Manual

for the Calculation of the Product Carbon Footprint for Products of Mannstaedt GmbH

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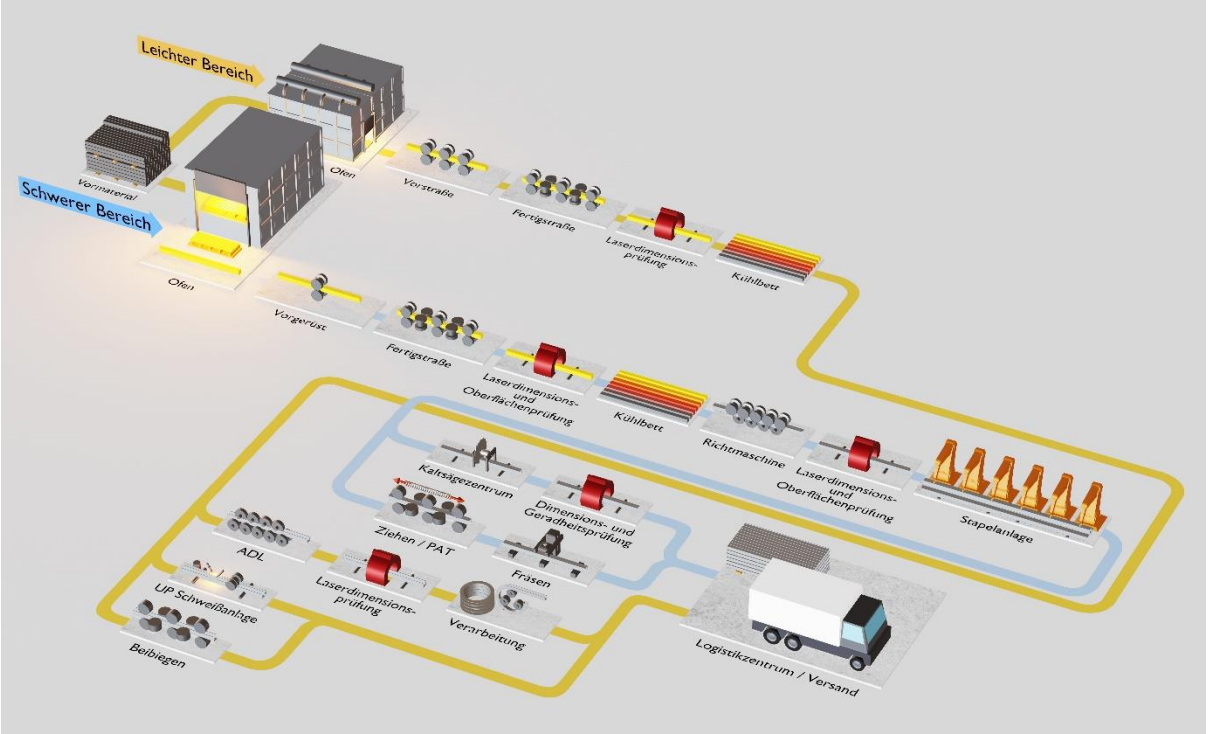
Inhalt

1 Introduction

Mannstaedt GmbH, located in Troisdorf, North Rhine-Westphalia, is the world's leading manufacturer of hot-rolled special steel profiles. As a company of the GMH Group, it supplies international industries with steel profiles that are individually tailored to the customer in terms of geometry and steel grade — from specific material properties, straightness, twist, bar or piece lengths to excellent surface quality. Application areas include the industrial truck industry, storage and conveyor technology, the automotive industry and the construction industry. A major share of the input material consists of "Green Steel" from the steel mill in Georgsmarienhütte, resulting in final special profiles with a low CO_2 footprint.

Beyond physical and chemical material properties, customers increasingly request information on the Product Carbon Footprint (PCF) of ordered products. Therefore, the sister company Georgsmarienhütte GmbH has developed and implemented a methodology to calculate this information according to ISO 14044 and ISO 14067. The objective is to compute the most accurate PCF possible for each product, based on primary data. Clustering into product groups — as practiced by some competitors — is avoided to achieve higher accuracy.



After Georgsmarienhütte GmbH developed a PCF calculation based on actual consumption data and had this methodology successfully verified by an independent third party, it was decided to implement and apply the same type of calculation at Mannstaedt GmbH.

This manual describes and explains the normative references of the methodology and its implementation in the calculation tool. The manual may be shared externally to explain the background of the complex calculation steps to customers.

Details on the calculation steps and their implementation in the organization's IT systems are contained in the annexes of this documentation. These internal annexes may only be used internally, as they provide insight into business and operational secrets.

To ensure that algorithms and data capture comply with the requirements of the relevant ISO standards, Mannstaedt GmbH intends to have the automated calculation model regularly verified by independent auditors.

2 Terms and Abbreviations

2.1.1 Product Carbon Footprint

The Product Carbon Footprint (PCF) corresponds to the quantity of greenhouse gas emissions associated with the considered product, expressed as [t CO_2e / product] or [kg CO_2e / t product]. The PCF corresponds to the CFP according to ISO 14067. The stated PCF is a partial PCF, as the organization has no knowledge of what happens to its products during further life cycle stages or the final use of the end product manufactured from the profiles.

To operationalize ISO 14067, definitions and explanations of Scope 1, Scope 2 and Scope 3 of the GHG Protocol are used for the calculation (see 2.3). The link between life-cycle stages and direct/indirect emissions corresponds to the "Product Life Cycle Accounting and Reporting Standard", Figure 1.1 of the GHG Protocol..

2.1.2 Greenhouse Gases

The PCF calculation of the organization includes the greenhouse gases CO_2, CH_4, N_2O, HFCs, PFCs, NF_3 and SF_6 according to the Kyoto Protocol. Climate impact is assessed using Global Warming Potential 100 (GWP100) according to IPCC AR6.

2.1.3 THG Emission

GHG emissions are greenhouse gases released into the atmosphere (see 2.1.2).

2.1.4 Organization

"Organization" refers exclusively to Mannstaedt GmbH at the location:

Mendener Str. 51
53840 Troisdorf.

2.1.5 Considered Emissions

In den Berechnungen des PCF werden folgende THG-Emissionen betrachtet und berechnet:

- Scope 1: direct GHG emissions
- Scope 2: indirect GHG emissions due to the direct GHG emissions of purchased and self-consumed electricity.
- Scope 3: indirect GHG emissions of the upstream supply chain.

Only the following Scope-3 emissions according to the Greenhouse Gas Protocol are considered:

- Scope 3.1: emissions from the provision of raw, auxiliary and operating materials
- Scope 3.3: energy-related upstream emissions,
- Scope 3.4: upstream products incl. transport to MWT.

2.1.6 Declared Unit

The declared unit is ton [t] of profile, related to GHG emissions in t CO_2e.

Input and output masses are expressed in tons [t], electricity in megawatt-hours [MWh], and natural gas in normal cubic meters[1] [10^3 m^3].

2.1.7 Waste

Waste includes all materials leaving the system boundary that meet the waste properties defined by the German Circular Economy Act (KrWG).

2.1.8 Supply Chain

The supply chain under consideration corresponds to the upstream supply chain.

2.1.9 Calculation Tool

The PCF calculation tool developed by the organization consists of an Oracle SQL database and a custom Qlik Sense evaluation. It is the only tool used for external PCF calculations.

2.2 Abbreviations

BImSchG	Bundes-Immissionsschutzgesetz (Federal Immission Control Act)
DEHSt	Deutsche Emissionshandelsstelle (German Emissions Trading Authority)
GHG	Greenhouse Gases
KrWG	Kreislaufwirtschaftsgesetz (Circular Economy Act)
PCF	Product Carbon Footprint

2.3 Normative Reference Documents

DIN EN ISO 14044:2006 + A1:2018

DIN EN ISO 14067:2018

Green House Gas Protocol: A Corporate Value Chain (Scope 3) Accounting and Reporting Standard

[1] T = 273,15 K, p = 1,01325 bar

3 Goal Definition

3.1 Goal of Inventory

3.1.1 Customer Requirements

For several years, the organization has increasingly been confronted with customer inquiries about the amount of greenhouse gas emissions associated with the production of a specific product of the organization. Companies wish to either pass on these values or incorporate them into their own PCF calculations.

To ensure the highest possible accuracy of the PCF for the customer, the organization has implemented a calculation model for partial PCF determination with precise allocation of input and output materials.

Since the organization has no knowledge of how the manufactured and delivered product will be used in subsequent life-cycle stages, only a partial PCF calculation can be performed.

3.1.2 Own Requirements

The GMH Group has developed its own roadmap supported by strategic objectives to achieve climate neutrality by 2039. The effects of implemented operational objectives in the process lines are digitally simulated and evaluated using the PCF calculation. By detailing the three different scopes, interactions between total emissions can be examined and undesirable developments avoided.

3.2 Boundaries of the Inventory

Various stakeholders are currently developing calculation rules for determining PCFs, some of which contain conflicting requirements. Since it is not feasible to comply with all of these specifications, the organization will continue to perform its PCF calculation on the basis of this manual until further notice. Future legal requirements will be implemented in accordance with the timelines defined for their entry into force and will be integrated into the calculation.

4 Inventory and Application

4.1 Framework of the PCF Determination

4.1.1 Typ of PCF Berechnung

The organization does not deliver products to its customers that are ready for installation or that already represent an end product for the consumer. The delivered product (see Chapters 4.1.3 and 4.1.4) is regarded as a semi-finished product. The company is generally not informed about which products the material will later be incorporated into after further processing steps. Therefore, the information provided on the PCF is exclusively a partial PCF.

4.1.2 System Boundary

In the PCF calculation, the materials and energy sources that are required and used directly for the production of the considered products within the plant are taken into account. The plant corresponds to the entire operational site of Mannstaedt GmbH,
Mendener Str. 51,

53840 Troisdorf.

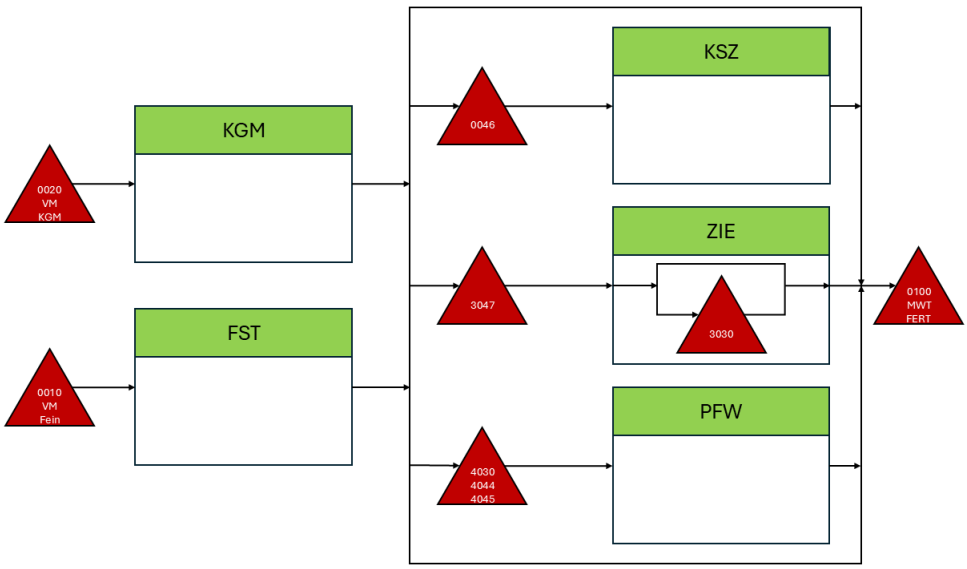
4.1.3 Products

The organization's PCF calculation program considers all special profiles manufactured within the plant boundaries of the company in 53840 Troisdorf. These include in particular:

- Forklift mast profiles
- Lock profiles
- Hinge profiles
- Anchor channel profiles
- Slewing ring profiles
- and other profiles (specialities)

4.1.4 Processes

The PCF calculation covers the operating units described below, including their individual process steps. Each operating unit outputs intermediate products, which are further processed in subsequent units within the system boundaries, or outputs final products. A PCF can be determined for each product. For the entire rolling mill, an operating permit according to BImSchG exists, which covers all process steps within the system boundaries.



4.1.4.1 KGM Mill Line

The subprocesses of the rolling mill are presented and defined in this permit. The validity of the permit is reviewed and confirmed annually through the organization's certified environmental management system (DIN EN ISO 14001:2015). The process steps consist of:

- Hearth furnace, the reheating furnace for the continuously cast billets to be rolled
- Descaling, to remove oxide layers from the heated billets
- Roughing stand
- Various Rolling Stands

- infrastructure units (summary of all material and energy flows that cannot be directly allocated).

Products leaving the KGM mill line:

- Profiles as finished product (leaving system boundary as product)
- Profiles for internal processing in the operating units:
  - KSZ
  - ZIE

4.1.4.2 Operating Unit Feinstraße

The subprocesses of the Feinstraße are covered by the rolling mill permit according to BImSchG. The process steps consist of:

- Furnace 10, the reheating furnace for the continuously cast billets to be rolled
- Descaling, to remove oxide layers from the heated billets
- Various rolling stands
- Shears, for cutting the profiles
- Infrastructure (summary of all material and energy flows that cannot be directly allocate).

Die Feinstraße verlassen als Produkt

- Profiles as finished product (leaving system boundary as product)
- Profiles for internal processing in the operating units:
  - KSZ
  - ZIE
  - PFW

4.1.4.3 Further Profil Processing (PFW)

Further processing of the rolled profiles from the KGM line and the fine rolling mill is carried out at the customer's request in the form of cold sawing (KSZ), drawing (ZIE), and additional profile finishing (PFW).

4.1.5 Period of Validity

The calculated and reported PCF is based on the current order being evaluated and the current emission factors applicable at the time of calculation.

The calculation methodology is verified annually — or immediately after any methodological change — by an independent auditor. Statements about the PCF may only be communicated to third parties using this verified methodology.

Emission factors used are updated regularly each year.

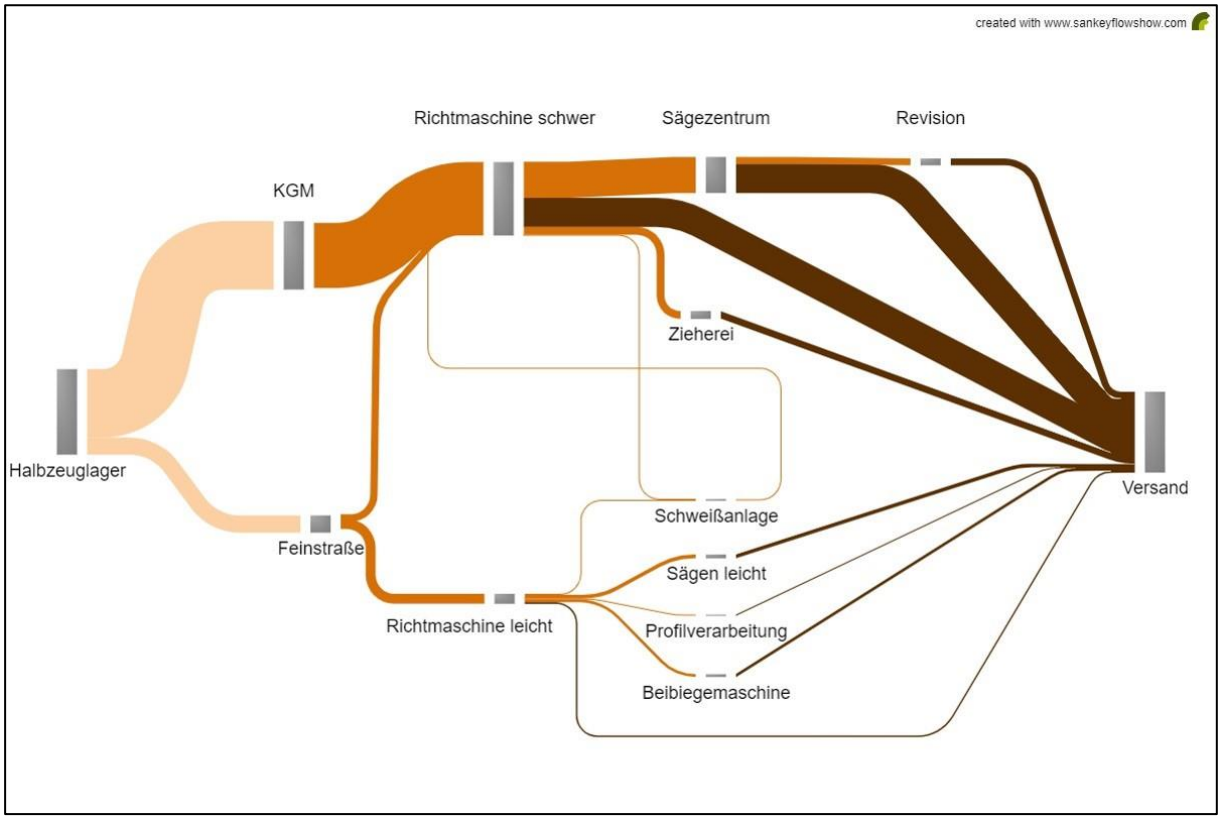
Consumption values used in the PCF calculation originate from the organization's ERP systems.

Consumption quantities directly attributable to an order relate to the specific order being calculated.

Non-directly attributable consumption quantities are represented using average values (see 5.2.3.2.3.2 "Single and Average Values").

4.1.6 Material Flow

The materials entering the production process as semi-finished products are processed exclusively at Mannstaedt GmbH. Mannstaedt GmbH does not use external service providers to process materials outside the system boundary.



Sankey diagram: Material Flow within the system boundary

4.1.6.1 Input Materials

Emission factors for Scope-1 values are, wherever possible, obtained from the current emissions reports submitted to DEHSt or the so-called DEHSt list[2]. The Scope-1 value for steel is determined based on the reported carbon content.

Emission factors for Scope-2 values for grey grid electricity correspond to the most recent notification of the electricity mix provided by the electricity supplier, which is, due to procedural

[2] DEHSt Liste: Leitfaden zur Erstellung von Überwachungsplänen und Emissionsberichten für stationäre Anlagen – 4. Handelsperiode

reasons, reported with a time delay from the transmission system operator (ÜNB). The Scope-2 emission factor for green electricity is 0 t CO_2/MWh, if the electricity is demonstrably sourced from renewable energy.

Electricity consumption is recorded on a second-by-second basis, aligned with process start and end times via the energy management system. All values since January 2022 are available as actual values.

Scope-3 values are reviewed annually and updated where necessary (see 5.2.1.3).

This usually applies when EcoInvent database revisions occurn.

4.1.6.2 Output Material

Output materials primarily consist of: rolled profiles, steel scrap and scale.

5 Methodology

5.1 General

The determination of greenhouse gas emissions is carried out within the framework of a mass balance, as described in ISO 14067. The requirements of ISO 14044 are observed accordingly.

The following applies:

$$GHG_{Totales} = \sum GHG_{Input} - \sum GHG_{Output}$$

GHG_{Total}: total greenhouse gas emissions
GHG_{Input}: possible greenhouse gas emissions of the considered input materials
GHG_{Output}: possible greenhouse gas emissions of the considered output materials

The carbon contained in the material under consideration is converted into CO_2 for the Scope-1 calculation using the factor 3.664057947 [CO_2/C].

5.2 Accounting Boundaries

The mass balance follows a cradle-to-gate approach, where:

- Cradle refers to the origin of the raw materials, auxiliary materials, operating supplies and energy used.
- Gate refers to the exit from the system boundary (loading edge of the means of transport) of the organization.

5.2.1 Handling of GHG Quantities

The emission values included in the PCF calculation encompass the greenhouse gases considered under the Kyoto Protocol (see Chapter 2.1.2).

5.2.1.1 Scope 1

Under EU-ETS reporting requirements, only direct CO_2 emissions must be reported. Therefore, the PCF calculation considers only CO_2 with the unit [t CO_2e] for Scope 1.

5.2.1.2 Scope 2

Emissions from indirect emissions of purchased electricity are provided by the electricity supplier in g CO_2/kWh. Thus, the PCF calculation uses the electricity mix with the unit t CO_2e/MWh.

If Mannstaedt GmbH generates green electricity itself and consumes it internally, this electricity is assigned an emission factor of 0 t CO_2e/MWh.

5.2.1.3 Scope 3

Emissions from purchased upstream products are based on primary data, where available. If no primary data exist, secondary default factors are used, differentiated between primary and secondary steel routes. Because no primary data for Scope-3 are currently available, secondary database values are used. The following material groups (Greenhouse Gas Protocol) are considered in the Scope-3 upstream emissions in the PCF calculation:

- Purchased goods and services (Scope 3.1)
  e.g., steel, propane, diesel, LPG.
- Energy-related upstream processes (Scope 3.3)
  e.g., electricity and natural gas
- Upstream transportation and distribution (Scope 3.4)
  e.g., transport of raw steel

5.2.2 Considered Materials and Energy

In calculating the PCF, only those materials and energy sources directly used in producing the product are considered. Emissions caused by the manufacturing of machines and equipment of the operating units are not included.

5.2.3 Data Scope and Data Quality

5.2.3.1 Data Scope

The objective of this partial PCF calculation is the most complete possible recording of all materials and energy sources required directly for manufacturing and processing the customer-ordered product. Since all mass and energy flows are digitally measured and recorded within the organization, a high data resolution is ensured. Where direct material tracking for certain production steps is not available, average values are used.

5.2.3.2 Data Origin

5.2.3.2.1 Own Data

Input and output materials are recorded via various calibrated and verified measurement systems and stored digitally in ERP systems. These measurement systems include:

- Calibrated weighbridges
- Calibrated feed-bed scales
- Calibrated electricity meters

- Calibrated and verified gas meters

Their functionality is regularly checked internally and externally.

5.2.3.2.2 Third-Party Data

Third-party data include information from external laboratories on carbon contents of input and output materials relevant for Scope-1 calculations. Suppliers provide quality documentation accepted by DEHSt for EU-ETS emissions reporting.

Scope-2 electricity information is provided by the electricity supplier. The transmission system operator calculates the electricity mix according to the BDEW guideline “Electricity Labeling Guide”. Exception: Year 2023 follows a special rule as defined in the original document.

Scope-3 information comes from scientific databases such as EcoInvent or GaBi, or governmental institutions such as the German Environment Agency (UBA). If a supplier provides upstream Scope-3 data based on its own primary data, the organization requires certification by an accredited auditing body. Scope-3 data are consolidated by the parent company GMH Gruppe SE & Co. KG and provided to Mannstaedt GmbH.

EcoInvent version 3.11.1, allocation model “Allocation at the point of substitution”, and GWP100 (IPCC 2021) are currently applied.

5.2.3.2.3 Assessment oft he Data Quality

5.2.3.2.3.1 Representativeness of Primary and Secondary Data

The calculation approach considers individual material numbers and individual work orders, not aggregated groups. To obtain representative figures for rolling-order batch evaluations, the current year is considered. Scope-1 and Scope-2 values are largely based on verified primary data, such as DEHSt emissions reporting. Thus, these scopes have high data quality. Mass quantities are based on weighed material flows, further supporting high accuracy. All emission-relevant materials such as natural gas and electricity are recorded as primary data, ensuring accurate attribution in the PCF.

The largest influence on the PCF is the steel used as semi-finished material. Since suppliers cannot currently provide delivery-specific primary data, default values for blast furnace steel, electric steel and stainless steel are applied.

Thus, data quality is not precise, but necessary due to lack of alternatives. The objective of the organization and its steel suppliers is to incorporate supplier-specific values into the calculation in the future, in order to demonstrate the transformative efforts of the upstream supplier to the customer with high data quality.

Only for continuous casting deliveries from Georgsmarienhütte GmbH is the specific PCF for the delivery, plus Scope-3 transport emissions, used — resulting in high data quality for these materials.

5.2.3.2.3.2 Single and Average Values

Where possible, order-specific single values are used — this applies when measurement systems can precisely record consumption and allocate it to the order (e.g. semi-finished materials or electricity).

Annual average values are used when consumption cannot be allocated directly to a production order. This applies primarily to natural gas, scrap and mill scale.

Natural gas has a relatively high impact on Scope 1, but consumption in the main consumers (HD furnace and Furnace 10) is relatively constant, so a rolling average over the last 12 months is a realistic approximation.

Scrap and scale have little effect due to low carbon content or low quantities.

Scope-2 values for electricity are always time-lagged, because the transmission system operator publishes the electricity mix with regulatory delay.

Scope-3 upstream data rely on database values, since suppliers generally lack primary data. The Scope-3 impact of purchased steel has the largest influence on Mannstaedt's PCF (view 5.2.3.2.3.1).

5.2.3.2.3.3 Error Assessment

Measurement errors may occur within predefined tolerances, which are regularly checked by calibration.

Potential inaccuracies from measurement errors or disturbances of individual production orders are smoothed by averaging 20 production orders, making deviations irrelevant for final data quality.

If a production order yields a PCF > 3.5 t CO_2e/t, the result is critically reviewed and potential error sources investigated. If no error is found, the calculated value is forwarded to the customer in the inspection certificate.

Due to the large number of data and measurement systems, errors cannot be completely excluded.

To counteract miscalculations, plausibility checks are performed before PCFs are issued to customers. Preventive maintenance and digital process monitoring minimize or prevent errors in operations.

5.2.4 Allocation

Die CO_2e-Emissionen werden grundsätzlich nur auf das Hauptprodukt Stahl bezogen und berechnet. Nebenprodukte und Abfälle werden nicht anteilig mit Emissionen beaufschlagt, die innerhalb der Systemgrenze und den vorgelagerten Prozessen entstehen.

Gutschriften aus vorherigen Lebenszyklusbetrachtungen werden nicht anerkannt und in der Berechnung berücksichtigt.

Alle THG-Emissionen der partiellen PCF-Berechnung beziehen sich auf die physikalische Einheit ‚Tonne'.

5.2.5 Abschneidekriterium

No cut-off criterion is applied in this partial PCF calculation. All materials that directly and intentionally flow into the product and are shown in the ERP systems are considered.

6 Reporting and Impact Assessment

6.1 General

The partial PCF applicable to the respective product is specified in detail with Scope-1, Scope-2, and Scope-3 values, using the physical units t CO_2e/t product or kg CO_2e/t product. The data is provided automatically in the factory inspection certificate. During a transitional period, the information may also be transmitted using a form filled in manually.

6.2 Evaluation of the Partial PCF

An evaluation and detailed analysis of the PCF is performed only upon customer request, as the number of annual PCF calculations does not allow for routine individual assessments.

General statements regarding GHG reductions are only partially meaningful within the considered system boundary, because it cannot be estimated to what extent an increase in GHG emissions within the boundary may enable reductions outside the boundary in subsequent life-cycle stages—especially during the use phase.

6.3 Written Form

The customer receives a written notification of the PCF of their calculated product, indicating Scope 1, 2 and 3 values in kg CO_2e/t. The values are provided as total values for the delivered product and not broken down into individual processes, as such a breakdown would disclose process-related know-how.

Evaluations and explanations of the values may be conducted with the customer upon request.

7 Critical Review

The scope and granularity of the partial PCF calculation are reviewed annually by Mannstaedt GmbH. The evaluation incorporates:

- customer feedback,
- industry perspectives, and
- political/regulatory requirements.

Based on this assessment, the management of Mannstaedt GmbH decides whether the PCF calculation is appropriate and whether it must be revised.

8 Annex

The internal data collection and database structures are described and defined as binding in the following document:

Dokumentation der PCF-Berechnung bei der Mannstaedt GmbH
Status: Dezember 2025
(T**his documentation is for internal use only and may not be passed on to third parties!**)

In contrast, the present “Manual for the Calculation of the Product Carbon Footprint for Products of Mannstaedt GmbH” is released for customers and interested parties and is publicly accessible.

Thomas Leven
02.02.2026 15:56:19 [UTC+1]