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

**Part 1:
Steel plant with blast furnace**

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

Partie 1: Usine sidérurgique avec fourneau



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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14404-1 was prepared by Technical Committee ISO/TC 17, *Steel*.

ISO 14404 consists of the following parts, under the general title of *Calculation method of carbon dioxide emission intensity from iron and steel production*:

Part 1: Steel plant with blast furnace

Part 2: Steel plant with electric arc furnace (EAF)

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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.

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 wide range of steel products, by-products, waste materials and waste heat.

Steel plants manufacture various products including: sheet products, plate products, long products, pipe and tubes and many other types of products. In addition, steel plants produce unique speciality grade steel products with high-performance, which are achieved by various sub-processes including micro-alloying and applying surface treatments like galvanizing and coating that require additional heat treatments. Therefore, none of the steel plants in the world is exactly 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.

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

The World Steel Association (worldsteel), which consists of more than 130 major steel companies in 55 countries and regions of the world, has been working on the development of a calculation method for CO₂ emission intensity of steel plants to facilitate steel plant CO₂ emissions improvement by the objective comparison of the intensity among the member companies' steel plants located in various 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.

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 equipments 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 commonly used data in the management of plants. However, because different regions have different energy sources and raw materials available to them, the resulting calculations cannot be used to determine a benchmark or best in class across regions.

With this method, a steel company can calculate a single figure for the CO₂ emissions intensity of a plant as a whole. As was explained earlier, most steel plants manufacture vast range of products with various shapes and specifications. This calculation method ensures the simplicity and universal applicability by not accommodating 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. Also, and for this reason, this method can be used neither for establishing caps or benchmarks for emissions under emissions trading scheme in any specific local or regional economic system, nor for the generation of CO₂ data that would allow a comparison of CO₂ intensities of production processes that are operated inside the site.

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

Part 1: Steel plant with blast furnace

1 Scope

This part of ISO 14404 specifies calculation methods for the carbon dioxide (CO₂) intensity of plant where steel is produced through a blast furnace.

NOTE The steel plant is generally called “the integrated steel works”.

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 part of ISO 14404 supports the steel producer to establish CO₂ emissions attributable to a site. This part of ISO 14404 cannot be used to calculate benchmarks or to compare CO₂ intensities of production processes that are operated inside the site.

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

2 Terms and definitions

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

2.1 Emissions

2.1.1

emission source

process emitting CO₂ during 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 part of ISO 14404 are given in 2.1.2, 2.1.3 and 2.1.4.

2.1.2

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.

2.1.3

upstream CO₂ emission

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

Note 1 to entry: Possible outsourced activities are, for example, production of coke, burnt lime, burnt dolomite, pellet, sintered ore, hot metal, cold iron, direct reduced iron, oxygen, nitrogen and argon.

Note 2 to entry: CO₂ emissions from imported material in this term is categorized as “other indirect GHG emissions” in ISO 14064-1.

Note 3 to entry: CO₂ emissions from imported electricity and steam in this term are categorized as “energy indirect GHG emissions” in ISO 14064-1.

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2.1.4

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.

2.2 Gas fuel

2.2.1

natural gas

mixture of gaseous hydrocarbons, primarily methane, occurring naturally in the earth and used principally as a fuel

2.2.2

coke oven gas

COG

gas recovered from coke oven

2.2.3

blast furnace gas

BFG

gas recovered from blast furnace

2.2.4

BOF gas

LDG

gas recovered from basic oxygen furnace (Linze Donawitz converter)

Note 1 to entry: BOF: basic oxygen furnace

2.3 Liquid fuel

2.3.1

heavy oil

No. 4- No. 6 fuel oil defined by ASTM

Note 1 to entry: ASTM: American Society for Testing and Materials

2.3.2

light oil

No. 2- No. 3 fuel oil defined by ASTM

2.3.3

kerosene

paraffin (oil)

2.3.4

LPG

liquefied petroleum gas

2.4 Solid fuel

2.4.1

coking coal

coal for making coke, including anthracite

2.4.2**BF injection coal**

pulverized coal injection (PCI) coal, including anthracite

Note 1 to entry: BF: blast furnace

2.4.3**sinter coal****BOF coal**

coal for sinter/BOF, including anthracite

2.4.4**steam coal**

boiler coal for producing electricity and steam, including anthracite

2.4.5**coke**

solid carbonaceous material

2.4.6**charcoal**

devolatilized or coked carbon neutral materials

EXAMPLE Trees, plants.

2.5 Auxiliary material**2.5.1****limestone**

calcium carbonate, CaCO_3

2.5.2**burnt lime**

CaO

2.5.3**crude dolomite**

calcium magnesium carbonate, $\text{CaMg}(\text{CO}_3)_2$

2.5.4**burnt dolomite**

CaMgO_2

2.5.5**nitrogen**

N_2

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

2.5.6**argon**

Ar

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

2.5.7**oxygen**

O_2

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

2.6 Energy carriers

2.6.1

electricity

electricity imported from outside the boundary or exported to outside the boundary

2.6.2

steam

pressurized water vapour imported from/exported to outside the boundary

2.7 Ferrous containing materials

2.7.1

pellets

agglomerated spherical iron ore calcinated by rotary kiln

2.7.2

sinter

bulk iron ore sintered by baking mixture of fine iron ore, coke breeze and pulverized lime

2.7.3

hot metal

intermediate liquid iron products containing 3 % to 5 % by mass carbon produced by smelting iron ore with equipment such as blast furnace

2.7.4

cold iron

solidified hot metal as an intermediate solid iron products

2.7.5

gas-based DRI

direct reduced iron (DRI) reduced by a reducing gas such as reformed natural gas

2.7.6

coal-based DRI

direct reduced iron (DRI) reduced by coal

2.8 Alloys

2.8.1

ferro-nickel

alloy of iron and nickel

2.8.2

ferro-chromium

alloy of iron and chromium

2.8.3

ferro-molybdenum

alloy of iron and molybdenum

2.9 Product and by-product

2.9.1

CO₂ for external use

CO₂ exported to outside the boundary

2.9.2**coal tar**

by-products of the carbonization of coal to coke, containing complex and variable mixtures of phenols and polycyclic aromatic hydrocarbons

2.9.3**coal light oil****benzole**

light oil recovered by COG gas purification, consisting mainly of benzene, toluene and xylene (BTX)

2.9.4**BF slag to cement**

blast furnace slag supplied to cement industry

2.9.5**BOF slag to cement**

BOF slag supplied to cement industry

2.10 Others**2.10.1****other emission source**

other related emission sources such as plastics, scraps, desulfurization additives, graphite electrodes, alloys, fluxes for secondary metallurgy, dust, sludges, etc.

2.10.2**boundary**

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

Note 1 to entry: Generally, the boundary is set to be the same as the site boundary.

Note 2 to entry: Major facilities in iron and steel production in boundaries are given in 2.10.2.1 to 2.10.2.13.

2.10.2.1**blast furnace****BF**

vertical shaft furnace for producing hot metal from iron ore

2.10.2.2**basic oxygen furnace****BOF**

vessel where hot metal from blast furnace and scrap is converted into molten steel using oxygen

2.10.2.3**casting**

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

2.10.2.4**sinter plant**

plant used to produce a fused clinker-like aggregate or sinter of fine iron-bearing materials suited for use in a blast furnace

2.10.2.5**pellet plant**

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

2.10.2.6**lime kiln**

kiln used to produce burnt lime by the calcination of limestone (calcium carbonate)

2.10.2.7

coke oven

oven for the conversion of coal into coke by heating the coal in the absence of air to distill the volatile ingredients

2.10.2.8

oxygen plant

cryogenic air separator to produce high-purity oxygen

2.10.2.9

steam boiler

boiler for production of steam

2.10.2.10

power plant

plant that generates electricity

2.10.2.11

hot rolling

rolling at elevated temperature

2.10.2.12

cold rolling

rolling at room temperature

2.10.2.13

coating

covering steel with another material (tin, chrome, zinc, etc.), primarily for corrosion resistance

Note 1 to entry: Coating materials may include tin, chrome, zinc, etc.

3 Symbols

The symbols used in this part of ISO 14404 are given in [Table 1](#).

Table 1 — Symbols

Symbol	Unit	Descriptions
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 (or tonne)	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 production
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

4 Principles

4.1 General

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

4.2 Relevance

Select all the direct source, upstream source and credits into and out of the boundary of steel production site, data and methodologies appropriate to the need of intended purpose.

4.3 Completeness

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

4.4 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.

4.5 Accuracy

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

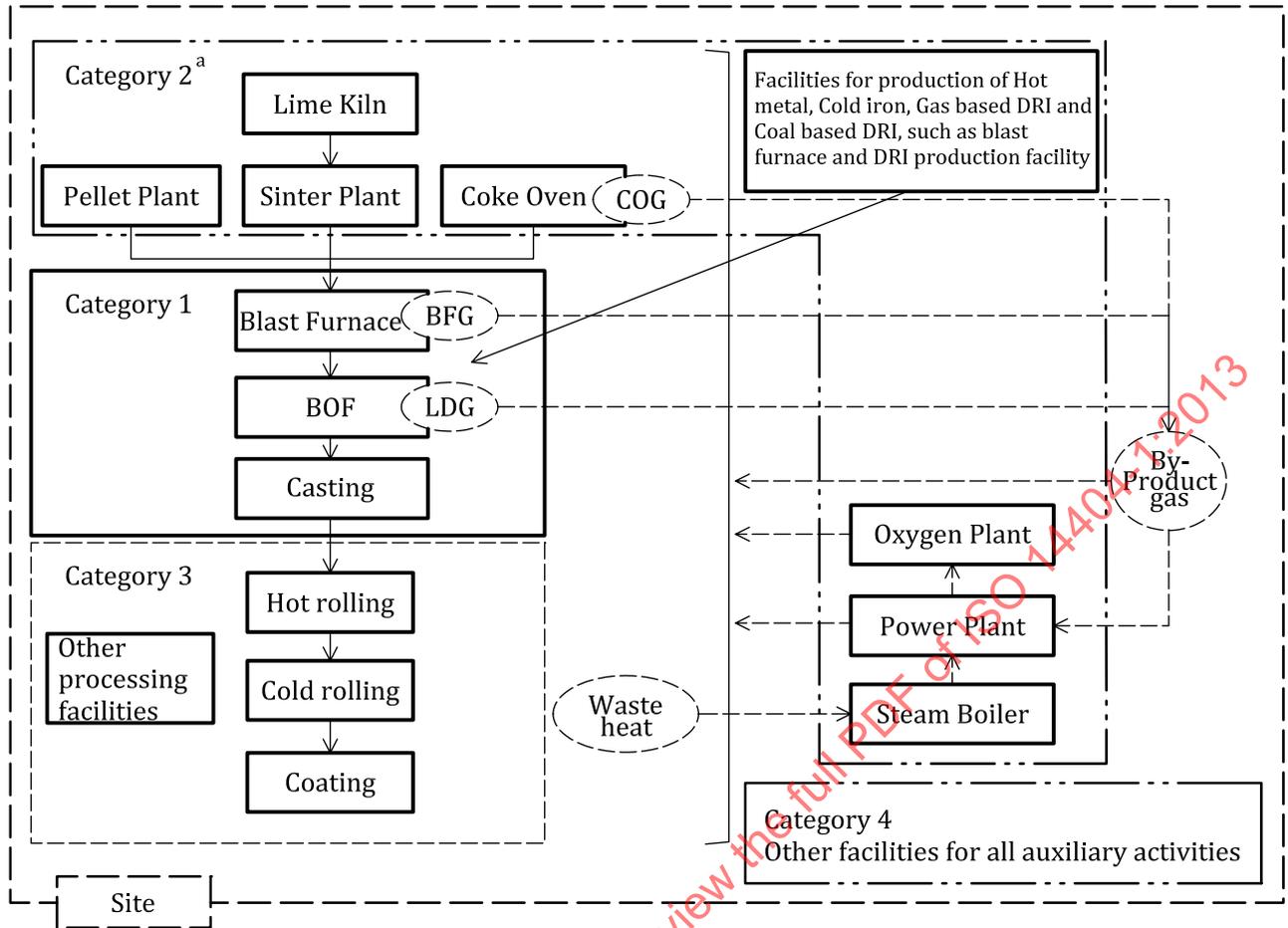
4.6 Transparency

Disclose CO₂ calculation method including emission factors to allow every steel producer assess its CO₂ intensity of steel production site universally.

5 Definition of boundary

5.1 General

This calculation method defines the boundary applied to the calculation of CO₂ emissions of the steel production as the following essential facilities. These essential facilities are categorized into four groups. (see [Figure 1](#)).



^a Equipment that can be outsourced.

Figure 1 — Essential facilities in the site

5.2 Category 1

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

- blast furnace;
- BOF;
- casting.

5.3 Category 2

The following facilities are classified as category 2. These facilities are operated in the site or operations of these facilities are outsourced. In the case where operations of these facilities are outsourced, intermediate products from these operations are imported and these upstream CO₂ emissions shall be calculated.

- sinter plant;
- lime kiln;
- pellet plant;
- coke oven;

facilities for production of hot metal, cold iron, gas-based DRI and coal-based DRI, such as blast furnace and DRI production facility;

oxygen plant;

steam boiler;

power plant.

5.4 Category 3

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

hot rolling;

cold rolling;

coating;

other processing facilities, such as pipe manufacturing facility.

5.5 Category 4

Other facilities for all auxiliary activities are classified as category 4.

6 Calculation

6.1 General

A plant manufacturing crude steel performs its calculations as follows.

- a) Step 1: Identify the categories.
- b) Step 2: Clarify the quantity of annual crude steel production at the plant.
- c) Step 3: Clarify the annual direct CO₂ emission sources and upstream CO₂ emission sources based on raw materials, intermediate products and energy imports to the plant.
- d) Step 4: Clarify the annual credit CO₂ emission sources based on raw materials, intermediate products and energy that the plant exports to outside users.
- e) Step 5: Calculate the annual CO₂ emissions and CO₂ intensity using the emission factors.

6.2 Calculation procedure

6.2.1 Data collection of crude steel production

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

6.2.2 Data collection direct and/or upstream CO₂ emission sources

A plant manufacturing steel records the quantities of raw materials, intermediate products, and energy that are imported from outside suppliers as the direct or upstream CO₂ emissions 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 ³ m ³ (stp ^b)	Q_{1,d,CO_2}	N/A ^c
2	Coke oven gas	10 ³ m ³ (stp)	Q_{2,d,CO_2}	N/A
3	Blast furnace gas	10 ³ m ³ (stp)	Q_{3,d,CO_2}	N/A
4	BOF gas	10 ³ m ³ (stp)	Q_{4,d,CO_2}	N/A
Liquid fuel				
5	Heavy oil	m ³	Q_{5,d,CO_2}	N/A
6	Light oil	m ³	Q_{6,d,CO_2}	N/A
7	Kerosene	m ³	Q_{7,d,CO_2}	N/A
8	LPG	t	Q_{8,d,CO_2}	N/A
Solid fuel				
9	Coking coal	dry t	Q_{9,d,CO_2}	N/A
10	BF injection coal	dry t	Q_{10,d,CO_2}	N/A
11	Sinter/BOF coal	dry t	Q_{11,d,CO_2}	N/A
12	Steam coal	dry t	Q_{12,d,CO_2}	N/A
13	Coke	dry t	Q_{13,d,CO_2}	Q_{13,u,CO_2}
14	Charcoal	dry t	Q_{14,d,CO_2}	N/A
Auxiliary material				
15	Limestone	dry t	Q_{15,d,CO_2}	N/A
16	Burnt lime	t	N/A	Q_{16,u,CO_2}
17	Crude dolomite	dry t	Q_{17,d,CO_2}	N/A
18	Burnt dolomite	t	N/A	Q_{18,u,CO_2}
19	Nitrogen	10 ³ m ³ (stp)	N/A	Q_{19,u,CO_2}
20	Argon	10 ³ m ³ (stp)	N/A	Q_{20,u,CO_2}
21	Oxygen	10 ³ m ³ (stp)	N/A	Q_{21,u,CO_2}
Energy carriers				
22	Electricity	MWh	N/A	Q_{22,u,CO_2}
23	Steam	t	N/A	Q_{23,u,CO_2}
Ferrous containing material				
24	Pellets	t	N/A	Q_{24,u,CO_2}
25	Sinter	t	N/A	Q_{25,u,CO_2}
26	Hot metal	t	Q_{26,d,CO_2}	Q_{26,u,CO_2}
27	Cold iron	t	Q_{27,d,CO_2}	Q_{27,u,CO_2}
28	Gas-based DRI	t	Q_{28,d,CO_2}	Q_{28,u,CO_2}
29	Coal-based DRI	t	Q_{29,d,CO_2}	Q_{29,u,CO_2}
Alloys				
30	Ferro-nickel	t	Q_{30,d,CO_2}	N/A
31	Ferro-chromium	t	Q_{31,d,CO_2}	N/A
32	Ferro-molybdenum	t	Q_{32,d,CO_2}	N/A
Product or by-product				

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}
33	CO ₂ for external use	t	Q_{33,d,CO_2}	N/A
34	Coal tar	t	Q_{34,d,CO_2}	N/A
35	Benzole (coal light oil)	t	Q_{35,d,CO_2}	N/A
Others				
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 =1000				
b Standard temperature and pressure.				
c Not applicable.				

6.2.3 Data collection of credit CO₂ emission sources

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

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	Coke oven gas	10 ³ m ³ (stp)	Q_{2,c,CO_2}
3	Blast furnace gas	10 ³ m ³ (stp)	Q_{3,c,CO_2}
4	BOF gas	10 ³ m ³ (stp)	Q_{4,c,CO_2}
Liquid fuel			
5	Heavy oil	m ³	Q_{5c,CO_2}
6	Light oil	m ³	Q_{6,c,CO_2}
7	Kerosene	m ³	Q_{7,c,CO_2}
8	LPG	t	Q_{8,c,CO_2}
Solid fuel			
9	Coking coal	dry t	Q_{9,c,CO_2}
10	BF injection coal	dry t	Q_{10,c,CO_2}
11	Sinter/BOF coal	dry t	Q_{11,c,CO_2}
12	Steam coal	dry t	Q_{12,c,CO_2}
13	Coke	dry t	Q_{13,c,CO_2}
14	Charcoal	dry t	Q_{14,c,CO_2}
Auxiliary material			
15	Limestone	dry t	Q_{15c,CO_2}
16	Burnt lime	t	Q_{16,c,CO_2}
17	Crude dolomite	dry t	Q_{17,c,CO_2}
18	Burnt dolomite	t	Q_{18,c,CO_2}

Table 3 (continued)

Subscript designator for Q_t	Emission sources	Unit	Quantities of credit emission source Q_{t,c,CO_2}
19	Nitrogen	10 ³ m ³ (stp)	Q_{19,c,CO_2}
20	Argon	10 ³ m ³ (stp)	Q_{20,c,CO_2}
21	Oxygen	10 ³ m ³ (stp)	Q_{21,c,CO_2}
Energy carriers			
22	Electricity	MWh	Q_{22,c,CO_2}
23	Steam	t	Q_{23,c,CO_2}
Ferrous-containing material			
24	Pellets	t	Q_{24,c,CO_2}
25	Sinter	t	Q_{25,c,CO_2}
26	Hot metal	t	Q_{26,c,CO_2}
27	Cold iron	t	Q_{27,c,CO_2}
28	Gas-based DRI	t	Q_{28,c,CO_2}
29	Coal-based DRI	t	Q_{29,c,CO_2}
Alloys			
30	Ferro-nickel	t	Q_{30,c,CO_2}
31	Ferro-chromium	t	Q_{31,c,CO_2}
32	Ferro-molybdenum	t	Q_{32,c,CO_2}
Product and by-product			
33	CO ₂ for external use	t	Q_{33,c,CO_2}
34	Coal tar	t	Q_{34,c,CO_2}
35	Benzole (coal light oil)	t	Q_{35,c,CO_2}
Others			
N	Other emission sources	—	Q_{N,c,CO_2}

a 10³=1000
 b Standard temperature and pressure.

6.2.4 Calculation

The annual CO₂ emissions ($E_{CO_2,annual}$) and CO₂ intensity (I_{CO_2}) of a site are calculated from Equations (1) and (2) using CO₂ emission factors that correspond to the direct CO₂ emission sources, upstream CO₂ emission sources and credit CO₂ emission sources recorded as specified in 6.2.2 and 6.2.3.

A calculation example is shown in Annex C.

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

$$I_{CO_2} = E_{CO_2,annual} / P \tag{2}$$

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

Table 4 — Indicative emission factors for CO₂ emission sources

Subscript designator for K_t	CO ₂ emission sources	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	2,014	N/A	2,014
2	Coke oven gas	0,836	N/A	0,977 ^a
				0,952 ^b
3	Blast furnace gas	0,891	N/A	0,170 ^a
				0,185 ^b
4	BOF gas	1,512	N/A	0,432 ^a
				0,470 ^b
Liquid fuel				
5	Heavy oil	2,907	N/A	2,907
6	Light oil	2,601	N/A	2,601
7	Kerosene	2,481	N/A	2,481
8	LPG	2,985	N/A	2,985
Solid fuel				
9	Coking coal	3,059	N/A	3,059
10	BF injection coal	2,955	N/A	2,955
11	Sinter/BOF coal	2,784	N/A	2,784
12	Steam coal	2,461	N/A	2,461
13	Coke	3,257	0,224	3,481
14	Charcoal	0,000	N/A	0,000
Auxiliary material				
15	Limestone	0,440	N/A	0,440
16	Burnt lime	N/A	0,950	0,950
17	Crude dolomite	0,471	N/A	0,471
18	Burnt dolomite	N/A	1,100	1,100
19	Nitrogen	N/A	0,103	0,103
20	Argon	N/A	0,103	0,103
21	Oxygen	N/A	0,355	0,355
Energy carriers				
22	Electricity	N/A	0,504	0,504
23	Steam	N/A	0,195	0,195
Ferrous-containing material				
24	Pellets	N/A	0,137	0,137
25	Sinter	N/A	0,262	0,262
26	Hot metal	0,172	1,855	2,027
27	Cold iron	0,172	1,855	2,027
28	Gas-based DRI	0,073	0,780	0,853
29	Coal-based DRI	0,073	1,210	1,283
Alloys				
30	Ferro-nickel	0,037	N/A	0,037
31	Ferro-chromium	0,275	N/A	0,275

Table 4 (continued)

Subscript designator for K_t	CO ₂ emission sources	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
32	Ferro-molybdenum	0,018	N/A	0,018
Product and by-product				
33	CO ₂ for external use	1,000	N/A	1,000
34	Coal tar	3,389	N/A	3,389
35	Benzole (coal light oil)	3,382	N/A	3,382
Others				
<i>N</i>	Other emission sources	<i>c</i>	<i>c</i>	<i>c</i>
If different emission factors or simplifications from Table 4 are applied, such emission factors or simplifications should be clearly identified and justified. If other 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 Annex B .				
<p>^a This credit emission factor is based on world average electricity equivalent based on worldsteel methodology. 1</p> <p>^b This credit emission factor is based on natural gas equivalent.</p> <p>^c The value shall be determined by using available data backed by reliable evidence.</p>				

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 blast furnaces can be calculated from Equations (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 6.2.2 and 6.2.3 and the energy conversion factors ($K_{t,d,E}$, $K_{t,u,E}$, and $K_{t,c,E}$):

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

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

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 in worldsteel CO₂ emissions data collection.^[1]

Annex B (informative)

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

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

Subscript designator for K 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	Coke oven gas				
3	Blast furnace gas				
4	BOF gas				
Liquid fuel					
5	Heavy oil				
6	Light oil				
7	Kerosene				
8	LPG				
Solid fuel					
9	Coking coal				
10	BF injection coal				
11	Sinter/BOF coal				
12	Steam coal				
13	Coke				
14	Charcoal				
Auxiliary material					
15	Limestone				
16	Burnt lime				
17	Crude dolomite				
18	Burnt dolomite				
19	Nitrogen				
20	Argon				
21	Oxygen				
Energy carriers					
22	Electricity				
23	Steam				
Ferrous-containing material					
24	Pellets				
25	Sinter				
26	Hot metal				

Table B.1 (continued)

Subscript designator for K 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
27	Cold Iron				
28	Gas-based DRI				
29	Coal-based DRI				
Alloys					
30	Ferro-nickel				
31	Ferro-chromium				
32	Ferro-molybdenum				
Product and by-product					
33	CO ₂ for external use				
34	Coal tar				
35	Benzole (coal light oil)				
Others					
N	Other emission sources				

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Annex C (informative)

An example of CO₂ emission and intensity calculations for a steel plant

C.1 Data of a steel plant

For an annual crude steel production: 7 000 000 t, the following applies.

Table C.1 — Example of imports and exports of a steel plant

Subscript designator for K_t	Emission sources	Unit	Imports	Exports
Gas fuel				
1	Natural gas	10 ³ a m ³ (stp b)	50 000	—
2	Coke oven gas	10 ³ m ³ (stp)	—	80 000
3	Blast furnace gas	10 ³ m ³ (stp)	—	100 000
4	BOF gas	10 ³ m ³ (stp)	—	10 000
Liquid fuel				
5	Heavy oil	m ³	5 000	—
6	Light oil	m ³	2 000	—
7	Kerosene	m ³	800	—
8	LPG	t	3 000	—
Solid fuel				
9	Coking coal	dry t	3 500 000	—
10	BF injection coal	dry t	1 000 000	—
11	Sinter/BOF coal	dry t	100 000	—
12	Steam coal	dry t	600 000	—
13	Coke	dry t	200 000	—
14	Charcoal	dry t	—	—
Auxiliary material				
15	Limestone	dry t	1 500 000	—
16	Burnt lime	t	500 000	—
17	Crude dolomite	dry t	10 000	—
18	Burnt dolomite	t	20 000	—
19	Nitrogen	10 ³ m ³ (stp)	1 000 000	20 000
20	Argon	10 ³ m ³ (stp)	—	—
21	Oxygen	10 ³ m ³ (stp)	800 000	—
Energy carriers				
22	Electricity	MWh	100 000	1 500 000
23	Steam	t	—	50 000
Ferrous-containing material				

Table C.1 (continued)

Subscript designator for K_t	Emission sources	Unit	Imports	Exports
24	Pellets	t	1 000 000	—
25	Sinter	t	—	—
26	Hot metal	t	—	—
27	Cold iron	t	—	—
28	Gas-based DRI	t	—	—
29	Coal-based DRI	t	—	—
Alloys				
30	Ferro-Nickel	t	—	—
31	Ferro-Chromium	t	—	—
32	Ferro-Molybdenum	t	—	—
Product and by-product				
33	CO ₂ for external use	t	—	—
34	Coal tar	t	—	90 000
35	Benzole (coal light oil)	t	—	30 000
Others				
<i>N</i>	Other emission sources	—	—	—

a 10³=1000
b Standard temperature and pressure.

Table C.2 — Example of the calculation result of a steel plant^a

Subscript designator for K_t	Emission sources	Unit	Calculation results		
			Direct emissions tCO ₂	Upstream emissions tCO ₂	Credit emissions tCO ₂
Gas fuel					
1	Natural gas	10 ³ b m ³ (stp) ^c	100 700	—	—
2	Coke oven gas	10 ³ m ³ (stp)	—	—	78 128 ^d
3	Blast furnace gas	10 ³ m ³ (stp)	—	—	16 962 ^d
4	BOF gas	10 ³ m ³ (stp)	—	—	4 318 ^d
Liquid fuel					
5	Heavy oil	m ³	14 533	—	—
6	Light oil	m ³	5 202	—	—
7	Kerosene	m ³	1 985	—	—
8	LPG	t	8 954	—	—
Solid fuel					
9	Coking coal	dry t	10 706 500	—	—
10	BF injection coal	dry t	2 954 500	—	—
11	Sinter/BOF coal	dry t	278 350	—	—
12	Steam coal	dry t	1 476 300	—	—
13	Coke	dry t	651 364	44 880	—
14	Charcoal	dry t	—	—	—
Auxiliary material					
15	Limestone	dry t	660 000	—	—