first choice as a basis for calculating an EPD.

For life cycle modeling of the considered products, the GaBi 6 Software System for Life Cycle Engineering, developed by PE INTERNATIONAL AG, is used /GaBi 6 2013/. The GaBi-database contains consistent and documented datasets which can viewed in the online GaBi-documentation /GaBi 6 2013D/.
To ensure comparability of results in the LCA, the basic data of GaBi database were used for energy, transportation and auxiliary materials.

3.6 Data quality

All relevant background datasets are taken from the GaBi 6 software database. The last revision of the used data sets took place less than 8 years ago. The study is based on high quality data.

3.7 Period under review

The considered primary data for the input and output of energy and materials were collected in the year 2011/12.

3.8 Allocation

The allocation method used here was developed by the *Worldsteel* Association and *EUROFER* to be in line with /EN 15804/. The methodology is based on physical allocation and takes account of the manner in which changes in inputs and outputs affect the production of co-products. The method also takes account of material flows that carry specific inherent properties. This method is deemed to provide the most representative partitioning of the processes involved. Economic allocation was considered, as slag is considered a low-value co-product under /EN 15804/, however, as neither hot metal nor slag are tradable products upon leaving the BF, economic allocation would most likely be based on estimates. Similarly BOF slag must undergo processing before being used as a clinker or cement substitute . *Worldsteel* and *EUROFER* also highlights that companies purchasing and processing slag work on long-term contracts which do not follow regular market dynamics of supply and demand.

3.9 Comparability

Basically, a comparison or an evaluation of EPD data is only possible if all the data sets to be compared were created according to EN 15804 and the building context, respectively the product-specific characteristics of performance, are taken into account.

4. LCA: Scenarios and additional technical information

Since only Module A1-A3 and Module D are declared in the EPD, only additional technical Information for Module D is given.

Reuse, recovery- and recyclingpotential (D)

Name	Value	Unit
Recovery	99	%
Recycling	88	%
Reuse	11	%
Loss	1	%

5. LCA: Results

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARYS
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement[1)]	Refurbishment[1)]	Operational energy use	Operational water use	De-construction demolition	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	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	X

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: 1 tonne structural steel

Parameter	Unit	A1 - A3	D
Global warming potential	[kg CO_2-Eq.]	1735	-959
Depletion potential of the stratospheric ozone layer	[kg CFC11-Eq.]	1.39E-7	6.29E-9
Acidification potential of land and water	[kg SO_2-Eq.]	3.52	-1.32
Eutrophication potential	[kg $(PO_4)^{3-}$- Eq.]	3.7E-1	-1.26E-1
Formation potential of tropospheric ozone photochemical oxidants	[kg Ethen Eq.]	6.98E-1	-4.14E-1
Abiotic depletion potential for non fossil resources	[kg Sb Eq.]	2.85E-4	-1.11E-4
Abiotic depletion potential for fossil resources	[MJ]	17000	-7450

RESULTS OF THE LCA - RESOURCE USE: 1 tonne structural steel

Parameter	Unit	A1 - A3	D
Renewable primary energy as energy carrier	[MJ]	840	92.4
Renewable primary energy resources as material utilization	[MJ]	0	0
Total use of renewable primary energy resources	[MJ]	840	92.4
Non renewable primary energy as energy carrier	[MJ]	17800	-7210
Non renewable primary energy as material utilization	[MJ]	0	0
Total use of non renewable primary energy resources	[MJ]	17800	-7210
Use of secondary material	[kg]	618	375
Use of renewable secondary fuels	[MJ]	1.75E-1	-5.29E-2
Use of non renewable secondary fuels	[MJ]	1.7	-0.461
Use of net fresh water	[m^3]	2.65	-0.275

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: 1 tonne structural steel

Parameter	Unit	A1 - A3	D
Hazardous waste disposed	[kg]	2.79E-1	-2.24E-1
Non hazardous waste disposed	[kg]	51.9	-26.3
Radioactive waste disposed	[kg]	3.15E-1	9.9E-2
Components for re-use	[kg]	0	0
Materials for recycling	[kg]	0	0
Materials for energy recovery	[kg]	0	0
Exported electrical energy	[MJ]	0	0
Exported thermal energy	[MJ]	0	0

6. LCA: Interpretation

This chapter contains an interpretation of the Life Cycle Impact Assessment categories with regards to the functional unit. It focuses on the dominant contributions during the production process.

For Ozon Creation Potential (POCP), production has an impact share of around 62% while for Eutrophication Potential (EP), the impact share is around 75%, with other categories between these two values. The outlier is ODP where the production stage has a share of almost 95%. For all the considered impact categories, besides ODP, a credit can be given for the end-of-life phase.

The main contributors to ODP are R11- (trichlorofluoromethane) and R114- (dichlorotetrafluoroethane), both of which are emissions from the pre-chains of power generation processes, in particular nuclear power generation where haloalkanes are used in cooling processes. ODP is therefore related to power consumption, especially the nuclear share of the grid mix. In the primary Blast Furnace with basic oxygen furnace (BF/BOF) Route fossil fuels, particularly hard coal, are used as the main energy carrier, whereas in the scrap-dominated electric arc furnace (EAF) route electrical energy is the main energy source. The lack of a credit for ODP is explained by the fact that the EAF process used for crediting in the end-of-life phase has high power consumption, including a proportion from nuclear power and this ultimately leads to an additional load in Module D.

The following picture shows the relative contribution of

the Product stage according to PCR Part A /IBU 2011/ (Module A1-A3) and the Benefits and loads beyond the product system boundary (Module D)

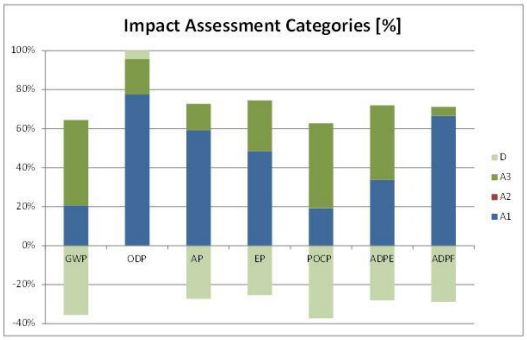

Figure: Relative contribution Module A1-A3 separated, Module D

Module A2 is not visible due to the very low contributions to each impact assessment category.

The Gobal Warming Potential (GWP) is dominated by on-site emissions associated with steelmaking processes and the production of ancillary materials/pre-products. The overall share for these processes is about 42%.

POCP is also dominated by on-site emissions and the production of ancillary materials/pre-products with a share of about 45%.

The Acidifiaction Potential (AP) is strongly dominated by the extraction and processing of raw materials and the generation of electricity, steam and heat from primary energy resources, including extraction, refining and transport, with module A1 having a total share of about 58%.

Similarly the EP is also strongly dominated by the extraction and processing of raw materials and the generation of electricity, steam and heat from primary energy resources, including extraction, refining and transport (Module A1) with a share of about 50%.

The Abiotic Depletion (elements) is dominated by the provision of auxiliary material e.g. dolomite. This is due to the fact, that the characterization factor in the CML-Methodology for dolomite is higher than metallic or mineral resources, for example iron ore.

The Abiotic Depletion Potential (fossil) is strongly dominated by the extraction and processing of raw materials and the generation of electricity, steam and heat from primary energy resources, including extraction, refining and transport (Module A1).

Total use of renewable primary energy carrier (PERT) and total use of non renewable primary energy (PENRT) are dominated by the extraction and processing of raw materials and the generation of electricity, steam and heat from primary energy resources, including extraction, refining and transport (Module A1).

For PERT module D shows a positive contribution of the Credit. This results in an additional burden from the “value of scrap”, comparable to the effect for ODP. This is caused by the different energy sources for the primary and secondary route. In the primary BF/BOF route fossil fuels, particularly hard coal, are used as the main energy carrier, whereas in the scrap-dominated EAF route electrical energy is the main energy source. The energy mix used in the secondary route contains a certain share of regenerative energy dependent on the grid mix. The lack of a credit for PERT is explained by the fact that the EAF process used for crediting in the end-of-life phase has high power consumption, including a proportion from regenerative power and this ultimately leads to an additional load in Module D. Overall the share of regenerative energy used is very low.

In general, the main contribution to primary energy in the BF/BOF route comes from the use of coal/coke as an energy and carbon source. For the EAF route, the provision of electrical energy is the main contributor.

The most significant emissions for AP and EP in the BF/BOF-Route steel making process are NOx and SOx from the sinter process. For the EAF route the main contribution comes from the provision of electrical energy.

The most significant source of emissions contributing to POCP is the BOF steel making process (BF/BOF-Route). For EAF steelmaking the main contribution comes from the provision of electrical energy.

Secondary materials are used in both steel making processes, although the BF/BOF route is mostly primary while scrap is the input to the EAF route.

Radioactive waste comes from the provision of electrical energy, especially from the share of nuclear power in the grid mix. Non-hazardous wastes include overburden and tailings. Hazardous waste for deposition is produced in small amounts during production.

7. Requisite evidence

This EPD covers semi-finished structural steel of hot-rolled construction products. Further processing and fabrication depends on the intended application. Therefore further documentation is not applicable.

7.1 Weathering performance

The rusting rate of unalloyed steel is depending on the position of the component and the conditions of the surrounding atmosphere (corrosivity categories according to /EN ISO 12944-2/).
If required, the surfaces of fabricated structural components are usually protected with anticorrosion material in order to prevent any direct contact with the atmosphere. The weathering of this protection is depending on the used protection system.

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