
**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 de fabrication d'acier dans des fours électriques à arc
(FÉA) et installations de production de minerais de fer pré-réduits
avec procédés au charbon ou au gaz*



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Contents

Page

Foreword.....	iv
Introduction.....	v
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	1
3.1 Emissions.....	1
3.2 Gas fuel.....	2
3.3 Liquid fuel.....	2
3.4 Solid fuel.....	2
3.5 Auxiliary material.....	3
3.6 Energy carriers.....	3
3.7 Ferrous containing materials.....	4
3.8 Alloys.....	4
3.9 Product and by-product.....	4
3.10 Others.....	4
4 Symbols.....	5
5 Principles.....	6
5.1 General.....	6
5.2 Relevance.....	6
5.3 Completeness.....	6
5.4 Consistency.....	6
5.5 Accuracy.....	6
5.6 Transparency.....	6
6 Definition of boundary.....	7
6.1 General.....	7
6.2 Category 1.....	7
6.3 Category 2.....	8
6.4 Category 3.....	8
6.5 Category 4.....	8
7 Calculation.....	8
7.1 General.....	8
7.2 Calculation procedure.....	8
7.2.1 Data collection of crude steel production.....	8
7.2.2 Data collection direct and/or upstream CO ₂ emission sources.....	8
7.2.3 Data collection of credit CO ₂ emission sources.....	10
7.2.4 Calculation.....	11
Annex A (informative) Calculation of energy consumption and intensity.....	14
Annex B (informative) An example of template for using different emission factors or emission sources from Table 4.....	15
Annex C (informative) An example of CO₂ emission and intensity data and calculations for a steel plant with a DRI facility.....	17
Bibliography.....	20

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 documents 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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 17, *Steel*.

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

Introduction

The steel industry recognizes there is an 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 role in achieving these reductions, it is necessary for steel plants to determine the amount of CO₂ emitted during the production of steel products, in order to identify further CO₂ reduction opportunities.

The steel production process involves complex chemical reactions, several heating cycles and the cycling 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 various products 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 produced and processes used means there are not two identical steel plants in the world.

Climate regulations in each country require steel companies to devise methods to lower CO₂ emissions 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 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.

The World Steel Association (worldsteel), which consists of more than 161 major steel companies in 60 countries and regions of the world, has been working on the development of a calculation method for CO₂ emission intensity to facilitate the improvement of steel plant CO₂ emissions. The calculation method is based on an objective comparison of CO₂ emissions intensity among the member steel companies located in different places in the world. An agreement was reached among members and worldsteel issued the method as "CO₂ Emissions Data Collection User Guide". Actual data collection among worldsteel members based upon the guide started in 2007. Furthermore, worldsteel is encouraging non-member steel companies to begin using the guide to calculate CO₂ emission intensity of their steel plants.

The calculation method establishes clear boundaries for the collection of CO₂ emissions data. The net CO₂ emissions and production from a steel plant are calculated using all the parameters within the boundaries. The CO₂ emission intensity is calculated by the net CO₂ emission from the plant using the boundaries divided by the amount of crude steel production of that plant. With this methodology, the CO₂ emission intensity of steel plants is calculated irrespective of 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 in the plant management. However, since 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 site as a whole. 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 various product production processes and it handles CO₂ data in a way that allows a comparison with 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 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 those companies using an electric arc furnace (EAF) to produce steel and having direct reduced iron (DRI) facilities within their premises. It can be used to evaluate the total annual carbon dioxide (CO₂) emissions and the emission factor of CO₂ per unit of steel production 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. This document 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 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 terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at www.iso.org/obp
- IEC Electropedia: available at 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](#).

ISO 14404-3:2017(E)

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 boundary and from imported electricity and steam into the 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 in the earth and used principally as a fuel

3.2.2

town gas

fuel gas manufactured for domestic and industrial use

3.3 Liquid fuel

3.3.1

heavy oil

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

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

3.3.2

light oil

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

3.3.3

kerosene

paraffin (oil)

3.4 Solid fuel

3.4.1

EAF coal

coal used for an electric arc furnace (EAF), including anthracite

3.4.2

steam coal

boiler coal for producing electricity and steam, including anthracite

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**

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

3.5 Auxiliary material**3.5.1****limestone**

calcium carbonate, CaCO_3

3.5.2**burnt lime**

CaO

3.5.3**crude dolomite**

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

3.5.4**burnt dolomite**

CaMgO_2

3.5.5**electric arc furnace graphite electrodes****EAF graphite electrodes**

net use of EAF graphite electrodes or attrition loss

3.5.6**nitrogen**

N_2

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**

O_2

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**

electricity 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

3.7 Ferrous containing materials

3.7.1

pellets

agglomerated spherical iron ore calcinated by rotary kiln

3.7.2

hot metal

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

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) reduced by a reducing gas such as reformed natural gas

3.7.6

coal-based DRI

direct reduced iron (DRI) reduced by coal

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

3.9 Product and by-product

3.9.1

CO₂ for external use

CO₂ exported to outside the boundary

3.10 Others

3.10.1

other emission source

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

3.10.2**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.

3.10.3**EAF****electric arc furnace**

furnace that melts and refines iron-bearing material into steel

3.10.4**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

3.10.5**lime kiln**

kiln used to produce *burnt lime* (3.5.2) by the calcination of limestone (calcium carbonate)

3.10.6**oxygen plant**

cryogenic air separator to produce high-purity oxygen

3.10.7**steam boiler**

boiler for production of steam

3.10.8**power plant**

plant that generates electricity

3.10.9**hot rolling**

rolling at elevated temperature

3.10.10**cold rolling**

rolling at room temperature

3.10.11**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.

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

Table 1 (continued)

Symbols	Unit	Description
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	—	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

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 the 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.

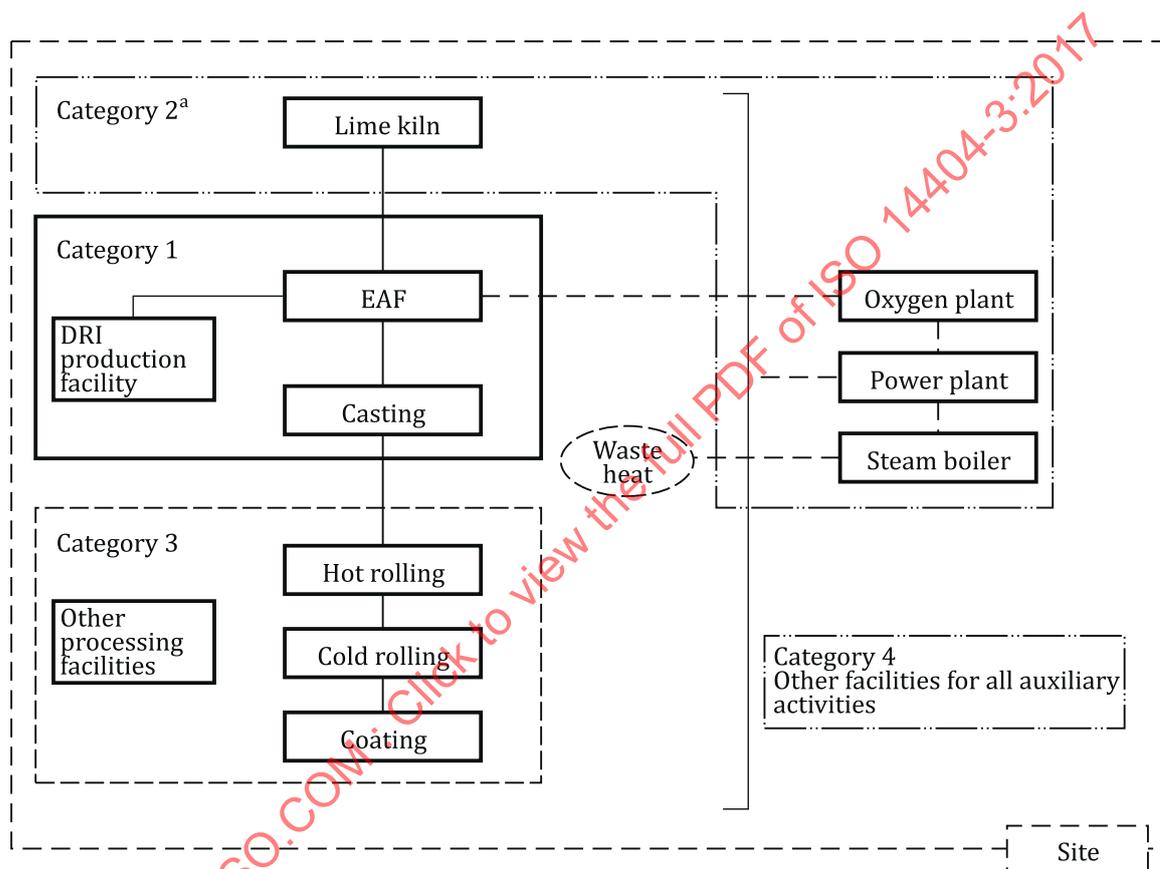
5.6 Transparency

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

6 Definition of 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](#).



Key

^a Equipment that can be outsourced.

Figure 1 — Essential facilities in the site

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.

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.

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.

7 Calculation

7.1 General

The calculations for a site producing crude steel are made 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 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	Quantities of upstream emission source
			Q_{t, d, CO_2}	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
Solid fuel				
7	EAF coal	dry t	Q_{7, d, CO_2}	N/A
8	Steam coal	dry t	Q_{8, d, CO_2}	N/A
9	Coke	dry t	Q_{9, d, CO_2}	N/A
10	Charcoal	dry t	Q_{10, d, CO_2}	N/A
11	SR/DRI coal	dry t	Q_{11, d, CO_2}	N/A
Auxiliary materials				
12	Limestone	dry t	Q_{12, d, CO_2}	N/A
13	Burnt lime	t	N/A	Q_{13, u, CO_2}
14	Crude dolomite	dry t	Q_{14, d, CO_2}	N/A
15	Burnt dolomite	t	N/A	Q_{15, u, CO_2}
16	EAF graphite electrodes	t	Q_{16, d, CO_2}	Q_{16, u, CO_2}
17	Nitrogen	10 ³ m ³ (stp)	N/A	Q_{17, u, CO_2}
18	Argon	10 ³ m ³ (stp)	N/A	Q_{18, u, CO_2}
19	Oxygen	10 ³ m ³ (stp)	N/A	Q_{19, u, CO_2}
Energy carriers				
20	Electricity	MWh	N/A	Q_{20, u, CO_2}
21	Steam	t	N/A	Q_{21, u, CO_2}
Ferrous-containing material				
22	Pellets	t	N/A	Q_{22, u, CO_2}
23	Hot metal	t	Q_{23, d, CO_2}	Q_{23, u, CO_2}
24	Gas-based DRI	t	Q_{24, d, CO_2}	Q_{24, u, CO_2}
25	Coal-based DRI	t	Q_{25, d, CO_2}	Q_{25, 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.				

Table 2 (continued)

Subscript designator for Q_t	Emission sources	Unit	Quantities of direct emission source	Quantities of upstream emission source
			Q_{t, d, CO_2}	Q_{t, u, CO_2}
Alloys				
26	Ferro-nickel	t	Q_{26, d, CO_2}	N/A
27	Ferro-chromium	t	Q_{27, d, CO_2}	N/A
28	Ferro-molybdenum	t	Q_{28, d, CO_2}	N/A
Product and by-product				
29	CO ₂ for external use	t	Q_{30, 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 =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](#).

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}
Solid fuel			
7	EAF coal	dry t	Q_{7, c, CO_2}
8	Steam coal	dry t	Q_{8, c, CO_2}
9	Coke	dry t	Q_{9, c, CO_2}
10	Charcoal	dry t	Q_{10, c, CO_2}
11	SR/DRI coal	dry t	Q_{11, c, CO_2}
a 10 ³ = 1 000.			
b Standard temperature and pressure.			

Table 3 (continued)

Subscript designator for Q_t	Emission sources	Unit	Quantities of credit emission source Q_{t,c,CO_2}
Auxiliary materials			
12	Limestone	dry t	Q_{12,c,CO_2}
13	Burnt lime	t	Q_{13,c,CO_2}
14	Crude dolomite	dry t	Q_{14,c,CO_2}
15	Burnt dolomite	t	Q_{15,c,CO_2}
16	EAF graphite electrodes	t	Q_{16,c,CO_2}
17	Nitrogen	10^3 m^3 (stp)	Q_{17,c,CO_2}
18	Argon	10^3 m^3 (stp)	Q_{18,c,CO_2}
19	Oxygen	10^3 m^3 (stp)	Q_{19,c,CO_2}
Energy carriers			
20	Electricity	MWh	Q_{20,c,CO_2}
21	Steam	t	Q_{21,c,CO_2}
Ferrous-containing material			
22	Pellets	t	Q_{22,c,CO_2}
23	Hot metal	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}
Alloys			
27	Ferro-nickel	t	Q_{27,c,CO_2}
28	Ferro-chromium	t	Q_{28,c,CO_2}
29	Ferro-molybdenum	t	Q_{29,c,CO_2}
Product and by-product			
30	CO ₂ for external use	t	Q_{30,c,CO_2}
Others			
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	2,014	N/A	2,014
2	Town gas	2,014	N/A	2,014
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
Solid fuel				
7	EAF coal	3,257	N/A	3,257
8	Steam coal	2,461	N/A	2,461
9	Coke	3,257	N/A	3,257
10	Charcoal	0,000	N/A	0,000
11	SR/DRI coal	2,955	N/A	2,955
Auxiliary materials				
12	Limestone	0,440	N/A	0,440
13	Burnt lime	N/A	0,950	0,950
14	Crude dolomite	0,471	N/A	0,471
15	Burnt dolomite	N/A	1,100	1,100
16	EAF graphite electrodes	3,663	0,650	3,663
17	Nitrogen	N/A	0,103	0,103
18	Argon	N/A	0,103	0,103
19	Oxygen	N/A	0,355	0,355
Energy carriers				
20	Electricity	N/A	0,504	0,504
21	Steam	N/A	0,195	0,195
Ferrous-containing material				
22	Pellets	N/A	0,137	0,137
23	Hot metal	0,172	1,855	2,027
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
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 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
Alloys				
27	Ferro-nickel	0,037	N/A	0,037
28	Ferro-chromium	0,275	N/A	0,275
29	Ferro-molybdenum	0,018	N/A	0,018
Product and by-product				
30	CO ₂ for external use	1,000	N/A	1,000
Others				
<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 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 [2].

Annex B (informative)

An 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				
Solid fuel					
7	EAF coal				
8	Steam coal				
9	Coke				
10	Charcoal				
11	SR/DRI coal				
Auxiliary materials					
12	Limestone				
13	Burnt lime				
14	Crude dolomite				
15	Burnt dolomite				
16	EAF graphite electrodes				
17	Nitrogen				
18	Argon				
19	Oxygen				
Energy carriers					
20	Electricity				
21	Steam				

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
Ferrous-containing material					
22	Pellets				
23	Hot metal				
24	Cold iron				
25	Gas-based DRI				
26	Coal-based DRI				
Alloys					
27	Ferro-nickel				
28	Ferro-chromium				
29	Ferro-molybdenum				
Product and by-product					
30	CO ₂ for external use				
Others					
<i>N</i>	Other emission sources				

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