SLOVENSKI STANDARD
SIST EN 19694-4:2017

01-julij-2017

Emisije nepremičnih virov - Določevanje emisij toplogrednih plinov (TGP) v energetsko intenzivnih industrijah - 4. del: Proizvodnja aluminija

Stationary source emissions - Determination of greenhouse gas (GHG) emissions in energy-intensive industries - Part 4: Aluminium industry

Emissionen aus stationären Quellen - Bestimmung von Treibhausgasen (THG) aus energieintensiven Industrien - Teil 4: Aluminiumindustrie

Émissions de sources fixes - Détermination des émissions des gaz à effet de serre dans les industries à forte intensité énergétique - Partie 4: Industrie de l'aluminium

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13.040.40	Emisije nepremičnih virov	Stationary source emissions
77.120.10	Aluminij in aluminijeve zlitine	Aluminium and aluminium alloys

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Stationary source emissions - Determination of greenhouse gas (GHG) emissions in energy-intensive industries - Part 4: Aluminium industry

Émissions de sources fixes - Détermination des émissions de gaz à effet de serre (GES) dans les industries énergo-intensives - Partie 4: Industrie de l'aluminium

Emissionen aus stationären Quellen - Bestimmung von Treibhausgasen (THG) aus energieintensiven Industrien - Teil 4: Aluminiumindustrie

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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European foreword

This document (EN 19694-4:2016) has been prepared by Technical Committee CEN/TC 264 “Air quality”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2017, and conflicting national standards shall be withdrawn at the latest by January 2017.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate M/478 given to CEN by the European Commission and the European Free Trade Association.

EN 19694, *Stationary source emissions — Determination of greenhouse gas (GHG) emissions in energy-intensive industries* is a series of standards that consists of the following parts:

— *Part 1: General aspects*

— *Part 2: Iron and steel industry*

— *Part 3: Cement industry*

— *Part 4: Aluminium industry*

— *Part 5: Lime industry*

— *Part 6: Ferroalloy industry*

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Introduction

This European Standard serves the following purposes:

— measuring, testing and quantifying GHG emissions from the aluminium industry;

— assessing the level of GHG emissions performance of production processes over time, at production sites;

— establishing and providing reliable, accurate and quality information for reporting and verification purposes.

This European Standard can be used to measure, report and compare the GHG emissions of an aluminium production facility. Data for individual facilities, sites or works may be combined to measure, report and compare GHG emissions for a company, corporation or group.

Direct fuel based emissions are not included; for calculation of this part of the GHG emissions, see EN 19694–1.

The European Standard deals with sector-specific aspects for the determination of greenhouse gas (GHG) emissions from aluminium production and is based on documents mentioned under tier 3 of Section 4.4.2.4 of the 2006 IPCC guidelines [6].

1 Scope

This European Standard specifies a harmonized method for calculating the emissions of greenhouse gases from the electrolysis section of primary aluminium smelters and aluminium anode baking plants. It also specifies key performance indicators for the purpose of benchmarking of aluminium. This also defines the boundaries.

NOTE Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 19694-1, *Stationary source emissions — Determination of greenhouse gas (GHG) 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 EN 19694-1 and the following apply.

3.1
aluminium electrolysis
section of an aluminium primary smelter where aluminium is converted from aluminium oxide to aluminium metal in electrolysis cells

3.2
anode baking plant
production of carbon anodes for use in aluminium prebake electrolysis cells

3.3
PFC gases
gas emitted from aluminium electrolysis consisting of CF_4 and C_2F_6

3.4
grid specific CO_2 factor
CO_2 factor (t CO_2/MWh) associated with the electricity delivered to a specific aluminium smelter from their supplier

4 List of abbreviated terms

AE Anode effect

CWPB Centre-Worked prebake

DAE Direct anode emissions

DEE Direct electrolysis emissions

GHG Green House Gas

HSS Horizontal Stud Søderberg

IPCC Intergovernmental Panel on Climate Change

PFPB Point Feeder prebake

SWPB Side-Worked prebake

TIE Electrolysis electricity consumption

VSS Vertical Stud Søderberg

WBCSD World Business Council for Sustainable Development (WBCSD)

WRI World Resources Institute

5 Symbols, units and chemical formulae

5.1 Symbols and units

Symbol	Quantity	Unit
A_{EM}	Anode effects, (= frequency x average duration)	minutes/cell day
A_{EO}	Anode effect overvoltage	millivolts
A_{NC}	Net anode consumption	wt %
A_{sha}	Ash content in baked anodes	wt %
A_{shp}	Ash content in pitch in weight %	wt %
A_{shpc}	Ash content in packing coke, wt %	wt %
B_A	Baked anode production	tonne/year
B_{AW}	Baked anode weight	tonne
C_{BA}	Carbon content of baked anodes,	wt %
C_{Butt}	Carbon content of anode butts	tonne/year
C_E	Current efficiency for aluminium production	%
C_{SM}	Emissions of cyclohexane soluble matter, kilograms per tonnes aluminium	kg/tonne
E_{CF_4}	Emissions of tetrafluoromethane, kg CF_4 per year	kg/year
$E_{C_2F_6}$	Emissions of hexafluoroethane, kg C_2F_6 per year	kg/year
E_{CO_2}	CO_2 emissions in tonnes per year	tonne/year
E_{FPC}	Emission factor of Packing Coke, tCO_2/t of Packing Coke	tonne

Symbol	Quantity	Unit
$F_{\frac{C_2F_6}{CF_4}}$	Weight fraction of $\frac{C_2F_6}{CF_4}$	dimensionless
G_A	Weight of loaded green anodes = $\left(\frac{G_{AW}}{B_{AW}}\right) B_A$	tonne/year
G_{AW}	Green anode weight	tonne
G_{WP}	Global warming potential. Use latest G_{WP} data from IPCC	tonnes CO_2 equivalent/tonne
H_w	Hydrogen content in green anode	wt %
M_{BA}	Total mass of baked anodes	tonne/year
M_{Butt}	Total mass of anode butts	tonne/year
M_P	Tonnes aluminium per year	tonne/year
N_{AC}	Net anode consumption, tonnes per tonnes aluminium	tonne/year
O_{FPC}	Oxidation factor of packing coke (typically 1 for this stream)	dimensionless
O_{VC}	Overvoltage coefficient for CF_4	$kg_{CF4}/t_{Al}/mV$
P_C	Paste consumption, tonnes per tonnes aluminium	tonne
P_{CC}	Packing coke consumed per tonnes of baked anode	tonne
P_{CW}	Packing coke weight	tonne
R_{CF_4}	Emission rates of CF_4, kg per tonne of aluminium produced	kg/tonne
$R_{C_2F_6}$	Emission rates of C_2F_6, kg per tonne of aluminium produced	kg/tonne
S_a	Sulphur content in baked anodes	wt %
S_{CF_4}	Slope coefficient for CF_4, kg CF_4 per tonne aluminium per anode effect minute per cell day	tonne/effect minute/cell day
W_t	Waste tar collected	tonne/year
wt	Weight	kg or tonne

5.2 Chemical formulae

Al	Aluminium
Al_2O_3	Aluminium oxide (Alumina)
C	Carbon
CF_4	Tetrafluoromethane
C_2F_6	Hexafluoroethane

CO	Carbon monoxide
CO_2	Carbon dioxide
$NaAlF_6$	Sodium aluminium hexafluoride (cryolite)
NaF	Sodium fluoride
PFC	Perfluorocarbon

6 Calculation methods – General remarks

6.1 Introduction

This standard shall be used in conjunction with EN 19694-1 which contains generic, overall requirements, definitions and rules applicable to the determination of GHG emissions for all energy-intensive sectors, provides common methodological issues and defines the details for applying the rules. The application of this standard to the sector-specific standards ensures accuracy, precision and reproducibility of the results.

6.2 Calculation methods for process GHG emissions from primary aluminium production

Figure 1 gives sources of process emissions and references to where in the standard calculation methods are described.

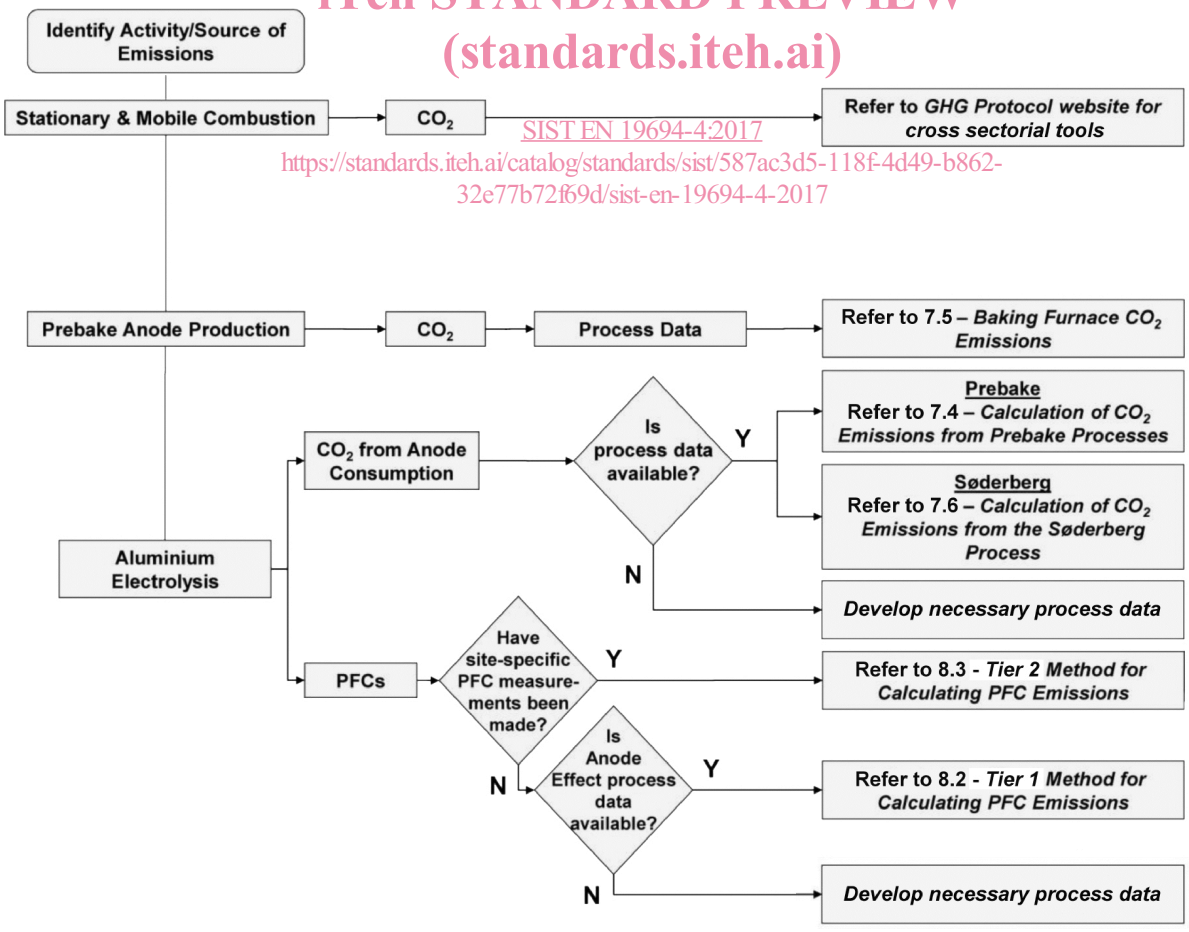

Figure 1 — Decision tree for process carbon dioxide and perfluorocarbon emissions from primary aluminium production

Process CO_2 emissions in state of the art aluminium smelters comprise around 90 % of total direct CO_2 equivalent emissions, with the balance of emissions consisting of CO_2 from fossil fuel combustion and PFC emissions. Guidance on CO_2 emissions from fuel combustion is not included in this document. Methodology for calculating CO_2 emissions from the combustion of fuel in anode baking furnaces is described elsewhere [6, 7], while methodology for calculating process CO_2 emissions is given in Clause 7.

6.3 Sources of carbon dioxide

6.3.1 Electrolysis

Most of the CO_2 emissions result from the electrolytic reaction of the carbon anode with alumina:

$$2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2 \quad (1)$$

Carbon dioxide is also emitted during the electrolysis reaction as the carbon anode reacts with other sources of oxygen, primarily from the air. Carbon dioxide is also formed as a result of the Boudouard reaction where CO_2 reacts with the carbon anode forming carbon monoxide, which is then oxidized to form CO_2. Each unit of CO_2 participating in the Boudouard reaction produces two units of CO_2 after air oxidation:

$$CO_2 + C \rightarrow 2CO \quad (2)$$

$$2CO + O_2 \rightarrow 2CO_2 \quad (3)$$

All carbon monoxide formed is assumed to be converted to CO_2. By industry convention no correction is made for the minute amount of carbon consumed as PFCs rather than CO_2 emissions. No CO_2 is produced from cathode consumption unless there is on-site incineration and no recommendation is included here for such operations CO_2 emission from addition of sodium carbonate to electrolyses cells is not included as this is added at infrequent intervals and is an insignificant source.

6.3.2 Anode baking

Another source of CO_2 emissions, specific to prebake technologies, is the baking of green anodes, wherein CO_2 is emitted from the combustion of volatile components from the pitch binder and, for baking furnaces fired with carbon based fuels, from the combustion of the fuel source. Some of the packing coke used to cover the anodes is also oxidized, releasing CO_2 during anode baking.

Carbon dioxide is emitted from the fuel used in the paste plant and the fuel used for firing the anode baking furnace.

6.3.3 Aluminium smelting supporting processes

A further source of carbon dioxide emissions is fuel used in the cast house for heating of the metal during treatment processes before casting, and some fuel may also be used in rodding operations.

6.3.4 Alumina refining

Carbon dioxide is not produced as process emission in the Bayer Process, the process through which alumina is refined from bauxite ore. Most of the emissions associated with alumina refining are from the combustion of fossil fuels, which are covered in the WRI/WBCSD [10] calculation tools for GHG emissions from energy and electricity.

6.4 Sources of PFC

Two perfluorocarbon gases (PFCs), tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6), may be produced during primary aluminium production.