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ANNEX 1

ANNEX

to the

Commission Implementing Regulation (EU) .../...

**on the monitoring and reporting of greenhouse gas emissions pursuant to Directive
2003/87/EC of the European Parliament and of the Council and amending Commission
Regulation (EU) No 601/2012**

ANNEX I

Minimum content of the monitoring plan (Article 12(1))

1. MINIMUM CONTENT OF THE MONITORING PLAN FOR INSTALLATIONS

The monitoring plan for an installation shall contain at least the following information:

- (1) general information on the installation:
 - (a) a description of the installation and activities carried out by the installation to be monitored, containing a list of emissions sources and source streams to be monitored for each activity carried out within the installation and meeting the following criteria:
 - (i) the description must be sufficient for demonstrating that neither data gaps nor double counting of emissions occur;
 - (ii) a simple diagram of the emission sources, source streams, sampling points and metering equipment must be added where requested by the competent authority or where such diagram simplifies describing the installation or referencing emission sources, source streams, measuring instruments and any other parts of the installation relevant for the monitoring methodology including data flow activities and control activities;
 - (b) a description of the procedure for managing the assignment of responsibilities for monitoring and reporting within the installation, and for managing the competences of responsible personnel;
 - (c) a description of the procedure for regular evaluation of the monitoring plan's appropriateness, covering at least the following:
 - (i) checking the list of emissions sources and source streams, ensuring completeness of the emission sources and source streams and that all relevant changes in the nature and functioning of the installation will be included in the monitoring plan;
 - (ii) assessing compliance with the uncertainty thresholds for activity data and other parameters, where applicable, for the applied tiers for each source stream and emission source;
 - (iii) assessing potential measures for improvement of the monitoring methodology applied;
 - (d) a description of the written procedures of the data flow activities pursuant to Article 58, including a diagram where appropriate for clarification;
 - (e) a description of the written procedures for the control activities established pursuant to Article 59;
 - (f) where applicable, information on relevant links with activities undertaken in the framework of the Community eco-management and audit scheme (EMAS) established pursuant to Regulation (EC) No 1221/2009 of the European Parliament and of the Council ⁽¹⁾, systems covered by harmonised standard

¹ OJ L 342, 22.12.2009, p.1.

- ISO 14001:2004 and other environmental management systems including information on procedures and controls with relevance to greenhouse gas emissions monitoring and reporting;
- (g) the version number of the monitoring plan and the date from which that version of the monitoring plan is applicable;
 - (h) the category of the installation;
- (2) a detailed description of the calculation-based methodologies where applied, consisting of the following:
- (a) a detailed description of the calculation-based methodology applied, including a list of input data and calculation formulae used, a list of the tiers applied for activity data and all relevant calculation factors for each of the source streams to be monitored;
 - (b) where applicable and where the operator intends to make use of simplification for minor and de-minimis source streams, a categorisation of the source streams into major, minor and de-minimis source streams;
 - (c) a description of the measurement systems used, and their measurement range, specified uncertainty and exact location of the measuring instruments to be used for each of the source streams to be monitored;
 - (d) where applicable, the default values used for calculation factors indicating the source of the factor, or the relevant source, from which the default factor will be retrieved periodically, for each of the source streams;
 - (e) where applicable, a list of the analysis methods to be used for the determination of all relevant calculation factors for each of the source streams, and a description of the written procedures for those analyses;
 - (f) where applicable, a description of the procedure underpinning the sampling plan for the sampling of fuel and materials to be analysed, and the procedure used to revise the appropriateness of the sampling plan;
 - (g) where applicable, a list of laboratories engaged in carrying out relevant analytical procedures and, where the laboratory is not accredited as referred to in Article 34(1) a description of the procedure used for demonstrating the compliance with equivalent requirements in accordance with Article 34(2) and (3);
- (3) where a fall-back monitoring methodology is applied in accordance with Article 22, a detailed description of the monitoring methodology applied for all source streams or emission sources, for which no tier methodology is used, and a description of the written procedure used for the associated uncertainty analysis to be carried out;
- (4) a detailed description of the measurement-based methodologies, where applied, including the following:
- (a) a description of the measurement method including descriptions of all written procedures relevant for the measurement and the following:
 - (i) any calculation formulae used for data aggregation and used to determine the annual emissions of each emission source;

- (ii) the method for determining whether valid hours or shorter reference periods for each parameter can be calculated, and for substitution of missing data in accordance with Article 45;
 - (b) a list of all relevant emission points during typical operation, and during restrictive and transition phases, including breakdown periods or commissioning phases, supplemented by a process diagram where requested by the competent authority;
 - (c) where flue gas flow is derived by calculation, a description of the written procedure for that calculation for each emission source monitored using a measurement-based methodology;
 - (d) a list of all relevant equipment, indicating its measurement frequency, operating range and uncertainty;
 - (e) a list of applied standards and of any deviations from those standards;
 - (f) a description of the written procedure for carrying out the corroborating calculations in accordance with Article 46, where applicable;
 - (g) a description of the method, how CO₂ stemming from biomass is to be determined and subtracted from the measured CO₂ emissions, and of the written procedure used for that purpose, where applicable;
 - (h) where applicable and where the operator intends to make use of simplification for minor emission sources, a categorisation of the emission sources into major and minor emission sources;
- (5) in addition to elements listed in point 4, a detailed description of the monitoring methodology where N₂O emissions are monitored, where appropriate in the form of description of the written procedures applied, including a description of the following:
- (a) the method and parameters used to determine the quantity of materials used in the production process and the maximum quantity of material used at full capacity;
 - (b) the method and parameters used to determine the quantity of product produced as an hourly output, expressed as nitric acid (100%), adipic acid (100%), caprolactam, glyoxal and glyoxylic acid per hour respectively;
 - (c) the method and parameters used to determine the N₂O concentration in the flue gas from each emission source, its operating range, and its uncertainty, and details of any alternative methods to be applied where concentrations fall outside the operating range and the situations when this may occur;
 - (d) the calculation method used to determine N₂O emissions from periodic, unabated sources in nitric acid, adipic acid, caprolactam, glyoxal and glyoxylic acid production;
 - (e) the way in which or the extent to which the installation operates with variable loads, and the manner in which the operational management is carried out;
 - (f) the method and any calculation formulae used to determine the annual N₂O emissions and the corresponding CO_{2(e)} values of each emission source;
 - (g) information on process conditions that deviate from normal operations, an indication of the potential frequency and the duration of such conditions, as

well as an indication of the volume of the N₂O emissions during the deviating process conditions such as abatement equipment malfunction;

- (6) a detailed description of the monitoring methodology as far as perfluorocarbons from primary aluminium production are monitored, where appropriate in the form of a description of the written procedures applied, including the following:
 - (a) where applicable, the dates of measurement for the determination of the installation-specific emission factors SEF_{CF4} or OVC, and F_{C2F6}, and a schedule for future repetitions of that determination;
 - (b) where applicable, the protocol describing the procedure used to determine the installation-specific emission factors for CF₄ and C₂F₆, showing also that the measurements have been and will be carried out for a sufficiently long time for measured values to converge, but at least for 72 hours;
 - (c) where applicable, the methodology for determining the collection efficiency for fugitive emissions at installations for primary aluminium production;
 - (d) a description of cell type and type of anode;
- (7) a detailed description of the monitoring methodology where transfer of inherent CO₂ as part of a source stream in accordance with Article 48, transfer of CO₂ in accordance with Article 49, or transfer of N₂O in accordance with Article 50 are carried out, where appropriate in the form of a description of the written procedures applied, including the following:
 - (a) where applicable, the location of equipment for temperature and pressure measurement in a transport network;
 - (b) where applicable, procedures for preventing, detecting and quantification of leakage events from transport networks;
 - (c) in the case of transport networks, procedures effectively ensuring that CO₂ is transferred only to installations which have a valid greenhouse gas emission permit, or where any emitted CO₂ is effectively monitored and accounted for in accordance with Article 49;
 - (d) identification of the receiving and transferring installations according to the installation identification code recognised in accordance with Regulation (EU) No 1193/2011;
 - (e) where applicable, a description of continuous measurement systems used at the points of transfer of CO₂ or N₂O between installations transferring CO₂ or N₂O or the determination method in accordance with Articles 48, 49 or 50;
 - (f) where applicable, a description of the conservative estimation method used for determining the biomass fraction of transferred CO₂ in accordance with Article 48 or 49;
 - (g) where applicable, quantification methodologies for emissions or CO₂ released to the water column from potential leakages as well as the applied and possibly adapted quantification methodologies for actual emissions or CO₂ released to the water column from leakages, as specified in section 23 of Annex IV.

2. MINIMUM CONTENT OF MONITORING PLANS FOR AVIATION EMISSIONS

- 1. The monitoring plan shall contain the following information for all aircraft operators:

- (a) the identification of the aircraft operator, call sign or other unique designator used for air traffic control purposes, contact details of the aircraft operator and of a responsible person at the aircraft operator, contact address, the administering Member State, the administering competent authority;
- (b) an initial list of aircraft types in its fleet operated at the time of the submission of the monitoring plan and the number of aircraft per type, and an indicative list of additional aircraft types expected to be used including, where available, an estimated number of aircraft per type as well as the source streams (fuel types) associated with each aircraft type;
- (c) a description of procedures, systems and responsibilities used to update the completeness of the list of emission sources over the monitoring year for the purpose of ensuring the completeness of monitoring and reporting of the emissions of owned aircraft as well as leased-in aircraft;
- (d) a description of the procedures used to monitor the completeness of the list of flights operated under the unique designator by aerodrome pair, and the procedures used for determining whether flights are covered by Annex I to Directive 2003/87/EC for the purpose of ensuring completeness of flights and avoiding double counting;
- (e) a description of the procedure for managing and assigning responsibilities for monitoring and reporting, and for managing the competences of responsible personnel;
- (f) a description of the procedure for regular evaluation of the monitoring plan's appropriateness, including any potential measures for the improvement of the monitoring methodology and related procedures applied;
- (g) a description of the written procedures of the data flow activities as required by Article 58, including a diagram, where appropriate, for clarification;
- (h) a description of the written procedures for the control activities established under Article 59;
- (i) where applicable, information on relevant links with activities undertaken in the framework of EMAS, systems covered by harmonised standard ISO 14001:2004 and other environmental management systems, including information on procedures and controls with relevance to greenhouse gas emissions monitoring and reporting;
- (j) the version number of the monitoring plan and the date from which that version of the monitoring plan is applicable;
- (k) confirmation if the aircraft operator intends to make use of the simplification pursuant to Article 28a(6) of Directive 2003/87/EC.

2. The monitoring plan shall contain the following information for aircraft operators which are not small emitters in accordance with Article 55(1) or which do not intend to use a small emitter tool in accordance with Article 55(2):

- (a) a description of the written procedure to be used for defining the monitoring methodology for additional aircraft types which an aircraft operator expects to use;
- (b) a description of the written procedures for monitoring fuel consumption in every aircraft, including:

- (i) the chosen methodology (Method A or Method B) for calculating the fuel consumption; and where the same method is not applied for all aircraft types, a justification for that methodology, as well as a list specifying which method is used under which conditions;
 - (ii) procedures for the measurement of fuel uplifts and fuel in tanks, a description of the measuring instruments involved and the procedures for recording, retrieving, transmitting and storing information regarding measurements, as applicable;
 - (iii) the method for the determination of density, where applicable;
 - (iv) justification of the chosen monitoring methodology, in order to ensure lowest levels of uncertainty, according to Article 56 (1);
- (c) a list of deviations for specific aerodromes from the general monitoring methodology as described in point (b) where it is not possible for the aircraft operator due to special circumstances to provide all the required data for the required monitoring methodology;
 - (d) emission factors used for each fuel type, or in the case of alternative fuels, the methodologies for determining the emission factors, including the methodology for sampling, methods of analysis, a description of the laboratories used and of their accreditation and/or of their quality assurance procedures;
 - (e) a description of the procedures and systems for identifying, assessing and handling data gaps pursuant to Article 66(2).

3. MINIMUM CONTENT OF MONITORING PLANS FOR TONNE-KILOMETRE DATA

- 1. The monitoring plan for tonne-kilometre data shall contain the following information:
 - (a) the elements listed in point 1 of section 2 of this Annex;
 - (b) a description of the written procedures used for determining tonne-kilometre data per flight, including:
 - (i) the procedures, responsibilities, data sources and calculation formulae for determining and recording the distance per aerodrome pair;
 - (ii) the tier used for determining the mass of passengers including the checked in baggage; in the case of tier 2, a description of the procedure for obtaining the mass of passengers and baggage is to be provided;
 - (iii) a description of the procedures used to determine the mass of freight and mail, where applicable;
 - (iv) a description of the measurement devices used for measuring the mass of passengers, freight and mail as applicable.

ANNEX II

Tier definitions for calculation-based methodologies related to installations (Article 12(1))

1. DEFINITION OF TIERS FOR ACTIVITY DATA

The uncertainty thresholds in Table 1 shall apply to tiers relevant to activity data requirements in accordance with point (a) of Article 28(1) and the first subparagraph of Article 29(2), and Annex IV, of this Regulation. The uncertainty thresholds shall be interpreted as maximum permissible uncertainties for the determination of source streams over a reporting period.

Where Table 1 does not include activities listed in Annex I to Directive 2003/87/EC and the mass balance is not applied, the operator shall use the tiers listed in Table 1 under ‘Combustion of fuels and fuels used as process input’ for those activities.

Table 1

Tiers for activity data (maximum permissible uncertainty for each tier)

Activity/source stream type	Parameter to which the uncertainty is applied	Tier 1	Tier 2	Tier 3	Tier 4
Combustion of fuels and fuels used as process input					
Commercial standard fuels	Amount of fuel [t] or [Nm ³]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Other gaseous and liquid fuels	Amount of fuel [t] or [Nm ³]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Solid fuels	Amount of fuel [t]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Flaring	Amount of flare gas [Nm ³]	± 17,5 %	± 12,5 %	± 7,5 %	
Scrubbing: carbonate (Method A)	Amount carbonate consumed [t]	± 7,5 %			
Scrubbing: gypsum (Method B)	Amount gypsum produced [t]	± 7,5 %			
Scrubbing: urea	Amount urea consumed	± 7,5 %			
Refining of mineral oil					
Catalytic cracker regeneration (*)	Uncertainty requirements apply separately for each emission source	± 10 %	± 7,5 %	± 5 %	± 2,5 %
Production of coke					
Mass balance methodology	Each input and output material [t]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Metal ore roasting and sintering					
Carbonate input and process residues	Carbonate input material and process residues [t]	± 5 %	± 2,5 %		
Mass balance methodology	Each input and output material [t]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Production of iron and steel					
Fuel as process input	Each mass flow into and from the installation [t]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %

Activity/source stream type	Parameter to which the uncertainty is applied	Tier 1	Tier 2	Tier 3	Tier 4
Mass balance methodology	Each input and output material [t]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Production of cement clinker					
Kiln input based (Method A)	Each relevant kiln input [t]	± 7,5 %	± 5 %	± 2,5 %	
Clinker output (Method B)	Clinker produced [t]	± 5 %	± 2,5 %		
CKD	CKD or bypass dust [t]	n.a. (**)	± 7,5 %		
Non-carbonate carbon	Each raw material [t]	± 15 %	± 7,5 %		
Production of lime and calcination of dolomite and magnesite					
Carbonates and other process materials (Method A)	Each relevant kiln input [t]	± 7,5 %	± 5 %	± 2,5 %	
Alkali earth oxide (Method B)	Lime produced [t]	± 5 %	± 2,5 %		
Kiln dust (Method B)	Kiln dust [t]	n.a. (**)	± 7,5 %		
Manufacture of glass and mineral wool					
Carbonates and other process materials (input)	Each carbonate raw material or additives associated with CO ₂ emissions [t]	± 2,5 %	± 1,5 %		
Manufacture of ceramic products					
Carbon inputs (Method A)	Each carbonate raw material or additive associated with CO ₂ emissions [t]	± 7,5 %	± 5 %	± 2,5 %	
Alkali oxide (Method B)	Gross production including rejected products and cullet from the kilns and shipment [t]	± 7,5 %	± 5 %	± 2,5 %	
Scrubbing	Dry CaCO ₃ consumed [t]	± 7,5 %			
Production of pulp and paper					
Make up chemicals	Amount of CaCO ₃ and Na ₂ CO ₃ [t]	± 2,5 %	± 1,5 %		
Production of carbon black					
Mass balance methodology	Each input and output material [t]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Production of ammonia					
Fuel as process input	Amount fuel used as process input [t] or [Nm ³]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Production of hydrogen and synthesis gas					
Fuel as process input	Amount fuel used as process input for hydrogen production [t] or [Nm ³]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Mass balance methodology	Each input and output material [t]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Production of bulk organic chemicals					

Activity/source stream type	Parameter to which the uncertainty is applied	Tier 1	Tier 2	Tier 3	Tier 4
Mass balance methodology	Each input and output material [t]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Production or processing of ferrous and non-ferrous metals, including secondary aluminium					
Process emissions	Each input material or process residue used as input material in the process [t]	± 5 %	± 2,5 %		
Mass balance methodology	Each input and output material [t]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
Primary aluminium production					
Mass balance methodology	Each input and output material [t]	± 7,5 %	± 5 %	± 2,5 %	± 1,5 %
PFC emissions (slope method)	primary aluminium production in [t], anode effect minutes in [number anode effects/cell day] and [anode effect minutes/ occurrence]	± 2,5 %	± 1,5 %		
PFC emissions (overtoltage method)	primary aluminium production in [t], anode effect overtoltage [mV] and current efficiency [-]	± 2,5 %	± 1,5 %		

(*) For monitoring emissions from catalytic cracker regeneration (other catalyst regeneration and flexi-cokers) in mineral oil refineries, the required uncertainty is related to the total uncertainty of all emissions from that source.

(**) Amount [t] of CKD or bypass dust (where relevant) leaving the kiln system over a reporting period estimated using industry best practice guidelines.

2. DEFINITION OF TIERS FOR CALCULATION FACTORS FOR COMBUSTION EMISSIONS

Operators shall monitor CO₂ emissions from all types of combustion processes taking place under all activities as listed in Annex I to Directive 2003/87/EC or included in the Union system under Article 24 of that Directive using the tier definitions laid down in this section. Where fuels or combustible materials which give rise to CO₂ emissions are used as a process input, section 5 of this Annex shall apply. Where fuels form part of a mass balance in accordance with Article 25(1) of this Regulation, the tier definitions for mass balances in section 3 of this Annex apply.

For process emissions from related exhaust gas scrubbing tier definitions according to sections 4 and 5 of this Annex shall be used, as applicable.

2.1 Tiers for emission factors

Where a biomass fraction is determined for a mixed fuel or material, the tiers defined shall relate to the preliminary emission factor. For fossil fuels and materials the tiers shall relate to the emission factor.

Tier 1: The operator shall apply one of the following:

- (a) the standard factors listed in section 1 of Annex VI;

- (b) other constant values in accordance with point (e) of Article 31(1), where no applicable value is contained in section 1 of Annex VI.

Tier 2a: The operator shall apply country specific emission factors for the respective fuel or material in accordance with points (b) and (c) of Article 31(1) or values in accordance with point (d) of Article 31(1).

Tier 2b: The operator shall derive emission factors for the fuel based on one of the following established proxies, in combination with an empirical correlation as determined at least once per year in accordance with Articles 32 to 35 and 39:

- (a) density measurement of specific oils or gases, including those common to the refinery or steel industry;
- (b) net calorific value for specific coal types.

The operator shall ensure that the correlation satisfies the requirements of good engineering practice and that it is applied only to values of the proxy which fall into the range for which it was established.

Tier 3: The operator shall apply one of the following:

- (a) determination of the emission factor in accordance with the relevant provisions of Articles 32 to 35;
- (b) the empirical correlation as specified for Tier 2b, where the operator demonstrates to the satisfaction of the competent authority that the uncertainty of the empirical correlation does not exceed 1/3 of the uncertainty value to which the operator has to adhere with regard to the activity data determination of the relevant fuel or material.

2.2 Tiers for net calorific value (NCV)

Tier 1: The operator shall apply one of the following:

- (a) the standard factors listed in section 1 of Annex VI;
- (b) other constant values in accordance with point (e) of Article 31(1), where no applicable value is contained in section 1 of Annex VI.

Tier 2a: The operator shall apply country specific factors for the respective fuel in accordance with point (b) or (c) of Article 31(1) or values in accordance with point (d) of Article 31(1).

Tier 2b: For commercially traded fuels the net calorific value as derived from the purchasing records for the respective fuel provided by the fuel supplier shall be used provided it has been derived based on accepted national or international standards.

Tier 3: The operator shall determine the net calorific value in accordance with Article 32 to 35.

2.3 Tiers for oxidation factors

Tier 1: The operator shall apply an oxidation factor of 1.

Tier 2: The operator shall apply oxidation factors for the respective fuel in accordance with point (b) or (c) of Article 31(1).

Tier 3: For fuels, the operator shall derive activity-specific factors based on the relevant carbon contents of ashes, effluents and other wastes and by-products, and other relevant

incompletely oxidised gaseous forms of carbon emitted except CO. Composition data shall be determined in accordance with Article 32 to 35.

2.4 Tiers for biomass fraction

Tier 1: The operator shall apply an applicable value published by the competent authority or the Commission, or values in accordance with Article 31(1).

Tier 2: The operator shall apply an estimation method approved in accordance with the second subparagraph of Article 39(2).

Tier 3: The operator shall apply analyses in accordance with the first sub-paragraph of Article 39 (2), and in accordance with Articles 32 to 35.

Where an operator assumes a fossil fraction of 100% in accordance with Article 39(1), no tier shall be assigned for the biomass fraction.

3. DEFINITION OF TIERS FOR CALCULATION FACTORS FOR MASS BALANCES

Where an operator uses a mass balance in accordance with Article 25, it shall use the tier definitions of this section.

3.1 Tiers for carbon content

The operator shall apply one of the tiers listed in this point. For deriving the carbon content from an emission factor, the operator shall use the following equations:

- (a) for emission factors expressed as t CO₂/TJ: $C = (EF \times NCV) / f$
- (b) for emission factors expressed as t CO₂/t: $C = EF / f$

In those formulae, C is the carbon content expressed as fraction (tonne carbon per tonne product), EF is the emission factor, NCV is the net calorific value, and f is the factor laid down in Article 36(3).

Where a biomass fraction is determined for a mixed fuel or material, the tiers defined shall relate to the total carbon content. The biomass fraction of the carbon shall be determined using the tiers defined in section 2.4 of this Annex.

Tier 1: The operator shall apply one of the following:

- (a) the carbon content derived from standard factors listed in Annex VI sections 1 and 2;
- (b) other constant values in accordance with point (e) of Article 31(1), where no applicable value is contained in Annex VI sections 1 and 2.

Tier 2a: The operator shall derive the carbon content from country specific emission factors for the respective fuel or material in accordance with point (b) or (c) of Article 31(1) or values in accordance with point (d) of Article 31(1).

Tier 2b: The operator shall derive the carbon content from emission factors for the fuel based on one of the following established proxies in combination with an empirical correlation as determined at least once per year in accordance with Articles 32 to 35:

- (a) density measurement of specific oils or gases common, for example, to the refinery or steel industry;

- (b) net calorific value for specific coals types.

The operator shall ensure that the correlation satisfies the requirements of good engineering practice and that it is applied only to values of the proxy which fall into the range for which it was established.

Tier 3: The operator shall apply one of the following:

- (a) determination of the carbon content in accordance with the relevant provisions of Articles 32 to 35;
- (b) the empirical correlation as specified for Tier 2b, where the operator demonstrates to the satisfaction of the competent authority that the uncertainty of the empirical correlation does not exceed 1/3 of the uncertainty value to which the operator has to adhere with regard to the activity data determination of the relevant fuel or material.

3.2 Tiers for net calorific values

The tiers defined in section 2.2 of this Annex shall be used.

3.3 Tiers for biomass fraction

The tiers defined in section 2.4 of this Annex shall be used.

4. DEFINITION OF TIERS FOR THE CALCULATION FACTORS FOR PROCESS EMISSIONS FROM CARBONATE DECOMPOSITION

For all process emissions, where they are monitored using the standard methodology in accordance with Article 24(2), the following tier definitions for the emission factor and the conversion factor shall be applied in the case of:

- (a) **Method A:** Input based, the emission factor and activity data related to the amount of material input into the process.
- (b) **Method B:** Output based, the emission factor and activity data related to the amount of output from the process.

4.1 Tiers for the emission factor using Method A:

Tier 1: The operator shall apply one of the following:

- (a) the standard factors listed in Annex VI section 2 Table 2;
- (b) other constant values in accordance with point (e) of Article 31(1), where no applicable value is contained in Annex VI.

Tier 2: The operator shall apply a country specific emission factor in accordance with point (b) or (c) of Art. 31(1), or values in accordance with point (d) of Article 31(1).

Tier 3: The operator shall determine the emission factor in accordance with Articles 32 to 35. Stoichiometric ratios as listed in section 2 of Annex VI shall be used to convert composition data into emission factors, where relevant.

4.2 Tiers for the conversion factor using Method A:

Tier 1: A conversion factor of 1 shall be used.

Tier 2: Carbonates and other carbon leaving the process shall be considered by means of a conversion factor with a value between 0 and 1. The operator may assume complete conversion for one or several inputs and attribute unconverted materials or other carbon to the

remaining inputs. The additional determination of relevant chemical parameters of the products shall be carried out in accordance with Articles 32 to 35.

4.3 Tiers for the emission factor using Method B:

Tier 1: The operator shall apply one of the following:

- (a) the standard factors listed in Annex VI section 2 Table 3.
- (b) other constant values in accordance with point (e) of Article 31(1), where no applicable value is contained in Annex VI.

Tier 2: The operator shall apply a country specific emission factor in accordance with point (b) or (c) of Article 31(1), or values in accordance with point (d) of Article 31(1).

Tier 3: The operator shall determine the emission factor in accordance with Articles 32 to 35. Stoichiometric ratios referred to in Annex VI section 2 Table 3 shall be used to convert composition data into emission factors assuming that all of the relevant metal oxides have been derived from respective carbonates. For this purpose the operator shall take into account at least CaO and MgO, and shall provide evidence to the competent authority as to which further metal oxides relate to carbonates in the raw materials.

4.4 Tiers for the conversion factor using Method B:

Tier 1: A conversion factor of 1 shall be used.

Tier 2: The amount of non-carbonate compounds of the relevant metals in the raw materials, including return dust or fly ash or other already calcined materials, shall be reflected by means of conversion factors with a value between 0 and 1 with a value of 1 corresponding to a full conversion of raw material carbonates into oxides. The additional determination of relevant chemical parameters of the process inputs shall be carried out in accordance with Articles 32 to 35.

5. DEFINITION OF TIERS FOR CALCULATION FACTORS FOR CO₂ PROCESS EMISSIONS FROM OTHER MATERIALS THAN CARBONATES

Process materials giving rise to CO₂ emissions, including urea, coke, graphite and other non-carbonate carbon containing materials, shall be monitored using an input-based approach according to this section, unless included in a mass balance.

5.1 Tiers for emission factors

The tiers defined in section 2.1 of this Annex shall be used.

5.2 Tiers for net calorific value (NCV)

If the process material contains combustible carbon, the operator shall report the NCV value. The tiers defined in section 2.2 of this Annex shall be used.

5.3 Tiers for conversion / oxidation factors

If the process material contains combustible carbon, the operator shall apply an oxidation factor. For this purpose the tiers defined in section 2.3 of this Annex shall be used.

In all other cases the operator shall apply a conversion factor. For this purpose the following tier definitions shall apply:

Tier 1: A conversion factor of 1 shall be used.

Tier 2: Carbon leaving the process shall be considered by means of a conversion factor with a value between 0 and 1. The operator may assume complete conversion for one or several inputs and attribute unconverted materials or other carbon to the remaining inputs. The additional determination of relevant chemical parameters of the products shall be carried out in accordance with Articles 32 to 35.

5.4 Tiers for biomass fraction

The tiers defined in section 2.4 of this Annex shall be used.

ANNEX III

Monitoring methodologies for aviation (Article 53 and Article 57)

1. CALCULATION METHODOLOGIES FOR THE DETERMINATION OF GHGS IN THE AVIATION SECTOR

Method A:

The operator shall use the following formula:

Actual fuel consumption for each flight [t] = Amount of fuel contained in aircraft tanks once fuel uplift for the flight is complete [t] – Amount of fuel contained in aircraft tanks once fuel uplift for subsequent flight is complete [t] + Fuel uplift for that subsequent flight [t]

Where there is no fuel uplift for the flight or subsequent flight, the amount of fuel contained in aircraft tanks shall be determined at block-off for the flight or subsequent flight. In the exceptional case that an aircraft performs activities other than a flight, including undergoing major maintenance involving the emptying of the tanks, after the flight for which fuel consumption is being monitored, the aircraft operator may substitute the quantity ‘Amount of fuel contained in aircraft tanks once fuel uplift for subsequent flight is complete + Fuel uplift for that subsequent flight’ with the ‘Amount of fuel remaining in tanks at the start of the subsequent activity of the aircraft’, as recorded by technical logs.

Method B:

The operator shall use the following formula:

Actual fuel consumption for each flight [t] = Amount of fuel remaining in aircraft tanks at block-on at the end of the previous flight [t] + Fuel uplift for the flight [t] - Amount of fuel contained in tanks at block-on at the end of the flight [t]

The moment of block-on may be considered equivalent to the moment of engine shut down. Where an aircraft does not perform a flight previous to the flight for which fuel consumption is being monitored, the aircraft operator may substitute the quantity ‘Amount of fuel remaining in aircraft tanks at block-on at the end of the previous flight’ with the ‘Amount of fuel remaining in aircraft tanks at the end of the previous activity of the aircraft’, as recorded by technical logs.

2. EMISSION FACTORS FOR STANDARD FUELS

Table 1

Aviation fuel CO₂ emission factors

Fuel	Emission factor (t CO₂/t fuel)
Aviation gasoline (AvGas)	3,10
Jet gasoline (Jet B)	3,10
Jet kerosene (Jet A1 or Jet A)	3,15

3. CALCULATION OF GREAT CIRCLE DISTANCE

Distance [km] = Great Circle Distance [km] + 95 km

The Great Circle Distance shall be the shortest distance between any two points on the surface of the Earth, which shall be approximated using the system referred to in Article 3.7.1.1 of Annex 15 to the Chicago Convention (WGS 84).

The latitude and longitude of aerodromes shall be taken either from aerodrome location data published in Aeronautical Information Publications (AIP) in compliance with Annex 15 to the Chicago Convention or from a source using AIP data.

Distances calculated by software or by a third party may also be used, provided that the calculation methodology is based on the formula set out in this section, AIP data and WGS 84 requirements.

ANNEX IV

Activity-specific monitoring methodologies related to installations (Article 20(2))

1. SPECIFIC MONITORING RULES FOR EMISSIONS FROM COMBUSTION PROCESSES

A. Scope

Operators shall monitor CO₂ emissions from all types of combustion processes taking place under all activities as listed in Annex I to Directive 2003/87/EC or included in the Union system under Article 24 of that Directive including the related scrubbing processes using the rules laid down in this Annex. Any emissions from fuels used as process input shall be treated like combustion emissions with regard to monitoring and reporting methodologies, without prejudice to other classifications applied to emissions.

The operator shall not monitor and report emissions from internal combustion engines for transportation purposes. The operator shall assign all emissions from the combustion of fuels at the installation to the installation, regardless of exports of heat or electricity to other installations. The operator shall not assign emissions associated with the production of heat or electricity that is imported from other installations to the importing installation.

The operator shall include at least the following emission sources: boilers, burners, turbines, heaters, furnaces, incinerators, calciners, kilns, ovens, dryers, engines, fuel cells, chemical looping combustion units, flares, thermal or catalytic post-combustion units, and scrubbers (process emissions) and any other equipment or machinery that uses fuel, excluding equipment or machinery with combustion engines that are used for transportation purposes.

B. Specific monitoring rules

The emissions from combustion processes shall be calculated in accordance with Article 24(1), unless the fuels are included in a mass balance in accordance with Article 25. The tiers defined in section 2 of Annex II shall apply. In addition, process emissions from flue gas scrubbing shall be monitored using the provisions laid down in subsection C.

For emissions from flares special requirements shall apply, as laid down in subsection D of this section.

Combustion processes taking place in gas processing terminals may be monitored using a mass balance in accordance with Article 25.

C. Flue gas scrubbing

C.1 Desulphurisation

Process CO₂ emissions from the use of carbonate for acid gas scrubbing from the flue gas stream shall be calculated in accordance with Article 24(2) on the basis of carbonate consumed, Method A as follows, or gypsum produced, Method B as follows. The following applies by way of derogation from section 4 of Annex II.

Method A: Emission factor

Tier 1: The emission factor shall be determined from stoichiometric ratios as laid down in section 2 of Annex VI. The determination of the amount of CaCO₃ and MgCO₃ or other carbonates in the relevant input material shall be carried out using industry best practice guidelines.

Method B: Emission factor

Tier 1: The emission factor shall be the stoichiometric ratio of dry gypsum ($\text{CaSO}_4 \times 2\text{H}_2\text{O}$) to CO_2 emitted: 0,2558 t CO_2 /t gypsum.

Conversion Factor:

Tier 1: A conversion factor of 1 shall be used.

C.2 De- NO_x

By way of derogation from section 5 of Annex II, process CO_2 emissions from the use of urea for scrubbing of the flue gas stream shall be calculated in accordance with Article 24(2) applying the following tiers.

Emission factor:

Tier 1: The determination of the amount of urea in the relevant input material shall be carried out using industry best practice guidelines. The emission factor shall be determined using a stoichiometric ratio of 0,7328 t CO_2 /t urea.

Conversion Factor:

Only tier 1 shall be applicable.

D. Flares

When calculating emissions from flares the operator shall include routine flaring and operational flaring (trips, start-up and shutdown as well as emergency relieves). The operator shall also include inherent CO_2 in accordance with Article 48.

By way of derogation from section 2.1 of Annex II, tiers 1 and 2b for the emission factor shall be defined as follows:

Tier 1: The operator shall use a reference emission factor of 0,00393 t CO_2 /Nm³ derived from the combustion of pure ethane used as a conservative proxy for flare gases.

Tier 2b: Installation-specific emission factors shall be derived from an estimate of the molecular weight of the flare stream, using process modelling based on industry standard models. By considering the relative proportions and the molecular weights of each of the contributing streams, a weighted annual average figure shall be derived for the molecular weight of the flare gas.

By way of derogation from section 2.3 of Annex II, only tiers 1 and 2 shall be applied for the oxidation factor in the case of flares.

2. REFINING OF MINERAL OIL AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall monitor and report all CO_2 emissions from combustion and production processes as occurring in refineries.

The operator shall include at least the following potential sources of CO_2 emissions: boilers, process heaters/treaters, internal combustion engines/turbines, catalytic and thermal oxidisers, coke calcining kilns, firewater pumps, emergency/standby generators, flares, incinerators, crackers, hydrogen production units, Claus process units, catalyst regeneration (from catalytic cracking and other catalytic processes) and cokers (flexi-coking, delayed coking).

B. Specific monitoring rules

The monitoring of mineral oil refining activities shall be carried out in accordance with section 1 of this Annex for combustion emissions including flue gas scrubbing. The operator

may choose to use the mass balance methodology in accordance with Article 25 for the whole refinery or individual process units such as heavy oil gasification or calcinations plants. Where combinations of standard methodology and mass balance are used, the operator shall provide evidence to the competent authority demonstrating the completeness of emissions covered, and that no double counting of emissions occurs.

Emissions from dedicated hydrogen production units shall be monitored in accordance with section 19 of this Annex.

By way of derogation from Article 24 and 25, emissions from catalytic cracker regeneration, other catalyst regeneration and flexi-cokers shall be monitored using a mass balance, taking into account the state of the input air and the flue gas. All CO in the flue gas shall be accounted for as CO₂, applying the mass relation: $t\text{ CO}_2 = t\text{ CO} * 1,571$. The analysis of input air and flue gases and the choice of tiers shall be in accordance with the provisions of Articles 32 to 35. The specific calculation methodology shall be approved by the competent authority.

3. PRODUCTION OF COKE AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall include at least the following potential sources of CO₂ emissions: raw materials (including coal or petroleum coke), conventional fuels (including natural gas), process gases (including blast furnace gas – BFG), other fuels and waste gas scrubbing.

B. Specific monitoring rules

For the monitoring of emissions from the production of coke, the operator may choose to use a mass balance in accordance with Article 25 and section 3 of Annex II, or the standard methodology in accordance with Article 24 and sections 2 and 4 of Annex II.

4. METAL ORE ROASTING AND SINTERING AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall include at least the following potential sources of CO₂ emissions: raw materials (calcination of limestone, dolomite and carbonatic iron ores, including FeCO₃), conventional fuels (including natural gas and coke/coke breeze), process gases (including coke oven gas – COG, and blast furnace gas – BFG), process residues used as input material including filtered dust from the sintering plant, the converter and the blast furnace, other fuels and flue gas scrubbing.

B. Specific monitoring rules

For the monitoring of emissions from metal ore roasting, sintering or pelletisation, the operator may choose to use a mass balance in accordance with Article 25 and section 3 of Annex II or the standard methodology in accordance with Article 24 and sections 2, 4 and 5 of Annex II.

5. PRODUCTION OF PIG IRON AND STEEL AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall include at least the following potential sources of CO₂ emissions: raw materials (calcination of limestone, dolomite and carbonatic iron ores, including FeCO₃),

conventional fuels (natural gas, coal and coke), reducing agents (including coke, coal and plastics), process gases (coke oven gas – COG, blast furnace gas – BFG and basic oxygen furnace gas – BOFG), consumption of graphite electrodes, other fuels and waste gas scrubbing.

B. Specific monitoring rules

For the monitoring of emissions from production of pig iron and steel, the operator may choose to use a mass balance in accordance with Article 25 and section 3 of Annex II, or the standard methodology in accordance with Article 24 and sections 2 and 4 of Annex II, at least for a part of the source streams, avoiding any gaps or double counting of emissions.

By way of derogation from section 3.1 of Annex II, tier 3 for the carbon content is defined as follows:

Tier 3: The operator shall derive the carbon content of input or output stream following Articles 32 to 35 in respect to the representative sampling of fuels, products and by-products, the determination of their carbon contents and biomass fraction. The operator shall base the carbon content of products or semi-finished products on annual analyses following Articles 32 to 35 or derive the carbon content from mid-range composition values as specified by relevant international or national standards.

6. PRODUCTION OR PROCESSING OF FERROUS AND NON-FERROUS METALS AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall not apply the provisions in this section for the monitoring and reporting of CO₂ emissions from the production of pig iron and steel and primary aluminium.

The operator shall consider at least the following potential emission sources for CO₂ emissions: conventional fuels; alternative fuels including plastics granulated material from post shredder plants; reducing agents including coke, graphite electrodes; raw materials including limestone and dolomite; carbon containing metal ores and concentrates; and secondary feed materials.

B. Specific monitoring rules

Where carbon stemming from fuels or input materials used at this installation remains in the products or other outputs of the production, the operator shall use a mass balance in accordance with Article 25 and section 3 of Annex II. Where this is not the case the operator shall calculate combustion and process emission separately using the standard methodology in accordance with Article 24 and sections 2 and 4 of Annex II.

Where a mass balance is used, the operator may choose to include emissions from combustion processes in the mass balance or to use the standard methodology in accordance with Article 24 and section 1 of this Annex for a part of the source streams, avoiding any gaps or double counting of emissions.

7. CO₂ EMISSIONS FROM PRODUCTION OR PROCESSING OF PRIMARY ALUMINIUM AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall apply the provisions of this section to the monitoring and reporting of CO₂ emissions from the production of electrodes for primary aluminium smelting, including stand-

alone plants for the production of such electrodes, and the consumption of electrodes during electrolysis.

The operator shall consider at least the following potential sources for CO₂ emissions: fuels for the production of heat or steam, electrode production, reduction of Al₂O₃ during electrolysis which is related to electrode consumption, and use of soda ash or other carbonates for waste gas scrubbing.

The associated emissions of perfluorocarbons – PFCs, resulting from anode effects, including fugitive emissions, shall be monitored in accordance with section 8 of this Annex.

B. Specific monitoring rules

The operator shall determine CO₂ emissions from the production or processing of primary aluminium using the mass balance methodology in accordance with Article 25. The mass balance methodology shall consider all carbon in inputs, stocks, products and other exports from the mixing, forming, baking and recycling of electrodes as well as from electrode consumption in electrolysis. Where pre-baked anodes are used, either separate mass balances for production and consumption may be applied, or one common mass balance taking into account both production and consumption of electrodes. In the case of Söderberg cells, the operator shall use one common mass balance.

For emissions from combustion processes the operator may choose to include them in the mass balance or to use the standard methodology in accordance with Article 24 and section 1 of this Annex at least for a part of the source streams, avoiding any gaps or double counting of emissions.

8. PFC EMISSIONS FROM PRODUCTION OR PROCESSING OF PRIMARY ALUMINIUM AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall apply the following for emissions of perfluorocarbons (PFCs) resulting from anode effects including fugitive emissions of PFCs. For associated CO₂ emissions, including emissions from electrode production, the operator shall apply section 7 of this Annex. The operator shall furthermore calculate PFC emissions not related to anode effects based on estimation methods in accordance with industry best practice, and any guidelines published by the Commission for this purpose.

B. Determination of PFC emissions

PFC emissions shall be calculated from the emissions measurable in a duct or stack ('point source emissions') as well as fugitive emissions using the collection efficiency of the duct:

PFC emissions (total) = PFC emissions (duct) / collection efficiency

The collection efficiency shall be measured when the installation-specific emission factors are determined. For its determination the most recent version of the guidance mentioned under Tier 3 of section 4.4.2.4 of the 2006 IPCC Guidelines shall be used.

The operator shall calculate emissions of CF₄ and C₂F₆ emitted through a duct or stack using one of the following methods:

- (a) Method A where the anode effect minutes per cell-day are recorded;
- (b) Method B where the anode effect overvoltage is recorded.

Calculation Method A – Slope Method:

The operator shall use the following equations for determining PFC emissions:

$$\text{CF}_4 \text{ emissions [t]} = \text{AEM} \times (\text{SEF}_{\text{CF}_4} / 1\,000) \times \text{Pr}_{\text{Al}}$$

$$\text{C}_2\text{F}_6 \text{ emissions [t]} = \text{CF}_4 \text{ emissions} * \text{F}_{\text{C}_2\text{F}_6}$$

Where:

AEM = Anode effect minutes / cell-day;

SEF_{CF_4} = Slope emission factor [(kg CF_4 / t Al produced) / (anode effect minutes / cell-day)].

Where different cell-types are used, different SEF may be applied as appropriate;

Pr_{Al} = Annual production of primary Aluminium [t];

$\text{F}_{\text{C}_2\text{F}_6}$ = Weight fraction of C_2F_6 (t C_2F_6 / t CF_4).

The anode effect minutes per cell-day shall express the frequency of anode effects (number anode effects / cell-day) multiplied by the average duration of anode effects (anode effect minutes / occurrence):

$$\text{AEM} = \text{frequency} \times \text{average duration}$$

Emission factor: The emission factor for CF_4 (slope emission factor, SEF_{CF_4}) expresses the amount [kg] of CF_4 emitted per tonne of aluminium produced per anode effect minute / cell-day. The emission factor (weight fraction $\text{F}_{\text{C}_2\text{F}_6}$) of C_2F_6 expresses the amount [t] of C_2F_6 emitted proportionate to the amount [t] of CF_4 emitted.

Tier 1: The operator shall use technology-specific emission factors from Table 1 of this section of Annex IV.

Tier 2: The operator shall use installation-specific emission factors for CF_4 and C_2F_6 established through continuous or intermittent field measurements. For the determination of those emission factors the operator shall use the most recent version of the guidance mentioned under Tier 3 of section 4.4.2.4 of the 2006 IPCC Guidelines ⁽²⁾. The emission factor shall also take into account emissions related to non-anode effects. The operator shall determine each emission factor with a maximum uncertainty of $\pm 15\%$.

The operator shall determine the emission factors at least every three years or earlier where necessary due to relevant changes at the installation. Relevant changes shall include a change in the distribution of anode effect duration, or a change in the control algorithm affecting the mix of the types of anode effects or the nature of the anode effect termination routine.

Table 1: Technology-specific emission factors related to activity data for the slope method.

Technology	Emission factor for CF_4 (SEF_{CF_4}) [(kg CF_4 /t Al) / (AE-Mins/cell-day)]	Emission factor for C_2F_6 ($\text{F}_{\text{C}_2\text{F}_6}$) [t C_2F_6 / t CF_4]
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² International Aluminium Institute; The Aluminium Sector Greenhouse Gas Protocol; October 2006; US Environmental Protection Agency and International Aluminium Institute; Protocol for Measurement of Tetrafluoromethane (CF_4) and Hexafluoroethane (C_2F_6) Emissions from Primary Aluminum Production; April 2008.

Technology	Emission factor for CF ₄ (SEF _{CF4}) [(kg CF ₄ /t Al) / (AE-Mins/cell-day)]	Emission factor for C ₂ F ₆ (F _{C2F6}) [t C ₂ F ₆ / t CF ₄]
Centre Worked Prebake (CWPB)	0,143	0,121
Vertical Stud Söderberg (VSS)	0,092	0,053

Calculation Method B – Overvoltage Method:

Where the anode effect overvoltage is measured, the operator shall use the following equations for the determination of PFC emissions:

$$\text{CF}_4 \text{ emissions [t]} = \text{OVC} \times (\text{AEO/CE}) \times \text{Pr}_{\text{Al}} \times 0,001$$

$$\text{C}_2\text{F}_6 \text{ emissions [t]} = \text{CF}_4 \text{ emissions} \times \text{F}_{\text{CF}_2\text{F}_6}$$

Where:

OVC = Overvoltage coefficient ('emission factor') expressed as kg CF₄ per tonne of aluminium produced per mV overvoltage;

AEO = Anode effect overvoltage per cell [mV] determined as the integral of (time × voltage above the target voltage) divided by the time (duration) of data collection;

CE = Average current efficiency of aluminium production [%];

Pr_{Al} = Annual production of primary Aluminium [t];

F_{CF₂F₆} = Weight fraction of C₂F₆ (t C₂F₆ / t CF₄);

The term AEO/CE (Anode effect overvoltage / current efficiency) expresses the time-integrated average anode effect overvoltage [mV overvoltage] per average current efficiency [%].

Emission factor: The emission factor for CF₄ ('overvoltage coefficient' OVC) shall express the amount [kg] of CF₄ emitted per tonne of aluminium produced per millivolt overvoltage [mV]. The emission factor of C₂F₆ (weight fraction F_{C₂F₆}) shall express the amount [t] of C₂F₆ emitted proportionate to the amount [t] of CF₄ emitted.

Tier 1: The operator shall apply technology-specific emission factors from Table 2 of this section of Annex IV.

Tier 2: The operator shall use installation-specific emission factors for CF₄ [(kg CF₄ / t Al) / (mV)] and C₂F₆ [t C₂F₆/ t CF₄] established through continuous or intermittent field measurements. For the determination of those emission factors, the operator shall use the most recent version of the guidance mentioned under Tier 3 of section 4.4.2.4 of the 2006 IPCC Guidelines. The operator shall determine the emission factors with a maximum uncertainty of ±15% each.

The operator shall determine the emission factors at least every three years or earlier where necessary due to relevant changes at the installation. Relevant changes shall include a change in the distribution of anode effect duration or a change in the control algorithm affecting the mix of the types of anode effects or the nature of the anode effect termination routine.

Table 2: Technology-specific emission factors related to overvoltage activity data.

Technology	Emission factor for CF ₄ [(kg CF ₄ /t Al) / mV]	Emission factor for C ₂ F ₆ [t C ₂ F ₆ / t CF ₄]
Centre Worked Prebake (CWPB)	1,16	0,121
Vertical Stud Söderberg (VSS)	N.A.	0,053

C. Determination of CO_{2(e)} emissions

The operator shall calculate CO_{2(e)} emissions from CF₄ and C₂F₆ emissions as follows, using the global warming potentials listed in Annex VI section 3 Table 6:

$$\text{PFC emissions [t CO}_{2(e)}] = \text{CF}_4 \text{ emissions [t]} * \text{GWP}_{\text{CF}_4} + \text{C}_2\text{F}_6 \text{ emissions [t]} * \text{GWP}_{\text{C}_2\text{F}_6}$$

9. PRODUCTION OF CEMENT CLINKER AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall include at least the following potential sources of CO₂ emissions: calcination of limestone in the raw materials, conventional fossil kiln fuels, alternative fossil-based kiln fuels and raw materials, biomass kiln fuels (biomass wastes), non-kiln fuels, organic carbon content of limestone and shales and raw materials used for waste gas scrubbing.

B. Specific monitoring rules

Emissions from combustion shall be monitored in accordance with section 1 of this Annex. Process emissions from raw meal components shall be monitored in accordance with section 4 of Annex II based on the carbonate content of the process input (calculation Method A) or on the amount of clinker produced (calculation Method B). In case of Method A, carbonates to be taken into account shall at least include CaCO₃, MgCO₃ and FeCO₃. In case of Method B, the operator shall take into account at least CaO and MgO, and shall provide evidence to the competent authority as to which extent further carbon sources have to be taken into account.

CO₂ emissions related to dust removed from the process and organic carbon in the raw materials shall be added in accordance with subsections C and D of this section of Annex IV.

Calculation Method A: Kiln Input Based

Where cement kiln dust (CKD) and bypass dust leave the kiln system the operator shall not consider the related raw material as process input, but calculate emissions from CKD in accordance with subsection C.

Unless the raw meal is characterised, the operator shall apply the uncertainty requirements for activity data separately to each of the relevant carbon-bearing kiln inputs, avoiding double counting or omissions from returned or by-passed materials. Where activity data is determined based on the clinker produced, the net amount of raw meal may be determined by means of a site-specific empirical raw meal/clinker ratio. That ratio shall be updated at least once per year applying industry best practice guidelines.

Calculation Method B: Clinker Output Based

The operator shall determine activity data as the clinker production [t] over the reporting period in one of the following ways:

- (a) by direct weighing of clinker;

- (b) based on cement deliveries, by material balance taking into account dispatch of clinker, clinker supplies as well as clinker stock variation, using the following formula:

$$\text{clinker produced [t]} = ((\text{cement deliveries [t]} - \text{cement stock variation [t]}) * \text{clinker / cement ratio [t clinker / t cement]}) - (\text{clinker supplied [t]}) + (\text{clinker dispatched [t]}) - (\text{clinker stock variation [t]}).$$

The operator shall either derive the clinker / cement ratio for each of the different cement products based on the provisions of Articles 32 to 35 or calculate the ratio from the difference of cement deliveries and stock changes and all materials used as additives to the cement including by-pass dust and cement kiln dust.

By way of derogation from section 4 of Annex II, tier 1 for the emission factor shall be defined as follows:

Tier 1: The operator shall apply an emission factor of 0,525 t CO₂/t clinker.

C. Emissions Related to Discarded Dust

The operator shall add CO₂ emissions, from bypass dust or cement kiln dust (CKD) leaving the kiln system, corrected for a partial calcination ratio of CKD calculated as process emissions in accordance with Article 24(2). By way of derogation from section 4 of Annex II, tiers 1 and 2 for the emission factor shall be defined as follows:

Tier 1: The operator shall apply an emission factor of 0,525 t CO₂/t dust.

Tier 2: The operator shall determine the emission factor (EF) at least once annually following Articles 32 to 35 and using the following formula:

$$EF_{CKD} = \left(\frac{EF_{Cli}}{1 + EF_{Cli}} \cdot d \right) / \left(1 - \frac{EF_{Cli}}{1 + EF_{Cli}} \cdot d \right)$$

Where:

EF_{CKD} = Emission factor of partially calcined cement kiln dust [t CO₂/t CKD];

EF_{Cli} = Installation-specific emission factor of clinker [t CO₂/t clinker];

d = Degree of CKD calcination (released CO₂ as % of total carbonate CO₂ in the raw mix).

Tier 3 for the emission factor is not applicable.

D. Emissions from non-carbonate carbon in raw meal

The operator shall determine the emissions from non-carbonate carbon at least from limestone, shale or alternative raw materials (for example, fly ash) used in the raw meal in the kiln in accordance with Article 24(2).

The following tier definitions for the emission factor shall apply:

Tier 1: The content of non-carbonate carbon in the relevant raw material shall be estimated using industry best practice guidelines.

Tier 2: The content of non-carbonate carbon in the relevant raw material shall be determined at least annually following the provisions of Article 32 to 35.

The following tier definitions for the conversion factor shall apply:

Tier 1: A conversion factor of 1 shall be applied.

Tier 2: The conversion factor shall be calculated applying industry best practice.

10. PRODUCTION OF LIME OR CALCINATION OF DOLOMITE OR MAGNESITE AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall include at least the following potential sources of CO₂ emissions: calcination of limestone, dolomite or magnesite in the raw materials, conventional fossil kiln fuels, alternative fossil-based kiln fuels and raw materials, biomass kiln fuels (biomass wastes) and other fuels.

Where the burnt lime and the CO₂ stemming from the limestone are used for purification processes, such that approximately the same amount of CO₂ is bound again, the decomposition of carbonates as well as the purification process shall not be required to be included separately in the monitoring plan of the installation.

B. Specific monitoring rules

Emissions from combustion shall be monitored in accordance with section 1 of this Annex. Process emissions from raw materials shall be monitored in accordance with section 4 and section 5 of Annex II. Carbonates of calcium and magnesium shall be always taken into account. Other carbonates and organic carbon in the raw material shall be taken into account, whenever they are relevant for emission calculation.

For the input based methodology, carbonate content values shall be adjusted for the respective moisture and gangue content of the material. In the case of magnesia production, other magnesium bearing minerals than carbonates must be taken into account, as appropriate.

Double counting or omissions resulting from returned or by-pass material must be avoided. When applying Method B, lime kiln dust shall be considered a separate source stream where relevant.

11. MANUFACTURE OF GLASS, GLASS FIBRE OR MINERAL WOOL INSULATION MATERIAL AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall apply the provisions in this section also to installations for the production of water glass and stone/rock wool.

The operator shall include at least the following potential sources of CO₂ emissions: decomposition of alkali- and alkali earth carbonates as the result of melting the raw material, conventional fossil fuels, alternative fossil-based fuels and raw materials, biomass fuels (biomass wastes), other fuels, carbon containing additives including coke, coal dust and graphite, post-combustion of flue gases and flue gas scrubbing.

B. Specific monitoring rules

Emissions from combustion, including flue gas scrubbing, shall be monitored in accordance with section 1 of this Annex. Process emissions from raw materials shall be monitored in accordance with section 4 of Annex II. Carbonates to be taken into account include at least CaCO₃, MgCO₃, Na₂CO₃, NaHCO₃, BaCO₃, Li₂CO₃, K₂CO₃, and SrCO₃. Only Method A shall be used. Emissions from other process materials including coke, graphite and coal dust shall be monitored in accordance with section 5 of Annex II.

By way of derogation from section 4 of Annex II, the following tier definitions for the emission factor shall apply:

Tier 1: Stoichiometric ratios as listed in section 2 of Annex VI shall be used. The purity of relevant input materials shall be determined by means of industry best practice.

Tier 2: The determination of the amount of relevant carbonates in each relevant input material shall be carried out in accordance with Articles 32 to 35.

For the conversion factor, only tier 1 shall be applicable.

12. MANUFACTURE OF CERAMIC PRODUCTS AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall include at least the following potential sources of CO₂ emissions: kiln fuels, calcination of limestone/dolomite and other carbonates in the raw material, limestone and other carbonates for reducing air pollutants and other flue gas cleaning, fossil/biomass additives used to induce porosity including polystyrol, residues from paper production or sawdust, fossil organic material in the clay and other raw materials.

B. Specific monitoring rules

Emissions from combustion including flue gas scrubbing shall be monitored in accordance with section 1 of this Annex. Process emissions from raw meal components and additives shall be monitored in accordance with sections 4 and 5 of Annex II. For ceramics based on purified or synthetic clays the operator may use either Method A or Method B. For ceramic products based on unprocessed clays and whenever clays or additives with significant organic content are used, the operator shall use Method A. Carbonates of calcium shall be always taken into account. Other carbonates and organic carbon in the raw material shall be taken into account, where they are relevant for emission calculation.

Activity data for input materials for Method A may be determined by a suitable back-calculation based on industry best practice and approved by the competent authority. Such back-calculation shall take into account what metering is available for dried green products or fired products, and appropriate data sources for moisture of clay and additives and annealing loss (loss on ignition) of the materials involved.

By way of derogation from section 4 of Annex II, the following tier definitions for emission factors for process emissions of raw materials containing carbonates shall apply:

Method A (Input based):

Tier 1: A conservative value of 0,2 tonnes CaCO₃ (corresponding to 0,08794 tonnes of CO₂) per tonne of dry clay shall be applied for the calculation of the emission factor instead of results of analyses. All inorganic and organic carbon in the clay material shall be considered as included in this value. Additives shall be considered as not included in this value.

Tier 2: An emission factor for each source stream shall be derived and updated at least once per year using industry best practice reflecting site-specific conditions and the product mix of the installation.

Tier 3: The determination of the composition of the relevant raw materials shall be carried out in accordance with Articles 32 to 35. Stoichiometric ratios as listed in section 2 of Annex VI shall be used to convert composition data into emission factors, where relevant.

Method B (Output based):

Tier 1: A conservative value of 0,123 tonnes of CaO (corresponding to 0,09642 tonnes of CO₂) per tonne of product shall be applied for the calculation of the emission factor instead of

the results of analyses. All inorganic and organic carbon in the clay material shall be considered as included in this value. Additives shall be considered as not included in this value.

Tier 2: An emission factor shall be derived and updated at least once per year using industry best practice reflecting site-specific conditions and the product mix of the installation.

Tier 3: The determination of the composition of the products shall be carried out in accordance with Articles 32 to 35. Stoichiometric ratios referred to in Annex VI section 2 Table 3 shall be used to convert composition data into emission factors assuming that all of the relevant metal oxides have been derived from respective carbonates, where relevant.

By way of derogation from section 1 of this Annex, for the scrubbing of flue gases the following tier for the emission factor shall apply:

Tier 1: The operator shall apply the stoichiometric ratio of CaCO_3 as shown in section 2 of Annex VI.

For scrubbing, no other tier and no conversion factor shall be used. Double counting from used limestone recycled as raw material in the same installation shall be avoided.

13. PRODUCTION OF GYPSUM PRODUCTS AND PLASTER BOARDS AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall include at least CO_2 emissions from all types of combustion activities.

B. Specific monitoring rules

Emissions from combustion shall be monitored in accordance with section 1 of this Annex.

14. PULP AND PAPER PRODUCTION AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall include at least the following potential sources of CO_2 emissions: boilers, gas turbines, and other combustion devices producing steam or power, recovery boilers and other devices burning spent pulping liquors, incinerators, lime kilns and calciners, waste gas scrubbing and fuel-fired dryers (such as infrared dryers).

B. Specific monitoring rules

The monitoring of emissions from combustion including flue gas scrubbing shall be carried out in accordance with section 1 of this Annex.

Process emissions from raw materials used as make-up chemicals, including at least limestone or soda ash, shall be monitored by Method A in accordance with section 4 of Annex II. CO_2 emissions from the recovery of limestone sludge in pulp production shall be assumed to be recycled biomass CO_2 . Only the amount of CO_2 proportional to the input from make-up chemicals shall be assumed to give rise to fossil CO_2 emissions.

For emissions from make-up chemicals, the following tier definitions for the emission factor shall apply:

Tier 1: Stoichiometric ratios as listed in section 2 of Annex VI shall be used. The purity of relevant input materials shall be determined by means of industry best practice. The derived values shall be adjusted in accordance with the moisture and gangue content of the applied carbonate materials.

Tier 2: The determination of the amount of relevant carbonates in each relevant input material shall be carried out in accordance with Articles 32 to 35. Stoichiometric ratios as listed in section 2 of Annex VI shall be used to convert composition data into emission factors, where relevant.

For the conversion factor, only tier 1 shall be applicable.

15. PRODUCTION OF CARBON BLACK AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall include at least all fuels for combustion and all fuels used as process material as sources for CO₂ emissions.

B. Specific monitoring rules

The monitoring of emissions from carbon black production may be monitored either as a combustion process, including flue gas scrubbing, in accordance with section 1 of this Annex or using a mass balance in accordance with Article 25 and section 3 of Annex II.

16. DETERMINATION OF NITROUS OXIDE (N₂O) EMISSIONS FROM NITRIC ACID, ADIPIC ACID, CAPROLACTAM, GLYOXAL AND GLYOXYLIC ACID PRODUCTION AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

Each operator shall consider for each activity from which N₂O emissions result, all sources emitting N₂O from production processes, including where N₂O emissions from production are channelled through any abatement equipment. This includes any of the following:

- (a) nitric acid production – N₂O emissions from the catalytic oxidation of ammonia and/or from the NO_x/N₂O abatement units;
- (b) adipic acid production – N₂O emissions including from the oxidation reaction, any direct process venting and/or any emissions control equipment;
- (c) glyoxal and glyoxylic acid production – N₂O emissions including from the process reactions, any direct process venting and/or any emissions control equipment;
- (d) caprolactam production – N₂O emissions including from the process reactions, any direct process venting and/or any emissions control equipment.

These provisions shall not apply to any N₂O emissions from the combustion of fuels.

B. Determination of N₂O emissions

B.1. Annual N₂O emissions

The operator shall monitor emissions of N₂O from nitric acid production using continuous emissions measurement. The operator shall monitor emissions of N₂O from adipic acid, caprolactam, glyoxal and glyoxylic acid production using a measurement-based methodology for abated emissions and a calculation-based method (based on a mass balance methodology) for temporary occurrences of unabated emissions.

For each emission source where continuous emissions measurement is applied, the operator shall consider the total annual emissions to be the sum of all hourly emissions using equation 1 given in section 3 of Annex VIII.

B.2. Hourly N₂O emissions

The operator shall calculate annual average hourly N₂O emissions for each source where continuous emission measurement is applied using equation 2 given in section 3 of Annex VIII.

The operator shall determine hourly N₂O concentrations in the flue gas from each emission source using a measurement-based methodology at a representative point, after the NO_x/N₂O abatement equipment, where abatement is used. The operator shall apply techniques capable of measuring N₂O concentrations of all emission sources during both abated and unabated conditions. Where uncertainties increase during such periods, the operator shall take them into account in the uncertainty assessment.

The operator shall adjust all measurements to a dry gas basis where required and report them consistently.

B.3. Determination of flue gas flow

The operator shall use the methods for monitoring flue gas flow set out in Article 43(5) of this Regulation for measuring the flue gas flow for N₂O emissions monitoring. For nitric acid production, the operator shall apply the method in accordance with point (a) of Article 43(5) unless it is technically not feasible. In that case and upon approval by the competent authority, the operator shall apply an alternative method, including by a mass balance methodology based on significant parameters such as ammonia input load, or determination of flow by continuous emissions flow measurement.

The flue gas flow shall be calculated in accordance with the following formula:

$$V_{\text{flue gas flow}} [\text{Nm}^3/\text{h}] = V_{\text{air}} * (1 - O_{2,\text{air}}) / (1 - O_{2,\text{flue gas}})$$

Where:

V_{air} = Total input air flow in Nm³/h at standard conditions;

$O_{2,\text{air}}$ = Volume fraction of O₂ in dry air [= 0,2095];

$O_{2,\text{flue gas}}$ = Volume fraction of O₂ in the flue gas.

The V_{air} shall be calculated as the sum of all air flows entering the nitric acid production unit.

The operator shall apply the following formula, unless stated otherwise in its monitoring plan:

$$V_{\text{air}} = V_{\text{prim}} + V_{\text{sec}} + V_{\text{seal}}$$

Where:

V_{prim} = Primary input air flow in Nm³/h at standard conditions;

V_{sec} = Secondary input air flow in Nm³/h at standard conditions;

V_{seal} = Seal input air flow in Nm³/h at standard conditions.

The operator shall determine V_{prim} by continuous flow measurement before the mixing with ammonia takes place. The operator shall determine V_{sec} by continuous flow measurement, including where the measurement is before the heat recovery unit. For V_{seal} the operator shall consider the purged airflow within the nitric acid production process.

For input air streams accounting for cumulatively less than 2,5% of the total air flow, the competent authority may accept estimation methods for the determination of that air flow rate proposed by the operator based on industry best practices.

The operator shall provide evidence through measurements under normal operating conditions that the flue gas flow measured is sufficiently homogeneous to allow for the proposed measurement method. Where non-homogeneous flow is confirmed through these

measurements, the operator shall take that into account when determining appropriate monitoring methods and when calculating the uncertainty in the N₂O emissions.

The operator shall adjust all measurements to a dry gas basis and report them consistently.

B.4. Oxygen (O₂) concentrations

The operator shall measure the oxygen concentrations in the flue gas where necessary for calculating the flue gas flow in accordance with subsection B.3 of this section of Annex IV. In doing so, the operator shall comply with the requirements for concentration measurements within Article 41(1) and (2). In determining the uncertainty of N₂O emissions, the operator shall take the uncertainty of O₂ concentration measurements into account.

The operator shall adjust all measurements to a dry gas basis where required and report them consistently.

B.5. Calculation of N₂O emissions

For specific periods of unabated emissions of N₂O from adipic acid, caprolactam, glyoxal and glyoxylic acid production, including unabated emissions from venting for safety reasons and when abatement plant fails, and where continuous emissions monitoring of N₂O is technically not feasible, the operator shall subject to the approval of the specific methodology by the competent authority calculate N₂O emissions using a mass balance methodology. For this purpose the overall uncertainty shall be similar to the result of applying the tier requirements of Article 41(1) and (2). The operator shall base the calculation method on the maximum potential emission rate of N₂O from the chemical reaction taking place at the time and the period of the emission.

The operator shall take the uncertainty in any calculated emissions for a specific emission source into account in determining the annual average hourly uncertainty for the emission source.

B.6. Determination of activity production rates

Production rates shall be calculated using daily production reports and hours of operation.

B.7. Sampling rates

Valid hourly averages or averages for shorter reference periods shall be calculated in accordance with Article 44 for:

- (a) concentration of N₂O in the flue gas;
- (b) total flue gas flow where this is measured directly and where required;
- (c) all gas flows and oxygen concentrations necessary to determine the total flue gas flow indirectly.

C. Determination of annual CO₂ equivalent – CO_{2(e)}

The operator shall convert the total annual N₂O emissions from all emissions sources, measured in tonnes to three decimal places, to annual CO_{2(e)} in rounded tonnes, using the following formula and the GWP values in Annex VI section 3:

$$\text{CO}_{2(e)} [\text{t}] = \text{N}_2\text{O}_{\text{annual}}[\text{t}] * \text{GWP}_{\text{N}_2\text{O}}$$

Where:

N₂O_{annual} = total annual N₂O emissions, calculated according to equation 1 given in section 3 of Annex VIII.

The total annual CO_{2(e)} generated by all emission sources and any direct CO₂ emissions from other emission sources included under the greenhouse gas permit shall be added to the total annual CO₂ emissions generated by the installation and shall be used for reporting and surrendering allowances.

Total annual emissions of N₂O shall be reported in tonnes to three decimal places and as CO_{2(e)} in rounded tonnes.

17. PRODUCTION OF AMMONIA AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall include at least the following potential emission sources for CO₂ emissions: combustion of fuels supplying the heat for reforming or partial oxidation, fuels used as process input in the ammonia production process (reforming or partial oxidation), fuels used for other combustion processes including for the purpose of producing hot water or steam.

B. Specific monitoring rules

For monitoring of emissions from combustion processes and from fuels used as process inputs, the standard methodology in accordance with Article 24 and section 1 of this Annex shall be applied.

Where CO₂ from ammonia production is used as feedstock for the production of urea or other chemicals, or transferred out of the installation for any use not covered by Article 49(1), the related amount of CO₂ shall be considered as emitted by the installation producing the CO₂.

18. PRODUCTION OF BULK ORGANIC CHEMICALS AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall take into account at least the following sources of CO₂ emissions: cracking (catalytic and non-catalytic), reforming, partial or full oxidation, similar processes which lead to CO₂ emissions from carbon contained in hydrocarbon based feedstock, combustion of waste gases and flaring, and the burning of fuel in other combustion processes.

B. Specific monitoring rules

Where the production of bulk organic chemicals is technically integrated in a mineral oil refinery, the operator of that installation shall apply the relevant provisions of section 2 of this Annex.

Notwithstanding the first subparagraph, the operator shall monitor emissions from combustion processes where the fuels used do not take part in or stem from chemical reactions for the production of bulk organic chemicals using the standard methodology in accordance with Article 24 and section 1 of this Annex. In all other cases, the operator may choose to monitor the emissions from bulk organic chemicals production by mass balance methodology in accordance with Article 25 or the standard methodology in accordance with Article 24. Where using the standard methodology, the operator shall provide evidence to the competent authority that the chosen methodology covers all relevant emissions that would also be covered by a mass-balance methodology.

For the determination of the carbon content under Tier 1, the reference emission factors as listed in Table 5 in Annex VI shall be applied. For substances not listed in Table 5 of Annex VI or other provisions of this Regulation, the operator shall calculate the carbon content from

the stoichiometric carbon content in the pure substance and the concentration of the substance in the input or output stream.

19. PRODUCTION OF HYDROGEN AND SYNTHESIS GAS AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The operator shall include at least the following potential emission sources for CO₂ emissions: fuels used in the hydrogen or synthesis gas production process (reforming or partial oxidation), and fuels used for other combustion processes including for the purpose of producing hot water or steam. Synthesis gas produced shall be considered as source stream under the mass balance methodology.

B. Specific monitoring rules

For monitoring of emissions from combustion processes and from fuels used as process inputs in hydrogen production, the standard methodology in accordance with Article 24 and section 1 of this Annex shall be used.

For the monitoring of emissions from the production of synthesis gas, a mass balance in accordance with Article 25 shall be used. For emissions from separate combustion processes, the operator may choose to include them in the mass balance or to use the standard methodology in accordance with Article 24 at least for a part of the source streams, avoiding any gaps or double counting of emissions.

Where hydrogen and synthesis gas are produced at the same installation, the operator shall calculate CO₂ emissions using either separate methodologies for hydrogen and for synthesis gas as outlined in the first two paragraphs of this subsection, or using one common mass balance.

20. PRODUCTION OF SODA ASH AND SODIUM BICARBONATE AS LISTED IN ANNEX I TO DIRECTIVE 2003/87/EC

A. Scope

The emission sources and source streams for CO₂ emissions from installations for the production of soda ash and sodium bicarbonate shall include:

- (a) fuels used for combustion processes, including fuels used for the purpose of producing hot water or steam;
- (b) raw materials, including vent gas from calcination of limestone, to the extent it is not used for carbonation;
- (c) waste gases from washing or filtration steps after carbonation, to the extent it is not used for carbonation.

B. Specific monitoring rules

For the monitoring of emissions from the production of soda ash and sodium bicarbonate, the operator shall use a mass balance in accordance with Article 25. For emissions from combustion processes, the operator may choose to include them in the mass balance or to use the standard methodology in accordance with Article 24 at least for a part of the source streams, avoiding any gaps or double counting of emissions.

Where CO₂ from the production of soda ash is used for the production of sodium bicarbonate, the amount of CO₂ used for producing sodium bicarbonate from soda ash shall be considered as emitted by the installation producing the CO₂.

21. DETERMINATION OF GREENHOUSE GAS EMISSIONS FROM CO₂ CAPTURE ACTIVITIES FOR THE PURPOSES OF TRANSPORT AND GEOLOGICAL STORAGE IN A STORAGE SITE PERMITTED UNDER DIRECTIVE 2009/31/EC

A. Scope

CO₂ capture shall be performed either by a dedicated installation receiving CO₂ by transfer from one or more other installations, or by the same installation carrying out the activities producing the captured CO₂ under the same greenhouse gas emissions permit. All parts of the installation related to CO₂ capture, intermediate storage, transfer to a CO₂ transport network or to a site for geological storage of CO₂ greenhouse gas emissions shall be included in the greenhouse gas emissions permit and accounted for in the associated monitoring plan. In the case of the installation carrying out other activities covered by Directive 2003/87/EC, the emissions of those activities shall be monitored in accordance with the other relevant sections of this Annex.

The operator of a CO₂ capture activity shall at least include the following potential sources of CO₂ emission:

- (a) CO₂ transferred to the capture installation;
- (b) combustion and other associated activities at the installation that are related to the capture activity, including fuel and input material use.

B. Quantification of transferred and emitted CO₂ amounts

B.1. Installation level quantification

Each operator shall calculate the emissions by taking into account the potential CO₂ emissions from all emission relevant processes at the installation, as well as the amount of CO₂ captured and transferred to the transport network, using the following formula:

$$E_{\text{capture installation}} = T_{\text{input}} + E_{\text{without capture}} - T_{\text{for storage}}$$

Where:

$E_{\text{capture installation}}$ = Total greenhouse gas emissions of the capture installation;

T_{input} = Amount of CO₂ transferred to the capture installation, determined in accordance with Article 40 to 46 and Article 49.

$E_{\text{without capture}}$ = Emissions of the installation assuming the CO₂ were not captured, meaning the sum of the emissions from all other activities at the installation, monitored in accordance with relevant sections of Annex IV;

$T_{\text{for storage}}$ = Amount of CO₂ transferred to a transport network or a storage site, determined in accordance with Article 40 to 46 and Article 49.

In cases where CO₂ capture is carried out by the same installation as the one from which the captured CO₂ originates, the operator shall use zero for T_{input} .

In cases of stand-alone capture installations, the operator shall consider $E_{\text{without capture}}$ to represent the amount of emissions that occur from other sources than the CO₂ transferred to the installation for capture. The operator shall determine those emissions in accordance with this Regulation.

In the case of stand-alone capture installations, the operator of the installation transferring CO₂ to the capture installation shall deduct the amount T_{input} from the emissions of its installation in accordance with Article 49.

B.2. Determination of transferred CO₂

Each operator shall determine the amount of CO₂ transferred from and to the capture installation in accordance with Article 49 by means of measurement methodologies carried out in accordance with Articles 40 to 46.

Only where the operator of the installation transferring CO₂ to the capture installation demonstrates to the satisfaction of the competent authority that CO₂ transferred to the capture installation is transferred in total and to at least equivalent accuracy, may the competent authority allow that operator to use a calculation-based methodology in accordance with Article 24 or 25 to determine the amount T_{input} instead of a measurement-based methodology in accordance with Article 40 to 46 and Article 49.

22. DETERMINATION OF GREENHOUSE GAS EMISSIONS FROM THE TRANSPORT OF CO₂ BY PIPELINES FOR GEOLOGICAL STORAGE IN A STORAGE SITE PERMITTED UNDER DIRECTIVE 2009/31/EC

A. Scope

The boundaries for monitoring and reporting emissions from CO₂ transport by pipeline shall be laid down in the transport network's greenhouse gas emissions permit, including all ancillary plant functionally connected to the transport network, including booster stations and heaters. Each transport network shall have a minimum of one start point and one end point, each connected to other installations carrying out one or more of the activities: capture, transport or geological storage of CO₂. Start and end points may include bifurcations of the transport network and cross national borders. Start and end points as well as the installations they are connecting to, shall be laid down in the greenhouse gas emissions permit.

Each operator shall consider at least the following potential emission sources for CO₂ emissions: combustion and other processes at installations functionally connected to the transport network including booster stations; fugitive emissions from the transport network; vented emissions from the transport network; and emissions from leakage incidents in the transport network.

B. Quantification Methodologies for CO₂

The operator of transport networks shall determine emissions using one of the following methods:

- (a) Method A (overall mass balance of all input and output streams) set out in subsection B.1;
- (b) Method B (monitoring of emission sources individually) set out in subsection B.2.

In choosing either Method A or Method B, each operator shall demonstrate to the competent authority that the chosen methodology will lead to more reliable results with lower uncertainty of the overall emissions, using best available technology and knowledge at the time of the application for the greenhouse gas emissions permit and approval of the monitoring plan, without incurring unreasonable costs. Where Method B is chosen each operator shall demonstrate to the satisfaction of the competent authority that the overall uncertainty for the annual level of greenhouse gas emissions for the operator's transport network does not exceed 7,5 %.

The operator of a transport network using Method B shall not add CO₂ received from another installation permitted in accordance with Directive 2003/87/EC to its calculated level of emissions, and shall not subtract from its calculated level of emissions any CO₂ transferred to another installation permitted in accordance with Directive 2003/87/EC.

Each operator of a transport network shall use Method A for the validation of the results of Method B at least once annually. For that validation, the operator may use lower tiers for the application of Method A.

B.1. Method A

Each operator shall determine emissions in accordance with the following formula:

$$Emissions [t CO_2] = E_{own activity} + \sum_i T_{IN,i} - \sum_i T_{OUT,i}$$

Where:

Emissions = Total CO₂ emissions of the transport network [t CO₂];

$E_{own activity}$ = Emissions from the transport network's own activity, meaning not emissions stemming from the CO₂ transported, but including emissions from fuel used in booster stations, monitored in accordance with the relevant sections of Annex IV;

$T_{IN,i}$ = Amount of CO₂ transferred to the transport network at entry point i , determined in accordance with Articles 40 to 46 and Article 49.

$T_{OUT,i}$ = Amount of CO₂ transferred out of the transport network at exit point i , determined in accordance with Articles 40 to 46 and Article 49.

B.2. Method B

Each operator shall determine emissions considering all processes relevant to emissions at the installation as well as the amount of CO₂ captured and transferred to the transport facility using the following formula:

$$Emissions [t CO_2] = CO_2 \text{ fugitive} + CO_2 \text{ vented} + CO_2 \text{ leakage events} + CO_2 \text{ installations}$$

Where:

Emissions = Total CO₂ emissions of the transport network [t CO₂];

$CO_2 \text{ fugitive}$ = Amount of fugitive emissions [t CO₂] from CO₂ transported in the transport network, including from seals, valves, intermediate compressor stations and intermediate storage facilities;

$CO_2 \text{ vented}$ = Amount of vented emissions [t CO₂] from CO₂ transported in the transport network;

$CO_2 \text{ leakage events}$ = Amount of CO₂ [t CO₂] transported in the transport network, which is emitted as the result of the failure of one or more components of the transport network;

$CO_2 \text{ installations}$ = Amount of CO₂ [t CO₂] being emitted from combustion or other processes functionally connected to the pipeline transport in the transport network, monitored in accordance with the relevant sections of Annex IV.

B.2.1. Fugitive emissions from the transport network

The operator shall consider fugitive emissions from any of the following types of equipment:

- (a) seals;
- (b) measurement devices;

- (c) valves;
- (d) intermediate compressor stations;
- (e) intermediate storage facilities.

The operator shall determine average emission factors EF (expressed in g CO₂/unit time) per piece of equipment per occurrence where fugitive emissions can be anticipated at the beginning of operation, and by the end of the first reporting year in which the transport network is in operation at the latest. The operator shall review those factors at least every 5 years in the light of the best available techniques and knowledge.

The operator shall calculate fugitive emissions by multiplying the number of pieces of equipment in each category by the emission factor and adding up the results for the single categories as shown in the following equation:

$$Fugitive\ Em\ [t\ CO_2] = \left(\sum_{Category} EF[g\ CO_2/occurrence] \cdot N_{occurrence} \right) / 10^6$$

The number of occurrences ($N_{occurrence}$) shall be the number of pieces of the given equipment per category, multiplied by the number of time units per year.

B.2.2. Emissions from leakage events

The operator of a transport network shall provide evidence of the network integrity by using representative (spatial and time-related) temperature and pressure data. Where the data indicates that a leakage has occurred, the operator shall calculate the amount of CO₂ leaked with a suitable methodology documented in the monitoring plan, based on industry best practice guidelines, including by use of the differences in temperature and pressure data compared to integrity related average pressure and temperature values.

B.2.3. Vented emissions

Each operator shall provide in the monitoring plan an analysis regarding potential situations of venting emissions, including for maintenance or emergency reasons, and provide a suitable documented methodology for calculating the amount of CO₂ vented, based on industry best practice guidelines.

23. GEOLOGICAL STORAGE OF CO₂ IN A STORAGE SITE PERMITTED UNDER DIRECTIVE 2009/31/EC

A. Scope

The competent authority shall base the boundaries for monitoring and reporting of emissions from geological storage of CO₂ on the delimitation of the storage site and storage complex as specified in the permit pursuant to Directive 2009/31/EC. Where leakages from the storage complex are identified and lead to emissions or release of CO₂ into the water column, the operator shall immediately carry out all of the following:

- (a) notify the competent authority;
- (b) include the leakage as an emission source for the respective installation;
- (c) monitor and report the emissions.

Only when corrective measures in accordance with Article 16 of Directive 2009/31/EC have been taken and emissions or release into the water column from that leakage can no longer be

detected shall the operator delete the respective leakage as emission source from the monitoring plan and no longer monitor and report those emissions.

Each operator of a geological storage activity shall consider at least the following potential emission sources for CO₂ overall: fuel use by associated booster stations and other combustion activities including on-site power plants; venting from injection or enhanced hydrocarbon recovery operations; fugitive emissions from injection; breakthrough CO₂ from enhanced hydrocarbon recovery operations; and leakages.

B. Quantification of CO₂ emissions

The operator of the geological storage activity shall not add CO₂ received from another installation to its calculated level of emissions, and shall not subtract from its calculated level of emissions any CO₂ which is geologically stored in the storage site or which is transferred to another installation.

B.1. Vented and fugitive emissions from injection

The operator shall determine emissions from venting and fugitive emissions as follows:

$$\text{CO}_2 \text{ emitted [t CO}_2\text{]} = V \text{ CO}_2 \text{ [t CO}_2\text{]} + F \text{ CO}_2 \text{ [t CO}_2\text{]}$$

Where:

V CO₂ = amount of CO₂ vented;

F CO₂ = amount of CO₂ from fugitive emissions.

Each operator shall determine V CO₂ using measurement-based methodologies in accordance with Articles 41 to 46 of this Regulation. By way of derogation from the first sentence and upon approval by the competent authority, the operator may include in the monitoring plan an appropriate methodology for determining V CO₂ based on industry best practice, where the application of measurement-based methodologies would incur unreasonable costs.

The operator shall consider F CO₂ as one source, meaning that the uncertainty requirements associated with the tiers in accordance with section 1 of Annex VIII are applied to the total value instead of the individual emission points. Each operator shall provide in the monitoring plan an analysis regarding potential sources of fugitive emissions, and provide a suitable documented methodology to calculate or measure the amount of F CO₂, based on industry best practice guidelines. For the determination of F CO₂ the operator may use data collected in accordance with Article 32 to 35 and Annex II(1.1)(e) to (h) of Directive 2009/31/EC for the injection facility, where they comply with the requirements of this Regulation.

B.2. Vented and fugitive emissions from enhanced hydrocarbon recovery operations

Each operator shall consider the following potential additional emission sources from enhanced hydrocarbon recovery (EHR):

- (a) the oil-gas separation units and gas recycling plant, where fugitive emissions of CO₂ could occur;
- (b) the flare stack, where emissions might occur due to the application of continuous positive purge systems and during depressurisation of the hydrocarbon production installation;
- (c) the CO₂ purge system, to avoid high concentrations of CO₂ extinguishing the flare.

Each operator shall determine fugitive emissions or vented CO₂ in accordance with subsection B.1 of this section of Annex IV.

Each operator shall determine emissions from the flare stack in accordance with subsection D of section 1 of this Annex, taking into account potential inherent CO₂ in the flare gas in accordance with Article 48.

B.3. Leakage from the storage complex

Emissions and release to the water column shall be quantified as follows:

$$CO_2\text{emitted [t CO}_2\text{]} = \sum_{T_{Start}}^{T_{End}} L\text{ CO}_2[\text{t CO}_2/\text{d}]$$

Where:

L CO₂ = the mass of CO₂ emitted or released per calendar day due to the leakage in accordance with all of the following:

- for each calendar day for which leakage is monitored, each operator shall calculate L CO₂ as the average of the mass leaked per hour [t CO₂/h] multiplied by 24;
- each operator shall determine the mass leaked per hour in accordance with the provisions in the approved monitoring plan for the storage site and the leakage;
- for each calendar day prior to commencement of monitoring, the operator shall take the mass leaked per day to equal the mass leaked per day for the first day of monitoring ensuring no under-estimation occurs;

T_{start} = the latest of:

- the last date when no emissions or release of CO₂ into the water column from the source under consideration were reported;
- the date the CO₂ injection started;
- another date such that there is evidence demonstrating to the satisfaction of the competent authority that the emission or release into the water column cannot have started before that date.

T_{end} = the date by which corrective measures in accordance with Article 16 of Directive 2009/31/EC have been taken and emissions or release of CO₂ into the water column can no longer be detected.

The competent authority shall approve and allow the use of other methods for the quantification of emissions or release of CO₂ into the water column from leakages where the operator can show to the satisfaction of the competent authority that such methods lead to a higher accuracy than the methodology set out in this subsection.

The operator shall quantify the amount of emissions leaked from the storage complex for each of the leakage events with a maximum overall uncertainty over the reporting period of 7,5 %. Where the overall uncertainty of the applied quantification methodology exceeds 7,5 %, each operator shall apply an adjustment, as follows:

$$CO_{2,Reported} [\text{t CO}_2] = CO_{2,Quantified} [\text{t CO}_2] * (1 + (Uncertainty_{System} [\%]/100) - 0,075)$$

Where:

CO_{2,Reported} = the amount of CO₂ to be included in the annual emission report with regards to the leakage event in question;

$CO_{2,Quantified}$ = the amount of CO_2 determined through the used quantification methodology for the leakage event in question;

$Uncertainty_{System}$ = the level of uncertainty associated with the quantification methodology used for the leakage event in question.

ANNEX V

Minimum tier requirements for calculation-based methodologies involving category A installations and calculation factors for commercial standard fuels used by category B and C installations (Article 26(1))

Table 1

Minimum tiers to be applied for calculation-based methodologies in the case of category A installations and in the case of calculation factors for commercial standard fuels for all installations in accordance with point (a) of Article 26(1); ('n.a.' means 'not applicable')

Activity/Source stream type	Activity data		Emission factor (*)	Composition data (carbon content) (*)	Oxidation factor	Conversion factor
	Amount of fuel or material	Net calorific value				
Combustion of fuels						
Commercial standard fuels	2	2a/2b	2a/2b	n.a.	1	n.a.
Other gaseous and liquid fuels	2	2a/2b	2a/2b	n.a.	1	n.a.
Solid fuels	1	2a/2b	2a/2b	n.a.	1	n.a.
Mass balance methodology for Gas Processing Terminals	1	n.a.	n.a.	1	n.a.	n.a.
Flares	1	n.a.	1	n.a.	1	n.a.
Scrubbing (carbonate)	1	n.a.	1	n.a.	n.a.	1
Scrubbing (gypsum)	1	n.a.	1	n.a.	n.a.	1
Scrubbing (urea)	1	1	1	n.a.	1	n.a.
Refining of mineral oil						
Catalytic cracker regeneration	1	n.a.	n.a.	n.a.	n.a.	n.a.
Production of coke						
Mass balance	1	n.a.	n.a.	2	n.a.	n.a.
Fuel as process input	1	2	2	n.a.	n.a.	n.a.
Metal ore roasting and sintering						
Mass balance	1	n.a.	n.a.	2	n.a.	n.a.
Carbonate input	1	n.a.	1	n.a.	n.a.	1
Production of iron and steel						
Mass balance	1	n.a.	n.a.	2	n.a.	n.a.
Fuel as process input	1	2a/2b	2	n.a.	n.a.	n.a.
Production or processing of ferrous and non-ferrous metals, including secondary aluminium						
Mass balance	1	n.a.	n.a.	2	n.a.	n.a.
Process emissions	1	n.a.	1	n.a.	n.a.	1
Primary aluminium production						
Mass balance for CO ₂ emissions	1	n.a.	n.a.	2	n.a.	n.a.
PFC emissions (slope method)	1	n.a.	1	n.a.	n.a.	n.a.

Activity/Source stream type	Activity data		Emission factor (*)	Composition data (carbon content) (*)	Oxidation factor	Conversion factor
	Amount of fuel or material	Net calorific value				
PFC emissions (overtoltage method)	1	n.a.	1	n.a.	n.a.	n.a.
Production of cement clinker						
Kiln input based (Method A)	1	n.a.	1	n.a.	n.a.	1
Clinker output (Method B)	1	n.a.	1	n.a.	n.a.	1
CKD	1	n.a.	1	n.a.	n.a.	n.a.
Non-carbonate carbon input	1	n.a.	1	n.a.	n.a.	1
Production of lime and calcination of dolomite and magnesite						
Carbonates (Method A)	1	n.a.	1	n.a.	n.a.	1
Other process inputs	1	n.a.	1	n.a.	n.a.	1
Alkali earth oxide (Method B)	1	n.a.	1	n.a.	n.a.	1
Manufacture of glass and mineral wool						
Carbonate inputs	1	n.a.	1	n.a.	n.a.	n.a.
Other process inputs	1	n.a.	1	n.a.	n.a.	1
Manufacture of ceramic products						
Carbon inputs (Method A)	1	n.a.	1	n.a.	n.a.	1
Other process inputs	1	n.a.	1	n.a.	n.a.	1
Alkali oxide (Method B)	1	n.a.	1	n.a.	n.a.	1
Scrubbing	1	n.a.	1	n.a.	n.a.	n.a.
Production of gypsum and plasterboard: see combustion of fuels						
Production of pulp and paper						
Make up chemicals	1	n.a.	1	n.a.	n.a.	n.a.
Production of carbon black						
Mass balance methodology	1	n.a.	n.a.	1	n.a.	n.a.
Production of ammonia						
Fuel as process input	2	2a/2b	2a/2b	n.a.	n.a.	n.a.
Production of bulk organic chemicals						
Mass balance	1	n.a.	n.a.	2	n.a.	n.a.
Production of hydrogen and synthesis gas						
Fuel as process input	2	2a/2b	2a/2b	n.a.	n.a.	n.a.
Mass balance	1	n.a.	n.a.	2	n.a.	n.a.
Production of soda ash and sodium bicarbonate						
Mass balance	1	n.a.	n.a.	2	n.a.	n.a.

(*) Tiers for the emission factor relate to the preliminary emission factor, and carbon content relates to the total carbon content. For mixed materials, the biomass fraction

must be determined separately. Tier 1 shall be the minimum tier to be applied for the biomass fraction in the case of category A installations and in the case of commercial standard fuels for all installations in accordance with point (a) of Article 26(1).

ANNEX VI

Reference values for calculation factors (Article 31(1)(a))

1. FUEL EMISSION FACTORS RELATED TO NET CALORIFIC VALUES (NCV)

Table 1: Fuel emission factors related to net calorific value (NCV) and net calorific values per mass of fuel.

Fuel type description	Emission factor (t CO ₂ /TJ)	Net calorific value (TJ/Gg)	Source
Crude oil	73,3	42,3	IPCC 2006 GL
Orimulsion	77,0	27,5	IPCC 2006 GL
Natural gas liquids	64,2	44,2	IPCC 2006 GL
Motor gasoline	69,3	44,3	IPCC 2006 GL
Kerosene (other than jet kerosene)	71,9	43,8	IPCC 2006 GL
Shale oil	73,3	38,1	IPCC 2006 GL
Gas/Diesel oil	74,1	43,0	IPCC 2006 GL
Residual fuel oil	77,4	40,4	IPCC 2006 GL
Liquefied petroleum gases	63,1	47,3	IPCC 2006 GL
Ethane	61,6	46,4	IPCC 2006 GL
Naphtha	73,3	44,5	IPCC 2006 GL
Bitumen	80,7	40,2	IPCC 2006 GL
Lubricants	73,3	40,2	IPCC 2006 GL
Petroleum coke	97,5	32,5	IPCC 2006 GL
Refinery feedstocks	73,3	43,0	IPCC 2006 GL
Refinery gas	57,6	49,5	IPCC 2006 GL
Paraffin waxes	73,3	40,2	IPCC 2006 GL
White spirit and SBP	73,3	40,2	IPCC 2006 GL
Other petroleum products	73,3	40,2	IPCC 2006 GL
Anthracite	98,3	26,7	IPCC 2006 GL
Coking coal	94,6	28,2	IPCC 2006 GL
Other bituminous coal	94,6	25,8	IPCC 2006 GL
Sub-bituminous coal	96,1	18,9	IPCC 2006 GL
Lignite	101,0	11,9	IPCC 2006 GL
Oil shale and tar sands	107,0	8,9	IPCC 2006 GL
Patent fuel	97,5	20,7	IPCC 2006 GL
Coke oven coke and lignite coke	107,0	28,2	IPCC 2006 GL
Gas coke	107,0	28,2	IPCC 2006 GL
Coal tar	80,7	28,0	IPCC 2006 GL
Gas works gas	44,4	38,7	IPCC 2006 GL

Fuel type description	Emission factor (t CO ₂ /TJ)	Net calorific value (TJ/Gg)	Source
Coke oven gas	44,4	38,7	IPCC 2006 GL
Blast furnace gas	260	2,47	IPCC 2006 GL
Oxygen steel furnace gas	182	7,06	IPCC 2006 GL
Natural gas	56,1	48,0	IPCC 2006 GL
Industrial wastes	143	n.a.	IPCC 2006 GL
Waste oils	73,3	40,2	IPCC 2006 GL
Peat	106,0	9,76	IPCC 2006 GL
Wood/wood waste	-	15,6	IPCC 2006 GL
Other primary solid biomass	-	11,6	IPCC 2006 GL (only NCV)
Charcoal	-	29,5	IPCC 2006 GL (only NCV)
Biogasoline	-	27,0	IPCC 2006 GL (only NCV)
Biodiesels	-	27,0	IPCC 2006 GL (only NCV)
Other liquid biofuels	-	27,4	IPCC 2006 GL (only NCV)
Landfill gas	-	50,4	IPCC 2006 GL (only NCV)
Sludge gas	-	50,4	IPCC 2006 GL (only NCV)
Other biogas	-	50,4	IPCC 2006 GL (only NCV)
Waste tyres	85,0 ⁽¹⁾	n.a.	WBCSD CSI
Carbon monoxide	155,2 ⁽²⁾	10,1	J. Falbe and M. Regitz, Römpf Chemie Lexikon, Stuttgart, 1995
Methane	54,9 ⁽³⁾	50,0	J. Falbe and M. Regitz, Römpf Chemie Lexikon, Stuttgart, 1995

⁽¹⁾ This value is the preliminary emission factor, i.e. before application of a biomass fraction, if applicable.

⁽²⁾ Based on NCV of 10,12 TJ/t

⁽³⁾ Based on NCV of 50,01 TJ/t

2. EMISSION FACTORS RELATED TO PROCESS EMISSIONS

Table 2: Stoichiometric emission factor for process emissions from carbonate decomposition (Method A)

Carbonate	Emission factor [t CO ₂ / t Carbonate]
CaCO ₃	0,440
MgCO ₃	0,522

Carbonate	Emission factor [t CO ₂ / t Carbonate]
Na ₂ CO ₃	0,415
BaCO ₃	0,223
Li ₂ CO ₃	0,596
K ₂ CO ₃	0,318
SrCO ₃	0,298
NaHCO ₃	0,524
FeCO ₃	0,380
General	Emission factor = $[M(\text{CO}_2)] / \{ Y * [M(x)] + Z * [M(\text{CO}_3^{2-})] \}$ X = metal M(x) = molecular weight of X in [g/mol] M(CO ₂) = molecular weight of CO ₂ in [g/mol] M(CO ₃ ²⁻) = molecular weight of CO ₃ ²⁻ in [g/mol] Y = stoichiometric number of X Z = stoichiometric number of CO ₃ ²⁻

Table 3: Stoichiometric emission factor for process emissions from carbonate decomposition based on alkali earth oxides (Method B)

Oxide	Emission factor [t CO ₂ / t Oxide]
CaO	0,785
MgO	1,092
BaO	0,287
general: X _Y O _Z	Emission factor = $[M(\text{CO}_2)] / \{ Y * [M(x)] + Z * [M(\text{O})] \}$ X = alkali earth or alkali metal M(x) = molecular weight of X in [g/mol] M(CO ₂) = molecular weight of CO ₂ [g/mol] M(O) = molecular weight of O [g/mol] Y = stoichiometric number of X = 1 (for alkali earth metals) = 2 (for alkali metals) Z = stoichiometric number of O = 1

Table 4: Emission factors for process emissions from other process materials (production of iron and steel, and processing of ferrous metals) ⁽³⁾

Input or output material	Carbon content (t C/t)	Emission factor (t CO ₂ /t)
Direct reduced iron (DRI)	0,0191	0,07
EAF carbon electrodes	0,8188	3,00

³ IPCC 2006 Guidelines for National Greenhouse Gas Inventories

Input or output material	Carbon content (t C/t)	Emission factor (t CO ₂ /t)
EAF charge carbon	0,8297	3,04
Hot briquetted iron	0,0191	0,07
Oxygen steel furnace gas	0,3493	1,28
Petroleum coke	0,8706	3,19
Pig iron	0,0409	0,15
Iron / iron scrap	0,0409	0,15
Steel / steel scrap	0,0109	0,04

Table 5: Stoichiometric emission factors for process emissions from other process materials (Bulk organic chemicals) ⁽⁴⁾

Substance	Carbon content (t C/t)	Emission factor (t CO ₂ / t)
Acetonitril	0,5852	2,144
Acrylonitrile	0,6664	2,442
Butadiene	0,888	3,254
Carbon black	0,97	3,554
Ethylene	0,856	3,136
Ethylene dichloride	0,245	0,898
Ethylene glycol	0,387	1,418
Ethylene oxide	0,545	1,997
Hydrogen cyanide	0,4444	1,628
Methanol	0,375	1,374
Methane	0,749	2,744
Propane	0,817	2,993
Propylene	0,8563	3,137
Vinyl chloride monomer	0,384	1,407

3. GLOBAL WARMING POTENTIALS FOR NON-CO₂ GREENHOUSE GASES

Table 6: Global warming potentials

Gas	Global warming potential
N ₂ O	298 t CO _{2(e)} / t N ₂ O
CF ₄	7 390 t CO _{2(e)} / t CF ₄
C ₂ F ₆	12 200 t CO _{2(e)} / t C ₂ F ₆

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ANNEX VII

Minimum frequency of analyses (Article 35)

Fuel/material	Minimum frequency of analyses
Natural gas	At least weekly
Other gases, in particular synthesis gas and process gases such as refinery mixed gas, coke oven gas, blast-furnace gas, convertor gas, oilfield and gasfield gas	At least daily — using appropriate procedures at different parts of the day
Fuel oils (for example light, medium, heavy fuel oil, bitumen)	Every 20 000 tonnes of fuel and at least six times a year
Coal, coking coal, coke, petroleum coke, peat	Every 20 000 tonnes of fuel/material and at least six times a year
Other fuels	Every 10 000 tonnes of fuel and at least four times a year
Untreated solid waste (pure fossil or mixed biomass/fossil)	Every 5 000 tonnes of waste and at least four times a year
Liquid waste, pre-treated solid waste	Every 10 000 tonnes of waste and at least four times a year
Carbonate minerals (including limestone and dolomite)	Every 50 000 tonnes of material and at least four times a year
Clays and shales	Amounts of material corresponding to 50 000 tonnes of CO ₂ and at least four times a year
Other materials (primary, intermediate and final product)	Depending on the type of material and the variation, amounts of material corresponding to 50 000 tonnes of CO ₂ and at least four times a year

ANNEX VIII

Measurement-based methodologies (Article 41)

1. TIER DEFINITIONS FOR MEASUREMENT-BASED METHODOLOGIES

Measurement-based methodologies shall be approved in accordance with tiers with the following maximum permissible uncertainties for the annual average hourly emissions calculated in accordance with Equation 2 set out in section 3 of this Annex.

Table 1

Tiers for CEMS (maximum permissible uncertainty for each tier)

In case of CO₂, the uncertainty is to be applied to the total amount of CO₂ measured. Where the biomass fraction is determined using a measurement based methodology, the same tier definition as for CO₂ shall be applied to the biomass fraction.

	Tier 1	Tier 2	Tier 3	Tier 4
CO ₂ emission sources	± 10 %	± 7,5 %	± 5 %	± 2,5 %
N ₂ O emission sources	± 10 %	± 7,5 %	± 5 %	N.A.
CO ₂ transfer	± 10 %	± 7,5 %	± 5 %	± 2,5 %

2. MINIMUM TIER REQUIREMENTS FOR CATEGORY A INSTALLATIONS

Table 2

Minimum tiers to be applied by category A installations for measurement-based methodologies in accordance with point (a) of Article 41(1)

Greenhouse gas	Minimum tier level required
CO ₂	2
N ₂ O	2

3. DETERMINATION OF GHGS USING MEASUREMENT-BASED METHODOLOGIES

Equation 1: Calculation of annual emissions in accordance with Article 43(1):

$$GHG\ Em_{total} [t] = \sum_{i=1}^{HoursOp} GHG\ conc_{hourly,i} \cdot V_{hourly,i} \cdot 10^{-6} [t/g]$$

Equation 2: Determination of average hourly emissions:

$$GHG\ Em_{average} [kg/h] = \frac{GHG\ Em_{total}}{HoursOp} \cdot 10^3 [kg/t]$$

Equation 2a: Determination of average hourly GHG concentration for the purpose of reporting in accordance with point 9(b) of Annex X, section 1:

$$GHG\ conc_{average} [g/Nm^3] = \frac{GHG\ Em_{total}}{\sum_{i=1}^{HoursOp} V_{hourly,i}} \cdot 10^6 [g/t]$$

Equation 2b: Determination of average hourly flue gas flow for the purpose of reporting in accordance with point 9(b) of Annex X, section 1:

$$Flow_{average} [Nm^3/h] = \frac{\sum_{i=1}^{HoursOp} V_{hourly,i}}{HoursOp}$$

Equation 2c: Calculation of annual emissions for the purpose of the annual emission report in accordance with point 9(b) of Annex X, section 1:

$$GHG\ Em_{total} [t] = GHG\ conc_{average} \cdot Flow_{average} \cdot HoursOp \cdot 10^{-6} [t/g]$$

The following abbreviations are used in Equations 1 to 2c:

The index *i* refers to the individual operating hour. Where an operator uses shorter reference periods in accordance with Article 44(1), that reference period shall be used instead of hours for these calculations.

GHG Em_{total} = total annual GHG emissions in tonnes

GHG conc_{hourly, i} = hourly concentrations of GHG emissions in g/Nm³ in the flue gas flow measured during operation for hour *i*;

V_{hourly, i} = flue gas volume in Nm³ for hour *i* (*i.e. integrated flow over the hour or shorter reference period*);

GHG Em_{average} = annual average hourly emissions in kg/h from the source;

HoursOp = total number of hours for which the measurement-based methodology is applied, including the hours for which data has been substituted in accordance with Article 45(2) to (4);

GHG conc_{average} = annual average hourly concentrations of GHG emissions in g/Nm³;

Flow_{average} = annual average flue gas flow in Nm³/h.

4. CALCULATION OF THE CONCENTRATION USING INDIRECT CONCENTRATION MEASUREMENT

Equation 3: Calculation of the concentration

5.

$$GHG\ concentration\ [\%] = 100\% - \sum_i Concentration\ of\ component\ i\ [\%]$$

SUBSTITUTION FOR MISSING CONCENTRATION DATA FOR MEASUREMENT-BASED METHODOLOGIES

Equation 4: Substitution for missing data for measurement-based methodologies

$$C_{subst}^* = \bar{C} + 2\sigma c_-$$

Where:

\bar{C} = the arithmetic mean of the concentration of the specific parameter over the whole reporting period or, where specific circumstances applied when data loss occurred, an appropriate period reflecting the specific circumstances;

$\sigma_{C_{-}}$ = the best estimate of the standard deviation of the concentration of the specific parameter over the whole reporting or, where specific circumstances applied when data loss occurred, an appropriate period reflecting the specific circumstances.

ANNEX IX

Minimum data and information to be retained in accordance with Article 67(1)

Operators and aircraft operators shall retain at least the following:

1. COMMON ELEMENTS FOR INSTALLATIONS AND AIRCRAFT OPERATORS

- (1) The monitoring plan approved by the competent authority;
- (2) Documents justifying the selection of the monitoring methodology and the documents justifying temporal or non-temporal changes of monitoring methodologies and, where applicable, tiers approved by the competent authority;
- (3) All relevant updates of monitoring plans notified to the competent authority in accordance with Article 15, and the competent authority's replies;
- (4) All written procedures referred to in the monitoring plan, including the sampling plan where relevant, the procedures for data flow activities and the procedures for control activities;
- (5) A list of all versions used of the monitoring plan and all related procedures;
- (6) Documentation of the responsibilities in connection to the monitoring and reporting;
- (7) The risk assessment performed by the operator or aircraft operator, where applicable;
- (8) The improvement reports in accordance with Article 69;
- (9) The verified annual emission report;
- (10) The verification report;
- (11) Any other information that is identified as required for the verification of the annual emissions report.

2. SPECIFIC ELEMENTS FOR STATIONARY SOURCE INSTALLATIONS:

- (1) The greenhouse gas emissions permit, and any updates thereof;
- (2) Any uncertainty assessments, where applicable;
- (3) For calculation-based methodologies applied in installations:
 - (a) the activity data used for any calculation of the emissions for each source stream, categorised according to process and fuel or material type;
 - (b) a list of all default values used as calculation factors, where applicable;
 - (c) the full set of sampling and analysis results for the determination of calculation factors;
 - (d) documentation about all ineffective procedures corrected and correction action taken in accordance with Article 64;
 - (e) any results of calibration and maintenance of measuring instruments.
- (4) For measurement-based methodologies in installations, the following additional elements:

- (a) documentation justifying the selection of a measurement-based methodology;
 - (b) the data used for the uncertainty analysis of emissions from each emission source, categorised according to process;
 - (c) the data used for the corroborating calculations and results of the calculations;
 - (d) a detailed technical description of the continuous measurement system including the documentation of the approval from the competent authority;
 - (e) raw and aggregated data from the continuous measurement system, including documentation of changes over time, the log-book on tests, down-times, calibrations, servicing and maintenance;
 - (f) documentation of any changes to the continuous measurement system;
 - (g) any results of the calibration and maintenance of measuring instruments;
 - (h) where applicable, the mass or energy balance model used for the purpose of determining surrogate data in accordance with Article 45(4) and underlying assumptions;
- (5) Where a fall-back methodology as referred to in Article 22 is applied, all data necessary for determining the emissions for the emission sources and source streams for which that methodology is applied, as well as proxy data for activity data, calculation factors and other parameters which would be reported under a tier methodology;
- (6) For primary aluminium production, the following additional elements:
- (a) documentation of results from measurement campaigns for the determination of the installation specific emission factors for CF₄ and C₂F₆;
 - (b) documentation of the results of the determination of the collection efficiency for fugitive emissions;
 - (c) all relevant data on primary aluminium production, anode effect frequency and duration or overvoltage data;
- (7) For CO₂ capture, transport and geological storage activities, where applicable, the following additional elements:
- (a) documentation of the amount of CO₂ injected into the storage complex by installations carrying out geological storage of CO₂;
 - (b) representatively aggregated pressure and temperature data from a transport network;
 - (c) a copy of the storage permit, including the approved monitoring plan, pursuant to Article 9 of Directive 2009/31/EC;
 - (d) the reports submitted in accordance with Article 14 of Directive 2009/31/EC;
 - (e) reports on the results of the inspections carried out in accordance with Article 15 of Directive 2009/31/EC;

- (f) documentation on corrective measures taken in accordance with Article 16 of Directive 2009/31/EC.

3. SPECIFIC ELEMENTS FOR AVIATION ACTIVITIES:

- (1) A list of aircraft owned, leased-in and leased-out, and necessary evidence for the completeness of that list; for each aircraft the date when it is added to or removed from the aircraft operator's fleet;
- (2) A list of flights covered in each reporting period, and necessary evidence for the completeness of that list;
- (3) Relevant data used for determining the fuel consumption and emissions;
- (4) Data used for determining the payload and distance relevant for the years for which tonne-kilometre data are reported;
- (5) Documentation on the methodology for data gaps where applicable, the number of flights where data gaps occurred, the data used for closing the data gaps, where they occurred, and, where the number of flights with data gaps exceeded 5% of flights that were reported, reasons for the data gaps as well as documentation of remedial actions taken.

ANNEX X

Minimum content of Annual Reports (Article 68(3))

1. ANNUAL EMISSION REPORTS OF STATIONARY SOURCE INSTALLATIONS

The annual emission report of an installation shall at least contain the following information:

- (1) Data identifying the installation, as specified in Annex IV to Directive 2003/87/EC, and its unique permit number;
- (2) Name and address of the verifier of the report;
- (3) The reporting year;
- (4) Reference to and version number of the latest approved monitoring plan and the date from which it is applicable, as well as reference to and version number of any other monitoring plans relevant for the reporting year;
- (5) Relevant changes in the operations of an installation and changes as well as temporary deviations that occurred during the reporting period to the monitoring plan approved by the competent authority; including temporal or permanent changes of tiers, reasons for those changes, starting date for the changes, and starting and ending dates of temporal changes;
- (6) Information for all emissions sources and source streams consisting of at least:
 - (a) the total emissions expressed as t CO_{2(e)};
 - (b) where greenhouse gases other than CO₂ are emitted, the total emissions expressed as t;
 - (c) whether the measurement or the calculation methodology referred to in Article 21 is applied;
 - (d) the tiers applied;
 - (e) activity data:
 - (i) in the case of fuels the amount of fuel (expressed as tonnes or Nm³) and the net calorific value (GJ/t or GJ/ Nm³) reported separately;
 - (ii) for all other source streams the amount expressed as tonnes or Nm³;
 - (f) emission factors, expressed in accordance with the requirements set out in Article 36(2); biomass fraction, oxidation and conversion factors, expressed as dimensionless fractions;
 - (g) where emission factors for fuels are related to mass or volume instead of energy, values determined pursuant to Article 26(5) for the net calorific value of the respective source stream;
- (7) Where a mass balance methodology is applied, the mass flow, and carbon content for each source stream into and out of the installation; biomass fraction and net calorific value, where relevant;
- (8) Information to be reported as memo items, consisting of at least:
 - (a) amounts of biomass combusted, expressed in TJ, or employed in processes, expressed in t or Nm³;

- (b) CO₂ emissions from biomass, expressed in t CO₂, where measurement-based methodology is used to determine emissions;
- (c) a proxy for the net calorific value of the biomass source streams used as fuel, where relevant;
- (d) amounts and energy content of bioliquids and biofuels combusted, expressed in t and TJ.
- (e) CO₂ or N₂O transferred to an installation or received from an installation, where Article 49 or 50 is applicable, expressed in t CO_{2(e)};
- (f) inherent CO₂ transferred to an installation or received from an installation, where Article 48 is applicable, expressed in t CO₂;
- (g) where applicable, the name of the installation and its identification code as recognised in accordance with the acts adopted pursuant to Article 19(3) of Directive 2003/87/EC:
 - (i) of the installation(s) to which CO₂ or N₂O is transferred in accordance with points (e) and (f) of this point (8);
 - (ii) of the installation(s) from which CO₂ or N₂O is received in accordance with points (e) and (f) of this point (8);

Where that installation does not have such identification code, the name and address of the installation as well as relevant contact information of a contact person shall be provided.

- (h) transferred CO₂ from biomass, expressed in t CO₂;
- (9) Where a measurement methodology is applied:
- (a) where CO₂ is measured as the annual fossil CO₂-emissions and the annual CO₂-emissions from biomass use;
 - (b) the hours of operation of the continuous emission measurement system (CEMS), the measured greenhouse gas concentrations and the flue gas flow expressed as an annual hourly average, and as an annual total value;
- (10) Where a methodology referred to in Article 22 is applied, all data necessary for determining the emissions for the emission sources and source streams for which that methodology is applied, as well as proxy data for activity data, calculation factors and other parameters which would be reported under a tier methodology;
- (11) Where data gaps have occurred and have been closed by surrogate data in accordance with Article 66(1):
- (a) the source stream or emission source to which each data gap applies;
 - (b) the reasons for each data gap;
 - (c) the starting and ending date and time of each data gap;
 - (d) the emissions calculated based on surrogate data;
 - (e) where the estimation method for surrogate data has not yet been included in the monitoring plan, a detailed description of the estimation method including evidence that the methodology used does not lead to an underestimation of emissions for the respective time period;

- (12) Any other changes in the installation during the reporting period with relevance for that installation's greenhouse gas emissions during the reporting year;
- (13) Where applicable, the production level of primary aluminium, the frequency and average duration of anode effects during the reporting period, or the anode effect overvoltage data during the reporting period, as well as the results of the most recent determination of the installation-specific emission factors for CF₄ and C₂F₆ as outlined in Annex IV, and of the most recent determination of the collection efficiency of the ducts.

Emissions occurring from different emission sources, or source streams of the same type of a single installation belonging to the same type of activity may be reported in an aggregate manner for the type of activity.

Where tiers have been changed within a reporting period, the operator shall calculate and report emission as separate sections of the annual report for the respective parts of the reporting period.

Operators of CO₂ storage sites may use simplified emission reports after closure of the storage site in accordance with Article 17 of Directive 2009/31/EC containing at least the elements listed under points 1 to 5, provided the greenhouse gas emissions permit contains no emission sources.

2. ANNUAL EMISSION REPORTS OF AIRCRAFT OPERATORS

The emission report for an aircraft operator shall at least contain the following information:

- (1) Data identifying the aircraft operator as set out by Annex IV to Directive 2003/87/EC, and the call sign or other unique designators used for air traffic control purposes, as well as relevant contact details;
- (2) Name and address of the verifier of the report;
- (3) The reporting year;
- (4) Reference to and version number of the latest approved monitoring plan and the date from which it is applicable, reference to and version number of other monitoring plans relevant for the reporting year;
- (5) Relevant changes in the operations and deviations from the approved monitoring plan during the reporting period;
- (6) The aircraft registration numbers and types of aircraft used in the period covered by the report to perform the aviation activities covered by Annex I to Directive 2003/87/EC carried out by the aircraft operator;
- (7) The total number of flights per State pair covered by the report;
- (8) Mass of fuel (in tonnes) per fuel type per State pair;
- (9) Total CO₂ emissions in tonnes of CO₂ disaggregated by the Member State of departure and arrival;
- (10) Where emissions are calculated using an emission factor or carbon content related to mass or volume, proxy data for the net calorific value of the fuel;
- (11) Where data gaps have occurred and have been closed by surrogate data in accordance with Article 66(2):

- (a) the number of flights expressed as percentage of annual flights (rounded to the nearest 0.1%) for which data gaps occurred; and the circumstances and reasons for data gaps that apply;
 - (b) the estimation method for surrogate data applied;
 - (c) the emissions calculated based on surrogate data;
- (12) Memo-items:
 - (a) amount of biomass used as fuel during the reporting year (in tonnes or m³) listed per fuel type;
 - (b) the net calorific value of alternative fuels;
- (13) As an annex to the annual emission report, the operator shall include annual emissions and annual numbers of flights per aerodrome pair. Upon request of the operator the competent authority shall treat that information as confidential.

3. TONNE-KILOMETRE DATA REPORTS OF AIRCRAFT OPERATORS

The tonne-kilometre data report for an aircraft operator shall at least contain the following information:

- (1) Data identifying the aircraft operator as set out by Annex IV to Directive 2003/87/EC, and the call sign or other unique designator used for air traffic control purposes, as well as relevant contact details;
- (2) Name and address of the verifier of the report;
- (3) The reporting year;
- (4) Reference to and version number of the latest approved monitoring plan and the date from which it is applicable, reference to and version number of other monitoring plans relevant for the reporting year;
- (5) Relevant changes in the operations and deviations from the approved monitoring plan during the reporting period;
- (6) The aircraft registration numbers and types of aircraft used in the period covered by the report to perform the aviation activities covered by Annex I to Directive 2003/87/EC carried out by the aircraft operator;
- (7) Chosen method for calculating the mass of passengers and checked baggage, as well as freight and mail;
- (8) Total number of passenger-kilometres and tonne-kilometres for all flights performed during the year to which the report relates falling within the aviation activities listed in Annex I of Directive 2003/87/EC;
- (9) For each aerodrome pair, the: ICAO designator of the two aerodromes; distance (great circle distance + 95 km) in km; total number of flights per aerodrome pair in the reporting period; total mass of passengers and checked baggage (tonnes) during the reporting period per aerodrome pair; total number of passengers during the reporting period; total number of passenger multiplied by kilometres per aerodrome pair; total mass of freight and mail (tonnes) during the reporting period per aerodrome pair; total tonne-kilometres per aerodrome pair (t km).

ANNEX XI

Correlation table

Commission Regulation (EU) No 601/2012	This Regulation
Article 1 to 49	Article 1 to 49
-	Article 50
Article 50 to 67	Article 51 to 68
Article 68	-
Article 69 to 75	Article 69 to 75
-	Article 76
Article 76 to 77	Article 77 to 78
Annex I to X	Annex I to X
-	Annex XI