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ISO 14404-4

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

Part 4: Guidance for using the ISO 14404 series

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

Partie 4: Lignes directrices pour l'utilisation de la série de normes ISO 14404

Reference number
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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: 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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

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

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

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

Introduction

The steel industry recognizes the urgent need to take actions concerning climate change. Slowing and halting global warming requires reductions in GHG emissions on a global scale. To play a part in achieving these reductions, it is necessary for steel plants to identify the amount of CO_2 emitted during the production of steel products, in order to identify next opportunities for reduction of CO_2.

As the calculation methods for CO_2 emission and intensity in iron and steel industry, ISO 14404-1 (for steel plants with blast furnace) and ISO 14404-2 (for steel plants with electric arc furnace) were published in 2013, and ISO 14404-3 (for steel plants with electric arc furnace and coal-based or gas-based direct reduction iron facility) was published in 2017.

The ISO 14404 series specifies calculation methods for the carbon dioxide (CO_2) intensity of a steel plant from the amounts of the major inputs (purchased items) and outputs (sold items), such as natural resources, intermediate products, and energy. The concept is shown in Figure 1.

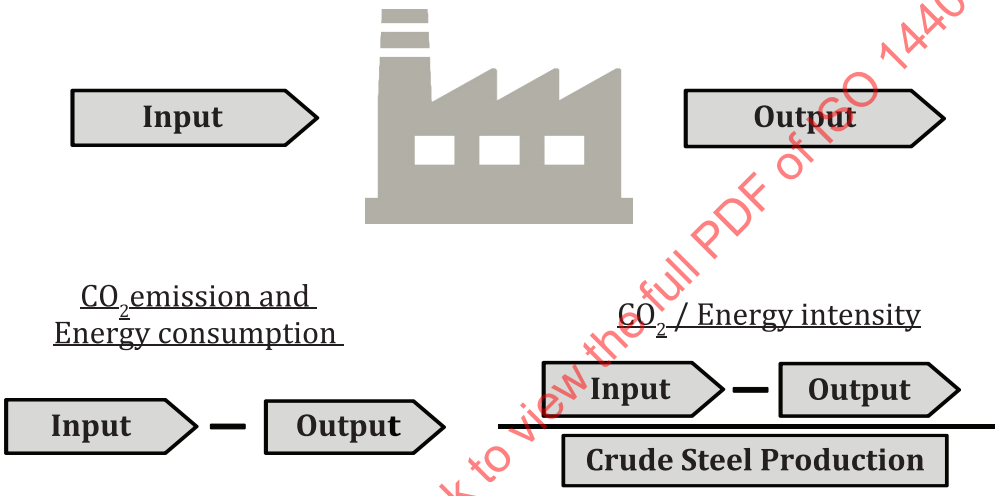

Figure 1 — Conceptual diagram of calculation method in the ISO 14404 series

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 commonly used data in the management of plants.

In addition, the ISO 14404 series provides the guidance to consider the activities in the boundary that are located outside of the site boundary by considering the upstream emissions of the intermediate products produced in such "outsourced steel production activities". The conceptual diagram of boundary and site boundary is shown in Figure 2.

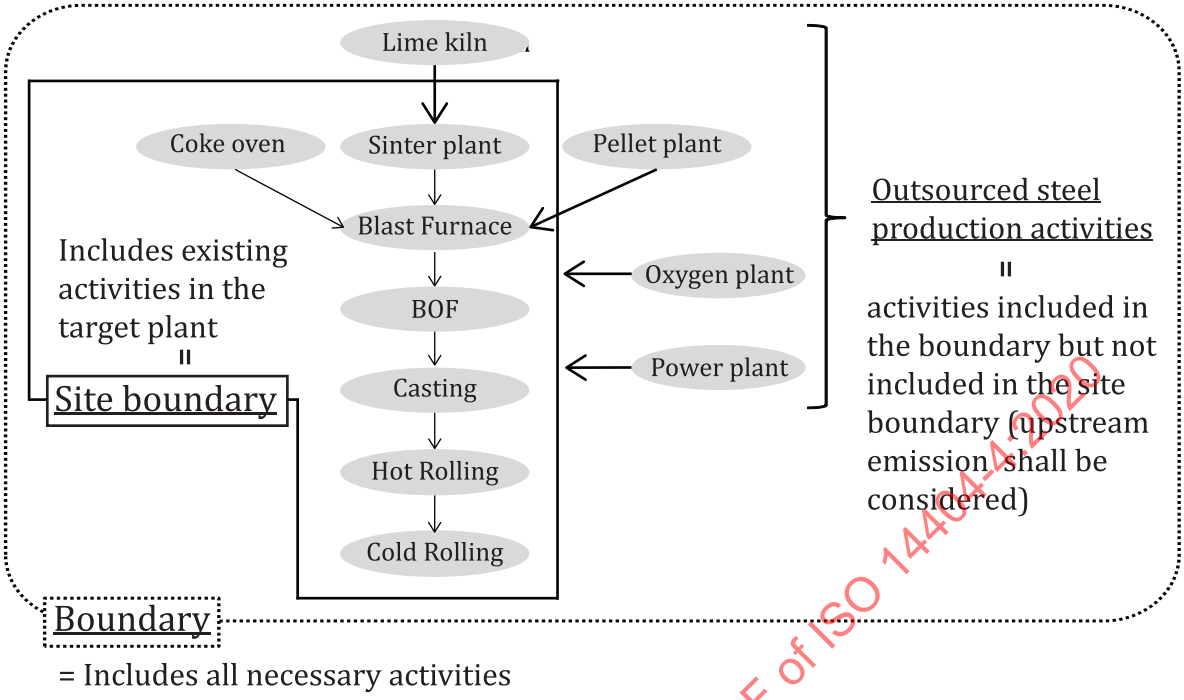

Figure 2 — Conceptual diagram of boundary and site boundary

Intermediate products with possibilities of considering upstream emissions include the following:

— Electricity / steam;

— Substances produced in the basic activities existing in the target process route (e.g. purchased coke used in the BF - BOF route);

— Substances that substitute the iron source of the process route even if they do not exist in the target process route (e.g. purchased DRI used in the BF - BOF route).

The ISO 14404 series is based on "CO_2 Emissions Data Collection User Guide" established by the World Steel Association (worldsteel), which consists more than 161 major steel companies in 60 countries and regions of the world. Actual data collection among worldsteel members has been conducted yearly based upon this guide since 2007. While the ISO 14404 series of standards and worldsteel "CO_2 Emissions Data Collection User Guide" share the same concept, they have different characteristics where the worldsteel's User Guide provides the method suitable for collecting data from steel plants across the world in a uniform way, and the ISO 14404 series provide methods suitable for the evaluation of CO_2 intensity of steel plant for each process route (i.e. combination of iron source and steelmaking process).

Therefore, while worldsteel method applies common boundary and CO_2 emission factors to all steelworks regardless of their process routes, the ISO 14404 series defines the boundary, CO_2 emission factors and intermediate products for which upstream emissions are considered for each of the process routes, such as BF-BOF (14404-1), Scrap-EAF (14404-2) and DRI-EAF (14404-3).

This document provides the guidance for calculating the CO_2 intensity at all types of steel plants, including steel plants with process routes not covered in ISO 14404-1, ISO 14404-2 and ISO 14404-3 (steel plants with process routes other than BF - BOF, Scrap - EAF, DRI - EAF) as well as steel plants with multiple process routes, by defining the boundary, CO_2 emission factors and the intermediate products for which upstream emissions are considered for each of all types of steel plants. This document also includes Universal Calculation Sheet, which covers all relevant emission sources from ISO 14404-1, ISO 14404-2 and ISO 14404-3 to assist the calculation of CO_2 emissions.

Moreover, this document provides additional guidance to the entire ISO 14404 series for the following topics, which have not been covered by ISO 14404-1, ISO 14404-2 and ISO 14404-3.

a) Evaluation of exported slags

b) Evaluation of by-product gas

c) Evaluation of stock

d) Selection of calorific values and emission factors for electricity and fuel

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

Part 4:
Guidance for using the ISO 14404 series

1 Scope

This document provides guidance for calculating the CO_2 intensity at steel plants with all types of process routes, by defining the boundary, CO_2 emission factors and the intermediate products for which upstream emissions are considered for all types of process routes. In particular, this document provides guidance applicable to the ISO 14404 series to the types of steel plants listed below. This document also includes the Universal Calculation Sheet, which covers all relevant emission sources from ISO 14404-1, ISO 14404-2 and ISO 14404-3 to assist the calculation of CO_2 emissions.

i. Steel plants with different process routes from ISO 14404-1, ISO 14404-2 and ISO 14404-3 (7.2.1)

ii. Steel plants with more than one process route (7.2.2)

iii. Steel plants purchasing pig iron from the outside (7.2.3)

iv. Steel plants and rerollers purchasing part or all of crude steel from outside (7.2.4)

Moreover, this document provides additional guidance to the entire ISO 14404 series for the following topics.

a) Evaluation of exported slags

b) Evaluation of by-product gas

c) Evaluation of stock

d) Selection of calorific values and emission factors for electricity and fuel

Conversion to energy consumption and to consumption efficiency can be obtained using Annex A.

While the use of the calculation result is outside the scope of this document, appropriate applications and inappropriate application are recommended in Annex B.

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 https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Emissions

3.1.1
emission source
process emitting CO_2 during the 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 document are given in *direct CO2 emission* (3.1.2), *upstream CO2 emission* (3.1.3) and *credit CO2 emission* (3.1.4).

[SOURCE: ISO 14404-1:2013, 2.1.1]

3.1.2
direct CO_2 emission
CO_2 emissions from steel production activity inside the *boundary* (3.10.2)

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

[SOURCE: ISO 14404-1:2013, 2.1.2]

3.1.3
upstream CO_2 emission
CO_2 emissions from imported material related to outsourced steel production activities outside the *site boundary* (3.10.3) and from imported *electricity* (3.6.1) and *steam* (3.6.2) into the *site boundary* (3.10.3)

Note 1 to entry: CO_2 emissions from imported material in this term are categorized as "other indirect GHG emissions" in ISO 14064-1.

Note 2 to entry: CO_2 emissions from imported *electricity* (3.6.1) and *steam* (3.6.2) in this term are categorized as "energy indirect GHG emissions" in ISO 14064-1.

[SOURCE: ISO 14404-1:2013, 2.1.3, modified — *boundary* (3.10.2) is changed to *site boundary* (3.10.3)]

3.1.4
credit CO_2 emission
CO_2 emission that corresponds to exported material and *electricity* (3.6.1) or *steam* (3.6.2)

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

[SOURCE: ISO 14404-1:2013, 2.1.4]

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

[SOURCE: ISO 14404-1:2013, 2.2.1]

3.2.2
coke oven gas
COG
gas recovered from *coke* (3.4.6) oven

[SOURCE: ISO 14404-1:2013, 2.2.2]

3.2.3
blast furnace gas
BFG
gas recovered from blast furnace

[SOURCE: ISO 14404-1:2013, 2.2.3]

3.2.4
BOF gas
LDG
gas recovered from basic oxygen furnace (Linz Donawitz converter)

Note 1 to entry: BOF: basic oxygen furnace

[SOURCE: ISO 14404-1:2013, 2.2.4]

3.2.5
town gas
fuel gas manufactured for domestic and industrial use

[SOURCE: ISO 14404-2:2013, 2.2.2]

3.2.6
COREX gas
gas recovered from COREX

3.2.7
other gas
gas other than *natural gas* (3.2.1), *coke oven gas* (3.2.2), *blast furnace gas* (3.2.3), *BOF gas* (3.2.4), *town gas* (3.2.5), and *COREX gas* (3.2.6)

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

[SOURCE: ISO 14404-1:2013, 2.3.1]

3.3.2
light oil
No. 2 to No.3 fuel oil defined by ASTM

[SOURCE: ISO 14404-1:2013, 2.3.2]

3.3.3
kerosene
paraffin (oil)

[SOURCE: ISO 14404-1:2013, 2.3.3]

3.3.4
LPG
liquefied petroleum gas

[SOURCE: ISO 14404-1:2013, 2.3.4]

3.4 Solid fuel

3.4.1
coking coal
coal for making *coke* (3.4.6), including anthracite

[SOURCE: ISO 14404-1:2013, 2.4.1]

3.4.2
BF injection coal
pulverized coal injection (PCI) coal, including anthracite

Note 1 to entry: BF: blast furnace

[SOURCE: ISO 14404-1:2013, 2.4.2]

3.4.3
sinter coal
BOF coal
coal for *sinter* (3.7.2)/BOF, including anthracite

[SOURCE: ISO 14404-1:2013, 2.4.3]

3.4.4
EAF coal
coal used for an *electric arc furnace (EAF)* (3.10.5), including anthracite

[SOURCE: ISO 14404-2:2013, 2.4.1, modified — "EAF" is changed to "electric arc furnace (EAF)". Note 1 to entry is deleted.]

3.4.5
steam coal
boiler coal for producing *electricity* (3.6.1) and *steam* (3.6.2), including anthracite

[SOURCE: ISO 14404-1:2013, 2.4.4]

3.4.6
coke
solid carbonaceous material

[SOURCE: ISO 14404-1:2013, 2.4.5]

3.4.7
charcoal
devolatilized or coked carbon neutral materials

EXAMPLE Trees, plants.

[SOURCE: ISO 14404-1:2013, 2.4.6]

3.4.8
SR/DRI coal
coal used for smelting reduction (SR, including COREX)/ direct reduction iron (DRI), including anthracite

[SOURCE: ISO 14404-2:2013, 2.4.5, modified — Note 1 to entry is integrated into the definition]

3.4.9
other coal
coal other than *steam coal* (3.4.5), *coking coal* (3.4.1), *BF injection coal* (3.4.2), *sinter coal* (3.4.3), *EAF coal* (3.4.4), *coke* (3.4.6), *charcoal* (3.4.7) and *SR/DRI coal* (3.4.8)

3.5 Auxiliary material

3.5.1
limestone
calcium carbonate
$CaCO_3$

[SOURCE: ISO 14404-1:2013, 2.5.1]

3.5.2
burnt lime
CaO

[SOURCE: ISO 14404-1:2013, 2.5.2]

3.5.3
crude dolomite
calcium magnesium carbonate
$CaMg(CO_3)_2$

[SOURCE: ISO 14404-1:2013, 2.5.3]

3.5.4
burnt dolomite
$CaMgO_2$

[SOURCE: ISO 14404-1:2013, 2.5.4]

3.5.5
electric arc furnace graphite electrodes
EAF graphite electrodes
net use of *EAF* (3.10.5) graphite electrodes or attrition loss

[SOURCE: ISO 14404-2:2013, 2.5.5]

3.5.6
nitrogen
N_2
inert gas separated from air at an *oxygen plant* (3.10.8), imported from/exported to outside the *boundary* (3.10.2)

[SOURCE: ISO 14404-1:2013, 2.5.5, modified — the definition is simplified]

3.5.7
argon
Ar
inert gas separated from air at an *oxygen plant* (3.10.8), imported from/exported to outside the *boundary* (3.10.2)

[SOURCE: ISO 14404-1:2013, 2.5.6, modified — the definition is simplified]

3.5.8
oxygen
O_2
gas separated from air at an *oxygen plant* (3.10.8), imported from/exported to outside the *boundary* (3.10.2)

[SOURCE: ISO 14404-1:2013, 2.5.7, modified — the definition is simplified]

3.6 Energy carriers

3.6.1
electricity
electrical energy imported from/exported to outside the *boundary* (3.10.2)

[SOURCE: ISO 14404-1:2013, 2.6.1, modified — the definition is simplified]

3.6.2
steam
pressurized water vapour imported from/exported to outside the *boundary* (3.10.2)

[SOURCE: ISO 14404-1:2013, 2.6.2]

3.7 Ferrous containing materials

3.7.1
pellets
agglomerated spherical iron ore calcinated by rotary kiln

[SOURCE: ISO 14404-1:2013, 2.7.1]

3.7.2
sinter
bulk iron ore sintered by baking mixture of fine iron ore, *coke* (3.4.6) breeze and pulverized lime

[SOURCE: ISO 14404-1:2013, 2.7.2]

3.7.3
hot metal
intermediate liquid iron products containing 30 g/kg to 50 g/kg by mass carbon produced by smelting iron ore with equipment such as blast furnace

[SOURCE: ISO 14404-1:2013, 2.7.3, modified — "3 %, 5 %" is replaced with "30 g/kg, 50 g/kg"]

3.7.4
cold iron
solidified *hot metal* (3.7.3) as an intermediate solid iron product

[SOURCE: ISO 14404-1:2013, 2.7.4]

3.7.5
scrap
used steel available for reprocessing

[SOURCE: ISO 14404-2:2013, 2.7.4]

3.7.6
gas-based DRI
direct reduced iron (DRI) reduced by a reducing gas such as reformed *natural gas* (3.2.1)

[SOURCE: ISO 14404-1:2013, 2.7.5]

3.7.7
coal-based DRI
direct reduced iron (DRI) reduced by coal

[SOURCE: ISO 14404-1:2013, 2.7.6]

3.8 Alloys

3.8.1
ferro-nickel
alloy of iron and nickel

[SOURCE: ISO 14404-1:2013, 2.8.1]

3.8.2
ferro-chromium
alloy of iron and chromium

[SOURCE: ISO 14404-1:2013, 2.8.2]

3.8.3
ferro-molybdenum
alloy of iron and molybdenum

[SOURCE: ISO 14404-1:2013, 2.8.3]

3.9 Product and by-product

3.9.1
CO_2 for external use
CO_2 exported to outside the *boundary* (3.10.2)

[SOURCE: ISO 14404-1:2013, 2.9.1]

3.9.2
coal tar
by-products of the carbonization of coal to *coke* (3.4.6), containing complex and variable mixtures of phenols and polycyclic aromatic hydrocarbons

[SOURCE: ISO 14404-1:2013, 2.9.2]

3.9.3
coal light oil
benzole
light oil (3.3.2) recovered by *COG* (3.2.2) purification, consisting mainly of benzene, toluene and xylene (BTX)

[SOURCE: ISO 14404-1:2013, 2.9.3, modified — "COG gas" is changed to "COG"]

3.9.4
BF slag to cement
blast furnace slag supplied to cement industry

[SOURCE: ISO 14404-1:2013, 2.9.4]

3.9.5
BOF slag to cement
BOF slag supplied to cement industry

[SOURCE: ISO 14404-1:2013, 2.9.5]

3.10 Others

3.10.1
other emission source
other related *emission sources* (3.1.1) such as plastics, *scraps* (3.7.5), desulfurization additives, alloys, fluxes for secondary metallurgy, dust, sludge, etc.

[SOURCE: ISO 14404-1:2013, 2.10.1]

3.10.2
boundary
limit of activity used to calculate CO_2 emissions intensity for steel production activities

Note 1 to entry: *boundary* (3.10.2) may be different from the *site boundary* (3.10.3)

[SOURCE: ISO 14404-1:2013, 2.10.2, modified — Note 1 and 2 to entry is deleted, and new Note 1 to entry is added]

3.10.3
site boundary
boundary (3.10.2) defined by the target steel production site for the calculation of CO_2 emission and intensity

3.10.4
process route
route of steel production defined by the combination of iron source and steel making process

3.10.5
EAF
electric arc furnace
furnace that melts and refines iron-bearing material into steel

[SOURCE: ISO 14404-2:2013, 2.10.2.1]

3.10.6
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

[SOURCE: ISO 14404-1:2013, 2.10.2.3]

3.10.7
lime kiln
kiln used to produce *burnt lime* (3.5.2) by the calcination of *limestone* (3.5.1)

[SOURCE: ISO 14404-1:2013, 2.10.2.6]

3.10.8
oxygen plant
cryogenic air separator to produce high-purity *oxygen* (3.5.8)

[SOURCE: ISO 14404-1:2013, 2.10.2.8]

3.10.9
steam boiler
boiler for production of *steam* (3.6.2)

[SOURCE: ISO 14404-1:2013, 2.10.2.9]

3.10.10
power plant
plant that generates *electricity* (3.6.1)

[SOURCE: ISO 14404-1:2013, 2.10.2.10]

3.10.11
RHF
reheating furnace
heating furnace used in *hot rolling* (3.10.12) mills to heat the steel stock (billets, blooms or slabs)

3.10.12
hot rolling
rolling at elevated temperature

[SOURCE: ISO 14404-1:2013, 2.10.2.11]

3.10.13
cold rolling
rolling at room temperature

[SOURCE: ISO 14404-1:2013, 2.10.2.12]

3.10.14
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.

[SOURCE: ISO 14404-1:2013, 2.10.2.13]

4 Symbols

The symbols used in this document are given in Table 1.

Table 1 — Symbols

Symbol	Unit	Description
Ed,CO_2	tonnes of CO_2	Direct CO_2 emissions
Eu,CO_2	tonnes of CO_2	Upstream CO_2 emissions
Ec,CO_2	tonnes of CO_2	Credit CO_2 emissions
Ea,CO_2	tonnes of CO_2	Annual CO_2 emissions
ICO_2	tonnes of CO_2 per tonne	CO_2 intensity factor
Kt,d,CO_2	tonnes of CO_2 per unit	Emission factor for calculation of direct CO_2 emissions
Kt,u,CO_2	tonnes of CO_2 per unit	Emission factor for calculation of upstream CO_2 emissions
Kt,c,CO_2	tonnes of CO_2 per unit	Emission factor for calculation of credit CO_2 emissions
P	—	Annual crude steel production
Qt,d,CO_2	—	Quantities of direct CO_2 emission sources
Qt,u,CO_2	—	Quantities of upstream CO_2 emission sources
Qt,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 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.

5.2 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.

5.3 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.

5.4 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.

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

6 Characteristic features of the ISO 14404 series

Characteristic features of the ISO 14404 series include the following:

— 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 commonly used data in the management of plants.

— The series defines the boundary (i.e. limit of activity used to calculate CO_2 emissions intensity for steel production activities) for CO_2 intensity calculation for each process route. Even in the case where the activities within the "boundary" are located outside the "site boundary" of the target steel plant, the series provides the guidance to include them to be inside the boundary by applying the concept of "upstream emissions" to the intermediate products produced in such "outsourced steel production activities". Intermediate products that may be produced in such "outsourced steel production activities" include the following:

  — Electricity / steam

  — Substances manufactured in the basic activity existing in the target process route (e.g. purchased coke used in the BF - BOF route)

  — Substances that substitute the iron source of the process route even if they do not exist in the target process route (e.g. purchased DRI used in the BF - BOF route)

7 Guidance for applying the ISO 14404 series to all types of steel plants

7.1 General

As shown in Figure 3, there are multiple combinations of iron source and steelmaking process, i.e. process routes, in the steel manufacturing process.

In Figure 3, each of the arrows represents a process route.

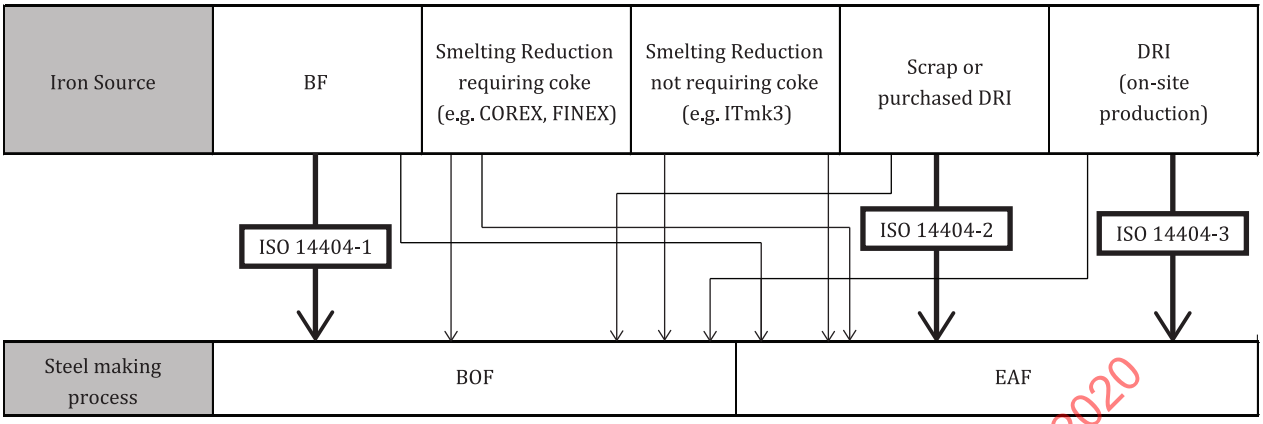

Figure 3 — Existing Process Routes in Steel Production

Process routes covered by ISO 14404-1, ISO 14404-2 and ISO 14404-3 are BF-BOF (ISO 14404-1), Scrap-EAF (ISO 14404-2), DRI (facility) -EAF (ISO 14404-3) only. However, by determining the intermediate products for which upstream emissions shall be considered according to the decision tree in Figure 4, it is possible to calculate the CO_2 intensity using ISO 14404 at all steel plants. Moreover, since the idea of boundary application described in Figure 4 is already reflected in the universal calculation sheet detailed in Clause 8, the sheet can be applied to all steel plants by entering the inputs and outputs for each item in the entry sheet.

Note that if the steel plant both produces crude steel and purchases semi-finished steel products, 7.2.4.2 and Annex E should be referred to.

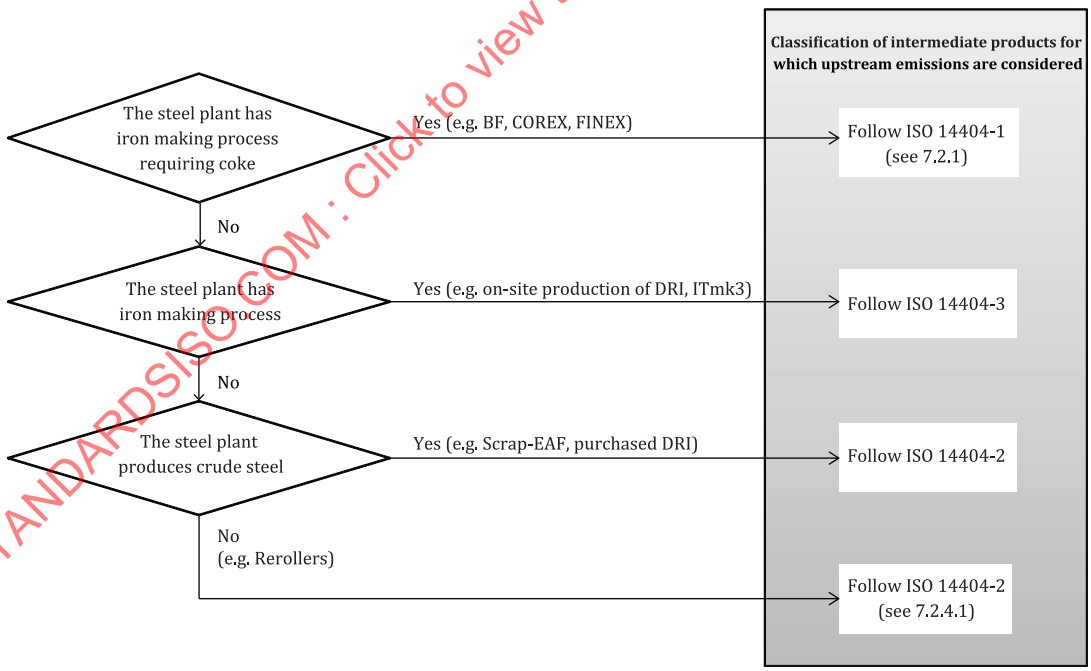

Figure 4 — Decision tree for the application of the ISO14404 series

Whether to consider the upstream emissions of purchased intermediate products or not is determined by whether the process producing the intermediate product is inside the boundary applied to the target steel plant or not. The essential facilities for steel production associated with each process route are considered to be inside the boundary, and if these processes are located outside of the steel plant site (i.e. these steel production activities are outsourced), then the emissions from such processes shall be taken into account by applying upstream emissions to the purchased intermediate products produced from such processes. On the other hand, upstream emissions of intermediate products produced in

non-essential processes shall not be considered. Since ISO 14404-1, ISO 14404-2 and ISO 14404-3 have different boundaries, each part has different set of intermediate products for which upstream emissions shall be considered.

As shown in Table 2, there are 14 intermediate products for which upstream emissions are considered in ISO 14404-1, 2, 3. For example, since coke oven is an essential facility in the BF-BOF process route, which is the target process route of ISO 14404-1, coke production is determined to be inside the boundary in 14404-1. Therefore, when coke is purchased from outside, the upstream emissions of such purchased coke shall be considered. On the other hand, coke oven is not an essential facility in the scrap-EAF process route, the target process route of ISO 14404-2, and therefore outside the boundary for calculation. For this reason, if the coke is purchased by a steel plant with scrap-EAF process route, the upstream emissions shall not be considered.

Table 2 organizes for which intermediate products upstream emissions are considered in each part of ISO 14404 series (considered→○, not considered→×, not applicable→ -). Among the 14 intermediate products, upstream emissions shall be considered in all 3 parts of the ISO 14404 series for the following 7 intermediate products: burnt lime, burnt dolomite, nitrogen, argon, oxygen, electricity and steam. When a steel plant has a blast furnace or an iron making process requiring coke, then upstream emissions shall be considered for all 14 intermediate products (i.e. the set of intermediate products for which upstream emissions shall be considered follows ISO 14404-1). When a steel plant has an iron making process not requiring coke, then upstream emissions shall be considered for pellet, hot metal, cold iron, gas-based DRI, coal-based DRI (i.e. the set of intermediate products for which upstream emissions shall be considered follows ISO 14404-3). Since sinter is used only in the blast furnace process, there is no entry space for its inputs and outputs in ISO 14404-2 or ISO 14404-3. Therefore, it is not necessary to determine whether to consider its upstream emissions or not.

Table 2 — Classifications of the intermediate products with/without upstream emissions

	ISO 14404-1	ISO 14404-2	ISO 14404-3	Condition for considering the upstream emissions
Coke	○	×	×	Presence of Iron making process requiring coke in the site boundary
Burnt lime	○	○	○	
Burnt dolomite	○	○	○	
Nitrogen	○	○	○	
Argon	○	○	○	
Oxygen	○	○	○	
Electricity	○	○	○	
Steam	○	○	○	
Pellets	○	×	○	Presence of Iron making process in the site boundary
Sinter	○	-	-	Presence of Iron making process requiring coke in the site boundary
Hot metal	○	×	○	Presence of Iron making process in the site boundary
Cold iron	○	×	○	Presence of Iron making process in the site boundary
Gas-based DRI	○	×	○	Presence of Iron making process in the site boundary
Coal-based DRI	○	×	○	Presence of Iron making process in the site boundary

As described above, whether to consider the upstream emission of a purchased intermediate product in the ISO 14404 series depend on the type of iron source (i.e. whether there is an iron making process or not, and whether there is an iron making process requiring coke or not), and it does not depend on the type of steel making process (i.e. BOF or EAF). Therefore, when selecting the part to be applied, there is

no need to differentiate between BOF and EAF, and only the type of iron source should be considered. Table 3 organizes the applicable part of the ISO 14404 series for the classification of intermediate products for which upstream emissions are considered for each iron source type.

Table 3 — Parts of the ISO 14404 series corresponding to iron source type

Iron source / Iron making process	Ironmaking process requiring coke (e.g. BF, COREX, FINEX)	Ironmaking process not requiring coke (e.g. ITmk3, Produced DRI)	Scrap Purchased DRI
Applicable Standard for the classification of intermediate products for which upstream emissions shall be considered	ISO 14404-1	ISO 14404-3	ISO 14404-2

Subclause 7.2 provides the guidance for applying the ISO 14404 series to steel plants, for which the determination of the part of ISO 14404 to be applied is considered difficult.

7.2 Application of the ISO 14404 series for steel plants not covered in ISO 14404-1, ISO 14404-2 and ISO 14404-3

7.2.1 Steel Plants with iron making processes other than BF and on-site production of DRI

For steel plants with iron making processes other than BF or on-site production of DRI, ISO 14404-1 should be applied if the iron making process requires coke (e.g. COREX, FINEX), and ISO 14404-3 should be applied if the iron making process does not require coke (e.g. ITmk3).

7.2.2 Steel Plants with multiple process routes

When a steel plant has two or more process routes, follow the decision tree in Figure 4 for determining which part of the ISO 14404 series should be followed for the classification of intermediate products for which upstream emissions shall be considered. In other words, the intermediate products for which upstream emissions shall be considered are determined by the presence of crude steel production process, iron making process and iron making process requiring coke in the steel plant. For example, for a steel plant with both BF process, which requires coke, and DRI process, which does not require coke, the upstream emissions shall be considered for all purchased coke of this steel plant.

7.2.3 Steel plants which purchase pig iron from outside

For steel plants which make all of their steel products such as special steel or special shaped steel using only purchased pig iron (hot metal/ cold iron), ISO 14404-2 should be applied.

7.2.4 Steel plants which purchase all or part of semi-finished steel product from outside

The method for considering purchased crude steel is not provided in ISO 14404-1, ISO 14404-2 and ISO 14404-3, while the method to consideration of purchased hot metal and cold iron are provided. Thus, the guidance is provided here.

2 types of steel plants are assumed (Figure 5).

Case 1: a steel plant which produces all steel products from purchased semi- finished steel product

Case 2: a steel plant which produces crude steel through process routes such as BF-BOF and scrap-EAF in addition to using purchased semi-finished steel products

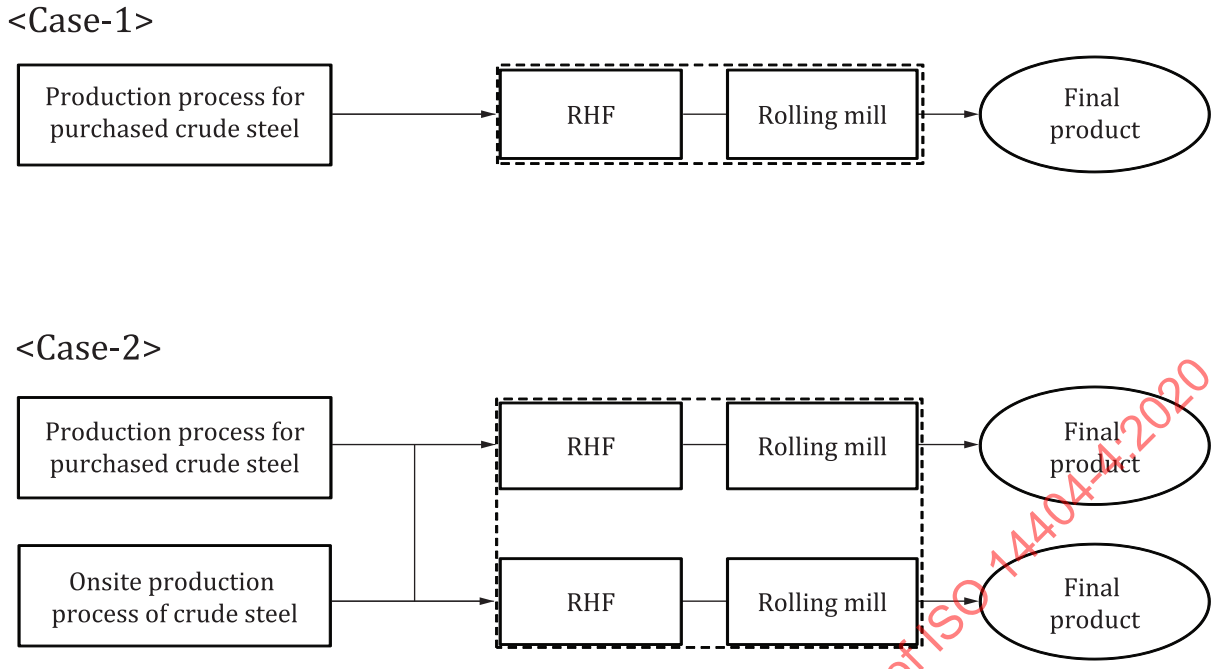

Figure 5 — Schematic diagram of Case-1 and Case-2

7.2.4.1 Case-1: a steel plant which produces all steel products are made by using from purchased semi- finished steel product (Re-Roller)

For rerollers that produce their steel products using only purchased semi-finished steel product (slab, bloom, billet etc.), ISO 14404-2 should be applied. In this case, expected input items are fuel for reheating the purchased semi-finished products and electricity for rolling. The amount of final product (or the amount of purchased semi-finished steel product) is used as parameter of CO_2 intensity instead of the amount of crude steel production.

7.2.4.2 Case-2: a steel plant which produces crude steel through process routes such as BF-BOF and scrap-EAF in addition to using purchased semi-finished steel products

Case-2 applies to a steel plant which purchases crude steel (slab, bloom, billet, etc.) in addition to on-site production of crude steel. In this case, the part of the ISO 14404 series to be applied should be determined by the process route of the on-site crude steel production. Therefore, a steel plant with BF or an iron making process requiring coke follows ISO 14404-1, a steel plant with an iron making process not requiring coke follows ISO 14404-3, and a steel plant without an iron making process follows ISO 14404-2 for determining for which intermediate products upstream emissions shall be considered. Depending on the purposes, a boundary should be applied and calculated. For the method to apply and calculate the boundary, refer to Annex E.

7.3 Guideline for making comparisons using the ISO 14404 series

In general, CO_2 emissions differ greatly depending on whether a steel plant has the iron making process, steel making process and rerolling process. In ISO 14404-1, ISO 14404-2 and ISO 14404-3, the boundary of each target process route is strictly defined, and therefore each steel plant that uses the same part of the ISO 14404 series (i.e. ISO 14404-1, ISO 14404-2 and ISO 14404-3) can be compared with each other.

In making comparisons beyond parts or comparisons of steel plants with process routes which are not covered by ISO 14404-1, ISO 14404-2 and ISO 14404-3, the prerequisite is for the steel plants being compared to have the same set of iron making, steel making and rolling processes.

In general, a steel plant with iron making process and plant without iron making process cannot be compared.

As for comparisons among steel plants with iron making process, when making a comparison between two or more steel plants with iron making process not requiring coke, the upstream emissions of coke shall not be considered (i.e. ISO 14404-3 shall be applied for the consideration of upstream emissions). On the other hand, when making a comparison between a steel plant with iron making process not requiring coke and a steel plant with iron making process requiring coke, then the upstream emissions of purchased coke shall be considered (i.e. ISO 14404-1 shall be applied for the consideration of upstream emissions).

When making a comparison between steel plant using purchased semi-finished steel product, the guidance below should be followed.

A reroller without steelmaking process should be compared only with another reroller without steelmaking process, and ISO 14404-2 should be applied for the consideration of upstream emissions (see 7.2.4.1 Case-1).

When making comparison between a steel plant using both self-produced crude steel and purchased semi-finished steel product with another steel plant with steel making process, consider the upstream emission of purchased semi-finished steel product (see 7.2.4.2 Case-2 and Annex E Boundary-3).

8 Calculation using the Universal Calculation Sheet

8.1 General

This document provides the Universal Calculation Sheet, which includes all emission sources that are covered in Annex C of the ISO 14404 series. In this calculation sheet, the emission factors to be applied are automatically selected according to the rules of upstream emission consideration as described in Figure 4. Therefore, this calculation sheet can be applied to all types of steel plants by entering the input/output data into the cell corresponding to the appropriate energy source type.

Table 4 lists all emission sources included in the universal calculation sheet. The universal calculation sheet includes all emission sources included in ISO 14404-1, ISO 14404-2 and ISO 14404-3 as well as COREX gas, other gas, and other coal (highlighted by gray color in Table 4), which are not included in ISO 14404-1, ISO 14404-2 and ISO 14404-3, in order to apply the ISO 14404 series for all steel plants. Since the types of "other gas" and "other coal" are different for each steel plant, the type and emission factor of these items shall be selected by each steel plant.

Table 4 — List of emission sources included in the Universal Calculation Sheet

	ISO 14404-1	ISO 14404-2	ISO 14404-3
Natural gas	○	○	○
Coke oven gas	○	×	×
Blast furnace gas	○	×	×
BOF gas	○	×	×
Town gas	×	○	○
COREX gas	-	-	-
Other gas	-	-	-
Heavy oil	○	○	○
Light oil	○	○	○
Kerosene	○	○	○
LPG	○	○	○
Coking coal	○	×	×
○: included in this part ×: not included in this part -: items newly added in this document			

Table 4 *(continued)*

	ISO 14404-1	ISO 14404-2	ISO 14404-3
BF injection coal	○	×	×
Sinter/BOF coal	○	×	×
Steam coal	○	○	○
Coke	○	○	○
Charcoal	○	○	○
EAF coal	×	○	○
SR/DRI coal	×	×	○
Other coal	-	-	-
Limestone	○	○	○
Burnt lime	○	○	○
Crude dolomite	○	○	○
Burnt dolomite	○	○	○
Nitrogen	○	○	○
Argon	○	○	○
Oxygen	○	○	○
EAF graphite electrodes	×	○	○
Electricity	○	○	○
Steam	○	○	○
Pellets	○	○	○
Sinter	○	○	○
Hot metal	○	○	○
Cold iron	○	○	○
Gas-based DRI	○	○	○
Coal-based DRI	○	○	○
Ferro-nickel	○	○	○
Ferro-chromium	○	○	○
Ferro-molybdenum	○	○	○
CO_2 for external use	○	○	○
Coal tar	○	○	○
Benzole (coal light oil)	○	○	○
Other emission sources	○	○	○
○: included in this part ×: not included in this part -: items newly added in this document			

A plant performs its calculations as follows.

a) Step 1: Clarify the quantity of annual crude steel production (or final steel production) at the plant.

b) Step 2: Clarify the annual direct CO_2 emissions sources and upstream CO_2 emissions sources based on raw materials, intermediate products and energy that the plant exports to outside users.

c) Step 3: Clarify the annual credit CO_2 emissions sources based on raw materials, intermediate products and energy that the plant exports to outside users.

d) Step 4: Calculate the annual CO_2 emissions and CO_2 intensity using the emission factor.

8.2 Calculation procedure

8.2.1 Data collection of crude steel production (or final steel production)

A plant manufacturing steel records its annual production of crude steel (P). If a plant uses any purchased semi-finished steel products, record the annual purchased amount of purchased semi-finished steel products or the plant's annual production of final steel products.

8.2.2 Data collection of direct and/or upstream CO_2 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 CO_2 emissions sources based on Table 5.

Table 5 includes all emission sources included in the ISO 14404 series.

Table 5 — Direct and/or upstream CO_2 emission sources

Subscript designator for Q t	Emission sources	Unit	Quantities of direct emission source Qt,d,CO_2	Quantities of upstream emission source Qt,u,CO_2
Gas fuel				
1	Natural gas	10^3 [a] m^3(stp[b])	$Q1,d,CO_2$	N/A[c]
2	Coke oven gas	10^3m^3(stp)	$Q2,d,CO_2$	N/A
3	Blast furnace gas	10^3m^3(stp)	$Q3,d,CO_2$	N/A
4	BOF gas	10^3m^3(stp)	$Q4,d,CO_2$	N/A
5	Town gas	10^3m^3(stp)	$Q5,d,CO_2$	N/A
6	COREX gas	10^3m^3(stp)	$Q6,d,CO_2$	N/A
7	Other gas	10^3m^3(stp)	$Q7,d,CO_2$	N/A
Liquid fuel				
8	Heavy oil	m^3	$Q8,d,CO_2$	N/A
9	Light oil	m^3	$Q9,d,CO_2$	N/A
10	Kerosene	m^3	$Q10,d,CO_2$	N/A
11	LPG	t	$Q11,d,CO_2$	N/A
Solid fuel				
12	Coking coal	dry t	$Q12,d,CO_2$	N/A
13	BF injection coal	dry t	$Q13,d,CO_2$	N/A
14	Sinter/BOF coal	dry t	$Q14,d,CO_2$	N/A
15	Steam coal	dry t	$Q15,d,CO_2$	N/A
16	Coke	dry t	$Q16,d,CO_2$	$Q16,u,CO_2$
17	Charcoal	dry t	$Q17,d,CO_2$	N/A
18	EAF coal	dry t	$Q18,d,CO_2$	N/A
19	SR/DRI coal	dry t	$Q19,d,CO_2$	N/A
20	Other coal	dry t	$Q20,d,CO_2$	N/A
Auxiliary materials				

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 5 *(continued)*

Subscript designator for Q t	Emission sources	Unit	Quantities of direct emission source Qt,d,CO_2	Quantities of up-stream emission source Qt,u,CO_2
21	Limestone	dry t	$Q21,d,CO_2$	N/A
22	Burnt lime	t	N/A	$Q22,u,CO_2$
23	Crude dolomite	dry t	$Q23,d,CO_2$	N/A
24	Burnt dolomite	t	N/A	$Q24,u,CO_2$
25	Nitrogen	10^3m^3(stp)	N/A	$Q25,u,CO_2$
26	Argon	10^3m^3(stp)	N/A	$Q26,u,CO_2$
27	Oxygen	10^3m^3(stp)	N/A	$Q27,u,CO_2$
28	EAF graphite electrodes	t	$Q28,d,CO_2$	$Q28,u,CO_2$
Energy carriers				
29	Electricity	MWh	N/A	$Q29,u,CO_2$
30	Steam	t	N/A	$Q30,u,CO_2$
Ferrous-containing material				
31	Pellets	t	N/A	$Q31,u,CO_2$
32	Sinter	t	N/A	$Q32,u,CO_2$
33	Hot metal	t	$Q33,d,CO_2$	$Q33,u,CO_2$
34	Cold iron	t	$Q34,d,CO_2$	$Q34,u,CO_2$
35	Gas-based DRI	t	$Q35,d,CO_2$	$Q35,u,CO_2$
36	Coal-based DRI	t	$Q36,d,CO_2$	$Q36,u,CO_2$
Alloys				
37	Ferro-nickel	t	$Q37,d,CO_2$	N/A
38	Ferro-chromium	t	$Q38,d,CO_2$	N/A
39	Ferro-molybdenum	t	$Q39,d,CO_2$	N/A
Product and/or by-product				
40	CO2 for external use	t	$Q40,d,CO_2$	N/A
41	Coal tar	t	$Q41,d,CO_2$	N/A
42	Benzole (coal light oil)	t	$Q42,d,CO_2$	N/A
Others				
N	Other emission sources	—	QN,d,CO_2	QN,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.

8.2.3 Data collection of credit CO_2 emissions sources

A plant manufacturing steel records the quantities of raw materials, intermediate products and energy that are exported to the outside users as the credit CO_2 emission sources based on Table 6.

Table 6 — Credit CO_2 emission sources

Subscript designator for Q t	Emission sources	Unit	Quantities of credit emission source Qt,c,CO_2
Gas fuel			
1	Natural gas	10^3 [a] m^3(stp[b])	$Q1,c,CO_2$
2	Coke oven gas	10^3m^3(stp)	$Q2,c,CO_2$
3	Blast furnace gas	10^3m^3(stp)	$Q3,c,CO_2$
4	BOF gas	10^3m^3(stp)	$Q4,c,CO_2$
5	Town gas	10^3m^3(stp)	$Q5,c,CO_2$
6	COREX gas	10^3m^3(stp)	$Q6,c,CO_2$
7	Other gas	10^3m^3(stp)	$Q7,c,CO_2$
Liquid fuel			
8	Heavy oil	m^3	$Q8,c,CO_2$
9	Light oil	m^3	$Q9,c,CO_2$
10	Kerosene	m^3	$Q10,c,CO_2$
11	LPG	t	$Q11,c,CO_2$
Solid fuel			
12	Coking coal	dry t	$Q12,c,CO_2$
13	BF injection coal	dry t	$Q13,c,CO_2$
14	Sinter/BOF coal	dry t	$Q14,c,CO_2$
15	Steam coal	dry t	$Q15,c,CO_2$
16	Coke	dry t	$Q16,c,CO_2$
17	Charcoal	dry t	$Q17,c,CO_2$
18	EAF coal	dry t	$Q18,c,CO_2$
19	SR/DRI coal	dry t	$Q19,c,CO_2$
20	Other coal	dry t	$Q20,c,CO_2$
Auxiliary material			
21	Limestone	dry t	$Q21,c,CO_2$
22	Burnt lime	t	$Q22,c,CO_2$
23	Crude dolomite	dry t	$Q23,c,CO_2$
24	Burnt dolomite	t	$Q24,c,CO_2$
25	Nitrogen	10^3m^3(stp)	$Q25,c,CO_2$
26	Argon	10^3m^3(stp)	$Q26,c,CO_2$
27	Oxygen	10^3m^3(stp)	$Q27,c,CO_2$
28	EAF graphite electrodes	t	$Q28,c,CO_2$
Energy carriers			
29	Electricity	MWh	$Q29,c,CO_2$
30	Steam	t	$Q30,c,CO_2$
Ferrous-containing material			
31	Pellets	t	$Q31,c,CO_2$
32	Sinter	t	$Q32,c,CO_2$
33	Hot metal	t	$Q33,c,CO_2$
34	Cold iron	t	$Q34,c,CO_2$

[a] 10^3=1 000

[b] Standard temperature and pressure.

Table 6 *(continued)*

Subscript designator for Q t	Emission sources	Unit	Quantities of credit emission source Qt,c,CO_2
35	Gas-based DRI	t	$Q35,c,CO_2$
36	Coal-based DRI	t	$Q36,c,CO_2$
Alloys			
37	Ferro-nickel	t	$Q37,c,CO_2$
38	Ferro-chromium	t	$Q38,c,CO_2$
39	Ferro-molybdenum	t	$Q39,c,CO_2$
Product and/or by-product			
40	CO2 for external use	t	$Q40,c,CO_2$
41	Coal tar	t	$Q41,c,CO_2$
42	Benzole (coal light oil)	t	$Q42,c,CO_2$
Others			
N	Other emission sources	—	QN,c,CO_2
[a] 10^3=1 000			
[b] Standard temperature and pressure.			

8.2.4 Calculation

The annual CO_2 emissions (Ea,CO_2) and CO_2 intensity (ICO_2) of a site are calculated from Formulae (1) and (2) using CO_2 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 8.2.2 and 8.2.3.

$$Ea,CO_2 = \sum_{t=1}^{N} Kt,d,CO_2 \times Qt,d,CO_2 + \sum_{t=1}^{N} Kt,u,CO_2 \times Qt,u,CO_2 - \sum_{t=1}^{N} Kt,c,CO_2 \times Qt,c,CO_2 \quad (1)$$

$$ICO_2 = Ea,CO_2 / P \quad (2)$$

Table 7 gives an indication of emission factors that can be used if no other reliable data are available. If different emission factors or simplifications from Table 7 are applied, such emission factors or simplifications should be clearly identified and justified. If other emission sources specified in No. N of Table 7 are applied, such sources should be clearly identified with their emission factors. An example of a template is available in Annex D.

Table 7 — Indicative emission factors for CO_2 emission sources

CO_2 Emission Source			Unit	CO_2 Emission Factor		
				Direct emission factor (*Kt*,d,-CO_2)	Up-stream emission factor (*Kt*,u,-CO_2)	Credit emission factor (*Kt*,c,-CO_2)
				t-CO_2/unit	t-CO_2/unit	t-CO_2/unit
Gas fuel	Natural gas		10^3m^3(stp)	2,014	N/A	2,014
	Coke oven gas		10^3m^3(stp)	0,836	N/A	0,977[a]
						0,952[b]
	Blast furnace gas		10^3m^3(stp)	0,891	N/A	0,170[a]
						0,185[b]
	BOF gas		10^3m^3(stp)	1,512	N/A	0,432[a]
						0,470[b]
	Town gas		10^3m^3(stp)	2,014	N/A	2,014
	COREX gas		10^3m^3(stp)	1,414	N/A	0,375
	Other gas		10^3m^3(stp)	c	N/A	c
Liquid fuel	Heavy oil		m^3	2,907	N/A	2,907
	Light oil		m^3	2,601	N/A	2,601
	Kerosene		m^3	2,481	N/A	2,481
	LPG		t	2,985	N/A	2,985
Solid fuel	Coking coal		dry t	3,059	N/A	3,059
	BF injection coal		dry t	2,955	N/A	2,955
	Sinter/BOF coal		dry t	2,784	N/A	2,784
	Steam coal		dry t	2,461	N/A	2,461
	Coke	for a steel plant with Iron making process requiring coke	dry t	3,257	0,224	3,481
		for a steel plant without Iron making process requiring coke	dry t	3,257	N/A	3,257
	Charcoal		dry t	0,000	N/A	0,000
	EAF coal		dry t	3,257	N/A	3,257
	SR/DRI coal		dry t	2,955	N/A	2,955
	Other coal		dry t	c	N/A	c

[a] This credit emission factor is based on world average electricity equivalent based on worldsteel methodology.

[b] This credit emission factor is based on natural gas equivalent.

[c] The value shall be determined by using available data backed by reliable evidence.

Table 7 *(continued)*

CO_2 Emission Source		Unit	CO_2 Emission Factor		
			Direct emission factor (Kt,d,-CO_2)	Up-stream emission factor (Kt,u,-CO_2)	Credit emission factor (Kt,c,-CO_2)
			t-CO_2/unit	t-CO_2/unit	t-CO_2/unit
Auxiliary material	Limestone	dry t	0,440	N/A	0,440
	Burnt lime	t	N/A	0,950	0,950
	Crude dolomite	dry t	0,471	N/A	0,471
	Burnt dolomite	t	N/A	1,100	1,100
	Nitrogen	10^3m^3(stp)	N/A	0,103	0,103
	Argon	10^3m^3(stp)	N/A	0,103	0,103
	Oxygen	10^3m^3(stp)	N/A	0,355	0,355
	EAF graphite electrodes	t	3,663	N/A	3,663
Energy carriers	Electricity	MWh	N/A	0,504	0,504
	Steam	t	N/A	0,195	0,195

[a] This credit emission factor is based on world average electricity equivalent based on worldsteel methodology.

[b] This credit emission factor is based on natural gas equivalent.

[c] The value shall be determined by using available data backed by reliable evidence.

Table 7 *(continued)*

CO_2 Emission Source			Unit	CO_2 Emission Factor		
				Direct emission factor (Kt,d,-CO_2)	Up-stream emission factor (Kt,u,-CO_2)	Credit emission factor (Kt,c,-CO_2)
				t-CO_2/unit	t-CO_2/unit	t-CO_2/unit
Ferrous-containing material	Pellets	for a steel plant with Iron making process	t	N/A	0,137	0,137
		for a steel plant without Iron making process	t	N/A	N/A	N/A
	Sinter		t	N/A	0,262	0,262
	Hot metal	for a steel plant with Iron making process	t	0,172	1,855	2,027
		for a steel plant without Iron making process	t	0,172	N/A	0,172
	Cold iron	for a steel plant with Iron making process	t	0,172	1,855	2,027
		for a steel plant without Iron making process	t	0,172	N/A	0,172
	Gas-based DRI	for a steel plant with Iron making process	t	0,073	0,780	0,853
		for a steel plant without Iron making process	t	0,073	N/A	0,073
	Coal-based DRI	for a steel plant with Iron making process	t	0,073	1,210	1,283
		for a steel plant without Iron making process	t	0,073	N/A	0,073
Alloys	Ferro-nickel		t	0,037	N/A	0,037
	Ferro-chromium		t	0,275	N/A	0,275
	Ferro-molybdenum		t	0,018	N/A	0,018
Product and by-product	CO_2 for external use		t	1,000	N/A	1,000
	Coal tar		t	3,389	N/A	3,389
	Benzole (coal light oil)		t	3,382	N/A	3,382
Others	Other emission sources		—	c	c	c

[a] This credit emission factor is based on world average electricity equivalent based on worldsteel methodology.

[b] This credit emission factor is based on natural gas equivalent.

[c] The value shall be determined by using available data backed by reliable evidence.

9 Additional guidance to the entire ISO 14404 series

9.1 Evaluation of slag

Slags which are produced in BF, BOF and EAF can be sold as a material for the production of cement and reduce CO_2 emissions and energy consumptions from the production processes of cement by replacing the use of natural resources such as limestone.

Because the ISO 14404 series aims to calculate CO_2 emission and intensity or energy consumption and intensity from a steel plant, emissions reduction outside of steel plants, such as the credit emission associated with exported slags for cement are not considered.

However, as there may be cases where the credit emissions of slags are considered depending on the purpose of the calculation, this subclause provides the calculation method to count the emission credit of exported slag. When making a comparison between steel plants, a care should be taken to make sure that both steel plants have the same conditions for the consideration of credit emissions.

When the emission credit of slag is considered, the emission factor and the source shall be made clear. Table 8 provides examples of CO_2 emission reduction from using BF slag and BOF slag as materials for cement production. Note that these values are examples, and most appropriate value depending on the specific conditions of the use of slags, such as the composition and emission factors of raw materials for cement production, in the area of study, should be applied.

Table 8 — CO_2 emission credit of BF/BOF slag

BF slag to cement	t- CO_2/t-slag	0,550
BOF slag to cement	t- CO_2/t-slag	0,300

(Source: CO_2 EMISSION DATA COLLECTION User Guide (worldsteel))

9.2 Explanation of emission factors for by-product gases

9.2.1 General

Coke oven gas, blast furnace gas and BOF gas, which are produced in coke making, blast furnace and BOF processes, and COREX gas, which are produced in COREX-BOF/EAF process, are generically called by-product gas. Although they are burnable and used as fuel, the gases are selectively utilized depending on their chemical composition and generated volume which differs largely from gas to gas. Especially, blast furnace gas, called lean gas due to the low heat value, is generally used as fuel for electrical power generation. Coke oven gas has higher heat value and then is widely used as fuel for a reheating furnace and other heating processes. The generated volume of BOF gas is not large and then the gas is often used as the mixture with other by-product gases.

In an integrated steel plant, by-product gases are used for various heat sources inside the plants, but excess by-product gases are often exported and used outside of the boundary. These exported by-product gases are subject to credit emission. As the energy amount of these exported gases is relatively large, their evaluation is critical to calculate CO_2 intensity of the steel plant.

Two credit emission factors for by-product gases are given in Table 7. The first one is based on world average electricity equivalent (9.2.2) and the second one is based on natural gas equivalent (9.2.3).

9.2.2 Explanation of emission factors based on world average electricity equivalent

Table 9 — Emission factors of by-product gases (excerpted from Table 7)

CO_2 emission sources	Direct CO_2 emission factor t $CO_2/10^3$ [a] m^3(stp[b])	Upstream CO_2 emission factor t $CO_2/10^3$ m^3 (stp)	Credit CO_2 emission factor t $CO_2/10^3$ m^3 (stp)
Coke oven gas	0,836	N/A	0,977
Blast furnace gas	0,891	N/A	0,170
BOF gas	1,512	N/A	0,432
COREX gas	1,414	N/A	0,345

[a] 10^3=1 000

[b] Standard temperature and pressure (0 degrees Celsius, 101,3 kPa).

Credit emission factors for by-product gases can be calculated based on world average CO_2 emission factor and energy intensity for electricity generation of power plant.

When the plants do not have an industrial owned power generation, blast furnace gas is usually used in the adjacent power plant out of the plants. Therefore, worldsteel methodology sets credit CO_2 emission factor of by-product gas A, expressed in t-$CO_2/10^3m^3$, can be calculated based on world average CO_2 emission factor and energy intensity for electricity generation of power plant, as given in Formula (3):

$$A = B \times \frac{C}{D} \tag{3}$$

where

A is credit CO_2 emission factor of by-product gas (t- $CO_2/10^3m^3$);

B is the world average CO_2 emission factor of electricity (t- CO_2/MWh);

C is the heat value of by-product gas ($GJ/10^3m^3$);

D is the world average energy intensity of electricity (GJ/MWh).

The credit CO_2 emission factors in Table 9 are calculated as follows.

coke oven gas: 0,977= 0,504 × 19/9,8

blast furnace gas: 0,170 = 0,504 × 3,31/9,8

BOF gas: 0,432 = 0,504 × 8,40/9,8

COREX gas: 0,345 = 0,504 × 6,70/9,8

where

0,504 is the world average CO_2 emission factor of electricity i.e. the CO_2 emission per MWh from electricity and heat generation (IEA global average 2006), (t- CO_2/MWh);

9,8 is the world average energy intensity of electricity i.e. the energy conversion coefficient for electricity on the premise of a power generation factor of 367 J/kJ, e.g. a typical efficiency for power generation (GJ/MWH);

19,0 is the heat value of COG, [$GJ/10^3m^3$ (stp)];

3,31 is the heat value of BFG, [GJ/10^3m^3 (stp)];

8,40 is the heat value of LDG, [GJ/10^3m^3 (stp)];

6,70 is the heat value of COREX gas, [GJ/10^3m^3 (stp)].

CO_2 emissions per MWh from electricity and heat generation and the power generation factor should be updated.

9.2.3 Explanation of emission factors based on natural gas equivalent

Table 10 — Emission factors of by-product gases (excerpted from Table 7)

CO_2 emission sources	Direct CO_2 emission factor t $CO_2/10^3$ [a] m^3(stp[b])	Upstream CO_2 emission factor t $CO_2/10^3$ m^3 (stp)	Credit CO_2 emission factor t $CO_2/10^3$ m^3 (stp)
Coke oven gas	0,836	N/A	1,064
Blast furnace gas	0,891	N/A	0,185
BOF gas	1,512	N/A	0,470
COREX gas	1,414	N/A	0,375

[a] 10^3=1 000

[b] Standard temperature and pressure. (0 degrees Celsius, 101,3 kPa).

Credit emission factors for by-product gases A_N, expressed in t-$CO_2/10^3m^3$, can be calculated based on CO_2 emission factor and heat value of natural gas as given in Formula (4):

$$A_N = B_N \times \frac{C_N}{D_N} \quad (4)$$

where

A_N is credit CO_2 conversion factor of by-product gas (t- $CO_2/10^3m^3$);

B_N is the CO_2 intensity of natural gas (t- $CO_2/10^3m^3$);

C_N is the heat value of by-product gas (GJ/10^3m^3);

D_N is the heat value of natural gas (GJ/10^3m^3).

The calculation of the credit CO_2 emission factos in Table 10 are calculated as follows:

Coke oven gas: 1,064 = 0,056 × 19

Blast furnace gas: 0,185 = 0,056 × 3,31

BOF gas: 0,470 = 0,056 × 8,40

COREX gas: 0,375 = 0,056 × 6,70

where

0,056 is 2,014/35,9;

2,014 is the CO_2 emission factor of natural gas (t- $CO_2/10^3m^3$(stp));

35,9 is the heat value of natural gas (GJ/10^3m^3);

19,0 is the heat value of COG (GJ/10^3m^3 (stp));

3,31 is the heat value of BFG (GJ/10^3m^3 (stp));

8,40 is the heat value of LDG (GJ/10^3m^3 (stp));

6,70 is the heat value of COREX gas (GJ/10^3m^3 (stp)).

NOTE When steel plants import by-product gas from other steel plant and/or coke plant, direct emission factors based on their carbon content are adopted.

9.2.4 Evaluation of stock

The timing of counting the input of an item can be either the timing of purchase or the timing of usage. This choice does not affect annual evaluation. If users want to take account of seasonal variation, they can enter the data into the input item at the timing of its usage.

9.3 Selection of calorific values and emission factors for electricity and fuel

As for the emission factors for electricity, when making comparisons between steel plants in different regions, indicative emission factors (global average value) provided in this document should be applied. When the goal of calculation is to calculate the emission value within a specific country or region, then the emission factors of the specific country or region should be selected.

As for fuels used in the steel plants, such as coal and gas, since calorific values and emission factors differ depending on the characteristics of each region, emission factors specific to the country or region should be selected whenever possible. The same guidance applies when making a comparison between steel plants located in different regions.

As mentioned in Table 7, when emission factors other than indicative emission factors are applied, such emission factors should be clearly identified and justified.

Annex A
(informative)

Calculation of energy consumption and intensity

The annual energy consumption, $C_{E,al}$, and intensity, I_E, at a plant manufacturing steel using blast furnaces can be calculated from Formulae (A.1) and (A.2) using $Q_{t,d,CO2}$, $Q_{t,u,CO2}$ and ,$Q_{t,c,CO2}$ collected as explained in 10.2.2 and 10.2.3 and the energy conversion factors ($K_{t,d,E}$, $K_{t,u,E}$, and $K_{t,c,E}$):

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

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

where

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

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

$Q_{t,c,CO2}$ are the quantities of credit CO_2 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 intention factor;

$C_{E,a}$ is the annual energy consumption;

P is the annual crude steel production.

In order to facilitate the calculation of energy consumption, this document provides energy consumption factors, which have not been provided in ISO 14404-1 and ISO 14404-2. Table A.1 gives an indication of energy conversion factors for energy consumption sources that can be used if no other reliable data are available. If different emission factors or simplifications from Table A.1 are applied, such emission factors or simplifications should be clearly identified and justified. If other emission sources specified in No. N of Table A.1 are applied, such sources should be clearly identified with their emission factors. An example of a template is available in Table D.1.

Table A.1 — Indicative energy conversion factors for CO_2 emission sources

Energy Consumption Source			Unit	Energy Consumption Factor		
				Direct energy consumption factor (Kt,d,E)	Upstream energy consumption factor (Kt,u,E)	Credit energy consumption factor (Kt,c,E)
				GJ/unit	GJ/unit	GJ/unit
Gas fuel	Natural gas		10^3m^3(stp)	35,900	N/A	35,900
	Coke oven gas		10^3m^3(stp)	19,000	N/A	19,000
	Blast furnace gas		10^3m^3(stp)	3,300	N/A	3,300
	BOF gas		10^3m^3(stp)	8,400	N/A	8,400
	Town gas		10^3m^3(stp)	35,900	N/A	35,900
	COREX gas		10^3m^3(stp)	6,700	N/A	6,700
	Other gas		10^3m^3(stp)		N/A	
Liquid fuel	Heavy oil		m^3	37,700	N/A	37,700
	Light oil		m^3	35,100	N/A	35,100
	Kerosene		m^3	34,700	N/A	34,700
	LPG		t	47,300	N/A	47,300
Solid fuel	Coking coal		dry t	32,200	N/A	32,200
	BF injection coal		dry t	31,100	N/A	31,100
	Sinter/BOF coal		dry t	29,300	N/A	29,300
	Steam coal		dry t	25,900	N/A	25,900
	Coke	for a steel plant with Iron making process requiring coke	dry t	30,100	4,000	34,100
		for a steel plant without Iron making process requiring coke	dry t	30,100	N/A	30,100
	Charcoal		dry t	18,800	N/A	18,800
	EAF coal		dry t	30,100	N/A	30,100
	SR/DRI coal		dry t	31,100	N/A	31,100
	Other coal		dry t		N/A	
Auxiliary material	Limestone		dry t	N/A	N/A	0,000
	Burnt lime		t	N/A	4,500	4,500
	Crude dolomite		dry t	N/A	N/A	0,000
	Burnt dolomite		t	N/A	4,500	4,500
	Nitrogen		10^3m^3(stp)	N/A	2,000	2,000
	Argon		10^3m^3(stp)	N/A	2,000	2,000
	Oxygen		10^3m^3(stp)	N/A	6,900	6,900
	EAF graphite electrodes		t	N/A	N/A	N/A
Energy carriers	Electricity		MWh	N/A	9,800	9,800
	Steam		t	N/A	3,800	3,800

Table A.1 *(continued)*

Energy Consumption Source			Unit	Energy Consumption Factor		
				Direct energy consumption factor (Kt,d,E)	Upstream energy consumption factor (Kt,u,E)	Credit energy consumption factor (Kt,c,E)
				GJ/unit	GJ/unit	GJ/unit
Ferrous-containing material	Pellets	for a steel plant with Iron making process	t	N/A	2,100	2,100
		for a steel plant without Iron making process	t	N/A	N/A	N/A
	Sinter			N/A	2,450	2,450
	Hot metal	for a steel plant with Iron making process	t	N/A	20,900	20,900
		for a steel plant without Iron making process	t	N/A	N/A	N/A
	Cold iron	for a steel plant with Iron making process	t	N/A	20,900	20,900
		for a steel plant without Iron making process	t	N/A	N/A	N/A
	Gas-based DRI	for a steel plant with Iron making process	t	N/A	14,100	14,100
		for a steel plant without Iron making process	t	N/A	N/A	N/A
	Coal-based DRI	for a steel plant with Iron making process	t	N/A	17,900	17,900
		for a steel plant without Iron making process	t	N/A	N/A	N/A
	Ferro-nickel		t	N/A	N/A	N/A
Alloys	Ferro-chromium		t	N/A	N/A	N/A
	Ferro-molybdenum		t	N/A	N/A	N/A
	CO_2 for external use		t	N/A	N/A	N/A
Product and by-product	Coal tar		t	37,000	N/A	37,000
	Benzole (coal light oil)		t	40,570	N/A	40,570
	Other emission sources		—			
Others	Other emission sources		—			

Annex B
(informative)

Application of the ISO 14404 series

The ISO 14404 series specifies calculation methods for CO_2 emission and intensity of a steel plant from the amounts of the major inputs (purchased items) and outputs (sold items), such as natural resources, intermediate products, and energy. The calculation result can be used for voluntary management of energy consumption and CO_2 emission by steel companies as a tool for determining the actions to take for reducing CO_2 emission of their plants and for checking the progress of such actions. For example, the result can be used for status review in energy management under ISO 50001. It can also be used to make a comparison of CO_2 emission and intensity among steel plants which have similar steel production processes.

Since this document provides the guidance for calculating the CO_2 emissions and intensity of a whole steel plant as one unit, it cannot be used for the calculation and comparison of the carbon footprint of a specific steel product or the CO_2 emissions and intensity of each process within a steel plant. Moreover, in order to allow comparison of all steel plants in the world under the same conditions, the indicative emission factors provided in the ISO 14404 series are world average values and are not adjusted to reflect the differences in energy sources and raw materials according to regions. Since available energy sources and raw materials differ according to the location of a steel plant in reality, this document cannot be used for calculating the total emissions used for inventory or for benchmarking. However, by selecting the emissions factors applicable to the conditions of the target country or region, the document can also be used for calculating the total emissions used for inventory as well as for benchmarking. In this case, appropriate emission factors shall be selected especially for electricity and fuel (such as coal and gas).

Annex C
(informative)

Universal Calculation Sheet

ISO 14404 universal sheet
(Please fill in colored cells)

Year of Assessment yyyy

Crude Steel Production t

Energy Consumption Source			Unit	Purchased Procured	Sold Delivered	Calculation results of energy consumption			Calculation results of CO_2 emission		
						Direct	Upstream	Credit	Direct	Upstream	Credit
						GJ/Plant/y			t-CO_2/Plant/y		
Gas fuel	1	Natural gas	10^3m^3(stp)			0	-	0	0	-	0
	2	Coke oven gas	10^3m^3(stp)			0	-	0	0	-	0
	3	Blast furnace gas	10^3m^3(stp)			0	-	0	0	-	0
	4	BOF gas	10^3m^3(stp)			0	-	0	0	-	0
		Town gas	10^3m^3(stp)			0	-	0	0	-	0
		COREX gas	10^3m^3(stp)			0	-	0	0	-	0
		Other gas ( )	10^3m^3(stp)			0	-	0	0	-	0
Liquid fuel	5	Heavy oil	m^3			0	-	0	0	-	0
	6	Light oil	m^3			0	-	0	0	-	0
	7	Kerosene	m^3			0	-	0	0	-	0
	8	LPG	t			0	-	0	0	-	0
Solid fuel	9	Coking coal	dry t			0	-	0	0	-	0
	10	BF injection coal	dry t			0	-	0	0	-	0
	11	Sinter/BOF coal	dry t			0	-	0	0	-	0
	12	Steam coal	dry t			0	-	0	0	-	0
	13	Coke for a steel plant with iron making process requiring coke	dry t			0	0	0	0	0	0
		Coke for a steel plant without iron making process requiring coke	dry t			0	-	0	0	-	0
	14	Charcoal	dry t			0	-	0	0	-	0
		EAF coal	dry t			0	-	0	0	-	0
		SR/DRI coal	dry t			0	-	0	0	-	0
		Other coal ( )	dry t								
Auxiliary material	15	Limestone	dry t			-	-	0	0	-	0
	16	Burnt lime	t			-	0	0	-	0	0
	17	Crude dolomite	dry t			-	-	0	0	-	0
	18	Burnt dolomite	t			-	0	0	-	0	0
	19	Nitrogen	10^3m^3(stp)			-	0	0	-	0	0
	20	Argon	10^3m^3(stp)			-	0	0	-	0	0
	21	Oxygen	10^3m^3(stp)			-	0	0	-	0	0
		EAF graphite electrodes	t			-	-	-	0	0	0
Energy carriers	22	Electricity	MWh			-	0	0	-	0	0
	23	Steam	t			-	0	0	-	0	0