INTERNATIONAL STANDARD

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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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# 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).

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

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

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.

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# Introduction

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

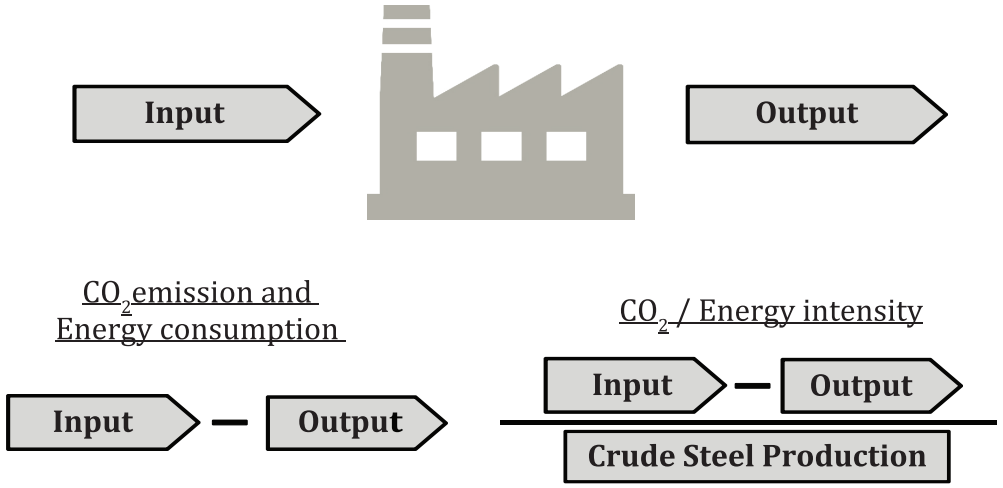



**Figure 1 — Conceptual diagram of calculation method in the ISO 14404 series**

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.


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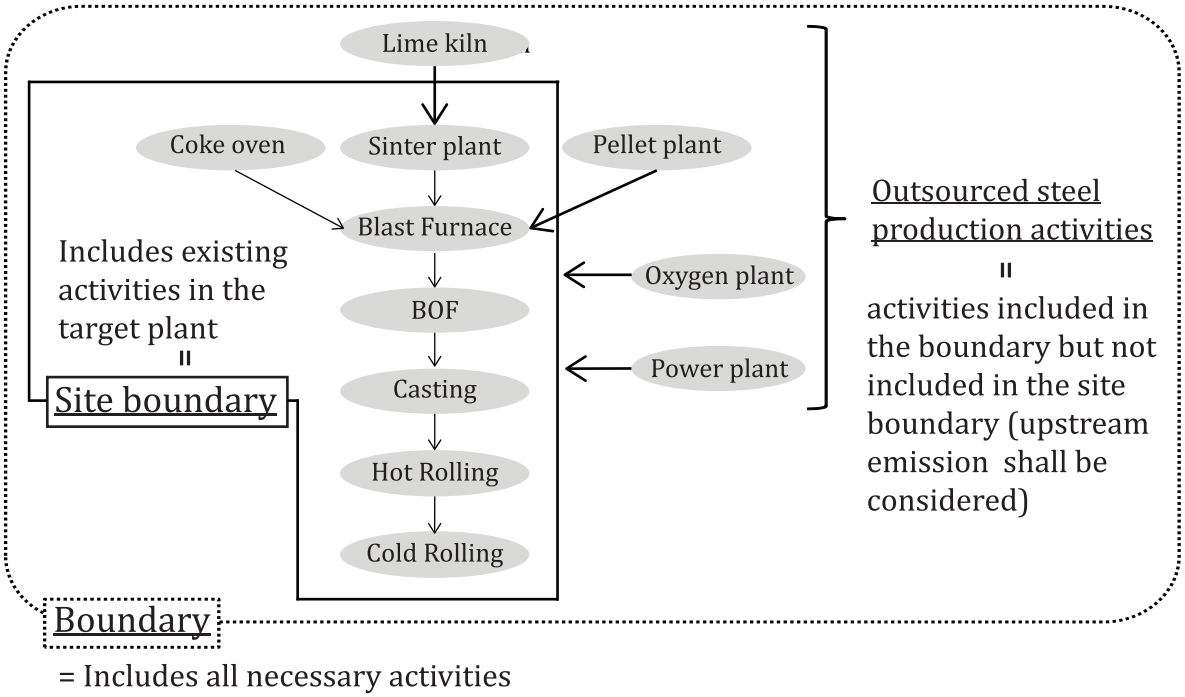



**Figure 2 — Conceptual diagram of boundary and site boundary**

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.

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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


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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

## 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/

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## 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]


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**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]

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**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]


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**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]

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**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]


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**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)

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[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]


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**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.

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