



**International
Standard**

ISO 14404-3

**Calculation method of carbon
dioxide emission intensity from
iron and steel production —**

Part 3:

**Steel plant with electric arc furnace
(EAF) and coal-based or gas-based
direct reduction iron (DRI) facility**

*Méthode de calcul de l'intensité de l'émission de dioxyde de
carbone de la production de la fonte et de l'acier —*

*Partie 3: Usine sidérurgique avec four électrique à arc (EAF)
et installation de réduction directe de la fonte (DRI) à base de
charbon ou de gaz*

**Second edition
2024-09**

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 21, *Environment related to climate change in the iron and steel industry*.

This second edition cancels and replaces the first edition (ISO 14404-3:2017), which has been technically revised.

The main changes are as follows:

- revision of Introduction, Terms and Definitions, and default emission factors;
- addition and revision of some emissions sources;
- clarification of the difference between "Boundary" and "Site boundary";
- addition a new informative annex, [Annex D](#) on "Decarbonization strategies and its impact in CO₂ Calculation Method" to give guidance on future relevant emission source categories as new materials and processes become widely applicable at industrial level.

A list of all the parts in the ISO 14404 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The steel industry recognizes the urgent need to take actions concerning climate change. Slowing and halting global warming requires reductions in GHG emissions on a global scale. To play a part in achieving these reductions, it is necessary for steel plants to identify the amount of CO₂ emitted during the production of steel products, in order to identify next opportunities for reduction of CO₂ on their pathway to decarbonization.

The production process of steel involves complex chemical reactions, various heating cycles, and the recycling of various by-products. This variety of imports, including raw materials, reactive agents, fuel and heat sources are transformed into a wide range of steel products, by-products, waste materials and waste heat.

Steel plants manufacture a vast range of products with various shapes and specifications including: flat items, long items, pipes, tubes and many others. In addition, they produce unique specialty-grade steel products with high-performance. These are achieved using a number of sub-processes including micro-alloying and applying surface treatments like galvanizing and coating, which require additional heat treatments. The variety of products manufactured, and processes used means there no two steel plants are identical.

Climate regulations in each country require steel companies to devise methods to lower CO₂ emissions from steel plants while continuing to produce steel products by these diverse and complex steelmaking processes. To accomplish this, it is desirable to have universally common indicators for determining steel plant CO₂ emissions.

Additionally, there are other aspects related to the heterogeneous nature of the steel industry around the globe other than assets characteristics, that should be taken into account (inputs availability; market and business environment, innovation), when looking for commonalities in calculation methodologies to ensure consistency and comprehensiveness.

There are many methods for calculating CO₂ emission intensity from steel plants and specific processes. Each method was created to meet the objectives of a particular country or region. In some cases, a single country can have several calculation methods in order to fulfil different objectives. Each one of these methods reflects the unique local characteristics of a particular country or region. Therefore, these methods cannot be used for comparisons of CO₂ emission intensity from steel plants located in different countries and regions.

To overcome this methodological fragmentation, the World Steel Association (worldsteel), has developed a calculation method for CO₂ emission intensity of steel plants. This calculation method was developed to facilitate the improvement of steel plant CO₂ emissions. It helps members keep track of their CO₂ emissions intensity relative to the other member steel companies located in different places in the world. An agreement was reached among members, and worldsteel has issued the method as a guideline called "CO₂ Emissions Data Collection User Guide." Actual data collection among worldsteel members based upon the guide started in 2007. Furthermore, worldsteel is encouraging even non-member steel companies to begin using the guide to calculate CO₂ emission intensity of their steel plants.

The present ISO 14404-3 revision is based on worldsteel's CO₂ Data Collection Users Guide, version 11^[4], reviewed in 2022, and follows ISO14404-4.

This calculation method establishes clear boundaries for collection of CO₂ emissions data. The net CO₂ emissions and production from a steel plant are calculated using all parameters within the boundaries. The CO₂ emission intensity of the steel plant is calculated by the net CO₂ emission from the plant using the boundaries divided by the amount of crude steel production of the plant. With this methodology, the CO₂ emission intensity of steel plants is calculated irrespective of the variance in the type of process used, products manufactured and geographic characteristics.

This calculation method only uses basic imports and exports that are commonly measured and recorded by the plants; thus, the method requires neither the measurement of the specific efficiency of individual equipment or processes nor dedicated measurements of the complex flow and recycling of materials and waste heat. In this way, the calculation method ensures its simplicity and universal applicability without requiring steel plants to install additional dedicated measuring devices or to collect additional dedicated data other than those commonly used data in the management. Even though, the use of measured carbon content and net calorific values are highly recommended to obtain more accurate emissions accounting for

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each material considered. Any home metrics needs to be referenced with link to a transparent and accessible source, including indirect emission factors. To ensure transparency in communicating results to interested parties, these distinctions should be clearly stated.

With this method, a steel company can calculate a single figure for the CO₂ emissions intensity of a steel plant as a whole. By observing changes in CO₂ emissions intensity over time using this methodology, steel companies can evaluate whether their efforts to reduce CO₂ emissions are being properly implemented. As was explained earlier, most steel plants manufacture a vast range of products with various shapes and specifications. This calculation method is simple and universally applicable because it is not affected by the differences in the production processes of such diverse products, and treats a whole steel plant as one unit with one CO₂ emission intensity. Therefore, this calculation method is not applicable for calculating and determining the carbon footprint of any specific steel product.

When comparing CO₂ emission intensity between different steel plants, it should be kept in mind that each steel plant has a different composition of manufacturing products and that the energy sources and raw materials available varies among countries and regions. In addition, since the ISO 14404 series strictly defines the boundary of the target process route for each part, only steel plants using the same part of the ISO 14404 series (i.e., ISO 14404-1, ISO 14404-2, ISO 14404-3) can be compared with each other. Note that the default emission factors provided in the ISO 14404 series are global averages and is not adjusted to reflect regional differences in energy sources and raw materials. When calculating total CO₂ emissions or CO₂ emission intensity for inventory or benchmarking purposes, the emission factors applicable to the conditions of the target country or region should be selected.

In order to give guidance to users on which areas of interest will be dealt with as future sources for direct and indirect CO₂ emission factors in programmed revisions of this document, a tentative list is provided in [Annex D](#).

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Calculation method of carbon dioxide emission intensity from iron and steel production —

Part 3:

Steel plant with electric arc furnace (EAF) and coal-based or gas-based direct reduction iron (DRI) facility

1 Scope

This document specifies calculation methods applicable to manufacturers using an electric arc furnace (EAF) to produce steel and having direct reduced iron (DRI) facilities within their premises.

This document allows the user to cover those particular cases of agglomeration of iron ore on site. It can be used to evaluate the total annual carbon dioxide (CO₂) emissions and the emission factor of CO₂ intensity of the entire steel production process. This document is applicable to plants producing mainly carbon steel.

It includes boundary definition, material and energy flow definition and emission factor of CO₂. Besides direct source import to the boundary, upstream and credit concept is applied to exhibit the plant CO₂ intensity.

This document supports the steel producer to establish CO₂ emissions attributable to a site.

Conversion to energy consumption and to consumption efficiency can be obtained using [Annex A](#).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 Emissions

3.1.1

emission source

process emitting CO₂ during the production of steel products

Note 1 to entry: There are three categories of CO₂ emission sources: direct, upstream and credit. Examples of emission sources that are subject to this document are given in [3.1.2](#), [3.1.3](#) and [3.1.4](#).

3.1.2

direct CO₂ emission

CO₂ emissions from steel production activity inside the boundary

Note 1 to entry: Direct CO₂ emission is categorized as “direct GHG emissions” in ISO 14064-1.

3.1.3

upstream CO₂ emission

CO₂ emissions from imported material related to outsourced steel production activities outside the site boundary and from imported electricity and steam into the site boundary

Note 1 to entry: CO₂ emissions from imported material in this term are categorized as “other indirect GHG emissions” in ISO 14064-1.

Note 2 to entry: CO₂ emissions from imported electricity and steam in this term are categorized as “energy indirect GHG emissions” in ISO 14064-1.

3.1.4

credit CO₂ emission

CO₂ emission that corresponds to exported material and electricity or steam

Note 1 to entry: Credit CO₂ emission is categorized as “direct GHG emissions” in ISO 14064-1.

3.2 Gas fuel

3.2.1

natural gas

mixture of gaseous hydrocarbons, primarily methane, naturally occurring on earth, and used in metallurgic plants either as a fuel or as raw material

3.2.2

town gas

fuel gas manufactured for domestic and industrial use

3.3 Liquid fuel

3.3.1

heavy oil

No. 4 and No. 6 fuel oil defined by the American Society for Testing and Materials (ASTM)

Note 1 to entry: For No.4 and No.6 fuel oil, see ASTM Fuel Oils Standard Specification.

3.3.2

light oil

No. 2 to No. 3 fuel oil defined by the American Society for Testing and Materials (ASTM)

Note 1 to entry: For No.2 and No.3 fuel oil, see ASTM Fuel Oils Standard Specification.

3.3.3

kerosene

light petroleum distillate that has maximum distillation temperature of 204 °C and a final boiling point of 300 °C

Note 1 to entry: Also known as paraffin (oil).

Note 2 to entry: U.S. Energy Information Administration, Petroleum and other liquids, units are modified.

3.3.4

liquefied natural gas

LNG

butane liquids composed predominantly of methane

[SOURCE: ISO 6578:2017, 3.1.4]

3.3.5

liquified petroleum gas

LPG

liquid composed predominantly of any of the following hydrocarbons or mixtures thereof: propane, propene, butanes and butene

[SOURCE: ISO 6578:2017. 3.1.4.]

3.4 Solid fuel

3.4.1

EAF coal

solid fuel used for an electric arc furnace *EAF* ([3.10.4](#)), including anthracite

Note 1 to entry: Coal can be either fossil coal derived from geological> deposits or biocoal derived from biomass.

3.4.2

steam coal

boiler coal for producing electricity and steam, including anthracite

Note 1 to entry: Coal can be either fossil coal derived from geological> deposits or biocoal derived from biomass.

3.4.3

coke

solid carbonaceous material

3.4.4

charcoal

devolatilized or coked carbon neutral materials

EXAMPLE Trees, plants.

3.4.5

SR/DRI coal

solid fuel used for smelting reduction (SR)/direct reduction iron (DRI), including anthracite

Note 1 to entry: Coal can be either fossil coal derived from geological> deposits or biocoal derived from biomass.

3.5 Auxiliary material

3.5.1

limestone

calcium carbonate, CaCO_3 mineral used in metallurgic plants as slag former or as raw material for *burnt lime* ([3.5.2](#))

3.5.2

burnt lime

calcium oxide

CaO

limestone ([3.5.1](#)) calcinated in blast furnaces or in lime kiln

Note 1 to entry: Usually used as slag former.

3.5.3

crude dolomite

calcium magnesium carbonate

$\text{CaMg}(\text{CO}_3)_2$

mineral used in metallurgic plants as raw material for *burnt dolomite* ([3.5.4](#))

3.5.4

burnt dolomite

CaMgO₂

crude dolomite (3.5.3) calcinated in lime kilns

Note 1 to entry: Usually used as slag former.

3.5.5

electric arc furnace graphite electrodes

EAF graphite electrodes

net use of EAF graphite electrodes or attrition loss

3.5.6

nitrogen

N₂

inert gas separated from air at an oxygen plant, imported from outside the boundary or exported to outside the boundary

3.5.7

argon

Ar

inert gas separated from air at an oxygen plant, imported from outside the boundary or exported to outside the boundary

3.5.8

oxygen

O₂

gas separated from air at an oxygen plant, imported from outside the boundary or exported to outside the boundary

3.6 Energy carriers

3.6.1

electricity

electrical power imported from outside the boundary or exported to outside the boundary

3.6.2

steam

pressurized water vapour imported from/exported to outside the boundary

3.6.3

waste heat

any heat that can be collected economically and re-used for low grade heating or even low pressure steam generation for social heating or process heating or cleaning, within the industry or other industries

3.7 Ferrous containing materials

3.7.1

pellets

agglomerated spherical iron ore calcinated by rotary kiln or other equipment

3.7.2

pig iron

hot metal, intermediate liquid iron products produced by smelting iron ore with equipment such as blast furnace.

Note 1 to entry: Many companies report emissions from purchased pig iron in solid state as metallic charge under this product category, for this specific process route.

Note 2 to entry: According to International Iron Metals Association, (IIMA) on average, pig iron makes up between 5-10 percent of the global EAF metallics charge. In some parts of the world where scrap is scarce, pig iron can be used at up to 60 percent of the charge.

3.7.3

cold iron

solidified hot metal as an intermediate solid iron product

3.7.4

scrap

used steel available for reprocessing

3.7.5

gas-based DRI

direct reduced iron (DRI) using natural gas as fuel and reduction agent.

3.7.6

coal-based DRI

direct reduced iron (DRI) using coal as fuel and reduction agent

3.8 Alloys

3.8.1

ferro-nickel

alloy of iron and nickel

3.8.2

ferro-chromium

alloy of iron and chromium

3.8.3

ferro-molybdenum

alloy of iron and molybdenum

3.8.4

ferro-manganese

alloy of iron and manganese

3.8.5

ferro-silicon

alloy of iron and silicon

3.8.6

silico-manganese

alloy of silicon and manganese

3.9 Product and by-product

3.9.1

crude steel

steel in its first solid (or usable) form

Note 1 to entry: Crude steel is the normalization unit for this calculation methodology.

Note 2 to entry: Crude steel examples are ingots and semi-finished products (billets, blooms, slabs) defined by Steel Statistical Yearbook.

3.9.2

CO₂ for external use

CO₂ exported to outside the boundary

3.10 Others

3.10.1

other emission source

other related *emission sources* ([3.1.1](#)) such as plastics, scraps, desulfurization additives, alloys, fluxes for secondary metallurgy, dust, sludges, etc., that can be used if not covered by any other specific source

3.10.2

boundary

limit of activity used to calculate CO₂ emissions intensity for steel production activities

Note 1 to entry: Boundary may be different from site boundary.

Note 2 to entry: Major facilities in iron and steel production in boundaries are given in [3.10.4](#) to [3.10.13](#).

3.10.3

site boundary

boundary defined by the target steel production site for the calculation of CO₂ emission and intensity

3.10.4

EAF

electric arc furnace

furnace that melts and refines iron-bearing material into steel

Note 1 to entry: It can include ladle furnace; degassing; alloying station, as minor related emission sources. It should not be assimilated to an EAF steel plant defined as a comprehensive production unit.

3.10.5

casting

pouring steel directly from a ladle through a tundish into a mould shaped to form billets, blooms or slabs, or pouring steel from a ladle into a mould shaped to form ingots

3.10.6

lime kiln

kiln used to produce *burnt lime* ([3.5.2](#)) by calcination of *limestone* ([3.5.1](#))

3.10.7

oxygen plant

cryogenic air separator to produce high-purity oxygen or other alternative technologies, such as hydrogen electrolysis plants

3.10.8

steam boiler

device to generate pressurized water vapour from heat

3.10.9

power plant

plant that generates electricity

3.10.10

hot rolling

rolling at temperatures above the recrystallisation temperature, normally above 500 °C

3.10.11

cold rolling

rolling at temperatures below the recrystallisation temperature, normally below 500 °C

3.10.12

coating

applying a protective layer to steel using various methods, such as galvanising, among others

Note 1 to entry: Coating materials may include tin, chrome, zinc, and other non-metallic materials, such as paints, etc.

3.10.13

iron ore agglomeration facility

plant for agglomeration and thermal treatment to convert the raw fine iron ore into spherical pellets with characteristics appropriate for use in a DRI production facility

4 Symbols

For the purposes of this document, the symbols given in [Table 1](#) apply.

Table 1 — Symbols

Symbols	Unit	Description
E_{d,CO_2}	Tons (or tonnes) of CO ₂	Direct CO ₂ emissions
E_{u,CO_2}	Tons (or tonnes) of CO ₂	Upstream CO ₂ emissions
E_{c,CO_2}	Tons (or tonnes) of CO ₂	Credit CO ₂ emissions
$E_{CO_2,annual}$	Tons (or tonnes) of CO ₂	Annual CO ₂ emissions
I_{CO_2}	Tons (or tonnes) of CO ₂ per ton	CO ₂ intensity factor
K_{t,d,CO_2}	Tons (or tonnes) of CO ₂ per unit	Emission factor for calculation of direct CO ₂ emissions
K_{t,u,CO_2}	Tons (or tonnes) of CO ₂ per unit	Emission factor for calculation of upstream CO ₂ emissions
K_{t,c,CO_2}	Tons (or tonnes) of CO ₂ per unit	Emission factor for calculation of credit CO ₂ emissions
P	tons (or tonnes)	Annual crude steel product ion
Q_{t,d,CO_2}	—	Quantities of direct CO ₂ emission sources
Q_{t,u,CO_2}	—	Quantities of upstream CO ₂ emission sources
Q_{t,c,CO_2}	—	Quantities of credit CO ₂ emission sources

5 Principles

5.1 General

The application of principles is a base to ensure that the calculated CO₂ intensity is effectively usable for steel producers to assess the efficiency of their production site universally without specificity of product configurations, location of site, and individual facility used in the site.

5.2 Relevance

Select all the direct source, upstream source and credits into and out of the boundary of steel production site, as well as data and methodologies that are appropriate to achieve the intended purpose.

5.3 Completeness

Include all the relevant imports to and exports from sources and credits to steel production site to calculate CO₂ intensity of steel production site.

5.4 Consistency

Enable universally meaningful assessment in CO₂ intensity of steel production site regardless of the product configurations, location of the site and individual facilities used in the site.

5.5 Accuracy

Reduce bias and uncertainties of the data being collected and used for the calculation and methodologies of the calculations as much as appropriate.

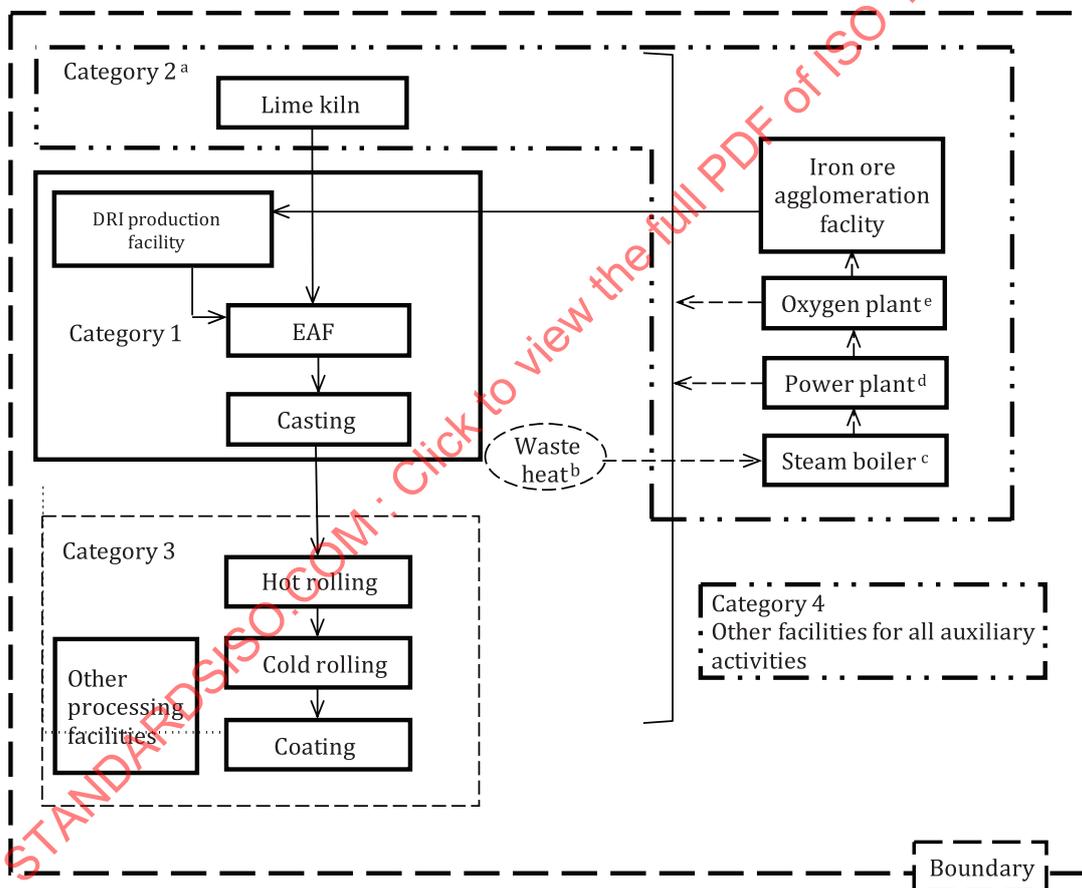
5.6 Transparency

Disclose the CO₂ calculation method, including emission factors – specifying if either default or actual site/supply chain values were used -, to allow every steel producer to assess universally its CO₂ intensity of steel production site.

6 Boundary

6.1 General

This calculation method defines the boundary applied to the calculation of CO₂ emissions of the steel production in terms of essential facilities as shown in [Figure 1](#). These essential facilities are categorized into four groups, as discussed in [6.2](#) to [6.5](#).



- a Equipment that can be outsourced.
- b The materials in the dotted circles are by-products, and the dotted arrows show the flow of by-product reuse.
- c Steam boilers reuse waste heat from the production facilities to produce steam.
- d Power plants use steam and by-product gas to generate electricity to supply power to oxygen plants and Category 1~3 facilities.
- e Oxygen plants supply oxygen to Category 1~3 facilities.

Figure 1 — Essential facilities within the boundary

6.2 Category 1

The following essential facilities are classified as category 1. These facilities shall be included in the site.

- Gas-based or coal-based DRI production facility.
- EAF.
- Casting.

NOTE EAF can include ladle furnace, degassing, alloying station, etc.

6.3 Category 2

The following facilities are classified as category 2. The operation of these facilities may be performed on-site or outsourced. In the case where operations are outsourced, intermediate products from these operations are imported and these upstream CO₂ emissions shall be calculated.

- Lime kiln.
- Oxygen plant.
- Power plant.
- Steam boiler.
- Iron ore agglomeration facility (only applicable to those specific cases having pellet production plants on site)

6.4 Category 3

The following processing facilities are classified as category 3. CO₂ emission from these facilities at the site shall be calculated.

- Hot rolling.
- Cold rolling.
- Coating.
- Other processing facilities.

6.5 Category 4

Other facilities for all auxiliary activities are classified as category 4. CO₂ emission from these facilities in the site, if any, shall be calculated.

EXAMPLE Office, on-site transport, etc.

7 Calculation

7.1 General

The calculations for a site producing crude steel are made as follows.

- Step 1: Identify the categories of processing facilities.
- Step 2: Clarify the quantity of annual crude steel production at the plant.
- Step 3: Clarify the annual direct CO₂ emission sources and upstream CO₂ emission sources based on raw materials, intermediate products and energy import to the plant.

- d) Step 4: Clarify the annual credit CO₂ emission sources based on raw materials, intermediate products and energy which the plant exports to external users.
- e) Step 5: Calculate the annual CO₂ emissions and CO₂ factor using the emission factors.

7.2 Calculation procedure

7.2.1 Data collection of crude steel production

A plant producing steel records its annual production of crude steel (*P*).

7.2.2 Data collection direct and/or upstream CO₂ emission sources

A plant producing steel records the quantities of raw materials, intermediate products and energy that are imported from outside suppliers as the direct or upstream CO₂ emission sources based on [Table 2](#).

Table 2 — Direct and/or upstream CO₂ emission sources

Subscript designator for Q_t	Emission sources	Unit	Quantities of direct emission source Q_{t,d,CO_2}	Quantities of upstream emission source Q_{t,u,CO_2}
Gas fuel				
1	Natural gas	10 ^{3a} m ³ (stp ^b)	Q_{1,d,CO_2}	N/A ^c
2	Town gas	10 ³ m ³ (stp)	Q_{2,d,CO_2}	N/A
Liquid fuel				
3	Heavy oil	m ³	Q_{3,d,CO_2}	N/A
4	Light oil	m ³	Q_{4,d,CO_2}	N/A
5	Kerosene	m ³	Q_{5,d,CO_2}	N/A
6	Liquefied petroleum gas	t	Q_{6,d,CO_2}	N/A
7	Liquefied natural gas	10 ³ m ³ (stp)	Q_{7,d,CO_2}	N/A
Solid fuel				
8	EAF coal	dry t	Q_{8,d,CO_2}	N/A
9	Steam coal	dry t	Q_{9,d,CO_2}	N/A
10	Coke	dry t	Q_{10,d,CO_2}	N/A
11	Charcoal	dry t	Q_{11,d,CO_2}	N/A
12	SR/DRI coal	dry t	Q_{12,d,CO_2}	N/A
Auxiliary materials				
13	Limestone	dry t	Q_{13,d,CO_2}	N/A
14	Burnt lime	t	N/A	Q_{14,u,CO_2}
15	Crude dolomite	dry t	Q_{15,d,CO_2}	N/A
16	Burnt dolomite	t	N/A	Q_{16,u,CO_2}
17	EAF graphite electrodes	t	Q_{17,d,CO_2}	N/A
18	Nitrogen	10 ³ m ³ (stp)	N/A	Q_{18,u,CO_2}

NOTE Raw materials that are recorded as both direct and upstream CO₂ emission sources are handled similarly as both direct and upstream CO₂ emissions sources when calculating CO₂ emissions.

^a 10³=1 000.

^b Standard temperature and pressure.

^c Not applicable.

Table 2 (continued)

Subscript designator for Q_t	Emission sources	Unit	Quantities of direct emission source Q_{t,d,CO_2}	Quantities of upstream emission source Q_{t,u,CO_2}
19	Argon	10 ³ m ³ (stp)	N/A	Q_{19,u,CO_2}
20	Oxygen	10 ³ m ³ (stp)	N/A	Q_{20,u,CO_2}
Energy carriers				
21	Electricity	MWh	N/A	Q_{21,u,CO_2}
22	Steam	t	N/A	Q_{22,u,CO_2}
Ferrous-containing material				
23	Pellets	t	N/A	Q_{23,u,CO_2}
24	Cold Iron	t	Q_{24,d,CO_2}	Q_{24,u,CO_2}
25	Gas-based DRI	t	Q_{25,d,CO_2}	Q_{25,u,CO_2}
26	Coal-based DRI	t	Q_{26,d,CO_2}	Q_{26,u,CO_2}
27	Pig iron	t	Q_{27,d,CO_2}	Q_{27,u,CO_2}
28	Iron ore	t	Q_{28,d,CO_2}	Q_{28,u,CO_2}
Alloys				
29	Ferro-nickel	t	Q_{29,d,CO_2}	N/A
30	Ferro-chromium	t	Q_{30,d,CO_2}	N/A
31	Ferro-molybdenum	t	Q_{31,d,CO_2}	N/A
32	Ferro-manganese	t	Q_{32,d,CO_2}	N/A
33	Ferro-silicon	t	Q_{33,d,CO_2}	N/A
34	Silico-manganese	t	Q_{34,d,CO_2}	N/A
Other imported materials				
35	CO ₂ for internal use	t	Q_{35,d,CO_2}	N/A
N	Other emission sources	—	Q_{N,d,CO_2}	Q_{N,u,CO_2}
NOTE Raw materials that are recorded as both direct and upstream CO ₂ emission sources are handled similarly as both direct and upstream CO ₂ emissions sources when calculating CO ₂ emissions.				
a 10 ³ =1 000.				
b Standard temperature and pressure.				
c Not applicable.				

7.2.3 Data collection of credit CO₂ emission sources

A plant producing steel records the quantities of raw materials, intermediate products and energy that it exports to outside users as the credit CO₂ emission sources based on [Table 3](#).

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Table 3 — Credit CO₂ emission sources

Subscript designator for Q _t	Emission sources	Unit	Quantities of credit emission source Q _t , c, CO ₂
Gas fuel			
1	Natural gas	10 ³ a m ³ (stp ^b)	Q ₁ , c, CO ₂
2	Town gas	10 ³ m ³ (stp)	Q ₂ , c, CO ₂
Liquid fuel			
3	Heavy oil	m ³	Q ₃ , c, CO ₂
4	Light oil	m ³	Q ₄ , c, CO ₂
5	Kerosene	m ³	Q ₅ , c, CO ₂
6	Liquefied petroleum gas	t	Q ₆ , c, CO ₂
7	Liquefied natural gas	10 ³ m ³ (stp)	Q ₇ , c, CO ₂
Solid fuel			
8	EAF coal	dry t	Q ₈ , c, CO ₂
9	Steam coal	dry t	Q ₉ , c, CO ₂
10	Coke	dry t	Q ₁₀ , c, CO ₂
11	Charcoal	dry t	Q ₁₁ , c, CO ₂
12	SR/DRI coal	dry t	Q ₁₂ , c, CO ₂
Auxiliary materials			
13	Limestone	dry t	Q ₁₃ , c, CO ₂
14	Burnt lime	t	Q ₁₄ , c, CO ₂
15	Crude dolomite	dry t	Q ₁₅ , c, CO ₂
16	Burnt dolomite	t	Q ₁₆ , c, CO ₂
17	EAF graphite electrodes	t	Q ₁₇ , c, CO ₂
18	Nitrogen	10 ³ m ³ (stp)	Q ₁₈ , c, CO ₂
19	Argon	10 ³ m ³ (stp)	Q ₁₉ , c, CO ₂
20	Oxygen	10 ³ m ³ (stp)	Q ₂₀ , c, CO ₂
Energy carriers			
21	Electricity	MWh	Q ₂₁ , c, CO ₂
22	Steam	t	Q ₂₂ , c, CO ₂
Ferrous-containing material			
23	Pellets	t	Q ₂₃ , c, CO ₂
24	Cold Iron	t	Q ₂₄ , c, CO ₂
25	Gas-based DRI	t	Q ₂₅ , c, CO ₂
26	Coal-based DRI	t	Q ₂₆ , c, CO ₂
27	Pig iron	t	Q ₂₇ , c, CO ₂
28	Iron ore	t	Q ₂₈ , c, CO ₂
Alloys			
29	Ferro-nickel	t	Q ₂₉ , c, CO ₂
30	Ferro-chromium	t	Q ₃₀ , c, CO ₂
31	Ferro-molybdenum	t	Q ₃₁ , c, CO ₂
32	Ferro-manganese	t	Q ₃₂ , c, CO ₂
33	Ferro-silicon	t	Q ₃₃ , c, CO ₂
34	Silico-manganese	t	Q ₃₄ , c, CO ₂
<p>^a 10³ = 1 000.</p> <p>^b Standard temperature and pressure.</p>			

Table 3 (continued)

Subscript designator for Q_t	Emission sources	Unit	Quantities of credit emission source Q_t, c, CO_2
Other exported materials			
35	CO ₂ for external use	t	Q_{35}, c, CO_2
N	Other emission sources	-	Q_N, c, CO_2
^a 10 ³ = 1 000. ^b Standard temperature and pressure.			

7.2.4 Calculation

The annual CO₂ emissions ($E_{CO_2,annual}$) and CO₂ intensity (I_{CO_2}) of a site are calculated from [Formula \(1\)](#) and [Formula \(2\)](#) using emission factors that correspond to the direct CO₂ emission sources, upstream CO₂ emission sources and credit CO₂ emission sources recorded as specified in [7.2.2](#) and [7.2.3](#):

A calculation example is shown in [Annex C](#).

$$E_{CO_2,annual} = \sum_{t=1}^N K_{t,d,CO_2} \times Q_{t,d,CO_2} + \sum_{t=1}^N K_{t,u,CO_2} \times Q_{t,u,CO_2} - \sum_{t=1}^N K_{t,c,CO_2} \times Q_{t,c,CO_2} \quad (1)$$

$$I_{CO_2} = E_{CO_2,annual} / P \quad (2)$$

[Table 4](#) gives an indication of emission factors that can be used if no other reliable data are available.

It is considered that the emissions associated with the carbon content of steel scrap, the final recarburants used to match the final composition of the steel are equivalent to the final steel grades produced and the carbon which is contained in the slag and dust. Therefore, steel scrap is considered to have an emission factor of zero and has been left out of the table.

Table 4 — Indicative CO₂ emission factors for CO₂ emission sources

Subscript designator for Q_t	CO ₂ emission source	Direct emission factor (K_{t,d,CO_2}) t CO ₂ /unit	Upstream emission factor (K_{t,u,CO_2}) t CO ₂ /unit	Credit emission factor (K_{t,c,CO_2}) t CO ₂ /unit
Gas fuel				
1	Natural gas	2,015	N/A	2,015
2	Town gas	2,015	N/A	2,015
Liquid fuel				
3	Heavy oil	2,907	N/A	2,907
4	Light oil	2,601	N/A	2,601
5	Kerosene	2,481	N/A	2,481
6	Liquefied petroleum gas	2,985	N/A	2,985
7	Liquefied natural gas	2,015	N/A	2,015
Solid fuel				
8	EAF coal	3,257	N/A	3,257

NOTE If different emission factors or simplifications from [Table 4](#) are applied, such emission factors or simplifications should be identified and justified. If another emission sources specified in No. N of [Table 4](#) are applied, such sources should be clearly identified with their emission factors. An example of a template is available in [Table B.1](#) of [Annex B](#).

^a The value shall be determined by using available data backed by reliable evidence.

Table 4 (continued)

Subscript designator for Q_t	CO ₂ emission source	Direct emission factor (K_{t,d,CO_2}) t CO ₂ /unit	Upstream emission factor (K_{t,u,CO_2}) t CO ₂ /unit	Credit emission factor (K_{t,c,CO_2}) t CO ₂ /unit
9	Steam coal	2,462	N/A	2,462
10	Coke	3,257	N/A	3,257
11	Charcoal	0,000	N/A	0,000
12	SR/DRI coal	2,953	N/A	2,953
Auxiliary materials				
13	Limestone	0,440	N/A	0,440
14	Burnt lime	N/A	0,950	0,950
15	Crude dolomite	0,476	N/A	0,476
16	Burnt dolomite	N/A	1,100	1,100
17	EAF graphite electrodes	3,663	N/A	3,663
18	Nitrogen	N/A	0,103	0,103
19	Argon	N/A	0,103	0,103
20	Oxygen	N/A	0,355	0,355
Energy carriers				
21	Electricity	N/A	0,504	0,504
22	Steam	N/A	0,195	0,195
Ferrous-containing material				
23	Pellets	N/A	0,137	0,137
24	Cold Iron	0,172	1,855	2,027
25	Gas-based DRI	0,073	0,780	0,853
26	Coal-based DRI	0,073	1,210	1,283
27	Pig iron	0,172	1,855	2,027
28	Iron ore	0,037	N/A	0,037
Alloys				
29	Ferro-nickel	0,037	N/A	0,037
30	Ferro-chromium	0,275	N/A	0,275
31	Ferro-molybdenum	0,018	N/A	0,018
32	Ferro-manganese	0,183	N/A	0,183
33	Ferro-silicon	0,004	N/A	0,004
34	Silico-manganese	0,018	N/A	0,018
Other imported/exported materials				
35	CO ₂ for internal/external use	1,000	N/A	1,000
<i>N</i>	Other emission sources	<i>a</i>	<i>a</i>	<i>a</i>
NOTE If different emission factors or simplifications from Table 4 are applied, such emission factors or simplifications should be identified and justified. If another emission sources specified in No. <i>N</i> of Table 4 are applied, such sources should be clearly identified with their emission factors. An example of a template is available in Table B.1 of Annex B.				
^a The value shall be determined by using available data backed by reliable evidence.				

Annex A (informative)

Calculation of energy consumption and intensity

The annual energy consumption, $C_{E,annual}$, and intensity, I_E , at a plant manufacturing steel using electric arc furnace can be calculated from [Formulae \(A.1\)](#) and [\(A.2\)](#) using Q_{t,d,CO_2} , Q_{t,u,CO_2} and Q_{t,c,CO_2} collected as explained in [7.2.2](#) and [7.2.3](#), and the energy conversion factors ($K_{t,d,E}$, $K_{t,u,E}$, and $K_{t,c,E}$):

$$C_{E,annual} = \sum_{t=1}^N K_{t,d,E} \times Q_{t,d,CO_2} + \sum_{t=1}^N K_{t,u,E} \times Q_{t,u,CO_2} - \sum_{t=1}^N K_{t,c,E} \times Q_{t,c,CO_2} \quad (A.1)$$

$$I_E = \frac{C_{E,annual}}{P} \quad (A.2)$$

where

- Q_{t,d,CO_2} are the quantities of direct CO₂ emission sources;
- Q_{t,u,CO_2} are the quantities of upstream CO₂ emission sources;
- Q_{t,c,CO_2} are the quantities of credit CO₂ emission sources;
- $K_{t,d,E}$ is the energy conversion factor for calculation of direct energy consumption;
- $K_{t,u,E}$ is the energy conversion factor for calculation of upstream energy consumption;
- $K_{t,c,E}$ is the energy conversion factor for calculation of credit energy consumption;
- I_E is the energy intensity factor;
- $C_{E,annual}$ is the annual energy consumption;
- P is the annual crude steel production.

NOTE Energy conversion factors for CO₂ emission sources are referred to in worldsteel CO₂ emissions data collection [\[4\]](#).

Additionally, upstream/credits factors for some materials should be dependent of electricity grid mix factor. The following formula guiding this assumption is provided by worldsteel.

For CO₂ emission sources :

- steam;
- oxygen;
- nitrogen;
- argon;
- waste heat.

Upstream K_{t,u,CO_2} and Credit K_{t,c,CO_2} emission factors are a function of the applicable Upstream emission factor for electricity.

$$K_{t,c,co_2} = K_{t,c,E} \times \frac{K_{20,c,co_2}}{K_{20,c,E}}$$

$$K_{t,u,co_2} = K_{t,u,E} \times \frac{K_{20,u,co_2}}{K_{20,u,E}}$$

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Annex B
(informative)

Example of template for using different emission factors or emission sources from [Table 4](#)

Table B.1 — Indicative emission factors for CO₂ emission sources

Subscript designator for Q_t	CO ₂ emission source	Direct emission factor (K_{t,d,CO_2}) t CO ₂ /unit	Upstream emission factor (K_{t,u,CO_2}) t CO ₂ /unit	Credit emission factor (K_{t,c,CO_2}) t CO ₂ /unit	Justification
Gas fuel					
1	Natural gas				
2	Town gas				
Liquid fuel					
3	Heavy oil				
4	Light oil				
5	Kerosene				
6	Liquefied petroleum gas				
7	Liquefied natural gas				
Solid fuel					
8	EAF coal				
9	Steam coal				
10	Coke				
11	Charcoal				
12	SR/DRI coal				
Auxiliary materials					
13	Limestone				
14	Burnt lime				
15	Crude dolomite				
16	Burnt dolomite				
17	EAF graphite electrodes				
18	Nitrogen				
19	Argon				
20	Oxygen				
Energy carriers					
21	Electricity				
22	Steam				
Ferrous-containing material					
23	Pellets				

Table B.1 (continued)

Subscript designator for Q_t	CO ₂ emission source	Direct emission factor (K_{t,d,CO_2}) t CO ₂ /unit	Upstream emission factor (K_{t,u,CO_2}) t CO ₂ /unit	Credit emission factor (K_{t,c,CO_2}) t CO ₂ /unit	Justification
24	Cold Iron				
25	Gas-based DRI				
26	Coal-based DRI				
27	Pig iron				
28	Iron ore				
Alloys					
29	Ferro-nickel				
30	Ferro-chromium				
31	Ferro-molybdenum				
32	Ferro-manganese				
33	Ferro-silicon				
34	Silico-manganese				
Other imported/exported materials					
35	CO ₂ for internal/external use				

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