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Stationary source emissions — Determination of greenhouse gas emissions in energy-intensive industries —

Part 6: Ferroalloys and silicon industry

Émissions de sources fixes — Détermination des émissions des gaz à effet de serre dans les industries à forte intensité énergétique —

Partie 6: Industrie des ferro-alliages et du silicium

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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 146, *Air quality*, Subcommittee SC 1, *Stationary source emissions.*

A list of all parts in the ISO 19694 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

0.1 Overview of the ferro-alloy manufacturing process

Ferroalloy production involves a metallurgical reduction process that results in significant carbon dioxide emissions. These emissions are the results of a carbothermic reaction which is intrinsic to the process. In ferroalloy production, ore, carbon materials and slag forming materials are mixed and heated to high temperatures for smelting.

Smelting in an electric arc furnace is accomplished by conversion of electrical energy to heat. An alternating current applied to the electrodes creates current to flow through the charge between the electrode tips. The heat is produced by the electric arcs and by the resistance in the charge materials. Emissions from the smelting process are therefore not to combustion emissions. The furnaces can be open, semi-closed or closed. Submerged electric arc furnaces with graphite electrodes or self-baking Søderberg electrodes are used (see Figure 1).

The reduction process is the main source of direct CO_2 emissions. Other CO_2 sources include direct emissions from calcination of calcium, magnesium and other carbonates (e.g. limestone) in some processes and from non-smelting fuels (e.g. dryers for ladles and refractory linings), room heating and indirect emissions from, for example, external power production.

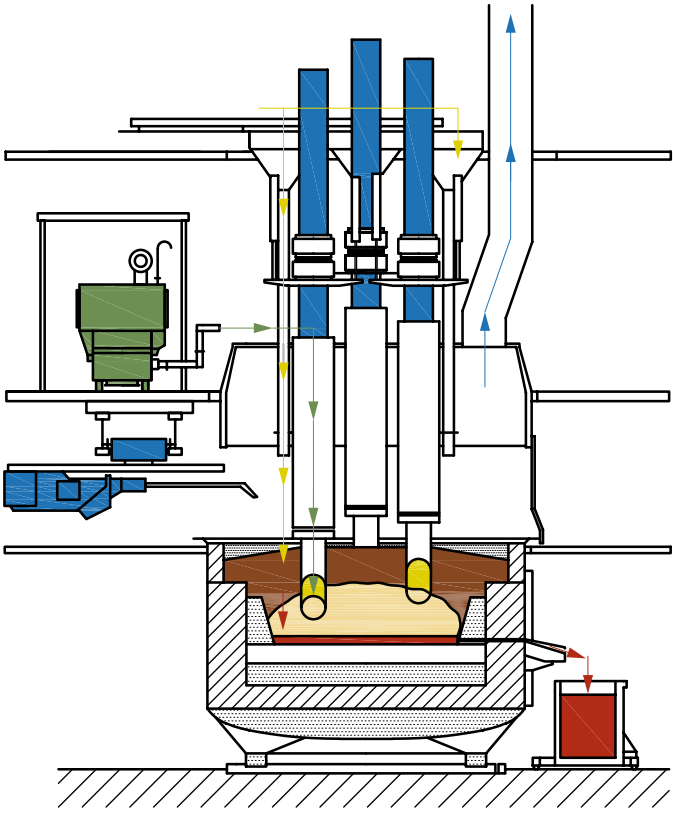


Figure 1 — Submerged electric arc furnace

0.2 CO_2 from the smelting of raw materials

In the smelting process, CO_2 is released due to the carbothermic reduction of the metallic oxides occurring with the consumption of both carbonaceous reductants and carbon-based electrodes. The carbon in the reductants reacts with oxygen from the metal oxides to form CO and then CO_2 (in different ways depending on the process), and the ores are reduced to molten base metals. For the calculation, the assumption is that all CO is assumed to be converted in the furnace to CO_2.

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The reductant carbon is used in the form of coke, coal, pet coke, anthracite, charcoal and wood chips. The first four are fossil-based and the charcoal and wood chips are bio-carbon.

In the carbothermic process, only the fixed carbon content is used as a reducing agent, which means that volatile matter, ashes and moisture mostly leave the furnace with the off-gas and slag.

The nature of reducing agents, price and electrodes depends on the localization of the plant, the raw material availability and it is presented in Table 1. It is variable from one site to another and from one year to another and also from one ferro-alloy to another.

Table 1 — Type of reducing agents and electrodes used in the electrometallurgy sector

Reducing agents	Electrodes
Crude petroleum coke	Graphite electrode
Calcinated petroleum coke	Prebaked electrodes
Coal coke	Søderberg paste
Coke from coal	Composite electrode
Wood	—
Calcinated wood	—
Charcoal	—
Graphite powder	—
Anthracite	—

CO_2 emissions are estimated with and calculated from the consumption of the reducing agents and electrodes, their carbon content, and the carbon content of the final products.

NOTE The basic calculation methods used in this document are compatible with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories issued by the Intergovernmental Panel on Climate Change (IPCC)[1].

Ores and reducing agent react to form ferro-alloys or metal, CO_2 and dust and other by-product (i.e. slags); amount of carbon can be found in the products

Default emission factors suggested in these documents are used, except where more recent, industry-specific data has become available.

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Stationary source emissions — Determination of greenhouse gas emissions in energy-intensive industries —

Part 6: Ferroalloys and silicon industry

1 Scope

This document provides a harmonized methodology for calculating GHG emissions from the ferro-alloys industry based on the mass balance approach. This document also provides key performance indicators over time for ferro-alloys plants. This document covers the following direct and indirect sources of GHG:

— direct GHG emissions [see ISO 14064-1:2018, 5.2.4 a)] from sources that are owned or controlled by the company, such as emissions resulting from the following sources:

  — smelting (reduction) process;

  — decomposition of carbonates inside the furnace;

  — auxiliaries operation related to the smelting operation (i.e. aggregates, drying processes, heating of ladles, etc.);

— indirect GHG emissions [see ISO 14064-1:2018, 5.2.4 b)] from the generation of purchased electricity consumed in the company's owned or controlled equipment.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14064-1:2018, *Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals*

ISO/IEC 17025, *2005, General requirements for the competence of testing and calibration laboratories*

ISO 19694-1:2021, *Stationary source emissions — Determination of greenhouse gas emissions in energy-intensive industries — Part 1: General aspects*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19694-1:2021 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

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

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

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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 https://www.electropedia.org/

3.1
auxiliary
equipment consuming electricity/power related to the *smelting* (3.5) process

EXAMPLE Fans, pumps, gas abatement systems (filter bags, venture scrubbers, etc.).

3.2
silica fume
amorphous silicon dioxide particles from the volatilization and vaporization of furnace feed materials in the manufacture of ferrosilicon and *silicon* (3.4)

Note 1 to entry: The process off-gas that contains silica fumes beings cleaned in a baghouse using fabric filters of the open or semi-closed *SEAF* (3.8).

3.3
ferro-alloy
alloy of iron and one or more metals such as *silicon* (3.4), manganese, chromium, molybdenum, vanadium and tungsten

3.4
silicon
metalloid produced by carbo-thermic reduction of quartz in an electric submerged arc furnace

3.5
smelting
industrial process where one or more ores or ore concentrates are heated and reduced (i.e. chemically modified) by, for example, aluminino-carbo-silico thermic reduction, to manufacture and mix the metals in one step

Note 1 to entry: Examples of smelted alloys are *ferro-alloys* (3.3).

3.6
gross GHG emission
absolute fossil direct GHG emission excluding GHG emissions from on-site power production

3.7
absolute gross GHG emission
total direct emission of GHGs within the boundaries excluding GHG emissions from biogenic CO_2 from biomass (i.e. wood chips and charcoal)

3.8
submerged electric arc furnace
SEAF
electric arc-heating furnace in which the arcs are completely submerged under the charge

Note 1 to entry: The arc forms between the electrode [graphite electrodes or self-baking *Søderberg electrodes* (3.12)] and metal surface or bottom lining. The heat being produced by the electric arcs and by the resistance in the charge materials initiates the reduction process. The furnaces can be open, semi-closed or closed, which can depend upon the *ferro-alloy* (3.3) to be produced.

3.9
biomass fuel
fuel with only biogenic carbon

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3.10
petroleum coke
petcoke
carbon-based solid fuel derived from oil refineries

3.11
sinter
sintering
process to form a coherent mass by heating without melting

3.12
Søderberg electrode
continuously self-baking carbon electrode used in electro-metallurgical furnaces for production of ferroalloys and *silicon* (3.4)

Note 1 to entry: The "Søderberg paste" is a preparation of coal tar pitch and carbonaceous dry aggregate.

3.13
composite electrode
electrode where the core is composed of graphite while the exterior is a self-baking carbon paste (which is a "Søderberg paste")

3.14
prebaked electrode
carbonaceous paste baked so as to carbonize coal tar pitch in order to form a solid pitch coke binder phase

Note 1 to entry: A carbonaceous paste is a mixing of coal tar pitch with a dry carbonaceous aggregate.

4 Abbreviated terms

For the purposes of this document, the following abbreviations apply.

CO	Carbon monoxide
CO_2	Carbon dioxide
EF	Emission factor
FA	Ferro-alloys
GHG	Greenhouse gases
HCV	High calorific value
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
KPI	Key performance indicator
SEAF	Submerged electric arc furnace
UNFCCC	United Nations Framework Convention on Climate Change

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