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

**Part 3:
Cement industry**

*Émissions de sources fixes — Détermination des émissions de gaz à
effet de serre dans les industries énérgo-intensives —*

Partie 3: Industrie du ciment



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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 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

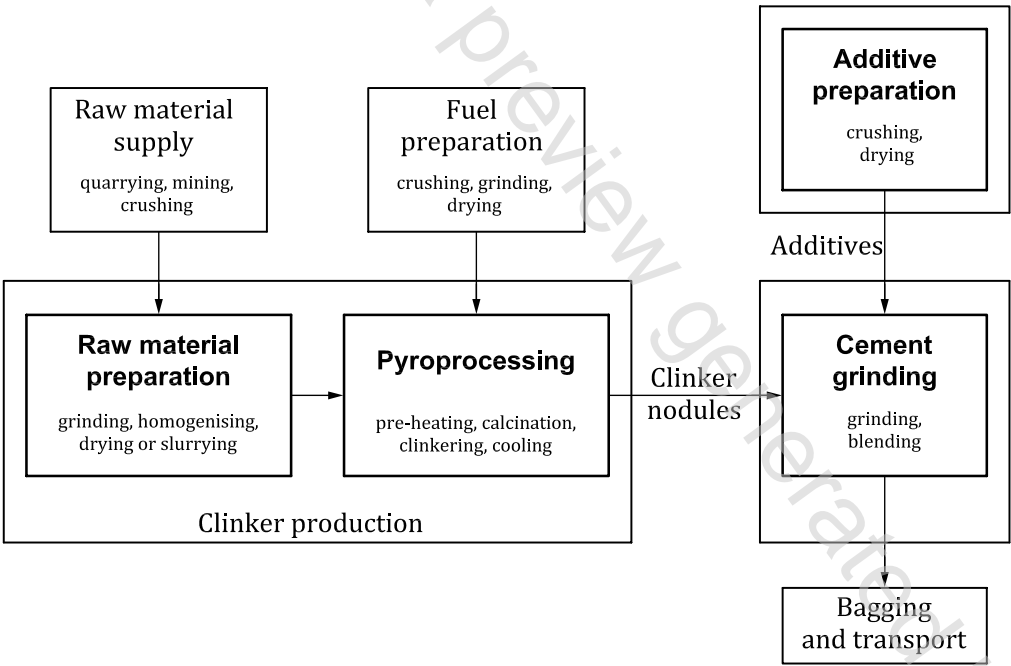
0.1 Overview of cement manufacturing process

Cement manufacture includes three main process steps (see [Figure 1](#)):

- a) preparing of raw materials and fuels;
- b) producing clinker, an intermediate, through pyro-processing of raw materials;
- c) grinding and blending clinker with other products (“mineral components”) to make cement.

There are two main sources of direct CO₂ emissions in the production process: calcination of raw materials in the pyro-processing stage, and combustion of kiln fuels. These two sources are described in more detail below. Other CO₂ sources include direct GHG emissions from non-kiln fuels (e.g. dryers for cement constituents products, room heating, on-site transports and on-site power generation), and indirect GHG emissions from, for example, external power production and transports. Non-CO₂ greenhouse gases covered by the Kyoto Protocol, apart from carbon monoxide (CO) methane (CH₄) and nitrous oxide (N₂O), are not relevant in the cement context in the sense that direct GHG emissions of these gases are negligible.

NOTE The non-CO₂ greenhouse gases covered by the Kyoto Protocol are: methane (CH₄), nitrous oxide (N₂O), sulfur hexafluoride (SF₆), partly halogenated fluorohydrocarbons (HFC) and perfluorated hydrocarbons (PFC).



SOURCE Reference [8], based on Reference [16]. Reproduced with the permission of the authors.

Figure 1 — Process steps in cement manufacture

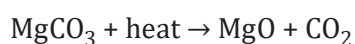
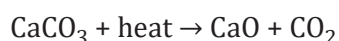
[Table 1](#) gives an overview of places where materials enter the cement production process.

Table 1 — Overview of input places of materials

Raw meal	Input place
Raw materials from natural resources	Raw mill
Alternative raw materials	Raw mill
Raw material flows for clinker production	Input place
Raw meal	Kiln feed
Fuel ashes	Burner or precalciner or fuel dryer
Additional raw materials not part of the kiln feed	Kiln inlet
Fuels flows for clinker and cement production	Input place
Fossil fuels	Burner or precalciner or fuel dryer or raw material dryer
Alternative fuels	Burner or precalciner or fuel dryer or raw material dryer
Alternative fossil fuels	Burner or precalciner or fuel dryer or raw material dryer
Mixed fuels	Burner or precalciner or fuel dryer or raw material dryer
Biomass fuels	Burner or precalciner or fuel dryer or raw material dryer
Cement kiln dust	Output place
Dust return	Preheater
Filter dust	Precipitator / filter
By pass dust	Bypass filter
Cement constituents-based products	Output place
Clinker	Kiln (cooler)
Cement	Cement mill
Blast furnace slag	Cement mill or grinding station
Fly ash	Cement mill or grinding station
Gypsum	Cement mill or grinding station
Cooler dust	Cooler, is normally added to the clinker flow to the clinker silo
Cement kiln dust	Preheater or precipitator or filter or bypass filter
Limestone	Cement mill or grinding station
Burnt shale	Cement mill or grinding station
Pozzolana	Cement mill or grinding station
Silica fume	Cement mill or grinding station

0.2 CO₂ from calcination of raw materials

In the clinker production process, CO₂ is released due to the chemical decomposition of calcium, magnesium and other carbonates (e.g. from limestone) into lime:



This process is called “calcining” or “calcination”. It results in direct CO₂ emissions through the kiln stack. When considering CO₂ emissions due to calcination, two components can be distinguished:

- CO₂ from raw materials actually used for clinker production, these raw materials are fully calcined in the clinker production process;

- CO₂ from raw materials leaving the kiln system as partly calcined cement kiln dust (CKD), or as normally fully calcined bypass dust.

CO₂ from actual clinker production is proportional to the lime content of the clinker, which in turn varies little in time or between different cement plants.

NOTE A second, but much smaller factor is the CaO and MgO content of the raw materials and additives used.

As a result, the CO₂ emission factor per tonne of clinker is fairly stable with a default value in this document of 525 kg CO₂/t clinker (IPCC default: 510 kg CO₂/t clinker, CSI default: 525 kg CO₂/t clinker^[19]).

The amount of kiln dust leaving the kiln system varies greatly with kiln types and cement quality standards, ranging from practically zero to over one hundred kilograms per tonne of clinker. The associated emissions are likely to be relevant in some countries or installations.

CO₂ emissions from calcination of raw materials can be calculated by two methods which are in principle equivalent: either based on the amount and chemical composition of the products (clinker plus dust leaving the kiln system, output methods B1 and B2), or based on the amount and composition of the raw materials entering the kiln (input methods A1 and A2). See 7.2.1 and 7.2.2 for details.

0.3 CO₂ from organic carbon in raw materials

The raw materials used for clinker production usually contain a small fraction of organic carbon, which can be expressed as TOC content. Organic carbon in the raw meal is converted to CO₂ during pyro-processing. The contribution of this component to the overall CO₂ emissions of a cement plant is typically very small (about 1 % or less). The organic carbon contents of raw materials can, however, vary substantially between locations and between the types of materials used. For example, the resulting emissions can be relevant if a cement company organization consumes large quantities of certain types of fly ash or shale as raw materials entering the kiln.

0.4 CO₂ from fuels for kiln operation

The cement industry traditionally uses various fossil fuels to operate cement kilns, including coal, petroleum coke, fuel oil and natural gas. Fuels derived from waste materials have become important substitutes for conventional fossil fuels. These AFs include fossil fuel-derived fractions such as, for example, waste oil and plastics, as well as biomass-derived fractions such as waste wood and dewatered sludge from wastewater treatment. Furthermore, fuels which contain both fossil and biogenic carbon (mixed fuels), like, for example, (pre-treated) municipal and (pre-treated) industrial wastes (containing plastics, textiles, paper etc.) or waste tyres (containing natural and synthetic rubber), are increasingly used.

Both traditional fossil and alternative fuels result in direct CO₂ emissions through the kiln stack. However, biomass and bioliquids are considered “climate neutral” in accordance with IPCC definitions. The use of alternative (biomass- or fossil-derived) fuels can, in addition, lead to important emission reductions elsewhere, for instance from waste incineration plants or landfills.

Mineral components are natural and artificial materials with latent hydraulic properties. Examples of MIC include natural pozzolana, blast furnace slag and fly ash. In addition, gypsum is within this document labelled as MIC. MICs are added to clinker to produce blended cement. In some instances, pure MICs are directly added to the concrete by the ready-mix or construction company. Use of MICs leads to an equivalent reduction of direct CO₂ emissions associated with clinker production, both from calcination and fuel combustion. Artificial MICs are waste materials from other production processes such as, for example, steel and coal-fired power production. Related GHG emissions are monitored and reported by the corresponding industry sector. Utilization of these MICs for clinker or cement substitution does not entail additional GHG emissions at the production site. Consequently, these indirect GHG emissions are not included in the cement production inventory.

The basic mass balance 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)^[4], and with the revised WRI / WBCSD Greenhouse Gas Protocol^[9]. Default emission factors

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

The 2006 IPCC Guidelines^[4] introduced a Tier 3 method for reporting CO₂ emissions from the cement production based on the raw material inputs (see Vol. III, Chapter 2.2.1.1, Formula (2).3^[4]). However, a large number of raw material inputs and the need to continuously monitor their chemical composition make this approach impractical in many cement plants. The different raw materials are normally homogenized before and during the grinding process in the raw mill. The WRI / WBCSD therefore recommended alternative methods for input-based reporting of CO₂ emissions from raw material calcination in cement plants. They rely on determining the amount of raw meal consumed in the kiln system. In many cement plants, the homogenized mass flow of raw meal is routinely monitored including its chemical analysis for the purpose of process and product quality control. The input methods based on the raw meal consumed are already successfully applied in cement plants in different countries and seem to be more practical than Tier 3 of Reference [4]. They were included in the Cement CO₂ and Energy Protocol Version 3^[1] (simple input method A1 and detailed input method A2, 7.2.1). This document provides guidance on how to compare the GHG performance of other companies or plants within a sector level which is different from a methodology of the IPCC National Inventory Guideline.

This document for the cement industry has been based on Reference [1].

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

Part 3: Cement industry

1 Scope

This document specifies a harmonized methodology for calculating greenhouse gas (GHG) emissions from the cement industry, with a view to reporting these emissions for various purposes and by different basis, such as, plant basis, company basis (by country or by region) or even international group basis. It addresses all the following direct and indirect sources of GHG included:

- Direct GHG emissions [ISO 14064-1:2018, 5.2.4, a)] from sources that are owned or controlled by the organization, such as emissions that result from the following processes:
 - calcinations of carbonates and combustion of organic carbon contained in raw materials;
 - combustion of kiln fuels (fossil kiln fuels, alternative fossil fuels, mixed fuels with biogenic carbon content, biomass and bioliquids) related to either clinker production or drying of raw materials and fuels, or both;
 - combustion of non-kiln fuels (fossil fuels, alternative fossil fuels, mixed fuels with biogenic carbon content, biomass and bioliquids) related to equipment and on-site vehicles, room heating and cooling, drying of MIC (e.g. slag or pozzolana);
 - combustion of fuels for on-site power generation;
 - combustion of carbon contained in wastewater;
- Indirect GHG emissions [ISO 14064-1:2018, 5.2.4, b)] from the generation of purchased electricity consumed in the organization's owned or controlled equipment;
- Other indirect GHG emissions [(ISO 14064-1:2018, 5.2.4, c) to f)] from purchased clinker. Excluded from this document are all other ISO 14064-1:2018, 5.2.4, c) to f) emissions from the cement industry.

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 12039, *Stationary source emissions — Determination of the mass concentration of carbon monoxide, carbon dioxide and oxygen in flue gas — Performance characteristics of automated measuring systems*

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 16911-1, *Stationary source emissions — Manual and automatic determination of velocity and volume flow rate in ducts — Part 1: Manual reference method*

ISO 16911-2, *Stationary source emissions — Manual and automatic determination of velocity and volume flow rate in ducts — Part 2: Automated measuring systems*

ISO 19694-1, *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 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/>

3.1 additional raw material ADRM

raw material (3.30) which is fed directly to the calciner or the *kiln inlet* (3.26)

Note 1 to entry: Additional raw materials are not part of the kiln feed.

3.2 alternative fuel AF

fuel derived from waste materials

Note 1 to entry: AF can be further divided into biogenic, *fossil* (3.18) and mixed alternative fuels.

3.3 automated measuring system AMS

measuring system permanently installed on site for continuous monitoring of emissions

Note 1 to entry: An AMS is a method which is traceable to a reference method.

Note 2 to entry: Apart from the analyser, an AMS includes facilities for taking samples (e.g. sample probe, sample gas lines, filters, flow meters, regulators, delivery pumps, blowers) and for sample conditioning (e.g. dust filter, water vapour removal devices, converters, diluters). This definition also includes testing and adjusting devices that are required for regular functional checks.

Note 3 to entry: In ISO 14064-1:2018, AMS are called "continuous emission monitoring systems (CEMS)".

3.4 alternative fossil fuel

fossil fuel derived from waste materials without biogenic content and not listed by IPCC

3.5 alternative raw material ARM

raw material (3.30) for *clinker* (3.13) production derived from artificial resources

3.6 bioliquid

liquid fuel for energy purposes other than for transport, including electricity and heating and cooling, produced from biomass