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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

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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.

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.

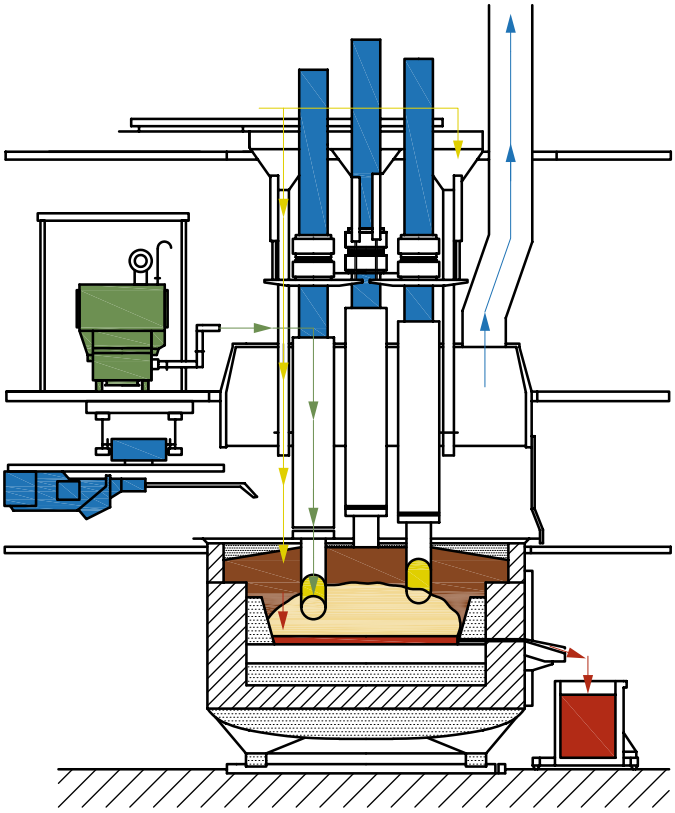

Figure 1 — Submerged electric arc furnace

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.

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.