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

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

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

Partie 2: Usine sidérurgique avec four à arc électrique

Reference number
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Foreword

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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 14404-2 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)

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 CO_2 emitted during the production of steel products, in order to identify next opportunities for reduction of CO_2.

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 CO_2 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 CO_2 emissions.

There are many methods for calculating CO_2 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 CO_2 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 CO_2 emission intensity of steel plants to facilitate steel plant CO_2 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 "CO_2 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 CO_2 emission intensity of their steel plants.

This calculation method establishes clear boundaries for collection of CO_2 emissions data. The net CO_2 emissions and production from a steel plant are calculated using all parameters within the boundaries. The CO_2 emission intensity of the steel plant is calculated by the net CO_2 emission from the plant using the boundaries divided by the amount of crude steel production of the plant. With this methodology, the CO_2 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 CO_2 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 CO_2 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 CO_2 data that would allow a comparison of CO_2 intensities of production processes that are operated inside the site.

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

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

1 Scope

This part of ISO 14404 specifies calculation methods which companies using EAF to manufacture steel can use to evaluate the total annual carbon dioxide (CO_2) emissions and the emission factor of CO_2 per unit of steel production of the entire steel production process. This part of ISO 14404 is applied to the plants that produce mainly carbon steel.

It includes boundary definition, material and energy flow definition, and emission factor of CO_2. Besides direct source import to the boundary, upstream and credit concept is applied to exhibit the plant CO_2 intensity.

This part of ISO 14404 supports the steel producer to establish CO_2 emissions attributable to a site. This part of ISO 14404 cannot be used to calculate benchmarks or to compare CO_2 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 CO_2 during production of steel products

Note 1 to entry: There are three categories of CO_2 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 CO_2 emission
CO_2 emissions from steel production activity inside the boundary

Note 1 to entry: Direct CO_2 emission is categorized as “direct GHG emissions“ in ISO 14064-1.

2.1.3
upstream CO_2 emission
CO_2 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: CO_2 emissions from imported material in this term is categorized as “other indirect GHG emissions“ in ISO 14064-1.

Note 2 to entry: CO_2 emissions from imported electricity and steam in this term is categorized as “energy indirect GHG emissions“ in ISO 14064-1.

2.1.4
credit CO_2 emission
CO_2 emission that corresponds to exported material and electricity or steam

Note 1 to entry: Credit CO_2 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
town gas
fuel gas manufactured for domestic and industrial use

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
EAF coal
coal for EAF, including anthracite

Note 1 to entry: EAF: electric arc furnace.

2.4.2
steam coal
boiler coal for producing electricity and steam, including anthracite

2.4.3
coke
solid carbonaceous material

2.4.4
charcoal
devolatilized or coked carbon neutral materials

EXAMPLE Trees, plants.

2.4.5
SR/DRI coal
coal for SR/DRI including anthracite

Note 1 to entry: SR: smelting reduction; DRI: direct reduction iron.

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, $CaMg(CO_3)_2$

2.5.4
burnt dolomite
$CaMgO_2$

2.5.5
electric arc furnace graphite electrodes
EAF graphite electrodes
net use of EAF graphite electrodes or attrition loss

2.5.6
nitrogen
N_2
inert gas separated from air at oxygen plant, imported from outside the boundary or exported to outside the boundary

2.5.7
argon
Ar
inert gas separated from air at oxygen plant, imported from outside the boundary or exported to outside the boundary

2.5.8
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
hot metal
intermediate liquid iron products containing 3 % to 5 % by mass carbon produced by smelting iron ore with equipments such as blast furnace

2.7.3
cold iron
solidified hot metal as an intermediate solid iron products

2.7.4
scrap
used steel available for reprocessing

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
CO_2 for external use
CO_2 exported to outside the boundary

2.10 Others

2.10.1
other emission source
other related emission sources such as plastics, scraps, desulfurization additives, alloys, fluxes for secondary metallurgy, dust, sludges, etc

2.10.2
boundary
limit of activity used to calculate CO_2 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 2.10.2.9.

2.10.2.1
electric arc furnaces
EAF
furnace that melts and refines iron-bearing material into steel

2.10.2.2
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 mold shaped to form ingots

2.10.2.3
lime kiln
kiln used to produce burnt lime by the calcination of limestone (calcium carbonate)

2.10.2.4
oxygen plant
cryogenic air separator to produce high-purity oxygen

2.10.2.5
steam boiler
boiler for production of steam

2.10.2.6
power plant
plant that generates electricity

2.10.2.7
hot rolling
rolling at elevated temperature

2.10.2.8
cold rolling
rolling at room temperature

2.10.2.9
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

Symbols	Unit	Description
$E_{d,CO2}$	tons (or tonnes) of CO_2	Direct CO_2 emissions
$E_{u,CO2}$	tons (or tonnes) of CO_2	Upstream CO_2 emissions
$E_{c,CO2}$	tons (or tonnes) of CO_2	Credit CO_2 emissions
$E_{CO2,annual}$	tons (or tonnes) of CO_2	Annual CO_2 emissions
I_{CO2}	tons (or tonnes) of CO_2 per ton	CO_2 intensity factor
$K_{t,d,CO2}$	tons (or tonnes) of CO_2 per unit	Emission factor for calculation of direct CO_2 emissions
$K_{t,u,CO2}$	tons (or tonnes) of CO_2 per unit	Emission factor for calculation of upstream CO_2 emissions
$K_{t,c,CO2}$	tons (or tonnes) of CO_2 per unit	Emission factor for calculation of credit CO_2 emissions
P	—	Annual crude steel production
$Q_{t,d,CO2}$	—	Quantities of direct CO_2 emission sources
$Q_{t,u,CO2}$	—	Quantities of upstream CO_2 emission sources
$Q_{t,c,CO2}$	—	Quantities of credit CO_2 emission sources

4 Principles

4.1 General

The application of principles is a base to ensure that calculated CO_2 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 CO_2 intensity of steel production site.

4.4 Consistency

Enable universally meaningful assessment in CO_2 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.

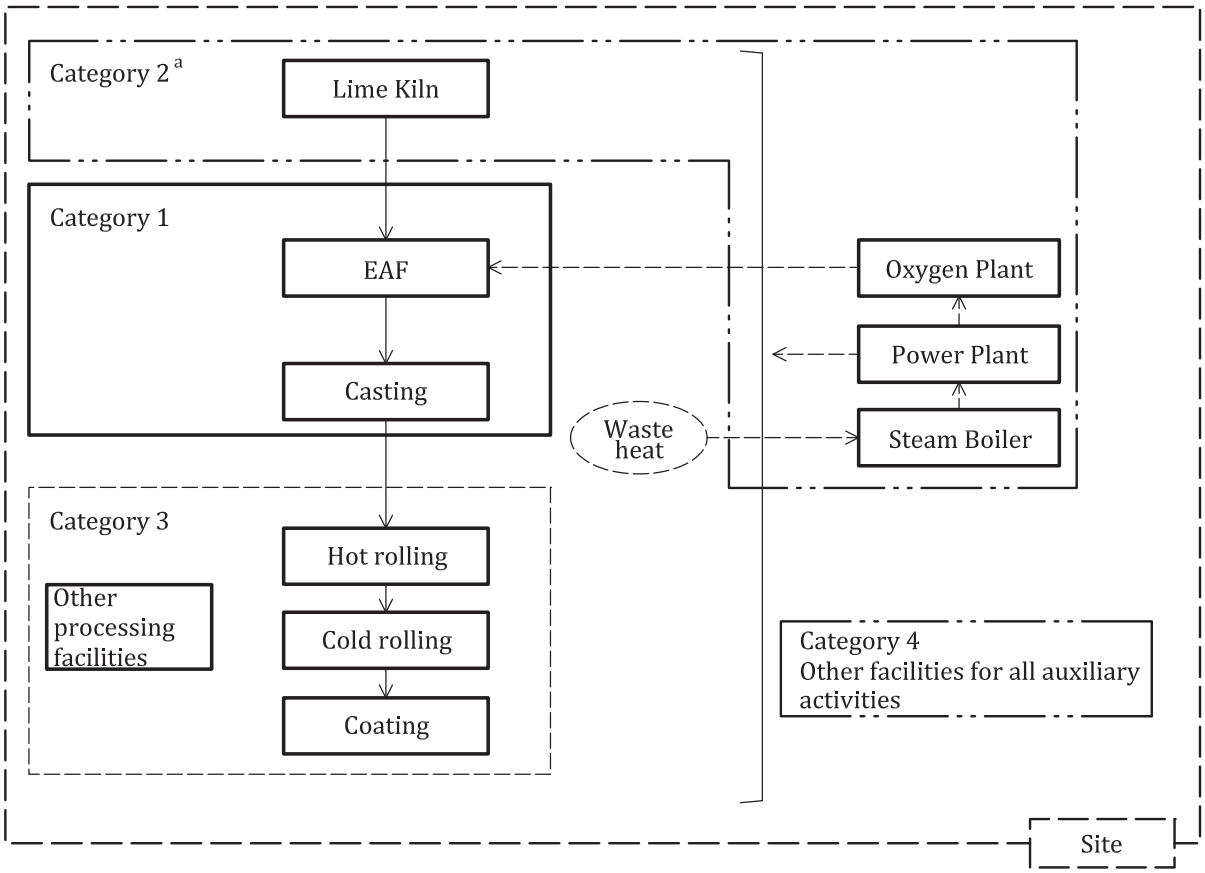
4.6 Transparency

Disclose CO_2 calculation method, including emission factors to allow every steel producer assess its CO_2 intensity of steel production site universally.

5 Definition of boundary

5.1 General

This calculation method defines the boundary applied to the calculation of CO_2 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.

EAF;

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 CO_2 emissions shall be calculated.

lime kiln;

oxygen plant;

steam boiler;

power plant.

5.4 Category 3

The following processing facilities are classified as category 3. CO_2 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 producing 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 CO_2 emission sources and upstream CO_2 emission sources based on raw materials, intermediate products and energy import to the plant.

d) Step 4: Clarify the annual credit CO_2 emission sources based on raw materials, intermediate products, and energy which the plant exports to outside users.

e) Step 5: Calculate the annual CO_2 emissions and CO_2 factor using the emission factors.

6.2 Calculation procedure

6.2.1 Data collection of crude steel production

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

6.2.2 Data collection direct and/or upstream CO_2 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 CO_2 emission sources based on Table 2.

Table 2 — Direct and/or upstream CO_2 emission sources

Subscript designator for Q t	Emission sources	Unit	Quantities of direct emission source $Q_{t,\mathrm{d,CO2}}$	Quantities of upstream emission source $Q_{t,\mathrm{u,CO2}}$
Gas fuel				
1	Natural gas	10^3[a] m^3(stp[b])	$Q_{1,\mathrm{d,CO2}}$	N/A[c]
2	Town gas	$10^3 m^3$(stp)	$Q_{2,\mathrm{d,CO2}}$	N/A

Table 2 *(continued)*

Subscript designator for Q t	Emission sources	Unit	Quantities of direct emission source $Q_{t,d,CO2}$	Quantities of upstream emission source $Q_{t,u,CO2}$
Liquid fuel				
3	Heavy oil	m^3	$Q_{3,d,CO2}$	N/A
4	Light oil	m^3	Q_{4dCO2}	N/A
5	Kerosene	m^3	$Q_{5,d,CO2}$	N/A
6	LPG	t	$Q_{6,d,CO2}$	N/A
Solid fuel				
7	EAF coal	dry t	$Q_{7,d,CO2}$	N/A
8	Steam coal	dry t	$Q_{8,d,CO2}$	N/A
9	Coke	dry t	$Q_{9,d,CO2}$	N/A
10	Charcoal	dry t	$Q_{10,d,CO2}$	N/A
11	SR/DRI coal	dry t	$Q_{11,d,CO2}$	N/A
Auxiliary materials				
12	Limestone	dry t	$Q_{12,d,CO2}$	N/A
13	Burnt lime	t	N/A	Q_{13uCO2}
14	Crude dolomite	dry t	$Q_{14,d,CO2}$	N/A
15	Burnt dolomite	t	N/A	$Q_{15,u,CO2}$
16	EAF graphite electrodes	t	$Q_{16,d,CO2}$	$Q_{16,u,CO2}$
17	Nitrogen	$10^3 m^3$(stp)	N/A	$Q_{17,u,CO2}$
18	Argon	$10^3 m^3$(stp)	N/A	$Q_{18,u,CO2}$
19	Oxygen	$10^3 m^3$(stp)	N/A	$Q_{19,u,CO2}$
Energy carriers				
20	Electricity	MWh	N/A	$Q_{20,u,CO2}$
21	Steam	t	N/A	$Q_{21,u,CO2}$
Ferrous-containing material				
22	Pellets	t	N/A	N/A
23	Hot metal	t	$Q_{23,d,CO2}$	N/A
24	Cold iron	t	$Q_{24,d,CO2}$	N/A
25	Gas-based DRI	t	$Q_{25,d,CO2}$	N/A
26	Coal-based DRI	t	$Q_{26,d,CO2}$	N/A
Alloys				
27	Ferro-nickel	t	$Q_{27,d,CO2}$	N/A
28	Ferro-chromium	t	$Q_{28,d,CO2}$	N/A
29	Ferro-molybdenum	t	$Q_{29,d,CO2}$	N/A
Product and by-product				
30	CO_2 for external use	t	$Q_{30,d,CO2}$	N/A
Others				
N	Other emission sources	—	$Q_{N,d,CO2}$	$Q_{N,u,CO2}$

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 CO_2 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 CO_2 emission sources based on Table 3.

Table 3 — Credit CO_2 emission sources

Subscript designator for Q t	Emission sources	Unit	Quantities of credit emission source $Q_{t,c,CO2}$
Gas fuel			
1	Natural gas	10^3[a] m^3(stp[b])	$Q_{1,c,CO2}$
2	Town gas	10^3m^3(stp)	$Q_{2,c,CO2}$
Liquid fuel			
3	Heavy oil	m^3	$Q_{3,c,CO2}$
4	Light oil	m^3	$Q_{4,c,CO2}$
5	Kerosene	m^3	$Q_{5,c,CO2}$
6	LPG	t	$Q_{6,c,CO2}$
Solid fuel			
7	EAF coal	dry t	$Q_{7,c,CO2}$
8	Steam coal	dry t	$Q_{8,c,CO2}$
9	Coke	dry t	$Q_{9,c,CO2}$
10	Charcoal	dry t	$Q_{10,c,CO2}$
11	SR/DRI coal	dry t	$Q_{11,c,CO2}$
Auxiliary materials			
12	Limestone	dry t	$Q_{12,c,CO2}$
13	Burnt lime	t	$Q_{13,c,CO2}$
14	Crude dolomite	dry t	$Q_{14,c,CO2}$
15	Burnt dolomite	t	$Q_{15,c,CO2}$
16	EAF graphite electrodes	t	$Q_{16,c,CO2}$
17	Nitrogen	10^3m^3(stp)	$Q_{17,c,CO2}$
18	Argon	10^3m^3(stp)	$Q_{18,c,CO2}$
19	Oxygen	10^3m^3(stp)	$Q_{19,c,CO2}$
Energy carriers			
20	Electricity	MWh	$Q_{20,c,CO2}$
21	Steam	t	$Q_{21,c,CO2}$
Ferrous-containing material			
22	Pellets	t	$Q_{22,c,CO2}$
23	Hot metal	t	$Q_{23,c,CO2}$
24	Cold iron	t	$Q_{24,c,CO2}$
25	Gas-based DRI	t	$Q_{25,c,CO2}$
26	Coal-based DRI	t	$Q_{26,c,CO2}$
Alloys			
27	Ferro-nickel	t	$Q_{27,c,CO2}$
28	Ferro-chromium	t	$Q_{28,c,CO2}$

Table 3 *(continued)*

Subscript designator for Q t	Emission sources	Unit	Quantities of credit emission source $Q_{t,c,CO2}$
29	Ferro-molybdenum	t	$Q_{29,c,CO2}$
Product and by-product			
30	CO_2 for external use	t	$Q_{30,c,CO2}$
Others			
N	Other emission sources	—	$Q_{N,c,CO2}$
a 10^3=1000			
b Standard temperature and pressure.			

6.2.4 Calculation

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

Calculation example is shown in Annex C.

$$E_{CO2,annual} = \sum_{t=1}^{N} K_{t,d,CO2} \times Q_{t,d,CO2} + \sum_{t=1}^{N} K_{t,u,CO2} \times Q_{t,u,CO2} - \sum_{t=1}^{N} K_{t,c,CO2} \times Q_{t,c,CO2} \quad (1)$$

$$I_{CO2} = E_{CO2,annual}/P \quad (2)$$

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 CO_2 emission factors for CO_2 emission sources

Subscript designator for Q t	CO_2 emission sources	Direct emission factor ($K_{t,d,CO2}$) t CO_2/unit	Upstream emission factor ($K_{t,u,CO2}$) t CO_2/unit	Credit emission factor ($K_{t,c,CO2}$) 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	LPG	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

Table 4 *(continued)*

Subscript designator for Q t	CO_2 emission sources	Direct emission factor ($K_{t,d,CO2}$) t CO_2/unit	Upstream emission factor ($K_{t,u,CO2}$) t CO_2/unit	Credit emission factor ($K_{t,c,CO2}$) t CO_2/unit
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 materials				
22	Pellets	0	N/A	0
23	Hot metal	0,172	N/A	0,172
24	Cold iron	0,172	N/A	0,172
25	Gas-based DRI	0,073	N/A	0,073
26	Coal-based DRI	0,073	N/A	0,073
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				
N	Other emission sources	[a]	[a]	[a]
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. *N* 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, $C_{\mathrm{E,annual}}$, and intensity, I_E, at a plant manufacturing steel using electric arc furnace can be calculated from Equations (A.1) and (A.2) using $Q_{t,\mathrm{d,CO2}}$, $Q_{t,\mathrm{u,CO2}}$ and $Q_{t,\mathrm{c,CO2}}$ collected as explained in 6.2.2 and 6.2.3, and the energy conversion factors ($K_{t,\mathrm{d,E}}$, $K_{t,\mathrm{u,E}}$, and $K_{t,\mathrm{c,E}}$):

$$C_{\mathrm{E,annual}} = \sum_{t=1}^{N} K_{t,\mathrm{d,E}} \times Q_{t,\mathrm{d,CO2}} + \sum_{t=1}^{N} K_{t,\mathrm{u,E}} \times Q_{t,\mathrm{u,CO2}} - \sum_{t=1}^{N} K_{t,\mathrm{c,E}} \times Q_{t,\mathrm{c,CO2}} \quad \text{(A.1)}$$

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

where

$Q_{t,\mathrm{d,CO2}}$ are the quantities of direct CO_2 emission sources;

$Q_{t,\mathrm{u,CO2}}$ are the quantities of upstream CO_2 emission sources;

$Q_{t,\mathrm{c,CO2}}$ are the quantities of credit CO_2 emission sources;

$K_{t,\mathrm{d,E}}$ is the energy conversion factor for calculation of direct energy consumption;

$K_{t,\mathrm{u,E}}$ is the energy conversion factor for calculation of upstream energy consumption;

$K_{t,\mathrm{c,E}}$ is the energy conversion factor for calculation of credit energy consumption;

I_{E} is the energy intention factor;

$C_{\mathrm{E,annnual}}$ is the annual energy consumption;

P is the annual crude steel production.

NOTE Energy conversion factors for CO_2 emission sources are referred in worldsteel CO_2 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 emission factors for CO_2 emission sources

Subscript designator for Q t	CO_2 emission sources	Direct emission factor ($K_{t,d,CO2}$) t CO_2/unit	Upstream emission factor ($K_{t,u,CO2}$) t CO_2/unit	Credit emission factor ($K_{t,c,CO2}$) t CO_2/unit	Justification
Gas fuel					
1	Natural gas				
2	Town gas				
Liquid fuel					
3	Heavy oil				
4	Light oil				
5	Kerosene				
6	LPG				
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				
Ferrous-containing material					
22	Pellets				
23	Hot metal				
24	Cold iron				
25	Gas-based DRI				
26	Coal-based DRI				
Alloys					

Table B.1 *(continued)*

Subscript designator for Q t	CO_2 **emission sources**	**Direct emission factor** ($K_{t,d,CO2}$) t CO_2/unit	**Upstream emission factor** ($K_{t,u,CO2}$) t CO_2/unit	**Credit emission factor** ($K_{t,c,CO2}$) t CO_2/unit	**Justification**
27	Ferro-nickel				
28	Ferro-chromium				
29	Ferro-molybdenum				
Product and by-product					
30	CO_2 for external use				
Others					
N	Other emission sources				

Annex C
(informative)

An example of CO_2 emission and intensity calculations for steel plant

C.1 Data of a steel plant

For an annual crude steel production: 710 000 t, the following applies.

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

Subscript designator for Q_t	Emission sources	Unit	Imports	Exports
Gas fuel				
1	Natural gas	10^3[a] m^3(stp[b])	7 000	—
2	Town gas	$10^3 m^3$(stp)	—	—
Liquid fuel				
3	Heavy oil	m^3	—	—
4	Light oil	m^3	—	—
5	Kerosene	m^3	—	—
6	LPG	t	—	—
Solid fuel				
7	EAF coal	dry t	6 500	—
8	Steam coal	dry t	12 000	—
9	Coke	dry t	3 000	—
10	Charcoal	dry t	—	—
11	SR / DRI coal	dry t	—	—
Auxiliary material				
12	Limestone	dry t	—	—
13	Burnt lime	t	20 000	—
14	Crude dolomite	dry t	—	—
15	Burnt dolomite	t	3 000	—
16	EAF graphite electorodes	t	1 050	—
17	Nitrogen	$10^3 m^3$(stp)	1 200	—
18	Argon	$10^3 m^3$(stp)	650	—
19	Oxygen	$10^3 m^3$(stp)	21 200	—
Energy carriers				
20	Electricity	MWh	335 000	—
21	Steam	t	—	—
Ferrous containing material				
22	Pellets	t	—	—
23	Hot metal	t	—	—
24	Cold iron	t	22 000	—
25	Gas-based DRI	t	—	—
26	Coal-based DRI	t	—	—

Table C.1 *(continued)*

Subscript designator for Q_t	Emission sources	Unit	Imports	Exports
Alloys				
27	Ferro-nickel	t	—	—
28	Ferro-chromium	t	—	—
29	Ferro-molybdenum	t	—	—
Product and by-product				
30	CO_2 for external use	t	—	—
Others				
N	Other emission sources	—	—	—
[a] 10^3=1000				
[b] Standard temperature and pressure.				

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

Subscript designator for Q_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])	14 098	—	—
2	Town gas	10^3m^3(stp)	—	—	—
Liquid fuel					
3	Heavy oil	m^3	—	—	—
4	Light oil	m^3	—	—	—
5	Kerosene	m^3	—	—	—
6	LPG	t	—	—	—
Solid fuel					
7	EAF coal	dry t	21 171	—	—
8	Steam coal	dry t	29 532	—	—
9	Coke	dry t	9 771	672	—
10	Charcoal	dry t	—	—	—
11	SR / DRI coal	dry t	—	—	—
Auxiliary material					
12	Limestone	dry t	—	—	—
13	Burnt lime	t	—	19 000	—
14	Crude dolomite	dry t	—	—	—
15	Burnt dolomite	t	—	3 300	—
16	EAF graphite electorodes	t	3 864	683	—
17	Nitrogen	10^3m^3(stp)	—	124	—
18	Argon	10^3m^3(stp)	—	67	—
19	Oxygen	10^3m^3(stp)	—	7 526	—
Energy carrier					
20	Electricity	MWh	—	168 840	—
21	Steam	t	—	—	—
Ferrous-containing material					
22	Pellets	t	—	—	—
23	Hot metal	t	—	—	—

Table C.2 *(continued)*

Subscript designator for Q t	Emission sources	Unit	Calculation results		
			Direct emissions tCO_2	Upstream emissions tCO_2	Credit emissions tCO_2
24	Cold iron	t	3 784	—	—
25	Gas-based DRI	t	—	—	—
26	Coal-based DRI	t	—	—	—
Alloy					
27	Ferro-nickel	t	—	—	—
28	Ferro-chromium	t	—	—	—
29	Ferro-molybdenum		—	—	—
Product and by-product					
30	CO_2 for external use	t	—	—	—
Others					
N	Other emission sources	t	—	—	—
Total			82 220	199 340	—
Total CO_2 emission			281 560		
Intensity			396 kg/ t crude steel		

[a] These calculation data and values use indicative factors in Table 4.

[b] 10^3=1000

[c] Standard temperature and pressure.

Bibliography

[1] *CO_2 EMISSIONS DATA COLLECTION. User Guide, Version 6.* World Steel Association. http://www.worldsteel.org/dms/internetDocumentList/downloads/steel-by-topic/Data-collection-user-guide_v6/document/Data%20collection%20user%20guide.pdf

[2] ISO 14064-1, *Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals*

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